

# COE CST First Annual Technical Meeting

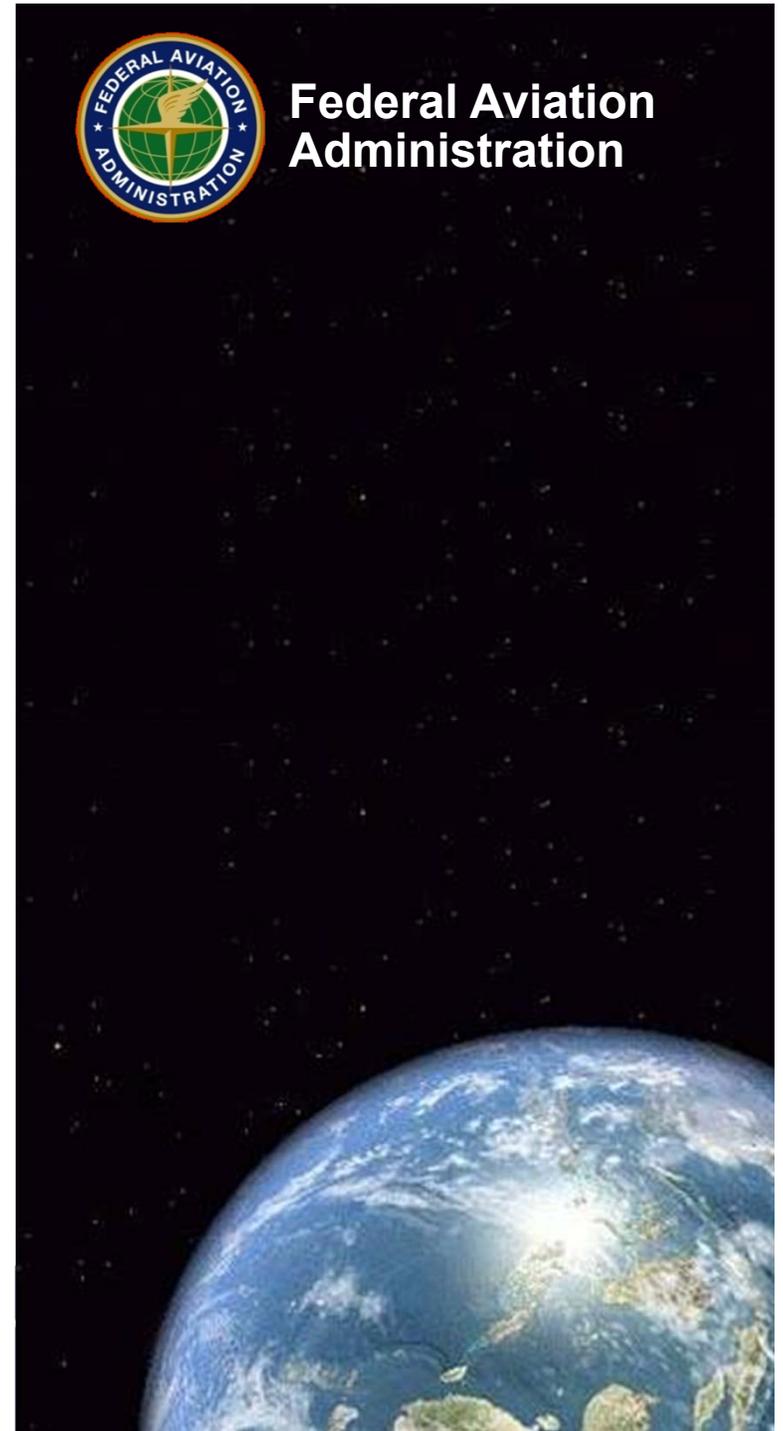
## Task 184 Human Rating of Commercial Spacecraft

David Klaus  
University of Colorado

*November 10, 2011*



**Federal Aviation  
Administration**



# Overview

- Team Members
- Purpose of Task
- Research Methodology
- Results or Schedule & Milestones
- Next Steps
- Contact Information



# Team Members - to date (in progress)

- **David Klaus**, PI, University of Colorado
- **Christine Fanchiang**, PhD student, CU Aerospace (funded by COE)
- **Robert Ocampo**, PhD student, CU Aerospace (funded by SNC)
- **Rene Rey**, FAA
- **Mark Weyland**, NASA JSC
- **Kenneth Stroud**, Sierra Nevada Corp.
- **Merri Sanchez**, Sierra Nevada Corp.
- **Scott Norris**, Lockheed Martin
- **Todd Sullivan**, Lockheed Martin
- **Paul Eckert**, Boeing (**Sheryl Kelley**)
- **Tim Bulk**, Special Aerospace Services
- **Jeffrey Forrest**, Metropolitan State College of Denver
- **John Dicks**, L3 Stratis, NASA IV&V



# Purpose of Task

- Purpose

- To define the criteria for human rating (or certification?) of an integrated commercial spacecraft and launch vehicle system

