“The Warfighters Simulation 2000: A Case For Technological Subject Matter Experts”

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I- Introduction

The Warfighter's Simulation 2000 (WARSIM 2K or simply, WARSIM) is intended to be the Army's next-generation simulation system spanning many levels of the organization hierarchy – from battalion to echelons above corps, WARSIM is supposed to provide a virtual (man-in-the-loop) and constructive (analytical) simulation systems to allow unit commanders and their staffs to train and improve their skills in a realistic simulation environment in order to enhance their live training and real-world mission execution. WARSIM is comprised of simulation software and associated hardware that, upon development and production, will be fielded at the Training and Doctrine Command's (TRADOC) training centers, commonly referred to as "schoolhouses", regional training centers, combat training centers, at various bases for the co-use of deployable units, and in mobile, deployable suites. Some WARSIM units will be fielded to the Army Reserve and National Guard Bureau.

WARSIM is supposed to replace several exiting "legacy" simulation systems, like the Corps Battle System (CBS), Combat Service Support Tactical Simulation System (CSSTSS) and Tactical Intelligence Simulation (TACSIM). While initially conceived of as a proprietary Army system, the scope of applicability of WARSIM was expanded in 1998 in order to satisfy the land component requirement of a broader simulation system to be used to train joint element commanders and staffs – this larger system is known as the Joint Simulation System (JSIMS). Joint operations are those that include two or more service components of the Department of Defense.

In December 2002, however, the Office of the Secretary of Defense issued a directive to cancel JSIMS and ordered the JSIMS program manager to close his office by the end of September 2003. The basis of this directive was delays in development and cost overruns.[1]

According to the JSIMS program manager, Army Brigadier General Stephen Seay, systems development is also plagued by issues of system integration and level of detail representation.[2]

With significant cause to cancel JSIMS, certainly there must be some unspecified technological hurdles present in WARSIM, the most fully developed component and biggest contributor to JSIMS. Herein we present an analysis of the WARSIM system requirements while highlighting four existing challenges manifested in those requirements, discuss the requirements specification process for WARSIM, and propose a framework wherein technological subject matter experts provide critical scrutiny of system requirements and an objective analysis of the feasibility of developing a system that satisfies requirements. While this framework applies specifically to the WARSIM case, the author proposes that this framework could be generalized to existing and future military modeling and simulation system acquisitions processes, as well as the acquisition of information technology systems as a whole.

II- Literature Review

The primary sources for analysis of WARSIM systems requirements are two publicly available documents titled "Operational Requirements Document (ORD) for Warfighters' Simulation 2000". There are two versions of these ORDs, which are made available by the National Simulation Center at Fort Leavenworth, KS. Version 2 is dated August 1996 and Version 3.7 is dated September 1998. Analysis of these documents provided tremendous insight into the rationale and basis for the development of WARSIM. Since they also included explicit and detailed system requirements, along with traceability documentation, it was clear what the sponsor expected of the developed system and from where requirements were derived from within the Army. What was not clear from the ORDs was what mechanisms or methodologies

were employed in order to specify the requirements. To that end, a series of papers by McNett, et al, described the development and employment of a multi-user database system called the Training Requirements Analysis Program (T-RAP) that allowed designated and approved subject-matter experts (SMEs) from across the Army to asses WARSIM's performance and training requirements.[3] A technical report on T-RAP detailed the design and implementation of this tool.[4] What became clear from these documents was that SMEs from across all specialties, and presumably, with experience at various levels of organizational hierarchy, were able to comment and provide input into the WARSIM requirements specification.

Several other papers discussed the development of WARSIM components, such as personnel modeling, Command, Control, Computers, Communications and Intelligence (C4I) interfaces, and multimedia training tools, along with hardware implications of such a large-scale, distributed, networked simulation system, but no others adequately addressed the requirements formulation or specification process. Numerous articles from non-academic sources provided the organizational and historical context of the conception of, and subsequent development of WARSIM. Several proprietary Army documents lent insight into the critical nature of WARSIM's linkages to JSIMS[5] and addressed the future of WARSIM considering the pending cancellation of its parent project.[6] An Army War College research project discussed the Army's software blocking policy as it pertains to information technology development and acquisition processes, and a number of papers were helpful in providing background pertaining to military simulations systems in general, including one by Page, et al.[7]

For the purposes of discussion herein, we focus on several requirements specifications extracted from the ORD Version 3.7. While various sources validate our claim that some of the requirements pose significant technological challenges, we feel that the ORD's speak for

themselves, as well they should. While the Army's spiral development process links developers and end-users in a series of feedback loops in order to streamline development and include as much user input as possible[8], the ORDs stand as artifacts of the development process and ultimately prove binding in any contractual arrangement between a sponsor and developer. The reasons that projects fall victim to cancellation could be numerous – funding and resource constraints, a fundamental shift of organizational focus or scope, personality conflict or even a change in leadership and administration are just a few possibilities that may be hard to pin down. Inherent technological challenges, however, would remain persistent in documents such as the ORD's and are worthy of analysis and discussion.

