COE CST First Annual Technical Meeting:

Commercial Spaceflight Operations Curriculum Development

Task 257: Masters’s Ops Lab
George H. Born

11.09.2011
Overview

- Team Members
- Task Purpose/Objectives
- Process
- Results and Output
- Feedback
- Next Steps
- Contact Information
Team Members

- **George H. Born** – Director, Colorado Center for Astrodynamics Research
- **Bradley Cheetham** – Graduate Research Assistant, Aerospace Engineering Sciences
- **Jules Feldhacker** – Graduate Research Assistant, Aerospace Engineering Sciences
- **Emil Heeren** – Visiting Scholar
- **Jon Herman** – Visiting Scholar/Graduate Research Assistant
Partnering Organizations

agi
Analysis software for land, sea, air, & space

SAS

SPACEX

Orbital

ULA
United Launch Alliance

CLEARCHANNEL SATELLITE

LOCKHEED MARTIN

JPL
Jet Propulsion Laboratory
California Institute of Technology

GeoEye

CLASP
LABORATORY FOR ATMOSPHERIC AND SPACE PHYSICS
UNIVERSITY OF COLORADO AT BOULDER

Sierra Nevada Corporation

Space Systems

BIGELOW AEROSPACE

SRi
SUBORBITAL SCIENCE

DIGITALGLOBE

arianespace

service & solutions

SPACE FOUNDATION

NASA

ALTIUS SPACE MACHINES
Purpose of Task

- Objectives:
  - Develop one-semester course
  - Develop one-semester lab
  - Refine content based on student and industry feedback
  - Standardize and establish Graduate Certificate
  - Increase collaboration between academia and industry
FAA COE CST Objectives

• Research
  • Student research projects investigate current constraints and explore potential solutions

• Training
  • Preparing students to enter industry with commercial perspective

• Outreach
  • Educating academia about developments in commercial space
Process/Approach

- Draft academic objectives based on industry discussion
- Solicit feedback on academic objectives
  - AIAA Spaceflight Operations Meeting
  - Over 21 industry/partner organizations
- Define curriculum topics and solicit feedback
- Identify subject matter experts to develop and deliver content
Academic Objectives - Overall

Course shall serve as a bridge between **theory** and **application** to prepare real world problem solvers
Academic Objectives

• Comprehension of total mission sequence
  • Mission initiation to end of mission
    • Course = overview
    • Lab = implement

• Constraints on design and operations (both understand and identify)
  • Technical – what can you do
  • Policy/Legal – what are you allowed to do
  • Business – what can you afford to do
  • Practical – how do you adapt
Academic Objectives

• Understanding of and insight into current industry practices
  • Comprehension of current industry practices
    • Past to present
      • Keep vs Change?
    • Critical review of potential improvements

• Overview of project management and team dynamics

• Cross cutting theme (through all objectives): RISK
  • Quantify and understand risk vs cost
## Course Schedule

<table>
<thead>
<tr>
<th>Theme</th>
<th>Topic/Subject</th>
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<tr>
<td><strong>Background</strong></td>
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<tr>
<td>Lecture 1</td>
<td>Course introduction</td>
<td>Cheetham/Born - CU</td>
<td>8.23.2011</td>
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<tr>
<td>Lecture 2</td>
<td>Industry &amp; Government intro</td>
<td>Steve Lindsey - SNC</td>
<td>8.25.2011</td>
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<tr>
<td>Lecture 3</td>
<td>Industry &amp; Government Challenges</td>
<td>Mike Gold – Bigelow Aerospace</td>
<td>8.30.2011</td>
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<tr>
<th>Launch</th>
<th>Topic/Subject</th>
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<tbody>
<tr>
<td>Lecture 2</td>
<td>Launch Vehicle Overview</td>
<td>Emil Heeren - CU</td>
<td>9.6.2011</td>
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<td>Lecture 4</td>
<td>Human launch considerations</td>
<td>John Reed - ULA</td>
<td>9.13.2011</td>
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<td>Lecture 5</td>
<td>Suborbital flight</td>
<td>Jon Turnipseed – Virgin Galactic</td>
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## Course Schedule

