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VIRTUALLY BEHIND THE TIMES: THE 20 YEAR LAG IN CANADA'S USE OF ENGAGEMENT MODELLING TO SUPPORT DEFENCE ACQUISITION

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JCSP 44

Exercise *Solo Flight*

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People sometimes think technology just automatically gets better every year, but it actually doesn't. It only gets better if smart people work like crazy to make it better. That's how any technology actually gets better.

—Elon Musk, CEO Tesla and SpaceX, 2016

As highlighted by Canada's latest defence policy, *Strong, Secure, Engaged* (SSE)[1], a flexible, yet stable, procurement process is the catalyst to the Canadian Armed Forces' (CAF) ability to acquire the needed equipment to achieve and maintain the necessary capabilities to accomplish the goals of the Defence Strategy.[2] However, as noted by Mr. Alan Williams, former Assistant Deputy Minister (Materiel) [ADM(Mat)], the procurement process provided to the CAF is severely deficient.[3]

This deficiency can be attributed to a number of challenges specific to defence spending. Firstly, the CAF holds the largest discretionary portion of the federally allocated budget in Canada at over 30 percent.[4] Secondly, understanding amongst the general population as to the goals and, more dramatically, the complexity of modern national defence is lacking.[5] For these reasons, the CAF's budget becomes an easy target for manipulation of the overall federal budget, whether that is done to bring in new federal programs, or to balance the federal budget. To complicate matters further, Canadian society is forced to trust that the CAF is getting the best

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[1] Department of National Defence, *Strong Secure Engaged: Canada's Defence Policy* (Ottawa: DND Canada, 2017).

[2] *Ibid*, 16

[3] Alan S Williams, *Reinventing Canadian Defence Procurement* (Kingston: Breakout Educational Network, 2006), 2-3.

[4] Department of Finance, *Fiscal Reference Tables* (Ottawa: Canada, 2017), 20.

[5] Department of National Defence. *Canadian Defence Beyond 2010 – The Way Ahead: An RMA Concept Paper* (Ottawa: DND Canada, 1999), 1.

value for cost,[6] yet at the same time requires fair, open, and transparent competitions, while also favouring the Canadian economy.[7] However, this is challenging and sometimes not possible as these criteria do not align in most cases.

Further, a major challenge with defence procurement is that it requires both a long-term outlook (on the order of 20-30 years),[8] and a quick turnaround time in order to take advantage of cutting-edge technology.[9] This carries two additional challenges respectively: Firstly, justification for cutting edge technology to combat future adversarial capability is very difficult, eroding the trust of society; and secondly, delays and funding instability in procurement projects lead to getting the equipment that CAF needed for yesterday, today.

One additional challenge to contend with is the overall complexity of defence as a whole, in preparing for conventional and unconventional conflict, protection of Canadian and North American sovereignty, and aiding domestic natural disasters and search and rescue, as well as the complexities of the technical environment that is projected into the future.[10] In order to get a handle on these complexities, speed up the procurement cycle, and regain the trust of society, all whilst remaining within the bounds of a transparent, and stable acquisition process, the CAF must embrace technology to simplify the complex problems it faces into a more palatable domain. As put by Drs Markowski, Hall, and Wylie, professors at the University of New South Wales:

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[6] J.C. Stone, "Defence Procurement and the Need for Disciplined Capital Investment," in *The Public Management of Defence in Canada*, ed. Craig Stone (Toronto: Breakout Education Network, 2009), 97.

[7] Stefan Markowski, and Peter Hall, "Mandated defence offsets: can they ever deliver?" *Defense & Security Analysis* 30, no. 2 (2014): 149.

[8] Department of National Defence, *Defence Strategy 2020: Formulating the DND/CF Statement of Strategy* (Ottawa: DND Canada, 2000), 1.

[9] Stone, *Defence Procurement and the Need…*, 103.

[10] DND, *Canadian Defence Beyond 2010…*, 2.

> We expect small, advanced economies not only to face different choices and constraints in their defence procurement than larger countries but also we expect different small countries to respond differently to challenges posed by the smallness of their demand for military equipment…A mark that being small is that, on average, those involved in defence procurement have to be 'smarter' to achieve the same results as their counterparts in larger countries where order size and scale economies are more relevant.[11]

This paper will demonstrate that the DND has lagged in its ability to embrace technology and employ a smarter, modelling and simulation based acquisition process into its procurement cycle, restricting the ability to purchase the right equipment, on time, and for the right price.

This will be accomplished by introducing the concept of Engagement Modelling Based Acquisition (EMBA) as a tool to improve the procurement cycle; a review of benefits and challenges identified by similarly simulation-based acquisition (SBA) tools in the defence acquisition processes of other nations; and lastly, a review of the historical process of the SBA concept throughout DND's past to determine what led to the lag in its employment.

This paper will not describe the detail on how such a system *will* work, but rather on the broad view of how it *could* work given the necessary requirements. It should also be noted that this type of capability will not be cost-neutral, it is likely that implementation of this tool across DND for acquisition would require significant investment and a large scientific- and maintenance-based effort in order to remain viable. However, the more effort that is put into a tool of this type would enable a plethora of benefits from capability gap identification, to joint

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[11] Stefan Markowski, Peter Hall, and Robert Wylie, *Defence Procurement and Industry Policy: A Small Country Perspective* (New York: Routledge, 2010), 6.

strategic decision making, to innovative collaboration with industry, and an overall quantum leap in the CAF's understanding of the function and inter-relation of its equipment.

