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MODELING AND SIMULATION-BASED OPERATIONAL TEST AND EVALUATION: IS THIS THE PANACEA FOR CF ACQUISITION?

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Abstract

Modeling and simulation (M&S) is a rapidly advancing technology where computer generated models of real world systems are manipulated and investigated in real and virtual environments. This paper addresses the use of M&S in operational test and evaluation (OT&E) and the degree to which it can enhance the Department of National Defence (DND) acquisition process. The discussion begins with an overview of the DND acquisition process and identifies four problem areas that are affected by OT&E. Firstly, there is a need for OT&E to be conducted earlier in the acquisition process. Secondly, test and evaluation (T&E) needs to be employed more effectively as a tool to reduce acquisition risks. Thirdly, the acquisition process must be shortened. And finally, there is a need to reduce acquisition costs.

The body of the paper continues by describing examples of how incorporating M&S into OT&E can benefit a test project. The paper argues that furthering the use of this technique in Canada could significantly enhance the DND acquisition process by helping to correct the four problems outlined above.

The paper finishes with a candid discussion of commonly used arguments against integrating M&S into OT&E and explains what steps can be taken to lessen their impact. Finally, the paper concludes that as long as the pitfalls are understood and accounted for, integrating M&S into OT&E can significantly enhance the DND acquisition process.

INTRODUCTION

The invention of the microcomputer has revolutionized the modern world. Computing technology has made rapid advances and according to Gordon Moore of the Intel Corporation, computing power doubles every 18 months. This prediction, dubbed Moore's Law, has proven remarkably accurate and, although empirically based, is considered by many experts to be a valid prediction for the future.[1] In contrast to the phenomenal rate of increase in computing power, the cost of the power continues to drop.[2] Accordingly, the resultant low cost abundance of potent computing technology has enabled many sections within the Department of National Defence (DND) to harness the power and apply it to many different applications. One major application that is beginning to become prevalent within DND is that of modeling and simulation (M&S).[3]

M&S can be used in many different applications: concept development, requirements capture, new equipment specifications, test and evaluation (T&E), training, mission rehearsal, and system upgrading.[4] One item in this list that has experienced very little emphasis[5] and use within DND is the application of M&S within the T&E portion

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[1] Nick Stam, "Moore's Law Will Continue to Drive Computers," *PC Magazine*, June 22, 1999, 146.

[2] James Bond, "The Drivers of the Information Revolution-Cost, Computing Power, and Convergence," (Viewpoint, The World Bank Group, July 1997), 2.

[3] Assistant Deputy Minister (Materiel), "JSMARTS Workshop CD," http://admmatapp.dnd.ca/cosmat/dmasp/downloads/ModellingSimulation/; Internet; accessed 13 March 2006.

[4] Jack P. Landolt and John R. Evans, "R&D Initiatives in Modelling [sic] and Simulation for Capability Modernization of the Canadian Air Force," *Canadian Military Journal* 2, no. 1 (Spring 2001): 38.

[5] Ibid., 37.

of the DND acquisition process.[6] This is likely due in part to an absence of awareness about the benefits that M&S can provide, and was one of several reasons that spurred the establishment of the DND Synthetic Environment Coordination Office (SECO) with the promotion of M&S within DND acquisition being included as one of its mandates.[7] As such, the benefits that M&S can bring to the DND T&E process warrant discussion and will be the focus of this paper.

T&E can be broken down into two sub-types, engineering test and evaluation (ET&E) and operational test and evaluation (OT&E). The United States Department of Defence (DoD) has made extensive use of M&S in the OT&E process and actively condones the use in it's M&S master plan.[8] This paper will be concerned with OT&E and argue that, as long as the pitfalls are understood and addressed, integrating M&S into OT&E evaluations could significantly enhance the DND acquisition process. This will be accomplished by firstly discussing the DND acquisition process and the part that OT&E has historically played. During this discussion four deficiencies attributable to ineffectual OT&E and problems with the process in general will be highlighted.

Following this, several benefits of integrating M&S into OT&E will be described to include examples of how these benefits have advantaged example acquisition programs. As these benefits are discussed they will be directly applied to the four

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[6] Maj Tony Massys of the DND Synthetic Environment Coordination Office, telephone conversation with author, 13 October 2005.

