WARSIM 2000: A Case for Technological Subject Matter Experts

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WARSIM, the U.S. Army's next-generation simulation and intended land component of JSIMS is supposed to replace several existing "legacy" simulations. With the cancellation of JSIMS as a result of technological and organizational hurdles, we review the literature documenting the development of WARSIM's requirements specifications; analyze some particularly challenging requirements manifested in Operational Requirements Documents; describe the methodology through which those requirements were composed and drafted; and propose a framework that would integrate the analysis and input of technological subject matter experts who can adequately assess the feasibility of developing and fielding future systems.

Keywords: Constructive and virtual simulations, subject matter experts, requirements specification, WARSIM, JSIMS

1. Introduction

The Warfighter's Simulation 2000 (WARSIM) is intended to be the Army's next-generation simulation system spanning many levels of the organizational hierarchy—from battalion to echelons above corps, WARSIM is supposed to provide a virtual (man-in-the-loop) and constructive (analytical) simulation system to allow unit commanders and their staffs to train and improve their skills in a realistic simulation environment. WARSIM consists of simulation software and associated hardware that, upon development and production, will be fielded at the Training and Doctrine Command's training centers, regional training centers, combat training centers, various bases for use by operational units, and in mobile, deployable suites. Some WARSIM units will be fielded to the Army Reserve and National Guard Bureau as well as the active duty Army.

WARSIM is supposed to replace several existing "legacy" simulation systems, like the Corps Battle System, Combat Service Support Tactical Simulation System, and Tactical Intelligence Simulation (TACSIM). While initially conceived of as a proprietary Army system, the intended role 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 (JSMIS) [1]. Joint operations are those that include two or more service components of the Department of Defense. At first, JSMIS was intended to be a tool designed particularly for use by joint staffs, but in 1998 JSIMS subsumed WARSIM and several other developmental systems. The resulting system specification covered the staggeringly complex domain of military operations—on land, at sea and in the air—with varying levels of detail.

In December 2002, 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 [2]. According to the JSIMS program manager, Army Brigadier General Stephen Seay, systems development also was plagued by issues of system integration and level of detail representation [3]. Since our intent is to address the requirements specification process and how it can be improved by using WARSIM as an example, further treatment of JSIMS, its requirements, and functionality are beyond the scope of this paper.

We present an analysis of the system requirements pertaining to WARSIM, while highlighting four existing challenges manifested in those requirements; discuss the requirements specification process for this particular system; and propose a framework wherein technological subject matter experts provide critical scrutiny of system

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requirements and an objective analysis of the feasibility of developing a system that satisfies requirements. While this framework applies specifically to the WARSIM case, we propose that it could be generalized to existing and future military modeling and simulation system acquisitions processes, as well as to the acquisition of various information technology systems.

2. 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, Kansas. Version 2 is dated August 1996 and Version 3.7 is dated September 1998. Analysis of these documents provided significant insight into the rationale for the development of WARSIM. Since they also include explicit and detailed system requirements, along with traceability documentation, it is clear what the sponsor expected of the developed system and from where requirements were derived. What is not clear from the ORDs is how the requirements were identified initially. To that end, a series of papers by McNett and colleagues [4, 5, 6] describe 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 assess WARSIM's performance and training requirements. A technical report on T-RAP details the design and implementation of this tool [5]. What these documents make clear is 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 discuss the development of WARSIM components, such as personnel modeling, Command, Control, Computers, Communications and Intelligence interfaces (C4I), multimedia training tools, as well as the hardware implications of such a large-scale, distributed networked simulation system. No others adequately addressed the requirements formulation or specification process. Numerous articles from non-academic sources provide the organizational and historical context of the conception of, and subsequent development of, WARSIM. Several proprietary Army documents lend insight into the critical nature of WARSIM's linkages to JSIMS and address the future of WARSIM [7,8] considering the imminent cancellation of its parent project. An Army War College research project discusses the Army's software blocking policy as it pertains to information technology development and acquisition processes [9], and a number of papers provide background pertaining to military simulations systems in general, especially that by Page and Smith [10].

In this paper, we explore and discuss 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 believe that the ORDs speak for themselves. 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 [9], 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. Inherent technological challenges would remain persistent in documents such as the ORDs and are worthy of analysis and discussion.

