Crashworthiness Research Programs at the FAA

Federal Aviation Administration

Fokker F28

Presented to: FAA Fire and Cabin Safety

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Date: October 2019

Overview

- **Previous experience**
- **Background**
- **Current test programs – NASA Collaboration**
  - Fokker F28
    - 2 Barrel drops
    - Seat sled tests
    - Full scale test

Drop Test of ATR 42 - Video

Drop Test of Shorts 3-30 - Video

Rulemaking Background

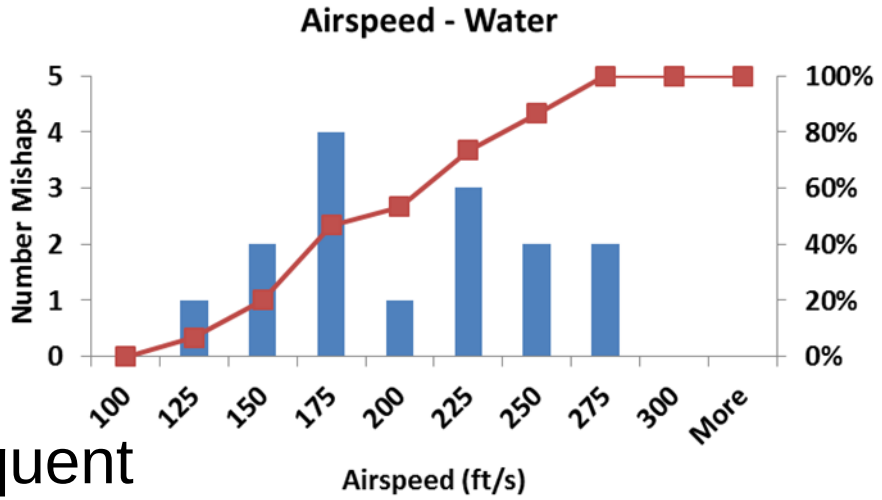
- **No Airframe level crashworthiness requirement**
- **Occupant protection covered under 14 CFR 2X.562**
  - Which assumes acceptable airframe crashworthiness
- **Aviation Rulemaking Advisory Committee tasked to make recommendations for regulations and guidance Crashworthiness and Ditching**

Survivable Crash Events

Ditching History

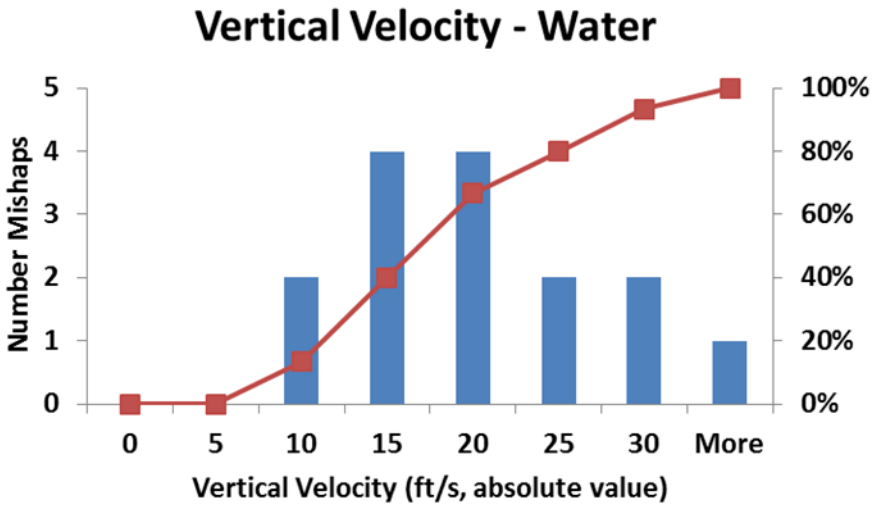
Ditching Scenario (22 Mishaps studied in detail)	Percent
Planned Ditch With Power (A)	14
Planned Ditch Without Power (B)	32
Landing Short in Water (C)	23
Level Flight into Water After Takeoff (D)	5
Runway Overrun (E)	27

- Scenarios A-C



- Landing without power very frequent
- Distance from shore very close

Distance of Impact From the Shore	Distance (miles)
Average	3.3
Median	0.4
Greatest	30.0
Least	0.0 (shoreline)



Crashworthiness Certification Today

- **Applies to novel or unusual designs**
- **Certain recent transport airplanes have had special conditions**
  - Maintain survivable volume
  - Maintain occupant loads
  - Retention of items of mass
  - Maintain egress paths
- **Assessment is comparative to existing airplane designs**

Objective of Rulemaking

- **Maintain** the crashworthiness and ditching level of safety already achieved by most airplanes designed using traditional metallic skin-stringer-frame construction to:
  - Accommodate new technology
    - New materials (e.g., non-metallics, hybrids, etc.)
    - New structural configurations (e.g., multiple decks, blended wing, honey comb, external fuel tanks, etc.)
    - Replace existing special conditions: ensure crashworthiness protection is equivalent to that provided by traditionally-configured airplanes, however address open issues
  - Update regulations and address unplanned ditching and inadvertent water impact events
    - Existing ditching rules are obsolete based on FAA, TCCA, UK CAA research findings over the past 30 years
    - Need to ensure that assumed ditching conditions are consistent with airplane performance

ARAC Tasking – Crashworthiness and Ditching

Develop recommendations for **Airframe-level crashworthiness and ditching standards and advisory material** for Title 14, Code of Federal Regulations (14 CFR) part 25

- Evaluate and recommend updates to existing regulations and associated regulatory guidance
- Provide recommendations for new standards and advisory material
- Estimate costs/benefits

