# COE CST Seventh Annual Technical Meeting

# TASK 320: Commercial Spaceflight Risk Assessment and Communication

**David Klaus**

***October 10, 2017***
***Las Cruces, NM***

Center of Excellence for Commercial Space Transportation

# Team Members

- People *(including 184 and 353)*
  - PI: David Klaus
  - 6 students cumulative from prior Task 184 Human-Rating and Task 320 Risk Assessment
    - Christine Fanchiang (PhD 2017), Robert Ocampo (PhD 2016), Stefan Neis (MS 2015), Roger Huang (MS 2014), Christine Escobar née Chamberlain (MS 2014, currently PhD student at CU)
    - (New student on Task 353 starting Jan 2018)

# Task Description

- Commercial space travel, as with any mode of transportation, inherently introduces some degree of risk to the onboard occupants and uninvolved public
  - Risks arise from potential for vehicle failures, environmental hazard interactions, or human errors
  - Outcomes range from discomfort or incomplete objectives, up to health impacts and loss of life
  - Potential for onboard illness or injury unrelated to vehicle failure can also be considered as a risk
  - Risks that cannot be mitigated must be characterized and effectively communicated to crewmembers and spaceflight participants

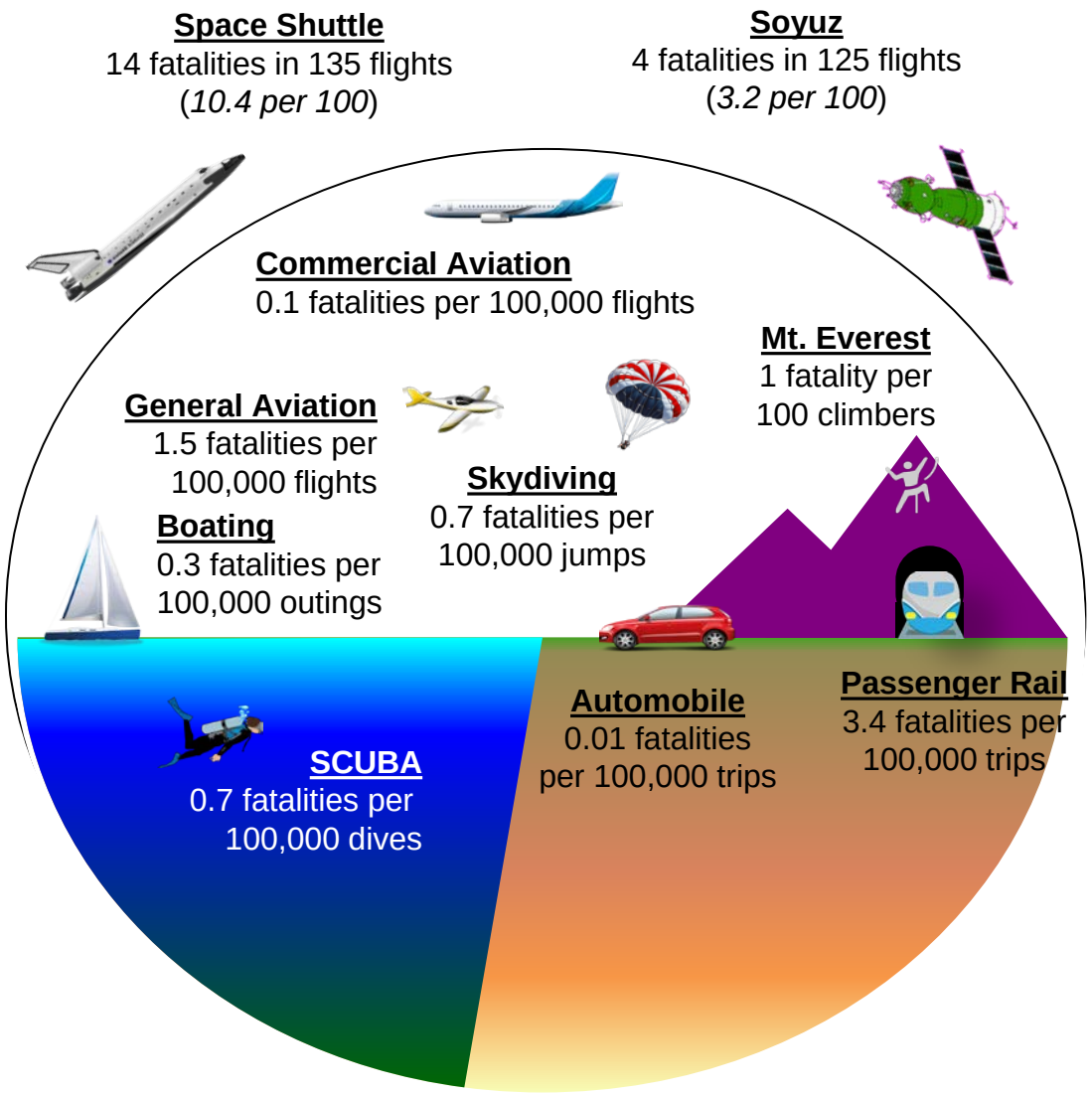
# Schedule

- **Year 1 of Task 320 (June 1, 2015 through May 31, 2016)**
  - Defined relative degrees of ‘safe’ and means of quantifying ‘acceptable’ levels of risk for commercial spaceflight
  - Framework developed to deal with inflight medical issues
  - Comparative perspective offered for understandable ways of communicating risks of spaceflight to the general public
- **Year 2 of Task 320 (June 1, 2016 through May 31, 2017)**
  - Characterize and evaluate risk reduction strategies associated with each phase of the various commercial space flight profiles, with emphasis on medical level of care
  - Outcome intended to facilitate the ability of commercial launch operators and the FAA to fulfill their responsibilities related to informed consent

# Goals

- The risks and hazards of space flight must be presented to space flight participants “in a manner that can be readily understood by a space flight participant with no specialized education or training.” - 14 CFR 460.45, Operator Informing Space Flight Participant of Risk, 2013

# Results


Space Shuttle
14 fatalities in 135 flights
(10.4 per 100)
Soyuz
4 fatalities in 125 flights
(3.2 per 100)
Commercial Aviation
0.1 fatalities per 100,000 flights
Mt. Everest
1 fatality per
100 climbers
General Aviation
1.5 fatalities per
100,000 flights
Skydiving
0.7 fatalities per
100,000 jumps
Boating
0.3 fatalities per
100,000 outings
SCUBA
0.7 fatalities per
100,000 dives
Automobile
0.01 fatalities
per 100,000 trips
Passenger Rail
3.4 fatalities per
100,000 trips

