

# The Design Of The M&S Acquisition Support Effort Of The SANDF GBADS Acquisition Programme<sup>1</sup>

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**Abstract.** The Ground Based Air Defence System (GBADS) acquisition programme, of the South African National Defence Force (SANDF), provided an opportunity to apply Modelling and Simulation (M&S), at a system of systems level, for acquisition risk reduction. At the same time it was used as a vehicle to establish a credible acquisition support capability. The purpose of this paper is to report on the design of the acquisition support effort and, to a certain extent, attempt to generalise some of the techniques employed. The paper firstly provides a brief background to the GBADS acquisition programme after which the SANDF acquisition process is briefly explained. The role of a Defence Evaluation and Research Institute is elaborated upon, focusing on the use of M&S to establish a shared Body of Knowledge and “concurrent” tactical doctrine development. It concludes by showing how the established capability needs to be expanded into other areas of the defence life cycle.

## 1. INTRODUCTION

1998 the Armaments Corporation of South Africa (Armscor) established a Modelling and Simulation for Decision Support capability at the Council for Scientific and Industrial Research (CSIR) as part of a Defence Evaluation and Research Institute (DERI) capability. The aim of the MSDS capability was to provide decision support during the phased acquisition of a Ground Based Air Defence System (GBADS) for the South African National Defence Force (SANDF).

Armscor is the primary acquisition agent of the South African Department of Defence (DOD). The CSIR in its role as a DERI contributes as impartial technical advisors during the acquisition process.

A brief overview of the GBADS acquisition programme and the DOD acquisition process is given in order to provide context. Three key issues are explored, which served to direct the approach followed in the acquisition support process. These are:

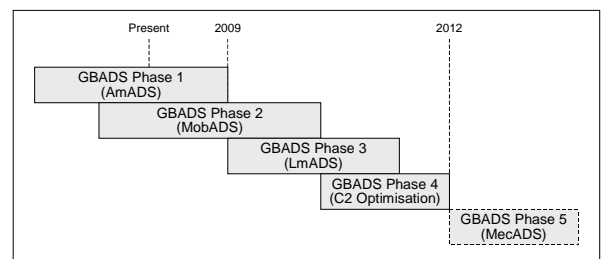
- Establishment and maintenance of a sustainable GBADS Body of Knowledge (BoK).
- The role of the DERI, specifically focusing on its contribution during capital acquisition projects.
- Identifying key performance driver(s) of GBADS and their impact on the simulation approach and focus.

The focus of the paper is on process establishment, though some information is provided on the simulation environment. The paper concludes by expressing an

opinion on the potential for wider application of Modelling and Simulation (M&S), and the associated processes, through the capability life cycle.

## 2. GBADS ACQUISITION PROGRAMME

The GBADS Programme Office adopted an acquisition strategy whereby the required GBADS capability is established in an incremental and systematic manner [1]. This strategy allows for the progressive expansion of air defence layers while maintaining an integrated system (refer to Figure 1).



**Figure 1:** GBADS Phased Acquisition.

The acquisition programme comprises five phases each addressing the acquisition of a specific element of the GBADS. Phase 1 addresses an Air-mobile Air Defence System (AmADS) utilising man-portable missiles that can also be employed as a component of a Mobile Air Defence System (MobADS). Phase 2 involves the acquisition of the remainder of the MobADS elements while Phase 3 provides for a Light Mobile Air Defence System (LmADS). The Command & Control (C2) building blocks acquired in Phases 1, 2 and 3 are optimised in Phase 4, with respect to technology obsolescence and standardisation on new generation

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<sup>2</sup> Constituted by an Act of Parliament in 1945, the CSIR is one of the leading scientific and technology research, development and implementation organizations in Africa. It is situated in Pretoria and is represented in each of the nine provinces of South Africa. (<http://www.csir.co.za>)

communications equipment, etc. Phase 5 addresses the Mechanised Air Defence System (MecADS) element of GBADS.