3. Technological Challenges Manifested in WARSIM Requirements

Requirements often change as organizations gain insight from an attempted implementation. Such is the case with WARSIM, but perhaps to its detriment. With just over two years spanning the publication of Version 2 and Version 3.7 of the WARSIM ORDs, 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 been specified previously. 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, and 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 creates an element of having to attack a moving-target for developers and makes it increasingly difficult to determine what performance capabilities must be included in the deliverable.

Regardless of the requirements respecification, 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 largely conceptual 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 requirement clearly specifies the level of detail that needs to be included in the simulation and implies a multi-resolution capability that must occur when entities of differing levels of detail interact. Modeling entities from individual persons and platforms to large units composed 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 multi-resolution modeling. Maintaining logical and temporal consistency as outlined in Specification 4.1.2.3 has been addressed in the literature [11,12] but has not been implemented successfully comparable to the scale and scope of WARSIM. 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. 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 a technological 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

While the role of behavior modeling featured in WARSIM has been downplayed, one of the WARSIM subcontractors reports that their work on the system includes agent-based modeling techniques [13]. Clearly, the specifications imply the use and application of human behavior modeling within a very broad domain. In previous work, we have discussed the challenges inherent in human behavior representation (HBR) and the risk that it adds to successful model development and implementation [14]. From the opinions and perceptions of the Army, the American public and, presumably, the host nation 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 in the military domain is a discipline that is just starting to bear fruit, but only within very tightly defined problem spaces corresponding to specific applications. These include domains 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 to implement agent-based models [15]. The technological capability has not accelerated from that point to where entire cultures can be adequately modeled as intended.

Challenge 3: Simulating the integration of loosely coupled, disparate legacy systems.

"The simulation must be capable of providing and accepting Combat Service Support 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 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

This 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 loosely coupled fashion.

For example, ULLS-G is used to manage the dispatch and maintenance of a unit's fleet of vehicles, including utility trucks, tanks, or other wheeled or tracked vehicles. ULLS-G reports include licensure records for individual vehicle operators (soldiers) within the unit, but SIDPERS manages the location, assignment, and personnel records for each soldier. While SIDPERS tracks the reassignment of soldiers to new units, that soldiers must be removed individually from the unit's ULLS-G system by a clerk or a soldier's records remain on the local system. There are many examples by which we can demonstrate that STAMIS are generally loosely coupled, but it suffices that their functionality is largely independent, with a few areas of overlap and very little interoperability. That is to be expected, since these "legacy" systems were developed independent of each other 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, STAMIS are nearly ubiquitous throughout the Army and there are projections that they will continue to be used well into the future [16].

WARSIM requirements specify the portrayal of units that use these systems in an integrated fashion across the spectrum of the organizational structure. In practice, 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 early-entry overseas scenario, dial-up or network connections may not be immediately available, thus data must be 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 legacy 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 indicates a need for 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. Together, these requirements imply a level of natural language processing and perhaps even a degree of artificial intelligence that must be engineered into WARSIM. Otherwise, the requirements would have specified a less complex and more 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 [17] and artificial intelligence is likely just as hard [18]. Researchers have had limited success in these fields, but within well defined problems having a scope and domain much narrower than WARSIM.

4. 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 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 feel they should be portrayed [4]. In order to do this, McNett and colleagues 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 [6]. 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 and colleagues 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 [6], 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 the requirements 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 ORD draft 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 comprise the proposed system 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 methodology.

