

# **COE CST Fourth Annual Technical Meeting**

## **Task 184: Human-Rating of Commercial Spacecraft**

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Washington, DC*

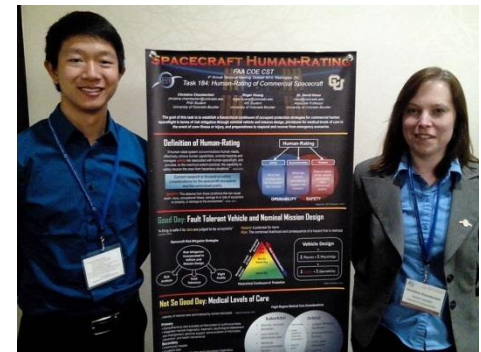


# Team Members

- FAA AST TM: **Henry Lampazzi** *(no photo)*
- Principal Investigator: **David Klaus** →
- Students



- *current*: **Christine Chamberlain**  
**Roger Huang** →



- *former*: **Christine Fanchiang** →
- *SNC*: **Robert Ocampo** →
- *unfunded*: **Stefan Neis**  
*(no photo)*



# Task Description

## Comprehensive

- Define and assess criteria and protocols typically employed for ensuring human-rating objectives (primarily safety) are met, including extension beyond crew and space flight participants toward an era of passenger carrying spacecraft, and while also minimizing risk to the uninvolved public

## Current Efforts

- Medical Levels of Care for CST
- Emergency Crew Survival Methods
- Risk Perception / Communication

# What does ‘human-rated’ mean?

- “A human-rated system **accommodates** human needs, effectively **utilizes** human capabilities, controls hazards and manages **safety** risk associated with human spaceflight, and provides, to the maximum extent practical, the capability to safely recover the crew from hazardous situations.” *NASA (2012)*
- **How is it assessed?**
  - Requirements-driven or Outcome-determined?
  - NASA Requirements and FAA Airworthiness Certificate?
- **How is it confirmed?**
  - License, Certificate, Permit, Waiver, Other?

# Human-Rating

**Utilize**

What the humans can do to support the mission

**Accommodate**

What the vehicle provides to support the humans

**Protect**

Ensure safety of the vehicle occupants (and uninvolved public)

**OPERABILITY**

**SAFETY**

# What does 'human-rated' mean?

- For CST, this translates to protect the crew and passengers (*occupants*) from harm, to accommodate their physiological needs, and to utilize the crew's capabilities to safely and effectively achieve the goals of the mission, *while also minimizing risk the uninvolved public.*
- The protection element of this research, which has been the focus to date, is directed at supporting an informed decision making process that will allow the FAA to ultimately develop appropriate safety regulations and verification strategies

# How is it confirmed?

- **License** (i.e., Driver's)
  - to give permission
  - document recording that permission
- **Certification** (i.e., Pilot's)
  - refers to certain characteristics of an object, person, or organization
  - some are valid for a lifetime, once the exam is passed, others have to be recertified again after a certain period of time
  - certification does not refer to the state of legally being able to practice or work in a profession (that is licensure)
  - usually, licensure is administered by a governmental entity for public protection purposes and a professional association administers certification
  - licensure and certification are similar in that they both require the demonstration of a certain level of knowledge or ability

# How is it confirmed?

- **Permit**

- authorization or consent to someone to do something
- a written warrant or license granted by one having authority
- various legal licenses

- **Waiver**

- regulatory agencies or governments may issue waivers to exempt companies from certain regulations

- **Other means of assuring safe operations?**

- Safety is addressed through use of published guidelines and recommendations, industry protocols and best practices, and established standards. Licensing, certification and requirements can also be used to systematically assess safety compliance. Ultimately, safety is a product of proper design, quality workmanship and proficient operations.