ARAC Status

- **Report was approved by the ARAC on September 20, 2018**
- **FAA has accepted the Recommendations**
- **FAA is considering how best to utilize the recommendations**

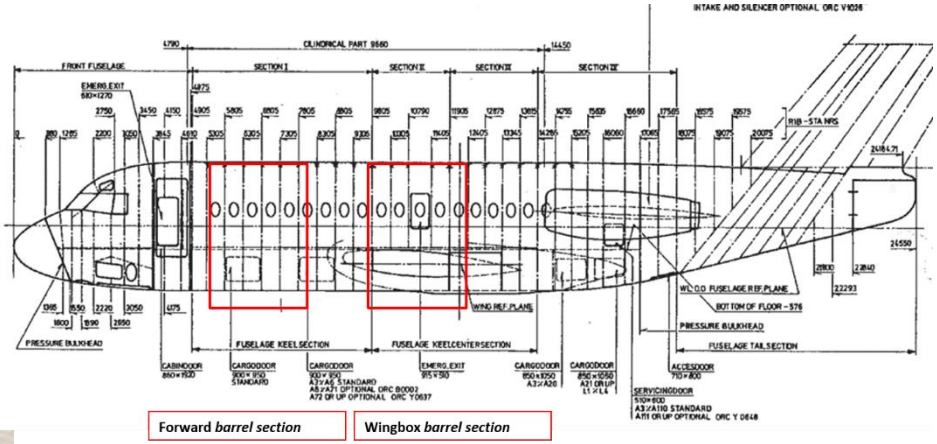
https://www.faa.gov/regulations_policies/rulemaking/committees/documents/media/ARAC-TACDWG_FAA_Report-Final_September20_2018ARAC%20W%20AFA%20DISSENT.pdf

Collaboration with NASA

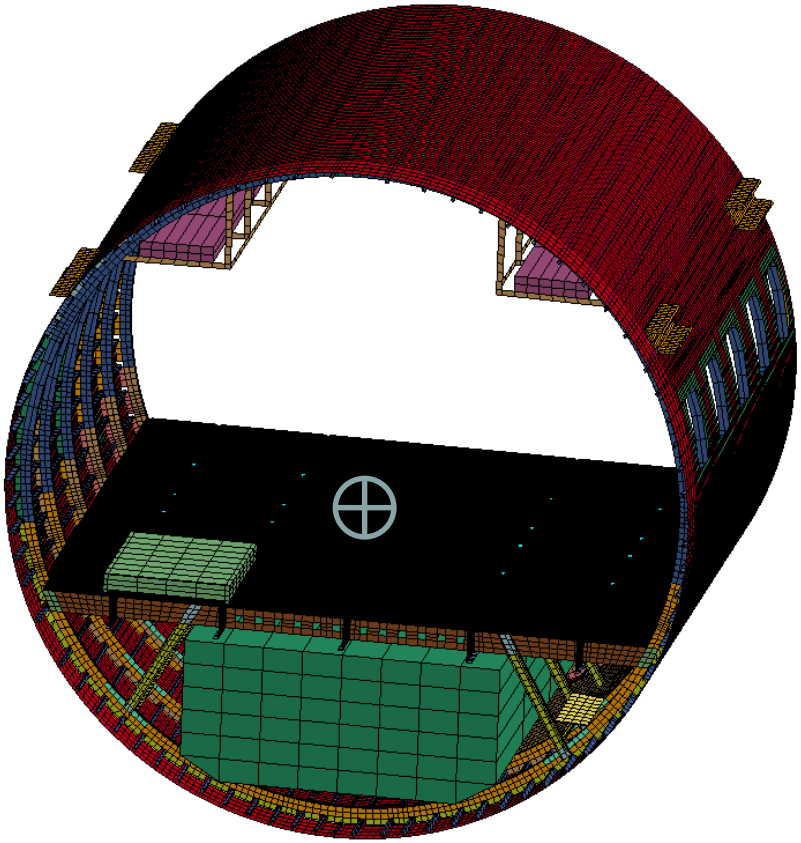
- **Investigate comparison of barrel tests with full scale tests**
- **Compare test results with analytical results**
- **Collect data for regional jet sized impacts – metallic baseline**

Fokker F28 – Regional Jet Impact

- Fokker F28
  - Compare barrel drop to full aircraft
  - Compare different drop conditions
  - Compare testing with modeling and simulation



F28 Model



- Analytical model to determine test conditions
  - Velocity
  - Surface
  - Configuration