CHALLENGES

As explained by former Assistant Deputy Minister (Materiel), Alan Williams, "the acquisition period from the identification of a deficiency to the close-out of a project was 15.8 years."[12] This concept is reflected throughout SSE, adding "…perhaps most challenging, 70 percent of all projects have not been delivered on time."[13] Although these lengthened timelines can be attributed to bureaucratic red-tape and the politicization of defence procurement,[14] the CAF's inability to process these acquisition projects in alignment with government and industry partners alike ultimately leads to the widely publicised political decisions that delay such projects.[15] This section will highlight some of these misalignments.

Building Requirements

One of the major challenges involved in procurement is the need to balance specific, detailed requirements with the need to maintain a small generalized list of requirements in order to avoid as many non-compliant bids as possible;[16] all whilst being able to justify the need of each requirement to government and society alike.[17] As discussed previously, this becomes

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[12] Williams, *Reinventing…*, 95.
[13] DND, *SSE*…, 74.
[14] J.C. Stone, *A Separate Defence Procurement Agency: Will it Actually Make a Difference?* (Ottawa: CDFAI, 2012), 10.
[15] *Ibid*, 15.
[16] Williams, *Reinventing…*, 39.
[17] Williams, *Reinventing…*, 9.

difficult since scaling a procurement project up in size results in a more specific, classified, and future-focused set of requirements. For example, being able to justify why a ship's radar ten years from now will need a detection range at 250 miles instead of 200 miles may be a difficult task.

Subsequently, the act of producing detailed technical specification causes, intentionally or otherwise, a bias towards a solution.[18] Instead of opening the problem-space to the experts (i.e. industry), creating specifications suppresses many of the creative solution decisions. This effort essentially transfers the technical risk to the buyers (i.e. DND)[19] as the contractor is only required to meet the specifications, not to provide an innovative and capability-compliant solution.

Design and Compliance

The concept of maximizing value for money, demanded by the Canadian public, forces the procurement process to somehow establish the overall value of a complex system-of-systems across a number of situations based on the individual specifications of a solution, which will occupy only a part of that system-of-systems.[20]

A further difficulty is the design review and compliance of the contract. Due to both the complexity of the problem/solution, and the time-restraints placed on the procurement by the time the design is produced, its review becomes a check to ensure that all areas of the requirements are being addressed, rather than a confirmation that the design represents a

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[18] Ugurhan Berkok, "Canadian Defence Procurement," in *Defence Procurement and Industry Policy: A Small Country Perspective*, ed. Stefan Markowski, Peter Hall, and Robert Wylie (New York: Routledge, 2010), 213.
[19] Williams, *Reinventing…*, 39.
[20] Stone, *Defence Procurement and the Need…*, 97.

workable solution to the problem. This inherently leads to difficulties in implementation, leading to delays and further costs to DND.[21] Further, the turnover rate of project officers is approximately three years, meaning that larger projects can see between three and six generations of project officers from capability gap identification to equipment employment.[22] Although most processes and knowledge is transferred between these generations, the lack of a full understanding of the background information and decisions made, causes complications with compliance and scope-creep of a project.[23]

Acceptance and Operation of Equipment

A final issue with the current procurement cycle is the slow transition between deliverable acceptance and the effective operation of the equipment. For good reasons, ownership of the equipment remains that of the contractor until after acceptance, despite being installed and integrated onboard the target platforms. This lack of ownership prevents a detailed Operational Test & Evaluation (OT&E) to be completed, which is necessary in order to produce detailed tactics leading to tactics training of the operators.[24] Operators are therefore not able to consider this new equipment as part of their capability set for some time until support establishments gain an understanding of its limitations and capabilities in order to produce necessary tactics. Often this transition can take a considerable amount of time as some equipment must be tested in specific locations (e.g. torpedo range) under specific conditions. The

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[21] Wenbi Wang, "Aligning modelling and simulation capabilities to support the Royal Canadian Navy's platform acquisition projects" (technical report, Defence R&D Canada Toronto, 2011), 10.

[22] Steven Whiting, "Streamlining Naval Project Procurements – Utilizing Collaborative Communications Between Stakeholders" (master's thesis, Royal Roads University, 2006), 49.

[23] *Ibid*, 64-65.

[24] Department of National Defence, *Creating the CF of 2020: Concept Development and Experimentation and Modelling and Simulation* (Ottawa: DND Canada, 2000), 54.

delay that occurs leads to confusion and rumours about the purpose of the equipment, and can lead to the equipment being 'worked around' and not taken seriously.

A number of problems seem to exist within the procurements cycle, some that can be attributed and others that are independent from the bureaucratic process. It is this set of difficulties that should be re-imagined in order to minimize the procurement cycle, maximize the value for money of future projects, and potentially remove the necessity for 'red tape'.

ENGAGEMENT MODELLING AS A SUPPORT TOOL FOR ACQUISITION

EMBA is the term used to reflect a method of Modelling and Simulation (M&S) that constitutes the use of integrated faster-than-real-time, physics-based models in a suitably similar synthetic environment, which is run in a parallel Monte-Carlo[25] scheme; essentially taking up the Mission/Battle and Engagement sections of Figure 1.

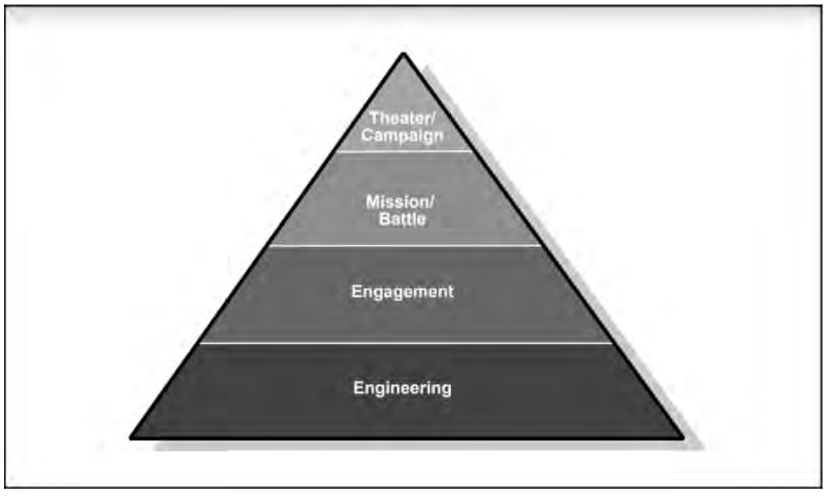

Figure 1 -- Hierarchies of Models and Simulations

Source: Johnson *et al*, *Simulation Based Acquisition: A New Approach*, 2-2.