<table>
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<tr>
<th>Operations</th>
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<td>Lecture 1</td>
<td>On-Orbit -</td>
<td>Cancelled</td>
<td>9.20.2011</td>
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<td></td>
<td>Attitude/Rendezvous &amp; Docking</td>
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<tr>
<td>Lecture 2</td>
<td>Operations Overview</td>
<td>Bill Possel - LASP</td>
<td>9.22.2011</td>
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<td>Lecture 4</td>
<td>Spacecraft Subsystems</td>
<td>Michael Begley - LMCO</td>
<td>9.29.2011</td>
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<tr>
<td>Lecture 5</td>
<td>Spacecraft Subsystems II</td>
<td>Scott Mitchell – Ball Aerospace</td>
<td>10.4.2011</td>
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<td>Lecture 6</td>
<td>Industry Overview</td>
<td>Alan Stern - SwRI</td>
<td>10.6.2011</td>
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<td>Lecture 7</td>
<td>Payloads</td>
<td>Martin Taylor/Michael Mahoney - GeoEye</td>
<td>10.11.2011</td>
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<td>Lecture 8</td>
<td>Human Factors</td>
<td>Jim Voss - SNC</td>
<td>10.13.2011</td>
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<td>Lecture 9</td>
<td>On-Orbit - OD</td>
<td>Jeff Parker - JPL</td>
<td>10.18.2011</td>
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<tr>
<td>Lecture 10</td>
<td>Conjunction/Debris</td>
<td>Dave Vallado - AGI</td>
<td>10.20.2011</td>
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<td>Lecture 11</td>
<td>Ground station operations/design</td>
<td>Byron Miller – Clear Channel Satellite</td>
<td>10.25.2011</td>
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<tr>
<th>End-of-Mission</th>
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<tr>
<td>Lecture 1</td>
<td>Re-entry Overview/Review</td>
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<tr>
<td>Lecture 2</td>
<td>End-of-mission options</td>
<td>Larry Williams/Scott Henderson - SpaceX</td>
<td>11.1.2011</td>
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<td>Lecture 3</td>
<td>Quality Sciences/Cost-Plus vs. Commercial Contracting</td>
<td>Jeff Luftig - CU</td>
<td>11.3.2011</td>
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## Course Schedule

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<th>Mission Planning</th>
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<td>Lecture 1</td>
<td>Mission design</td>
<td>Mike McGrath - LASP</td>
<td>11.8.2011</td>
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<td>Lecture 2</td>
<td>Construction/Integration Overview</td>
<td>David Termohlen – Orbital Sciences Corp.</td>
<td>11.10.2011</td>
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<td>Lecture 4</td>
<td>Financial/Contracting Overview</td>
<td>Clay Mowry - Arianespace</td>
<td>11.29.2011</td>
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<th>Misc. Topics</th>
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<tr>
<td>Lecture 1</td>
<td>On-orbit Fuel Depots/Satellite Servicing</td>
<td>Jon Goff – Altius Space Machines</td>
<td>11.17.2011</td>
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<th>Conclusions</th>
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<tr>
<td>Lecture 1</td>
<td>Overview/Summary/Current issues</td>
<td>Mark Sirangelo - SNC</td>
<td>12.1.2011</td>
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<td>Lecture 2</td>
<td>Space Policy Overview</td>
<td>Bill Possel - LASP</td>
<td>12.6.2011</td>
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<tr>
<td>Lecture 3</td>
<td>Course Summary</td>
<td>Cheetham - CU</td>
<td>12.8.2011</td>
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<tr>
<td>Student Presentations</td>
<td>Individual research projects</td>
<td>Selected by students and assisted by industry</td>
<td>FINALS</td>
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COE CST First Annual Technical Meeting (ATM1)
November 9 & 10, 2011
Student Products

• Total students enrolled: 28
  • 19 on-campus
  • 9 off-campus (enabled by distance technology)

• Assignments
  • Weekly discussion
  • 4 Open Ended Assignments
  • 4 Labs
  • 1 Research Paper
Student Feedback

Course Content
Overall

- Very - 42%
- Somewhat - 54%
- Neutral - 4%

Lectures

- Very - 50%
- Somewhat - 42%
- Neutral/Below - 8%

Comparison

- Exceeds - 46%
- Same - 42%
- Below - 12%

“I really enjoy this course. It is information that every aerospace engineer should know.”

“It is extremely valuable to gain insight from professionals, as opposed to the usually somewhat-limited academic presentation of material.”

“I am finishing my Master’s degree this semester and a lot of this information is useful to me in understanding how the industry works.”

“I like the variety of topics that are covered.”

“This course has really stood out to me so far in how everything is very investigative.”
Next Steps

• Spring-Summer 2012:
  • Continued development/revision of course
  • Initiate development of lab portion
• Fall 2012
  • Offer lecture for second time
• Spring 2013
  • Offer lab for first time
• Continue alternating course/lab
  • Formalize Certificate program
Contact Information

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Questions