F28 Barrel Sections

Forward

- **Target impact**
  - 30 ft/s vertical
  - Soil
  - Underfloor baggage

Wingbox

- **Emergency exit door**
- **Target impact**
  - 10º sloped soil

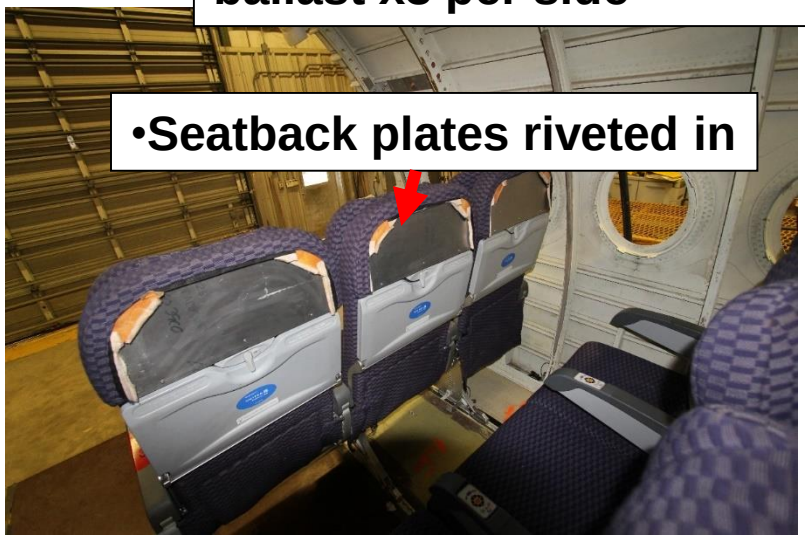
Seats

- Removed from service
- Modified
  - Cut down
  - Leg spacing differences

Large Overhang

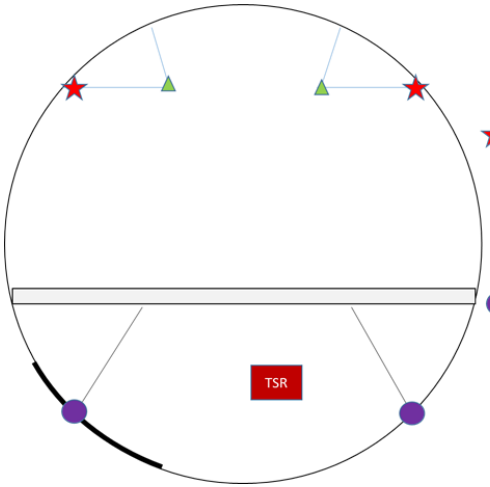
Buildup progress

•25lb instrumented lead ballast x3 per side



•Seatback plates riveted in

F28 Instrumentation

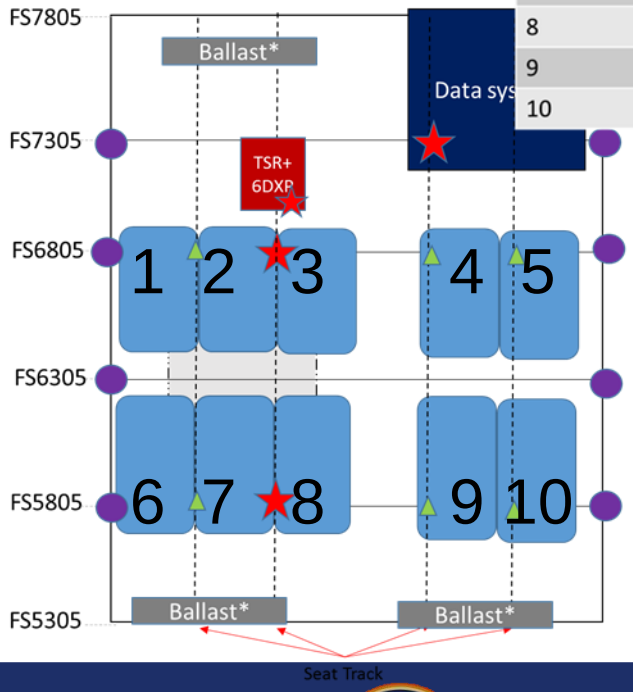


x,z accelerometer on overhead bin attachments on sections 6305 and 6805

z accelerometer on bin ballast on sections 6305 and 6805

Z accelerometer on stanchion to barrel attachment on frames 5805 and 6805

Location	Owner	ATD
1	NASA	H3 5th
2	NASA	H3 95th
3	FAA	FAA H3 50th
4	FAA	H2 50th
5	NASA	H2 50th
6	FAA	H2 50th
7	NASA	H2 50th
8	NASA	FAA H3 50th
9	NASA	H2 50th
10	FAA	FAA H3 50th