[7] DND Synthetic Environment Coordination Office, "Welcome," http://www.drdc-rddc.gc.ca/seco/welcome_e.html; Internet; accessed 16 April 2006.

[8] United States, Under Secretary of Defense for Acquisition and Technology, DoD 5000.59-P *Modeling and Simulation (M&S) Master Plan* (Washington, D.C.: Government Printing Office, 1995), 2-6.

previously described deficiencies within the DND acquisition process to demonstrate how the technology could address the problems.

Thirdly, the potential pitfalls and drawbacks to simulation based OT&E will be acknowledged. Along with these acknowledgements, mitigating techniques will be suggested to show how the impact of these potential down sides may be either removed completely or worked around such that the benefits can still be realized.

Finally, all the factors will be compared to conclude that in the balance, considering the incorporation of simulation based OT&E into any DND acquisition program could significantly enhance the process.

OT&E AND THE DND ACQUISITION PROCESS

OT&E Defined

OT&E is a vital part of any military acquisition project and is employed by Canada and many of its allies. Different organizations of course have different definitions for OT&E. One Canadian Air Division Orders state that "OT&E is normally required to assess or determine the operational effectiveness, operational suitability and/or operational airworthiness of a weapon system,"[9] while the DoD defines it as follows:

> The field test, under realistic operational conditions, of any item (or key component) of weapons, equipment, or munitions for the purpose of determining the operational effectiveness and operational suitability of the weapons, equipment, or munitions for operational use, including

[9] Department of National Defence, 1 CDN AIR DIV ORDERS, Vol 1, 1-611 *1 Canadian Air Division Orders Volume 1: General Administration* (Ottawa: DND Canada, 1998), 2.

> combat, by typical military users, and the evaluation of the results of such test.[10]

The common theme with most definitions of OT&E is that it aims to determine the suitability of a piece of military equipment for a defined role. It is generally not concerned with the certification or accreditation of the equipment but rather whether it is capable of fulfilling its defined role from a user perspective in the operational environment it was acquired to function in.

OT&E In the DND Acquisition Process

The military acquisition process can be broken down into six steps:[11] a need is identified, purchase approval is obtained, a contract is awarded, initial delivery occurs, full operating capability is achieved, and finally the acquisition program is closed out.[12] OT&E usually occurs during the phase after initial delivery has occurred; this has historically been for two reasons. Firstly, when simulation based OT&E is not used, "it is not always possible to trial equipment (such as ships, for example) prior to its purchase."[13] This of course is intuitively obvious. If the equipment has not yet been purchased or constructed there is no way that the operational test community can gain access to the real world equipment to test the article in question. The Canadian Maritime

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[10] United States, Department of Defense, *Department of Defense Directive* Number 5141.2 (Washington D.C.: Department of Defense, 2000), 1.

[11] A more detailed explanation of the DND acquisition process is contained in the 2nd draft of the DND Acquisition Reform Guide. A reference to this document is contained in the bibliography.

[12] Senate Committee on National Security and Defence, *Wounded: Canada's Military and the Legacy of Neglect* Fourteenth Report (September 2005), 110; available from http://www.parl.gc.ca/38/1/parlbus/commbus/senate/com-e/defe-e/rep-e/repintsep05-e.htm; Internet; accessed 12 March 2006.

[13] Office of the Auditor General of Canada, "1998 Report of the Auditor General of Canada," http://www.oag-bvg.gc.ca/domino/reports.nsf/html/9804ce.html#0.2.2Z141Z1.RL0RBG.KYQPRE.46; Internet; accessed 12 March 2006.

Coastal Defence Vessel (MCDV) was a prime example of this[14] with OT&E "not carried out early enough to identify problems that now affect the entire fleet."[15] Invariably in cases like this, unforeseen contractual difficulties have prevented access to the equipment until it has been officially accepted by DND.