[25] Wikipedia, "Monte-Carlo," last accessed 7 May 2018, https://en.wikipedia.org/wiki/Monte_Carlo.

Amongst other things, this type of M&S aids in simplifying the complexity of real life while maintaining confidence in the results [despite the imperfect nature of the models] through introducing random disturbances and 'averaging' their impacts on a scenario. Ultimately, rather than attempt to understand the detailed aspects of a study individually, EMBA enables the study of the impact of a discrepancy on a scenario, providing the CAF with a *What-If* machine.[26]

Situation-Based Requirements

Since EMBA can focus on the overall impacts at a complex, integrated, and joint level, it can presumably help with the requirements definition problem of procurement. Instead of being concerned with specific requirements of a system, such as detection range of a radar system, focus can be placed on the overall mission or potential scenario that involves the equipment.[27] The requirements document used during Request For Proposal (RFP), and throughout the process then becomes a set of models that represent the potential situation(s) that the equipment will occupy. This provides numerous benefits to the overall process of requirements building: Enabling a more visual and comprehensible justification on why the solution is needed;[28] and enabling and encouraging bidders to be innovative in their approach to the solution.[29]

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[26] Michael V.R. Johnson Sr, Mark F. McKeon, and Terence R. Szanto, "Simulation Based Acquisition: A New Approach" (master's thesis, Defense Systems Management College, Fort Belvoir, 1998), 4-5.

[27] Wang, *Aligning modelling and simulation capabilities…*, 16.

[28] DND, *Creating the CF of 2020…*, 58.

[29] Ned H. Criscimagna, "Simulation-Based Acquisition," *Selected Topics in Assurance Related Technologies* 8, no. 2 (2000): 1.

Cradle-to-Grave Body-Of-Knowledge

Since the requirements are therefore provided as models, EMBA allows for retention of all steps of the procurement process to be stored and referred to at any other stage of the cycle, maintaining a cradle-to-grave body-of-knowledge of the problem and of each version of the solution throughout the entire cycle.[30] This can benefit defence procurement in a number of ways. Firstly, at each step of the procurement project, when the bidder/contractor submits updates to the solution/design in the form of a model set, they can be instantly and quickly compared and analysed against all other models, including the original problem scenario, ensuring absolute compliance at all stages. Secondly, the impact of project officer turn-around is lessened as new project members will not need to familiarize themselves with the details of the requirements and the decisions for which they were made, only to understand the scenarios that describe the initial problem-space. Thirdly, changes to the requirement can be quickly created, communicated and reflected on by the contractor.[31] Lastly, and related to the latter, changes that are being made to other integrated systems interfaced to the procured equipment can be investigated to determine their impact on the procurement and potentially changed accordingly.

Concurrent Design and Test

One final benefit of EMBA is the ability to enable Design Test and Evaluation (DT&E), tactics development, and tactical/operational training concurrently to the design and build phases of the contract delivery,[32] leading to a faster transition from delivery acceptance to operations.

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[30] Wang, *Aligning modelling and simulation capabilities…*, 14-15.
[31] DND, *Creating the CF of 2020…*, 58-59.
[32] DND, *Creating the CF of 2020…*, 59.

Figure 2 demonstrates the relative procurement cycle time savings by explaining the current timeline [in brown], and suggesting a streamlined process facilitated by EMBA [in blue].

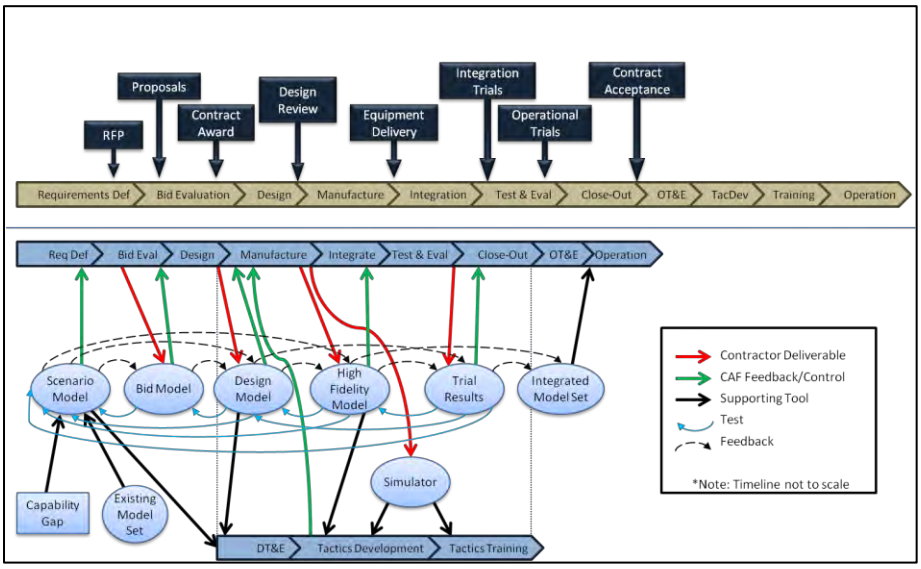

Figure 2 -- Timeline of Procurement Cycle with and without EMBA Support

Additionally, and as mentioned above, the ability to concurrently evaluate and design tactics enables the CAF to find problems and gaps in the designed system with time to have a correction identified and implemented early in the manufacturing phase, lessening the impact to cost and schedule.

