Summary of Results from a Fokker F-28 Full Scale Crash Test

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Purpose

- Evaluate transport category aircraft under dynamic conditions which includes a forward velocity
  - Evaluate missing factors from a pure vertical component test
- Evaluate advanced Anthropomorphic Test Devices (ATD's aka crash test dummies) for injury
- Evaluate experimental ATDs
- Generate data for computer modelling purposes

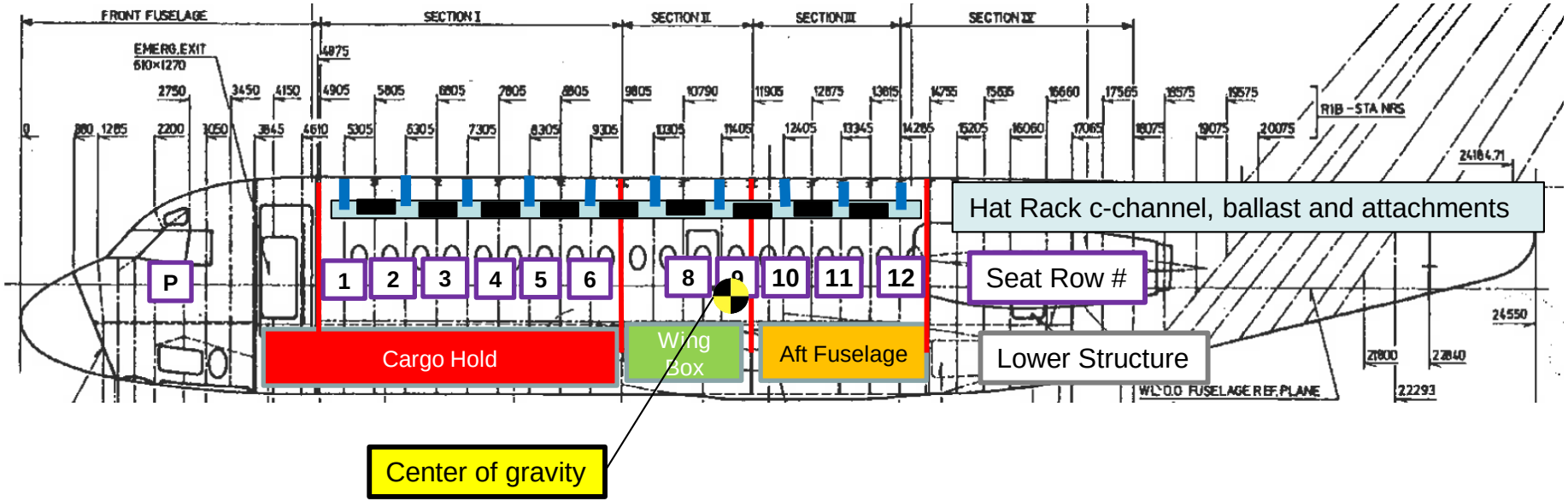
F-28 taxi into LaRC - 2001

F-28 before paint – Oct 2018

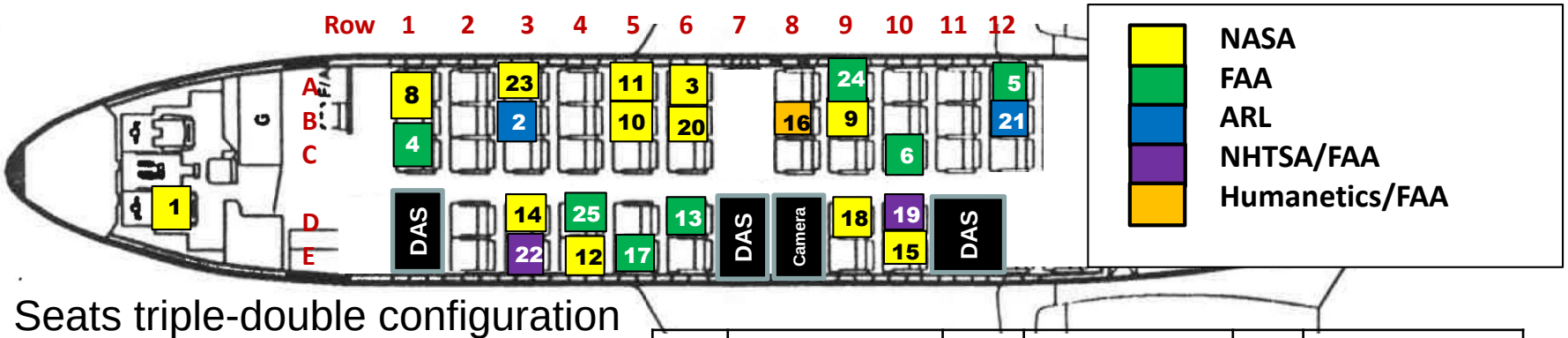
Test parameters

- Retired F-28 MK-1000 aircraft formerly Canada Regional Tail# C-GCRN
- Measured test weight ~33,306 lb.
  - Airframe ~ 17,500 lb.
  - Wings = 4,800 lb.
  - Luggage = 923 lb.
  - ATDs + Seats = 5,095 lb.
  - Data Acquisition Systems ~ 500 lb.
  - Lifting hardware ~ 2000 lb.
  - Hat rack simulators = 500 lb.
  - Ballast = 2,000 lb.
- NASA LaRC designed hardware interface wingbox spars to facility cables
  - Sandwiched between wings and fuselage
- Planned impact conditions
  - 70 ft/s horizontal, 30 ft/s vertical, <2 degree pitch, roll, yaw nominal
- Impact surface – Gantry Unwashed Sand (dirt) built into a 2’ bed at impact site

Airframe configuration



Anthropomorphic Test Device (ATD) layout

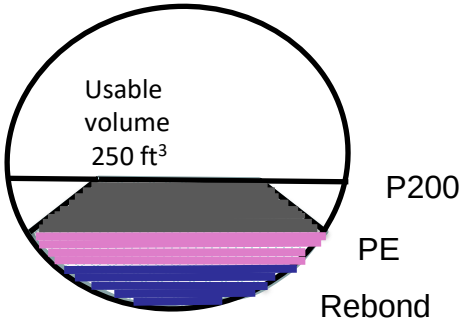


- Seats triple-double configuration
- 24 ATDs total
- 7 different ATD sizes
- 5 partners supplying ATDs
- 3 experimental ATD types
- Standard 50th percentile H2 and FAA H3 used injury
- Brace position
- Child seats

ID	Experiment	ID	Experiment	ID	Experiment
1	H2 – 50	10	H3 – 5	18	H2 -50
2	WIAMan	11	H3 – 95	19	LODA – 10 YO
3	H2 – 50	12	H3 – 6 YO	20	H2 – 50 *Brace
