NASA / FAA eVTOL Crashworthiness Workshop Series: Virtual Meeting #2: 
Professional Organizations, Stakeholders and Regulatory Approaches for Crashworthiness for eVTOL Vehicles 

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Introduction

• Second in a series of workshops
  – The first provided the historical perspective and overall regulatory considerations

• This installment will review the considerations for vehicle crashworthiness from the perspective of Professional Organizations and eVTOL stakeholders

• Present current Regulatory Approaches as they pertain to certification efforts with specific regard to Crashworthiness
  – U.S and European perspective
Meeting Logistics

- Speakers and Moderators are on TEAMS meeting
- Participants will be using YouTube link available on website
- Enter your name and contact information in the ConferenceIO poll so that you can be kept up to date on future meetings
- Participants can ask questions using ConferenceIO link available on website  
  - Questions will be cleared between speakers, but all questions (answered and unanswered) will be saved and used for potential discussion topics for future workshop/meetings
- NASA or FAA will introduce each speaker and ask questions to that speaker at the end of their presentation
- Speakers will screen-share their presentation on the TEAMS meeting

[Meeting website: https://nari.arc.nasa.gov/crashworthiness]
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<thead>
<tr>
<th>Speaker</th>
<th>Organization</th>
<th>Time (Eastern)</th>
<th>Presentation Title</th>
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<tr>
<td>Justin Littell / Joseph Pellettiere</td>
<td>NASA / FAA</td>
<td>12:00 – 12:15</td>
<td>Introduction and the Need for Crashworthiness in eVTOL applications</td>
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<tr>
<td>Mike Hirschberg</td>
<td>Vertical Flight Society (VFS)</td>
<td>12:15 – 12:45</td>
<td>Enabling a Safe Electric VTOL Revolution</td>
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<tr>
<td>Lowell Foster</td>
<td>General Aviation Manufacturers Association (GAMA)</td>
<td>12:45 – 13:15</td>
<td>Opportunities for Crashworthiness Features in New Aircraft</td>
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<td>Ryan Naru</td>
<td>Uber</td>
<td>13:15 – 13:45</td>
<td>Operational Expectations of eVTOL Aircraft</td>
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<td>Break</td>
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<td>13:45 – 14:00</td>
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<tr>
<td>Bob Stegeman</td>
<td>Federal Aviation Administration (FAA)</td>
<td>14:00 – 14:30</td>
<td>EVTOL Crashworthiness Moving Forward</td>
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<tr>
<td>Aiko Duehne</td>
<td>European Union Aviation Safety Agency (EASA)</td>
<td>14:30 – 15:00</td>
<td>General Presentation: Special Condition VTOL</td>
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<tr>
<td>Eric Nottorf</td>
<td>ASTM International</td>
<td>15:00 – 15:30</td>
<td>ASTM F44 as Means of Compliance for Part 23</td>
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The Need for Crashworthiness in eVTOL Vehicles: Case Study

• A fall from only 14 feet (30 ft/s) has the capability of causing occupant injury if not protected
  – Impact shape from the below test is a current 14 CFR § 27.562 Regulation

The Need for Crashworthiness in eVTOL Vehicles: 
*Market Demand – Now and Upcoming*

- NASA Strategic Framework for On-Demand Air Mobility
  - Demand now and upcoming
    - 3,570,000 trips x 12 min / trip = 714,000 Flight Hours (FH) / year (2015 data)
    - 29,008,000 trips x 12 min / trip = 5.8M FH / year (2035 est)
- Booz-Allen-Hamilton study suggests 500B market value using best unconstrained scenarios
- UBER Elevate
  - 2,800 FH / year utilization
  - Long term 5000 units produced per year (2030s)
  - 14,000,000 FH / year (assume produced = utilized)
- NTSB data: 18.5M flight hours for 2017

- Points to tremendous growth in the coming years
The Need for Crashworthiness in eVTOL Vehicles: Public Perception – Crown Consulting

• Findings
  – Concerns fall into 5 categories – Safety being one of them
    • Others privacy, job security, environmental threats, noise and visual disruption
  – Consumers cite proven safety records and demonstrations as factors that would most increase their level of comfort

• Crown suggests 3 strategies that could help address public acceptance
  – Technology R&D – establish safety standards, focus on noise abatement and safety systems
  – Unified messaging – address public concerns and emphasize benefits
  – Proactive engagement with concerned groups – identify and reach out to groups with resistance to UAM
The Need for Crashworthiness in eVTOL Vehicles: Analysis Example

- Using 30 ft/s from NASA Case Study for impact velocity
- NASA RVLT Lift+Cruise baseline vs added occupant protection

**Carbon fiber structure**
- Non energy absorbing seat
- No other EA structure added

Injury loads approximately 1.5 x injury limits

**Carbon Airframe**
- Carbon/Kevlar hybrid structure
- Add stroking seat with seat foam
- Add energy attenuating subfloor

Injury loads 20% below injury limits

The Need for Crashworthiness in eVTOL Vehicles: Why Now?

• Now is the time
  – Early in the vehicle development cycle
  – Will pay great dividends in the future

• Expect that accidents will happen
  – Protect the occupants to ensure continued growth and acceptance

• Current regulatory framework is based upon other designs
  – This may change in the future depending on performance
  – Attention to system level safety now, will prepare for the future
Continued Engagement

• Stay tuned for information on future workshops
  – DoD considerations later this year
  – Application focused early next year
  – Possibly still on onsite working group meeting/discussion/tour in the spring