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Impact of a Distributed Intelligent System in a Large Scale Safety Critical System

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Safety critical large scale systems are complex, physically extensive socio-technical systems, extending over a range of domains, and are of interest because of the enormous catastrophic potential on their constituents, bystanders and the environment. Often, failures in such systems are traced to human error, as well as to unforeseen and unanticipated combinations of causal factors arising from the size, scope and complexity of the systems. Technologies developed to support these systems are often distributed, supporting subsystems with specific local requirements.

The marine transportation system (MTS) is an example of a safety critical large scale system consisting of ports and waterways, traffic management systems, regulatory agencies, vessels, pilots and shipping companies. Technical advances in the MTS have aimed at supporting individual components of the system such as integrated ship's bridge systems (IBS) to support bridge watch teams. This paper focuses on one example of distributed intelligent information technology deployed to mitigate risk in a large scale safety critical system: a distributed intelligent ship's piloting system (DIPS) resident within both a shipboard IBS and a shore-based vessel traffic services (VTS) system. Intelligent information sharing between ships and shore, using common displays of the waterway, is intended to facilitate the development of shared mental models of the waterway, and enhance the safety of navigation.

Research questions associated with distributed intelligent systems address concepts from several different research areas, including computer mediated communications (CMC), group decision support systems (GDSS), computer supported cooperative work (CSCW), knowledge-based systems, and safety research. While sharing concepts such as reducing communication barriers, providing task support and ensuring equitable distribution of additional workload with CMC, GDSS and CSCW systems, distributed intelligent systems also differ significantly from them. For instance, such systems can enrich the communication medium, and evaluating the impact of such systems in a real-time operational environment with "open" operating groups can provide fertile research territory.

The research experiment proposed is a longitudinal field study in a real-time operational environment (aboard ships and in the vessel traffic services of the St. Lawrence Seaway). The research framework utilizes evaluation metrics from input-output assessment, process evaluation and behavioral evaluation approaches. Input-output assessment metrics evaluate the effect of distributed intelligent systems on such metrics as decision quality, the correlation between decision quality and number of participants, user confidence and user satisfaction. Process evaluation metrics evaluate the effects on communications and participation in the system. Behavioral assessments evaluate effects on the attitudes of participants, their perception of progress, perceived effort, and system usage over time and by member type.

The experiment is a 2x3 design with the technology treatment (baseline condition of the waterway and with the DIPS installed) and the voyage stress levels (low, medium and high) being the independent variables. System architecture design has been completed and a suitable test bed has been identified. System development and data collection in the baseline conditions are underway. Preliminary investigations suggest that major findings may be in the areas of communications among participants, participation, and behavioral issues such as attitudes of participants and system usage.