x,z accelerometer on seat track

z accelerometer on seat track

Z accelerometer on frame section

*Ballast added as needed

F28 Forward Drop Test

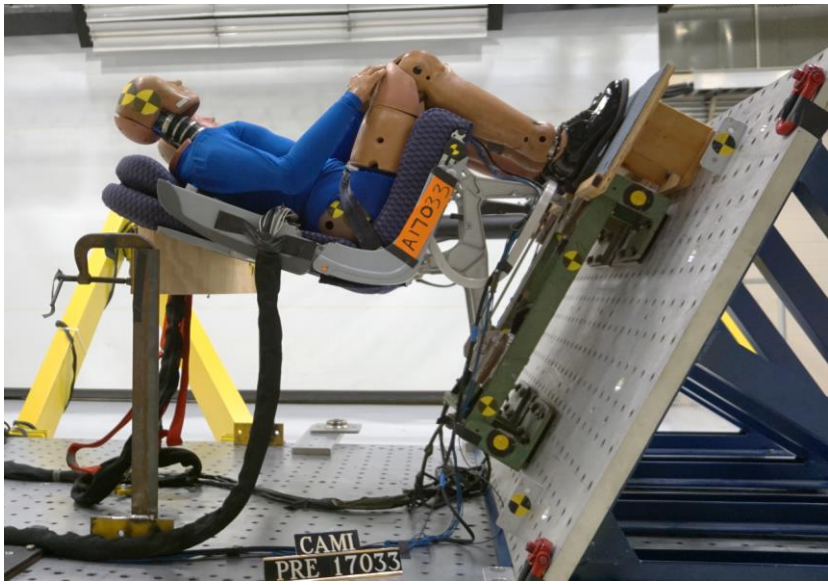
F28 Wingbox Drop test

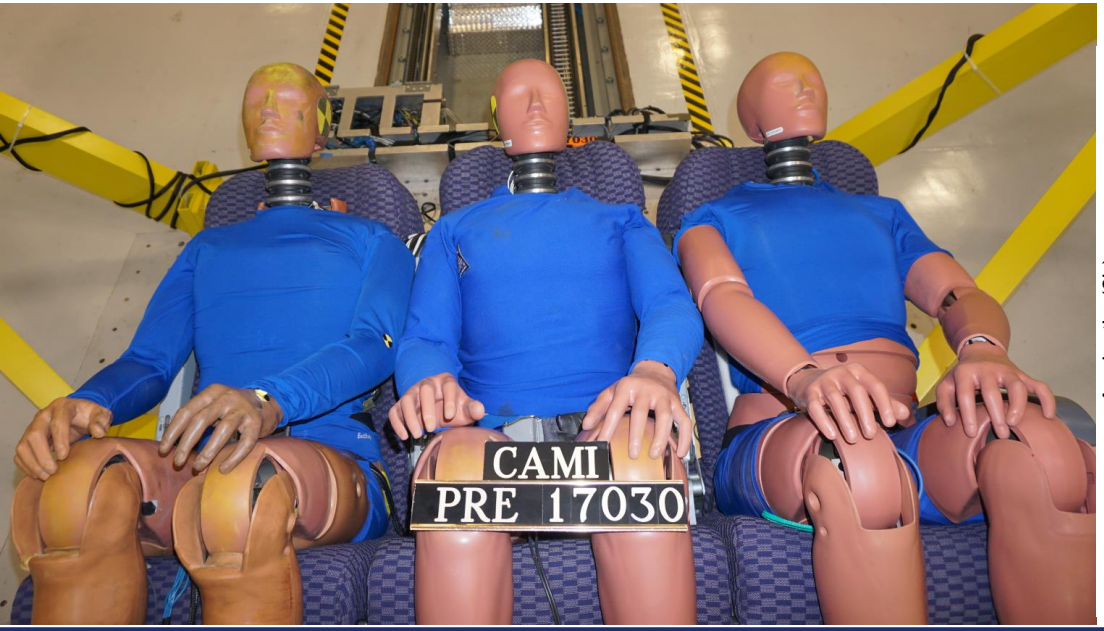
Lab Testing

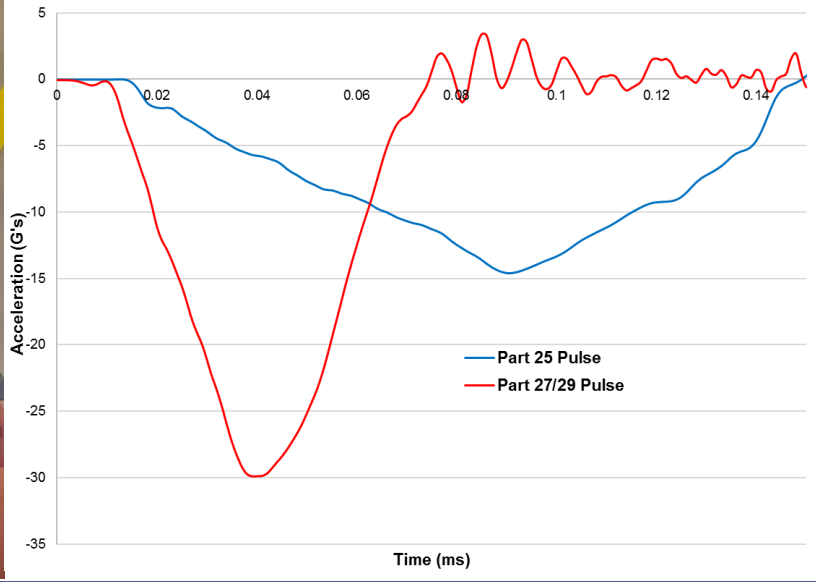