*(Ocampo and Klaus, 2013)*



# Historical Perspective

*“In the early days of airmail flying, the mail pilots came to believe that their crash rate was unacceptable, even for people accustomed to danger. Finally a group of them convinced the US. Air Mail Service that postal supervisors at the airports were ordering them aloft in bad storms and poor visibility. The solution? Not a new regulation spelling out what weather was safe and unsafe, but rather this simple order: if an outgoing pilot desired, his supervisor had to join him in the cockpit to fly a circuit around the airport before the pilot went off on his mail run. Quickly the supervisors’ tolerance for bad weather dropped.”*

“Inviting Disaster: Lessons from the Edge of Technology” by James Chiles, 2002

# Historical Perspective

- The human-rating process for the Mercury, Gemini, and Apollo Programs was centered on **safety**
- As Mercury and Gemini evolved into Apollo and Skylab, human-rating began to focus on improvements to **operability** in addition to the focus on safety
- Skylab and Shuttle Programs added an emphasis on human **performance** and **health** management
- CST focus is on **safety**

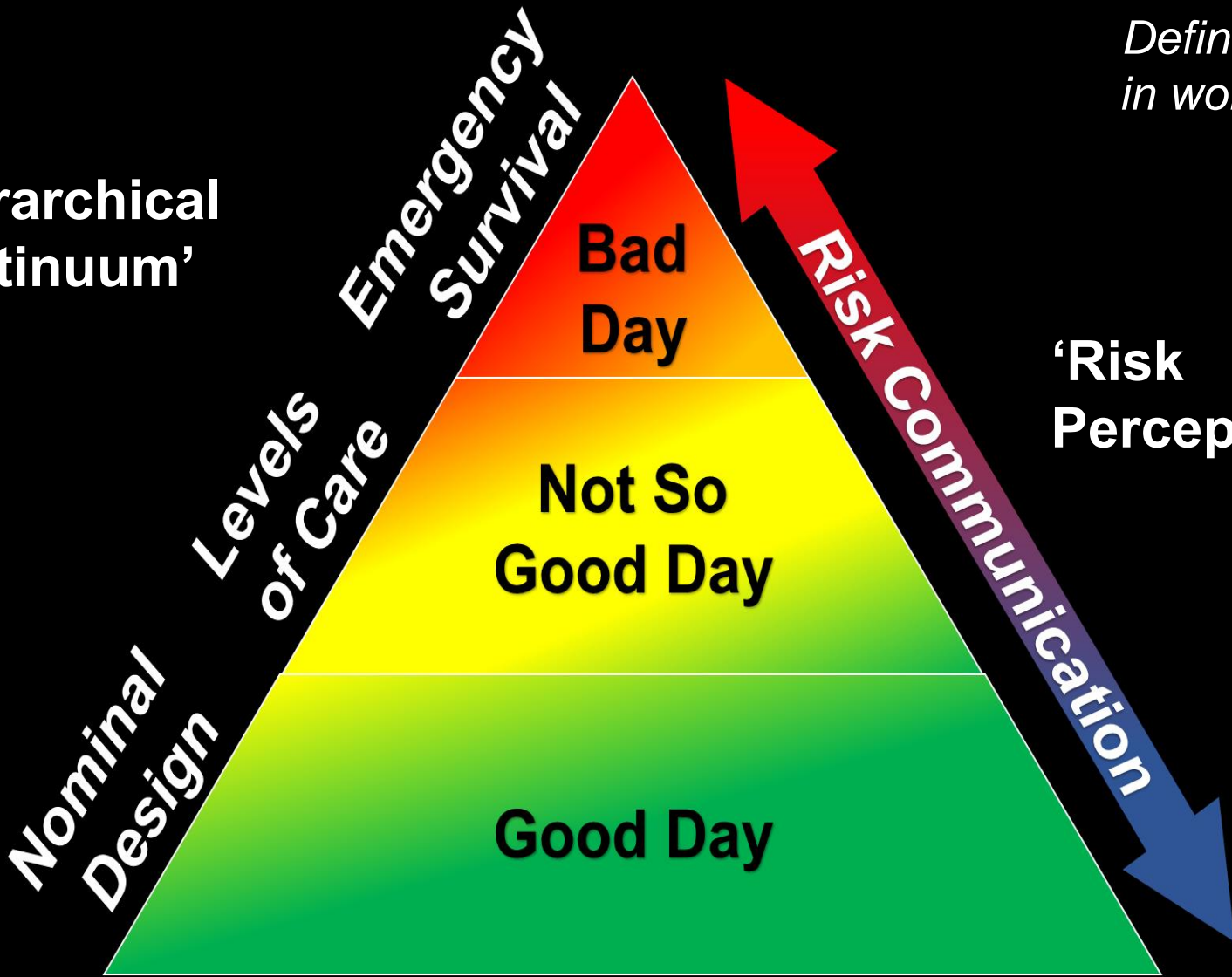
# Schedule (comprehensive *June 2011 through December 2014*)

