Potential Role of an Enterprise Service Bus (ESB) in Simulation

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ABSTRACT

This paper considers eight areas where an Enterprise Service Bus (ESB) can contribute to the end state of "Live and Virtual" simulation in the NATO context, with application to the acquisition lifecycle.

1. Populating the "Area of Operations" with environmental models

Progressive layers of detail that can be provided to different standards and degrees of resolution.

2. Translation services between standards and versions of standards

Simulators can make a service request for data in their preferred format. The ESB can fulfil that request, either directly from the master data set or via a conversion routine, to procure the data for the "area of operations" into the appropriate format including translation into different versions of the same standard.

3. Parallel testing concepts for introducing a new service

There is a way of allowing a service under test to see the stream of production data, which allows for parallel testing of new services before they are introduced.

4. Exercise Control

Simulation Control Concepts

5. Battle Damage Assessment

There is difficulty obtaining damage assessments both on potential adversary equipment and from allies.

6. Tactical Messaging

The scenario of a real jet flying over the area of operations and a simulated air defence missile launch.

7. Digital concepts of a "fair fight"

Calculations can be made dynamically to adjust the overall performance.

8. Acquisition modelling and simulation

By designing a model of the projected maintenance requirements, this simulation run forward can give deep insight into the availability of the military platform. Reshape the design of the maintenance workload to maximise availability and meet preparedness goals.

1.0 INTRODUCTION

A number of modelling and simulation (M&S) standards have evolved over time to meet the interoperability needs of the simulation community. The main framework today is the High Level Architecture (HLA), which is the IEEE 1516 standard and mandated by the NATO M&S Interoperability STANAG 4603[1].

The world of live military operations is often brought together on the command and control networks by the use of Service Oriented Architecture constructs implemented by an Enterprise Service Bus. To link together both "Live" and "Virtual" simulations implies linking an ESB to HLA implementations.

This paper considers the potential role of an Enterprise Service Bus in addressing three key problem areas in simulation:

1. Data translation services

2. How to link simulations with the live military environment.

3. Bringing corporate data into a simulation environment such as for acquisition modelling

1.1 Enterprise Service Bus

An Enterprise Service Bus (ESB) is the run time infrastructure that implements the Services Oriented Architecture pattern. ESBs are a proven, reliable and high volume infrastructure foundation. They are used for the management of events, as well as security policy enforcement. ESBs are ideally suited to triggering the recording of a collection of events for post engagement analysis.

One implementation pattern of an ESB is the publish / subscribe model which removes the point to point spaghetti of system connections, making it practical to design a loosely coupled messaging infrastructure that can incorporate new end points and processes over time — thereby making it an ideal construct to support Live and Virtual simulation.

A service is an abstract concept that is valid in the context of a business process, or in software design and deployment. To the business, the key principle of a service is that the focus is on what it does---and is independent of how it does it, or which resource performs it. To the architect, the focus is on the service contract, which is the technology-neutral but business-specific representation of the service. The focus of the developer is on how the components and resources implement the service, and not on which process(es) it is part of.

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[1] AMSP-01(B) - NATO MODELLING AND SIMULATION STANDARDS PROFILE, page 32

2.0 DATA TRANSLATION SERVICES

2.1 Populating the "Area of Operations" with environmental models

A primary use case for an ESB in simulation is to facilitate the translation services between standards and versions of standards.

When populating the "area of operations" as illustrated in Figure 1 below, there are progressive layers of detail about the terrain. For example vegetation, man-made structures, weather etc., that can be provided to differing standards and degrees of resolution.

Figure 1: Area of Operations

This needs to cater for different simulators that require different base data to be part of an overall simulation.

Naturally, increasing degrees of realism take higher levels of computing power. It may be sufficient in 'Development' and 'Test' to work with stick figures and block structures, progressing towards high fidelity augmented reality in the Production instance.