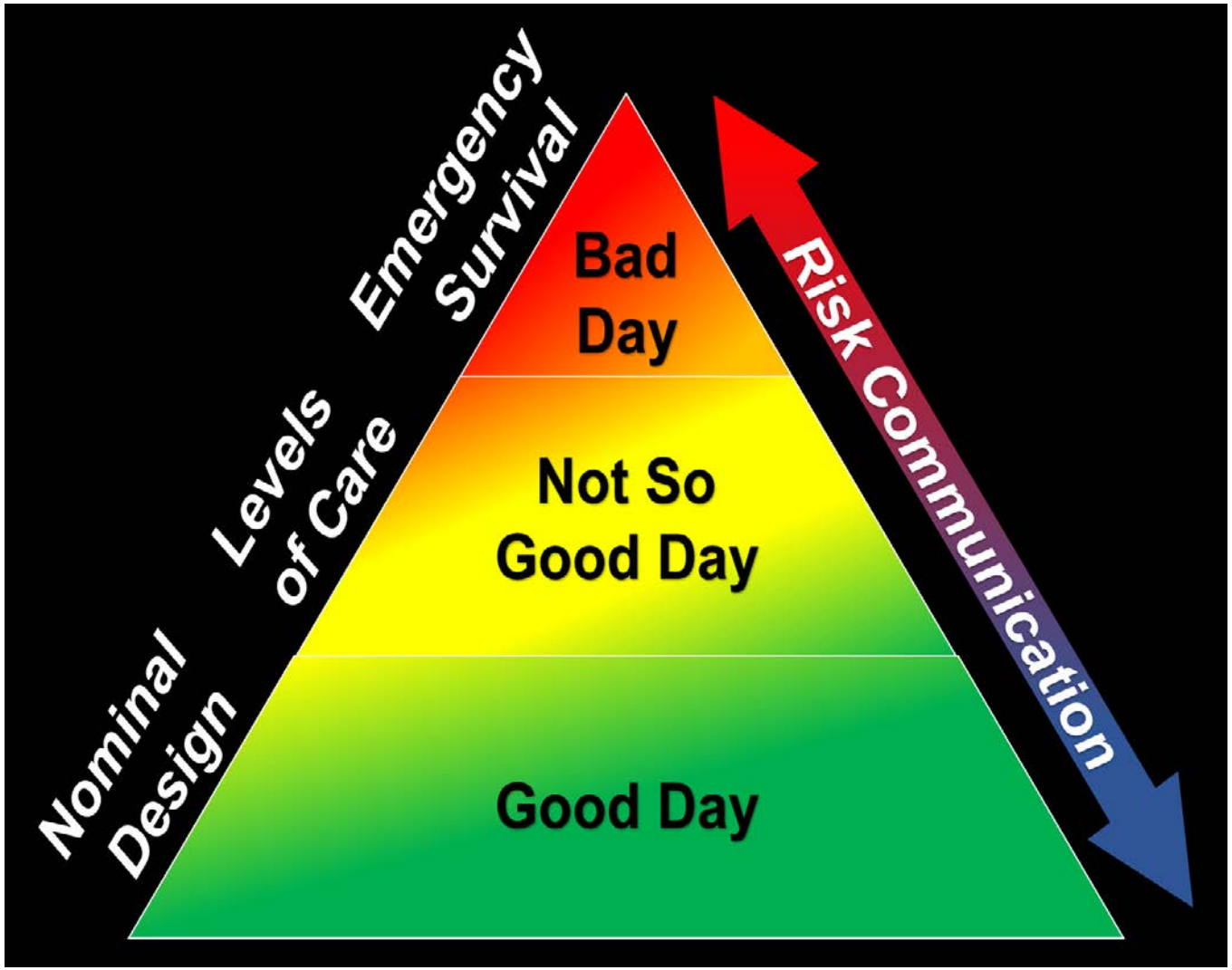
# Results

- ***Good Day*** **–necessary elements in place for a safe and successful flight**
  - ‘human-rated’ system
  - preflight participant ‘fitness to fly’ and medical certification for the crew
  - no occurrence of injury or illness during the flight

- ***Not so Good Day*** **– successful flight accomplished with ‘fault tolerance’**
  - non-catastrophic vehicle failure, workaround available
  - minor (non-life threatening) injury or illness, onboard medical ‘Level of Care’ provided

- ***Bad Day*** **– emergency survival to keep a ‘bad day’ from getting ‘worse’**
  - catastrophic vehicle failure or occurrence of a life threatening illness or injury
  - planned emergency scenarios such as aborts, bailouts, pressure suits, etc.
  - characterization of human tolerance limits associated with potentially extreme environments experienced in the event of such maneuvers
  - ensure appropriate medical care is on standby at the landing site

# Results


Emergency Survival
Levels of Care
Nominal Design
Bad Day
Not So Good Day
Good Day
Risk Communication

# Results

**Task 320**

- Ocampo, R and Klaus, D (2017c) A Risk vs. Usage Perspective on Human Space Flight Safety. [in revision]
- Ocampo, R and Klaus, D (2017b) Adapting Pre-Hospital Emergency Medical Protocols for Commercial Space Flight [in review]
- Ocampo, R and Klaus, D (2017a) Challenges in Determining 'Safe Enough' in Human Space Flight. International Association for the Advancement of Space Safety (IAASS) Proceedings, Paper 153, 9th IAASS Conference, Toulouse, France, Oct 2017
- Klaus, DM (2017) Functional Integration of Humans and Spacecraft through Physics, Physiology, Safety and Operability. IEEE Aerospace Proceedings, paper no. 2346 (8.0505)
- Ocampo, RP and Klaus, DM (2016b) Comparing the Relative Risk of Space Flight to Terrestrial Modes of Transportation and Adventure Sport Activities. New Space, 4(3): 190-197