Secondly, even when items under test may have been available for OT&E to have occurred earlier in the acquisition cycle, unforeseen schedule delays cause milestones to slip into the future and the slack time that would have been available is lost, thus forcing a postponement of the operational test (OT) effort until after official acceptance.[16]

It follows then that the first problem in the DND acquisition process that is affected by OT&E is that testing does not occur far enough forward in the procedure. The end result is that equipment finds its way into service before critical problems with operational employment are discovered. The following extract from the *1998 Report of the Auditor General of Canada* serves to illustrate this point:

> Operational tests that could have been carried out on the Griffon to assess the aircraft's suitability for military use were not done before acquisition. As a result, the Department is now discovering that the aircraft's capabilities are being stretched to their limits, particularly when the Griffon is used in applications that push its envelope, such as search and rescue operations. Problems not yet resolved include engine overtorques, [sic] and electrostatic shocks to personnel who ground the aircraft as it hovers.[17]

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[14] Undiscovered problems in the MCDV included malfunctioning water purification units that were critical in providing fresh water for the vessel thus limiting the range of operation to the amount of fresh water that could be loaded at the start of a voyage. Additionally, shutdowns of the main propulsion system during vessel operation severely hampered employment.

[15] Office of the Auditor General of Canada, "1998 Report of the Auditor General of Canada."

[16] Ibid.

[17] Ibid.

Other Problems in the DND Acquisition Process

A review of the report by the Senate Committee on National Security and Defence entitled *Wounded: Canada's Military and the Legacy of Neglect* reveals a major problem within the DND acquisition system; the procurement process is unsatisfactorily long and needs to be shortened. The report identified that the phase of acquisition from initial delivery to full operating capability typically takes 4 years and 10 months to complete.[18] Since this is the phase where OT&E has historically taken place, any amount of OT&E time savings that can be realized will help to shorten the duration of acquisition and speed up the fielding of equipment. Thus the second problem in the DND acquisition process that can be affected by OT&E is the need to shorten the time it takes.

Another area of concern in the DND procurement process involves the effective use of T&E to manage risk. The *1998 Report of the Auditor General of Canada*, noted the following on risk management in procurement:

> We found that the weaknesses we have noted in risk management are linked to the Department's inadequate use of testing and evaluation. Unlike defence organizations in other countries, the Department does not use the function as part of an overall strategy to manage project risks.[19]

[18] Senate Committee on National Security and Defence, "Wounded: Canada's Military and the Legacy of Neglect," 110.

[19] Office of the Auditor General of Canada, "1998 Report of the Auditor General of Canada."

Clearly then, the third problem in the DND acquisition process that can be affected by OT&E is the requirement for more effective application of testing[20] to manage program risk.

One final concern with procurement that needs to be mentioned is cost with any savings that can be realized in the acquisition of military equipment being a benefit. The more money that can be saved, the more the CF will be able to accomplish. This is the fourth problem within the DND acquisition process where OT&E can make an impact. The more cost effective the OT&E process is, the more that can be accomplished within the defence budget.

THE BENEFITS OF SIMULATION BASED OT&E

The preceding section has highlighted four problem areas within the DND acquisition process that have direct links to OT&E. This paper will now turn its attention to the application of M&S within the OT process beginning with a short description of what is entailed with simulation based OT&E. This will be followed by a discussion of some of the benefits that simulation based OT&E can bring and how they are applicable in helping to alleviate the four procurement problems that have been highlighted in the section above.

What Is Simulation Based OT&E?

DND recognizes three levels of modeling and simulation: live simulation that involves the use of real people and real equipment to simulate war, virtual simulation that

[20] As previously discussed, OT&E is a subset of T&E.

involves real people using real or virtual equipment in a synthetic environment, and constructive simulation that involves neither real people nor real equipment.[21]

Live simulation is already used extensively in OT&E and involves the use of the real world article of interest in an operationally representative environment. An example might be the trial of a Light Armoured Vehicle (LAV) on a military training range. Short of actual war it is considered to be "the closest exercise to real use"[22] and is the most basic form of OT. Although defined as simulation, it is not the intent of this paper to deal with current practice but rather analyse new options. As such live simulation will not be considered to fall under the definition of simulation base OT&E. Where simulation based OT&E diverges from traditional OT is in the realm of virtual and constructive simulation. Conducting OT&E with these types of simulations can range from a hardware-in-the-loop test (where virtual or simulated equipment is incorporated with real hardware) "to an entirely computer-generated representation (i.e., no system components involved) of how a system will react to various inputs."[23] These are the types of simulation that will be considered to comprise simulation based OT&E for the purposes of this discussion.