### 3. M&S SUPPORT IN PHASED ACQUISITION

The phased, integrative approach toward establishing the new Air Defence capability presented a number of challenges. First, because acquisition phases overlap, system performance information is not available as inputs to a next phase. System performance parameters must therefore be determined in another way in order to ensure that subsequent phases are suitably designed.

Second, the GBADS acquisition programme is spread over a relatively long period of time (calendar years), posing the challenge of retaining a GBADS BoK. The need arose for a mechanism to capture, facilitate and maintain the GBADS BoK.

The above requirements, combined with risk reduction, suggested the use of M&S as an acquisition tool. This approach is not new and Jackson [2] reports on how Synthetic Environments (SE) and M&S are applied to the field of capability acquisition during the major phases of the capability life-cycle for capability visualisation, solution trade-offs and risk reduction, human factors evaluation and design, system integration, test and acceptance.

### 4. DERI ROLE IN SOUTH AFRICA

DERIs are defence-funded organisations responsible for providing decision support to the DOD and Armscor. Although the DERIs contribute to the whole capability life cycle it is its contribution to the acquisition process that is of primary importance.

The DERI Decision Support Model (DDSM) relates to the systems hierarchy as shown in Figure 2. Domain-specific expertise focuses on the upper levels of the systems hierarchy, whilst enabling expertise focuses on the lower levels of the systems hierarchy, as well as providing support to domain-level expertise.

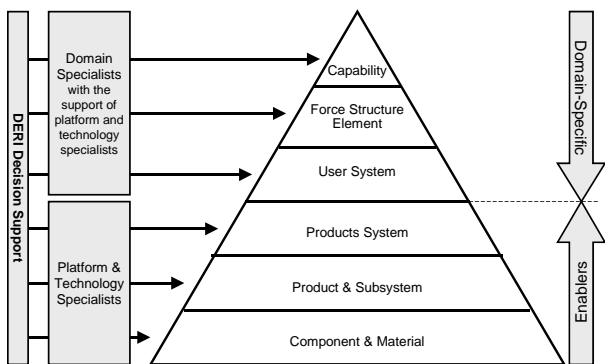


Figure 2: DDSM & Systems Hierarchy [3].

Due to resource constraints the domain-specific and enabling expertise within the DERI is not all encompassing. A method is therefore required to leverage this capability by means of domain-specific capabilities within the DOD and enabling expertise

vested in industry, the latter without compromising the impartiality of the DERI decision support.

### 5. C2 AS GBADS PERFORMANCE DRIVER

During the early development of the Synthetic Environment (SE) elements to support the acquisition process, it became clear (and not surprisingly so) that the timeline of events is an important element to model properly. Credible results rely primarily on successful rendering of the temporal behaviour of events. This temporal behaviour of the system under consideration is in turn driven by C2 characteristics and doctrine. At worst, the SE can become just a discrete event engine, yielding satisfactory and repeatable outcomes within a bound space of possibilities. At best, and when the simulation is designed well on top of the appropriately pitched models, the SE could deliver surprising, validate-able results.

Such a SE is valuable in that it not only mimics the “what is”, but allows for the synthesis of the “what could be”. This was exactly what became an important consideration in the later phases of the GBADS project. It became clear that C2 comprised the one element that could be optimised and modified to give a tactical advantage and leverage system performance. Where it was initially thought that the doctrine would need only slight adjustment, the SE allowed the GBADS users to play what-if games using doctrine as a variable in addition to hardware and software system components. Now the battle handling procedures became the focus, necessitating changes to the SE to allow for real time intervention and operator integration during experimentation. New analysis approaches had to be introduced to ensure SE integrity. The user played a valuable role in validation through inspection processes [4] (Delphi, Turing, causality & logic and event sequencing) and demonstration tests, using prior experience and new insight to test the validity of models and interpretation of results. This forced the simulation architects to consider hybrid approaches to the modelling, introducing more behavioural elements into the simulation framework. Two approaches were followed namely to capture “automatic” operators exercising the different doctrinal options while also allowing for operators to “manually” interact with the simulation and test certain battle handling.