Test 1 of 14 CFR 2X.562

60° pitched up

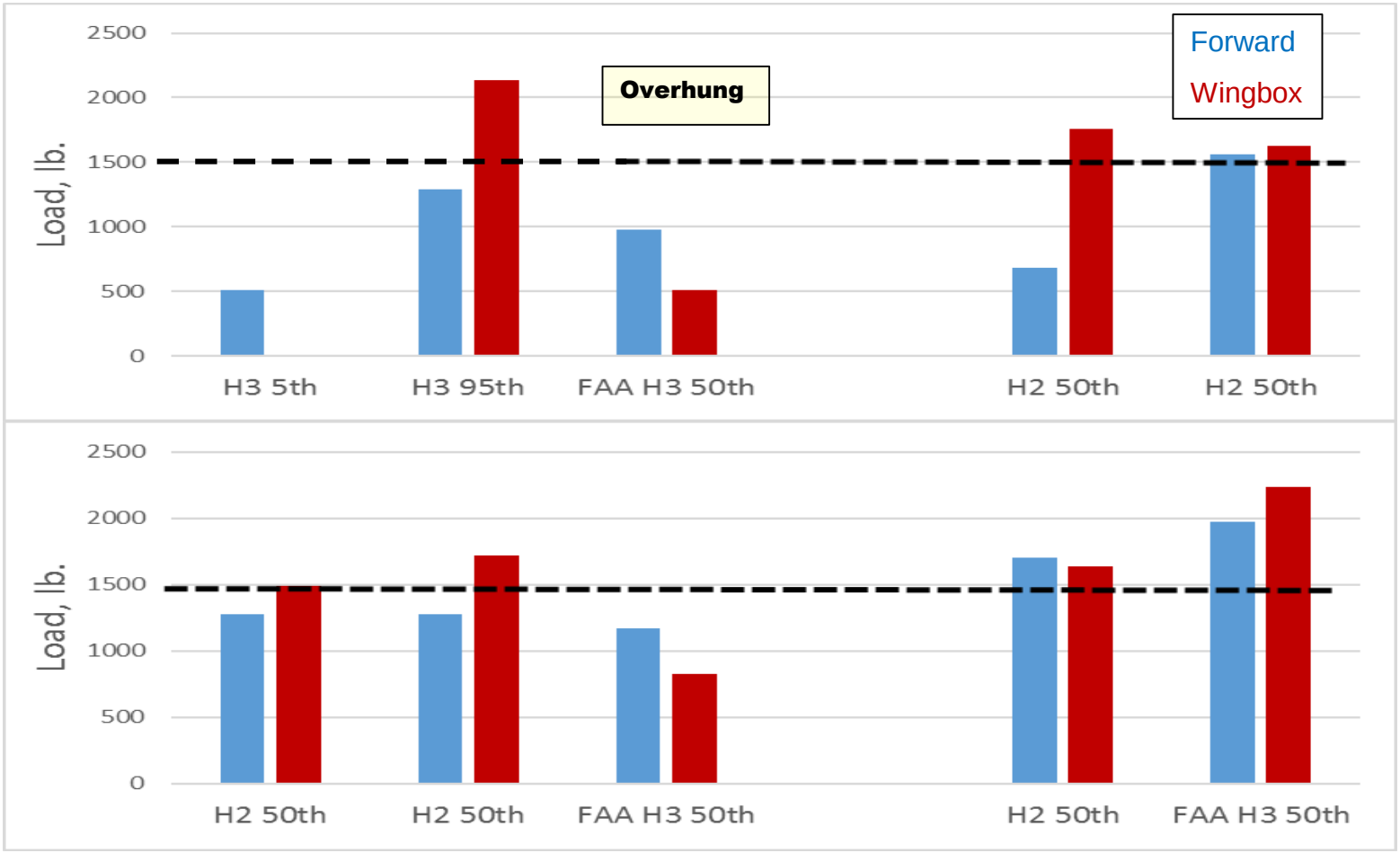
FAA Hybrid III in all positions



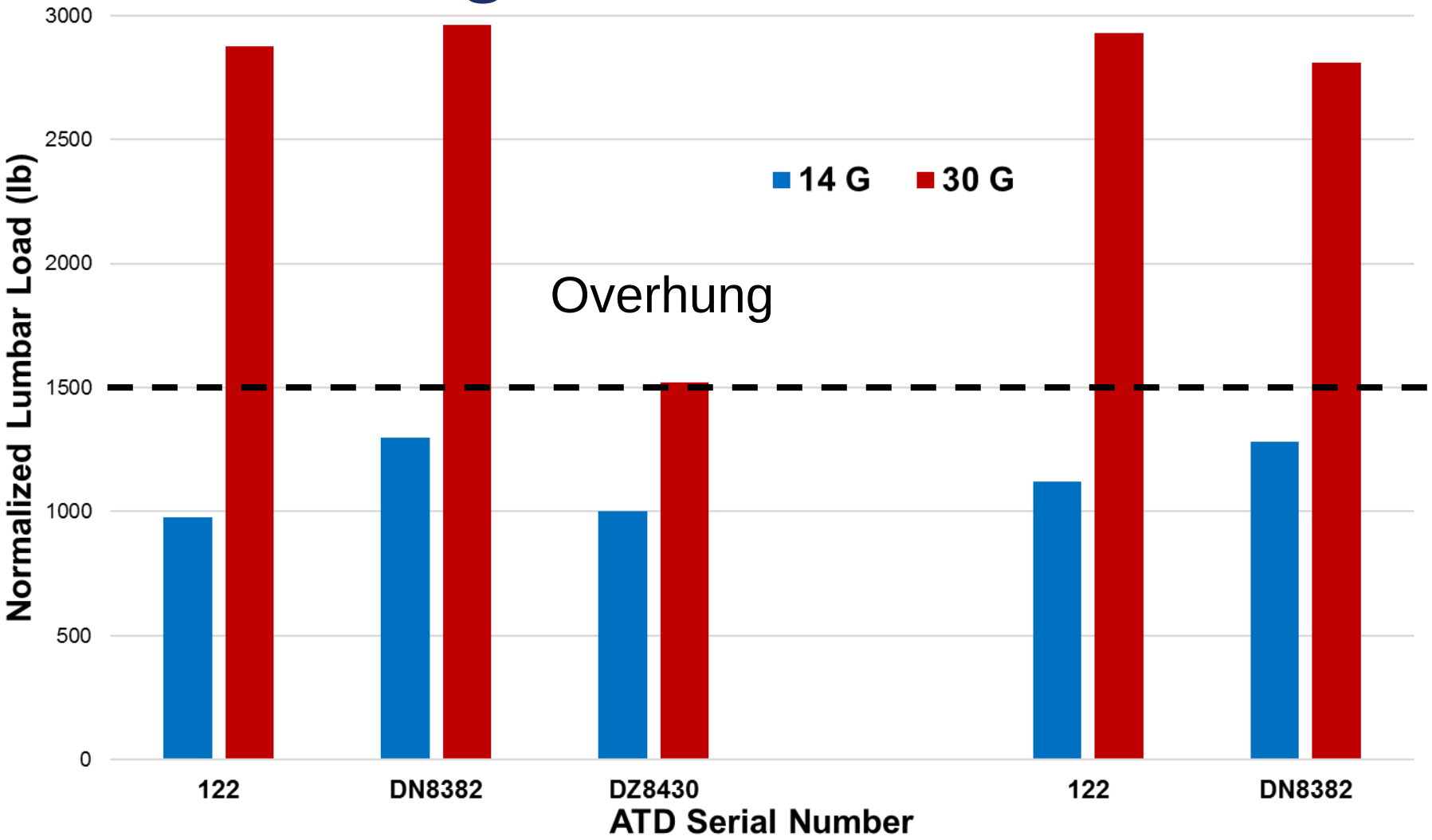




Drop Test Lumbar Loading



Lab Testing Lumbar Loads



Overhung Seat Deformation

Wingbox Drop Front Seat

Rear tube bent down approximately 5”

