

Space Mission Human Reliability Analysis (HRA) Project

Center Innovation Fund: JSC CIF (Also Includes JSC IRAD) Program

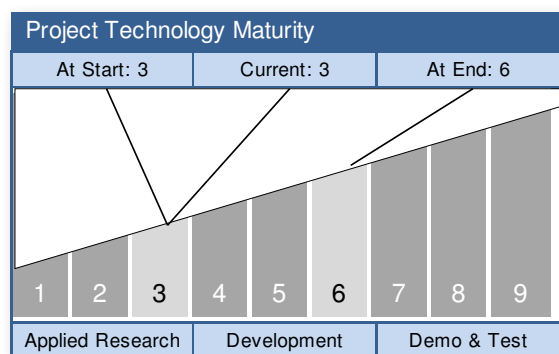
Office Of Safety And Mission Assurance (OSMA)

National Aeronautics and
Space Administration

ABSTRACT

The purpose of the Space Mission Human Reliability Analysis (HRA) Project is to extend current ground-based HRA risk prediction techniques to a long-duration, space-based tool. Ground-based HRA methodology has been shown to be a reasonable tool for short-duration space missions, such as Space Shuttle and lunar fly-bys. However, longer-duration deep-space missions, such as asteroid and Mars missions, will require the crew to be in space for as long as 400 to 900 day missions with periods of extended autonomy and self-sufficiency.

Current indications show higher risk due to fatigue, physiological effects due to...***Read more on the last page.***



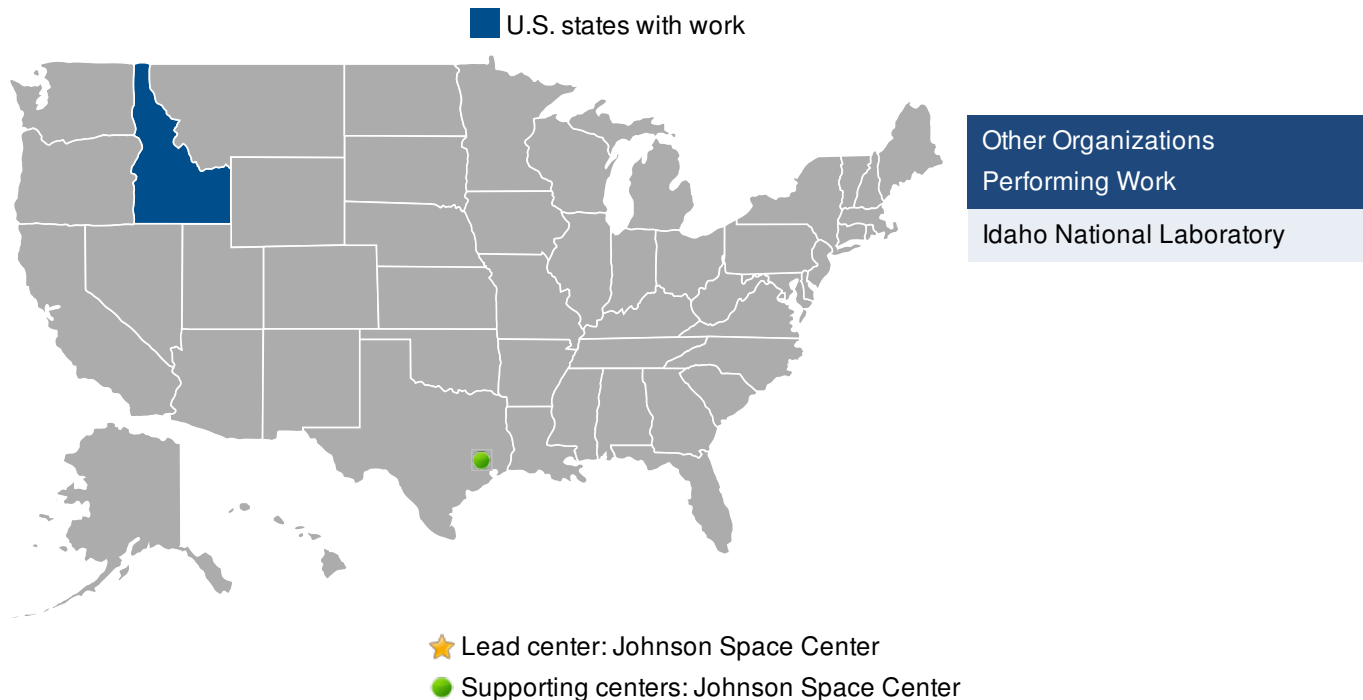
Technology Area: Human Health, Life Support & Habitation Systems
TA06 (Primary)
Modeling, Simulation, Information Technology &
Processing TA11 (Secondary)

ANTICIPATED BENEFITS

To NASA funded missions:

HRA provides a risk prediction analysis tool for assessing the human's role in the Human System Integration (HSI) process (human, hardware, and software). In general, this project extends our current understanding of crew reliability for long duration space missions by assessing the human error probability portion of the HSI process to yield safer and more reliable human space missions.