It must be pointed out at this stage that it is not the intent of this paper to suggest that M&S can replace live OT&E entirely. To test a system by simulating it with a model alone is not sufficient. As accurate as a model may be, it is not the actual item under

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[21] Sub-Committee of the Strategic Capability Planning Working Group, *Modelling and Simulation: Enabling the Creation of Affordable, Effective 2020 Canadian Forces* (Ottawa: NDHQ, April 2000): 3.

[22] United States, Committee on National Statistics, *et al*, *Statistics, Testing, and Defense Acquisition: New Approaches and Methodological Improvements*, ed. Michael L. Cohen, John E. Rolph, and Duane L. Steffey (Washington, D.C.: National Academy Press, 1998), 138.

[23] Ibid., 138.

investigation. "Consequently, it is almost axiomatic that for many systems a simulation can never fully replace an operational test."[24] Indeed, it would not be intelligent to allow equipment into service having never conducted operational trials on the real world equipment, a practice which is strictly prohibited in the DoD under the legislation of the U.S. Code.[25]

OT&E Earlier in the Acquisition Cycle Is Possible

One of the main benefits of simulation based OT&E from a DND perspective is the ability it provides to facilitate investigation up front in the acquisition cycle. In this case "the system's digital representation precedes system development and is updated as the system matures."[26] The conduct of virtual prototyping means that "testers can evaluate human factors engineering and performance much earlier in the system development cycle."[27] The US Army certainly took advantage of virtual prototyping during development of the Comanche next-generation helicopter to conduct OT&E as far forward in the program as possible by using the Comanche simulator to train evaluators and develop concepts before a flying prototype had been built.[28]

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[24] United States, Committee on National Statistics, *et al*, *Statistics, Testing, and Defense Acquisition*..., 139.

[25] United States, GPO Access, "Title 10, Subtitle A, Part IV, Chapter 141, Section 2399, Paragraph (h)(1)," in *United States Code*, 2000 ed., Supplement 2; available from http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=browse_usc&docid=Cite:+10USC2399; Internet; accessed 16 March 2006.

[26] Priscilla A. Glasow and Michael Borowski, "When Systems are Simulations: T&E, VV&A, or Both?" *ITEA Journal* 20, no. 1 (March/April 1999): 21.

[27] LTG Paul J. Kern and Ellen M. Purdy, "Integrating Army Test and Simulation: A Window of Opportunity for Tomorrow," *ITEA Journal* 20, no. 4 (December 1999/January 2000): 66.

[28] Kern and Purdy, "Integrating Army Test and Simulation: A Window of Opportunity for Tomorrow," 66.

For DND, the benefit that M&S brings by enabling early conduct of OT&E is clear. By using a modeling based approach to the conduct of OT&E, DND will be able to gain early insight into potential mission suitability deficiencies. In consideration of the example given at the start of this paper where OT&E was not conducted far enough forward during the purchase of the MCDV, using a modeling based approach prior to the actual vessel being available would have identified future problems early enough in the program to allow correction prior to fielding. For instance the faults in the water purification system could have been identified in a model and corrected prior to manufacture of the vessel. Additionally, operational suitability problems discovered late in a program are often more time consuming to rectify than they would be if they were discovered up front in the OT&E effort.[29] By discovering deficiencies at the start of the acquisition cycle, problems can be corrected at a time where the corrective action is less time consuming and causes less impact on the overall program length.[30] Integrating M&S with OT&E would undoubtedly help alleviate the problems associated with OT&E not being conducted far enough forward in the DND acquisition cycle as well as helping to shorten the overall process.

Facilitation of Effective OT&E Planning

Any endeavour involving OT&E requires detailed planning to ensure that the correct test methods are used and the appropriate scenarios are selected for investigation.

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[29] Philip E. Coyle III, "Evolutionary Acquisition: Seven Ways to Know If You Are Placing Your Program at Unnecessary Risk," *Program Manager* 29, no. 6, (November-December 2000): 5.

[30] Ibid., 5.

If this is not done accurately, the data obtained and the results of the test effort may not uncover underlying suitability deficiencies in the equipment under test.