III- Technological Challenges Present in WARSIM Requirements

One could presume that systems requirements that are refined and republished after the development and iterative improvement of a tool designed specifically to facilitate requirement specification would result in a significant difference in content or level of detail. Such is the case with WARSIM, but perhaps to its detriment. With just over 2 years spanning the publication of Version 2 and Version 3.7 of the WARSIM ORD's, examination reveals that not only were requirements refined during this time but some were expanded in scope and magnitude, while others were added in Version 3.7 that had not existed prior. Version 2 included about 85 requirement specifications regarding design, performance and configuration. Its successor included almost twice as many specifications - about 165 in all - covering the same scope, but in greater, more explicit detail, an in several instances, in areas that had not been addressed in the previous version. Perhaps this is due solely to the inclusion of WARSIM as the JSIMS land component in 1998. While an organization is free to modify its requirements during the

development process, it is well known that this introduces a moving-target aspect for a developer and makes it increasingly difficult to determine what performance capabilities must be included in the deliverable.

Regardless of the requirements re-specification, Version 3.7 of the ORD included several requirements that we propose present significant, if not insurmountable challenges to any developer, as the technology to address these challenges has foundered, is still in its infancy or is only theoretical at this point in time. These inherent challenges and the corresponding requirements are presented in no particular order. The magnitude of several of these challenges is, in some cases, tied to grand challenges in modeling and simulations that have yet to be adequately addressed.

Challenge #1- Implementing and Enforcing Consistency in Multi-Resolution Modeling (MRM).

> *"The WARSIM 2000 system will use a computer-based simulation and associated hardware to support the training of unit commanders and their staffs from battalion through theater level."*
>
> ORD Version 3.7, Specification 1.1

> *"The simulation must be able to portray a level of detail that captures the effects of individual entities on the battle. Entities that operate as cohesive units may be portrayed in aggregated units from team to battalion that represent normal mode of employment. Individual, low-density, entities that operate in a geographically dispersed mode must be portrayed as they are employed. At Initial Operation Capability, WARSIM 2000 will track individual platform locations in the synthetic environment and maintain consistency of these locations in time and space within simulated units"*
>
> ORD Version 3.7, Specification 4.1.2.3

With an intended training audience from battalion level through echelons above corps, the latter specification clearly identifies the level of detail that needs to be included in the simulation and infers the need for aggregation-disaggregation that must occur when entities of differing levels of detail interact. Modeling entities from individual persons and platforms to large units comprised of hundreds or thousands of instances of these entities, along with the hierarchical stratification between parent and child units poses some of the classic challenges of cross-

resolution modeling. Maintaining logical and temporal consistency as outlined in Specification 4.1.2.3 is a problem that has been addressed in the literature[9] but has not be implemented with any great success on the scale inherent in this specification. This is an example of a requirement that remained largely unchanged between the two versions of the ORD, but certainly presents a significant hurdle for developers to overcome. Arguably, WARSIM requires a simulation that tracks tens of thousands of entities, almost all of which are assigned to particular units and interact with the synthetic environment as well as local populations and enemy forces. Ensuring that the simulation maintains consistency between all of these entities is an implementation problem that the developer will have to overcome by the Initial Operation Capability scheduled for Fiscal Year 2005.

Challenge #2- Implementing Agent-Based Behavior Modeling

> *"The simulation must consider the impact of public affairs operations. This must include, at a minimum: the effect of decisions made on public opinion; keeping the Army and American public informed; combating misinformation; enemy propaganda; facilitating media and information operations."*
> ORD Version 3.7, Specification 4.1.1.3.4.4
>
> *"The simulation must simulate the effects of religious support operations on the battlefield. In addition to the effect on human factors, the simulation must provide information on simulated unit morale, cohesion and perceptions to the unit chaplain."*
> ORD Version 3.7, Specification 4.1.1.3.7.10