The NASA Johnson Space Center Safety and Mission Assurance Directorate (S&MA) currently performs Human Reliability Analysis (HRA) for all human space programs' Probabilistic Risk Assessment (PRAs), except the International Space Station...



Contributing Partners

Idaho National Laboratory

DETAILED DESCRIPTION

The purpose of this project is to extend current ground-based Human Reliability Analysis (HRA) techniques to a long-duration, space-based tool to more effectively predict the risk associated with human actions on long-duration missions. By doing so, the agency will be able to focus resources on the risk drivers, such as specific training, conditioning, procedures, exercising, etc. for these future missions. NASA uses Probabilistic Risk Assessments (PRAs) to assess the probability of Loss of Crew (LOC) and Loss of Mission (LOM). PRAs take into account multiple contributing factors and their interactions, such as how the crew, software, and hardware work together to achieve mission objectives. HRA is used to assess the human contribution to risk in PRAs. Current HRA techniques were developed for ground applications using Earth based human reliability data to estimate human error probability. These ground-based HRA techniques have been shown to be a reasonable tool for short-duration space missions, such as Space Shuttle and lunar fly-bys. However, longer-duration beyond Earth orbit missions, such as asteroid and Mars missions, will require crews to be in space for 400 to...

MANAGEMENT

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John Falker

Program Manager:
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Principal Investigator:
Roger Boyer

DETAILED DESCRIPTION (CONT'D)

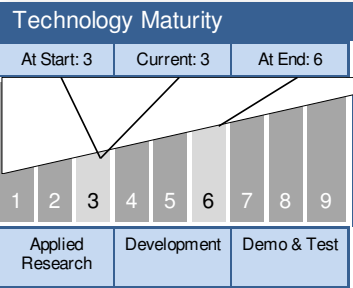
900 days with periods of extended autonomy and self-sufficiency. Current indications show higher risk due to fatigue, physiological effects due to extended low gravity environments, and others, which may impact HRA predictions by affecting the crew's cognitive abilities, as well as their physiology, and yield a higher probability for LOC and LOM (e.g. early return). PRAs will need to account for these affects in order to provide management, designers, and the crew our best estimate of risk.

With the funding of this IR&D project over the next three years, Safety & Mission Assurance (S&MA) will collaborate with Human Health & Performance (HH&P) to establish what is currently used to assess human reliability for human space programs, identify human performance factors that may be sensitive to long duration space flight, collect available historical data, and update current tools to account for performance shaping factors believed to be important to such missions. JSC's Human System Integration (HSI) initiative is a work in progress to better understand how the crew, software, and hardware work together and ensure that HSI is accounted for in future space mission designs.



TECHNOLOGY DETAILS

Space Based Human Reliability Analysis (HRA)



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using current ground-based human reliability analysis (HRA) techniques combined with what NASA has learned from years of human experience in space to produce an HRA approach for long-duration space missions.

- This technology is categorized as firmware for engineering, design, modeling, or analysis
- Technology...

Performance Metrics		
Metric	Unit	Quantity
report	1	1

TECHNOLOGY DETAILS

TECHNOLOGY DESCRIPTION (CONT'D)

Area

- TA06 Human Health, Life Support & Habitation Systems (Primary)
- TA11 Modeling, Simulation, Information Technology & Processing (Secondary)

CAPABILITIES PROVIDED

The NASA Johnson Space Center Safety and Mission Assurance Directorate (S&MA) currently performs Human Reliability Analysis (HRA) for all human space programs' Probabilistic Risk Assessment (PRAs), except the International Space Station (ISS). Human Health and Performance (HH&P) is the recognized subject matter expert for HH&P. In order to safely execute a long-duration mission, we must have a more accurate HRA prediction model. This collaboration is aimed at taking current knowledge and modifying the approach used for short-duration missions to produce a method that can be applied to long-duration missions. It is utilizing the experience and resources of those who perform HRA at NASA with HH&P's data and expertise to upgrade the current approach based on existing human research and operational data. S&MA and HH&P began a couple of years ago to identify all of the factors that may influence human performance in space, and ultimately the success of the mission. The resulting "factor map" will be leveraged by this project to identify which factors may be the most influence by long-duration missions. Programs want to implement technology that is affordable, reliable, and repeatable. This project is aimed at developing an HRA method that will meet those three criteria when Exploration Systems Development (ESD) is able to strategically plan for long-duration missions.