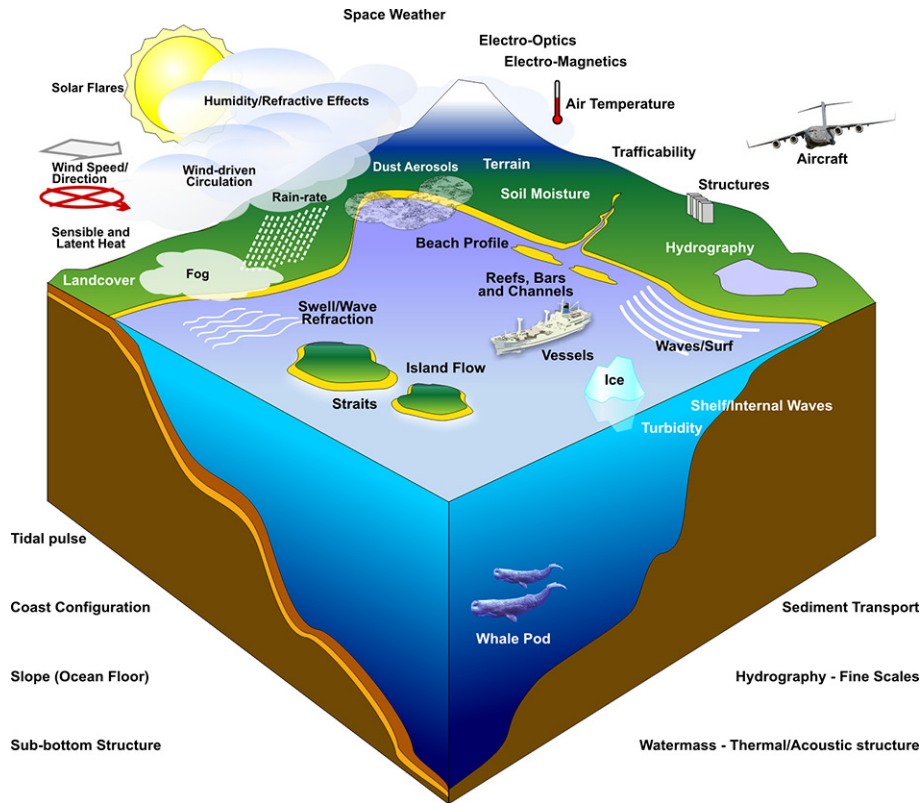## 2.2   Translation services between standards and versions of standards

Figure 2: Environment Models

In Figure 2 above, the illustration shows some of the possible environmental details which are modelled for the simulators. Over time, multiple standards for Synthetic Environments have arisen, including:

- SEDRIS (sponsored by US DoD, now ISO 18023+) STANAGs (4662 to 4664)
    - Environmental Data Coding Specification (EDCS) STANAG 4662
- Common Database (CDB)
- X3D Extensible 3D (replaces VRML)
- Open Flight
- Terrapage
- Compact Terrain Database (CTDB)
- Digital Terrain Elevation Data (DTED) STANAG 3609
- Other Proprietary Formats …

There are multiple standards for Synthetic Environments which make it almost impossible to 'standardise' on particular formats and risk excluding otherwise viable simulators. One solution to this problem is to facilitate the translation of different standards as required.

An organisation can make its own decision about the standards for keeping various environmental and geospatial data.
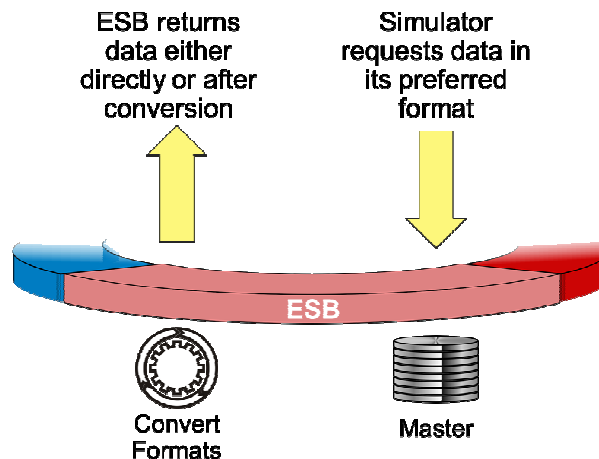
Figure 3: Design concepts for multiple disparate simulators

Simulators can make a service request for data in their preferred format and, as illustrated in Figure 3 above, the ESB can fulfil that request — either directly from the master data set, or via a conversion routine to get the data for the "area of operations" into the right format.

Translation services can apply equally to different versions of the same standard. The ESB can provide the translation service from one version of a standard to the next as illustrated by the seven versions of Distributed Interactive Simulation – Application Protocol, shown in Figure 4 below.
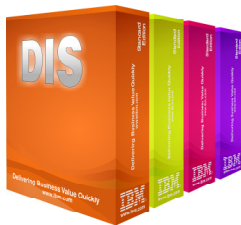
- Version 1 - 1992
- Version 2 - IEEE 1278-1993
- Version 3 - May 1993
- Version 4 - March 1994
- Version 5 - IEEE 1278.1-1995
- Version 6 - IEEE 1278.1a-1998 (amendment to IEEE 1278.1-1995)
- Version 7 - IEEE 1278.1-2012 (also called DIS 7)

Figure 4: DIS Application Protocols – examples of multiple versions of a standard.

