Project Title: SAFETY IN SPACE: PREDICTING AND MITIGATING SAFETY HAZARDS ABOARD SPACECRAFT AND SPACE STATIONS

Title	Name	Field of Expertise	Telephone	Email	Organization
Lead	Marilyn Dudley-Rowley, Ph.D.	Space Human Factors, Organizational Behavior Analysis of Base and Field Settings, Social Interaction	707-773-1037	md-r@ops-alaska.com	OPS-Alaska
Co-Lead	Marc Cohen, Arch.D.	NASA Safety Concerns, Aerospace Architect; Habitability Issues	650 604-0068	marc.m.cohen@nasa.gov	NASA-ARC
Other	Constance Adams, M. Arch.	NASA Safety/Health Concerns; Aerospace Environments, Architecture	713-862.5959	constance.m.adams@lmco.com www.synthesis-intl.com	Independent space architect consultant with Synthesis International USA.
Other	Sheryl Bishop, Ph.D.	Space Human Factors, Organizational Behavior Analysis, Social Psychology	407-747-6027	slb@ops-alaska.com	OPS-Alaska and the University of Texas-Medical Branch, Galveston
Other	Pablo Flores, Cosmonaut-Engineer	*Mir* space station operations, Russian spaceflight, aerospace engineering	c/o 707-773-1037	pcf@ops-alaska.com	OPS-Alaska and the Moscow Aviation Technical Institute (MATI)

Other Relevant NASA Personnel	NASA Organization

Provide work background summaries of key personnel relative to the type of project that is being proposed. For Advanced Space Technology Program projects, where appropriate include titles of 1-2 papers that each key member has published or presented at a conference.

Max 75 words per member

Project Lead: Dudley-Rowley. Over 20 years' experience in the study of space and polar exploration environments, quantifying data for metric profiling techniques of expeditions. Skilled in the DARPA project management style. Expert agreement with Human Systems Information Analysis Center (USAF Research Laboratory's Human Effectiveness Directorate). Invited member, DoD Human Factors Engineering Technical Advisory Group. Design of space station human factors metric profiling techniques for use in Russian simulations and NASA astronaut training venues. Active, AIAA.

Dudley-Rowley, Marilyn, Cohen, Marc M., Flores, Pablo. (2004, March), 1985 NASA Rockwell Space Station Crew Safety Study: Results From *Mir.* In *The Journal of Aerospace and Environmental Medicine, Moscow.*

Dudley-Rowley, Marilyn, Bishop, Sheryl L. (2002 October), Extended Mission Systems Integration Standards for the Human-Environment and Human-Human Interfaces (AIAA 2002-6110). 1st Space Architecture Symposium (SAS 2002), Houston, Texas, USA, 10-11 October 2002. Reston, Virginia, USA: American Institute of Aeronautics and Astronautics.

Co-Lead: Cohen. Marc M. Cohen is a licensed architect who has over 20 years of experience in Space Architecture design research and development, specializing in space living and working environments. Marc was first author of NASA's 1997 Habitats and Surface Construction Technology R&D Roadmap. Marc has an extensive record of accomplishment in developing architectural concepts for space stations, interplanetary vehicles, and lunar and Mars surface habitats. He conducts advanced materials research and quantitative modeling of habitat designs.

Cohen, Marc M. (2004, July), Habitat Multivariate Design Model (SAE 2004-01-2366). 34th International Conference on Environmental Systems (ICES), Colorado Springs, Colorado, USA, July 2004. Warrendale, Pennsylvania, USA: Society of Automotive Engineers.

Cohen, Marc M. (2004, July), Carbon Radiation Shielding for the Habot Mobile Lunar Base, accepted to the SAE Transactions, *Journal of Aerospace.*

Other: Constance Adams is a registered Architect (M.Arch Yale 1990) with a background in sociology (BA Harvard 1987) who has built large-scale commercial, residential, urban and healthcare projects. In 7+ years at NASA-JSC, Adams' work includes design of BIO-Plex Hab, ISS TransHab, ISS Crew Systems, Mars Surface Habitats, X-38, Crew Transfer Vehicle (CTV), crew hardware for the ISS, cabin architecture for the Orbital Space Plane and system architecture for ISS Crew Health Care System (CHeCS).

Adams, Constance M. (1998 July). Defin(design)ing the Human Domain: the Process of Architectural Integration in Long-Duration Space Facilities (SAE 981789). 28th International Conference on Environmental Systems (ICES), Danvers, Massachusetts, USA, 13-16 July 1998. Warrendale, Pennsylvania, USA: Society of Automotive Engineers.

Adams, Constance M. (2002). "Sociokinetic Analysis as a Tool for Optimization of Environmental Design." In H. Lane, R. Sauer, D. Feeback (Eds.), *Isolation: NASA Experiments in Closed-Environment Living* (American Astronautical Society, Science and Technology Series, Vol. 104, chapter 3.7, p. 165-175). San Diego, California, USA: Univelt, Inc.

