NASA LaRC Full Scale F28 Barrel Drop Summary

With analysis suited for ARAC TACDWG

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Impact conditions

- F28 MK4000 MTOW = 73,000 lb (wiki)
- ARAC requirement = 18 ft/sec

Impact conditions
Vz= 28.9 ft/sec
Pitch = - 1.3 deg
Roll = 0 deg
Flat soil

Impact conditions (local)
Vx= 1.1 ft/sec
Vz= 29.1 ft/sec
Pitch = -2.9 deg
Roll = 0 deg
10 deg sloped soil

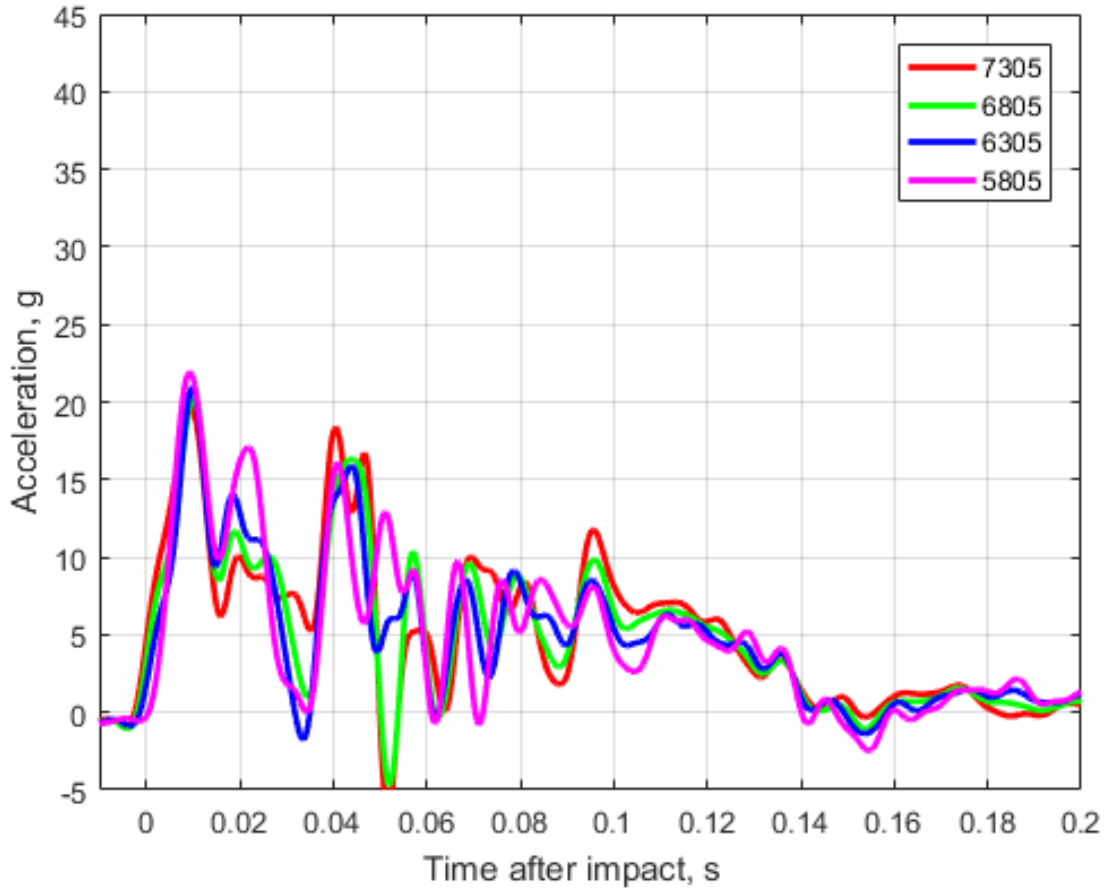
For reference, a 4 frame barrel drop was conducted at NASA LaRC in 2002

- Impact velocity of 30 ft/sec
- Weight of 2210 lb, length of 58 in.
- Floor loading of ~331 lb / linear foot on the floor
  - 20 x 75 lb lead masses + DAS

- *For reference floor loading*
  - *Forward barrel = ~300 lb. / linear foot*
  - *Wingbox = ~237 lb. / linear foot*

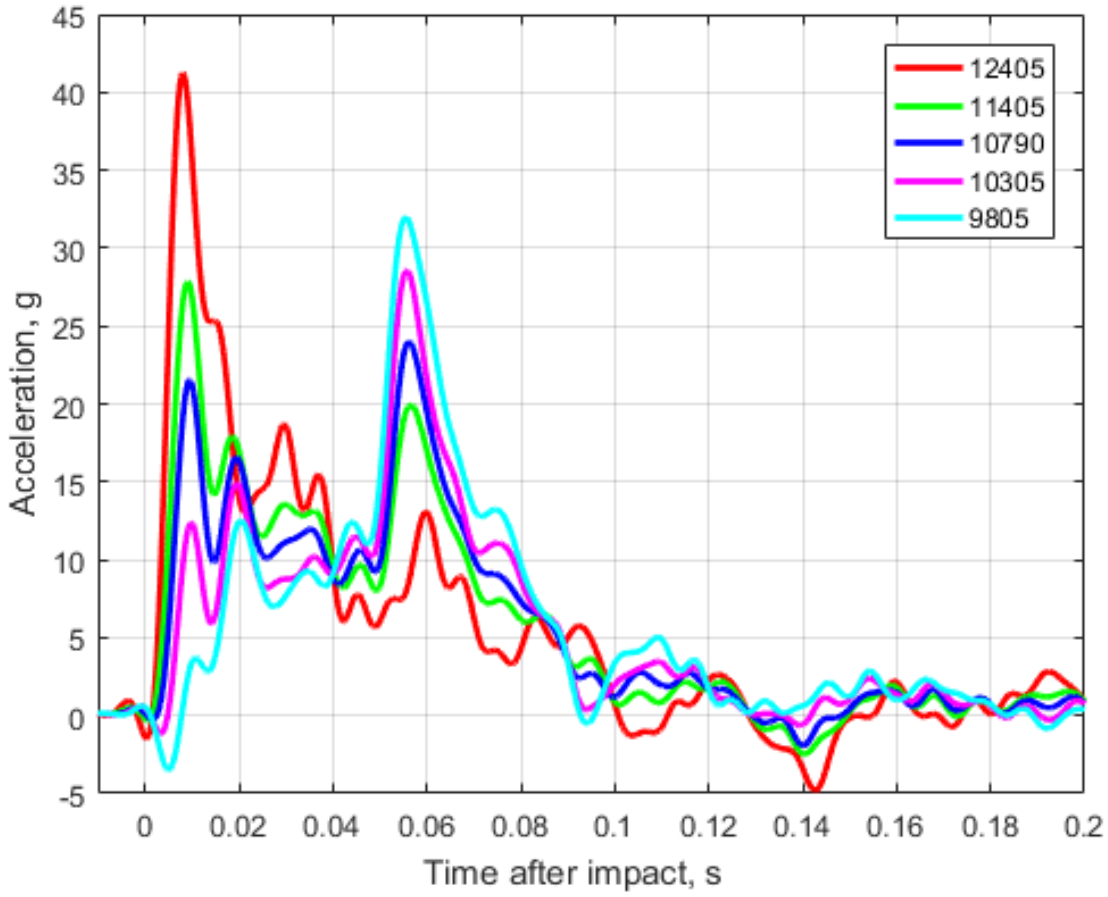
Airframe vertical acceleration – starboard side

