

NASA LaRC Full Scale F28 Barrel Drop Summary

With analysis suited for ARAC TACDWG

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NOTE: Data is considered PRELIMINARY and subject to change

Impact conditions

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



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



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

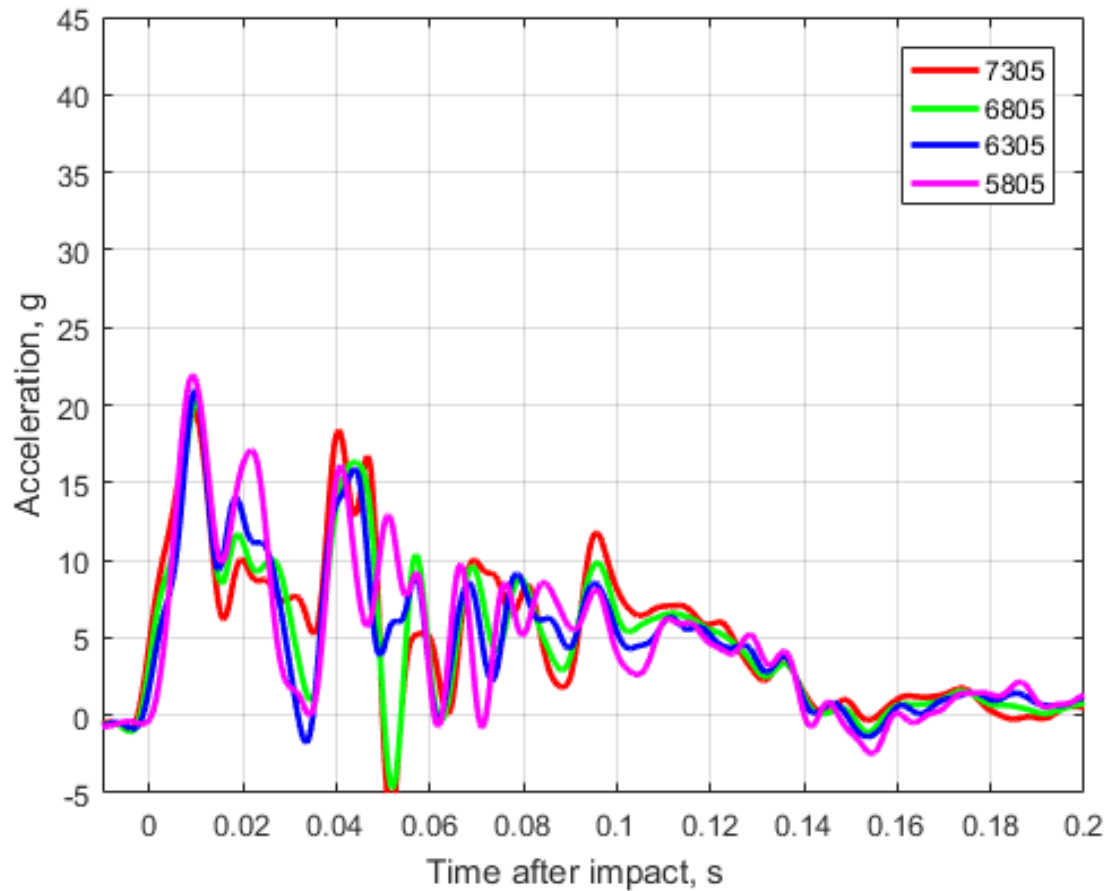
For reference, a 4 frame barrel drop was conducted at NASA LaRC in 2002

