Risk of Error Due to Inadequate Information

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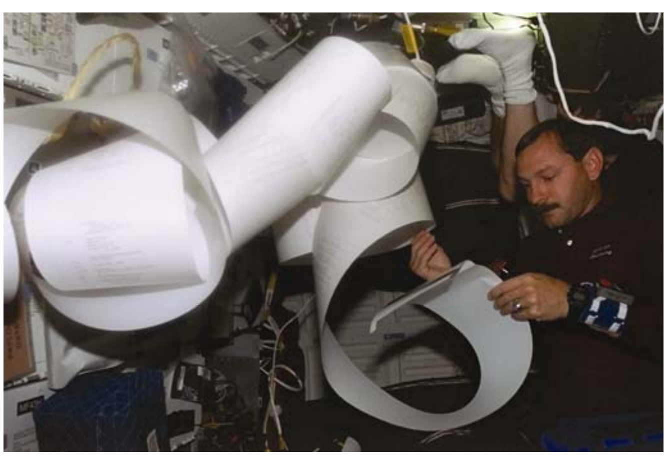
Information presentation, acquisition and processing significantly affect human task performance. Effective information availability directly impacts all aspects of communication, which is a vital element to all space missions. Task errors during human spaceflight missions could have significant consequences to performance of mission objectives as well as human safety. Therefore further research regarding proper information presentation will allow for opportunities to optimize presentation of information, its timeliness, the user's level of awareness of the information, modes of information presentation, proper information comprehension, training methods, and development of procedures. – *Human Research Program Requirements Document*, HRP-47052, Rev. C, dated Jan 2009.



Astronauts must monitor systems and perform critical operations daily while in space. Data monitoring in the past has required the review of numerous pages of paper data, as pictured here. Extensive ongoing NASA activity mitigates the risk of operator error by improving the display of information, the types of controls that interface between the human and the displays, and the procedures necessary to accomplish tasks.

Executive Summary

Human-centered design is essential to implement effective information management. The inadequate provision of information can increase the probability of operator error, thus impacting the safety and productivity of space flight missions. Evidence that is relevant to the risk of error due to inadequate information illustrates that effective information management and communications are critical to mission success.

Although operator errors are common in all work environments, task errors that occur during human space flight missions could have drastic consequences. Errors can be due to inadequate information, which, in turn, may be caused by (a) a lack of situational awareness, (b) forgetting, (c) an inability to access appropriate data and procedures, or (d) a failure of judgment. The causation trail that is engendered by errors leads to (a) a lack of situational awareness that can result from poorly designed interfaces, poorly designed tasks, or cognitive decrements that are caused by, for example, fatigue or exposure to toxic environments; (b) forgetting, which can result from inadequate training, poorly designed procedures, or cognitive decrements; (c) an inability to access appropriate data and procedures, which can be a result of poorly designed interfaces, poorly designed tasks, or cognitive decrements; and (d) a failure of judgment that can be the product of incorrectly perceived or interpreted cues, inappropriately estimated results of decisions, or inadequate data.

This chapter focuses on identifying the causes of risk that are associated with error due to inadequate information, and on developing information presentation standards for reducing operator errors in space flight through adequate understanding of the causes. Mitigating this risk involves addressing the display of information, the types of controls that provide an interface between the human and the displays, and the procedures that are necessary to accomplish tasks.

Introduction

Human factors and human-centered design

The study of human factors engineering embraces the design of tools, machines, systems, tasks and environments to ensure safety, efficiency, habitability, and optimized human performance (Chapanis, 1996). The study of space human factors focuses on the need for safe, efficient, and cost-effective operations, maintenance, and training in flight, on orbit, and on the ground. The purpose of space human factors is to create and maintain a safe and productive environment for humans in space. The domain of space human factors engineering consists of three sub-domains of knowledge: task design; the design of the vehicle, the environment, the tools, and the equipment; and information.

The SHFH Element contains five risks, three of which are associated with space human factors engineering. These are: (a) the risk of error due to inadequate information, (b) the risk that is associated with poor task design, and (c) the risk of reduced safety and efficiency due to an inadequately designed vehicle, environment, tools, or equipment. All of these risks have the same underlying root cause: the lack of human-centered design (figure 9-1).