Costs and Challenges

However, despite the general idea that M&S enables operational status quo for less cost,[33] the reality is quite the opposite. Tied to these benefits of EMBA is a substantial set-up and operating cost: system and environmental models need to be built to a high level of fidelity;

[33] Jack P. Landolt, and John R. Evans. "R&D Initiatives in Modelling and Simulation for Capability Modernization of the Canadian Air Force," *Canadian Military Journal* (Spring 2001): 38.

modelling tools need to be properly and efficiently integrated;[34] high-powered compute clusters must be purchased, integrated and maintained; models need to be constantly updated with changes to the systems they represent and as R&D improves its ability to understand systems; trained operators are needed to run these models and control the compute clusters;[35] and new processes for Verification, Validation and Accreditation (VV&A)[36] and model-based risk must be developed and maintained.[37] These are necessarily scalable depending on the size of the system of interest and the level of detail that is desired. EMBA will save some cost in the procurement cycle, however *this is not an overall cost-savings effort*. Rather, EMBA offers the CAF *a better product and better timeline with reduced risk* to meet the needs of the CAF at the expense of the aforementioned costs.

Further, if fully implemented, EMBA could open up a number of knowledge-based tactical, operational, and strategic opportunities. Possible examples include, but are not limited to: thorough and efficient gap identification ability, and understanding of such a gap's impact on tactics/operations; breakdown of joint-level stovepiped acquisitions; and an increased realism of systems responses [blue, red, green, and white] within individual, collective, and joint training events.

As can be seen, EMBA offers to support a number of challenges throughout the entire procurement cycle, while also opening a number of capabilities that would otherwise be overwhelming to achieve.

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[34] Randy C. Zittel, "The Reality of Simulation-Based Acquisition – and an Example of U.S. Military Implementation," *Acquisition Review Quarterly* (Summer 2001): 129.

[35] Wang, *Aligning modelling and simulation capabilities…*, 14.

[36] Simply put, Verification determines if the model was built to specifications, Validation determines how well the model matches reality, and Accreditation authorizes the intended use of a model. Department of Defence, Directive 5000.59-M, *DoD Modeling and Simulation (M&S) Glossary* (Washington: DoD USA, 1998), 106.

[37] R.G. Sargent, "Verification and validation of simulation models," *Journal of Simulation*, no. 7 (2013): 12-13.

ANALYSIS OF INTERNATIONAL SIMULATION-BASED ACQUISITION

With the benefits discussed in the previous section, why is it that Canada has not established such a capability? Are there underlying difficulties or downfalls to this capability, or would the promises simply become unfulfilled? In order to help answer these questions, this section will focus on the defence procurement stances on the use of M&S to support acquisition in the US, UK, and smaller nations in order to compare priorities and glean whether such a move has been seen as positive or negative.

United States (US)

The US Department of Defense (DoD) have encouraged and worked towards the implementation of what they refer to as Simulation Based Acquisition (SBA)[38] for over two decades.[39] Although significant effort had been established in the way of M&S to support training (i.e. simulators), there were some in the late 1990's, such as General Richard Hawley, Commander US Air Combat Command, who believed that "…we've never fully exploited the contributions that modeling and simulation can make to our readiness programs."[40] A flurry of activity with the goal of setting up a SBA program occurred for a number of years over the late 1990's and early 2000's, including the standing up of a Joint SBA Task Force (JSBATF) in

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[38] Simulation-Based Acquisition is defined as "an iterative, integrated product and process approach to acquisition, using modeling and simulation, that enables the warfighting, resource allocation, and acquisition communities to fulfill the warfighter's materiel needs, while maintaining Cost As an Independent Variable (CAIV) over the system's entire life cycle and within the DoD's system of systems." Johnson *et al*, *Simulation Based Acquisition…*, 2-7.

[39] *Ibid*, 3-1.

[40] *Ibid*, 2-6.

1998.[41] Along with the extensive and detailed work that was produced by the JSBATF, it was confirmed that the architecture created would be able to aid in the collapsing of acquisition timelines:

> …a [model repository tool] provides a common product view to all [integrated product team] participants at all times during the acquisition process, allowing simultaneous evaluation of the current product configuration from the perspective of each functional discipline. Thus, product designers can measure the performance of a product at the same time that product manufacturers evaluate the producibility of the product and logisticians assess the supportability of the product…[42]

Overall, the JSBATF investigated and produced the roadmap and architecture that SBA would follow, with a goal of maximizing model/simulation re-use, reducing stovepiping amongst acquisitions, and ensuring access of all necessary tools to the project officers that need then when they need them.[43]

The concept of SBA was quickly adopted by the maturing Joint Strike Fighter (JSF) program, which aimed at using simulation in order to manage an extensive set of requirements through a flexible and dynamic development process.[44] By 2001, JSF established an iterative and dynamic requirements and design structure through a synthetic environment named the Virtual Strike Warfare Environment (VSWE).[45] VSWE was an integrated collection of seven simulation

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[41] John F. Keane, Robert R. Lutz, Stephen E. Myers, and James E. Coolahan, "An Architecture of Simulation Based Acquisition," *Johns Hopkins APL Technical Digest* 21, no. 3 (2000): 348.
[42] *Ibid*, 354.
[43] *Ibid*, 348.
[44] Zittel, *The Reality of Simulation-Based Acquisition…*, 128.
[45] *Ibid*, 129.