- Objectives - *year 1 of 3 planned (6/1/11 to 5/31/12)*

- Review and summarize human rating literature and practice
- Compile database of guidelines for commercial spaceflight
- Identify and seek collaboration with individuals to participate in a Working Group to identify and address implementation needs

- Goals

- Develop baseline Human Rating (Certification?) Guidelines and Considerations for Commercial Space Transportation addressing requirements, validation & verification, and flight certification processes
- Extend study from initial needs and capabilities of crew and space flight participants toward era of passenger carrying space vehicles

# Research Methodology

- Fundamental tenets underlying Human Rating are to:
  - **accommodate** physiological needs of the crew
  - **protect** the crew and passengers from harm, including ground crew and public
  - **utilize** the crew's capabilities to safely and effectively achieve the goals of the mission
- Essentially, to Protect and Utilize the Crew
  - Drives Life Support Requirements, Risk Mitigation Strategies, and Vehicle Functionality Design Goals

# Research Methodology

- No spacecraft to date has been *Human Rated* \*
  - Relevancy to launch vehicle or aircraft design / certification practices?
  - Legal / liability issues? International law implications...
- Assess and define appropriate criteria and protocols needed to achieve the essential Human Rating '**accommodate, protect and utilize**' objectives, and to characterize and quantify ensuing associated **hazards** and **risks**
- **Risk mitigation** success ultimately captured by predicted Loss of Crew (LOC), Loss of Vehicle (LOV) and/or Loss of Mission (LOM) probabilities (per passenger, flight, mission?)
- **Risk acceptance** is a programmatic decision

\*per literature, to the best of our knowledge

# Research Methodology

## Some Perspective...

- 6.8 commercial air carrier fatalities per 100,000,000 passengers (FAA FY09 Citizens' Report)
  - **1 in ~15 million passengers**
- Shuttle LOC/LOV ultimately was **2 out of 135**
  - **1 in ~68 missions (or ~4 in 270)**
- Shuttle fatalities **14 out of ~800 'passengers'**
  - **1 in ~60 / passengers over ~30 yrs**
- Overall LOC probability distribution for an ISS mission shall have a mean value no greater than... (NASA CCT-REQ-1130, 4.0)
  - **1 in 270**

# Research Methodology

**$\Sigma$  S/C =  $f$  (physics) +  $f$  (physiology)**

*Non-negotiable Design Parameters*

→ required to effectively accomplish mission objectives

**+  $f$  (safety) +  $f$  (operability)**

*Design Trade Space 'Figures of Merit'*

→ incorporated to reduce risk and improve crew utilization

# Research Methodology

## Governing Documents

## *Requirements*

**NASA NPR 8705.2B**

*Human-Rating Requirements for Space Systems*

131

**ESMD-CCTSCR-12.10**

*CCTS Certification Requirements for NASA LEO Missions*

31

**NASA CCT-REQ-1130**

*ISS Crew Transportation and Services Requirements Document*

258

**NASA SSP-50808**

*ISS to COTS Interface Requirements Document*

724

**AFSPCMAN-91-710**

*Range Safety User Requirements*

4692

---

**5721**

# Research Methodology

## Select Literature (of ~160+)

- NASA (1965), “Apollo Launch-Vehicle Man-Rating: Some Considerations and an Alternative Contingency Plan”, RM-4489-NASA, May 1965.
- Hacker, BC and Grimwood, JM (1977), “On the Shoulders of Titans: A History of Project Gemini”, NASA SP-4203.
- NASA (1988), “Guidelines for Man Rating Space Systems,” JSC-23211, September 1998.
- NASA (1995), “A Perspective on the Human-Rating Process of U.S. Spacecraft: Both Past and Present”, NASA-SP-6104, 1995.
- Bond, AC (1998), “A Review of the Man-Rating in Past and Current Manned Space Flight Programs”
- Aerospace America (2010), “Human Rating: A Roundtable Discussion”, American Institute of Aeronautics and Astronautics, Vol. 48, No. 7
- Franzini, BJ and Fragola, JR (2011), "Human rating of launch vehicles: Historical and potential future risk," Reliability and Maintainability Symposium, Lake Buena Vista, FL, Jan 24-27, 2011.

# Results or Schedule/Milestones ~yr 1

- **Task 1** – Literature review, ~160 papers compiled and categorized to date, government / industry practice surveys in work
- **Task 2** – Attended COE Roadmap Workshop Wash. DC (August 2011) and assimilated outcome into research objectives
- **Task 3** – Collaboration with stakeholders initiated, other commercial partners are being contacted
  - Goals identified during the Washington DC Roadmap Workshop to be further reviewed with industry and government partners
- **Task 4** – COE research objectives for Human Rating task being aligned with academic plans for the PhD student, Christine, working on this project



# Next Steps – outcome from Aug 2011 Roadmap Workshop



# Next Steps – outcome from Aug 2011 Roadmap Workshop

## 3.2 ECLSS & Habitability

### High Priority Actions

Conduct research to help the FAA develop ECLSS standards and requirements.