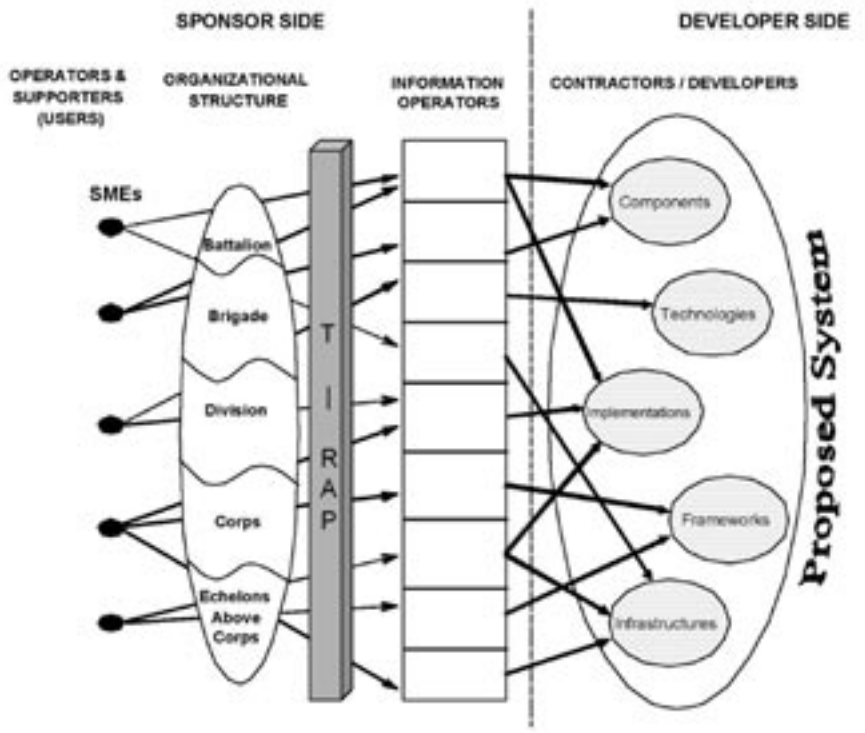

Figure 1. WARSIM requirements specification process

5. 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 can also invite risk. In the case of WARSIM, SMEs from across the enterprise provided input that helped shape the system requirements. The developers, in this case government contractors, likely will be reluctant to disclose to 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 adequately fulfill the requirements as specified in the ORD, that some fundamental problems and challenges in the field of computer science, and more specifically, within the domain of modeling and simulation, must be overcome before the system can be implemented. Developers lack an incentive to indicate their inability to include critical, required 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 demise of JSIMS is that far-reaching military simulations may be too broad in their scope considering the current state of technology. We have documented that such is the case with HBR, particularly in military simulations [14], and that a more enlightened approach to design and development is necessary.

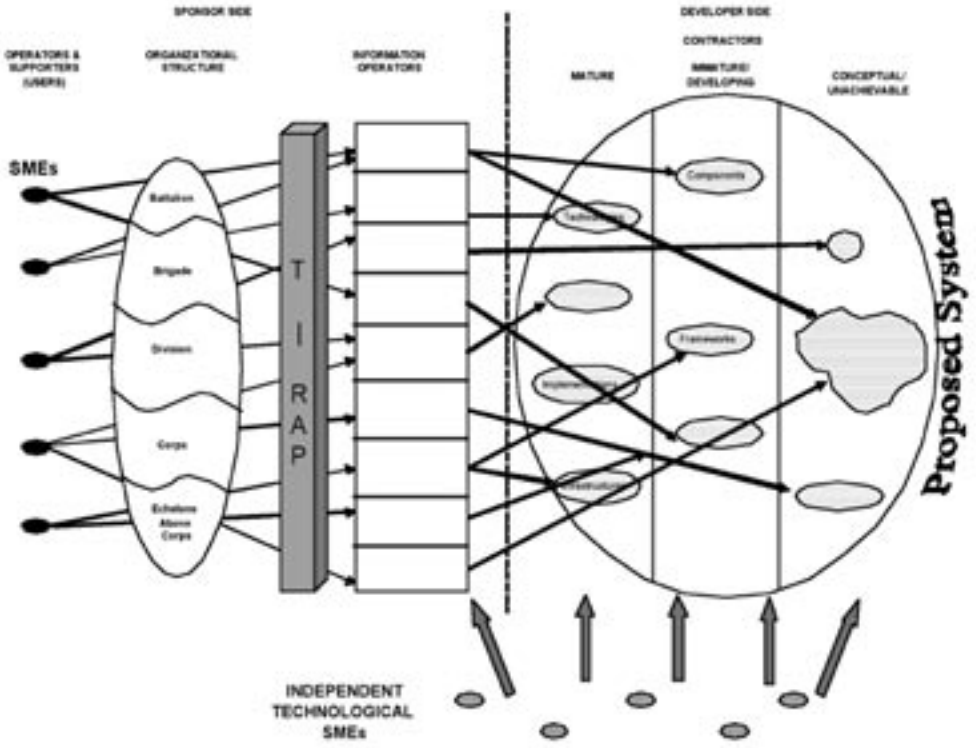

Figure 2. Proposed requirements specification framework

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
- Conceptual, perhaps unachievable

We have considered these categories in our assessment of the inherent challenges of HBR [14]. In the case of WARSIM, it can be argued that while agent-based behavior simulations have been successfully implemented, it has only occurred in a scope, relative to WARSIM, that is narrow and well defined. We find the agent-based behavior required in WARSIM falls into the immature/developing category. The aspects of artificial intelligence required in WARSIM should be viewed as a largely conceptual component until someone successfully implements a system that can pass the Turing test.