High Level Architecture (HLA) was produced by the merger of the DIS protocol with the Aggregate Level Simulation Protocol (ALSP) designed by MITRE.

"HLA is defined as a set of services, provided by a C++ or Java API. There is no standardised on-the-wire protocol. Participants in a federation must use Run Time Infrastructure (RTI) libraries from the same provider and usually also of the same version in order for applications to interoperate[2]."

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[2] http://en.wikipedia.org/wiki/High_Level_Architecture_(simulation)

The ESB can provide that interoperability between different providers of RTI libraries to support participants in a federation of simulators.

In the Health domain, HL7 is one of the main interoperability protocols and is itself subject to different versions. The HL7 version 2 standard aims to support hospital workflows. It was originally created in 1989.

HL7 version 2 defines a series of electronic messages to support administrative, logistic and financial as well as clinical processes. Since 1987 the standard has been updated regularly, resulting in versions 2.1, 2.2, 2.3, 2.3.1, 2.4, 2.5, 2.5.1 and 2.6. The v2.x standards are backward compatible (e.g., a message based on version 2.3 will be understood by an application that supports version 2.6).

The HL7 version 3 standard aims to support all healthcare workflows. Development of version 3 started around 1995, resulting in an initial standard publication in 2005. The v3 standard, as opposed to version 2, is based on a formal methodology (the HDF) and object-oriented principles[3].

The ESB can facilitate the translation between simulators using various versions of HL7. This concentrates the translation services into one logical place on the SOA backbone. Simplifies the simulator requirements; as conceptually illustrated in Figure 5 below.
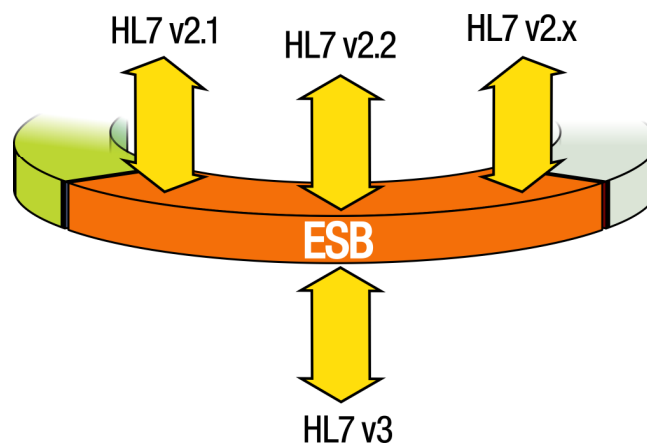

Figure 5: HL7 Translation Services

3 http://www.hl7.org/implement/standards/product_brief.cfm?product_id=77

2.3 Parallel testing concepts for introducing a new service

Components of a simulation can become so complex that they are not easily replaced by simple software upgrades. An example we might consider would be Interactive Voice Recognition (IVR). There is much tuning work to be done to make an IVR system perform at an acceptable level of recognition. There is no one configuration item to release in the upgrade, but rather the combined result of complex testing and tuning. In Figure 6 (below), we see how parallel testing concepts are used to simplify the introduction of complex new simulation services.
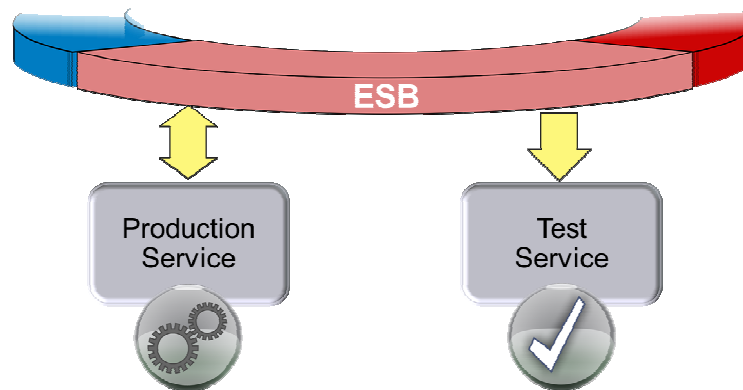

Figure 6: Parallel testing concepts

The Test Service receives the same input as the Production Service but does not affect the results – its performance is analysed until it can be promoted into Production. Thus in the IVR example, a new service can be configured to see the same input and voice tracks as the Production Service. The output is analysed and the Test Service reconfigured until such time as it provides acceptable results.