- 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*



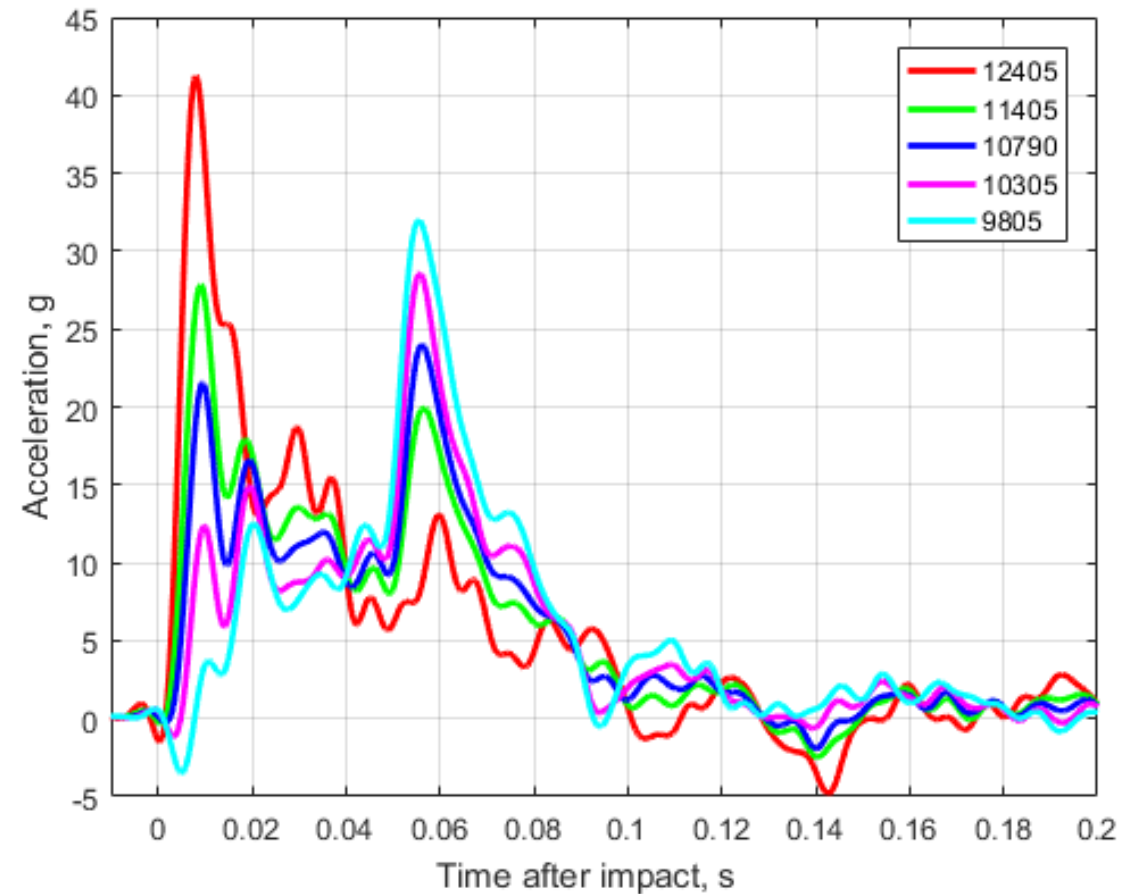
Airframe vertical acceleration – starboard side