tools consisting of sensor and weapons models to kinematics, mission planning, and Human Machine Interfaces (HMI) through a scenario generator (game board) managing them all.[46] This particular set-up of SBA was built from the ground up for the JSF project, but the concept of SBA provided JSF with "…the ability to compare and trade off performance against operator capability…"[47] in the requirements/design phase of the project. The inception of M&S into the JSF program was so positive that Frank Cappuccio, Vice-President of JSF at Lockheed Martin, stated "[The company had] achieved a 50 plus percent reduction in acquisition cycle time and cost via M&S, and the savings have been incorporated into our proposal bid."[48]

Since then, SBA continues to be a consideration within the DoD's acquisition process, yielding expected feedback with reference to the high development and maintenance cost of using such a tool: "…a comprehensive SBA-compliant operating environment is expensive to set up and administer. And, while any given contract may not require SBA, its benefits to any product development program are too strong to ignore."[49]

United Kingdom (UK)

The UK has shared a very similar timeline for SBA. Realization in the late 1990's that M&S technologies, if accredited and operated at the correct level, could provide a through-life risk-reduction and reuse of effort for ongoing and future acquisition projects.[50] This growth in

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[46] *Ibid*.
[47] *Ibid*, 130.
[48] Monty Long, and Steve Gale, "Simulation Based Acquisition: The Ground Truth" (report, UK Synthetic Environment Co-ordination Office, 2002), 3.
[49] Michael S. Anderson, Puja Gupta, and Michelle W. Chen, "Simulation Based Acquisition for the Rest of Us," *IEEE Aerospace Conference* (March 2006): 7.
[50] Long and Gale, *Simulation Based Acquisition…*, 5.

SBA, otherwise known in the UK as Synthetic Environment Based Acquisition (SEBA),[51] happened concurrently with, but not seemingly dependent on the UK's Acquisition reform towards what was termed 'Smart acquisition'.[52] Smart acquisition, like any attempt at acquisition reform, sought to reduce the number of major decision gates within the overall process. As can be seen in Figure 3, what used to require four separate decision gates, now only uses two,[53] removing major roadblocks from the overall process, especially when the gates are sufficiently separated in time that decision-makers had changed in between.

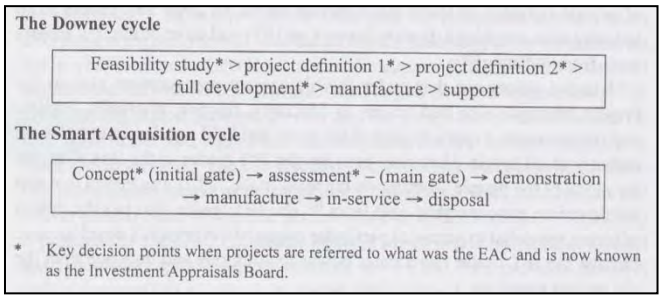

Figure 3 -- Comparing new and old UK procurement cycles

Source: Chin, *British Weapons Acquisition Policy*, 256.

The obvious problem is that with a reduced set of decision gates, large risk is introduced in the procurement. This is likely where SEBA had initially provided its best advantage.[54] First, it provides for thorough testing and simplification of a complex concept, "…in today's complex systems-of-systems, [Synthetic Environments] can often offer the only way to fully stimulate and

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[51] *Ibid*, 1.

[52] Ron Matthews, "Smart Management of Smart Weapons", in *Studies in Defence Procurement* (Kingston: Claxton Papers, 2006), 87.

[53] G. Doiran, "Canadian Defence Procurement Strategy: Can Canada's Acquisition Process be Accelerated and Made More Efficient?" (National Security Studies Course paper, Canadian Forces College, 2008), 9.

[54] Ken Hambleton *et al, Conquering Complexity: Lessons for defence systems acquisition* (Norwich: The Stationery Office, 2005), 82.

test a new capability."[55] Second, since models can be stored and tests revisited at any time in the future, it provides a record trail of the decisions made at any point, as put by the UK Synthetic Environment Coordination Officer (SECO):

> The information gleaned at any stage is not only the springboard for the next phase, but must also form the audit trail to show why the project has arrived at a particular point. This audit trail is also essential when, inevitably, something upstream is changed and the project has to revisit earlier assumptions.[56]

However, the overall benefits of the UK's use of SEBA has not been simply for demonstration and auditing purposes, but rather to benefit the process from the reuse of the models generated for use in OT&E[57] and in training and in-service use.[58]

Overall, the UK has generated and evolved SEBA as a key portion of its acquisition process, providing significant support to major capital projects such as Future Carrier Vessel, Watchkeeper, Network Enabled Capability (NEC), Ground Based Air Defence (GBAD), [59] and Future Attack Sub.[60] SEBA has become so embraced within the UK procurement process that "in some programmes the analyst/designer has to strongly justify where he does <u>not</u> use [SEBA]."[61]

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[55] Peter Jackson, "Effective Use of Synthetic Environments to Support the Acquisition Life Cycle" (report, Thales Training & Simulation Ltd, 2018), 3.
[56] Long and Gale, *Simulation Based Acquisition…*, 2.
[57] Hambleton *et al, Conquering Complexity…*, 202.
[58] Jackson, *Effective Use of Synthetic Environments…*, 5.
[59] *Ibid*, 2-3.
[60] Long and Gale, *Simulation Based Acquisition…*, 3.
[61] Jackson, *Effective Use of Synthetic Environments…*, 5.