Promotion to Production can reasonably be done when the Test Service obtains 'as good' or 'better' results than the current Production Service.

3.0 LINKING SIMULATIONS WITH THE LIVE MILITARY ENVIRONMENT

3.1 Exercise Control

Simulation exercises are typically divorced from real time, with each simulator needing to be coordinated with "exercise time". Exercise control is a coordination application where the ESB can be the master timekeeper across simulations.

- Multiple named exercises in various stages of development at any one time

- A simulator 'instance' subscribes to the ESB for an exercise name and type

- The ESB sets the clock signal for each exercise that keeps all simulators in sync.

An example might be a named exercise such as "*Talisman Indigo 2014*" which itself may be in different stages of development and thus appear in three different states: Development | Test | Production.

All connected simulators can have their clocks synchronised according to the time pulse distributed by the ESB. A simulation exercise can be setup with its own name, state (Development, Test, Production etc.) and timing. The ESB can keep these different simulation exercises completely separate. Thus a simulator would 'subscribe' to a particular scenario and be provided with its initial area of operations, geospatial data, timing and so on.

3.2 Battle Damage Assessment

The fidelity of battle damage assessment can be refined according to the state (such as 'Development, 'Test' or 'Production') and other parameters. For example, a 'Development' or 'Test' scenario can calculate damage to a tank from an incoming round, according to basic second year university physics. Meanwhile, the Production scenario can give more refined and realistic assessments based on engineering data from the military.

At the 2013 NATO MSG conference held in Sydney October 2013, the DSTO presented a paper that noted the difficulty of obtaining damage assessments both on potential adversary equipment and from allies[4]. Precise engineering data is only made available if the simulation is limited to appropriately cleared and authorised users. The result of the "*Battle Damage Assessment*" service is dynamic according to the state (Development | Test | Production) and the security level of the participants, including their country of origin to cover releasability guidelines.

3.3 Tactical Messaging – Bringing "Live" and "Virtual" Simulation Together

The incorporation of tactical messaging into the simulation network can bring Live and Virtual simulation together.

Consider the military scenario of a real jet flying over the area of operations and a simulated air defence missile launch. From the Common Operating Picture (COP), we need the 'track' transferred across to introduce the jet into the simulator's world view.

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[4] Frank, T., Hemming, D., Holden, L., Mazonka, O., & Shine, D., (2013). A Methodology for the Generation, Storage, Verification and Validation of Performance Data for Modelling and Simulation, NMSG 2013, Sydney, Australia.
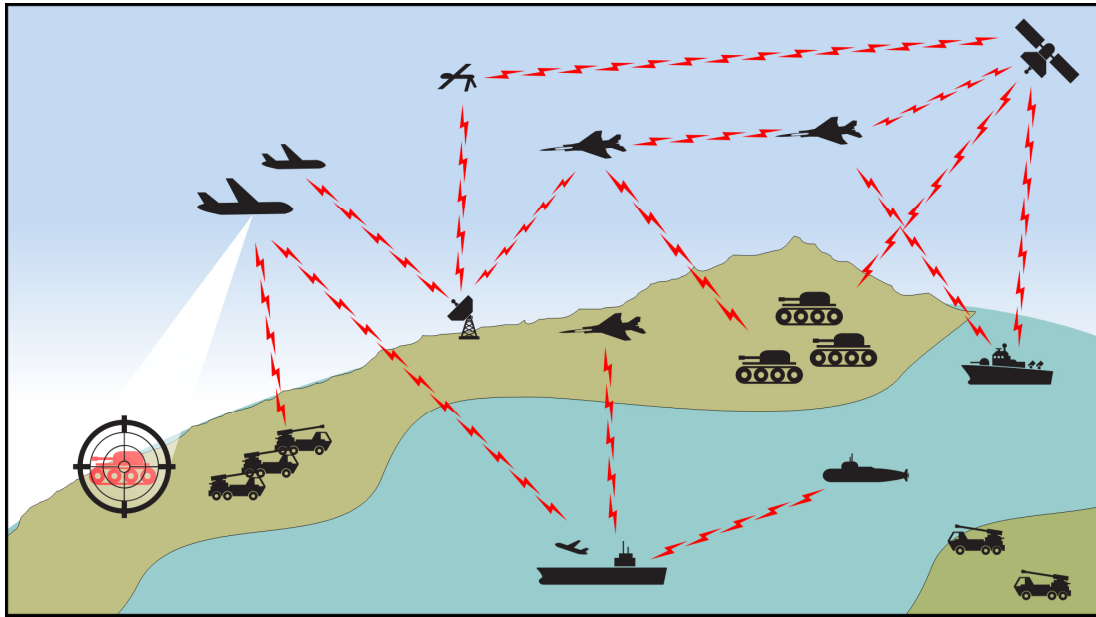
Figure 7: Tactical Information Exchange Domain