Starboard Frame Section at Floor



Forward Barrel

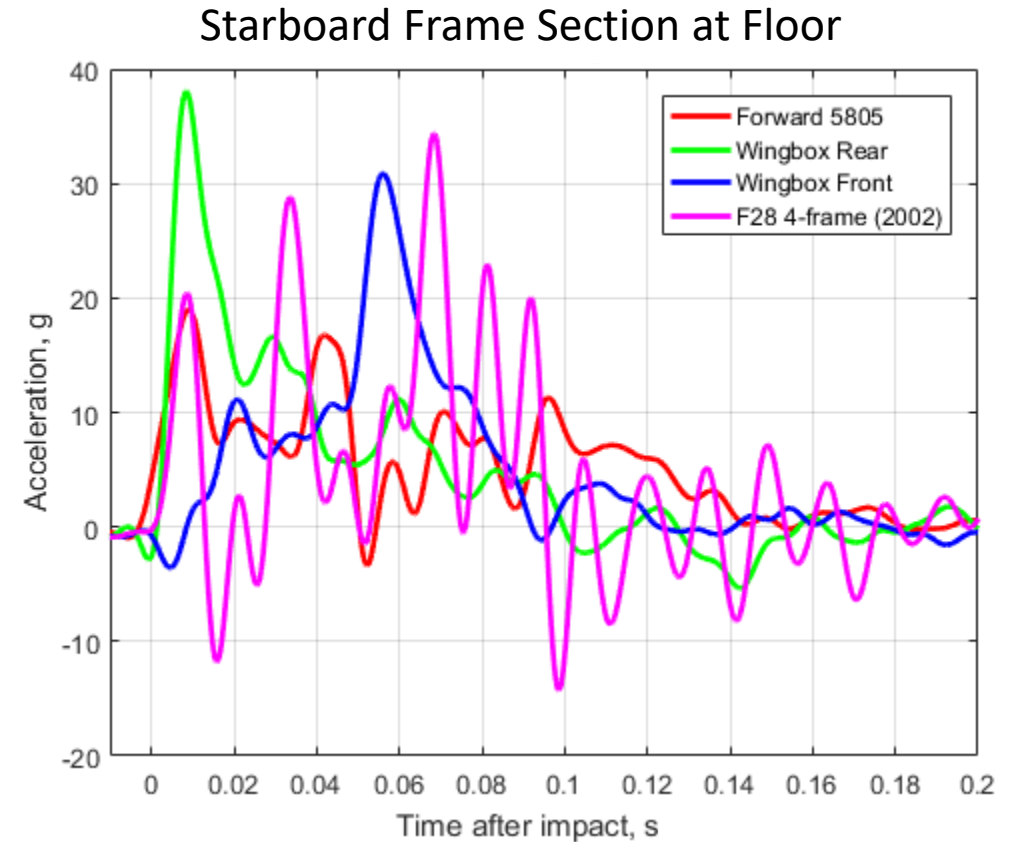
Starboard Frame Section at Floor



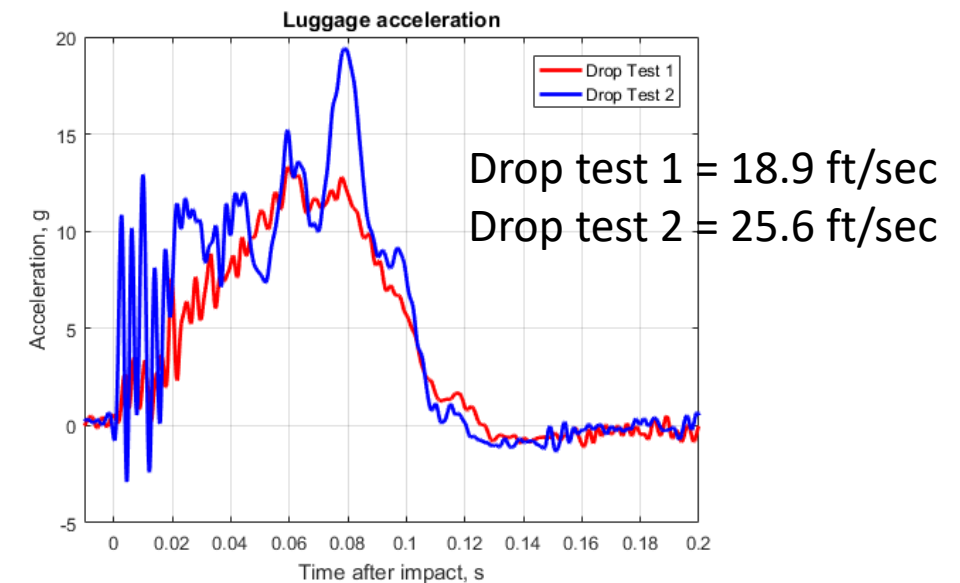
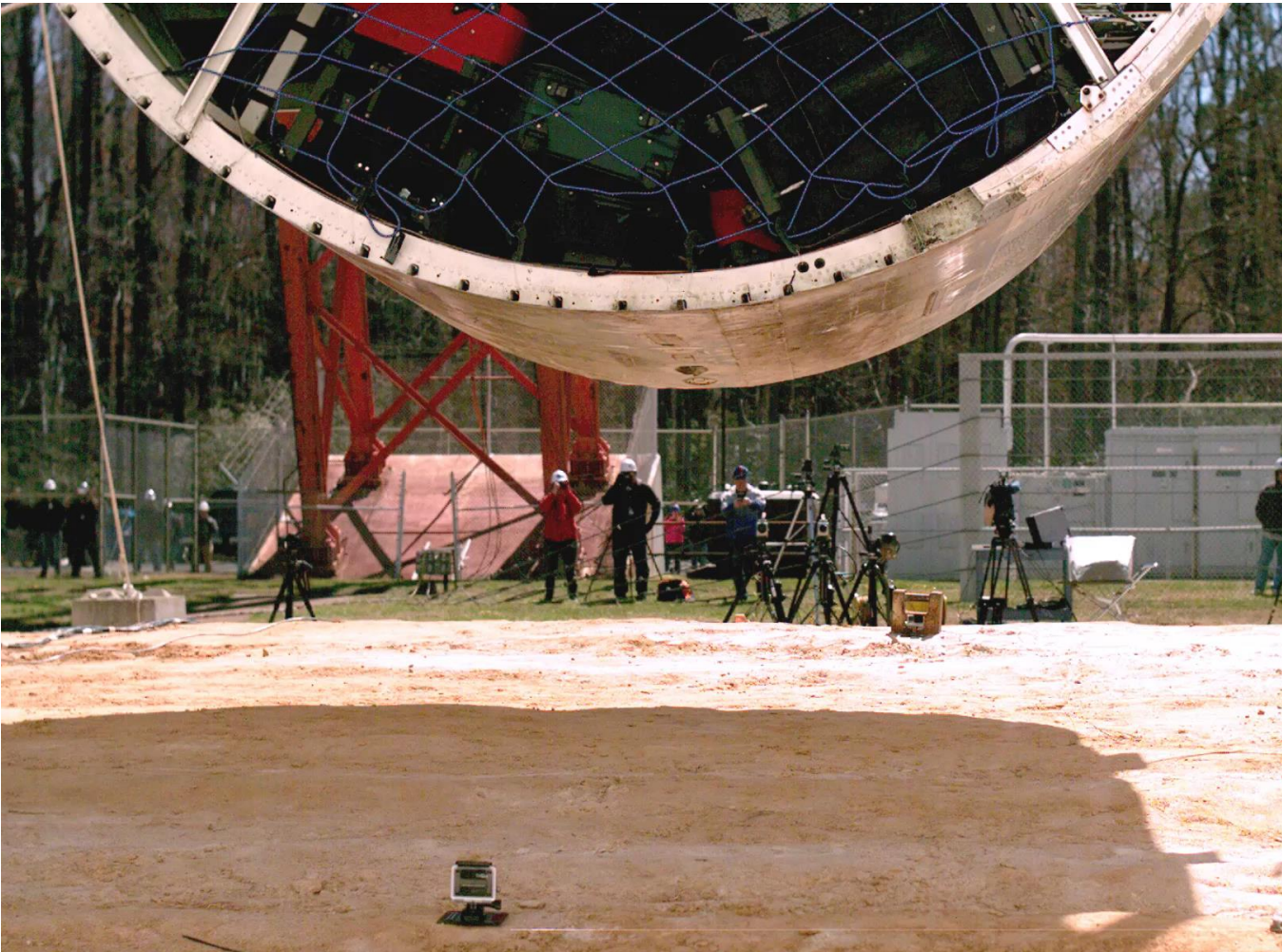
Wingbox

