Development of an intellectually responsive aerospace workforce for the emerging AAM enterprise

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Aerospace engineers engaged with large & growing industry

Academia
- 78 schools in US offer aerospace degrees
- Undergraduate engineering enrollment ≈ 600,000 (=22,000 in aerospace)
- ≈100,00 Bachelor degrees/yr (=4,000 aerospace)
- ≈60,000 M.S degrees/yr (=1500 aerospace)
- ≈12,000 Ph.D/yr (350 aerospace)

Industry
- 845,000 direct jobs
- $872 billion in sales
- $146 billion in exports
- 346 companies in AIA
- New initiatives (e.g., FVL)

Government
- DoD Labs
- NASA
- DOE Labs

eVTOL needs?
- Fragmented industry
- Small businesses
- Large companies

Bureau of Labor Statistics

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Average ~ 6%/year
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**COVID-19 impact?**

**Bureau of Labor Statistics**

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<td>$116,500 per year $56.01 per hour</td>
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<td><strong>Typical Entry-Level Education</strong></td>
<td>Bachelor's degree</td>
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<td><strong>Work Experience in a Related Occupation</strong></td>
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<td><strong>On-the-job Training</strong></td>
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<td><strong>Number of Jobs, 2018</strong></td>
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<td><strong>Job Outlook, 2018-28</strong></td>
<td>2½ (Slower than average)</td>
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Aerospace Engineering today is built primarily around [integration of] “Breguet disciplines”

The Breguet Range Equation:

\[ R = \frac{\eta_i}{g c_p} \frac{C_L}{C_D} \ln \frac{W_1}{W_2} \]

- Propulsion
- Structures
- Aero

Core Aero Engineering disciplines

Courtesy of: Dr. John Langford, CEO, Electra.aero, Inc.

Credit: Joby Aviation
Credit: Airbus/Vahana
Need to expand aero education to include more software, airspace management, and operational infrastructure in an integrated, system of systems approach

- Establishing, certifying, and growing core competency in Intelligent Systems, including traffic management
- Robust system design + failure modes and effects analyses
- Smart heuristics and algorithms
- Pattern recognition derived input (AI)
- Human-machine interactions
- Cyber security
- Proof that it works: verifiable, certifiable processes
How do we get from here to there?

Think holistically, be agile and flexible with curriculum and training options

Combine strength of different university programs, training opportunities, experimental facilities, innovation incubators, etc.

Address continuing education by certificate programs, online training, advanced degrees from university teams

Build on the infrastructure we have in place (VLRCOEs, AFRL Collaborative Centers, industry partnerships, etc.)

Foster further (pre-competitive) fundamental research with close industry/government participation

1. Unsteady CFD Model Reduction with Error Estimation
2. Appropriate Fidelity Level Modeling of Aircraft with Very Flexible Wings
3. Geometrically Nonlinear Effects and Dynamic Aeroelasticity in MDO
4. Aeroelastic Tailoring for Gust Loads and Maneuver Loads
5. Control Oriented Modeling and Requirements Development
6. Nonlinear Control Development for MLA/GLA/Shape Control and Flight Demonstration
“Innovation is a battlefield”

W. Roper

- To win the fight, we need to have the best prepared “warfighters”
- U.S. universities have the infrastructure to spearhead the type of education and training needed for AAM workforce
- Sustained government and private financial support essential to enable
  - Continued basic education
  - Advanced research
  - Enhanced training options
- Flexible and agile curriculum from consortium of universities can provide portfolio of topics required for AAM workforce education and training

“Academia is our training camp”

C. Cesnik