This allowed the users to “experience” the emergent behaviour of the system being acquired and to assess the application boundary of the system. Furthermore, it allowed the user the opportunity to experiment and assess the impact of critical performance parameters on system effectiveness, thus establishing BoK in the user environment prior to system delivery. This concurrent doctrine development is expected to result in enhanced operational capability at system handover to the user.

## 6. DESIGN OF THE M&S ACQUISITION SUPPORT CAPABILITY

South Africa is a small economy, thus little duplication of efforts can be afforded. This necessitated the development of a support capability that could analyse the effects of using different system components on mission outcomes (often in a many-on-many mode), and would allow for doctrinal variation and synthesis of new battle handling procedures in a very flexible manner.

The first objective was achieved either by specifying and procuring the appropriate level of model from equipment suppliers where possible, or by developing suitable “generic” alternatives with behaviour closely following performance reported in the open literature. In cases where system performance is sensitive to the behaviour of a particular subsystem, suppliers were commissioned to assist with the validation of in-house developed “generic” models. It is obvious that good relationships had to be established with suppliers and the suppliers had to feel confident that the models were adequate representations of the real systems. This was only possible given the specific DERI role of the CSIR, which precludes it from competing with the equipment suppliers in a normal commercial sense.

Secondly, the system had to allow for the synthesis of battle handling procedures other than those typically prescribed by the equipment suppliers, but without invalidating the applicability of the models. This proved difficult and again good relationships with suppliers played a major role in achieving this goal. Keep in mind that doctrine often contains secret tactics, which cannot be shared freely with suppliers. Mission effectiveness was shown to be the key element to be optimised and investigated and using this higher level of operational goal, it was possible to convince both the users and suppliers of the value of this approach. In order to facilitate this collaborative approach, a DDTG (Doctrine Development Task Group) was established, with the following goals:

- It provided the underlying scientific process of hypotheses, synthesis and analysis;
- It provided a mechanism to access the enabling technologies not inherently part of the DERI but located in industry;
- It provided a forum for joint conceptualisation, definition, experimentation and analysis by all stakeholders, thus a forum for facilitating GBADS BoK establishment and maintaining.

The GBADS support capability established consists of a Doctrine Development Process and a Virtual GBADS Demonstrator (VGD), the SE underpinning acquisition support. Note that this support capability was utilised for dual purposes on GBADS. One part of the activities focused on providing decision support to Armscor with the impartial assessment of different system options

while the other addressed enhancements to doctrine in order to optimise the finally acquired system.

### 6.1 Doctrine Development Process

The doctrine development process as governed by the DDTG is described in detail in [5]. What is however of importance is the use of this process to gain access to domain expertise as well as enabling expertise. The relationship between key stakeholders in the DDTG is illustrated in Figure 3.

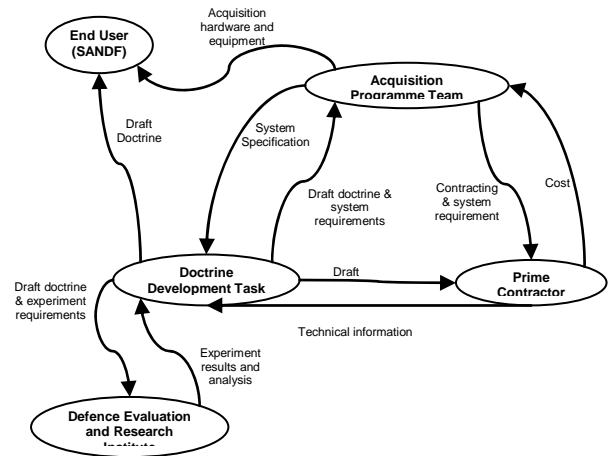


Figure 3: DDTG Stakeholders (adapted from [5]).