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

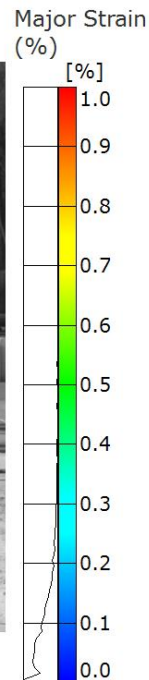
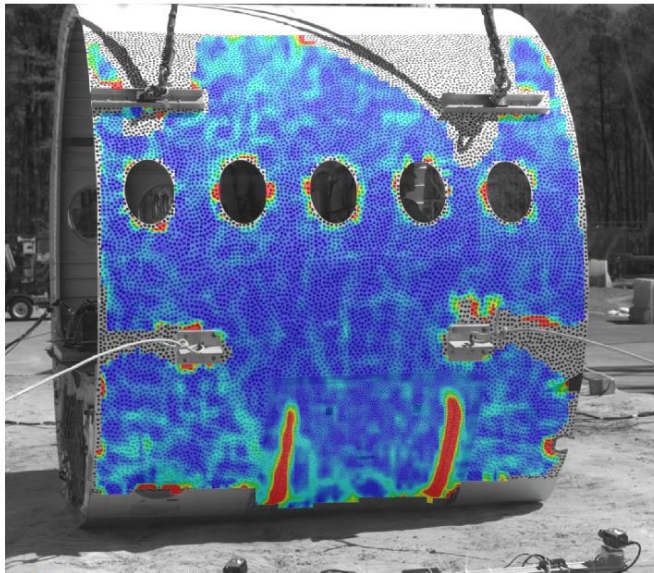