The stratification we have put forth suggests the need for the involvement of subject matter experts in the requirements gathering process who understand it and can offer independent guidance to a sponsor. These SMEs must have no links to the system being considered and should assess 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 notion is not a revolutionary one and coincides with widely accepted software design methodologies. The identification and consideration of technological constraints, risks, and tradeoffs are essential elements of well documented software engineering techniques [20]. 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 officers serving as information technology project managers hold advanced technical degrees and have had some number of years experience in dealing with technological applications, they largely are managerial generalists [21] who could benefit from the objective, unbiased feedback provided by technological SMEs who can provide not only expertise but adequate objectivity, either individually or collectively. The promise and potential of emerging technologies, such as those found in simulation software intended for entertainment or commercial purposes [22], must be tempered by the rigorous demands and broad applicability that military users require. Ignoring the complexity of the technology required to fulfill requirements can be equally as wasteful as ignoring the needs for new simulations and capabilities.

Our proposed framework, including its 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 wish to be made aware of inherent risks by non-stakeholders who are well versed in 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.

6. Benefits and Drawbacks

Our proposed framework can be viewed as an extension of the work done by McNett and colleagues, except whereas they sought to include the input of organizational SMEs, we seek feedback from truly independent technological SMEs in order to better critique and construct requirement specifications in the future. Presuming 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 believe that our framework adds tremendous value to the design phase and will contribute to the successful completion of complex, yet feasible projects.

The earlier that technological SMEs are included in the requirements specification process, the greater the likelihood that proposed 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 concerning a proposed system that project managers can leverage in order to refute claims of feasibility made by developers during the contract solicitation process. They also can 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 even the entire system.

This proposed framework has some potential challenges and risks 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 qualified SMEs can be a fairly subjective process, and obtaining their commitment to a project with a long term development timeline can be risky. Our 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.

7. Conclusions and Future Work

The 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 a cancelled program. (Despite the Office of the Secretary of Defense's announcement in November 2002, the JSIMS project office delivered Version 1.0 of its software in the following month.) We have demonstrated a need for expert feedback regarding system requirements in order to avoid future cancellations that could result in the wasting of resources and leave our defense agencies lacking tools they so desperately need. Any framework may be circumvented or ignored as a result of external forces. Cultural issues and problems with the acquisition process itself could prevent the success of the framework we have proposed. Our approach is necessary to the success of M&S programs but quite likely not sufficient. Much remains to be done.

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 and colleagues will bring the intellectual concerns of technological insiders into balance with the pragmatism of user requirements, even those that might outstrip existing capabilities. In the end, the motivation remains the same: to facilitate the development of cutting edge systems to provide our warfighters with a distinct advantage on future battlefields.

8. References

[1] Bennington, R.W. 1995. Joint Simulation System (JSIMS)—An Overview. *Proceedings of the IEEE 1995 National Aerospace and Electronics Conference*, Vol. 2, 804-809.

[2] Tiron, Roxana. 2003. Pentagon Cancels Program with "Checkered" Past. *National Defense Magazine*, April 2003. Available at http://www.nationaldefensemagazine.org/article.cfm?Id=1081.

[3] Tiboni, Frank. 2003. Overdue and On the Ropes—Pentagon Eyes Alternatives to Troubled Joint Simulation System. *Training and Simulation Journal,* April/May 2003, 16.

[4] McNett, Michael D., Robert G. Phelan, Jr., Michael L. McGinnis. 1997. WARSIM 2000: Combining Multiple Expert Opinions From Subject Matter Experts to Generate Requirements for Staff Training at Battalion Level and Above. *Proceedings of the IEEE International Conference on Systems, Man, and Cybernetics 1997,* Vol. 2, 1280–1284.

[5] Phelan, Major Robert G., Captain Michael McNett, Lieutenant Colonel Michael McGinnis. 1997. Warfighters Simulation 2000 Training Requirements Analysis Program. West Point, New York: Operations Research Center, U.S. Military Academy.

[6] Phelan, Jr., Robert G., Michael D. McNett, Michael L. McGinnis. 1997. Design and Implementation of a WWW-Based Database System to Support Software Development of Computer Generated Forces for U.S. Army Simulation Training. *Proceedings of the IEEE International Conference on Systems, Man, and Cybernetics 1997,* Vol. 2, 1270.

