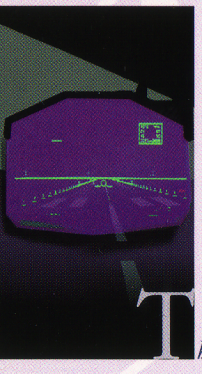
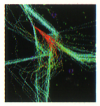


The Human Factors Research and Technology Division advances human-centered design and operations of complex aerospace systems through analysis, experimentation and modeling of human performance and human-automation interaction to make dramatic improvements in safety, efficiency and mission success.

HUMAN FACTORS RESEARCH & TECHNOLOGY

http://human-factors.arc.nasa.gov

RESEARCH CHALLENGES IN HUMAN FACTORS RESEARCH & TECHNOLOGY



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 evaluate 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-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

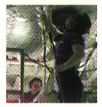
We are developing new concepts for air traffic management that involve an increased role for pilots compared to current operations in which controllers direct traffic flow and are solely responsible for aircraft separation. Evaluation of these concepts is accomplished in the Airspace Operations Laboratory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

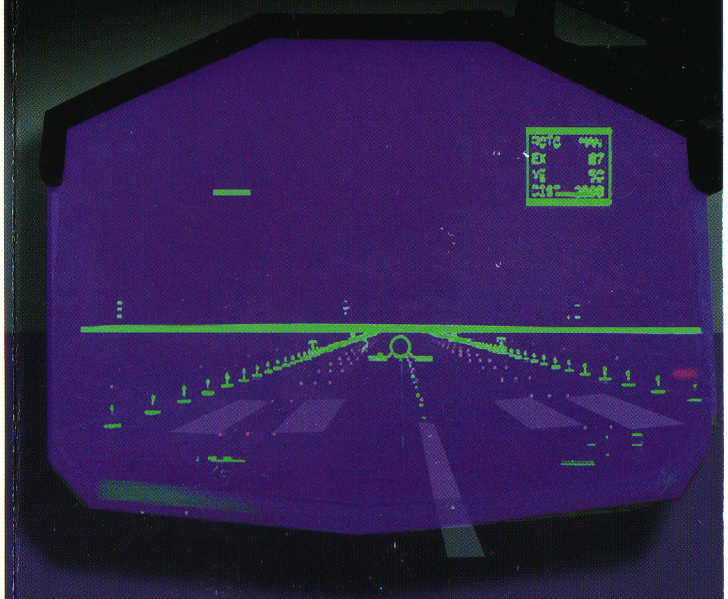


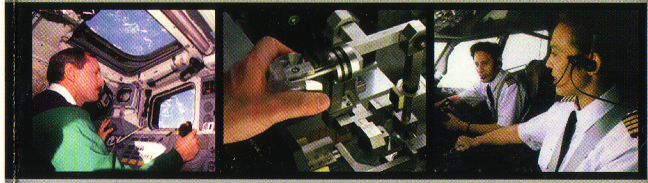
Human Performance in Complex Operations

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.

HUMAN FACTORS RESEARCH & TECHNOLOGY DIVISION

A Research Cornerstone of Information Technology





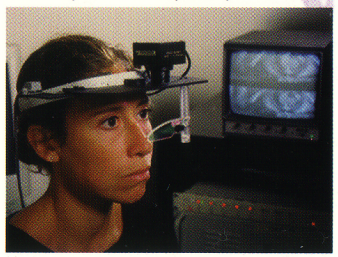
NASA Ames Research Center • Moffett Field, CA