4	H2 – 50	13	FAA H3 – 50	21	WIAMan
5	FAA H3 – 50	14	H2 – 50	22	THOR
6	FAA H3 – 50	15	H3 – 10 YO	23	FAA H3 – 50
8	H2 – 50	16	Obese H3	24	H3 – 3 YO CARES
9	H3 – 3YO	17	Q1 Infant	25	CRABI

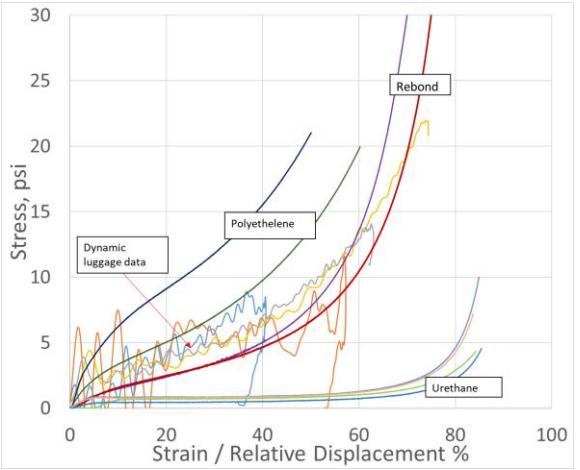
Luggage design and installation – Forward cargo hold

Forward section with luggage



Full-scale luggage layout

Full-scale luggage install



Dynamic foam response curves

- Combination of three energy absorbing foams necessary to optimize performance and weight
- 36% 6 pcf Rebond, 35% 2.2 pcf Polyethylene, 28% 2 pcf P200
- Stiffness makes a greater difference over weight as a reaction surface
  - Luggage weight 906 lb.
- Stiffness was tuned though various stacking sequences to obtain correct “luggage simulant” properties

Seats and hat rack ballast

- Seats removed from in-service (2016) United Airlines 737 triple place seats
  - Triple cut into double for F-28 port side
  - Seat leg spacing changed to 21.75”
  - Pitch 32”
- Hat rack
  - Attached at 3 spots every other frame section – using actual locations
  - 50 lb ballast mass every other frame section
  - Also served as onboard camera attachment locations

Weight and balance

- Initial Weight and balance 5/29/19
  - Aircraft weight of 32,370 lb.
  - CG @ ST10709; 3.29’ forward of center lift point
  - 1,900 lb. ballast added aft to move CG to center pickup location for stability
  - Ballast removed from forward aircraft
  - Vertical CG not measured due to CG location

- Second weight and balance 6/03/2019
  - Aircraft final weight of 33,306 lb
  - Longitudinal CG @ pick up point, ST11555
  - Vertical CG @ WL-80
  - Lateral CG @ centerline
  - Acceptable limits according to Fokker W&B