M&S can greatly enhance the OT&E planning process in a number of ways. Firstly, it is an invaluable tool for the selection of operational test scenarios. For example if the objective of the test for a new sensor on an existing platform "is to determine system performance in the most stressful scenario(s), a simulation model can help select the most stressful scenario(s)."[31] Rather than relying entirely on the operational planner's experience in devising an appropriate test profile, running the scenario through a model based simulation will either confirm the planner's hypothesis, or refine the construction of the test scenario to ensure the desired objective is achieved. The added benefit is that evaluators can be more certain they have covered all of the scenarios desired and thus avoid the costly and lengthy execution of multiple additional scenarios to ensure the intended test point has been achieved. The end result is a cost and time savings.

Secondly, by employing M&S in the test planning process, the model itself will undergo continuous refinement. This is achieved because "every instance in which a simulation model is used to design an operational test, and the test is then carried out, presents an opportunity for model validation."[32] As the model becomes more refined, it becomes more accurate and thus increasingly useful for test planning in future projects

[31] United States, Committee on National Statistics, *et al*, *Statistics, Testing, and Defense Acquisition*..., 149.

[32] Ibid., 149.

that involve the same equipment. This could include further operational tests on the same piece of equipment, system upgrades, or additions of supplementary peripheral items.[33]

Lastly, the model itself can be used to retain data and form "a living repository of information collected about a system's operational performance."[34] This is very important when considering system upgrades and looking towards growth potential. For instance if an improved electronic counter measures defensive system has been purchased for a platform, the existing model can be used to provide a baseline for original system performance and steer operational test planners in the definition of increased measures of performance that should be targeted in requirements documents. This technique was employed by the United States Air Force (USAF) during the B-1B Lancer bomber defensive system upgrade program allowing test planners to select meaningful measures of performance by which to assess the modified system.[35]

The advantages listed here have obvious benefit to the DND acquisition process. By reducing the quantity of required test points there is an immediate reduction in acquisition cost and time. Additionally, an improved OT&E planning process results in a more thorough and accurate execution of the test. This in turn means there is greater potential to uncover operational deficiencies and reduce the risk that crippling problems will remain undiscovered until after the equipment enters service. These benefits would clearly help in addressing the OAG concern about making more effective use of T&E to

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[33] United States, Committee on National Statistics, *et al*, *Statistics*, *Testing*, *and Defense Acquisition*..., 149.

[34] Ibid., 149.

[35] Ibid., 149.

manage acquisition risk, as well as the general problems of reducing the cost and length of the acquisition process.

Enabling OT&E in Otherwise Unachievable Circumstances

For many military applications, the ideal environment for perfect OT&E would be to evaluate the item under test in real combat, with real munitions, against real threats. Considering that the objective of military OT&E is to establish operational suitability for combat before a piece of equipment is used for that purpose, "in real world OT, it is not possible to conduct a test in actual combat conditions."[36] Additionally, during OT&E there will be occasions when it is not possible to conduct live OT&E. For example in the case when there is a requirement to test multi-threat engagements, there simply may not be enough captured real world enemy systems available to conduct testing.[37]

Clearly in these situations M&S can help accomplish the evaluation. The US Army has made significant advances in the application of M&S to enable testing where multiple virtual threat systems can be employed in operational tests. They have developed a virtual proving ground[38] that "is a composite of facilities and technologies throughout DTC [Developmental Test Command] that enhance test programs with the aid of computer modeling and realistic simulations."[39] Multiple modeled threat systems from

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[36] Steven K. Whitehead, "Modeling and Simulation – A New Role for the Operational Tester." *Program Manager* 26, no. 5 (September-October 1997): 83.

[37] United States, Committee on National Statistics, *et al*, *Statistics, Testing, and Defense Acquisition*..., 140.

[38] See the US Army virtual proving ground website at http://vpg.dtc.army.mil/ which details much of the unclassified capability provided at this facility and the advantage that M&S has given their OT&E effort.

[39] Mike Cast, "Army Tests Move to 'Virtual Proving Ground'," *National Defense Magazine*, November, 2001, 63.

across DTC can be brought to bear on a piece of equipment under test to simulate a multi-threat engagement in conditions that approximate real world combat as closely as possible.