Starboard Frame Section at Floor



Forward Barrel

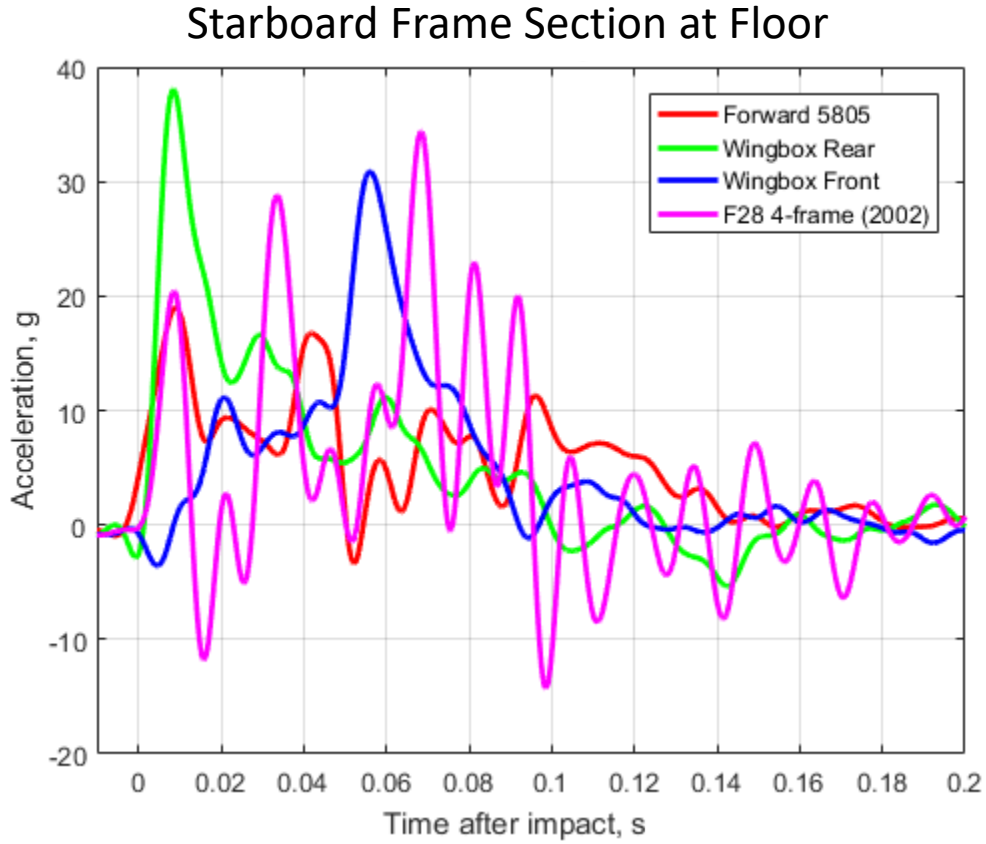
Starboard Frame Section at Floor



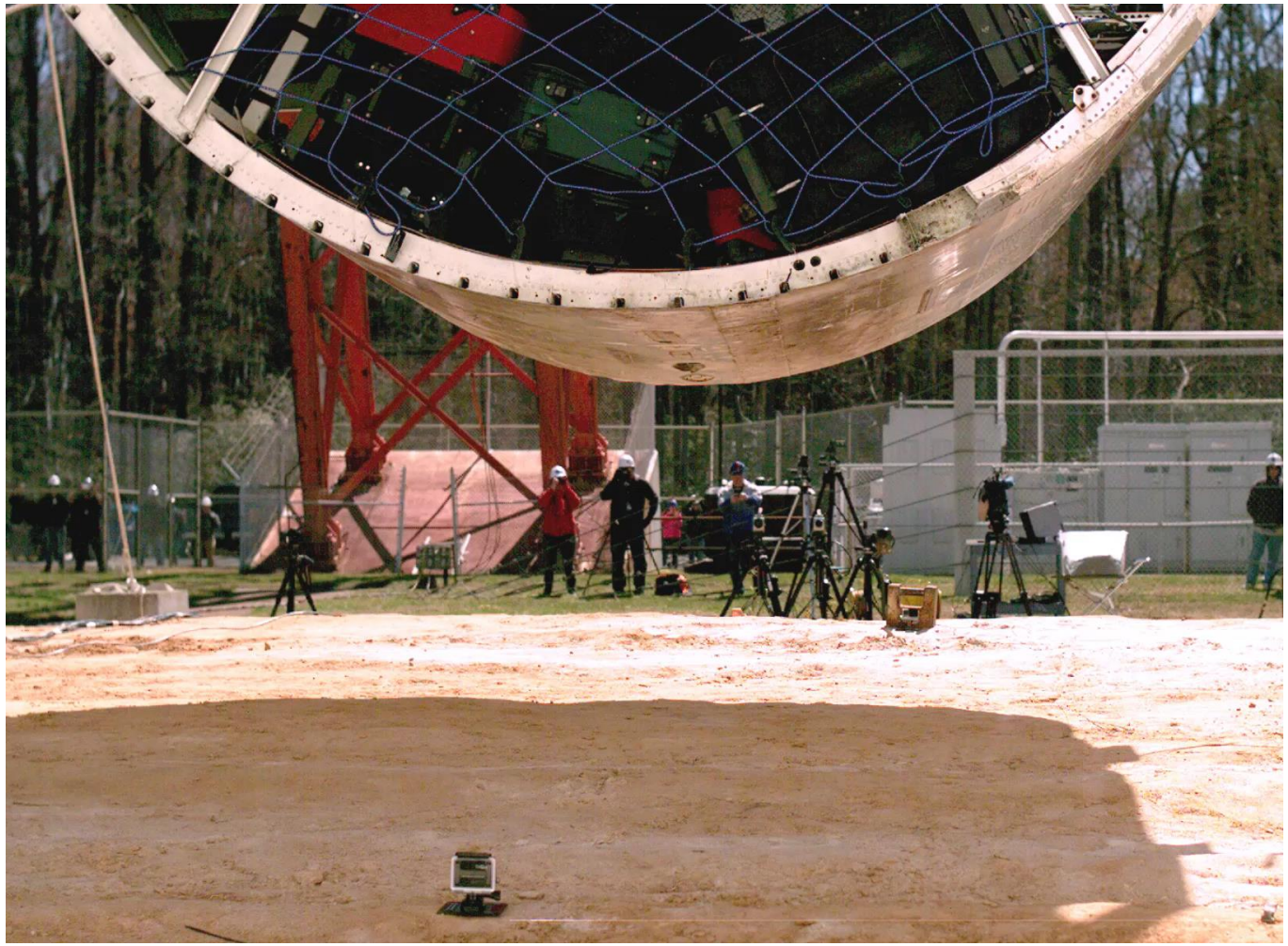
Wingbox

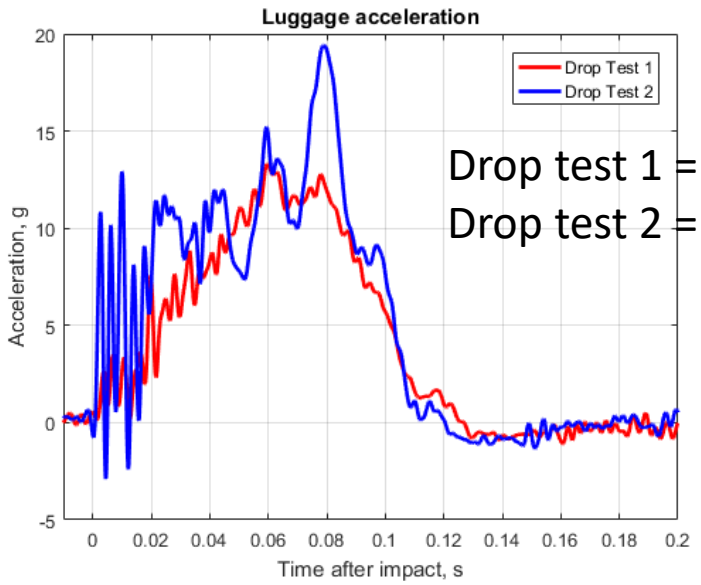
F28 accelerations from 3 tests

- Does luggage affect ATD response?
  - 2002 vs 2017 forward barrel
  - Will examine next slides
- Does the section location affect ATD response?
  - 2017 forward barrel
  - 2017 wingbox
- Does luggage affect airframe deformation?
  - Yes 2002 F28 test different than 2017 F28 test



Luggage response characterization



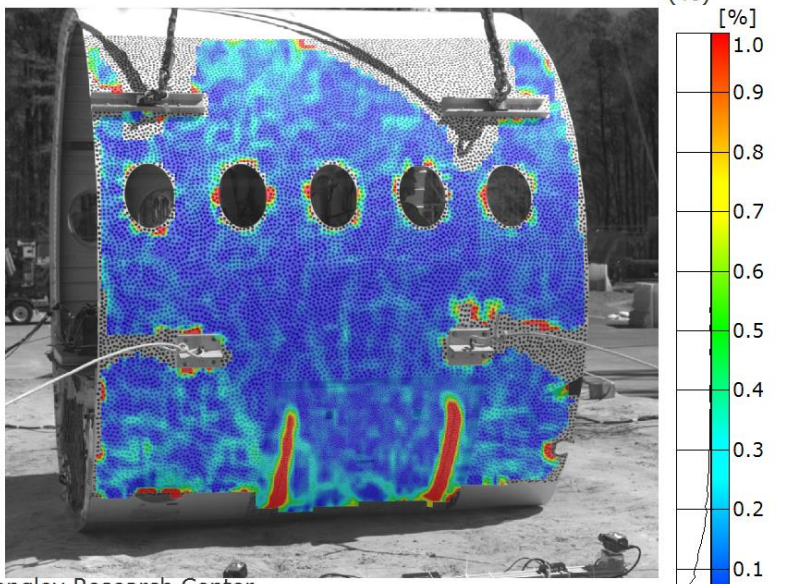


Drop test 1 = 18.9 ft/sec

Drop test 2 = 25.6 ft/sec

Cargo door response forward barrel

NASA / FAA Fokker F28 Foward Barrel Drop Test
March 23, 2017



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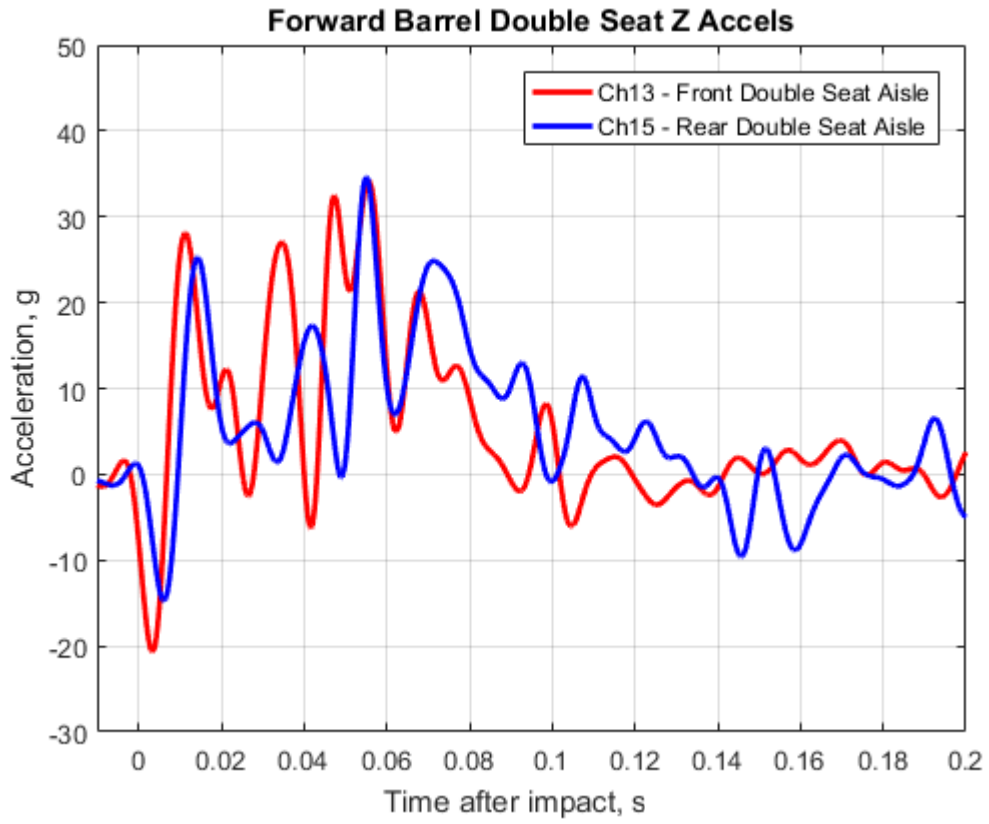
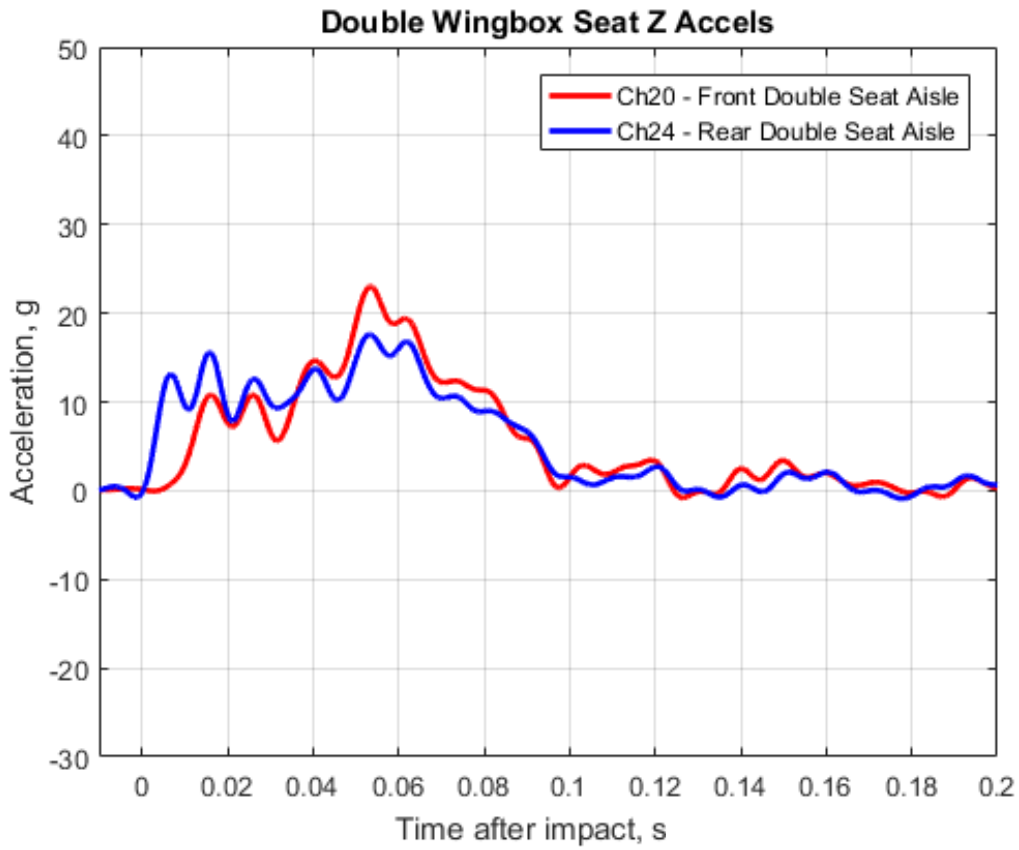
Emergency Exit door response - Wingbox