Human-centered, or user-centered, design is a design approach that focuses on humans and their interaction with procedures, products, equipment, facilities, and environments. It seeks to use known information concerning human capabilities and develop designs that better match systems with human capabilities. To do this, practitioners of human-centered design capitalize on the strengths of the human in the system design while limiting the potential impacts resulting from human limitations. Human-centered design focuses on the users throughout the planning, concept development, design, and final implementation phases of a product or a system. Good human-centered design practices reduce the elements of risk that can lead to human error in the human-machine system and improve the efficiency of operation and safety of all system components, including the human.

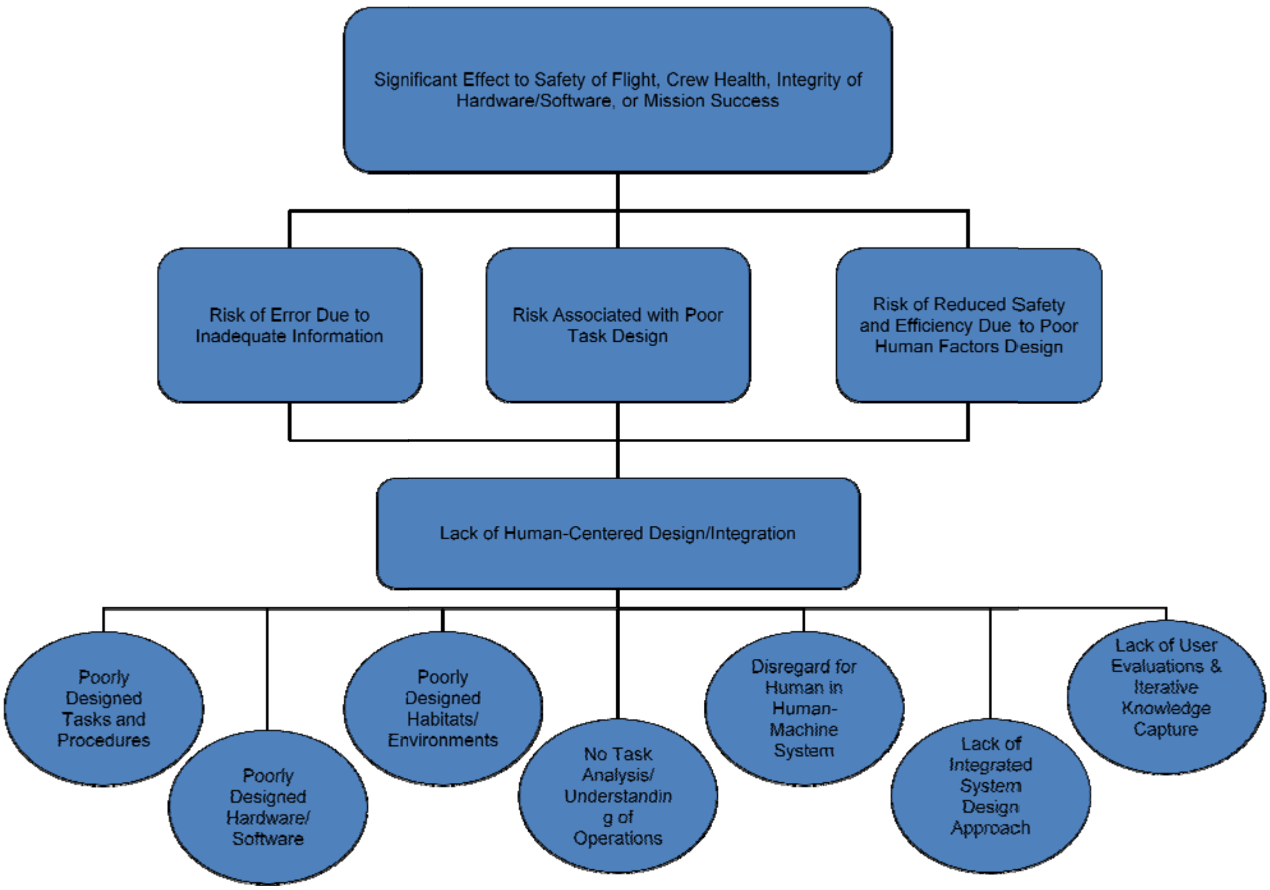


Figure 9-1. ***Fault tree for lack of human-centered design*.**

Multiple contributing components can cause a lack of human-centered design. These include poorly designed tasks and procedures, poorly designed hardware and software, poorly designed habitats and environments, a lack of task analysis and understanding of operations, disregard for the human in the human-machine system, the lack of an integrated system design approach, and a lack of user evaluations and iterative knowledge capture. Without proper integration between the human and the system, the risk of reduced safety and efficiency due to poor human factors design may arise. If risks are not mitigated, the safety of the flight, the health of the crew, hardware and software integrity, and mission success may be significantly affected.