[7] Thomson, Colonel Peter W. 2000. Information Paper on Warfighter's Simulation (WARSIM) 2000. Fort Leavenworth, Kansas: National Simulation Center.

[8] Black, Mike. 2002. Information Paper on JSIMS/WARSIM Contingency Planning. Fort Leavenworth, Kansas: National Simulation Center.

[9] Ferrell, Lieutenant Colonel Robert S. 2002. Army Transformation and Digitization—Training and Resource Challenges, 6. Carlisle Barracks, Pennsylvania: U.S. Army War College.

[10] Page, Ernest H., Roger Smith. 1998. Introduction to Military Training Simulations: A Guide for Discrete Event Simulationists. *Proceedings of the 30th Winter Simulation Conference*, IEEE Computer Society Press, Los Alamitos, California, 53-60.

[11] Reynolds, Paul F., Anand Natrajan, Sudhir Srinivasan. 1997. Consistency Maintenance in Multiresolution Simulations. *ACM Transactions on Modeling and Simulation,* Vol. 7, No. 3, 368-392.

[12] Davis, Paul K., James H. Bigelow. 1998. *Experiments in Multiresolution Modeling*. Santa Monica, CA: RAND MR-1004-DARPA.

[13] Bouwens, Christina L. 2001. Frameworks Based Behavior Environments, 17. Orlando, Florida: Final Report Submitted to Naval Warfare Systems Division, Contracts Division.

[14] Giordano, John C., Paul F. Reynolds Jr., David C. Brogan. 2004. Exploring the Constraints of Human Behavior Representation. To appear in *Proceedings of the 36th Winter Simulation Conference,* Washington D.C.

[15] Oren, Tuncer I., S.K. Numrich, Adeline M. Uhrmacher, Linda F. Wilson, Erol Gelenbe. 2000. Agent-Directed Simulations: Challenges to Meet Defense and Civilian Requirements. *Proceedings of the 32nd Winter Simulation Conference*, Society for Computer Simulation International, San Diego, California, 1757-1762.

[16] Miller, Sergeant First Class Ronald. 2001. Status of STAMIS Warranty and Post-Warranty Support & Review of Ongoing Initiatives to Further Improve STAMIS Readiness. Fort Lee, Virginia: Logistics Division, Program Executive Office–STAMIS, briefing slides.

[17] Dale, Robert. 2000. *Handbook of Natural Language Processing*. New York: Marcel Dekker, Inc., iii.

[18] Partidge, Derek. 1998. *Artificial Intelligence and Software Engineering: Understanding the Promise of the Future*. , (Chicago, Illinois: AMACOM Books, 215.

[19] Butler, Tom. Brian Fitzgerald. 1997. A Case Study of User Participation in the Information System Development Process. *Proceedings of the 18th International Conference on Information Systems*, Association for Information Systems, Atlanta, Georgia, 423.

[20] Kazman, Rick, Robert L. Nord, Mark Klein. 2003. *A Life-Cycle View of Architecture Analysis and Design Methods.* Pittsburgh, Pennsylvania:Carnegie Mellon—Software Engineering Institute.

[21] Department of the Army. 1998. DA Pamphlet 600-3: Commissioned Officer Development and Career Management. Washington, D.C.: Headquarters, Department of the Army, 219.

[22] Committee on Modeling and Simulation, Computer Science and Telecommunications Board, National Research Council. 1997 *Modeling and Simulation: Linking Entertainment and Defense.* Washington, D.C.: National Academy Press.

[23] Uhrmacher, Adelinde M., Paul FIshwick, Berard Zeigler (eds.). 2001. Special Issue: Agents and Simulation—Exploiting the Metaphor. *Proceedings of the IEEE,* Vol. 89.

[24] Committee on Modeling and Simulation Enhancements, Board on Manufacturing and Engineering Design, National Research Council. 2002. *Modeling and Simulation in Manufacturing and Defense Acquisition: Pathways to Success.* Washington, D.C.: National Academy Press.

[25] Commission on Physical Sciences, Mathematics, and Applications, Naval Studies Board, National Research Council. 1997. *Technology for the United States Navy and Marine Coprs: 2000-2035.* Washington, D.C.: National Academy Press.

[26] Davis, Paul K. 2001. Effects-Based Operations: A Grand Challenge for the Analytical Community. Santa Monica, CA: RAND MR-1477.