The CF is in the process of refining and expanding its CF Experimentation Network (CFXNet) which "will provide an excellent vehicle to link dispersed experimentation across the CF and across the country."[40] Rather than simply using this resource for wargaming and experimentation, the OT&E community could also make use of the resources that this network will bring together in order to enable the evaluation of scenarios that would otherwise be impossible to achieve. The end result is that, as mandated by the Auditor General, OT&E can be made more effective and thus reduce the risks involved in the acquisition process.

Cost Savings

There is a large benefit to be realized in cost savings by using simulation based OT&E. This is especially true when considering evaluations of weapons systems that require the expenditure of live ordnance.

One of the main ways that cost savings can be realized with simulation based OT&E is that the evaluation can be confined to high risk test scenarios by "identifying areas with high risk, or areas with the highest payoff for testing."[41] Thus, limited test resources are not wasted testing scenarios that that are low risk and therefore very

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[40] Department of National Defence, File: 1950-9 (CAT 2) *Enabling Transformation: CDS Action Team 2 Report* (Ottawa: DND Canada, 30 June 2005), 2-50.

[41] Military Operations Research Society, *MORS Workshop Test & Evaluation, Modeling and Simulation and VV&A: Quantifying the Relationship Between Testing and Simulation* (Alexandria, VA: Military Operations Research Society, 2004), 20.

unlikely to reveal deficiencies.[42] By using M&S as a tool to analyze identified scenarios for the investigation of operational suitability, planners can confidently rule out low risk areas that will not require testing and subsequently realize a cost savings whilst at the same time executing more effective testing.

Another way that integrating M&S with OT&E can reduce costs is by reducing the number of expendable items that must be consumed during the course of an evaluation. For example, by reducing the number of rounds that are consumed in a weapon upgrade program where live-fire OT must be conducted, whilst at the same time achieving an equivalent or better level of effectiveness, costs will be reduced. The USAF put this to great use in their trials of the AIM-120 Advance Medium Range Air-to-Air Missile (AMRAAM) with M&S allowing them to complete "300 runs for the same price as one live test."[43] The implications here are not simply a case of reducing costs but instead a case of cost avoidance.[44] In other words for the same financial cost more test firings can be executed thereby achieving a higher level of effectiveness.

For DND these factors directly benefit the procurement process and address the identified need to cut costs. By integrating simulation techniques into the OT&E planning process, DND can make efficient financial expenditures for evaluations that avoid the excesses involved when less scientific planning techniques are used. These savings could be boosted further in projects such as weapon acquisitions or those that

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[42] Military Operations Research Society, *MORS Workshop*..., 20.

[43] Steven C. Gordon, "Determining the Value of Simulation," http://www.scs.org/scsarchive/getDoc.cfm?id=1126; Internet; accessed 14 March 2006.

[44] Ibid.

involve the destruction of the test item, by decreasing the amount of physical assets that must be expended since they can be supplemented or replaced by virtual models.

Time Savings

Live OT&E is often very dependant on having adequate access to ranges and facilities that are required to support the execution of test scenarios. These facilities are often in high demand and over tasked.[45] Additionally, live test will depend to a large extent on favourable weather and environmental conditions as well as equipment and personnel availability. Failure to satisfy any of these requirements can cause delays in the execution of a test program.

In addition to the time savings previously identified, simulation based OT&E can also address the historical live OT&E time delays highlighted above. Since M&S enables a portion of the test effort to be conducted in a virtual environment, there will be less dependence on the availability of live ranges and favourable weather or environmental conditions allowing the test program to proceed uninterrupted. All these time saving benefits will help address the identified problem of needing to shorten the DND acquisition process.

UNDERSTANDING AND MITIGATING POTENTIAL PITFALLS

It is important to understand that one cannot blindly adopt the practice of simulation based OT&E and expect to reap all the benefits all of the time. One must realize and understand the potential pitfalls and how they may affect selection of a course

[45] Gordon, "Determining the Value of Simulation."

of action for a particular project. In the end it is likely that the potential pitfalls to be discussed below will dictate that varying degrees of M&S be employed. The degree to which this is the case will depend on the circumstances surrounding the program and "specific guidance on when *modeling and simulation* can be successfully applied cannot be a cookbook approach."[46]