Evidence that will be presented in this and the next two SHFH chapters effectively illustrates the breadth and depth of the risks that are associated with a lack of human-centered design. These are: the risk of error due to inadequate information, the risk that is associated with poor task design, and the risk of reduced safety and efficiency due to an inadequately designed vehicle, environment, tools, or equipment. The intention of the SHFH chapters is to provide a narrative discussion of the risk, together with the evidence that supports its existence or the potential for risk. This evidence provides the basis for analysis of the risk likelihood and consequence, and may provide the information that is needed to eventually develop standards for reducing operator errors in space flight through adequate understanding of the causes and mitigations of operator errors.

The review of these risks is important, as space flight crew performance is heavily influenced by the way in which the crews are able to obtain situational awareness and safely and effectively perform tasks. Current and future missions will require that the crews perform a wide variety of tasks under dramatically different conditions: i.e., 1g, hypergravity, microgravity, unsuited, suited, and pressurized. Mission success will require a more complete understanding of information and how it is best presented, acquired, and processed.

Evidence

The evidence that is presented in this chapter encompasses the lessons learned from 50 years of space flight experience related to the risk of error due to inadequate information. It is classified in this chapter, as it is in the other chapters, by categories and topic areas. Category I and II[16] evidence consists of quantitative and qualitative findings from research and development. Data are classified as Category I or II, depending on the specific testing protocol that is used and the data that are sought. Category III evidence consists of summaries of subjective experience data, as well as nonexperimental observations and comparative, correlation, and case or case-series studies. It should be noted that evidence that is derived from the ISS Life Sciences Crew Comments Database is essentially Category III evidence. Although summaries of ISS crew comments are presented as evidence, the Life Sciences Crew Comments Database, due to the sensitive nature of the raw crew data that it contains, is protected and not publicly available. Category IV evidence consists of expert committee reports and respected authority opinion based on clinical experiences, bench research, or "first principles."

The evidence that is presented here details human space flight issues that are related to inadequate information, specifically those that address presentation, acquisition, and processing. Inefficiencies and impacts that are related to information can restrict human performance in space flight conditions and affect safety and habitability. Therefore, these issues must be assessed and properly addressed to ensure that all potential hazards are mitigated or monitored. If the information that is necessary to complete the tasks is not presented, acquired, or processed appropriately, the likelihood of errors or the inability to successfully complete a task increases.

Information acquisition

Information acquisition is defined as the way in which a user or a system obtains information. This acquisition can occur through various means. Most of the information that is needed for space flight missions is obtained through training, both on the ground and on orbit. Information is also obtained on orbit via crew-to-crew and

[16]To help characterize the kind of evidence that is provided in each of the risk reports in this book, the authors were encouraged to label the evidence that they provided according to the "NASA Categories of Evidence."

- Category I data are based on at least one randomized controlled trial.
- Category II data are based on at least one controlled study without randomization, including cohort, case-controlled or subject operating as own control.
- Category III data are non-experimental observations or comparative, correlation and case, or case-series studies.
- Category IV data are expert committee reports or opinions of respected authorities that are based on clinical experiences, bench research, or "first principles."

crew-to-ground communication, as well as through robotics and automation. Regardless of the mode that is used to acquire information, it is important that the process be refined to ensure that the right methods are being used, the method duration is appropriate for the type of information that is being transferred, and the amount of time between receiving and processing the information is adequate. Proper definition and execution of these elements will ensure the successful acquisition of information in the space environment, thus leading to mission success. The paragraphs below describe cases in which the acquisition of information was unsuccessful or improvements should have been made.

Improved information acquisition is needed with ISS task procedures. As documented in the ISS Life Sciences Crew Comments Database, ISS crew members have consistently commented that the procedures are too complex, lengthy, and difficult to follow. Procedures can often complicate or impede the performance of daily tasks because they may call for an inadequate number of crew members to perform a task, or the specified duration for a task may be inappropriate. Progress is being made in improving procedures and in enhancing the crew members' abilities to acquire information by including more graphic content (diagrams and images). The goal is to improve the procedures so that they can better reflect how operations are actually conducted. Other types of improvements will also be needed to adequately inform the crew.