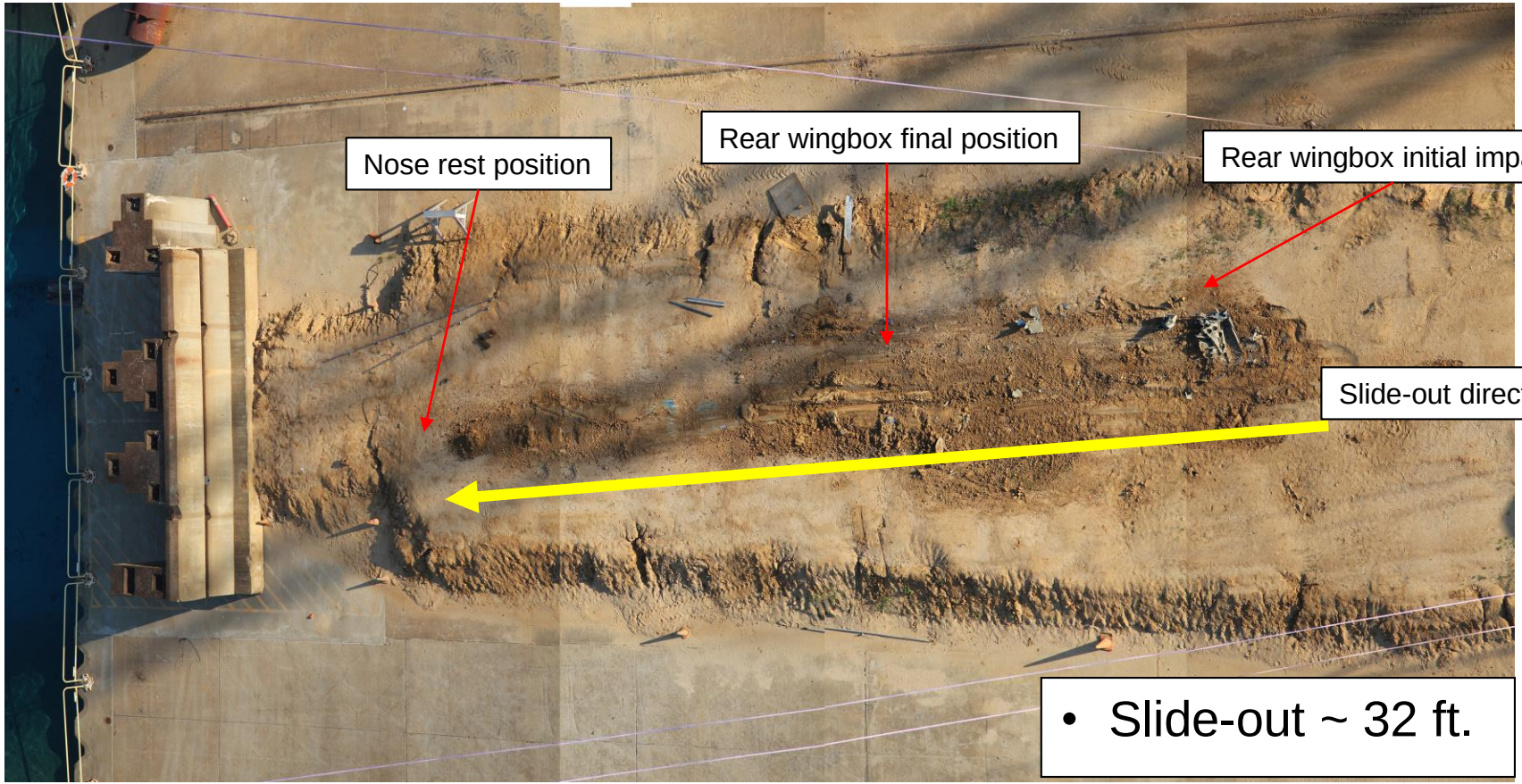
Test video

Impact conditions

Horizontal Velocity	65.3 ft/s
Vertical Velocity	31.8 ft/s
Lateral Velocity (assumed)	0 ft/s
Pitch	0.38 degree nose down
Roll	4.3 degree stbd side down
Yaw	2.58 degree nose left

Slide-out

Slide-out (cont.)