Verification, Validation, and Accreditation

The question of verification, validation, and accreditation (VV&A) is quite likely one of the biggest pitfalls awaiting the unwary user of M&S in any application. VV&A is quite simply the process by which the technical community answers the following two questions: "'Did I build the right model?' and 'Did I build the model right?'"[47] Firstly, validation determines that a model accurately describes the item it was designed to represent. Secondly, verification determines how closely the model resembles the real world. Finally, accreditation complements validation and verification by providing official certification that the M&S product meets the demands of its design purpose.[48] The VV&A process is designed to give M&S credibility and is vital if the technology is to be used in OT&E to provide meaningful results that can be analyzed and concluded upon.[49] The requirement for VV&A presents somewhat of a problem for OT&E in that

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[46] Whitehead, "Modeling and Simulation – A New Role for the Operational Tester," 85.

[47] United States, Department of the Navy, COMOPTEVFORINST 5000.1A *Use of Modeling and SImulation (M&S) in Operational Testing (OT)* (Norfolk, VA: Department of the Navy, September 9, 2004), 2.

[48] United States. Committee on modeling and Simulation Enhancements for 21st Century Manufacturing and Acquisition *et al*, *Modeling and Simulation in Manufacturing and Defense Systems Acquisition: Pathways to Success* (Washington, D.C.: National Research Council, 2002), 95.

[49] Glasow and Borowski, "When Systems are Simulations: T&E, VV&A, or Both?" 22.

the process takes time, resources, and monetary commitment to complete.[50] This has the potential to undermine the equivalent benefits that M&S can bring to OT&E.

Given that VV&A is a vital part of M&S in the OT&E process, methods to mitigate its minimizing effects on the benefits of the technology must be implemented. This may be achieved in a number of ways. Firstly, simulation does not need to be used in all phases of OT&E for one to be able to realize its benefits. This is of value since "validation for test design, although necessary, does not need to be as comprehensive as validation for simulation that is used for augmenting operational test evaluation."[51] A less comprehensive VV&A effort will take less time and less money. The downside of course is that benefit is lost by not using M&S as much as would be desired.

Secondly, the cost of VV&A may be reduced by DND conducting the accreditation in house instead of paying the contractor. Much work has been completed towards the CF adopting a department wide VV&A policy that will go a long way towards establishing a credible in-house VV&A capability. The soon to be published DND/CF Strategic Modeling and Simulation Plan will contain a lot of these details.[52]

For DND the issue will ultimately boil down to a question of cost-benefit analysis. Regardless of VV&A concerns, the benefit of M&S in OT&E stands. The program manager in question must decide what risks they are willing to accept in the program, how much they can afford to pay for the reduced risk, and how much time is

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[50] Glasow and Borowski, "When Systems are Simulations: T&E, VV&A, or Both?" 23.

[51] United States, Committee on National Statistics, *et al*, *Statistics, Testing, and Defense Acquisition*..., 150.

[52] Major Tony Massys of the DND Synthetic Environment Coordination Office, e-mail to authour, 13 October 2005.

available to devote to VV&A. In the end, the likely course of action will permit the integration of a degree of M&S into the OT&E effort with all its added benefits. A final note is that the cost-benefit analysis cannot be conducted in the isolation of a single project. Once the VV&A effort has been conducted, the data is non-volatile and may be reused in any future employment of the model thus passing its benefits on to future OT&E efforts.[53]

VV&A is a crucial part of M&S. The evidence presented in this section has shown how the requirement can be accommodated and how it should not deter the OT&E community from integrating M&S into test programs, reaping the benefits, and enhancing the DND acquisition process.

The Development Cost and Availability of Models

Another potential drawback to the use of M&S in OT&E is the cost of producing models and ensuring that adequate supplies of models will be available for use. These problems were highlighted in a survey prepared for the DoD Deputy Director, OT&E. The report highlighted concerns that models were not being reused and that "DoD may be paying more than once for the same models."[54] Of course if the costs to secure sufficient availability of models for use in OT&E are prohibitive, the benefits that M&S brings will be marginalized.

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[53] James F. O'Bryon, "Meet 'MASTER' – Modeling & Simulation Test & Evaluation Reform," *Project Managaer* 28, no. 2, (March-April 1999): 10.