Paper checklists are an example of inadequate information acquisition. They have been used by on-orbit crews for many years, but navigating through paper checklists has been difficult. Procedures are coded with specialized symbols, abbreviations, boundary delimiters, and spatial configurations that collectively require extensive training to decipher and understand. Individual instructions in these cue cards and checklists frequently take the form of conditional expressions (i.e., IF-THEN-ELSE statements), which crew members must evaluate by manually cross-checking systems or flight status information on cockpit instruments and displays. The outcome of this evaluation of the logical expression determines which path should be taken through the remainder of the checklist; and that path, in turn, determines which subsequent instructions must be carried out, and in what order. Wrong choices that are based on an inappropriate assessment of the state of information that was presented can endanger the crew (Hudy and Woolford, 2007) (Category III).

Data that are contained in the (ISS) Life Sciences Crew Comments Database indicate that the ISS crews rely heavily on auditory information and warnings on orbit. Auditory information has as its main advantage that the crew does not need to be looking at a display to be aware of an alarm. The acoustic levels on board the ISS have been historically high and have impacted communication and the receipt of some information. These high levels of continuous and intermittent noise require the use of earplugs or noise-canceling headsets to mitigate noise exposure. Although this protection assists with decreasing detrimental noise exposure, communications among crew members and between the crew and the ground may be degraded. On a few occasions, the elevated noise levels have prevented the crew from hearing caution-and-warning alarms and other monitoring signals. In addition, crew members may also become uncomfortable while wearing this protection (Rando et al., 2005) (Category III).

Effective information acquisition has also been decreased by other communication issues that have been encountered on the ISS, such as miscommunications, unrealistic demands, ineffective interpersonal communication techniques, and a lack of understanding of on-orbit life. Inadequate communication between the ground and the crew can cause frustration that can, in turn, negatively affect performance. Ground operators have, in the past, had difficulty understanding how much time it actually takes to complete tasks on orbit, which frustrates both the crew and the ground personnel. Many times crew members have been unaware of what the ground personnel could assist with and what tasks could be automated to facilitate crew productivity. There have also been cases in which ground personnel should have relied on the crew to do many things and should not have overridden crew member suggestions (Rando et al., 2005) (Category III).

Information presentation and processing

Information is presented most effectively when the users' interests, needs, and knowledge are considered. Effective presentation of information can be accomplished by ensuring that (a) operations concepts are fully developed, (b) task analysis is conducted at a low enough level of detail, and (c) task analysis is accurate and its completeness is verified. The designer must also ensure that the user has complete awareness by considering both perceptual thresholds and good information display design. Lastly, information must be presented using the correct mode. If information is not presented clearly, the user may process the message incorrectly, and may misinterpret, overlook, or ignore the original intent of the information.

Information processing can be accomplished either through individual or multi-agent distribution. In designing for individual information processing, the thought process of the receiver should be considered, as well as how the individual may execute the information. This consideration is critical for successful task execution. Although for multi-agent or distributed processing the elements for individual processing also apply, the processing is more complex because additional users and/or automation are involved. When information is not processed as intended, the outcome of a task can be jeopardized and mission success can be put at risk. The following examples are cases in which the presentation or processing of information was degraded or unsuccessful, or could have been improved to be more effective.

As simulated environments and ground-based full-scale models or mockups cannot be completely representative of flight conditions, representing a true zero-g environment on the ground has presented many challenges for training and information presentation. Thus, simulations may not provide adequate information during preflight training. As documented in the ISS Lessons Learned Database, a true representation of the stowage of equipment and materials aboard the ISS is very difficult to achieve on the ground and can create issues for the crew. Stowage mockups in 1g are limited because gravity restricts operations and translation in the training facilities. Given the constraints of a 1g-based translation path, it is neither possible nor safe to place things where they would potentially be stowed on board the ISS. The weightless environment on orbit benefits the crew in that it allows items to be stowed on any axis with proper restraint. In addition, the crew members can translate through the available volume and position their bodies to move around obstructions or protrusions in the translation paths.

In summary, given the gravitational differences between Earth and orbit and the disconnect between ground training and actual life on orbit, crew members often experience steep learning curves once they are on board the ISS because the simulators and mockups, which are not completely representative of zero-g conditions, do not provide adequate information. The result is that on arrival on board the ISS, crew members often experience difficulty managing stowage and operating nominally, and errors result (see figures 9-2 and 9-3) (Category III).