Other Smaller Nations using SBA

Outside of the larger countries, there are examples of other nations embracing one form of SBA or another. The Australian Defence Force (ADF), in the late 1990's, along with other allied nations, investigated and began implementation of an SBA capability.[62] By the mid-2000's, their Australian Defence Simulation Office (ADSO) had established[63] policy and guidance documents on a SBA-like capability.[64] Although there do not seem to be explicit examples of success with SBA, there exists a mutual level of capability that has been established between the ADF, Defence Science and Technology Organisation (DSTO),[65] and industry.[66] This is made clear, as an example, by Boeing Australia's collaborative employment of their Systems Analysis Laboratory (SAL), using the Boeing Analysis Simulation Environment (BASE) to provide analyse mission effectiveness to complex systems-of-systems.[67] Overall, the ADF has established the governance, policy, direction, and effort to establishing an SBA.

South Africa also maintains and benefits from SBA programs. Examples from South Africa include the procurements of the Gripen Aircraft,[68] and the A-Darter air-to-air missile.[69] However, as a nation with an much smaller defence budget than Canada,[70] the concept of creating a stand-alone, enterprise level M&S infrastructure to use towards an SBA capability is

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[62] D. McFarlane, and E. Kruzins, "Australian Defence Simulation – Status", in *Transforming Training and Experimentation through Modelling and Simulation* (Canberra, Australian Department of Defence, 2006), 2-2.

[63] McFarlane and Kruzins, *Australian Defence Simulation…*, 2-4.

[64] Department of Defence, *Capability Systems Life Cycle Simulation Support: In-Service Phase Guide Version 2.1* (Canberra: DoD Australia, 2013).

[65] McFarlane and Kruzins, *Australian Defence Simulation…*, 2-5.

[66] Charles Herdy, "The Application of Simulation to Battlespace Communications" (report, Boeing Australia Limited, 2002), 4-5.

[67] *Ibid*, 5.

[68] Arnold J. Swart, and André J. Buys, "Simulation-Based Defence Acquisition in South Africa," *Portland International Conference on Management of Engineering & Technology* (2008): 2545.

[69] *Ibid*, 2546.

[70] Trading Economics, "Military Expenditure – By Country," last accessed 7 May 2018, https://tradingeconomics.com/country-list/military-expenditure.

difficult to achieve. This morphs their SBA capabilities into the creation of one-time toolsets, tailored for the acquisition at hand, mostly on the part of the contractor, and shared with forces personnel as necessary.[71] However, the concept and benefits of such a tool are recognized and the acquisition branch strives to employ simulation tools in their processes whenever possible.[72]

In all, the concept of an SBA-like capability has been embraced and exploited to differing level, mostly based on overall national defence funding, by other friendly nations, and likely others. The overall result of such efforts indicate that the establishment of such a capability needs to be thoroughly tailor-suited to a nation's needs and will be difficult and costly. Yet the overall consensus is that SBA promises the procurement of equipment cheaper,[73] faster,[74] and with better quality,[75] all attributes that are sought by most nations' defence procurement strategies.

REVIEW OF CANADA'S ADOPTION OF EMBA

Given the benefits and adoption of such policies amongst allies and similarly sized defence forces, one must ask 'why has the CAF not manoeuvred to exploit this type of tool in the realm of defence procurement?' In order to gain further insight, this section will analyse the history of M&S within the DND procurement community.

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[71] Swart and Buys, *Simulation-Based Defence Acquisition…*, 2548.
[72] *Ibid*.
[73] Alan M. Christie, "Simulation: An Enabling Technology in Software Engineering," *Crosstalk: The Journal of Defense Software Engineering* (April 1999): 25.
[74] Long and Gale, *Simulation Based Acquisition…*, 3.
[75] Swart and Buys, *Simulation-Based Defence Acquisition…*, 2545.

Early Guidance

In 1998, the Director General Strategic Planning (DGSP) and the Chief of Research and Development (CRAD), realizing that the defence environment had changed dramatically following the end of the Cold War, produced a concept paper named 'Canadian Defence Beyond 2010 – The Way Ahead'.[76] This was created in the hopes of aligning Canada with the Revolution in Military Affairs (RMA) concept, towards which many of the other Western nations were steering.[77] This document discussed the difficulties in understanding and evaluating new concepts and technologies,[78] rapid equipment obsolescence,[79] and the creation of capability-based requirements for new equipment.[80] In an attempt to solve this set of problems, and likely as a result of international forums on this topic, the paper recommended that "[the] establishment of a [focused] capability (adapted for Canada) in SMART (Simulation and Modelling for Acquisition, (Mission) Rehearsal, and Training) is essential for a coherent approach to 2010 and beyond."[81]

This recommendation spawned a concept paper on Concept Development and Experimentation (CD&E) and Modelling and Simulation (M&S),[82] produced by a symposium looking to understand and recommend a roadmap for CD&E/M&S support to a number of initiatives, acquisition being one area. This document described the benefits offered by a SBA-like tool and the challenges that it will come with, recommending that a culture change is implemented throughout the DND/CAF, government, and industry to enable an

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[76] DND, *Canadian Defence Beyond 2010...*
[77] *Ibid*, 4-6.
[78] *Ibid*, 18.
[79] *Ibid*, 23.
[80] *Ibid*, 31.
[81] *Ibid*, A-2.
[82] DND, *Creating the CF of 2020…*

institutionalization of SBA in the acquisition process with the aim to reduce acquisition times.[83] In this document, a recommendation was also put forward to institute a DND/CAF Modelling and Simulation Coordination Office (MSCO) to "…enforce standards, to set up a common technical framework and standards, and to represent Canada on NATO and other groups dealing with M&S)"[84] This seemed to be a promising start to Canada's ability to exploit its technical proficiency and use it to be smarter, more efficient buyers of defence systems, especially complex integrated weapon systems. However, this vision proved to be relatively short-lived as the direction of SBA receded in subsequent years.