Lab Test

Front tube bent down approximately 2”

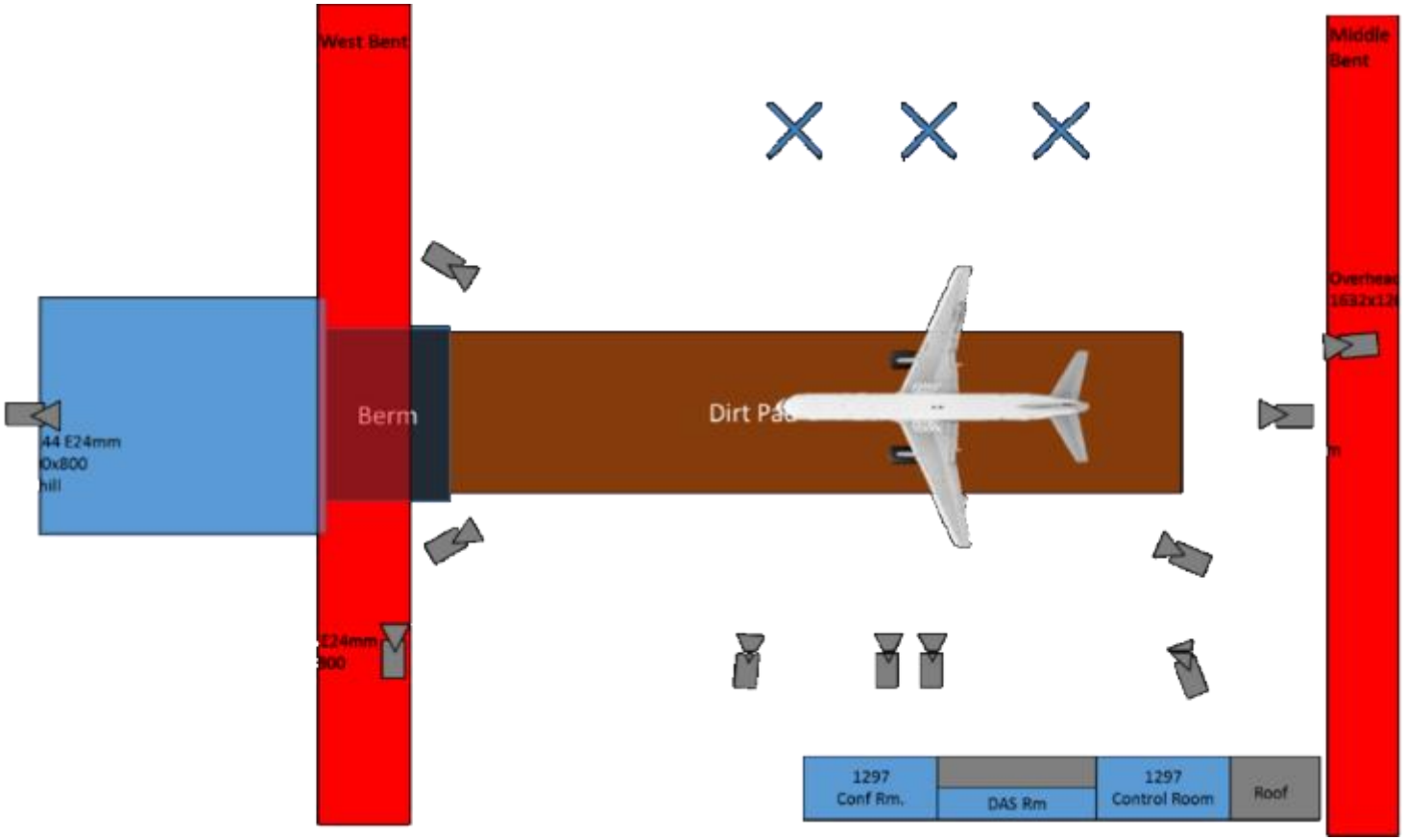
Discussion

- **Overhung seat lower**
- **Brace position lower**
- **Pitch orientation delays peaks**
- **Some loads lower/higher than cert loads**
  - All seat places passed lumbar loads for lab cert type test