Although the incoming deputy director of the Army Modeling and Simulation Office downplays the role of behavior modeling featured in WARSIM,[10] Christina Bouwens of Science Applications International Corporation, one of the WARSIM subcontractors, reports that their work on WARSIM includes agent-based modeling techniques.[11] Certainly, the specifications above infer the use and application of human behavior modeling, and, at that, in a very broad realm. From the opinions and perceptions of the Army, the American public and presumably, the host nation public in overseas scenarios, numerous populations with varying demographics, attitudes and perceptions must be modeled and subsequently simulated with a degree of

convincing fidelity. Agent-based simulation is a discipline that is just starting to bear fruit, but only within very tightly defined problems corresponding to specific applications, such as logistics, supply chain management and even urban warfare, but certainly in nothing as broad as what is described above. As late as the year 2000, a panel chaired by Tuncer Ören decried that there were no tried and trusted techniques available to developers in order to implement agent-based models[12]. Certainly the field has not accelerated from that point to where entire cultures can be adequately modeled as intended.

Challenge #3- Simulating the Integration & Interoperability of Loosely Coupled, Disparate Legacy Systems.

> *"The simulation must be capable of providing and accepting Combat Service Support (CSS) information to the level of detail and format (i.e. – Standard Army Management Information System) needed to train warfighters at all levels, logisticians, and commanders and staffs of CSS units from battalion through theater level in CSS functions. These units operate in direct and general support from theater down to company level. This includes the interactions that these units have with higher, lower or adjacent units; with other services; and with supporting STAMIS and Automated Data Processing (ADP) systems reports and outputs in logistical exercises as well as combat arms and combined arms exercises."*
>
> ORD Version 3.7, Specification 4.1.1.3.7

The above requirement entails simulating existing "legacy" Army logistics information systems, or STAMIS. These systems include the Unit Level Logistics System Ground, Air and S-4 varieties (ULLS-G, ULLS-A and ULLS S-4 respectively), the Standard Army Maintenance Systems (SAMS), the Standard Installation/Division Personnel System (SIDPERS) and the Standard Property Book System – Redesigned (SPBS-R) among others. These systems, in their current legacy role, help provide for the management and accountability of personnel, material and weapons systems, but they do so in a somewhat fractured fashion.

For example, ULLS-G is used to manage the dispatch and maintenance of a unit's fleet of vehicles, including tanks, trucks, or other wheeled or tracked vehicles. ULLS-G reports include licensure records for individual vehicle operators (soldiers) assigned to the unit, but SIDPERS manages the assignment and personnel records for each soldier. While SIDPERS tracks the

reassignment of soldiers to new units, those soldiers must be removed individually from the unit's ULLS-G system by a clerk or the soldiers' records remain persistent on the local system. There are many examples by which we can demonstrate that STAMIS are generally loosely coupled, but suffice it to say that their functionality is largely independent, with a few areas of overlap and very little interoperability. That is to be expected, as each system was developed independently for a distinct purpose and they were not intended to function together as a suite of logistics information systems. While there are emerging and proposed replacements for these legacy systems, legacy STAMIS are nearly ubiquitous throughout the Army and there are projections that they will continue to be used into the future.[13]

WARSIM requirements portray units that use these systems in an integrated fashion across the spectrum of the organizational structure, when in fact, most of the data collection is done at the lowest level, i.e. company, and consolidated at successively higher levels of the hierarchy, where reports are generated, analyzed and disseminated. Depending on the available infrastructure in an overseas scenario, dial-up or network connections may not be available, thus data is gathered and forwarded via floppy disk. This certainly is not an attribute of a highly cohesive, tightly coupled system-of-systems, yet WARSIM lumps logistics STAMIS together under one requirement specification, effectively asking a developer to simulate the interoperability of systems that are largely not interoperable.

Challenge #4- Voice Recognition/Response, Natural Language Processing, Artificial Intelligence

> *"A unique user-interface requirement is needed for unit personnel to interact directly with the simulation via voice instructions using organizational communications systems; i.e., the simulation must be able to recognize a multitude of voice commands as well as generate appropriate voice responses or independent reports."*
>
> ORD Version 3.7, Specification 5.4.3

In its simplest interpretation, this requirement seems to indicate a need for some type of voice recognition and response capability, wherein users can make oral requests for information about the ongoing simulation – perhaps akin to a commander asking for a situation report while in his or her tactical operations center. Upon close analysis of the requirement, though, some disturbing aspects emerge. The first sentence specifies that the unit personnel will interact directly with the simulation, and the second sentence indicates that the simulation will generate appropriate responses or independent reports. This implies a level of natural language processing and perhaps even a degree of artificial intelligence that must be engineered into WARSIM; otherwise, the requirement would have specified a more simplistic (and tractable) voice recognition system coupled with a deterministic voice menu type interaction, or a capability similar to this. Natural language processing is known to be very difficult to implement and is considered, even among researchers, to be the stuff of science fiction.[14] Artificial intelligence is just as hard of a problem to implement[15]. That is not to say that researchers have had little or no success in these fields, but, admittedly, it has been within well defined problems with a scope much narrower that WARSIM.

