Today’s Students – Tomorrow’s Engineers: Jump-Starting the Transition from University to Industry

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“Houston, We have a problem”

- Too few higher education STEM* graduates to fill current and future space science and aerospace engineering workforce needs with highly qualified US citizens
- New hires lacking in critical skills: e.g. Systems Engineering, Project Management
- Inadequacy of workgroup skills: hands-on experience, interdisciplinary teaming, rigorous documentation and document control, communications skills.
- Employer impact: Costly training and lost productive time during the post-hire months

* STEM = Science, Technology, Engineering, Mathematics
Potential Solutions

- Alter top level policy
- Adopt paradigm-shifting legislation
- Throw money at the problem
- Grass Roots approach
  - Evolve space systems training centers-of-excellence with hands-on emphasis
  - Students taken beyond the traditional lecture-based structured-laboratory university curriculum through hands-on workgroup immersion in technically challenging tasks gain the required skills
  - As the “great” research universities turn attention to more glamorous, cutting edge pursuits, the mid-tier of research active PhD-granting institutions is taking up the challenge.

Active hands-on involvement accompanied by decision-making authority is a key attribute to success
How does one build the needed skills?

- By putting the students in charge
  - If it is their project; given authority, they will take responsibility for the success of the project.
- By providing professional mentoring

Experience is the best teacher: finding out what works (and what doesn’t) by trial and error enhances learning. Making mistakes, experiencing failure is necessary.
Traditional Pedagogical Approach is Insufficient

- Lecture-based instruction with structured laboratories is necessary but not sufficient
- The Aerospace discipline requires extraordinary discipline, adherence to specific processes and procedures, and an extraordinary level of interdisciplinary teaming by its workforce.
- The traditional university curriculum inadequately supplies the full tool-set for the fresh-out to immediately practice the discipline
  - Missing: creatively explore full technical solution space, defense of chosen approach, systems-level cognizance, self-confidence, presentation and communications skills, importance of documentation and configuration management, customer-client relations, schedule adherence, interpersonal workgroup skills
The Montana Spiral Development Program --
Founded in Science, Fortified by Formal
Engineering Practice

- Immersion of students in actual hands-on practice; cradle-to-grave project lifecycle
- Manage, design, build, test, rebuild, fly and operate space flight systems as undergraduate students.
- Multidisciplinary workgroups performing in a project-based cooperative learning environment fosters *esprit de corps*.
- Acquisition of aerospace skills concurrently with formal curriculum
- Tiered program: 2-4 years; spiraling through the development cycle multiple times with progressively more challenging projects and increasing individual responsibility.
- Each turn of the spiral results in flight and operations
- Students mentored by professionals
The Spiral Development Pyramid

- Interplanetary or planetary orbiters, landers, crawlers: Flights per year .05-.1
- Earth Orbital Missions: .2-.5
- Sounding Rocket Payloads: .5-2
- High Altitude Float Balloons: 1-2
- Latex Sounding Balloons: 8-12

The Montana Space Science and Engineering Laboratory’s Tiered Pyramid for Hands-On Space Flight
Tier 1 -- Suborbital under local control

- Local control -- fly on our own flight platforms
- Fly in our own “backyard”
- Very low cost
- Low(er) tech hardware
- Start-up students incubator

- In-house high power rockets:
  - Engineering Design Challenges
  - Payload flight opportunities
  - Recovery Systems
Tier 1: Balloon Outreach, Research, Education And Land Imaging System (BOREALIS)

High Altitude Balloon Program: Frequent flight opportunities, Montana Launch sites

✓ Tier 1 Characteristics
✓ Low cost
✓ Local venues
✓ Frequent flights/reflights
✓ Frequent field activities (up to ~12 flights or reflights per yr) provide rapid spiral hardware development
✓ Getting new students “hooked” by the excitement of flight
✓ Create challenging (yet doable) experiments
✓ Development of interdisciplinary teaming skills
Near Space Imagery
Tier 2: High Altitude Float Balloons (more big boys with big toys)