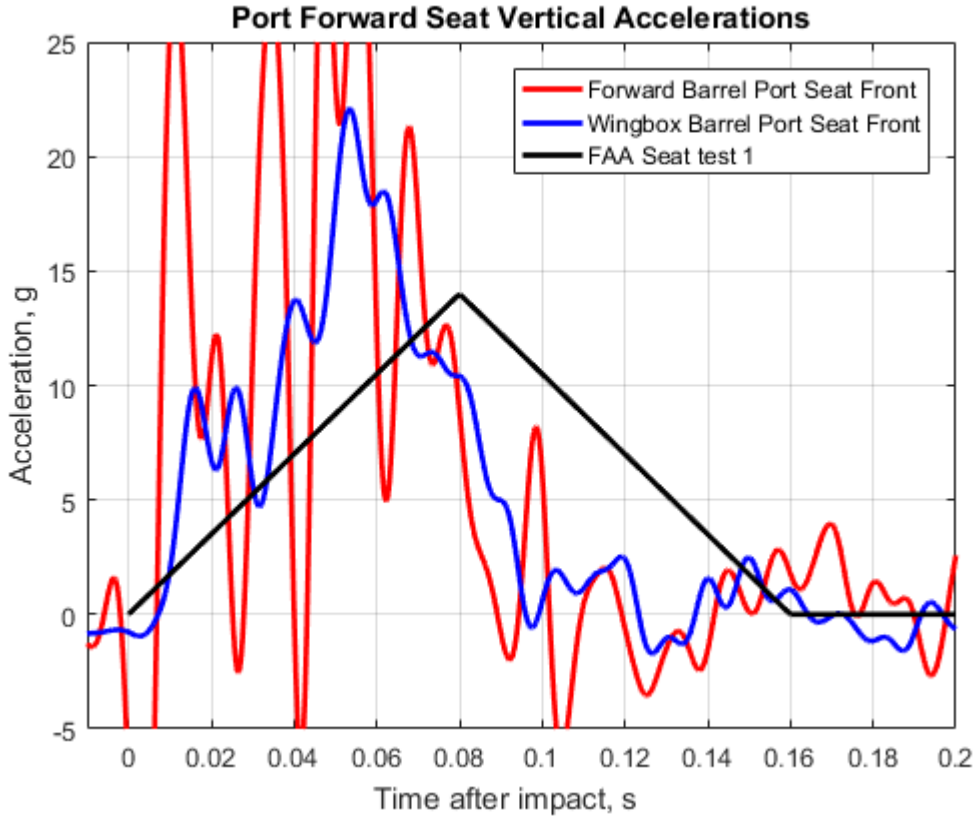
Port seat z accelerations

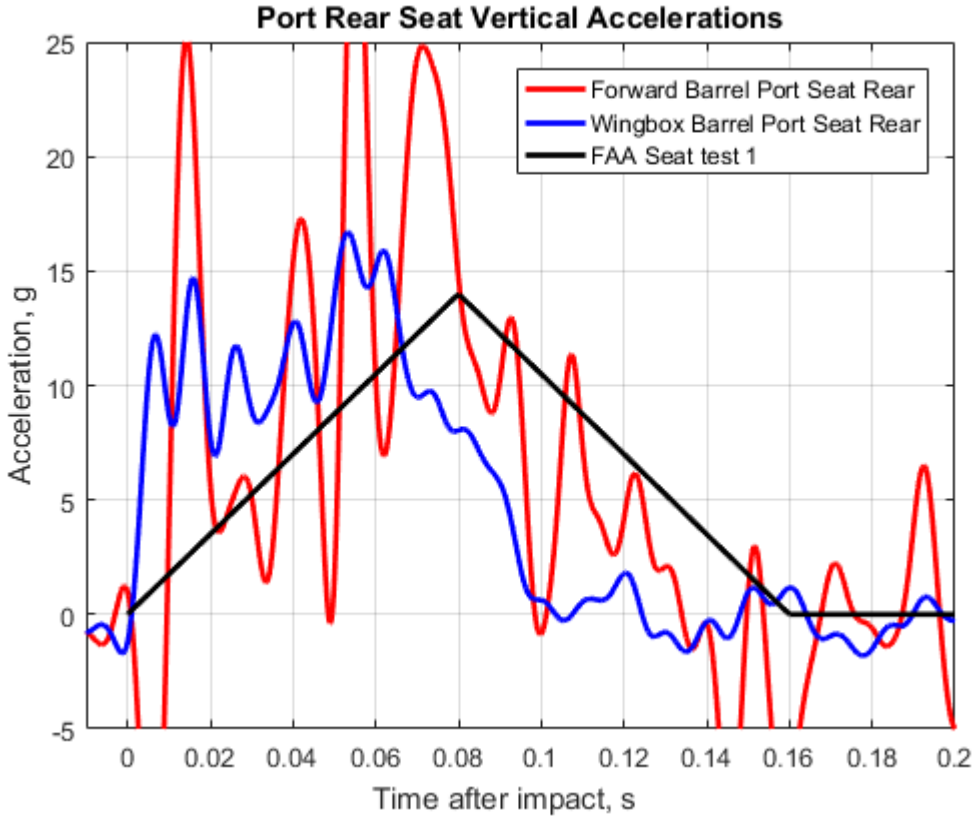
- Side by side of port side forward and rear seat accelerometers port side