Using the DDTG process, valuable insights are gained to determine not only relevant doctrine but also to establish and isolate those performance drivers that need to be considered in more detail in support of the acquisition process. This must be captured in such a way that a SE can be constructed, typically as is shown in Figure 4.

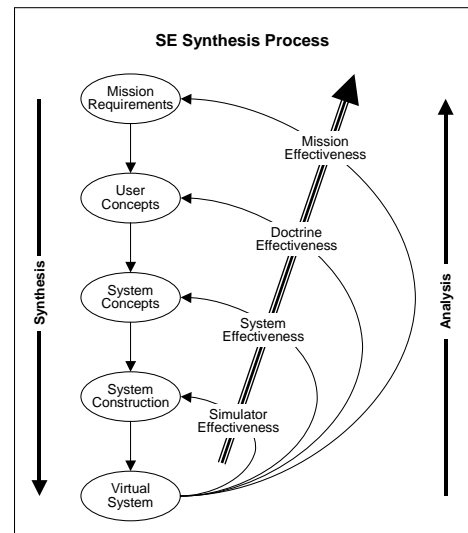


Figure 4: Typical SE Synthesis Process.

The virtual system embedded in the SE, which is a result of the general synthesis process, is in effect a realisation of a system exhibiting the characteristics of the user requirement for a capability that could perform certain predefined mission requirements. Using the SE it is possible, through iterative analysis loops, to investigate elements of doctrine that can improve

mission effectiveness, because the focus is placed on the warfighter as part of an integrated user system.

Synthesis is informed by field trials, MoDAF tools and other ways of capturing information, e.g. the DDTG. At the same time, the behaviour and effects of possible platforms are tightly integrated and used as an integrated part of the analysis. By using operator-in-the-loop elements in the SE, it is possible to bring the contribution of the warfighter into the analysis.

### 6.2 Virtual GBADS Demonstrator

The VGD was developed to provide for the simulation and analysis of virtual GBADS entities deployed in a defined scenario, in order to observe the behaviour and interaction between the various operators and GBADS subsystems.

In order to do systematic validation of battle handling doctrine provision was made for the support of both constructive and virtual simulation. This allows for both “automatic” and “manual” experimentation.

The VGD architecture supports distributed simulation of many-on-many engagements. The behaviour of equipment and operators is modelled, as well as the interaction between these entities. For more detail on the architecture and functioning of VGD the reader is referred to Le Roux [6].

## 7. BROADENING THE ACQUISITION SUPPORT BASE

### 7.1 DERI Decision Support Framework (DDSF)

The DDSF manifests itself as a three-dimensional space defined by the DERI decision support focus areas on the x-axis, the system hierarchy on the y-axis and the DERI decision support domains on the z-axis as illustrated in Figure 5 [adapted from 2].

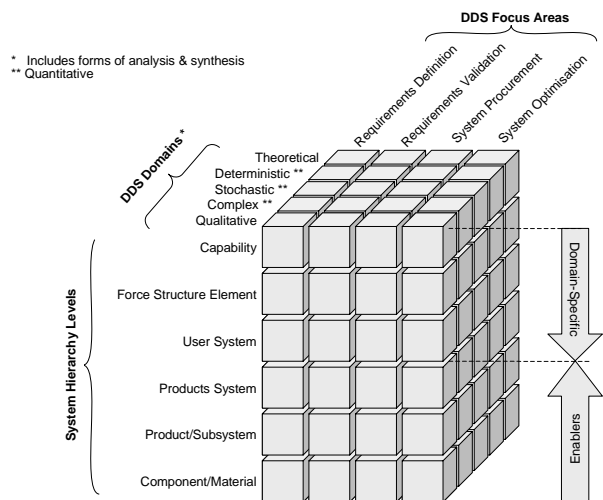


Figure 5: DERI Decision Support Framework [3].

### 7.2 Capability Life Cycle

The DDSF makes provision for support over the entire capability life cycle by virtue of the fact that the DERI

decision support focus areas align with the primary capability life cycle phases as illustrated in Figure 6.

