NASA / FAA eVTOL Crashworthiness Workshop Series: Virtual Meeting #2:

Professional Organizations, Stakeholders and Regulatory Approaches for Crashworthiness for eVTOL Vehicles

October 9, 2020

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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

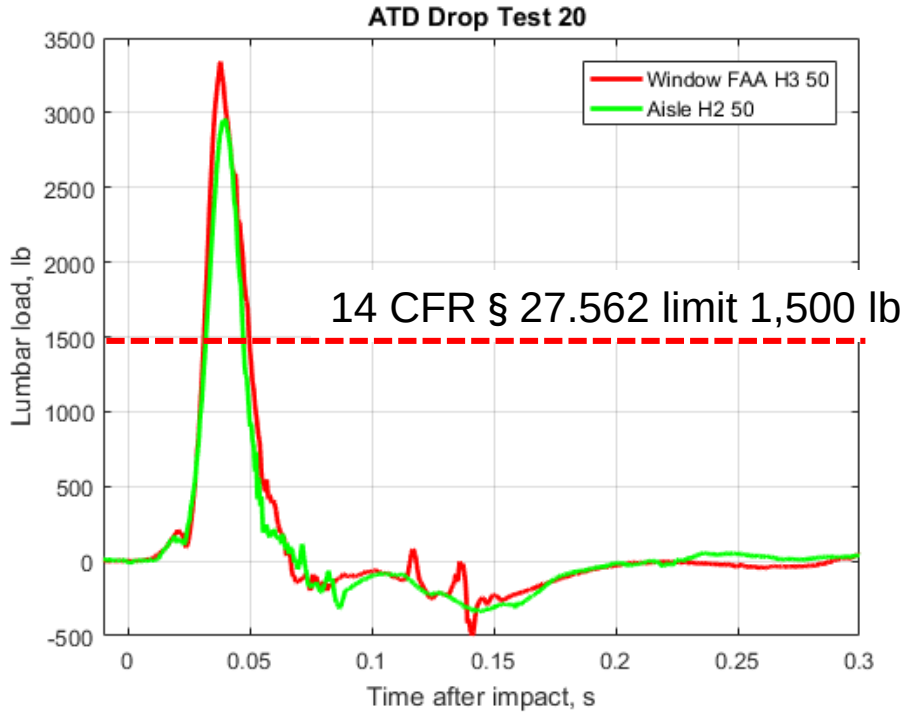
- Meeting website: https://nari.arc.nasa.gov/crashworthiness

Agenda – October 9, 2020

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

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



Littell, J.D. and M.S. Annett. "The Evaluation of Anthropomorphic Test Device Response under Vertical Loading." Proceedings from the American Helicopter Society International Annual Forum 74, Phoenix, AZ, May 14-17, 2018.

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

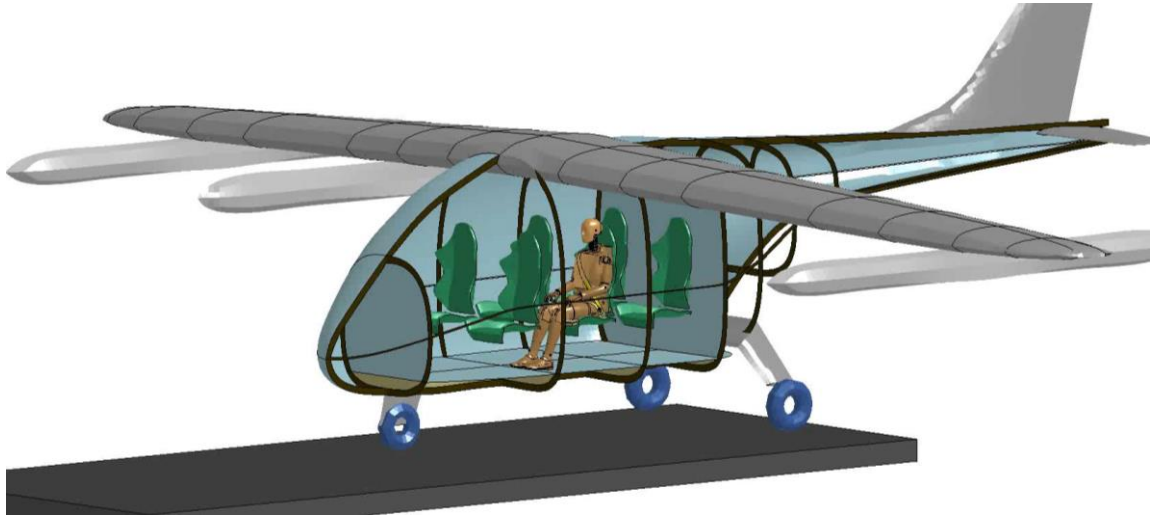
- Points to tremendous growth in the coming years

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

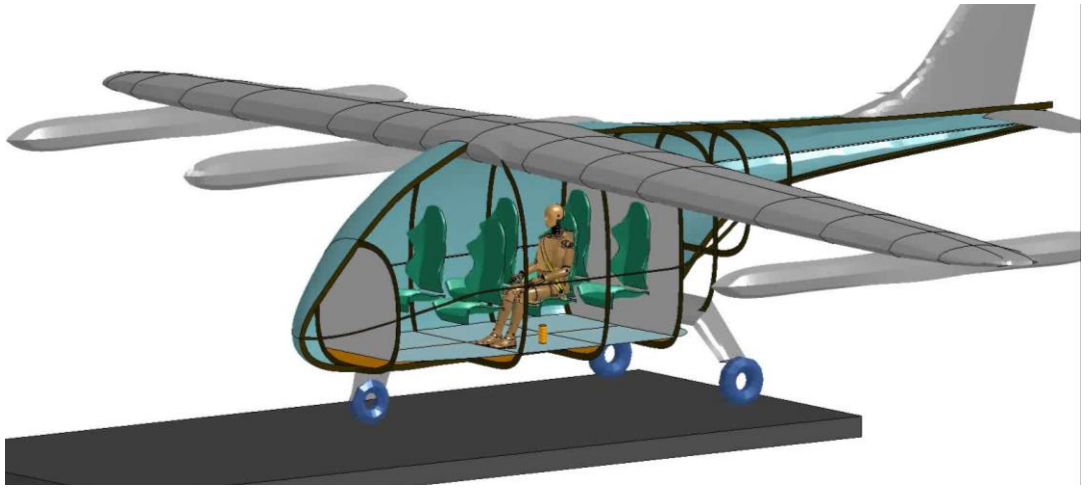
The Need for Crashworthiness in eVTOL Vehicles: *Analysis Example*

- 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

Putnam, J.B. and Littell, J.D. "Crashworthiness of a Lift plus Cruise eVTOL Vehicle Design within Dynamic Loading Environments." Presented at the Vertical Flight Society International Annual Forum 76

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