Other: Bishop. Also, faculty member of the International Space University. Research include prevention of CAD in commercial airline pilots, (collaborating with Stanford University and United Airlines), extending the MSIS, and the development of a database on multicultural group dynamics. Publication topics include assessment in astronaut screening and evaluation, the interrelated aspects of physiology, psychology, human factors and life support in space, the psychological selection of astronauts and cosmonauts, gender in space, space mission support parameters. **Dudley-Rowley, Marilyn, Whitney, Stewart, Bishop, Sheryl, Caldwell, Barrett, Nolan, Patrick D. (2001, July), Crew Size, Composition, and Time: Implications for Habitat and Workplace Design in Extreme Environments, SAE 2001-01-2139), 31st International Conference on Environmental Systems (ICES), Orlando, Florida, USA, 9-12 July 2001. Warrendale, Pennsylvania, USA: Society of Automotive Engineers.**
Other: Flores. Cosmonaut trained for *Mir* mission, various aerospace engineering specialties from Argentine and Russian universities. Working insights on space station operations, Russian spaceflight, and multicultural issues of space operations. **Dudley-Rowley, Marilyn, Okushi, Jun, Gangale, Thomas, Flores, Pablo.; Diaz, Eduardo. (2003 September), Design Implications of Latent Challenges to the Long-Duration Space Mission (AIAA 2003-6239). AIAA Space 2003 Conference & Exposition, Long Beach, California, USA, 23-25 September 2003. Reston, Virginia, USA: American Institute of Aeronautics and Astronautics.**

Lead Organization: OPS-Alaska

Names of any additional participating NASA and other collaborating institutions, if applicable.

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Brief Summary - which will serve as proposal abstract
Max 750 words

This project will develop the Crew Safety-Human Factors Interaction Model (Cohen-Junge Model) as a tool for use in all human space missions. In 1984, Marc Cohen and Maria Junge at Ames Research Center published their model. In 1985, Rockwell devoted Volume 3, "Safety Impact of Human Factors" in their five-volume Space Crew Safety Alternatives Study to supporting the Cohen-Junge Model. Because it focuses on the long-term development of stressors, it took a long time to test and evaluate this model in human space missions. The *Mir* space station (1986-2001) afforded this basis for evaluation (Dudley-Rowley, Cohen, Flores, [2003, Nov]). This model is especially well-suited for the long-duration missions that exploration will require

The starting TRL is at Level 3 proof of concept, based upon the results from *Mir*. A two-year ASTP study would bring that up to Level 6.

The 1985 Rockwell International (now Boeing-North American) *Space Station Crew Safety Alternatives Study* identified a wide range of potential safety threats/hazards that the crew might encounter on the future International Space Station. These threats included fire, explosion, collision, decompression, contamination, and radiation, among many others. The human factors volume featured the Crew Safety-Human Factors Interaction Model (the Cohen-Junge Model). In this model, a stressor (i.e., one of the threats) can lead to degraded performance, which can contribute to human error, unless appropriate and effective countermeasures are available to the crew.

During 2002-2003, Dudley-Rowley, Cohen, and Flores exhaustively re-examined the Cohen-Junge Model (that was contemporaneous with the construction and launch of *Mir*) against the safety record on *Mir,* drawing evidence from several missions. Pablo Flores presented *"1985 NASA Rockwell Space Station Crew Safety Study: Results From Mir,"* at the Institute for Biomedical Problems' 40th anniversary conference in Moscow.[1] The IBMP is Russia's leading research institution in space biology and medicine. In March 2004, their paper was published in *The Journal of Aerospace and Environmental Medicine, Moscow.*

The Cohen-Junge Model proved remarkably good at predicting safety problems that arose for crews on *Mir*, predicting approximately 70-80% of the life-threatening events, including fire, contamination, collision, depressurization, fatigue, human error, disorientation, and social friction. What came out of this study with the *Mir* data were ways to expand the set of the countermeasures against stress and against errors, and to review the definition, incidence, detection, prevention, and mitigation of safety hazards aboard the International Space Station and exploration missions.

An important step in developing this model as a useful instrument is to provide more quantitative rigor. In particular, the model must resolve the question: How do we deal with the fact that a behavior or an event can be viewed as a stressor over different parts of the model, both a matter of critical habitability and tasking, for instance? In such a case, which countermeasures take precedent? This approach would involve a system of weighting the various stressors and countermeasures in order to evaluate their relative importance. Future research must consider weighting stressors according to a severity index where destruction of all hands would be the worst-case value. Similarly, weighting countermeasures according to an efficacy index could value the immediate reversal of the stressor as the best-case value. It seems prudent to follow up on Cohen's and Junge's original recommendation that weighting should take into account mission interval (i.e., beginning, middle, end) and its role in the severity of stressors and efficacy of countermeasures in order to look for any short- and long-term patterns of stressors and countermeasures in time.

The first year of the study would focus on confronting the quantification task and examining a range of quantitative indicators that could profile crew safety and related human factors support

[1] Living Beings and Environment: Adaptation to Extreme Conditions, Session 12: Reserve Capacities of the Human Body and Occupational Risks, Presidium of Science, Moscow, Russia, 4 Nov 2003.

over time. The second year would follow up on an expanded set of the countermeasures against stress and against errors, and review the definition, incidence, detection, prevention, and mitigation of safety hazards that do and could occur aboard the International Space Station and exploration missions.

The deliverable is a quantitative instrument that can be applied to an already-flown mission to get a detailed metric profile of its crew safety and related human factors support for comparison to other missions, or that can be applied to an ongoing space mission as a situation estimator.

Milestone: Year 1: Step 1

Deliverable: Year 1: Expanded Model TRL 4-5 expanded and enhanced model at the component and subsystem levels.

Milestone: Year 2: Step 2: TRL-6 useful instrument at the system level

Deliverable: Year 2: Expanded Model

Quarterly reporting of substantive progress, in addition to the monthly technical-financial/EVM reporting.