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# Cross-Industry Performance Modeling: Toward Cooperative Analysis

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# CROSS-INDUSTRY PERFORMANCE MODELING: TOWARD COOPERATIVE ANALYSIS

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One of the current unsolved problems in human factors is the difficulty in acquiring information from lessons learned and data collected among human performance analysts in different domains. There are several common concerns and generally accepted issues of importance for human factors, psychology and industry analysts of performance and safety. Among these are the need to incorporate lessons learned in design, to carefully consider implementation of new designs and automation, and the need to reduce human performance-based contributions to risk. In spite of shared concerns, there are several roadblocks to widespread sharing of data and lessons learned from operating experience and simulation, including the fact that very few publicly accessible data bases exist (Gertman & Blackman, 1994, and Kirwan, 1997). There is a need to draw together analysts and analytic methodologies to comprise a centralized source of data with sufficient detail to be meaningful while ensuring source anonymity. We propose that a generic source of performance data and a multi-domain data store may provide the first steps toward cooperative performance modeling and analysis across industries.

## STATEMENT OF THE PROBLEM

Historically, industries conducting performance analysis have kept their efforts to themselves. Human factors professionals and research psychologists studying performance issues and providing consultation in various applied settings have developed domain-specific methods and data stores, which have been in many cases proprietary. This amounts to some level of duplicated efforts across domains as analysts work without the knowledge of what others have done, analyzed, and concluded. Clearly, there is a lack of availability and sharing of reliability information and lessons learned among analysts working in different domains.

The existing performance databases provide limited coverage of reliability in different domains. Most are exist are industry-specific (predominantly nuclear) with little or no treatment of human factors. Potentially valuable sources of information are being neglected, including data generated from simulator training, maintenance records, and experimental literature. Existing databases have limited ability to extract lessons learned, information regarding factors that influence performance, or quantitative success/failure data. Many data bases are also not computerized; the ones that are have search schemes that are constrained by technology and codification. Implicit lessons that may be learned from the data, including interactions between mechanical components and human actions and general human performance issues, are not being generated.

Advanced digital control and display systems permeate new designs in multiple industries, as trends to increase automation and the use of computerized interfaces is evident in domains as diverse as transportation, energy, and manufacturing. These applications are creating new requirements for human operators as well as new modes of failure. Regardless of specific application, there is a need to examine the impact of new technologies on human performance and system safety.

Human performance in advanced, complex systems can be expected to differ from performance in traditional control environments. With an increase in computer-based control and the automation of functions, worker roles change. While human workload might be expected to decrease when more tasks are handled by computers, the opposite effect may occur in some circumstances (Byers, Reece & Hill, 1995).

Increased automation may also create conflicts in maintaining situation awareness when additional mental burden is placed on the workers to understand the functioning of automated systems (Billings, 1991). Operator performance has been shown to degrade in some highly-automated environments due to a diminished ability to detect system-level or automation errors and intervene to carry out the correct manual task. Several industries have experienced incidents in which worker misunderstanding of automated systems contributed directly to catastrophic outcomes (Carmody & Gluckman, 1993).

While increased operational reliance upon computerized instrumentation and controls may create new performance problems, it increases the feasibility and validity of applying computer-based interface simulation. Further, the pervasive use of computerized interfaces increases the usability of generic HCI lessons learned across domains.

Regardless of particular industry focus, human performance analysts agree:

- New technological systems include increased reliance upon computerized control.
- Human error accounts for about 70% of incidents and accidents.
- The impact of new technologies on performance and safety must be studied. (Woods et al, 1994)

Additionally, it seems the international reliability community recognizes need to share information as evidenced by the increasing number of international workshops and conferences on reliability research (Blackman, 1998, Harris, 1997, Reece, 1993). However, problems inhibiting the ability to successfully share results and conclusions may include:

- management and organizational culture,
- fear of regulatory reprisal,
- inability to finance efforts, or
- the need for an honest broker to facilitate sharing and provide analytic assistance.

While several roadblocks may be insurmountable in the near term, steps could be taken to address them, with the sole purpose of working toward more cooperative cross-industry reliability analyses.