- Ocampo, R and Klaus, D (2016a) A Quantitative Framework for Defining "How Safe is Safe Enough?" in Crewed Spacecraft. New Space, 4(2): 75-82
- Ocampo, R (2016) Defining, Characterizing and Establishing 'Safe Enough' Risk Thresholds for Human Space Flight, Doctoral Dissertation, University of Colorado

# Results

**Task 184**


- Fanchiang, C (2017) A Quantitative Human Spacecraft Design Evaluation Model for Assessing Crew Accommodation and Utilization, Doctoral Dissertation, University of Colorado
- Neis, S and Klaus, D (2014) Considerations toward Defining Medical 'Levels of Care' for Commercial Spaceflight. New Space, December 2014, 2(4): 165-177
- Klaus, D Ocampo, R and Fanchiang, C. (2014) Spacecraft Human-Rating: Historical Overview and Implementation Considerations. IEEE Aerospace Proceedings, no. 2272
- Ocampo, R and Klaus, D (2013) A Review of Spacecraft Safety: from Vostok to the International Space Station. New Space 1(2): 73-80
- Klaus, D Fanchiang, C and Ocampo, R (2012) Perspectives on Spacecraft Human-Rating. AIAA-2012-3419
- Fanchiang, C (2012) Characterization and Evaluation of Manned Spacecraft Operability Factors. 63rd International Astronautical Congress, Naples, Italy, Oct 2012

# Conclusions and Future Work

- Task 320 has been completed and closeout paperwork initiated.
  - 6 resultant publications complete or in progress.
- Next Steps
  - Task 353 Design and Operational Considerations for HSF Occupant Safety (6/1/17-5/31/18)
    - 3 way collaboration with UTMB and FIT
    - AIM 1: Review the FAA Recommended Practices (2014) and provide suggested edits and/or additional topic areas to be included in any future versions released;
    - AIM 2: Provide design and operational considerations for each topic area including additional details, quantified where possible, and/or candidate design and operational solutions.