

# COE CST Second Annual Technical Meeting:

## Commercial Spaceflight Operations Curriculum Development

Task 257: Masters' Ops Lab  
George H. Born

*31 October 2012*



**Federal Aviation  
Administration**



# Overview



- Team Members
- Purpose of Task
- Development Process
- Results
- Next Steps
- Contact Information



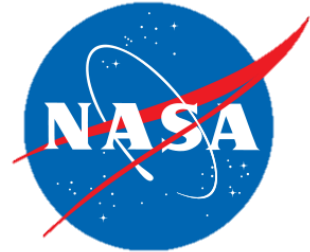
# Team Members



- **George H. Born** – Director, Colorado Center for Astrodynamics Research
- **Bradley Cheetham** – Graduate Research Assistant, CU Boulder, Aerospace Engineering Sciences
- **Juliana Feldhacker** – Graduate Research Assistant, CU Boulder, Aerospace Engineering Sciences
- **Jon Herman** – Graduate Research Assistant, CU Boulder, Aerospace Engineering Sciences



# Partnering Organizations



# Purpose of Task



To develop graduate level curriculum that will serve as a bridge between academic theory and commercial applications and to prepare students to become real-world problem solvers.

# Purpose of Task - Objectives



- Bridge theory and application in the educational process
- Foster and facilitate collaboration between academia and the commercial space industry
- Provide a venue for dialogue and research into operational improvement for the space industry



# Purpose of Task - Objectives



- Students should gain:
  - A comprehension of the mission lifetime
  - An understanding of constraints
  - Insight into and understanding of industry practices
  - An overview of project management and team dynamics
  - An understanding of risk



# Purpose of Task - Goals



- Develop a one-semester lecture course
- Build an on-campus mission operations lab
- Develop a one-semester lab course
- Refine content based on student and industry feedback
- Standardize and establish a Graduate Certificate
- Increase collaboration between academia and industry



# Development Process



- Draft academic objectives and lecture schedule
- Solicit feedback from industry
- Iterate to refine course outline
- First offering of lecture course (fall)
- Collect lessons learned and student feedback
- Refine lecture curriculum
- Second offering of lecture course (fall)

# Development Process



- Consult with industry to build on-campus missions operations center
  - Acquire funding
  - Acquire hardware and industry-donated software
- Develop student labs
- First offering of lab course (spring)
- Collect lessons learned and student feedback
- Refine lab curriculum

# Results



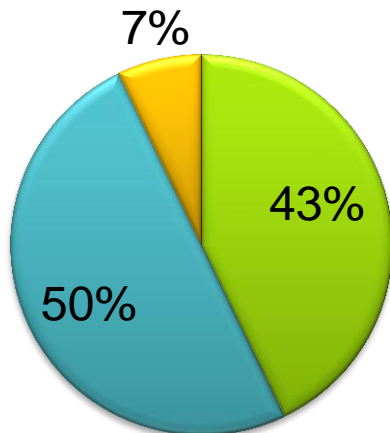
- Lecture course curriculum
  - 5 main subject areas
    1. Background
    2. Launch Operations
    3. On-Orbit Operations
    4. End-of-Mission
    5. Mission Planning
  - Assignments: discussion boards, mini research assignments, labs, final research project

# Results

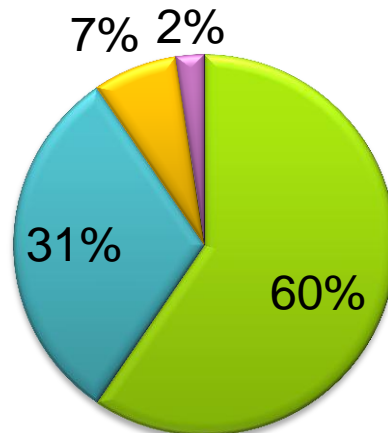


- Commercial Spaceflight Operations Lecture
  - Fall 2011: 28 students (19 in-class, 9 distance)
  - Spring 2012: 20 students
  - >20 organizations participating as guest lectures