Luggage response characterization



Cargo door response forward barrel

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



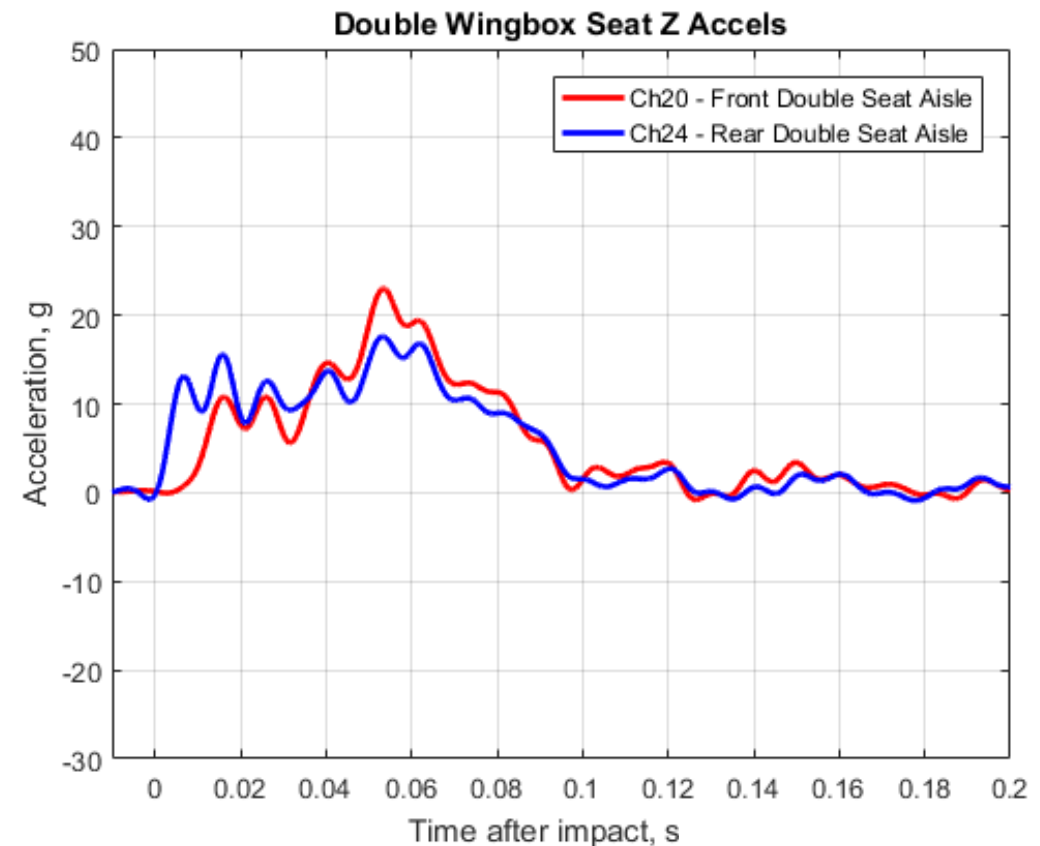
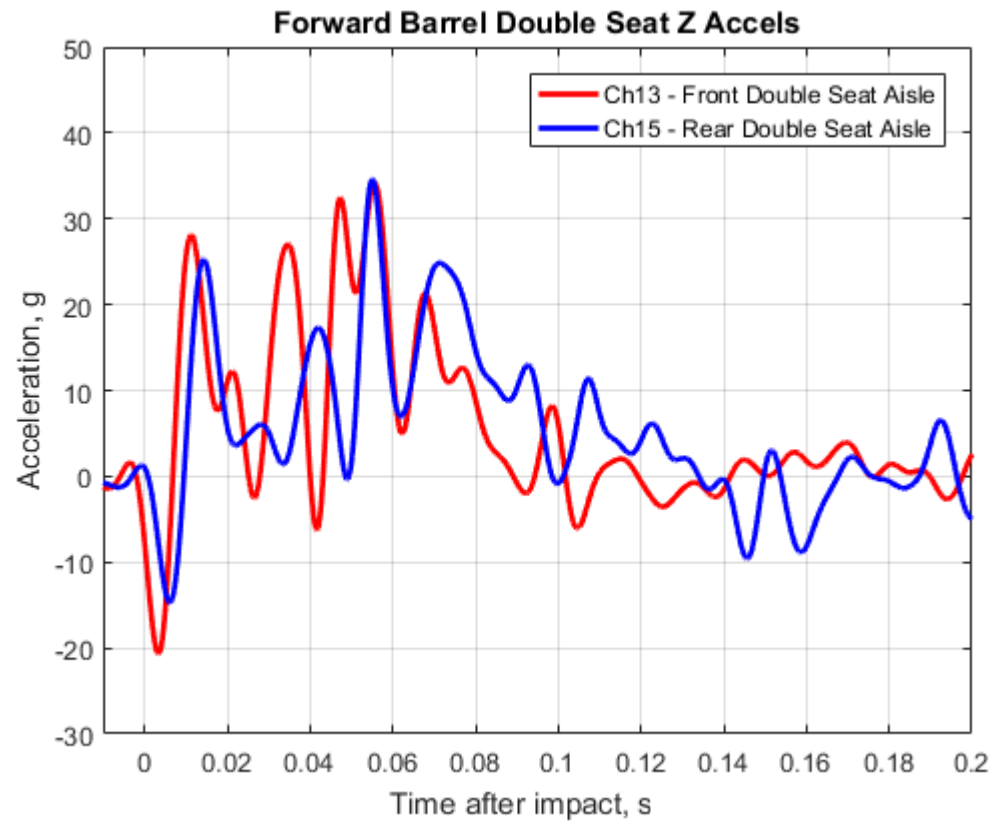
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Emergency Exit door response - Wingbox