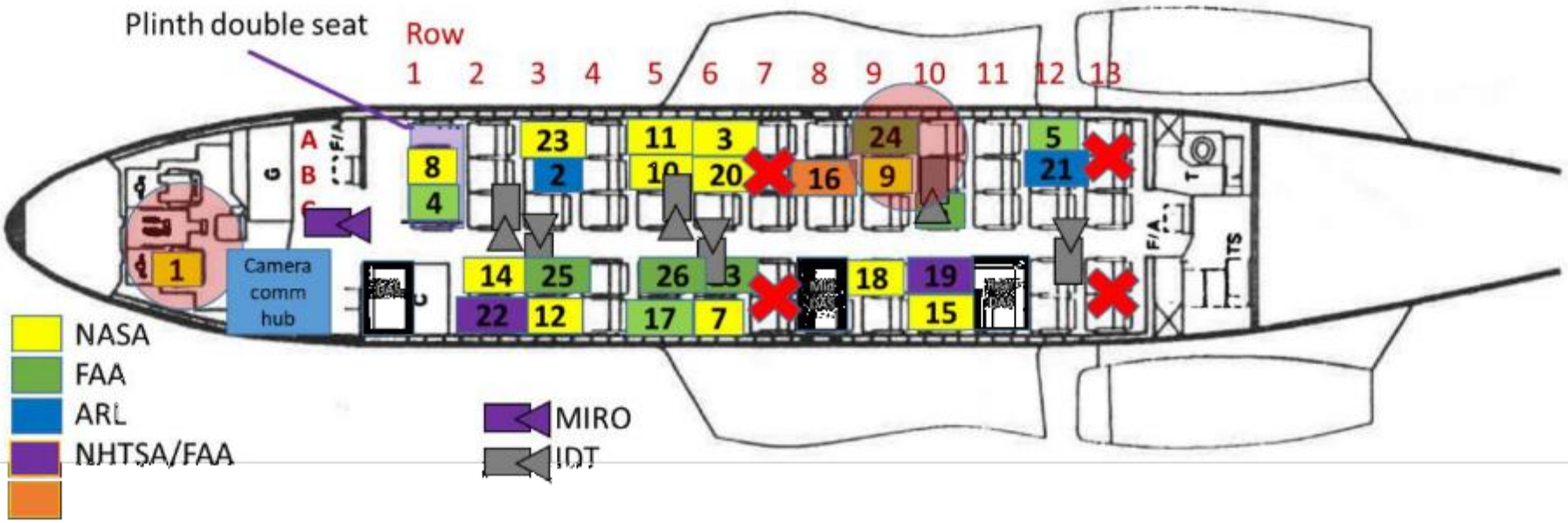
Full Scale Test

- **Planned conditions;**
  - 70 ft/sec longitudinal
  - 30 ft/sec vertical
  - No more than 2^{o} pitch up
  - Dirt berm