Seat accelerations – with 25.562(b)(2) overlay





Triple seat video comparisons

Forward Barrel

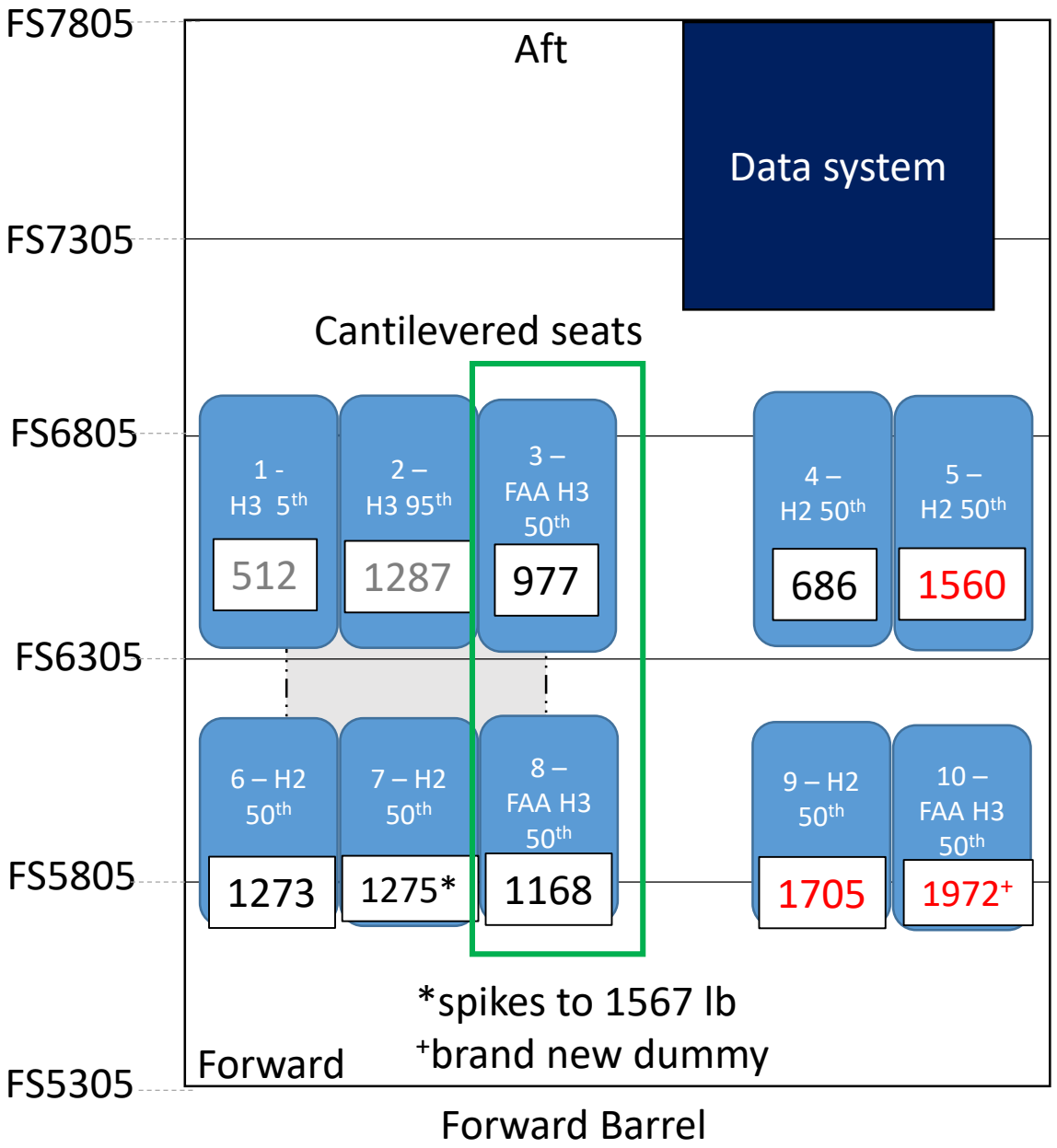
Wingbox

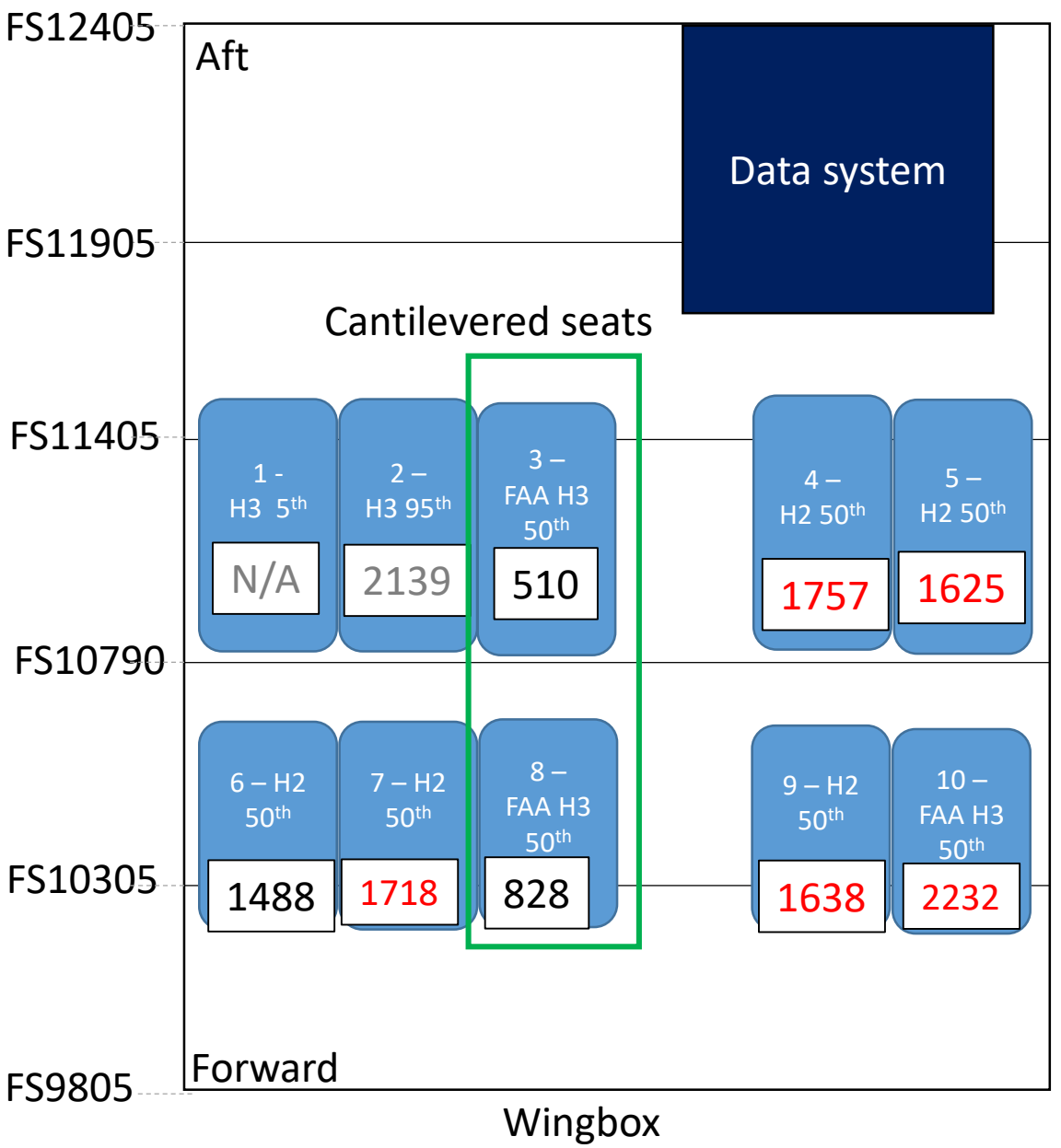
Double seat video comparisons

Forward Barrel

Wingbox

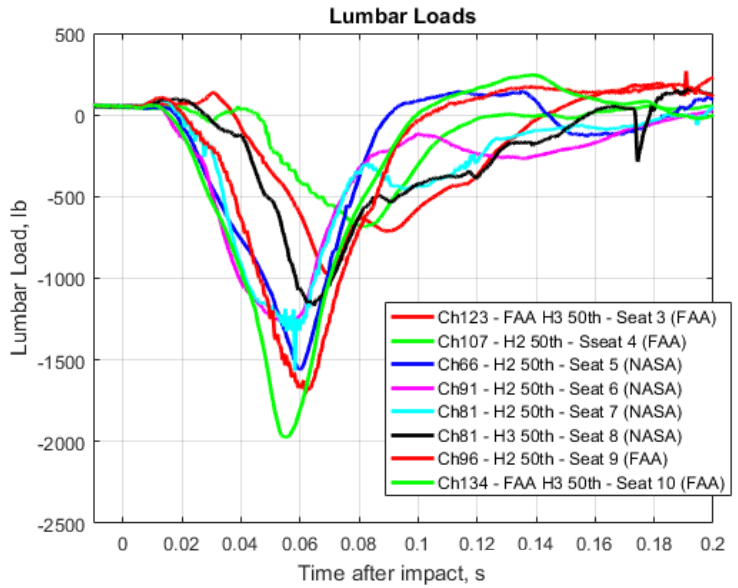
Lumbar loads - Peak values (lb.)