As illustrated in Figure 7 above, the track from the real world can be introduced into a simulator's world view to allow for 'Live' and 'Virtual' simulations.

This leads to a reference architecture illustrated in Figure 8 below that shows how an ESB can link both live and virtual simulations, utilising information from the Battle Management System (BMS).
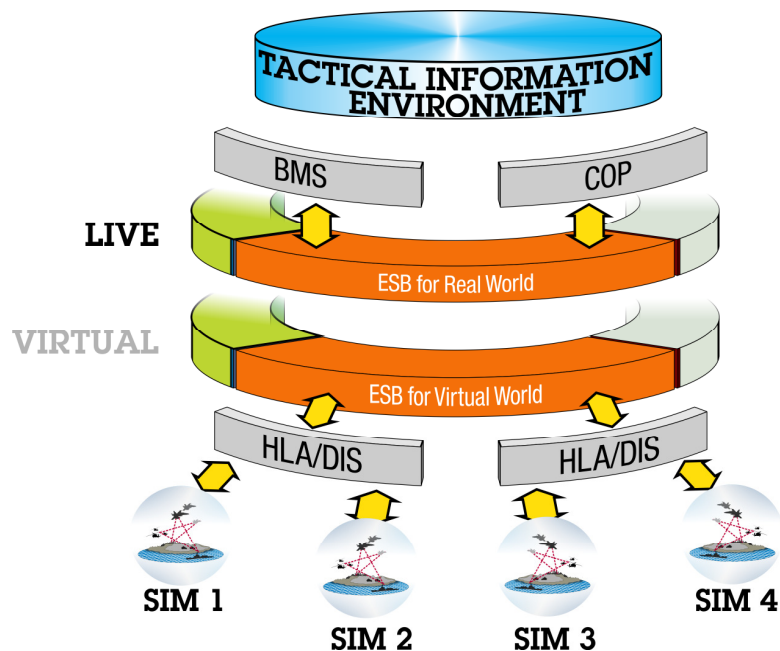

Figure 8: Reference Architecture Linking Live and Virtual Simulations

3.4 Digital concepts of a "fair fight"

Electronic simulators highlight the issue of how we deal with the electronic equivalent of a "fair fight". There is an inherent disadvantage if one simulator can display a threat and respond to it faster than another player in the simulation. Obtaining a credible, realistic mutual response time scenario is an area rich in potential for research assistance.

As a simple concept, if the ESB was coordinating several simulators with different physical performance characteristics, calculations can be made dynamically to adjust the overall performance.

In practical terms this may mean delaying a message to one simulator until an incoming aircraft becomes visible in two different simulators at the same time, thus ensuring a "fair fight".

4.0 BRINGING CORPORATE DATA INTO A SIMULATION ENVIRONMENT

4.1 Acquisition modelling and simulation

By designing a model of the projected maintenance requirements, the simulation run forward can give deep insight into the availability of the military platform and reshape the design of the maintenance workload to maximise availability and meet preparedness goals.

The acquisition of military platforms can be looked at from a number of perspectives. Typically a key perspective is to map the availability of the platforms as the old fleet is retired and new acquisitions are brought online. Another perspective is to look at the efficiency of the maintenance windows and intervals. A suitable model can examine the most efficient set of maintenance activities and intervals to maximise the availability of the platform.

A question that can be answered by simulation is: "If a major platform is being taken offline for a deep maintenance cycle, what other activities can be done at that time to avoid or minimise future maintenance periods?"

These calculations are necessarily complex, so that a computer model is the only practical way to calculate the optimal outcome. High availability may also come at a high cost, so the model can be optimised for the best platform availability within acceptable cost parameters. Historically it is now well accepted that the initial acquisition cost is only a small proportion of the life cycle costs. Thorough acquisition modelling that looks at the full life cycle costing can provide strategic input into the decisions covering changeover between platforms and information on the cost versus capability debate.