NASA is currently assessing the risk (loss of crew and loss of mission) for long-duration space missions, such as to Mars. This tool will help establish the contribution of crew to the overall mission risk as well as helping to identify where improvements can be made via training, crew equipment, and autonomous functions.

POTENTIAL APPLICATIONS

performing human reliability analysis for long duration space...

TECHNOLOGY DETAILS

POTENTIAL APPLICATIONS (CONT'D)

missions.

NASA is currently assessing the risk (loss of crew and loss of mission) for long-duration space missions, such as to Mars. This tool will help establish the contribution of crew to the overall mission risk as well as helping to identify where improvements can be made via training, crew equipment, and autonomous functions.

ABSTRACT (CONTINUED FROM PAGE 1)

extended low gravity environments, and others, may impact HRA predictions. For this project, Safety & Mission Assurance (S&MA) will work with Human Health & Performance (HH&P) to establish what is currently used to assess human reliability for human space programs, identify human performance factors that may be sensitive to long duration space flight, collect available historical data, and update current tools to account for performance shaping factors believed to be important to such missions. This effort will also contribute data to the Human Performance Data Repository and influence the Space Human Factors Engineering research risks and gaps (part of the HRP Program). An accurate risk predictor mitigates Loss of Crew (LOC) and Loss of Mission (LOM). The end result will be an updated HRA model that can effectively predict risk on long-duration missions.



ANTICIPATED BENEFITS

To NASA funded missions: (CONT'D)

(ISS). Human Health and Performance (HH&P) is the recognized subject matter expert for HH&P.

HH&P has expertise in human error testing of human-system interface design and performance, behavioral, physiological health, and performance research on long-duration space-flight impacts, and effective and affordable human factors methodologies. The resulting tool can be used by both organizations to improve crew safety, performance, and design of future missions, such as Mars, asteroid, and lunar surface missions. HRA is also required for human rating of exploration flights. The ESD has long-duration space flight missions identified in their "Architectural" DRMs. An updated HRA model that can accurately predict risk on such missions will be needed by ESD in the near future in order to verify the LOC requirements of these missions.

A space-based HRA can be used:

- To help guide and design the autonomy supporting the human aspect of the HSI triangle by informing the designers as to the likelihood of the crew performing the intended action. For example, one must take into account how the crew member interacts with it and how the crew member benefits from it. This is a role that HRA can provide and the space based addition can make it more specific to future long duration space missions.
- To help plan mission training and operations. Our current HRA approach is cognitive-based, thus can be directly applicable to addressing cognitive performance issues. Upgrading our HRA approach to include long duration space mission attributes, such as fatigue and low gravity physiological effects, is applicable to risk-ranking this HAT need.
- And finally to first help assess the likelihood of human error and then to assess the proposed improvement to determine the worthiness of the effort. In developing on-board decision support tools, the designer must keep the crew in mind for the environment and condition of a long duration space mission. This project will provide information as to how the design benefits or degrades its support and crew training before and during the mission.

To NASA unfunded & planned missions:

This effort will also contribute data to the Human Performance Data Repository and influence the Space HFE research risks and gaps as part of the HRP. The HRP is actively doing research on long-duration performance and the impacts that long-duration spaceflight may have on the human. The results of the HRP research, analog studies, and work on performance shaping factors can be leveraged to update the model. FCI Operational Habitability Database can also be leveraged for the ISS and Shuttle operational human performance data. The model for long-durations missions will only be as...

ANTICIPATED BENEFITS

To NASA unfunded & planned missions: (CONT'D)

good as the data available to input, thus it is critical that we take the time to identify all of the data required. This effort may also benefit the HRP in planning of research in the field, by highlighting focus areas needed for more accurate predictions. In this time of doing more with less, HRP may be able to focus on a smaller number of factors, as predicted by the method.

To other government agencies:

Depending on the results of the proposed data analysis, long-term effects on human isolation and fatigue may apply to the US Navy's submarine crews and Antarctica expeditions, as well as the US Coast Guard.

To the commercial space industry:

as the commercial space industry expands to longer duration missions and/or beyond low Earth orbit, the same effects observed by NASA will also be applicable to commercial crews.

To the nation:

This will be the first HRA approach developed for space missions. Having this tool will help better understand the risks associated with crewed missions, thus helping to identify what needs to be addressed to reduce risk and what needs additional studying.