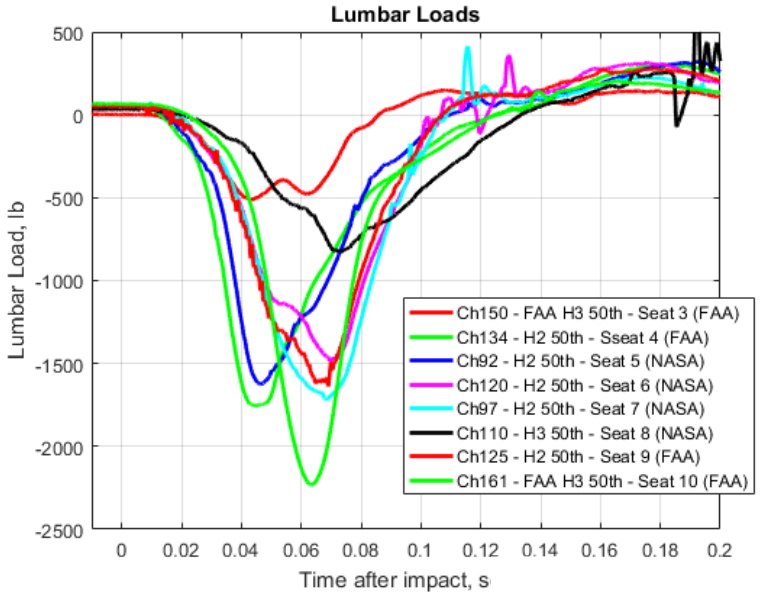


Lumbar loads peaks occur ~0.060 s

Forward barrel

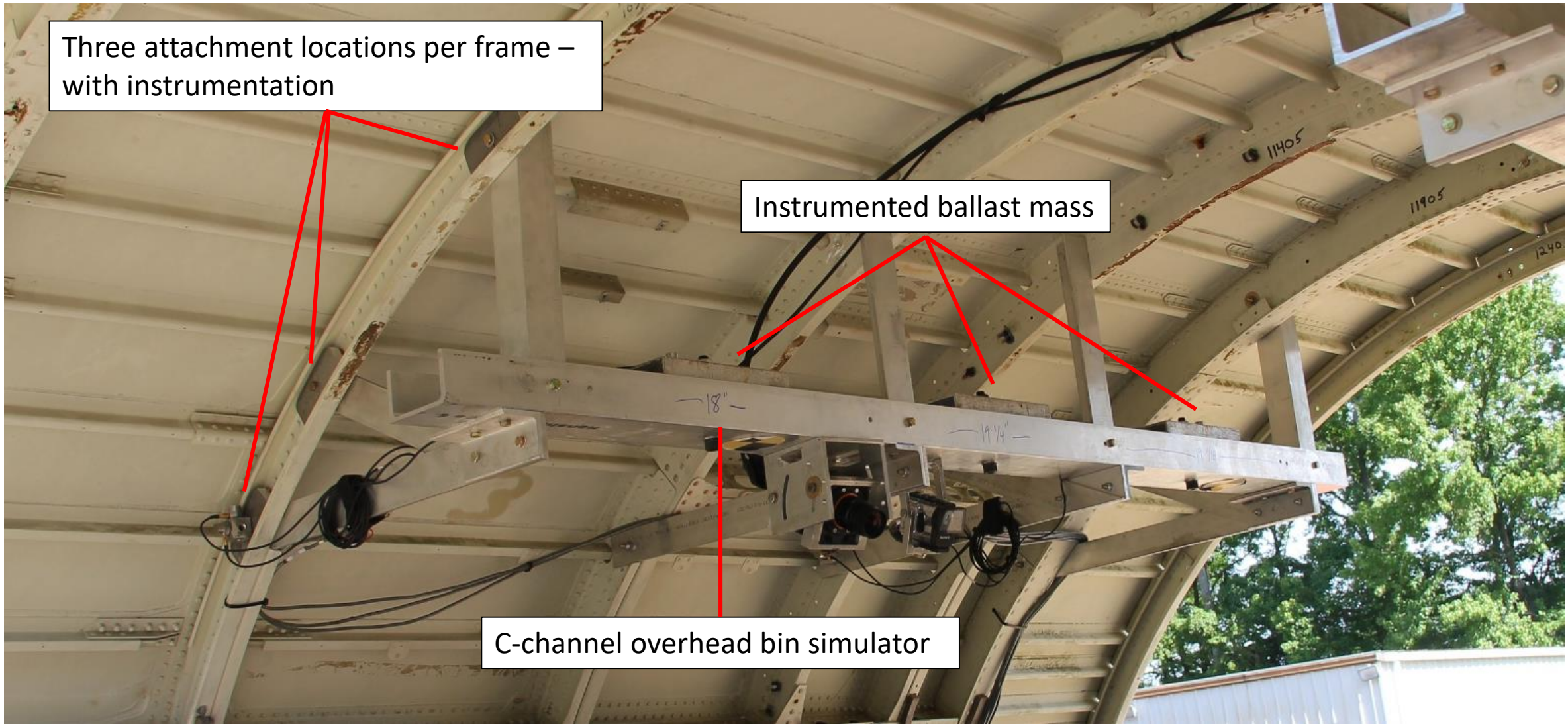


Wingbox



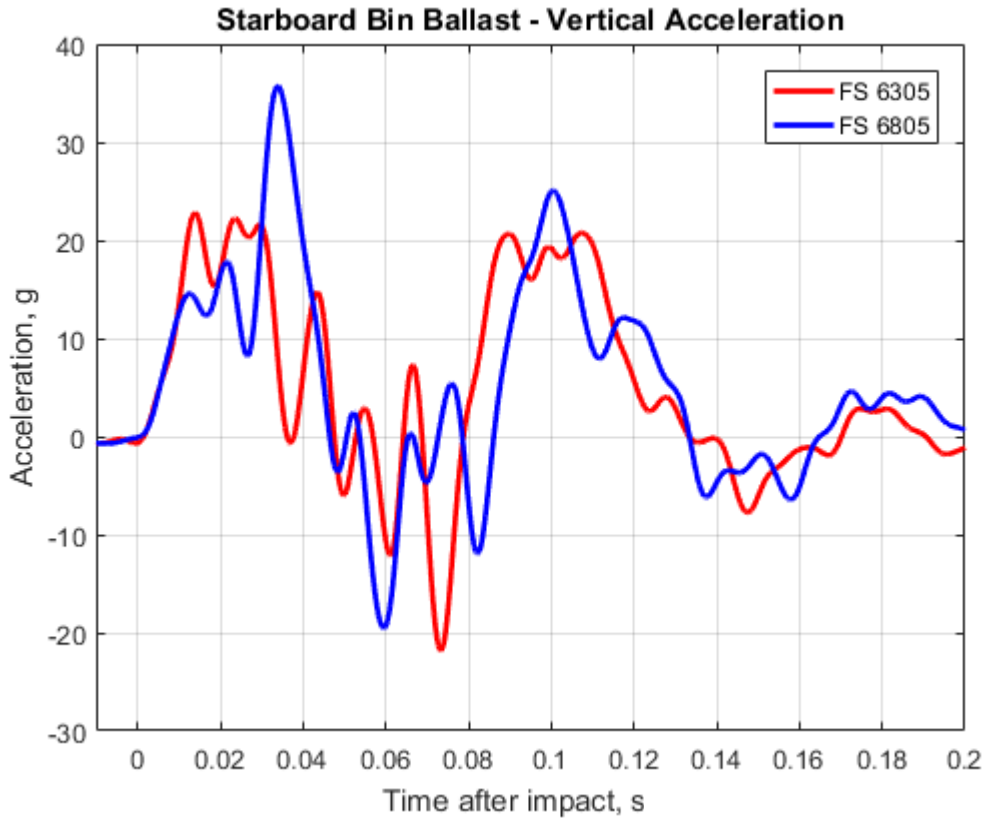
Frame at t+0.060 sec

Overhead bin attachment configuration ~116 lb per side

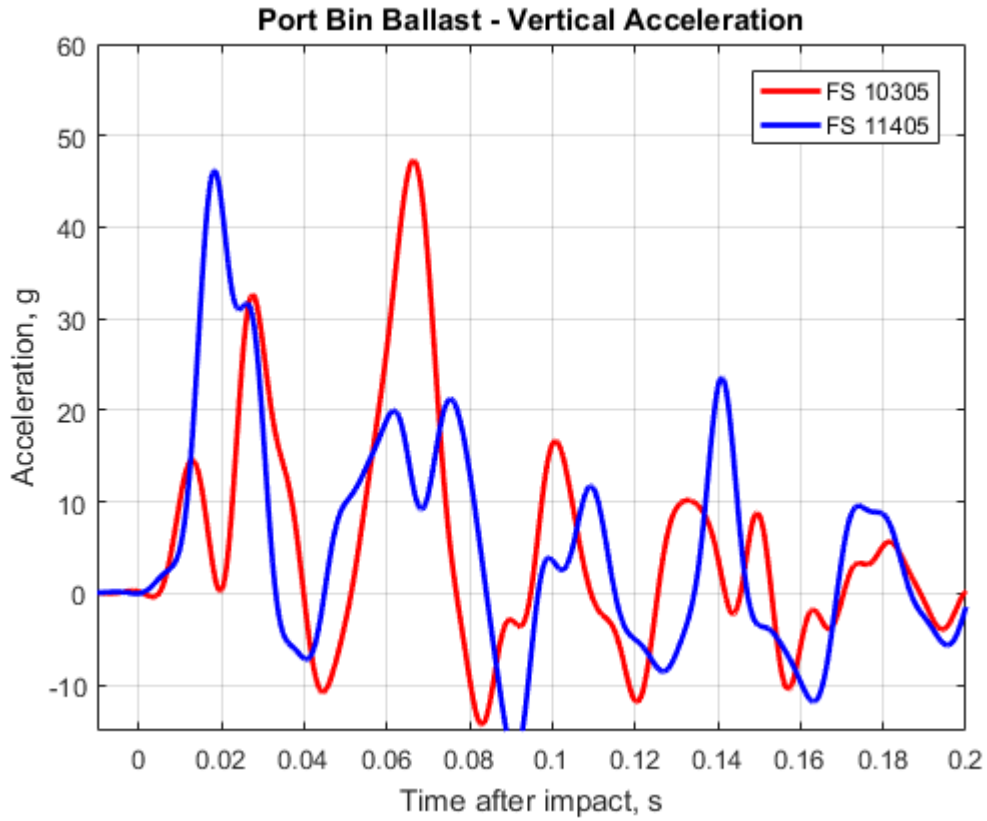


Overhead bin attachment results

Forward Barrel

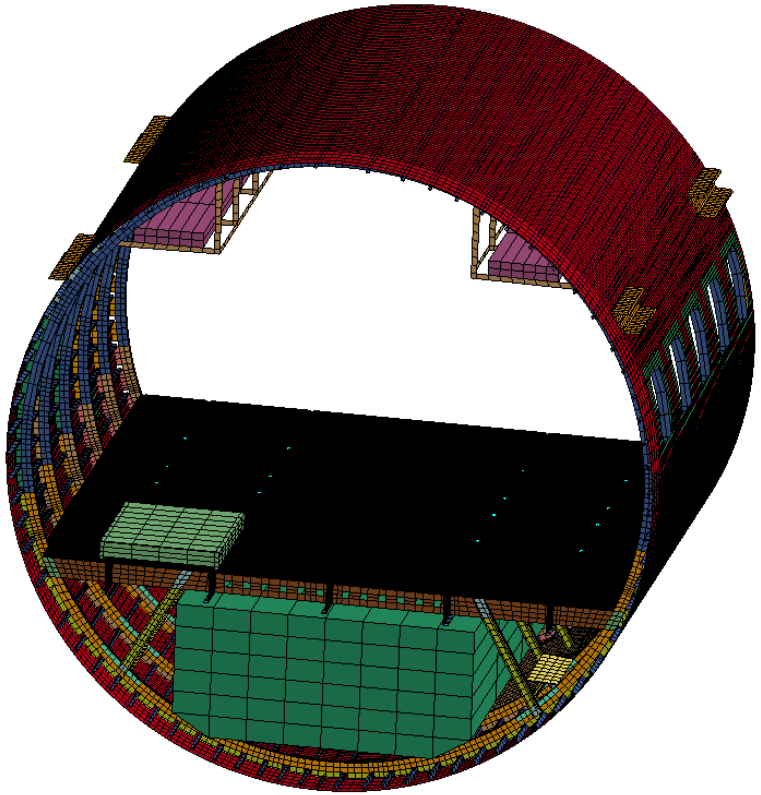


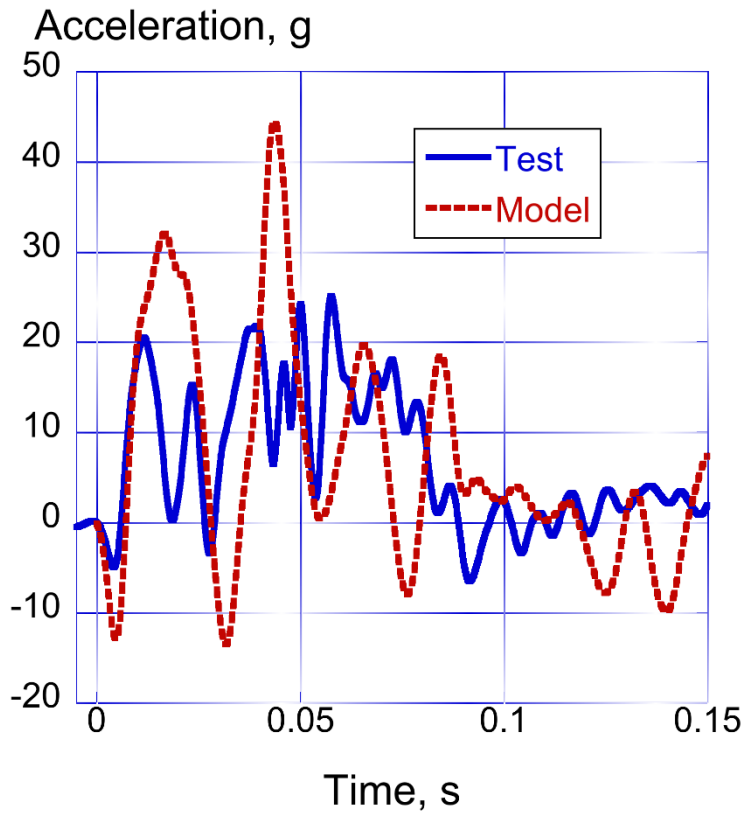
Wingbox



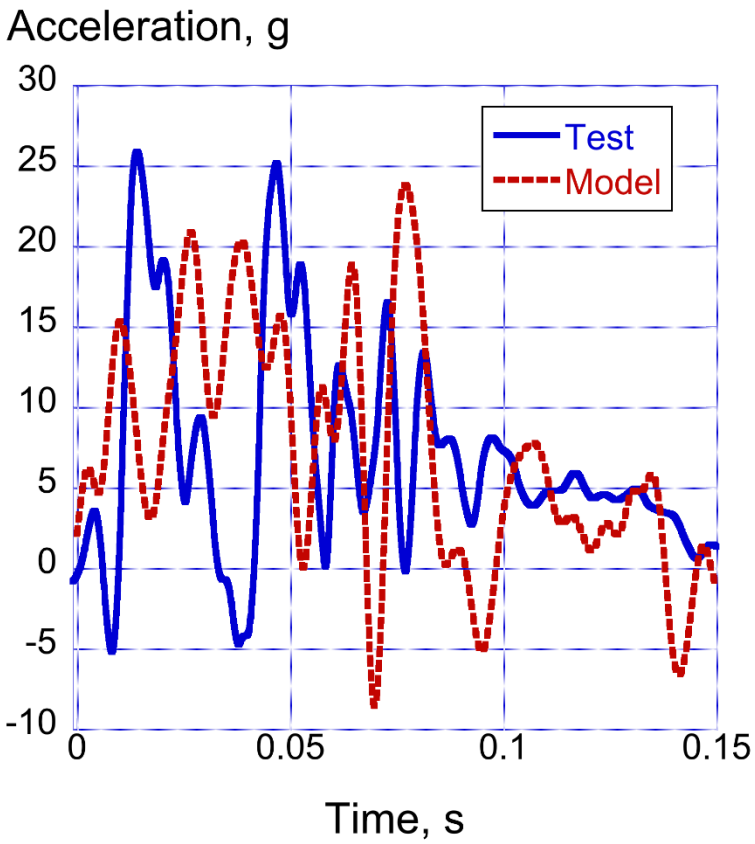
- Peaks (20 to 35 g) x bin mass = 2,320 to 4,060 lb dynamic load on attachments forward barrel
- Peaks (47 to 53 g) x bin mass = 5,452 to 6,148 lb dynamic load on attachments wingbox