Real world experience is a key input to the accurate simulation of the model over time. Real values for maintenance parameters can be derived from logistics systems via the corporate ESB and used along with the design parameters for the proposed platform as illustrated in Figure 9 below. These inputs are then modelled to achieve the optimum outputs in terms of availability, cost and capability.

This process can also be turned around to help specify the design parameters of a new platform, in order to meet certain maintainability objectives. An example might be found by exploration: "If the maintenance interval on a diesel engine could be extended to a particular figure, then that would have a significant impact on the availability of the platform?" That exploration process, when fed by achievable real world figures, can help to specify the most suitable platform at the time of acquisition.
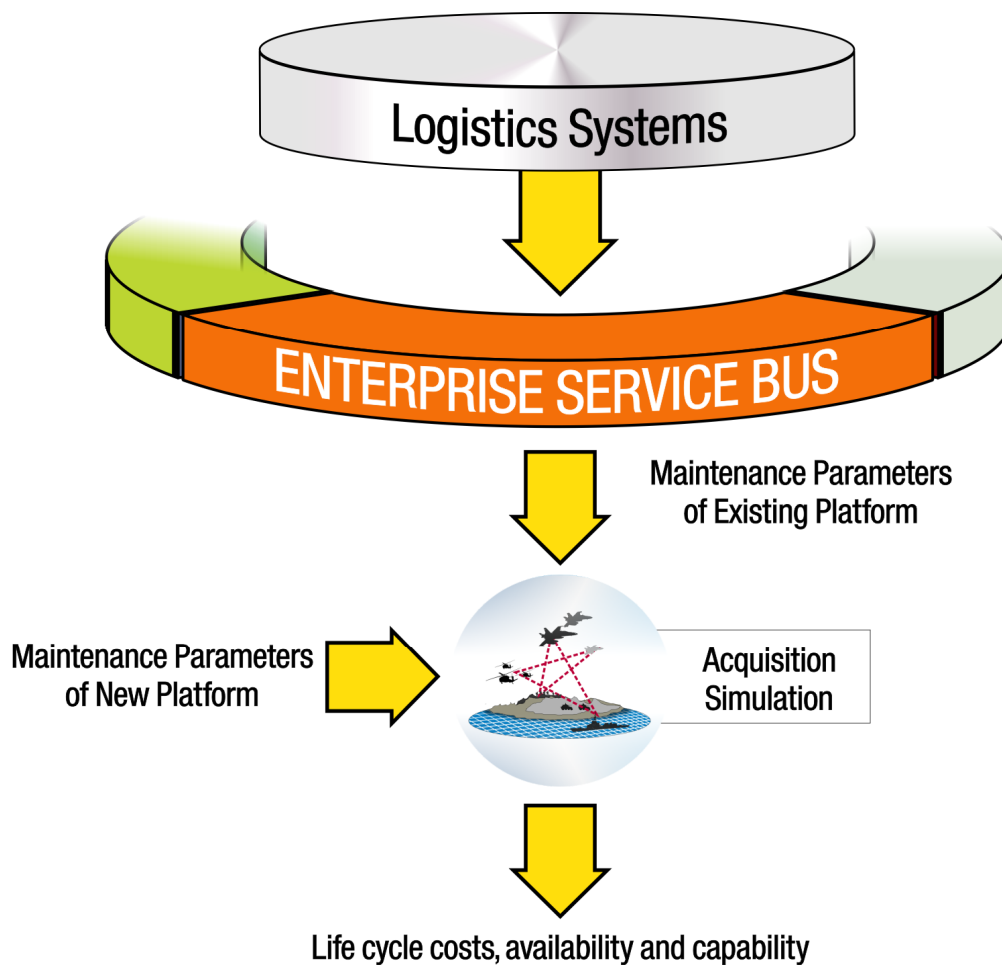
Figure 9: Input to acquisition modelling from corporate logistics systems

5.0   CONCLUSION

While the close and dynamic interaction between real time simulators is generally catered for by the HLA standards, this paper has considered three broad problem areas where an Enterprise Service Bus (ESB) can contribute to the end state of "Live and Virtual" simulation:

1. Data translation services

2. How to link simulations with the live military environment.

3. Bringing corporate data into a simulation environment such as for acquisition modelling