## PROPOSED SOLUTION

The solution proposed here consists of three efforts: generation of sharable data, facilitation of sharing lessons learned, and provision of data and analysis support. The data store for this system needs to be structured such that it will facilitate the use by multiple users including systems analysts, system designers, facility operators, accident investigators, regulators, and researchers. It also must be available to all interested groups including government, industry , and the public. There also needs to be multiple usage modes to support parameter estimation, lesson extraction, free form learning, and monitoring of different industry groups. The database would include both qualitative and quantitative information as well as the smart tools necessary for analyzing and using the information.

As depicted in Figure 1, human performance information collected from simulation experiments, actual events or other databases could be assembled to feed a generic data store. In the approach proposed, an analytic software tool would process the data and generate qualitative insights and quantitative estimations of performance. The tool would need to be easily configurable to match domain-specific questions (e.g., performance on a tracking task versus a diagnosis task). The database would necessarily supply sufficient information to describe the contexts of situations under study.

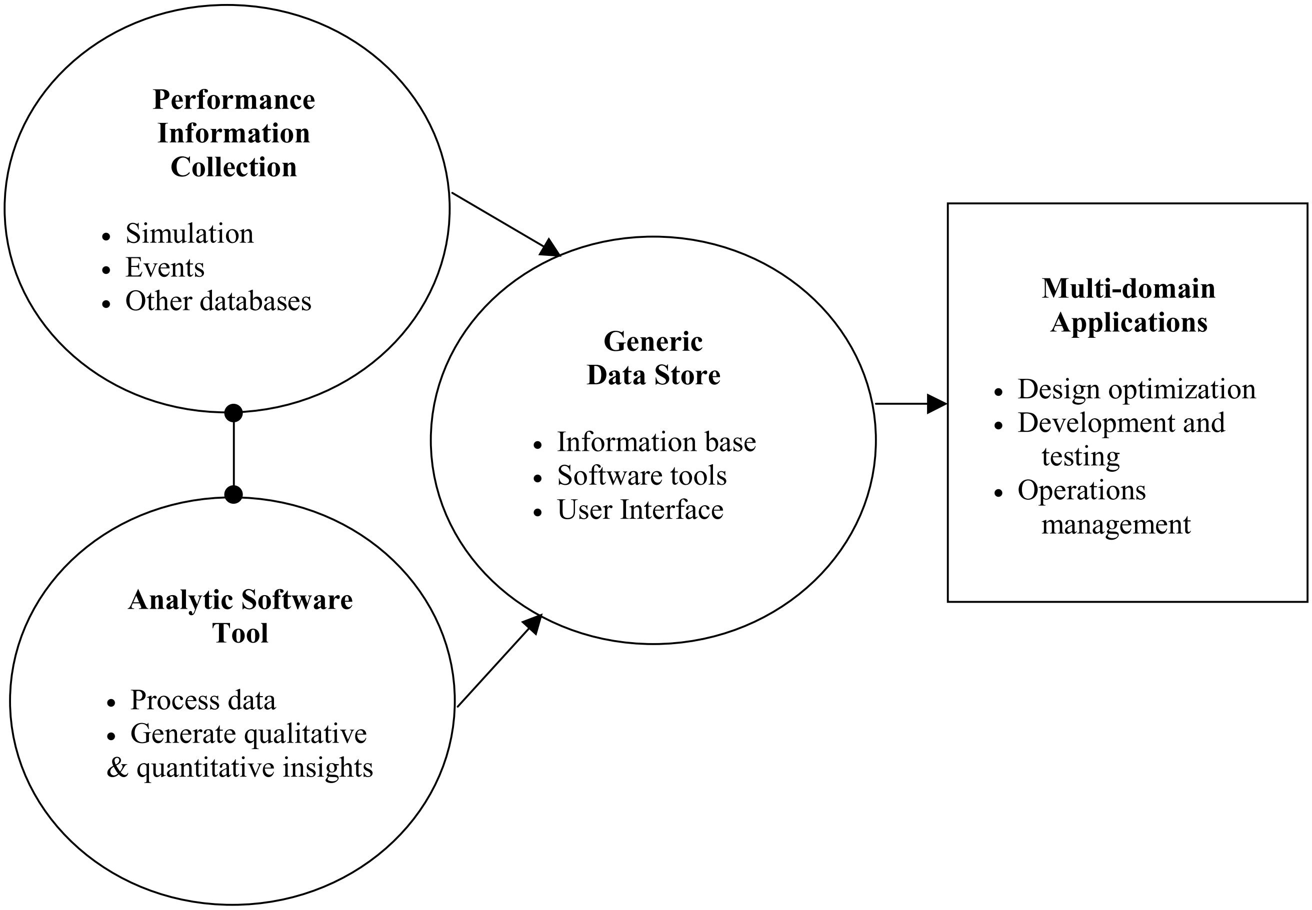


Figure 1. Processing generic performance information.