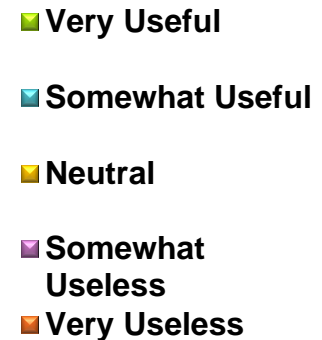
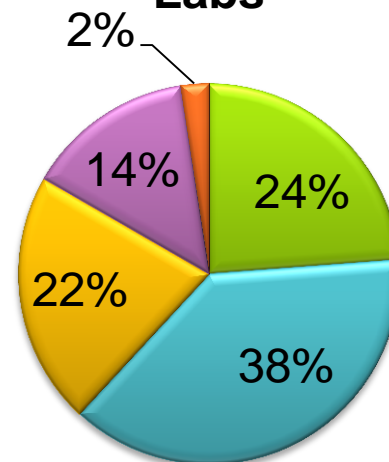
Overall Course



Lectures



Labs



# Results



- Student feedback:
  - *“I really enjoy this course. It is information that every aerospace engineer should know.”*
  - *“Guest lecturers...provide an outside-of-academia view, one that I believe is a more practical and real-world view. It's something that's traditionally not provided [in school].”*
  - *“I like the way that the course has been organized as well. It is not an easy thing to coordinate all the guest speakers in an order that makes sense for teaching a class, but on the whole I think that this class has been successful in doing just that.”*

# What We Have To Date



- Commercial Spaceflight Operations Lecture (Fall 2012)
  - 20 students enrolled
  - Guest lecturers include:
    - Lori Garver (NASA Headquarters)
    - Bretton Alexander (Blue Origin)
    - Bobby Braun (Georgia Tech)
    - Alan Stern (SwRI)

# What We Have To Date



- Mission Operations Center
  - Room and hardware procured
  - Software down-select in progress
- Student lab research and development
  - Launch
  - On-Orbit (2)
  - Re-Entry
  - Suborbital

# What We Have To Date





# What We Have To Date



# Conclusions



- Spaceflight operations is an area with great potential for academic involvement
  - Considered to be of great value to industry
  - Not well covered in established academic curriculum
- Comops lecture course has been successful in beginning to address this need
  - Extensive industry involvement
  - Expressed interest by students

# Future Work



- Complete development of operations center and lab course
- Continue offering alternating semesters of the lecture and lab
- Develop Graduate Certificate in Spaceflight Operations



# Next Steps



- Commercial Spaceflight Operations Lab (Spring 2012)
  - Complete setup of Mission Operations Center
  - Develop student labs (launch, on-orbit, reentry, and suborbital operations)
- Collect feedback from students to refine lab

# TASK 257. MASTERS LEVEL COMMERCIAL SPACE OPERATIONS INSTRUCTION CRITERIA



## PROJECT AT-A-GLANCE

- AST RDAB POC: Ken Davidian
- AST RESEARCH AREA: 2.1 Ground Systems & Ops Safety
- UNIVERSITY: University of Colorado at Boulder
- PRINCIPAL INVESTIGATOR: Dr. George Born
- STUDENT RESEARCHER: Mr. Bradley Cheetham (PhD), Ms. Jules Feldhacker (PhD), Jon Herman (PhD)
- PERIOD OF PERF: Jan 1, 2011 – May 31, 2013
- STATUS: Ongoing

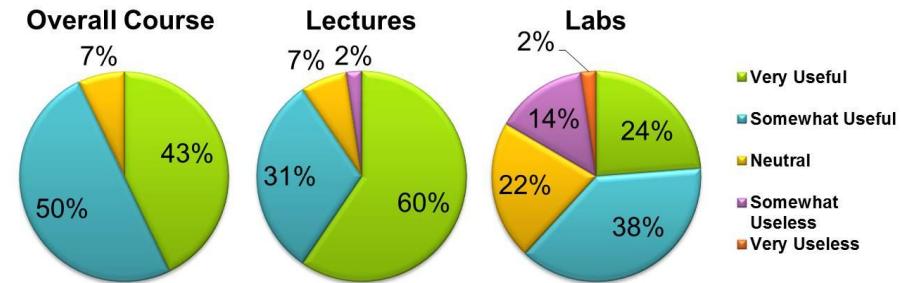
## RELEVANCE TO COMMERCIAL SPACE INDUSTRY

- This course provides insight to graduate level aerospace students on both operational and industrial dynamics to ensure the availability a highly-trained workforce required by commercial space transportation operators.