- Tier 2 High Altitude float balloons (NASA launched)
  - Ratchet up the challenge
  - Proposal and report writing
  - Dealing with external customer and external launch provider
  - Teamwork/workgroup skills develop further
  - The beginnings of leadership develop
Tier 3 -- Suborbital; “the big boys with big toys”

- Advance technical skills
- More challenging engineering
- Advanced hardware sophistication
- Develop management and systems engineering skills
- External interactions with customers & professionals
Recent Orbital (Tier 4) Projects

- 1 kg nanosatellites: MEROPE, Explorer-1 Prime
  - Reflights of the Explorer-1 science mission (Radiation Belts)

30 - 50 kg microsatellites:
- **Maia**: Monitor variations in the radiation belts
- **SpaceBuoy**: Ionospheric density, Total Electron Content

**BarnacleSat** – Launched into orbit outside the fairing, an electrodynamic tether deorbiter

Actively monitored materials and powered electronics testing on ISS aboard **MISSE-6**
Current Tier 4 Flight Projects (deliveries next 6-mo)

- AFRL/AIAA University Nanosat - 5 Program
- “Spacebuoy” -- A 50 kg space mission for Space Weather
- Ionospheric density and Total Electron Content
- Montana Space Grant Consortium Project
- “Explorer-1 Prime” -- 50th anniversary reflight of the science mission of Explorer-1
- Van Allen Radiation Belt dynamics
Tier 4: MISSE-6 on International Space Station: Two active, powered experiments in orbit

- **Left**: Frame capture of MISSE-6B (AO-UV Tray) taken during EVA on March 22, 2008 by Astronaut Robert Behnken’s Helmet video camera upon deployment. SSEL’s materials experiment is highlighted by white rectangle.
- **Right**: SSEL’s materials experiment in the lab before integration with MISSE-6
As Endeavor Undocked March 24, 2008
(two days exposed in space)
Tier 4+ Major Missions/Big Science (June 2008 NASA selection)

- NASA Small Explorer -- $100M-class
- Competitively selected June 2008
- MSU Partnering with an aerospace prime-led team
- Solar Physics Mission Instrument role for SSEL
- AND Student Collaboration Investigation with flight hardware for SSEL
- NASA-funded 6-mo Phase A Concept study

Gegenschein Imager Student Collaboration

Distribution and Dynamics of interplanetary Dust

- 1 Mpixel cooled CMOS Camera
- sub arc-second pointing stability on s/c
Tier 4: Explorer-1 Prime
Radiation Belt Dynamics

A candidate P-PoD Payload for NASA’s first university rideshare - 2009

View our Explorer-1 [Prime] video on ‘You Tube’:
http://www.youtube.com/watch?v=x2STzHXv9IY
The Partnership Proposition: The role of government and industry

- Financial support for these extracurricular endeavors fall beyond the university’s instructional budget
- University provides philosophical commitment, physical infrastructure
- Government Role:
  - equipment, grants, contracts: fundamental research
  - access to GFE
  - access to specialized facilities on non-interference basis.
  - tax incentives to industry
- Industry Role
  - directed research in partnership with university laboratory
  - challenging technical problems
  - access to professionals (technical interchange and mentoring)
  - access to idle facilities (non-interference)
  - donations of surplus equipment

EVERYONE WINS
Summary -- Jump-starting the Transition from University to Industry

- A growing need for young highly-trained aerospace professionals (systems engineering, project management) -- replacing retirees
- Hands-on experiential programs at mid-tier research-active universities provide an immediate solution.
- Traditional academic curriculum is generally insufficient to provide the required workgroup skills required of (aero)space professionals. Pre-employment experience is essential.
- Montana State University’s approach through a hands-on training spiral of flight hardware development with increasing sophistication produces workforce-ready graduates
- Stakeholders: Government and industry support is essential; through directed research, partnering on IRAD tasks, mentoring, and in-kind support.
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Design, Build, Test, Fly
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