- Equivalent static to dynamic loading?

Forward barrel model/test comparison





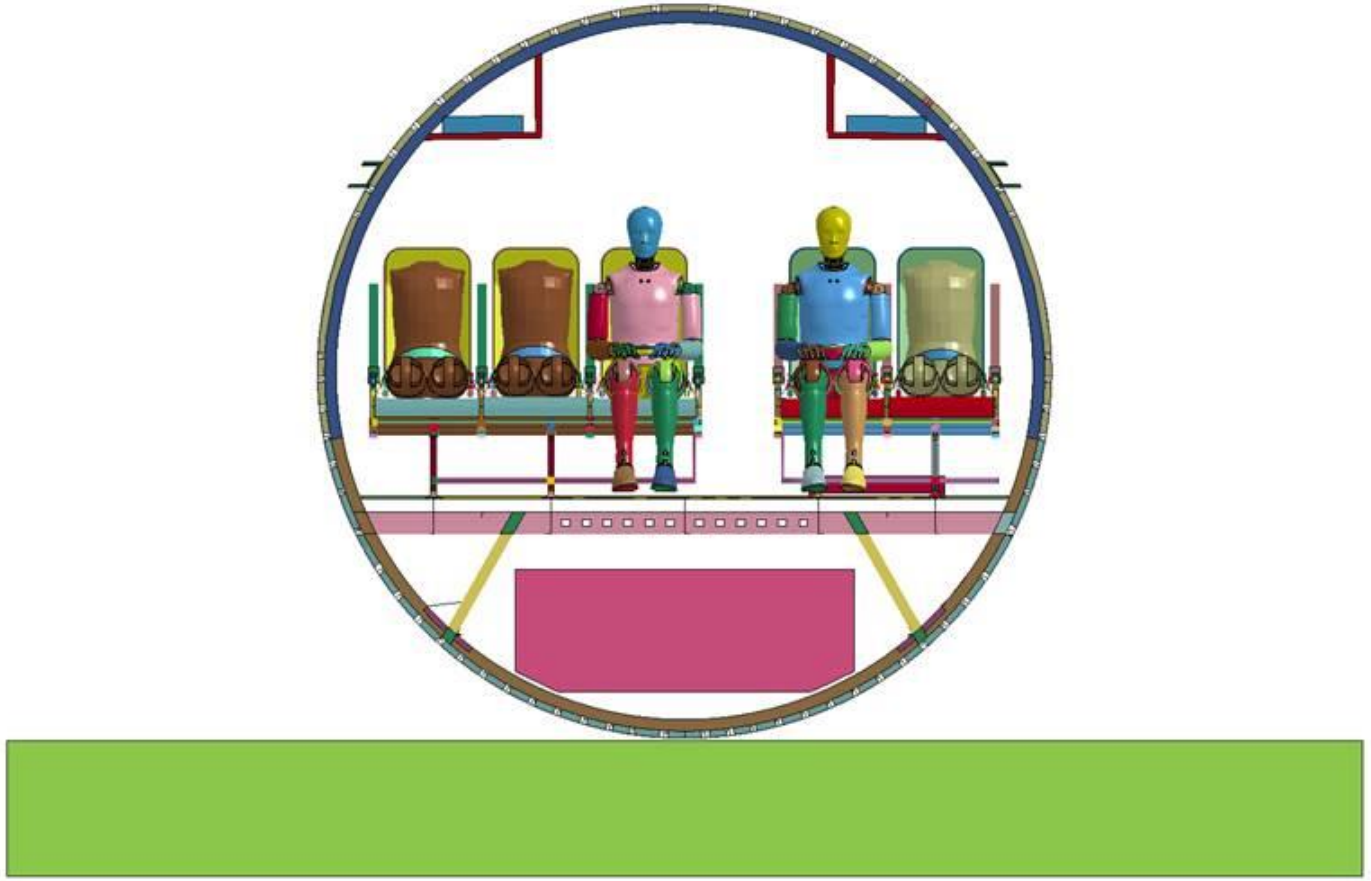
Left Side Window
at FS 5805



Right Side Window
at FS 6805

F28 model with seats and ATDs in test configuration

- Model with only 2 ATDs is 450,000 elements
- ATDs are LSTC Hybrid III 50th percentile in 2 seats only
  - Curved lumbar spine/load
  - Other seats include mass simulants
- Runtime is 48 hours for 0.120 seconds of simulation

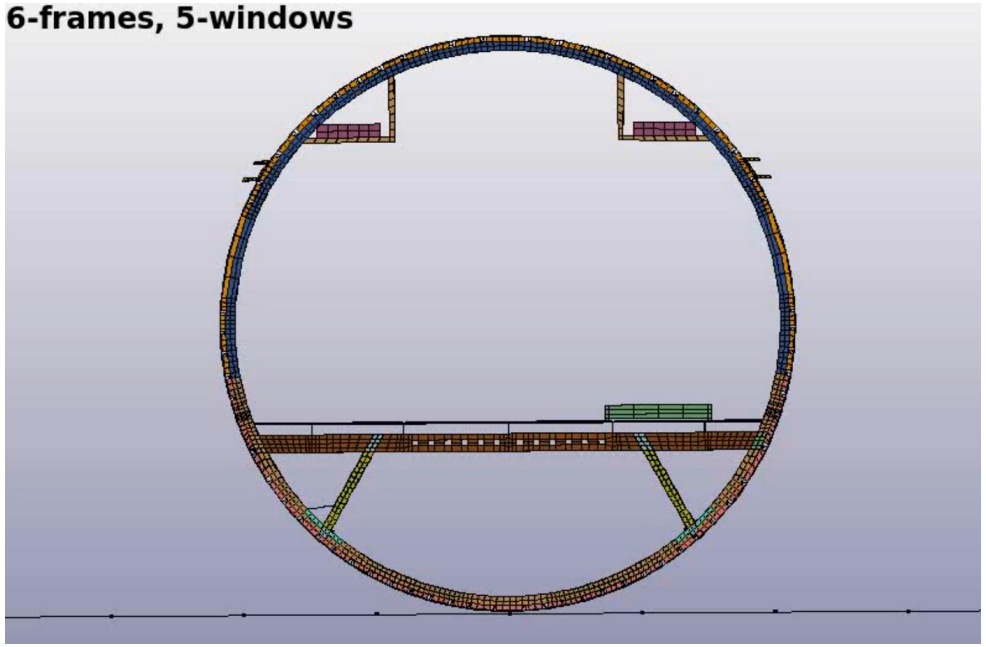


F28 model instabilities due to contact issues

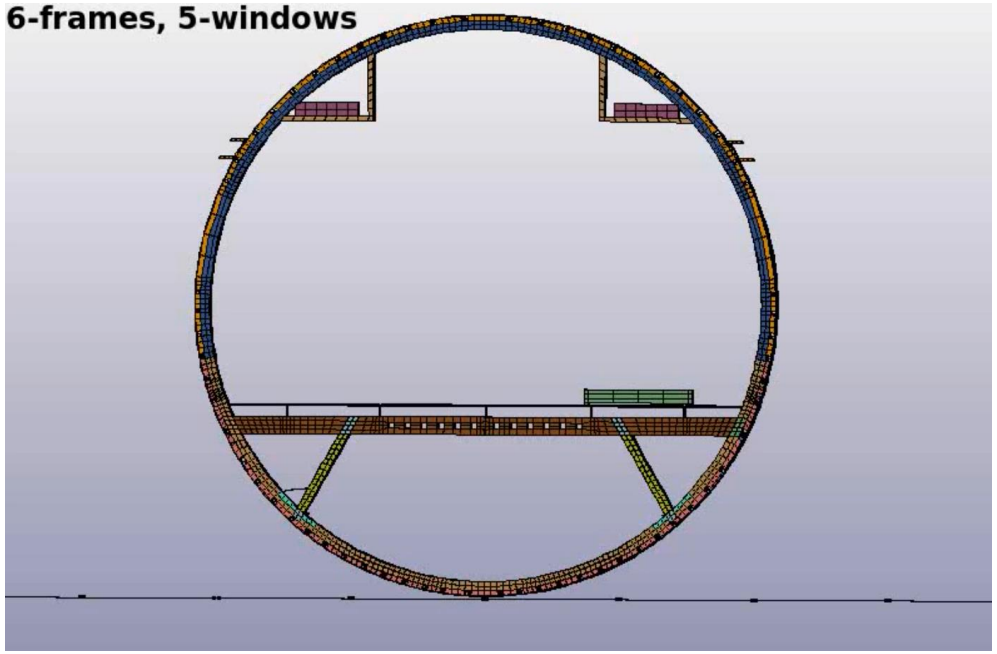
Model terminates at 0.090 sec due to contact instabilities between ATD pelvis and seat foam