## STATEMENT OF WORK

- Develop one-semester course and one-semester lab; refine content based on student and industry feedback; standardize and establish Graduate Certificate.
- Draft academic objectives based on industry discussion; solicit feedback on academic objectives; define curriculum topics and solicit feedback; identify subject matter experts who develop and deliver content.
- Academic objectives include: (a) Comprehension of total mission sequence; (b) Constraints on design and operations including: Technical, Policy/Legal, Business, and Practical; (c) Understanding of and insight into current industry practices: Past to present; (d) Overview of project management and team dynamics; (e) Cross cutting theme of Risk (through all objectives).

## STUDENT COURSE SATISFACTION SURVEY RESULTS



## STATUS

- 30 Course Lectures in Background (3), Launch (5), Operations (11), End of Mission (3), Mission Planning (4), Misc (1), Conclusion (3).
- Total students enrolled: 48 (34 on-campus, 14 off-campus).
- Assignments: Weekly discussion, 4 Open Ended Assignments, 4 Labs, 1 Research Paper.

## FUTURE WORK

- Fall 2012: Second lecture offering, lab development
- Spring 2013: First lab offering
- Summer 2013: Continued refinement of lecture/lab, begin formalizing certificate



# Budget



- Gross funding through May 2013
  - FAA Funding: \$75,024
  - Cost Share: \$3,626,126
    - Financial support: \$53,000 + salary
    - In-kind support



# Contact Information



**George H. Born**

George.Born@Colorado.edu

**Bradley Cheetham**

Bradley.Cheetham@Colorado.edu

**Juliana Feldhacker**

Juliana.Feldhacker@Colorado.edu



# TASK #257. Development of Masters Level Commercial Launch, On-orbit, and Re-entry Operations Instruction Criteria



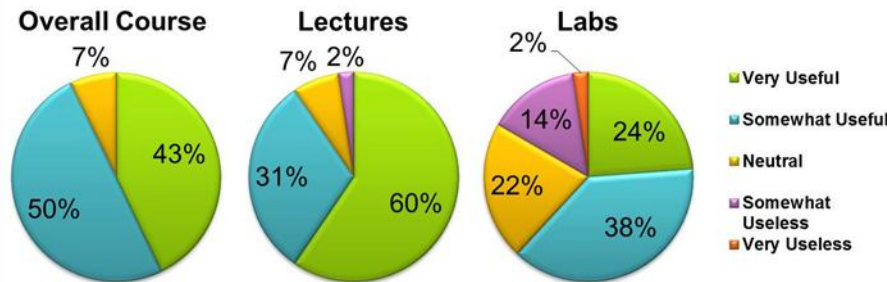
## MAJOR MILESTONES - PAST

- Solicited industry input
- Completed development of lecture course
- 1<sup>st</sup> offering of lecture course
- Refinement of lecture course
- 2<sup>nd</sup> offering of lecture course

## MAJOR MILESTONES - FUTURE

- Fall 2012 – Complete construction of operations center
- Fall 2012 – Complete development of lab course
- Spring 2012 – 1<sup>st</sup> offering of lab course
- Summer/Fall 2013 – Formalize Commercial Spaceflight Operations graduate certificate

## STUDENT COURSE SATISFACTION SURVEY RESULTS



## BUDGET

- FY13 - FY14 - FY15 - FY16 - FY17
- \$33,486\* - \$75K - \$75K - \$0 - \$0K
- Cost-sharing to date:
  - \$3,626,126
  - Including financial and in-kind
- \* these funds support this task through May 31, 2013 only