- **2011/12**
  - Historical Perspectives on Human-Rating
  - Human-Rating Terms and Definitions
- **2012/13**
  - FAA Human-Rating Ground Rules and Assumptions
  - FAA Established Practices for Human Spaceflight Occupant Safety
- **2013/14**
  - FAA Recommended Practices for Human Space Flight Occupant Safety
  - **Medical 'Levels of Care' for Commercial Spaceflight**
  - **Crew Survival Methods**
  - **Risk Perception / Communication**

# Goals: Risk perception/communication plan

- **Human-Rating Guidelines** – defined to help ensure a ‘good day’ occurs through risk mitigation and fault tolerant vehicle design
- **Medical ‘Levels of Care’** – intended to address minor (non-life threatening) injury or illness leading to a ‘not so good day’
- **Emergency Survival** – allow potential to deal with life-threatening illness/injury or recover from catastrophic vehicle failure to keep a ‘bad day’ from getting worse...

**'Hierarchical  
Continuum'**



# Medical 'Levels of Care' for CST

- **Primary** care covers generalized treatment for minor, acute injuries or illnesses.
- **Secondary** care follows with more specialized services on specific body systems or for specific diseases or chronic health conditions.
- **Ambulatory** care typically refers to outpatient treatment.
- **Tertiary** care involves highly specialized equipment and expertise for complex treatments such as surgeries or other procedures associated with hospitalization.
- **Quaternary** care is an extension into even more specialized and highly unusual treatment options, up to and including experimental medicine

# Medical 'Levels of Care' for CST

- **Determining appropriate 'Level of Care' for commercial space flights should consider**
  - unique risks posed by each phase of suborbital and orbital flight
  - means of effectively accommodating safety and medical concerns as they relate to the vehicle design and operations and the onboard crew's degree of training
- **Implementing an appropriate 'Level of Care'**
  - function of vehicle design and operations, including personnel training

# Results: COE Reports to FAA

1. Safe Return to Earth, 2012
2. Human Spaceflight Terminology and Definitions, 2013
3. Human Spaceflight Safety Terms and Definitions, 2013
4. Human Spaceflight Safety Perspectives, 2013
5. Thoughts and Considerations on Necessary Levels of Care for Commercial Spaceflight Transportation, 2014



# Results: Contributions to FAA Documents

1. FAA Human-Rating Ground Rules and Assumptions Document (pre-decisional, 2013)
2. FAA Established Practices for Human Spaceflight Occupant Safety draft (7/31/13), with rationale (9/23/13)
3. FAA Recommended Practices for Human Space Flight Occupant Safety Version 1.0, (8/27/2014)

# Results: Publications to date

1. Fanchiang, C. **Characterization and Evaluation of Manned Spacecraft Operability Factors**. 63rd IAC, Naples, Italy, Oct 2012 (presentation and proceedings)
2. Fanchiang, C., Johnson, M., and Ocampo, R. (2012) **Evaluation of Commercial Human Spaceflight Laws and Regulations in the United States**, IAC-12-D6.1.7 63rd IAC, Naples, Italy, Oct 2012
3. Klaus, D.M., Fanchiang, C. and Ocampo, R.P. (2012) **Perspectives on Spacecraft Human-Rating**. AIAA 2012-3419
4. Ocampo, R.P. and Klaus, D.M. (2013) **A Review of Spacecraft Safety: from Vostok to the International Space Station**. New Space 1(2): 73-80
5. Klaus, D.M., Ocampo, R.P. and Fanchiang, C. (2014) **Spacecraft Human-Rating: Historical Overview and Implementation Considerations**. IEEE Aerospace Proceedings (978-1-4799-1622-1/14, no. 2272)
6. Neis, S.M. and Klaus, D.M. (2014) **Considerations toward Defining Medical 'Levels of Care' for Commercial Spaceflight**. New Space [accepted]

# Conclusions and Future Work

## • Next Steps

- Explore Emergency Crew Survival Methods
  - All occupants should have a 'reasonable chance of survival' in the event of an emergency. (FAA, 2014)
- Assess Risk Perception / Communication
  - Contrasting with familiar Earth-based activities can be used to improve public perception of spaceflight risk
  - *e.g., In recent years, the odds of dying on Mount Everest were virtually equivalent to those of dying in a space shuttle accident*
- Compile Final Report for Task 184
  - Guidelines and Considerations for Spacecraft Human-Rating

## • Final Remarks

- *Current funding runs out 12/31/14*