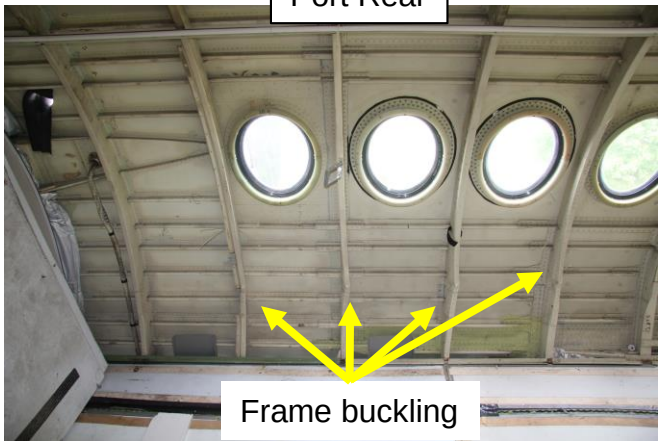
- Slide-out ~ 32 ft.

Post-test airframe overview

Post-test airframe detail

Port Rear

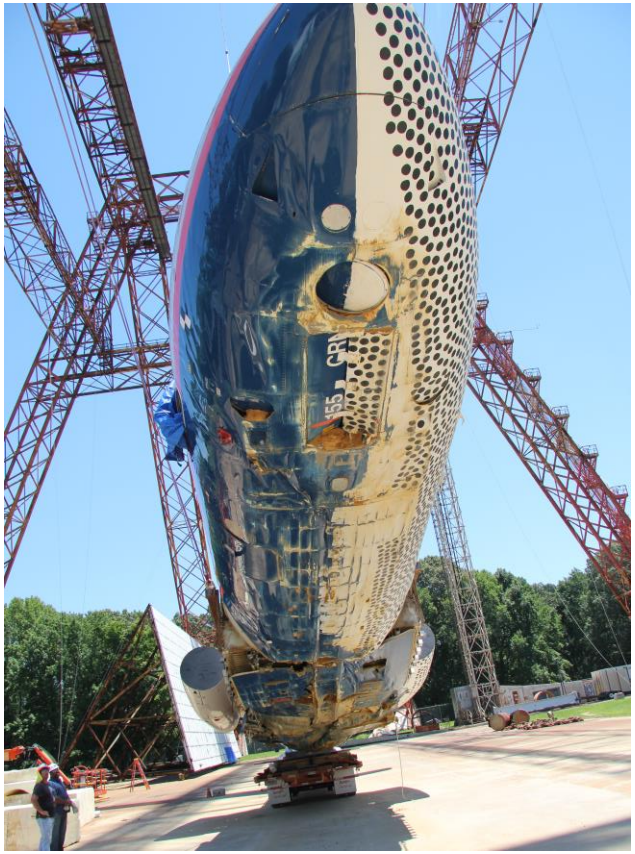
Stbd Mid



Frame buckling

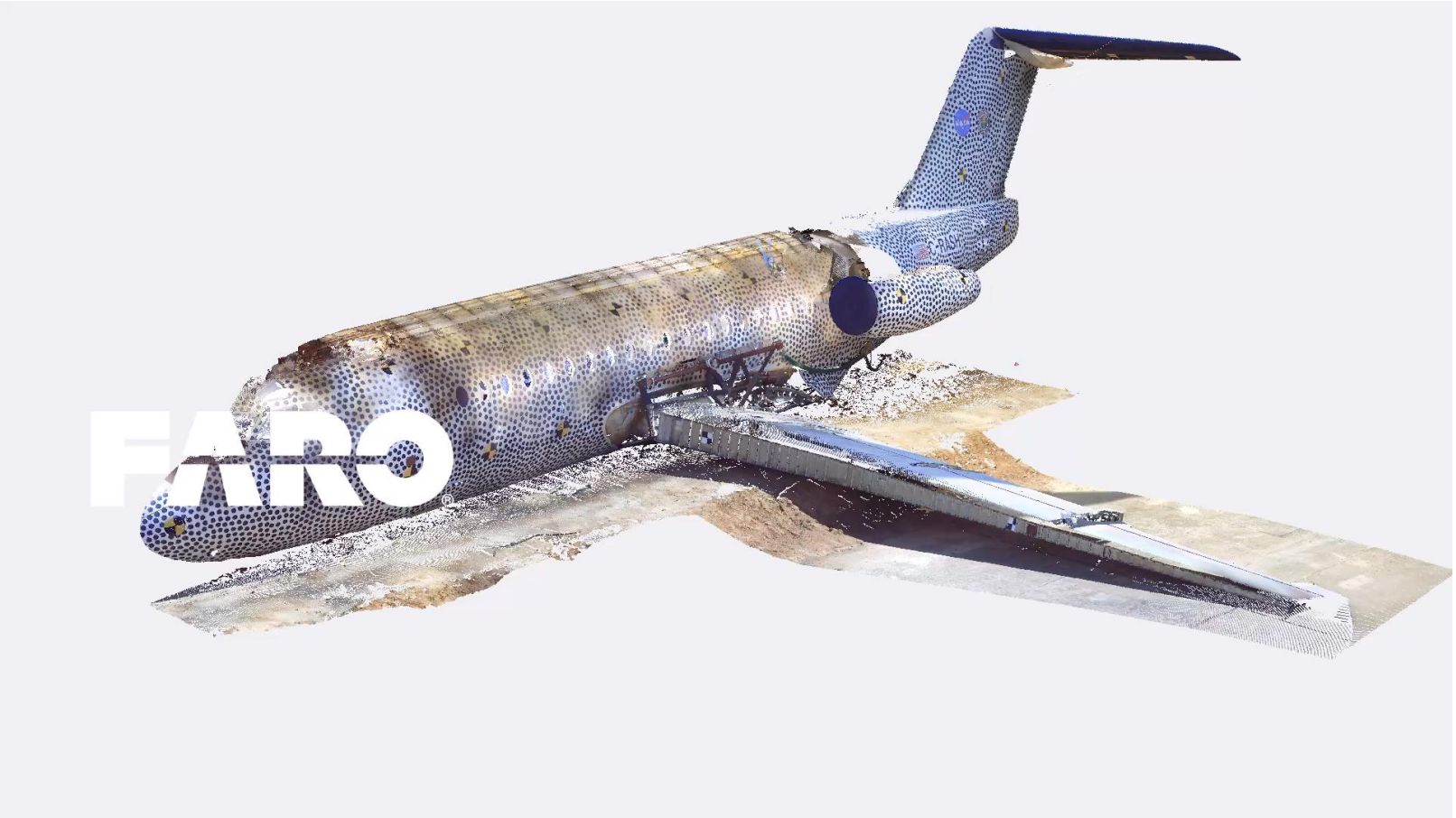
Skin buckling from mismatched stiffness
Between forward section and wingbox

