Project Summary

In this proposal, we describe how simulation model repositories and distributed simulation can be used to enhance instruction and learning in engineering undergraduate curricula. Our overall objective is to demonstrate the viability of a medium-scale, multi-university (including minority universities and community colleges) cyber-infrastructure for education and training, called *CI-MUST: Cyber-Infrastructure for Multi-University Simulation Training and Education*. CI-MUST spans students, courses, and instructors at multiple universities and community colleges, exploiting natural synergies among our respective engineering curricula, the Modeling and Simulation Resource Repository (MSRR) <http://www.msrr.dmso.mil/> developed and maintained by the Defense Modeling and Simulation Office (publicly available), and an evolving Simulation Model Repository (SMR) jointly developed by CreateASoft and UA <http://www.sie.arizona.edu/faculty/son/CI_TEAM.html>. In particular, we propose to:

1. demonstrate the use of the MSRR and SMR for queueing, service, and defense systems to enhance instruction and learning in freshmen-, sophomore-, junior-, and senior-level engineering courses, including issues related with accessing, storing, searching, and (re)using simulation models and data;

2. implement CI-MUST in more than ten simulation courses across the curricula taught by Drs. **Son** and **Goldberg** at UA, Dr. **Wysk** at PSU, Dr. **McGinnis** at GT, Dr. **Smith** at Auburn, Dr. **Fowler** at ASU; Dr. **Pignatiello** at FSU-FA&M (minority university), and Mr. **Forster** at PIMA College (minority college); and

3. assess the impact on the educational experience, learning, and practical knowledge of the undergraduate students who will interact with the MSRR and SMR via CI-MUST. Dr. **Franklin** at UA Learning Technologies Center will take a lead in this endeavor. Phase I experiments will be conducted involving lower-division courses as they allow a more controlled setting. For example, we can partition the sections, teaching half with and half without involving CI-MUST, while keeping the course materials identical. The experiments will then be extended to the upper-division courses (Phase II).

Our technology base for this work consists of expertise in 1) system dynamics simulation (**Goldberg**), 2) discrete event simulation (**Son, Smith, Fowler**), 3) ontology development (**McGinnis**, **Wysk**), 4) reusable modeling (**Son, Wysk**), 5) input and output analysis (**Pignatiello**, **Fowler**), 6) distributed environs (**Son, McGinnis**), 7) World Wide Web technology (**Smith**, **Son**), and 8) instructional design and assessment (**Franklin**). There is a strong history of collaboration among the PIs involved with CI-MUST.

***Intellectual Merit*:** There is strong agreement that engineering leadership in the future will come from one's ability to deal with large-scale, complex, dynamic systems. Students generally have no technical basis for working with such systems, nor much in the way of helpful intuition. As games such as SimCity and SimEarth have shown, simulations can be an excellent platform for developing a more robust systems understanding. For the kinds of technical systems that engineers confront in manufacturing, logistics, homeland security, health care, or defense, simulations offer a mechanism for engaging students, motivating their technical engineering courses, and giving them both experience and intuition with large-scale, complex and dynamic systems that are representative. The fundamental problem is that, today, such simulations are custom-built, one-off, and often throw-away artifacts of the engineering process of analyzing or designing such systems. What CI-MUST seeks to do is to establish the intellectual as well as IT infrastructure necessary to make simulations a more persistent element in the educational process. The initial intellectual challenges are those associated with creating and using simulation-oriented repositories. Once we have shown the feasibility of such repositories, the intellectual challenges will be how to conceptualize, develop, and validate simulation models that truly can be shared, federated, and extended across multiple institutions.

Broader Impacts: The diversity and strength of the seven undergraduate engineering programs represented in the proposal will help prepare a new generation of engineers to develop, exploit, and promote the use of simulation and repositories to support distributed analysis of complex systems. In three years, 3,030+ undergraduate students will participate in CI-MUST, helping to prepare them to enter the workforce with a more effective understanding of working in a distributed, technology mediated environment. These students will be exposed to technologies that are representative of those that will shape the growth of the CI. The project will include diverse groups of people, including students at one historically black university and one minority (Hispanic) community college. We also plan to engage 200+ high school students in CI-MUST through ongoing summer outreach activities. The plan of work will pave the way for wider dissemination of CI-MUST in the future to include graduate students as well as other institutions nationally and internationally. Finally, INFORMS and IIE societies will help us promote the CI-MUST activities in modeling and simulation curricular in their web site as well as periodicals.