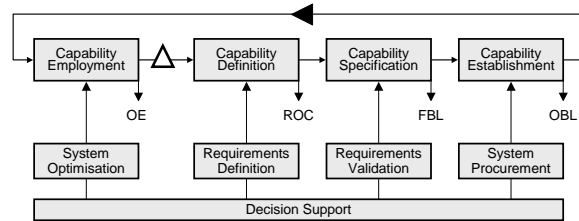


Figure 6: Capability Life Cycle [3].

System optimisation support is provided during the capability employment phase. Operational effectiveness (OE) is assessed and a shortcoming results in a “delta” that triggers capability definition. DERI requirements definition support is provided during the capability definition phase, leading to the Required Operational Capability (ROC), which initiates the acquisition process. Requirements validation support is provided during the capability specification phase, resulting in a functional baseline (FBL) used for contracting purposes. System procurement support, e.g. concurrent doctrine development, is provided during the capability establishment phase, leading to an operating baseline (OBL) upon handover of the system to the user.

### 7.3 DDSF Evolution

The support capability established for GBADS, and much of the traditional DERI support on other defence programmes, occupy only a portion of the DDSF as illustrated in Figure 7.

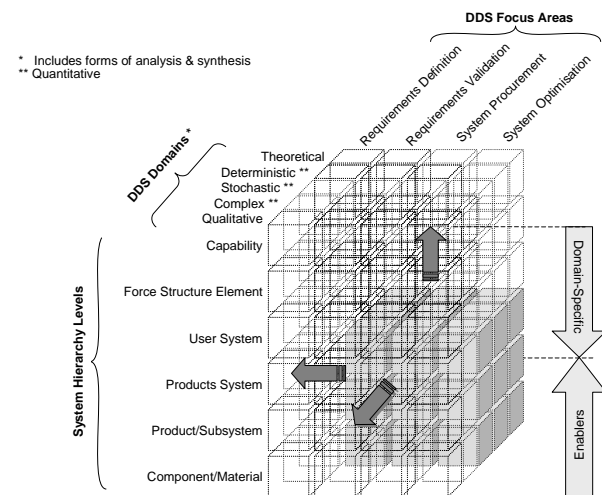


Figure 7: DDS Evolution (adapted from [2]).

It is possible that the process followed by the DDTG and the general synthesis and analysis loops described earlier, could be used as basis for expanding DDS into other areas of the DDSF as indicated by the arrows in Figure 7.

### 7.4 Some Considerations for DDS Evolution

Two issues must be considered for future acquisition support efforts: First, the warfighter is becoming a central element in modern warfare, being at the core of

distributed decision making paradigms, and secondly, the networked nature of modern forces bring new complexities to the fore that must be reflected when developing tools to support systems throughout the entire capability life cycle.

Simulated environments must be made more flexible to discover emerging patterns and surprising situations, before the force is put into action on a mission. This is obviously an important aspect for training as well, where “train as you would fight” is becoming an imperative for success, especially when considering new asymmetric situations.

Agent based simulation appears to be able to capture the complexity of interacting elements and to discover patterns that may make the system more robust. It is now possible to use new methods for reasoning under uncertainty to discover patterns in behaviour that may be reflected in a SE to further enhance the experience of the end user during analysis of system and mission effectiveness and to extract new ways of battle handling under new threat scenarios. These technologies and paradigms are now being studied to incorporate such elements in future versions of VGD and similar simulators.

## 8. CONCLUSION

In this paper the authors discussed the issues impacting on the design of a support capability to the SANDF GBADS acquisition programme. It was shown that merely developing a system of systems simulation does not address the critical performance drivers but that an additional process, developing and evaluating doctrine, is necessary to interface to other domain and enabling technology specialists.

Although some significant successes were achieved in the GBADS programme, to expand the capability into higher level capability definition and evaluation dictates that new simulation architectures be developed to cope with the complexity and that new analysis tools be considered by the scientists and engineers to ensure integrity of the SE used during acquisition decision support.

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