### Long-Term Considerations

## 3.4 Human Rating

### High Priority Actions

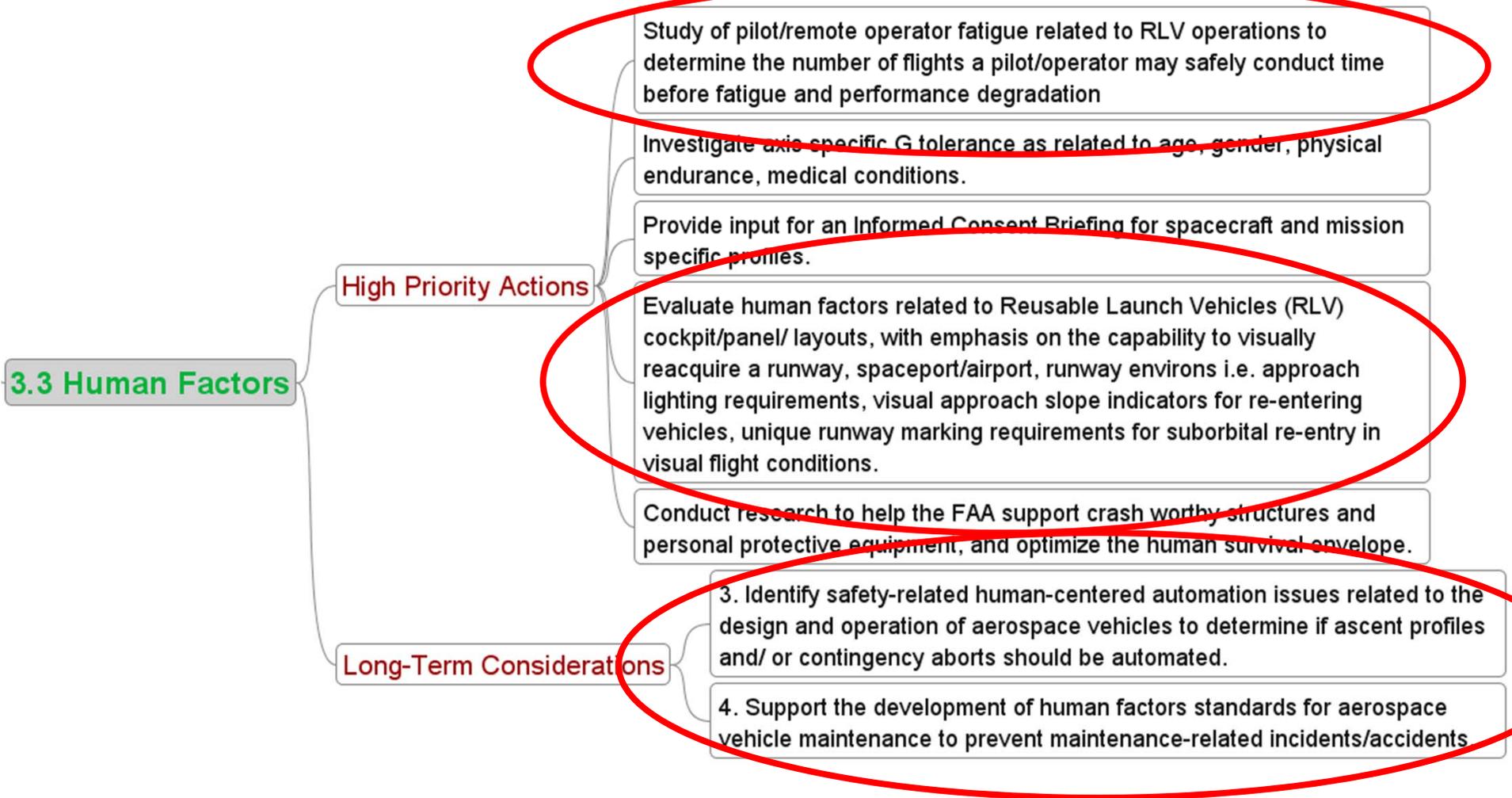
Assist the FAA with data to develop guidance and an occupational and safety database for risks outside OSHA standards.

Compile Human Rating and Spacecraft Lessons Learned Database, with focus on close calls and mishaps and recent work (ie Orion capsule).

Adapt existing NASA modeling tools for commercial human spaceflight, such as MMOD Model (Bumper) and Cabin Depressurization Model (Killer Press) to allow comparison of tradeoffs and risks.

### Long-Term Considerations

# Next Steps – outcome from Aug 2011 Roadmap Workshop



# Next Steps – new AIAA ICES Conference Session, July 2012

## Human Rating for Space Systems

This session engages industry, government, and academia in the definition and analysis of safety and mission assurance parameters as they relate to the design and operations of spacecraft intended for human occupancy. One key objective is to assess the relevancy and commonality of requirements and policies for NASA and FAA commercial human spaceflight missions.

### Organizers:

David Klaus, University of Colorado, klaus@colorado.edu

Rene Rey, FAA



# Contact Information

Professor David Klaus  
Aerospace Engineering Sciences Dept.  
University of Colorado / 429 UCB  
Boulder, CO 80309-0429

303-492-3525  
klaus@colorado.edu