OF THE HUMAN FACTORS RESEARCH & TECHNOLOGY DIVISION

People are the most critical element in system safety, reliability and performance. Their creativity, adaptability and problem-solving capabilities are key to resilient operations across the gamut of aerospace applications. Advances in computing power and communications, increased automation and access to distributed information resources for collaboration, monitoring and control, all contribute to new challenges for humans as critical decision-makers in complex systems. In aviation, people are the backbone of a national aviation system that is straining to meet growing consumer demands. In space, long-duration missions and reusable launch vehicles will increase the requirement for safe and effective human performance in the harsh environments surrounding our planet. Human-centered design must address the need for safe, efficient and cost-effective operations, maintenance and training, both in flight and on the ground. The Human Factors Research and Technology Division is creating and applying a new understanding of how individuals and teams assimilate and act on information in pursuit of goals critical to the success of NASA missions. Our core competency in visionary human factors research and technology pays immediate and long-term dividends for NASA and the aerospace community as we move forward to meet the emerging challenges of the 21st century.

To advance our fundamental understanding of how people process information, make decisions and collaborate with human and machine systems.

Human Factors researchers are advancing psychological theory and computational capability to advance our understanding of



the principles of human information processing and human-machine interaction at multiple levels of analysis. At a fundamental level, people are complex biological devices with remarkable capacities for sensory, motor and cognitive processing. Our sophisticated information processing mechanisms can be reverse-engineered to provide new approaches to intelligent systems and human performance across a wide variety of conditions, including sensorimotor adaptation in long-duration space missions. At the individual level, integrated models of human information processing provide a basis for measuring and predicting human workload, situation awareness, decision-making capabilities and the potential for errors. At the collaborative level, assessment and design of team and organizational behavior can be used to increase productivity and enhance safety of aerospace systems.

To enhance aviation safety and performance by designing human-centered automation and interfaces, decision support tools, training, and team and organizational practices.

Aviation in the 21st century is poised for revolutionary change. Human factors research and technology are critical elements in successfully navigating that change, enabling aviation professionals including pilots, controllers, dispatchers and maintenance crews to satisfy new requirements for flexibility, collaboration and strategic thinking. These needs are prompted primarily by rapidly escalating demands for increased capacity and more efficient use of the national air space while maintaining or improving safety.

The Human Factors Division at Ames Research Center has a 25-year history of successful collaboration with the airline industry and other government agencies. The Division produces both scientifically sound and operationally relevant results by integrating knowledge of aviation operations with deep research expertise in psychology, computer science and engineering. The Division uses a wide variety of methods. Field observations, laboratory experiments, task analyses, human-in-the-loop simulations, and field and flight research all contribute to the solution of operational concerns through improved designs, training, procedures, and standards. Computational models of human performance and prototypes of human-centered automation and interfaces bring human factors knowledge to the design of advanced cockpits and air traffic management systems. Monitoring, analysis, interpretation, and visualization tools, combined with system-wide models and simulations, provide a basis for proactive management of aviation risk and will enable simulation-based evaluation of system changes.

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.

People play necessary and critical roles in space missions. On the ground, humans play key roles in mission preparation, launch, mission control, and science teams. Improved procedures, training and design tools are needed to understand these ground-based operations. In space, missions are increasing in duration and frequency. In order to design missions that accomplish scientific goals, while keeping humans safe, human factors researchers are needed to increase our understanding of humans in isolation, individual and team performance, humans coordinating decisions at great distances, and humans interacting with complex space systems. New concepts for the organization and conduct of missions are needed especially for those missions servicing multiple coordinated spacecraft.

The challenges of future space exploration will require high levels of performance from combined human and machine systems. New technologies are being developed using human factors research to make work more efficient, reduce workload and

enable humans to respond more quickly and effectively to the unexpected. Integrated human performance models of individuals and teams will allow prediction of workload levels and operator states that could disrupt psychosocial adaptation in long-duration missions. Fatigue countermeasures will increase astronaut ability to overcome the tiring effects of extended work schedules, loss of sleep, microgravity, and other stressors. By aiding the development of usable intelligent automation for the International Space Station, the next generation of reusable launch vehicles, and unmanned robotic missions, human factors expertise will streamline work processes and increase mission science return. Mission success will depend on our skill in taking advantage of the complementary capabilities of humans and their information technology partners.