Figure 9-2. ***JSC2007-E-46438 (September 2007) — Astronaut Peggy A. Whitson, Expedition 16 commander, and cosmonaut Yuri I. Malenchenko, flight engineer representing the Russian Federal Space Agency, participate in a training session at the Gagarin Cosmonaut Training Center, Star City, Russia (NASA Human Spaceflight Gallery, 2008).***

Figure 9-3. ***ISS016-E-022130 — Cosmonaut Yuri I. Malenchenko, Expedition 16 flight engineer representing the Russian Federal Space Agency, uses a communication system while working in the Zvezda service module of the ISS (NASA Human Spaceflight Gallery, 2008).***

Computer displays and software technology that are on the ground are constantly changing and improving. Computer and software technologies on board the ISS have historically lagged behind these available ground-based technologies. Displays and software platforms often differ from application to application, depending on the task that is being supported. Many interfaces on the ISS are not the same as those that are commonly used on Earth. This inconsistency between ground and space has been a source of operational frustration for crewmembers. Therefore, it is important to provide crews with systems that are similar to those used on the ground to improve in-flight information presentation and avoid impacts on human and system efficiency and performance in space.

As documented in the ISS Life Sciences Crew Comments Database, usability issues have occurred that are associated with the use of displays that lack a common overall infrastructure and layout that would promote ease of use and understanding of intended operations. Valuable ISS crew time has been lost in trying to understand the use of disparate displays, which has led to incorrect data entry, navigational errors, or inaccurate interpretation of data in the displays. When display interfaces are dissimilar and the information is not presented consistently, crew members may require additional training and time to master the use of the displays. Crew members may also revert to an uncomplimentary skill base from another display design. This natural human tendency may override training and lead to errors that can compromise crew safety, especially in the event of an emergency (Category III).

ISS crews are inundated daily with information concerning procedures. Some ISS electronic procedures and formats have been especially difficult to use. Frequently, crew members have spent excessive amounts of time navigating among various menus because the procedures were difficult and lengthy or contained unnecessary information. In many cases, the content of a procedure contributed to inadvertent skipping of steps in the procedure and poor task execution.

A number of complaints have been received from ISS crew members concerning the implementation and overabundance of cautions and warnings (C&Ws) in procedures. The primary reason for using C&W advisory blocks in procedures is to protect the crew members and the hardware from potentially unsafe conditions or incidents. The overuse of C&Ws in procedures has contributed to the desensitization of the crew to C&W (as shown by accidental procedure step-skipping and inattention to important C&Ws because they are embedded in trivial warnings).

Issues that are associated with procedures have occurred during ISS missions and are directly related to the provision of too much information, lack of diagrams and schematics to illustrate necessary information, and confusion and missed steps caused by multiple links in procedures. These issues have frustrated crew members and directly affected the efficient performance of tasks because the information that was needed for a given task was not presented in a usable format (Rando et al., 2005) (Category III).

As documented in the ISS Life Sciences Crew Comments Database, other issues occurred because electronic updates to procedures often have to be printed out to update procedure books with new information, costing the crew time to print and change out the affected pages. Moreover, printing compounds the issues with information processing as issues often arise with printers on orbit, leading to frustration among crew members. These crew members have commented that although the ISS printing procedure worked during ground training in the simulator, it did not work on orbit because the on-orbit printer was not the same printer as the one that was used during training. Clearly, therefore, the information and hardware that are provided for training must be as similar as possible to what will be provided on orbit to avoid learning curves once crew members arrive at the ISS (see figure 9-4).

Figure 9-4. ISS015-E-17702 — ***Cosmonaut Fyodor N. Yurchikhin, Expedition 15 commander representing the Russian Federal Space Agency, holds a camera while looking over procedures checklists in the Zvezda service module of the ISS (NASA Human Spaceflight Gallery, 2008).***

On Apollo 10, at the end of the second pass over lunar landing site 2, the two crew members were preparing to separate the two stages of the lunar lander and return to the command module in orbit around the moon when the mode of the guidance and navigation system was inadvertently changed by one of the crew members. A couple of seconds later, the other crew member reached up, without looking, and changed the mode of the guidance system, which canceled the change that had been made by the first crew member. As a result, the lunar module, *Snoopy*, began firing thrusters in all axes, pushing the gyroscopes into gimbal lock and making the navigation system useless until it was reset. The crew member then toggled the navigation system switch again and, although he now put it into the mode it should have been in to start with, it made things worse. At this point the crew overrode the computer and took manual control.