Airframe belly



Interior videos

NTSB Faro 3-D Post-test scan data



Emergency exit door removal

- Only port side was installed. Stbd side was removed to allow a secondary access to cabin

Post-test interior

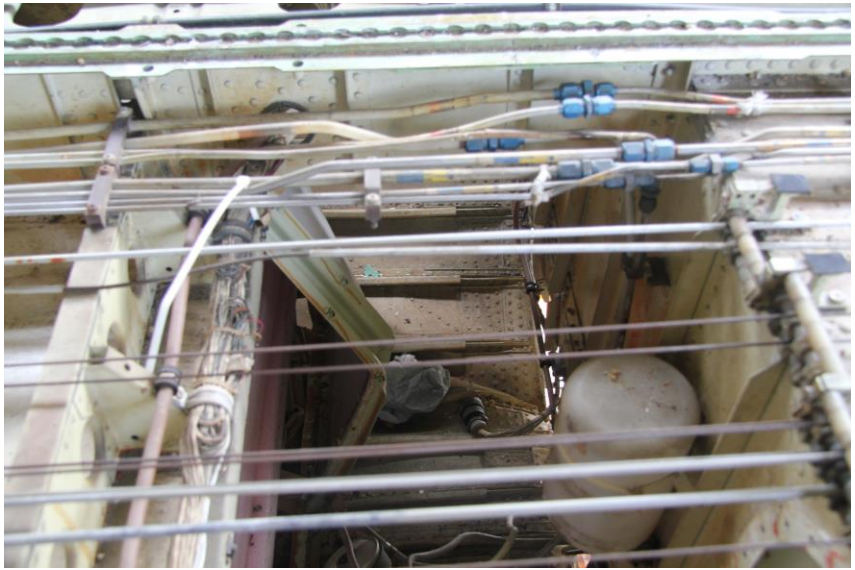
- Measurements still needed to determine total cabin deformation
  - 3-D laser scanner system at LaRC