Direction Taken

Following, and in response to the above concept paper, a study was conducted by DRDC(T) focused on the Canadian Air Force's requirement for M&S to support their efforts. This study concluded primarily that M&S (through distributed simulation) can support force development, acquisition, and training, and that teams collaborating interactively enable alternate ways of approaching these concepts.[85] While not incorrect, this inference aids in the misinterpretation that M&S relates solely to visualizations and simulator-based capability. This flavouring of M&S as primarily useful in visualization is indicative of, and perhaps has incited, a general limitation of understanding of the breadth of capability M&S offers. Indeed, mention the word 'simulation' and likely the first thought one will have is a flight simulator. The progression of this misunderstanding more than a decade later is evident in the Chief of the Defence Staff's (CDS's) 2015 guidance, "We must continually leverage modelling and simulation to improve

[83] *Ibid*, 56.
[84] *Ibid*, A-1.
[85] Landolt and Evans. *R&D Initiatives in Modelling and Simulation…*, 41.

planning, increase readiness, and stimulate change"[86]; the complete lack of mention of modelling or simulation in the Procurement Administration Manual (PAM);[87] and in the Project Approval Directive (PAD), where the only reference to modelling or simulation is found under 'Training Equipment Requirements':

> Projects are required to acquire all necessary training aids to support new capabilities introduced, including integration into any existing training systems, simulators, etc. Any simulation or modelling required to support new capabilities introduced by a project is the responsibility of the project. Projects shall liaise with all related Training Authorities to ensure simulation and modelling is compliant with current standards in use.[88]

This automatic inference of M&S being solely based on simulators for training likely stems from mainstream availability of such systems in the form of computer games, which precludes one from considering the surplus of benefits and capabilities that M&S can bring to most problems.

As had been recommended in the aforementioned concept paper,[89] the Modelling and Simulation Coordination Office (MSCO) was stood up in 2006[90] initially under the Deputy Chief of Defence Staff (DCDS), and subsequently transferred to Canadian Joint Operations Command (CJOC). In 2013, the MSCO presented its Capstone M&S Strategy,[91] setting vision for a more controlled, and widely connected enterprise-level M&S capability. Although the strategy

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[86] Department of National Defence, *Chief of the Defence Staff Guidance to the Canadian Armed Forces* (Ottawa: DND Canada, 2015), 6.

[87] Public Works and Government Services Canada, *Procurement Administration Manual* (Ottawa: PWGSC Canada, 2015).

[88] Public Works and Government Services Canada, *Project Approval Directive 2015* (Ottawa: PWGSC Canada, 2015), 86.

[89] DND, *Creating the CF of 2020…*, A-1.

[90] Department of National Defence, *Defence Administrative Order and Directive 2010-0: Modelling and Simulation* (Ottawa: DND Canada, 2006).

[91] Department of National Defence, *DND/CAF Capstone M&S Strategy* (Ottawa: DND Canada, 2011).

discussed the benefits of M&S toward acquisition, the strategic goals, provided at Figure 4, only vaguely implies such a SBA capability.

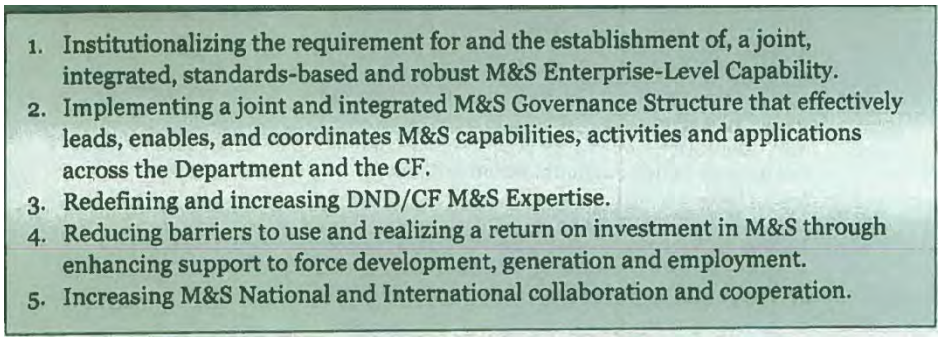
1. Institutionalizing the requirement for and the establishment of, a joint, integrated, standards-based and robust M&S Enterprise-Level Capability.
2. Implementing a joint and integrated M&S Governance Structure that effectively leads, enables, and coordinates M&S capabilities, activities and applications across the Department and the CF.
3. Redefining and increasing DND/CF M&S Expertise.
4. Reducing barriers to use and realizing a return on investment in M&S through enhancing support to force development, generation and employment.
5. Increasing M&S National and International collaboration and cooperation.

Figure 4 -- DND/CAF MSCO Capstone M&S Strategic Goals

Source: DND, *Capstone M&S Strategy*, 4.

Therefore, when the roadmap to achieving these strategic goals was created,[92] the tasks therein have little in relation to acquisition, but rather focus on providing training and simulator-based capability.[93] Despite the MSCO's intention to follow the guidance of the 'Creating the CF of 2020' paper, a lack of interest, understanding, and resources within the organization led to a disconnect between the CAF and ADM(Mat) in instigating a SBA-like capability.

Current EMBA Capability

This lag in establishing an M&S-based capability within DND/CAF for the purpose of acquisition support was later noted through the deficiency of the RCN's ability to support the acquisition of its three new platforms with SBA: Arctic/Offshore Patrol Ship (AOPS); Joint Support Ship (JSS); and Canadian Surface Combatant (CSC). As was noted by Dr. Wenbi Wang, defence scientist at Defence Research and Development Canada – Toronto (DRDC(T)):

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[92] Department of National Defence, *DND/CAF M&S Roadmap* (Ottawa: DND Canada, 2017).
[93] *Ibid*, 8-12.