IV- Requirements Specification Methodology for WARSIM

Certainly it was not the intent of the WARSIM sponsors to draft requirements specifications fraught with insurmountable hurdles. In fact, the Army was quite scrupulous in garnering the input of SMEs from within the organization in order to help shape the requirements that are manifested in the ORD. Knowing that individuals within the Army posses a wealth of institutional knowledge of complex processes, designers turned to geographically dispersed, officially designated SMEs to provide quantifiable evaluations of performance and training

requirements to be supported within the simulation environment, as well as explanatory comments describing relationships and entities as they see feel they should be portrayed.[16] In order to do this, McNett, et al, developed and refined the T-RAP tool that SMEs could access via the internet in order to provide their input regarding the 262 Mission Training Plans (MTPs) that were under consideration for inclusion in WARSIM.[17] These MTPs provide the basis of evaluating mission performance and execution Army wide, and they provide a detailed framework for planning and execution down to the junior leader level.

Balancing the tasks specified in the MTPs with the WARSIM requirements, designers were able to prioritize the functional components to be included in WARSIM based on the input of the SMEs. As McNett, et al, described the evolution of the T-RAP tool from a simple spreadsheet application to an increasingly complex relational database backend with a web-enabled graphical user interface,[18] so, too, did the requirements generated as a result of this process evolve and become more sophisticated, detailed and precise. Unfortunately, as the requirements grew in complexity between Version 2 and Version 3.7 of the ORD, it does not appear that they were scrutinized by the sponsor for feasibility in development and implementation. For clarity, Figure 1 graphically depicts the requirements specification process wherein the SMEs utilized the T-RAP tool to help Army information operators responsible for compiling the