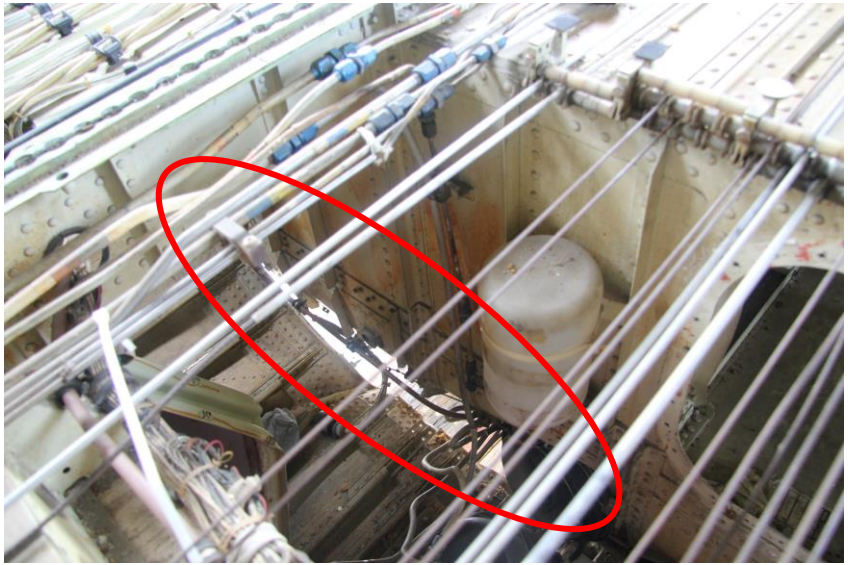
Post-test floor structure

- Seat track deformation – pushes into lower structure at seat leg positions

- Rear floor bulge / cabin intrusion

Post-test Sub-floor structure

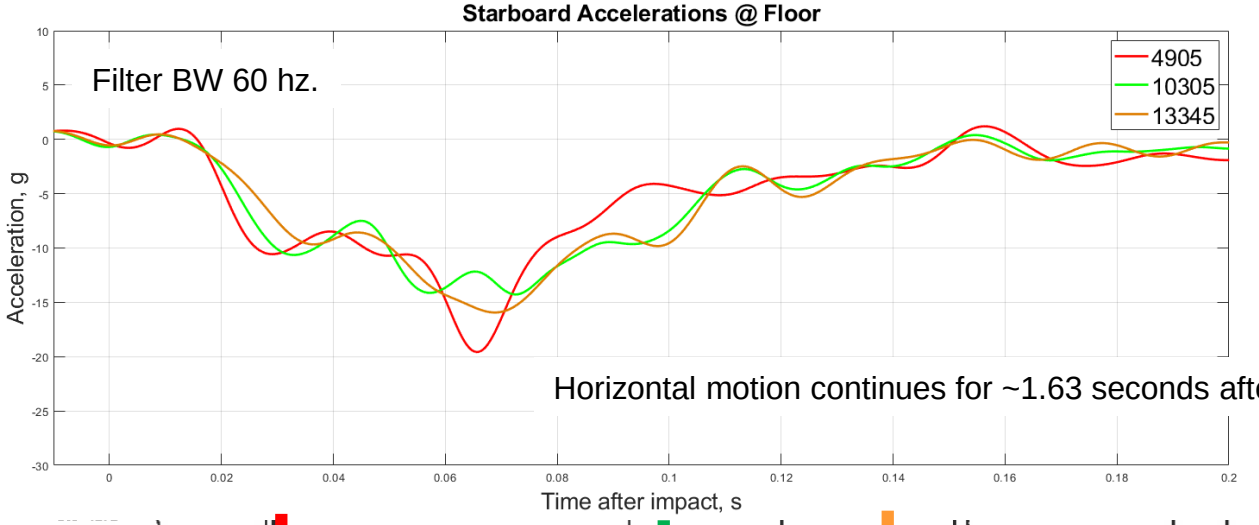




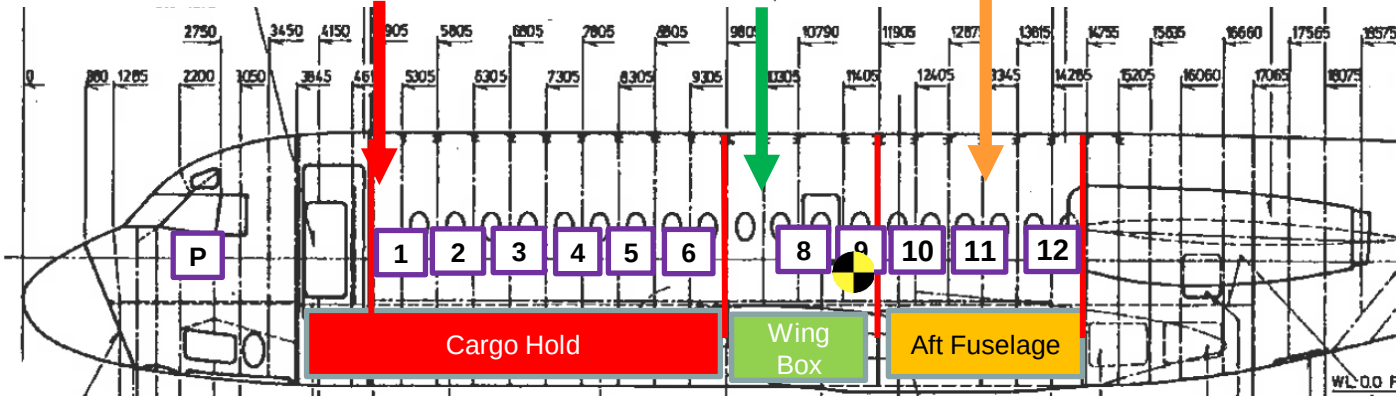
- Forward/Wingbox junction stanchion buckling
- Wingbox detach from skin