> An interesting finding in this study was that M&S support for the design and evaluation of individual equipment systems was not considered a high priority from the PMO's [Project Management Office's] perspective. The reason is that systems design is mostly performed by the vendor, as is the assessment of individual system components. As a result, the PMO considers the need for M&S support to examine individual component systems as a low priority. In contrast, significant concerns arise regarding system interoperability, particularly the effectiveness of integrating different equipment systems together and its impact on operator performance.[94]

In essence, the ability for the RCN to use EMBA to support the acquisition of the CSC platforms may have greatly assisted the process. However, for such a large project, much of the foundation work would need to have been put in place by that stage of CSC's procurement. Unfortunately, it seems, the ambitions from 10 years previously had dwindled, resulting in an inability to action a SMART[95] capability to assist the largest[96] and most complex capital projects to date.[97] Effort was still expended in order to take advantage of M&S as much as possible by PMO CSC, but the expertise, process, policy, and modelling software tools were simply not available at the maturity levels they needed to be in order to significantly improve CSC's acquisition process.

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[94] Wang, *Aligning modelling and simulation capabilities…*, 17.
[95] DND, *Canadian Defence Beyond 2010...*, 18.
[96] Department of National Defence, *Audit of the Canadian Surface Combatant Project* (Ottawa: DND Canada, 2015), 1.
[97] *Ibid*, 15.

Incompatibility with Canadian Defence Procurement Process

One might argue that Canada and its policies cannot be directly compared with, or expected to implement, those policies implemented by the UK or the US, since their size, budgets, and resources are far greater. Whilst that is true, it is worth pointing out that effort need not come to fruition instantaneously as it did with the DoD.[98] Rather, EMBA is a tool that can, and should, be built and utilized in a step-by-step fashion, one achievement building upon the previous and enabling the next.[99] Surely a simulation-based approach across the entire spectrum of simulation tools throughout the entirety of defence acquisition is ideal, yet a slow methodical process to introduce and exploit its capabilities will ensure M&S is able to support the acquisition process in an optimal manner.

Although implementing such a large and seemingly burdensome capability may seem to not be worth the effort, as mentioned earlier, models can represent the body of knowledge of a system (or system-of-systems) of interest. Therefore, the CAF would gain potential benefits by extending the use of these models throughout the spectrum of CAF activity. If these M&S tools are built and operated in a common framework, and are able to easily integrate throughout the various organizations and environments; using the detailed models received through the procurement of equipment for use with R&D, individual and collective training, operational planning and tactical decision aids, to name a few, greatly increases the overall speed of capability, in essence, decreasing the operational and procurement decision loops.

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[98] Keane *et al*, *An Architecture…*, 348-349.
[99] Long and Gale, *Simulation Based Acquisition…*, 4.

It is clear that, similar to allied nations, Canada was once invested in moving towards a Simulation Based Acquisition process.[100] However, disconnect with ADM(Mat), ignorance, and apathy seem to have stunted the growth of an EMBA-like capability despite success stories in allies and a SBA-ready industry. This lack of progress has led to missed opportunities to exploit the abilities of SBA.[101]

CONCLUSION

This paper has considered some areas of difficulty that cause delay and cost overrun in the acquisition cycle; provided a description of EMBA and how it can help ease these difficulties; reviewed the international usage of similar capability; and examined the overall history of CAF's use of SBA since being considered an enabler in Force Development and Force Generation in the late 1990's.

Despite an initial optimism towards Canada's usage of Simulation-Based Acquisition, it is clear that vague direction,[102] a lack of foresight, and a misunderstanding of its benefits have prevented and lagged its establishment when compared to ally and industry progress. The procurement cycle contains many roadblocks that can be overcome, or at least supported, through the use of an all-up enterprise level M&S toolset, the likes of which have been successfully utilized in the US DoD and others for decades.[103] Further, the implementation of an EMBA capability enables a holistic approach, and more control over risk in the procurement

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[100] DND, *Creating the CF of 2020…*, 47.
[101] Wang, *Aligning modelling and simulation capabilities…*, 17.
[102] DND, *CDS Guidance…*, 6.
[103] Department of Defense, DoD Directive 5000.1, *The Defense Acquisition System* (Washington: DoD USA, 2000), 8-9.

process.[104] The challenge is in the implementation; creating such a capability is a long-term, complicated, and resource dependant task; and to further this point, the return on investments of such a toolset are neither obvious, nor timely.

As put by Boeing employee, Charles Herdy, "…a perfect solution should not be a pre-requisite for engaging M&S tools. Existing M&S tools should be used to the benefit of Defence. New acquisition projects should be both beneficiaries of and learning vehicles for SBA…"[105] It is true that significant effort is needed before an EMBA capability is fully functional, but there is no reason to ignore such a force multiplier simply because it is not ready yet. Every project that uses an M&S tool for support will gain some benefit and will overall improve the EMBA capability itself. Only once EMBA exists as a toolset, woven throughout every corner of the DND/CAF from R&D, FD, FG, and FE, will the true benefit of M&S be evident and exploitable.

In the end, EMBA does not provide Canada with a cheaper method of acquisition, it is complex, far-reaching, and resource intensive. However with its ability to become definitive in the need for a capability (or capability upgrade), remain solution-agnostic, and become better able to understand the complexities of its systems-of-systems against a variety of threats and scenarios, EMBA promises to transform the CAF into a smarter, and more trusted, buyer and employer of the capabilities it needs to fulfill its mandate.

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[104] Wang, *Aligning modelling and simulation capabilities…*, 15.
[105] Herdy, *The Application of Simulation…*, 4.

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