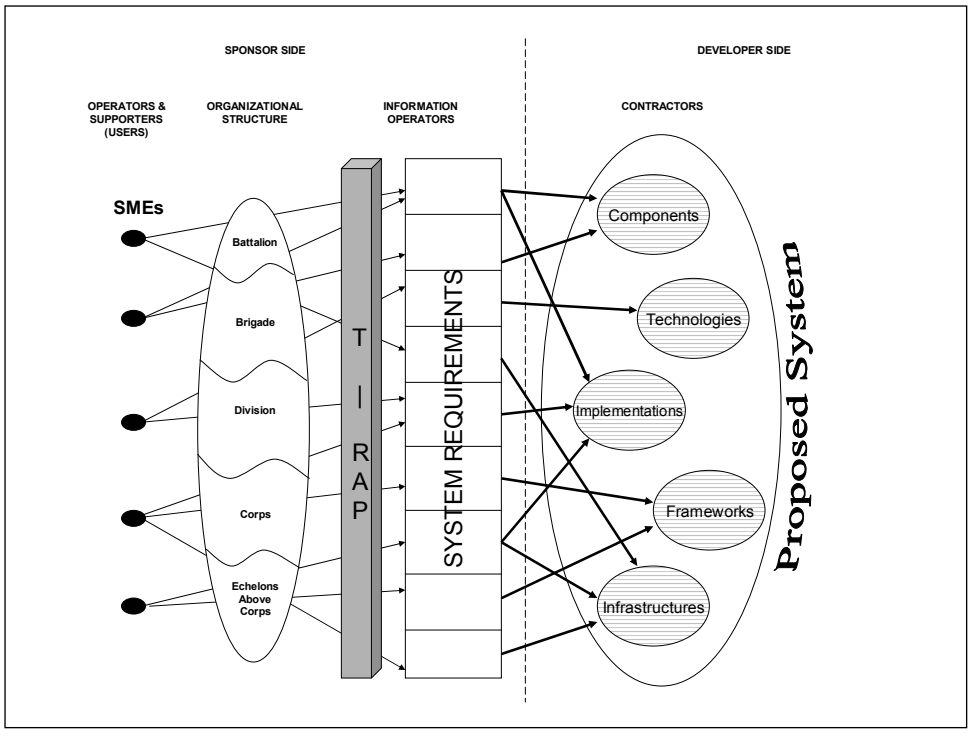

Figure 1

ORD draft the formal requirements specifications. This process occurs entirely on the sponsor side. The requirements specification induces a mapping to various technologies, frameworks, infrastructures and other developmental components that the proposed system must be comprised of in order to meet requirements. While the implementation of these is a result of the developers' effort, the developer is contractually bound to deliver a product or service that fulfills requirements. Failure to do so, as we have seen in the JSIMS case, can jeopardize the success of the project. Surely, there must be another step that the sponsor can take in order to ensure the feasibility of their requirements and reduce the amount of risk inherent in the development and acquisition of such a far-reaching and revolutionary system. Herein, we propose such a step.

V- Proposed Framework

Including user input in the requirements specification adds to the richness and capability of a system in development,[19] but, as we have seen, it also presents its hazards. In the case of WARSIM, SME's from across the enterprise provided input that helped shape the system requirements. Certainly the developers, in this case government contractors, will be reluctant to tell their potential customers that they can't have what they want – that is, to point out at or before contract award time that in order to truly fulfill the requirements as specified in the ORD, that fundamental problems and challenges in the field of computer science, and more specifically, within the domain of modeling and simulation, must be overcome, and then the solutions must be applied to the particular implementation being developed. There certainly is no incentive for developers to indicate an inability to include critical, requested functionality while bidding for the contract is still open. Should it be up to the developer to request a

refinement or restatement of the requirements, or should the sponsor more carefully specify the desired system requirements so as not to be requesting what is infeasible or intractable? While the competitive nature of the acquisition process probably does not contribute to potential contractors being frank about technological limitations, one of the lessons that we can extrapolate from the apparent demise of JSIMS is that far-reaching military simulations may be too broad in their scope or over-specified considering the current state of technology.

The first element of the framework we propose is the consideration that the developmental components needed to fulfill system requirements should be stratified into three categories; mature, immature/developing, and theoretical. In the WARSIM case, it can be argued that while agent-based behavior simulations have been successfully implemented, it has only been done so in a scope, relative to WARSIM, that is narrow and well defined – hence, an ideal candidate for the immature/developing category. The aspects of artificial intelligence, however, should be viewed as a theoretical component until someone successfully implements a system that can pass the Turing test.

Following from this stratification is the most critical part of the proposed framework – the sponsor solicitation of input from truly independent technological SMEs to asses the feasibility of implementing system requirements and the likelihood that a developer can meet the contract timeline or blocking requirements, considering the current state of technology. We propose that these technological SMEs can work concurrently with organizational SMEs in helping to shape system requirements, or they can simply comment on published or pre-published ORDs, providing critical analysis of the requirements and a risk analysis of system development and acquisition with regard to the particular elements of the pending contact. This type of non-stakeholder input can provide project managers with the basis for refining or restating

requirements early on, or perhaps allow for the justification to modify the scope of the project as a whole. Although most Army information technology project managers hold advanced technical degrees and have had some number of years experience in dealing with technological applications, they are largely managerial generalists[20] who could benefit from the objective feedback provided by technological SME's from academia, industry and research who have no particular ties to defense agencies or the firms that routinely contract with them.

This stratification of developmental components and the role of technological SMEs is depicted in Figure 2. While the independence of these SMEs is critical, what is even more important is the source of their legitimacy. Assuming that project managers would want to be made aware of the inherent risks by non-stakeholders who are attuned to the nuances of modeling and simulation technology, the sponsor agency must provide the resources and funding for these SMEs to participate in the requirements specification process; their role should be defined and promulgated early on in the project management life cycle; and they must have access to organizational and institutional knowledge bases, as well as tools such as T-RAP.