The incident lasted about 15 seconds, during which *Snoopy* made eight complete rolls. It was estimated that if the crew members had not regained control within another 2 seconds, it would have been too late to avoid impact with the moon. Without clear information processing and communication between crew members concerning their dedicated duties, there is real risk to safety from accidental operations (Shayler, 2000) (Category III).

Computer-based Simulation Information

Understanding human integration with systems and identifying the risks that may be inherent in a concept or a design is often achieved via computer-based simulation. Computer-based simulation tools have multiple uses including detection of potential risks to the human. Computer-based simulation and virtual environments create a metaphor for the real world with which the user interacts. With the aid of equipment such as head-mounted displays, data gloves, three-dimensional audio, and haptic or tactile feedback, the individual can interact with a virtual world as that world simulates reality. These virtual environments can be used to create simulations for training or, perhaps, interacting with prototypes that do not yet exist in the real world.

Inefficient or inadequate presentation of information presents a risk to crew effectiveness and safety, especially during off-nominal operations. In 1999, NASA JSC initiated the process of upgrading the cockpits of the space shuttle orbiters. The primary impetus for this upgrade was the perceived risk of reduced safety and efficiency of shuttle operations due to the lack of a human-centered design approach to information conveyance by the 1970s-era display formats.

The product of the cockpit avionics upgrade (CAU) effort was a new suite of explicitly task-oriented display formats that (a) consolidated and integrated task-related information; (b) more clearly supported fault detection, isolation, and recovery operations; (c) used color-coding to guide and manage the attention of operators; and (d) streamlined display navigation with new display control devices.

As part of the CAU project, engineers conducted a thorough human-in-the-loop evaluation of the CAU display formats in the Shuttle Mission Simulator that directly measured operational efficiency and error rate in a series of full-mission simulations of off-nominal ascent and entry scenarios. The scenarios were completed with both the existing (i.e., 1970s-era format) display suite and cockpit interface devices and the upgraded displays and interfaces. The results provided an empirical database quantifying the performance benefits and enhanced operational efficiency that accompanied the human-centered redesigns. When questioned concerning conditions during their just-completed scenarios, crew members who had trained in the CAU cockpit answered almost 75% of the questions correctly as compared to the typically less than 40% who had trained in the existing cockpit. The workload was rated 38% lower with the CAU cockpit. The incidence of a particularly safety-critical form of operator error (the percentage of system malfunctions and flight anomalies that went unrecognized) stood at 30% in the existing cockpit; however, in the CAU cockpit, the rate of error was only 10%, which is a 67% reduction.

Finally, while little difference was apparent between the existing and CAU cockpits when crew members diagnosed the easiest malfunctions, there was a distinct latency advance for the CAU cockpit for the more difficult malfunctions. In the very slowest (most difficult) cases, the average CAU advantage was 40 seconds. This demonstrates how improved display formats can reduce the risk of operation error due to inadequate information (McCandless et al., 2005; Hayashi et al., 2005) (Category II). Figure 9-5 demonstrates how Man-machine Integration Design and Analysis System (MIDAS) simulations reproduced the findings of the CAU display suite evaluation.

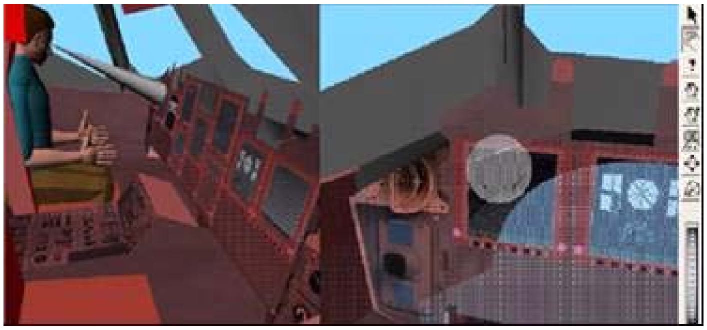


Figure 9-5. ***MIDAS simulations were conducted to reproduce the findings of the CAU display suite evaluation. Task timelines and workload outputs were examined as part of these simulations (NASA Human Spaceflight Gallery, 2008).***

Risk in Context of Exploration Mission Operations Scenarios

Future Exploration missions will increase in length. Lunar missions will provide a substantial set of independent lessons learned, experiences, and more definitive knowledge gaps that will apply to Mars exploration. Crews will face the challenges of physical deconditioning, prolonged isolation and confinement, significant communication latencies, environmental stressors, and increased responsibility and autonomy. Effective design solutions for vehicles, habitats, and missions need to allow the management and control of all aspects of Exploration mission operational scenarios.