Model differences - 18 ft/sec vs. 30 ft/sec – no luggage

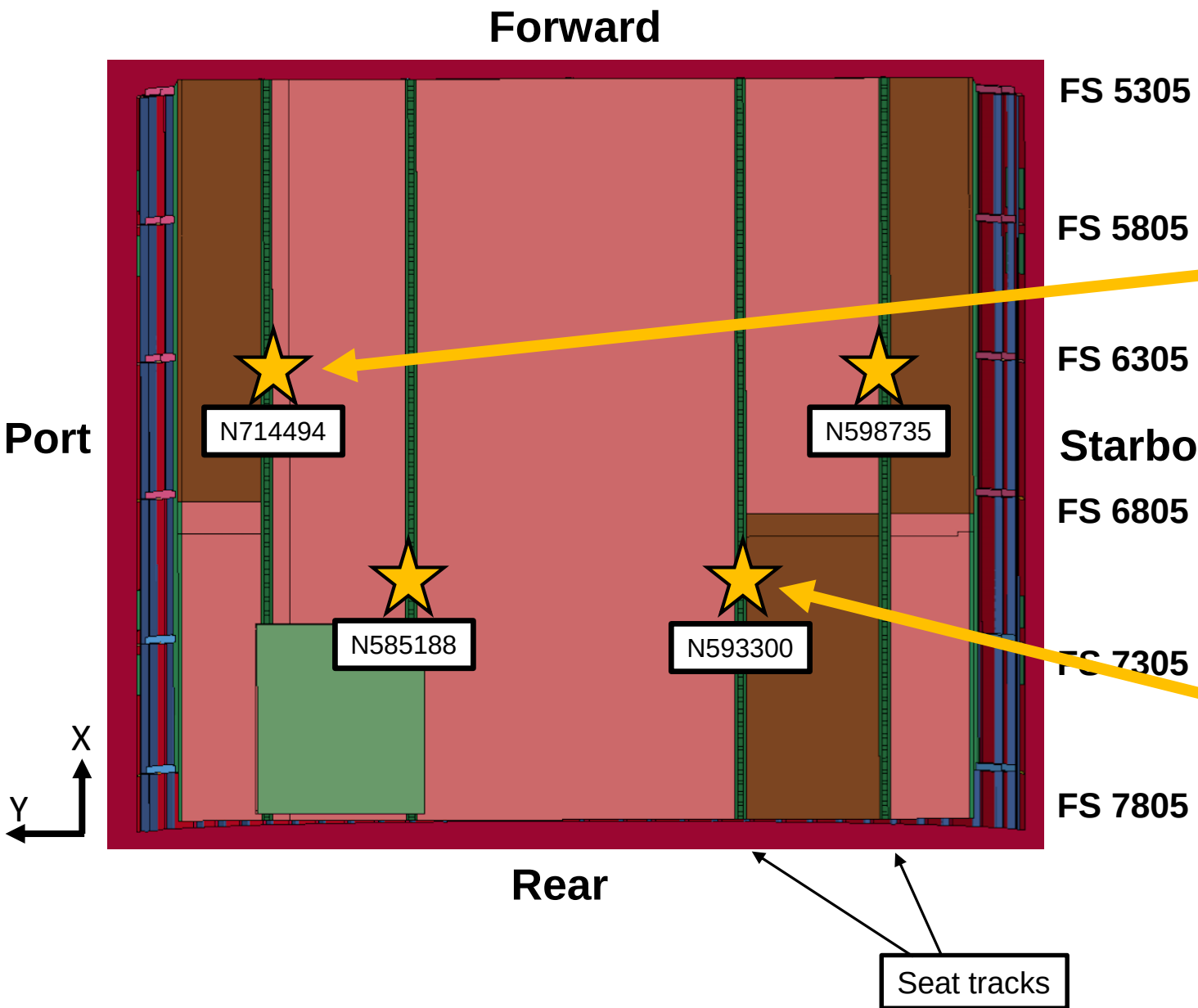
18 fps

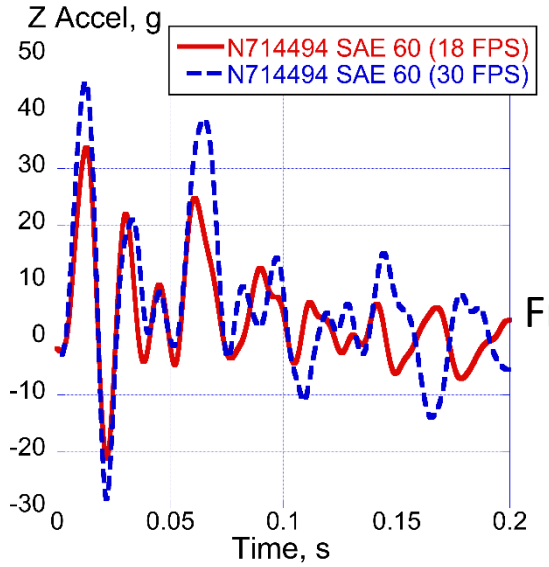


30 fps (2002 test condition)