Using the analytic software tool in conjunction with organized information collection, the generic performance data store could support applications such as evaluations of designs, system prototype development and testing and operations management.

To support performance information collection, a generic simulator facility is proposed. The simulator would be used to test and evaluate human-computer interface design considerations, assess human performance, and model control processes. The simulator would have flexible computer-based displays and controls, readily reconfigurable to simulate human-computer interfaces and equipment responses for different environments. It would also be capable of simulating the human operator and running process modeling simulations. The flexible nature of the simulator would provide the capacity to develop generic lessons learned, and facilitate learning and data exchange between applications. Along with PC-based controls and displays, virtual reality technologies provide the capability to simulate additional contextual modes.

As depicted in Figure 2, the proposed operating protocol for the simulator includes a model for matching research needs with simulator capabilities and lessons learned from previous studies. By considering a set of rules to match research requirements and experience, the model would suggest a research plan tailored to the specific application. The rules the model would use to complete a match include consideration of tasks, budgets, and schedules, as well as theoretical and

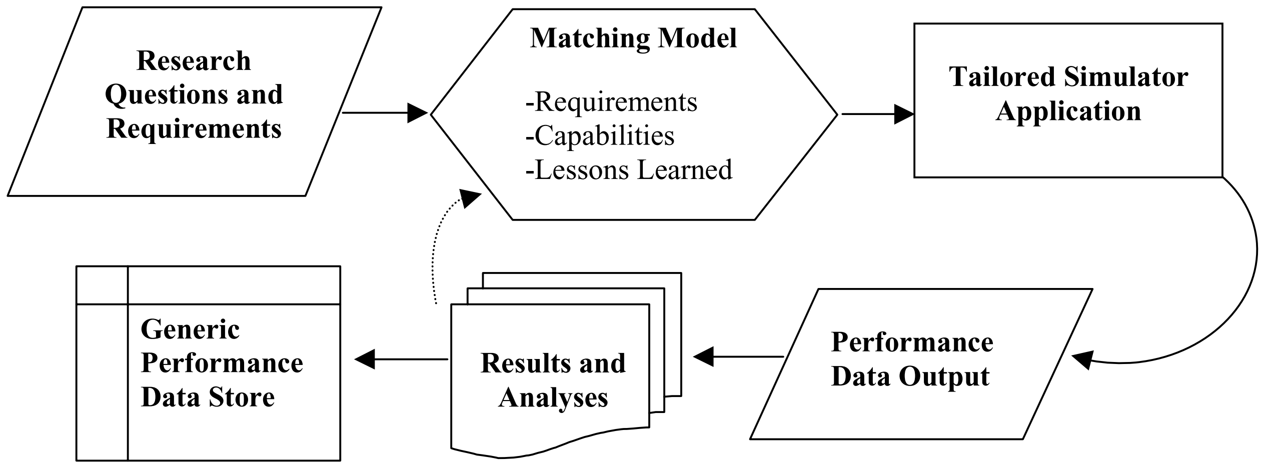


Figure 2. Generic simulator operating protocol.

applied research considerations. The matching model would allow full consideration of the simulator's capabilities with each application. Data output from simulator applications would be analyzed for specific conclusions and generic lessons learned. The results would be stored for retrieval by the matching model, and also output to the generic performance data store. Key to this is the development of a cross-industry protocol for extracting lessons learned from each study. Ideally, data resulting from multiple industry simulation research facilities would also be included in the generic data store.

The data store would be made publicly available and supported by a cadre of human reliability and performance analysts, serving as a centralized source of generic performance information. Drawing together analysts from a variety of industries, access to the generic simulator facility and data store would promote sharing of lessons learned. Reliability data from simulator studies of human performance in advanced computer-based systems could support various design, development and testing efforts across domains as, by definition, generic lessons learned should provide meaningful information for multiple applications.

The human factors group at the Idaho National Engineering & Environmental Laboratory is attempting to address the problem discussed here with the development of a simulator facility and a performance database. By using a generic simulator and storing multi-domain data for use across industries, we hope to provide a first step toward cooperative exchange of lessons learned and performance analysis results.

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