Human-centered design must be implemented in all aspects of the design process to mitigate or prevent space human factors engineering risks from occurring. Designing for reduced gravity will be critical. Lunar and martian environmental conditions – air quality, lunar or martian dust, radiation exposure, and lighting – must be addressed. Stowage provisions need to ensure that appropriate spares and stowage volumes are available and accessible in a timely manner. Intuitive human-computer interaction will be necessary owing to increasingly complex task demands and the need for autonomy. A reduction in required maintenance and interface with complex systems should be implemented. Commonality in design and implementation should cross all hardware and tool designs. Procedures and training should accommodate the increased autonomy to provide appropriate information and avoid excessive workload.

Conclusion

The risk of error due to inadequate information stems from a broader cause of human error: the lack of human-centered design. To reduce or eliminate this risk requires that designers focus on the user throughout the design process. Good human-centered design practices strive to improve the efficiency of operation and safety of all system components, including the human, and should reduce the life cycle cost of the project. The risk that is associated with error due to inadequate information focuses on identifying the causes of that risk – e.g., the lack of situational awareness that might be due to poorly designed interfaces or tasks – and the subsequent development of information presentation standards for reducing operator errors in space flight through the development of an adequate understanding of the causes and mitigations of the errors.

The human-machine system emphasizes the importance of the human element as the central focus of the human-centered design process. This includes consideration for human capabilities, limitations, and interaction with automation and hardware. Knowledge gaps or holes that are related to the lack of an integrated system design approach for information acquisition, presentation, and processing must be addressed to ensure quality standards, requirements, tools, and techniques are developed that will allow positive crew-system integration and interaction, and, ultimately, mission success.

The evidence that is discussed in the SHFH chapters identifies risks. To alleviate these risks, "knowledge gaps" or "holes" and future research directions have been identified. Some of these knowledge gap considerations are related to the constant need for efficient information acquisition, presentation, and processing, and an improved understanding of the crew and mission requirements and constraints for task design and training.

References

Chapanis A. (1996.) *Human factors in systems engineering. Wiley series in systems engineering*. John Wiley and Sons, Inc., N.Y.

Hayashi M, Huemer V, Renema F, Elkins S, McCandless JW, McCann RS. (2005) Effects of the space shuttle cockpit avionics upgrade on crewmember performance and situation awareness. In: Proceedings of the Human Factors and Ergonomics Society 49th Annual Meeting. Human Factors and Ergonomics Society, Orlando, Fla., Sep 26–30, 2005, pp. 54–58.

Hudy C, Woolford B. (2007) *Space Human Factors Engineering Gap Analysis Project final report*. Retrieved Feb 12, 2008 from the following Website: http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20070020456_2007018857.pdf.

McCandless JW, McCann RS, Berumen KW, Gauvain SS, Palmer VJ, Stahl WD, Hamilton AS. (2005) Evaluation of the space shuttle cockpit avionics upgrade (CAU) displays. In: Proceedings of the Human Factors and Ergonomics Society 49th Annual Meeting. Human Factors and Ergonomics Society, Orlando, Fla., Sep 26–30, 2005, pp. 10–14.

NASA. Human Spaceflight Gallery [photographs on the Internet]. Retrieved Jan 26, 2008 from the following Website: http://spaceflight.nasa.gov/gallery/index.html.

Rando C, Baggerman SD, Duvall LE. (2005) Habitability in space. In: Proceedings of the Human Factors and Ergonomics Society 49th Annual Meeting, Aerospace Systems. Human Factors and Ergonomics Society; Orlando, Fla., Sep 26–30, 2005, p. 59.

Shayler DJ. (2000) Lunar module checkout-mode error. In: Mason J (Ed.), *Disasters and accidents in manned spaceflight*. Springer-Praxis, Chichester, U.K., pp. 216–220.

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