[54] Anne Hillegas *et al*, *The Use of Modeling & Simulation (M&S) Tools in Acquisition Program Offices: Results of a Survey*, Survey prepared for the DoD Deputy Director OT&E (McLean, VA: Hicks & Associates, Inc., 31 January 2001), 4; available from http://www.msiac.dmso.mil/sba_documents/DOT&E%20(Hicks)%20M&S%20Study%20-2001%20.pdf; Internet; accessed 18 March 2006.

The answer to these concerns lies in ensuring interoperability of models within DND and there are already positive steps being taken to this end.[55] Through the DND Synthetic Environment Coordination Office (SECO) there are a plethora of models available that have already been used in previous programs. These models and M&S resources are available across the force for reuse.[56] Additionally the previously described CFXNet will ensure that users across the force will have easy access to existing models not only in the CF but also through international partners on the Combined Federated Battle Lab Network (CFBLNet) of which the CFXNet is part.[57] The CF is also taking steps to ensure that all the models employed within DND will be able to communicate through a common language. The CF and many of its international partners are building models that comply with the high level architecture (HLA).[58] This technology will ensure that models can be federated and reused with those built at a later date.

By using these interoperability initiatives for models used in OT&E, DND can distribute the costs over time so that the longer the technology is used, the more the benefits of integrating M&S into OT&E can be realized. Additionally, these interoperability initiatives will provide adequate access to existing resources for future users. In this way DND can ensure that regardless of the initial cost for models, the

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[55] A document entitled *DND/CF Strategic Modelling & Simulation Plan* is being drafted by DND SECO. This document is to become the guidance for an overall DND/CF policy and strategy towards M&S. Discussion with Mr. Bob Elliot, head of DND SECO, on 31 March 2006 revealed that within this document, DND is planning to adopt the High Level Architecture (HLA) as the common model language to ensure federation of models within DND. In the future this will ensure seamless interoperability of new and existing models not only within DND but also with many of its allies who have also adopted the HLA.

[56] For a complete listing, see the DND SECO website at http://www.drdc-rddc.gc.ca/seco/msrr/browse_e.asp.

[57] Department of National Defence, File: 1950-9 (CAT 2) *Enabling Transformation: CDS Action Team 2 Report*, 2-50.

[58] Bob Elliot (Head DND/CF SECO), telephone conversation with author, 13 March 2006.

advantages that integrating M&S into OT&E brings can still help to address the four identified problems in the acquisition process and contribute to its enhancement.

CONCLUSION

The early discussion in this paper identified four critical areas of the DND acquisition process that must be corrected to streamline the effort and ensure its future effectiveness. These four areas have a direct link to the OT&E process and can therefore benefit from its enhanced execution. Conducting OT&E earlier in the acquisition process to identify areas of concern is one way that has been identified. Additionally, overall acquisition risk can be reduced by employing more effective OT&E techniques. The acquisition process must also be shortened to keep pace with rapidly changing technology and costs must be reduced to ensure fiscal efficiency for equipment purchases. An enhanced OT&E process can help address these time and cost concerns.

The evidence presented in this paper has demonstrated how integrating M&S into OT&E can be leveraged to enhance the execution of operational test. The technology however cannot be applied blindly. It must be employed with considerable forethought and consideration for the potential pitfalls. Simulation based OT&E will not be the wisest choice for all acquisition projects. The costs in terms of time, resources, and financial investment must be weighed against the degree of risk reduction that can be achieved. Notwithstanding however, this paper has clearly shown that with careful planning and a view to the long term, the integration of M&S into most OT&E evaluations will be the right thing to do. Simulation based OT&E is an opportunity that DND must take maximum advantage of to ensure that the T&E portion of the

procurement cycle can help realize the acquisition process improvements that are required.

M&S will never remove the requirement for at least some live OT&E and it is not the intent of this paper to suggest otherwise. What has been demonstrated however, is that incorporation of M&S into the OT&E process can reduce risk, shorten the time requirements for the test effort, cut costs, and enable up front testing to identify problems earlier in acquisition and prevent costly mistakes. M&S is an enabling technology that is here to stay and by employing this technology to the maximum extent possible, DND stands to make significant enhancements to the acquisition process. Ultimately this will propel the Canadian war fighter into the future more effectively equipped and better prepared to achieve overwhelming mission success in any of Canada's future endeavours.

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