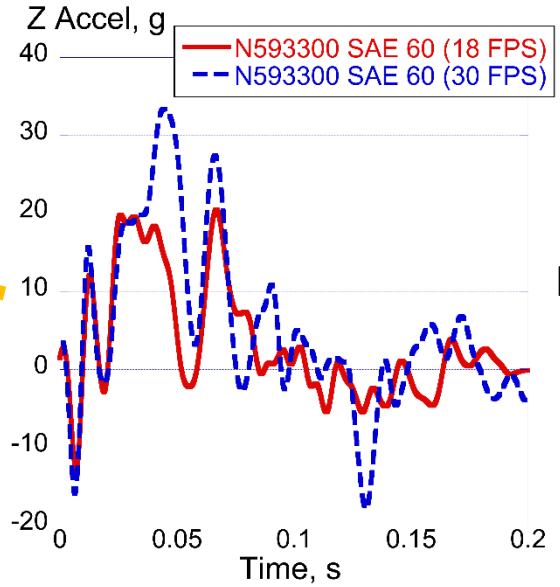


Model differences - 18 ft/sec vs. 30 ft/sec – no luggage



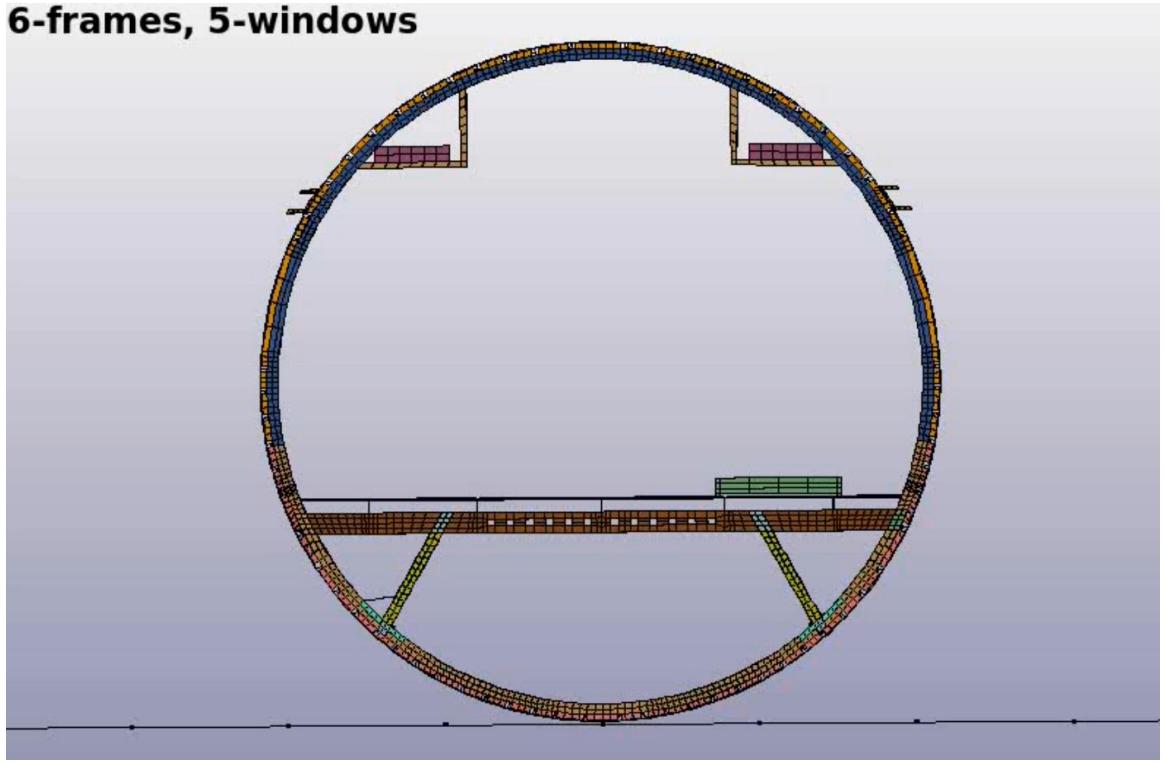


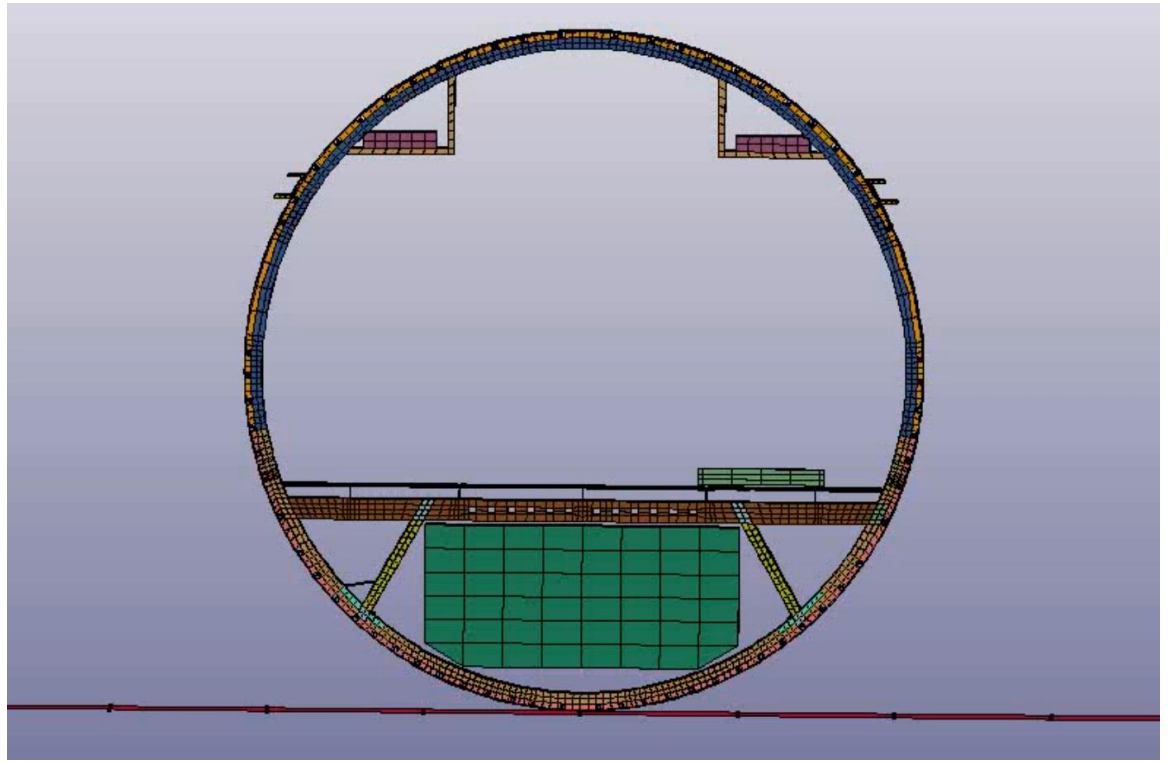
Front Double Seat



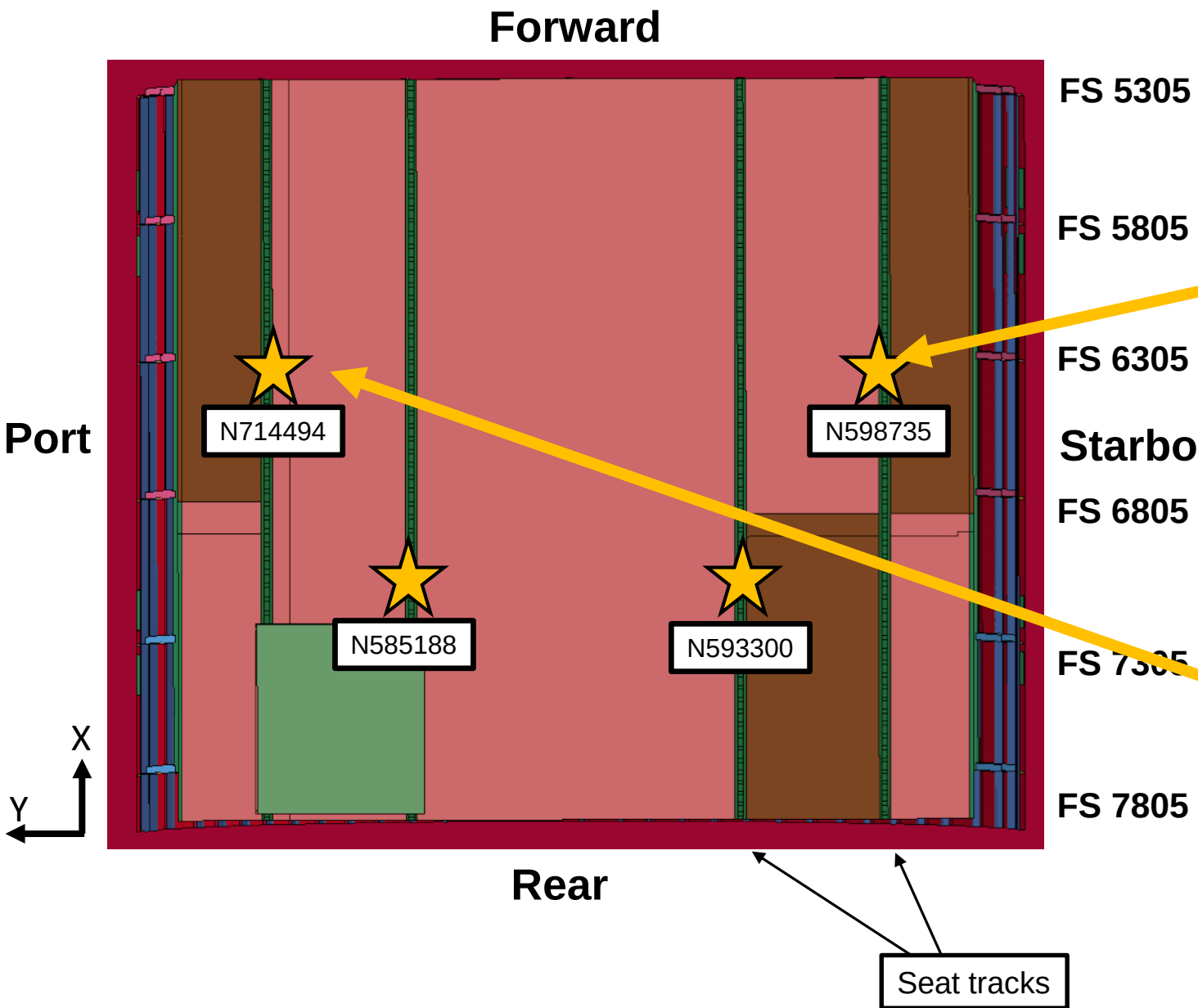
Rear Triple Seat

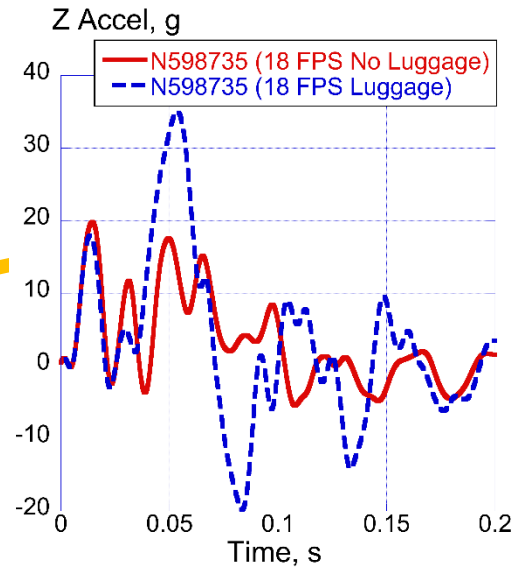
Model differences - 18 ft/sec vs. 18 ft/sec with luggage



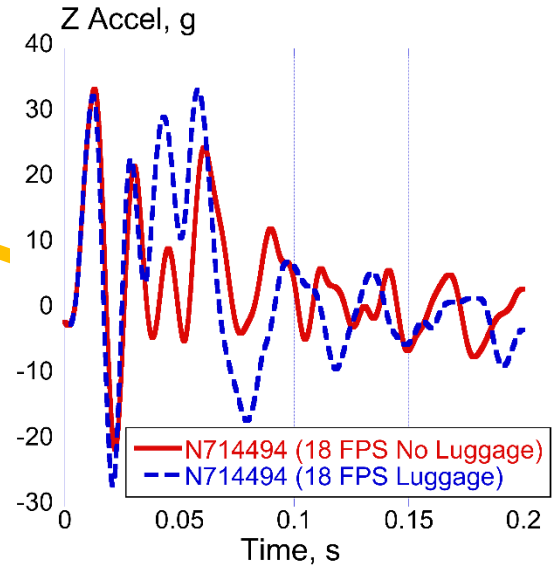


Model differences - 18 ft/sec vs. 18 ft/sec with luggage





Front Triple Seat



Front Double Seat

Lessons Learned from F28 drop testing

- Doing a canted/sloped test is much harder than a flat test from a logistical standpoint
  - 10 deg slope did not significantly load the occupants in my opinion, but it did induce a forward load
- Luggage vs no luggage
  - Criteria 1 – N/A
  - Criteria 2 – Potentially makes no difference in lumbar response
  - Criteria 3 – Makes big difference
  - Criteria 4 - Makes big difference
- Bin Attachment ballast was included to generate ARAC results, however since bins were not included, criteria are N/A
  - Dynamic load factor shown
- ATD injury criteria shows some ATDs over and some ATDs under critical lumbar load limit of 1,500 lb.
  - Must evaluate all ATDs present
  - Criteria – N/A
  - Criteria 2 – Fail (test at 30 ft/sec)
  - Criteria 3 – N/A
  - Criteria 4 – N/A

Lessons Learned from F28 analyses

- Models need test data in order to accurately capture loading
  - Ideally full scale or large scale test data is needed
- ATDs need precise positioning, and cannot use Hybrid III lumbar results due to spinal curvature
- ATD/Seat/Airframe interaction is critical when trying to extract injury criteria
  - Must use correct ATD
  - Must use correct 25.562 seat