# Human Systems Integration Division Overview

The Human Systems Integration Division has been chartered to develop, validate, and implement a human-centered engineering process for designing complex information systems for aerospace applications.  The Division is composed of the following Technical Competencies:

### - Human-Machine Interaction
- Human-Computer Interaction for Planning and Mission Operations
- Cockpit/Flight Deck Design and Development

### - Human Performance
- Advanced Controls and Displays
- Perceptual and Cognitive Modeling, and Metrics
- Physiological Processes and Countermeasures

### - Integration and Training
- Distributed Supervisory Control Systems
- Safety Analysis, Monitoring, and Reporting Systems
- Training, Procedures, and Team Coordination

## Mission:

The Human Systems Integration Division advances human-centered design and operations of complex aerospace systems through analysis, experimentation, and modeling of human performance and human-automation interaction to make dramatic improvements in safety, efficiency, and mission success.

## Strategic Goals:

- To advance our fundamental understanding of how people process information, make decisions and collaborate with human and machine systems.
- To enhance aviation safety and performance by designing human-centered automation and interfaces, decision support tools, training, and team and organizational practices.
- To extend human capabilities in space by advancing our knowledge of human performance during space missions and developing tools, technologies and countermeasures for safe and effective space operations.

## Research Challenges

### Proactive Management of Risk

Monitoring and data analysis tools are being developed that predict problems in aviation safety before accidents or incidents occur, in contrast to existing methods that rely on retroactive analysis. Products for aviation professionals include tools to convert monitored aviation data into useful information and data mining methodologies to analyze textual as well as digital information. Integrated human performance models and operational simulations are being used to elevate system-wide overall changes in the national airspace through longitudinal survey techniques. Together these approaches will provide the understanding required for predicting and proactively managing aviation safety risk.

### Human Performance in Virtual Environments

Advances in human-centered computing require new approaches to human-computer interaction. Human performance in virtual environments is a key area of our human factors research and includes significant advances in visual, auditory, and haptic interfaces. To support a truly immersive experience, virtual environments are needed to provide users with rich multi-sensory inputs, including a sense of space (through three-dimensional auditory displays) and sense of touch (haptic interface). We have pioneered the use of algorithms to generate three-

## Research Challenges Cont'd:

### Human Performance in Virtual Environments (cont'd)

dimensional auditory displays and demonstrated their effectiveness in aviation systems. Also, we have patented a novel kinematic architecture for haptic interfaces to virtual environments (US Patent 5,816,105). Future research is expected to focus on the best ways to configure virtual environments to enhance human performance of complex tasks.

### Distributed Air Traffic Management

We are developing new concepts for air traffic management that involve an increased role for pilots compared to current operations in which controllers direct traffic flow and are solely responsible for aircraft separation. Evaluation of these concepts is accomplished in the Airspace Operations Laboratory which supports fast-time and human-in-the-loop simulations of pilots and controllers interacting to manage their aircraft's flight plan. Major enhancements to air traffic capacity and efficiency are expected from optimally allocating separation and flow management responsibility between controllers and pilots.

### Computational Model of Human-Automation Interaction

A general computational model of human-automation interaction is being developed to predict and correct usability problems in aerospace automation systems. The model incorporates the latest advances in research on human cognition and artificial intelligence. It systematically reviews automation designs for error-prone features, allowing redesign to eliminate these features and improve usability before expensive prototyping and testing is undertaken.

### Cognitive Models of Complex Performance

Flight crew and controller errors resulting in aviation incidents and accidents have often been associated with failures of executive control, which can in turn be attributed to the limited capacity of human cognition. New techniques for measuring complex performance are being investigated using a combination of empirical research, modeling, and direct measurement of brain activity. Research focuses on environmental factors that modulate executive control, including task practice, interruption, and diversion of attention. Improved understanding of cognitive resources is significantly increasing our understanding of how errors are generated in performing tasks. This in turn will facilitate the design of error tolerant and error resistant systems.

### Human Performance in Complex Operations

The aerospace domain, which includes both flight and ground support, presents a complex operational environment that demands highly proficient human performance. The challenge to humans includes, but goes well beyond, the reduction of human error. Humans bring to missions unique capabilities that make exceptional performance possible and also correct for unanticipated system failures. To improve Human Performance in Complex Operations, research in operational settings addresses issues such as attention, memory, communication, crew coordination, fatigue countermeasures, documentation of procedures, decision making, and perception of risk. The emphasis is on the performance of teams, rather than individuals, with special attention given to how team members, who are physically separated from one another, attain and maintain proficient performance.

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