- *NOTE: Deformation still largely unknown in the sub-floor region for the forward compartment (cargo hold)*

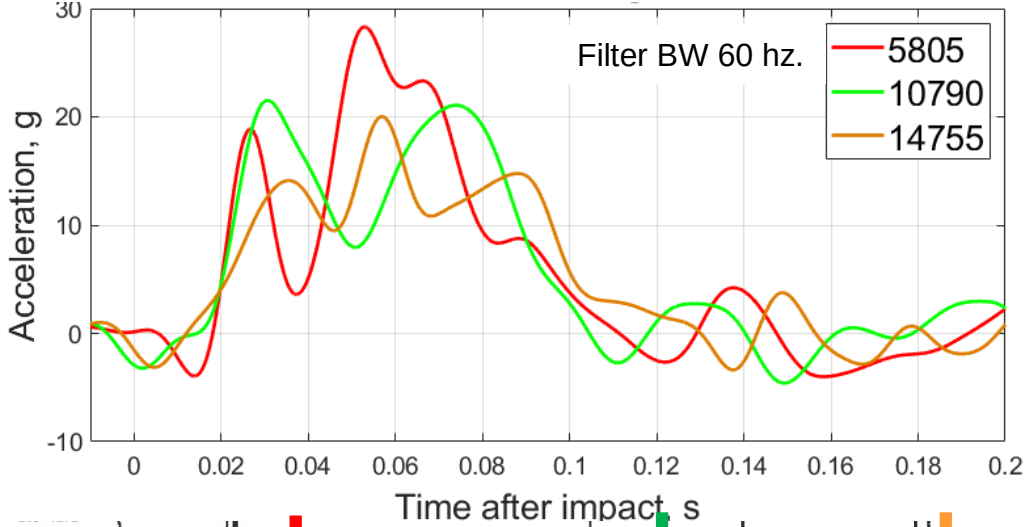
Starboard side horizontal accelerations

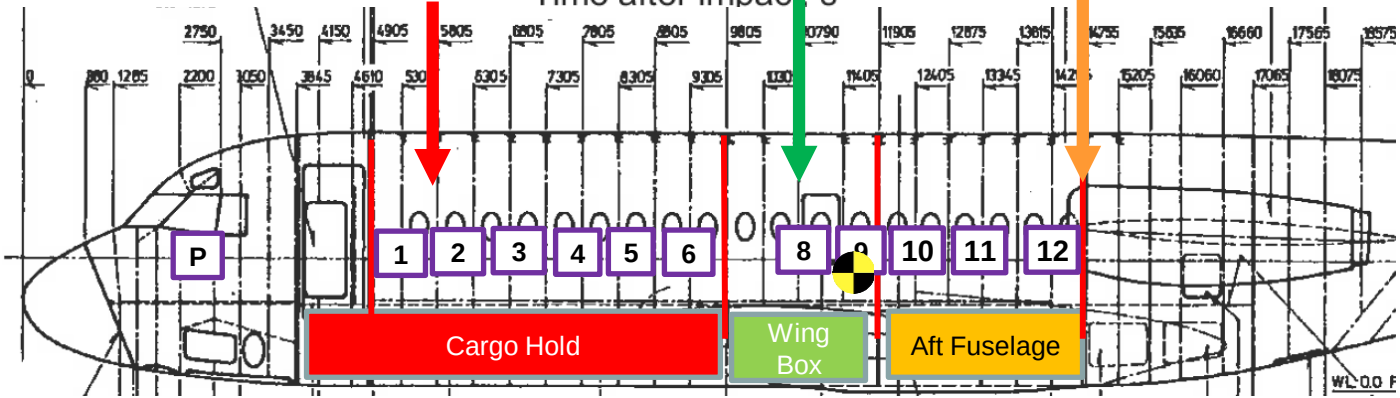


Horizontal motion continues for ~1.63 seconds after initial impact

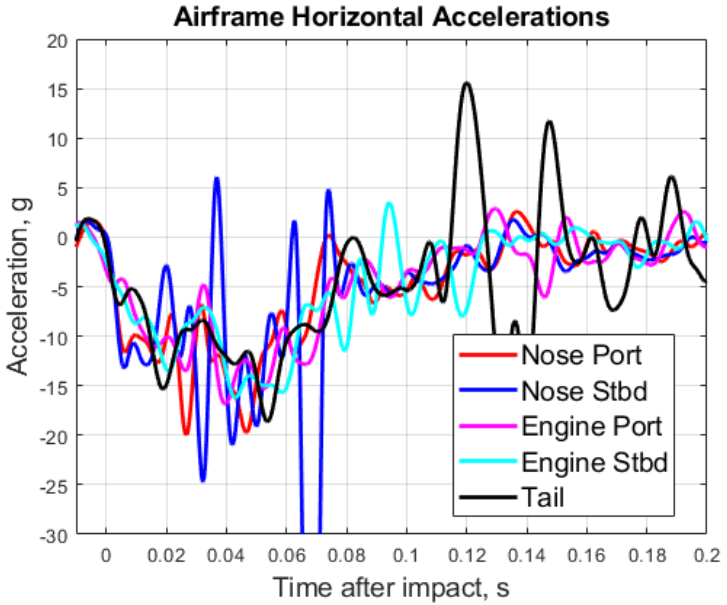


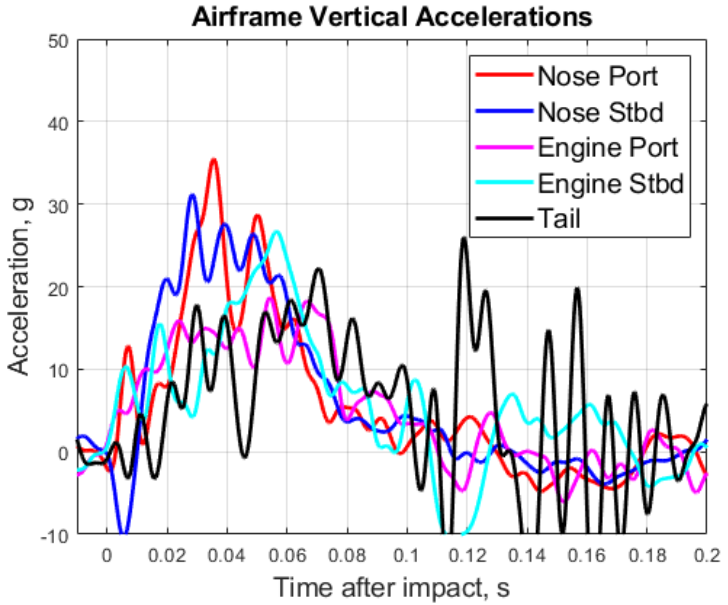
Port side vertical accelerations





Engine, tail and nose accelerations





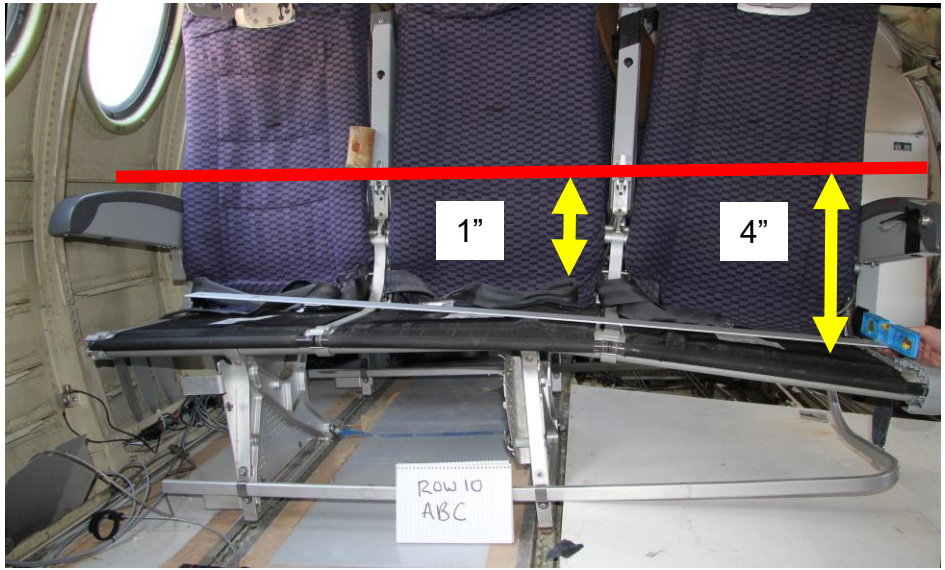
- Horizontal
- Vertical

Summary and looking forward

- *Now:*
  - Data analysis
- *Next up:*
  - Conduct next round of post-test 3-D scans of empty interior to obtain fully documented cabin deformation quantitative numbers
  - Remove luggage foam and further document subfloor deformation
    - F-28 will collapse if foam is removed with aircraft weight on top
    - Must cut up/section then document
- *Later:*
  - Compare F-28 section drop tests to F-28 full-scale crash test

backup

Seat deformation



- For the triple place, only ATD seated in overhung seat was row 10 (seat C) - H3 50th
- Double seat Row 2 (seat D) seatback fail

ATD motion – Double seats

- Port row 9 - ATD with no seat to impact

- Port row 3 - ATD with seat in adjacent row

ATD Motion – Triple seats

- Stbd Row 5 – 5th to 95th
- Stbd Row 6 - Braced to non-braced

- Stbd Row 12 - WIAMan to H3