

INTEGRATED SIMULATION OF SPACE HABITAT WORK PRACTICES AND SYSTEMS

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This project investigates integrating simulations human behavior, life support systems, and software agents. The objective is to develop tools for enhancing the safety and effectiveness of facilities, procedures, schedules, and automation software in operational contexts. Specifically, a crew activity simulation represents a day-in-the-life of a habitat (e.g., the ISS), including coordination of work, chores, habits, and entertainment. Failures in system components and errors and lapses in agent capabilities and communications can be modeled, to evaluate how robust the designs are to problems, and to identify vulnerabilities. At the same time, positive aspects of crew preferences, physiological conditions, and interpersonal activities (e.g., playing games) are also included, so system and software designs may take into account the broad context of life in the hab.

Models of activities, goals, and schedules provide a means for human operators to visualize alternatives for procedures and to invent new operations concepts. A Brahms simulation might be used to generate day-to-day scheduling and evaluate implications of a new procedure on team coordination across different activities. Interactions between diverse types of daily activity such as systems maintenance and scientific work can be discovered and appropriately accounted for in design of automated systems, procedures, training, and external support.

By modeling physical layout explicitly and including models of human activity (the crew's life, not just control actions), perspectives of multiple disciplines (e.g., architects, life support engineers, crew planners) can be integrated, such that layout designs and crew work schedules can be planned and understood. Complicating factors from this work environment can also be used in setting up simulations to evaluate effects of distance and delay on communication and coordination among mission support and remote science teams.

The **CONFIG** simulation tool provides advanced capabilities for modeling systems of multiple interacting components and controls; the **Brahms** environment provides advanced capabilities for modeling multiple interacting agent activities, work practices and physical layout. Each tool includes some simple modeling capabilities that mirror the advanced capabilities in the other environment, providing the basis for integration between them. To initially demonstrate feasibility and analysis capabilities, the integrated simulations have been interfaced to the 3T intelligent control software for managing life support equipment in a space vehicle or surface habitat.

By integrating the Brahms and CONFIG environments with 3T it will be possible to simulate crewmember interaction with the life support systems and intelligent agents, as part of work practice in a vehicle or base. CONFIG will be used to model and simulate the life support systems, and Brahms will be used to model and simulate the activities and

interaction of the crewmembers. The integrated simulations are demonstrated in a scenario where the intelligent agent and crew interact to manage a failure in the life support system.

In this presentation, we report on the logistic difficulties and research problems raised in integrating tools implemented in different languages and deployed on different computer platforms. Contrary to talk about "components off the shelf" and "plug and play" compatibility, we found that existing architectures are barely capable of allowing us to integrate our simulations. Not just any combination of existing tools will work together in a practical way. Interoperability requires careful choice of communication standards (e.g., Corba) and simplified installation procedures for deploying the software on distributed machines. We include specific recommendations for carrying our work forward, to develop integrated crew-system simulations of broad value for Space Station and planetary habitats.