

A Comparative Analysis of Occupant Response Between Component and Full Vehicle Tests of Fokker F28 Aircraft Hardware

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Jacob Putnam Structural Dynamics Branch NASA Langley Research Center



### **Fokker F28 : Full Vehicle Drop Test**



Vehicle Specifications: 33,306 lb, 3+2 Seating, 85p capacity Test Conditions: 32 ft/s Vertical & 65 ft/s Horizontal Velocity







### **Protect The Occupant**



https://apex.aero/2015/07/22/airborne-improv

<u>Develop the tools and understanding to ensure new and novel aircraft keep</u> <u>occupants safe in an off-nominal event</u>



## FAA sponsored test to inform regulation

- Non-traditional aircraft development is expanding
  - Novel commercial aircraft designs Composites
  - Novel aerospace vehicles and transportation markets Urban Air Mobility
- No airframe level crashworthiness requirements
  - Current occupant protection certification relies on airframe similarity to traditional aircraft design (14 CFR 2X.562)
  - Novel design will necessitate vehicle testing
  - Goldilocks regulation: safe without being too restrictive



# Assess the fidelity of test needed to quantify aircraft crashworthiness

### **Vehicle Component Sections**





### **Component Level Fuselage Testing**



### **Front Section**

30 ft/s vertical drop



## <u>Wingbox</u>

30 ft/s vertical drop w/  $\sim$ 5° forward tilt







### Anthropomorphic Test Device (ATD) – "Crash Test Dummy"





### **ATDs Tested**



#### Hybrid II & III Family



http://2.bp.blogspot.com/\_DPT4DunakfY/RuvkpcPLGkl/AAAAAAABFs/8KzATo3pDrA/s400/dummy.family.500.jpg

- Hybrid II

- Hybrid III FAA
- Hybrid III 95<sup>th</sup>
- Hybrid III 5<sup>th</sup>
- Hybrid III 3 y/o
- Hybrid III 6 y/o
- Hybrid III 10 y/o

#### <u>WIAMAN</u>



https://www.dtsweb.com/project/wiaman/





https://www.humaneticsatd.com/crash-test-dummies/frontal-impact/thor-50 https://www-esv.nhtsa.dot.gov/Proceedings/24/files/24ESV-000325.PDF

#### Various Child ATD's



https://www.humaneticsatd.com/crash-test-dummies/children/q-series

- Q1 - LODC - CRABI





## **ATD Injury Metric Evaluation**



- Injury metrics calculated for Hybrid II and FAA Hybrid III 50<sup>th</sup> ATDs
  - Lumbar Load Criteria : Compressive force measured at the L-5 vertebra approximate location
  - HIC (Head Injury Criteria) : Resultant acceleration measured at the Head CG
  - Nij (Neck Injury Criteria) : Moment and forces measured at the neck Occipital Condyle location



### **ATD Response – Front Section**



### **Fuselage Section**



#### **Full Vehicle**



### **ATD Response – Wingbox**



### **Fuselage Section**



#### **Full Vehicle**



### ATD Response / Lumbar Load – Overall Comparison







- Full vehicle test resulted in higher lumbar loads across all sections
  - Increased stiffness of complete fuselage
  - Horizontal velocity effects on compressive lumbar load change in ATD position with respect to seat frame
- Higher loads in Wingbox section observed in component tests were not observed in the full vehicle
  - Section stiffness differences reduced with complete fuselage
  - Rotation of full vehicle on impact increased frontal impact velocity

## Seat Location: Lumbar Load Comparison



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- Overhanging seat produced lower lumbar loads in both component and full vehicle tests
- · Associated with increased seat compliance under vertical load
  - Seat deformation observed in all test configurations



#### Front Section Test



#### Full Vehicle Test

### **Occupant Position: Bracing vs Upright**



### **Fuselage Section**









### **Occupant Position : Human Model Evaluation**





### Conclusions



- Significant differences in occupant response observed between component and full vehicle testing
  - Full vehicle test results in increased occupant loading
  - Opposite trends observed in loading differences between fuselage regions
- Difference driven by differences in structure and conditions
  - Increased stiffness in full vehicle drive higher vertical loads into occupant system
  - Forward motion changes ATD/occupant position with respect to more rigid components of the seat frame
- Overhanging seat reduces occupant loading in each test configuration
- Braced positioning in full vehicle test presented trade-off between neck and spinal compression risk within the full vehicle test condition



## **Questions?**

Jacob Putnam jacob.b.putnam@nasa.gov 757.864.9480





- Full vehicle test resulted in severe neck bending in the braced ATD
  - Combined forward/downward torso motion drove compression and extension into cervical spine
- Reduction to lumbar compressive load in braced position traded for increased risk in other areas
  - Neck injury risk dramatically increased
  - Risk due to lumbar moment / shear forces not quantified in current metrics
- Human model exhibited increased spinal compliance compared to ATD
  - Reduced head strike in upright configuration
  - Similar neck bending in braced configuration

## ATD Configuration : Hybrid III 5<sup>th</sup> & 95th



### **Fuselage Section**



#### **Full Vehicle**



### **ATD Response / Lumbar Load – Front Section**





### **ATD Response / Lumbar Load – Wingbox Section**