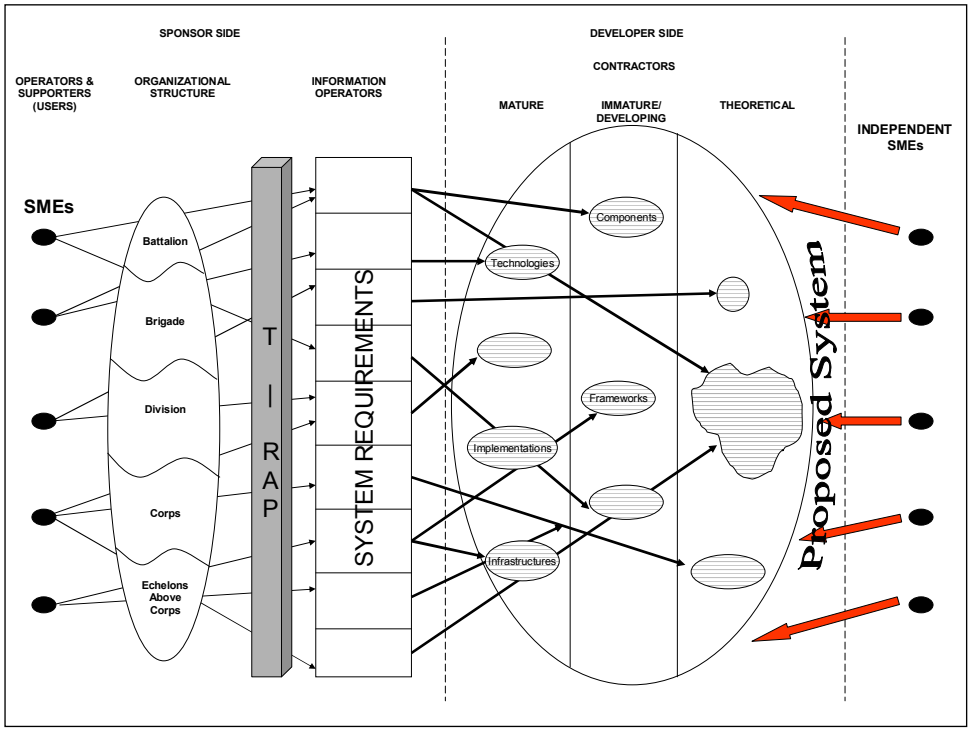

Figure 2

VI- Benefits & Drawbacks

The framework proposed herein, while not revolution by any stretch of the imagination, can be viewed as an extension of the work done by McNett, et al, except whereas they sought to include the input of organizational SMEs, we propose feedback from technological SMEs in order to better construct requirement specifications in the future. Presuming that the sponsor's organizational culture is receptive to the kind of feedback that can result from what we propose, and can successfully integrate it while shaping new systems requirements, we feel that our framework adds tremendous value to the design phase and will contribute to the successful completion of complex, yet feasible projects.

This is not to say that developers intentionally mislead sponsor agencies regarding the inherent risk in attempting to develop systems with broad technological goals. In fact, the earlier that technological SMEs are included in the requirements specification process, the greater the likelihood that proposed IT systems will be developed on time and within budgeting constraints. Since they are not tied to the organization, or the success or failure of a particular system, technological SMEs can provide the candid feedback about a proposed system that project managers can leverage in order to refute claims of feasibility made by developers during the contract solicitation process. They can also provide an independent risk analysis regarding a proposed system meeting its development timeline, or make general comments about a system's feasibility as a whole. If they desire, project managers can use this feedback to refine requirements or perhaps the scope of a component of the system or the entire system itself.

This proposed framework has its drawbacks as well. Identifying and assembling a cadre of technological SMEs for any project is going to incur administrative and resource overhead. Determining what individuals are eminent SMEs can be a fairly subjective process, and

obtaining their commitment to a project with a long term development timeline can be risky. This framework also introduces another layer in the acquisition process, which the Army has been working very hard to streamline. Adding another layer can introduce further delays and organizational lag. One could argue that the feedback of these SMEs might create a risk-averse atmosphere or stymie the innovative capabilities of firms contracting with the government. Ultimately, if technological SMEs provide the type of feedback that results in the early termination of a project or concept, existing shortcomings that helped spawn the project might not be addressed.

VII- Conclusions

The pending cancellation of JSIMS leaves the need for a joint staff training simulation unfulfilled. The intent of developing the framework outlined herein is not to breathe life back into cancelled programs. In spite of the Office of the Secretary's announcement in November 2002, the JSIMS project office delivered Version 1.0 of its software the following month and a great success by WARSIM during testing in the summer of 2003 could revive the parent project.[21] We hope to have demonstrated a need for expert feedback regarding system requirements in order to circumvent future cancellations that could result in the unneeded waste of resources and leave our defense agencies lacking tools they so desperately need. A more informed approach to requirements specification, and requirements engineering in general, can aid the acquisition of the technological components of tomorrow's simulation and information technology systems. Extending the process developed by McNett, et al, will bring the pragmatic concerns of technological insiders into balance with user requirements that might exceed existing capabilities. In the end, from all perspectives, the motivation remains the same – to facilitate the

development of cutting edge systems to provide our warfighters with a distinct advantage on future battlefields.

ENDNOTES

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