Full-Scale Setup – Camera Locations

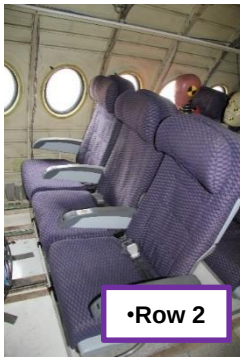


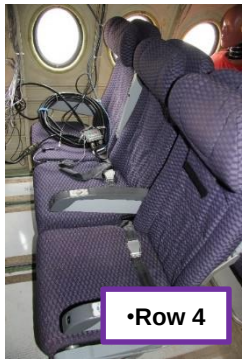
Full-Scale Setup – Seat Layout

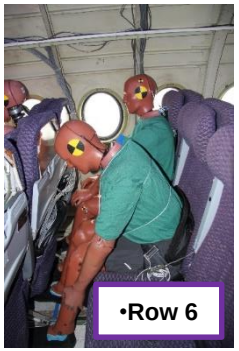


24 ATDs!

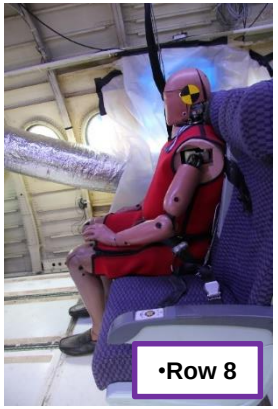
Starboard Side ATDs





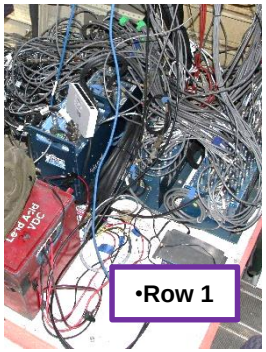


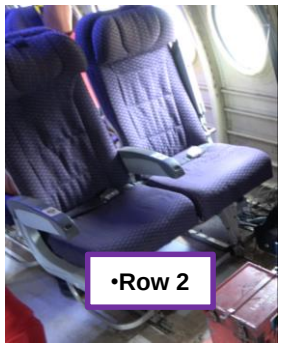
•STBD Side ATD



Other side

Port Side ATDs


•Row 1


•Row 2

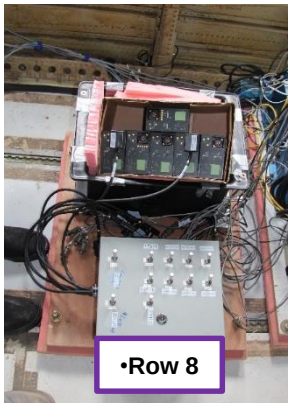

•Row 3


•Row 4


•Row 5

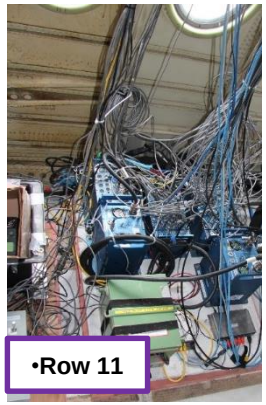

•Row 6

•PORT Side ATD


•Row 8


•Row 9

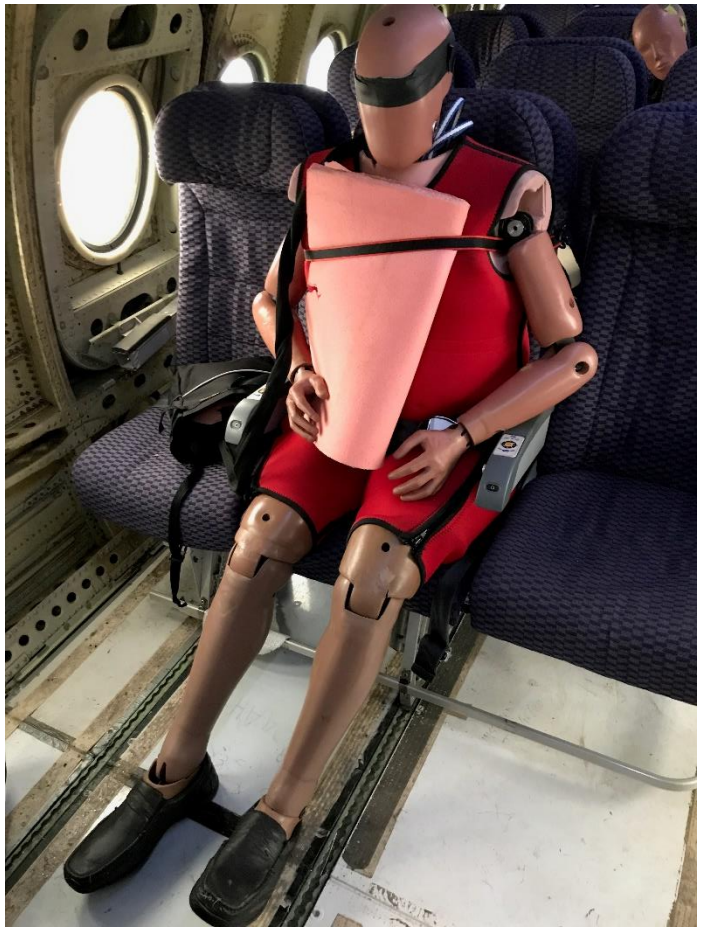

•Row 10


•Row 11

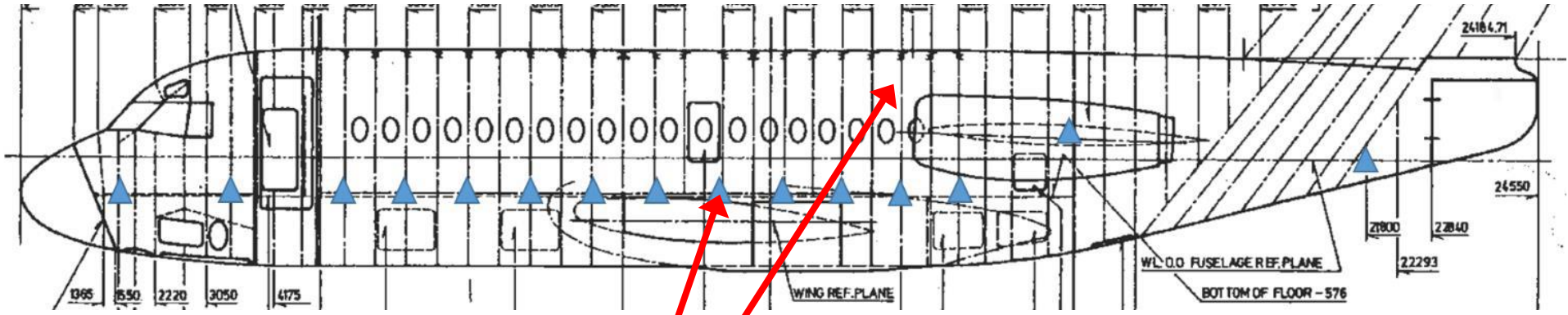
•Row 12

Other side

ATDs Cont'd

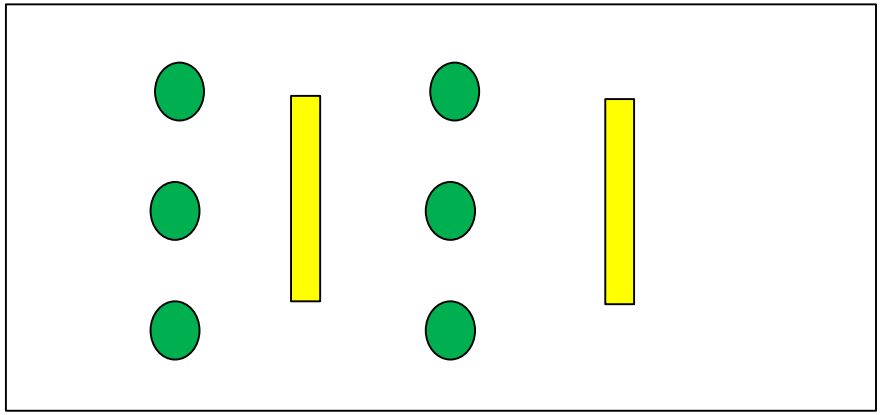


Full-Scale Setup - Accelerometers



- Airframe accelerometers
- C-Channel attachments – accelerometers and ballast mass
- Seat leg accelerometers

Full-Scale Setup – Adapter Plate



20.75”

Load cell
Fx, Fy, Fz

Seat leg

- ½” AL
- 36” x 47”
- Double seat

ATD Installation

ATD Installation

Overview

Tail

Front View

Rear View

Port Row 3

Port

Stbd

Row 5

Port

Stbd

Port Row 9

Port Row 10

Obese ATD

Conclusions

- **FAA is conducting several research programs to support development of future crashworthiness guidance for transport airplanes**
- **Results will be published and made available once ready**

Remaining Session

- **Development of a Full-Scale Finite Element Model of the Fokker F-28 Fellowship Aircraft and Crash Simulation Prediction** - Jacob Putnam for Karen Jackson (NASA)
- **Summary of Results from a Fokker F-28 Full Scale Crash Test** – Martin Annett (NASA)
- **Response from a Range of Occupants in Fokker F-28 Full Scale Crash Test** - Amanda Taylor (FAA)
- **Simulation Development and Prediction of Occupant Response in a Fokker F-28 Full Scale Crash Test** – Jacob Putnam (NASA)

Questions?