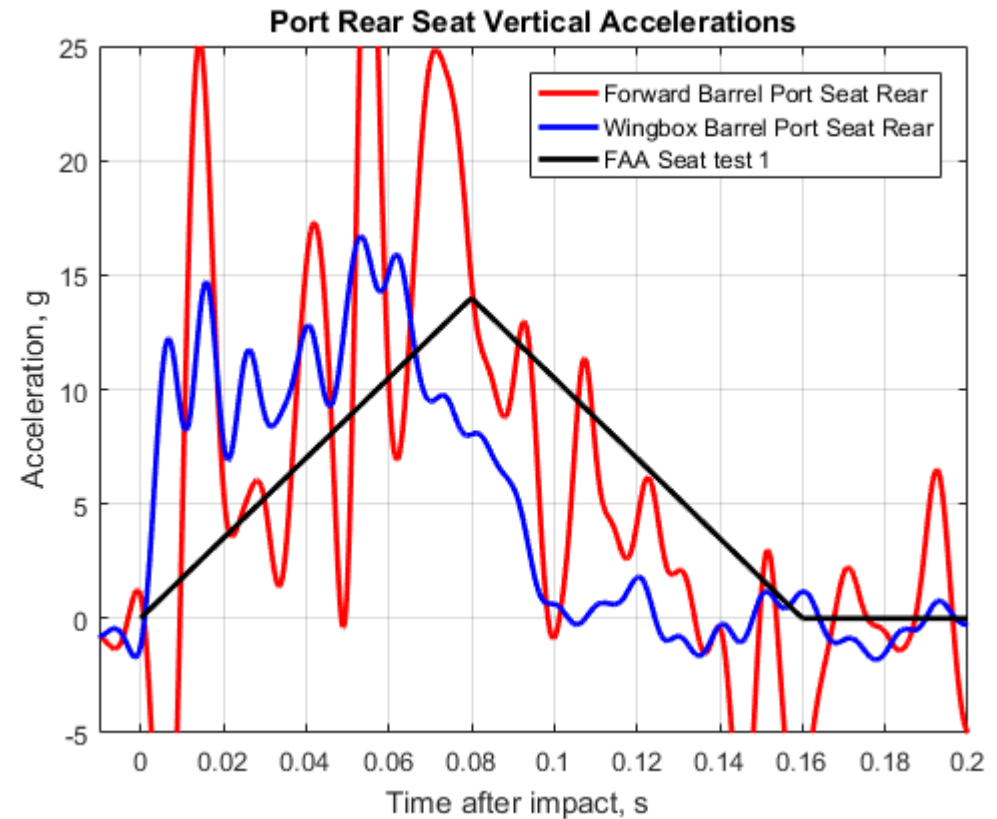
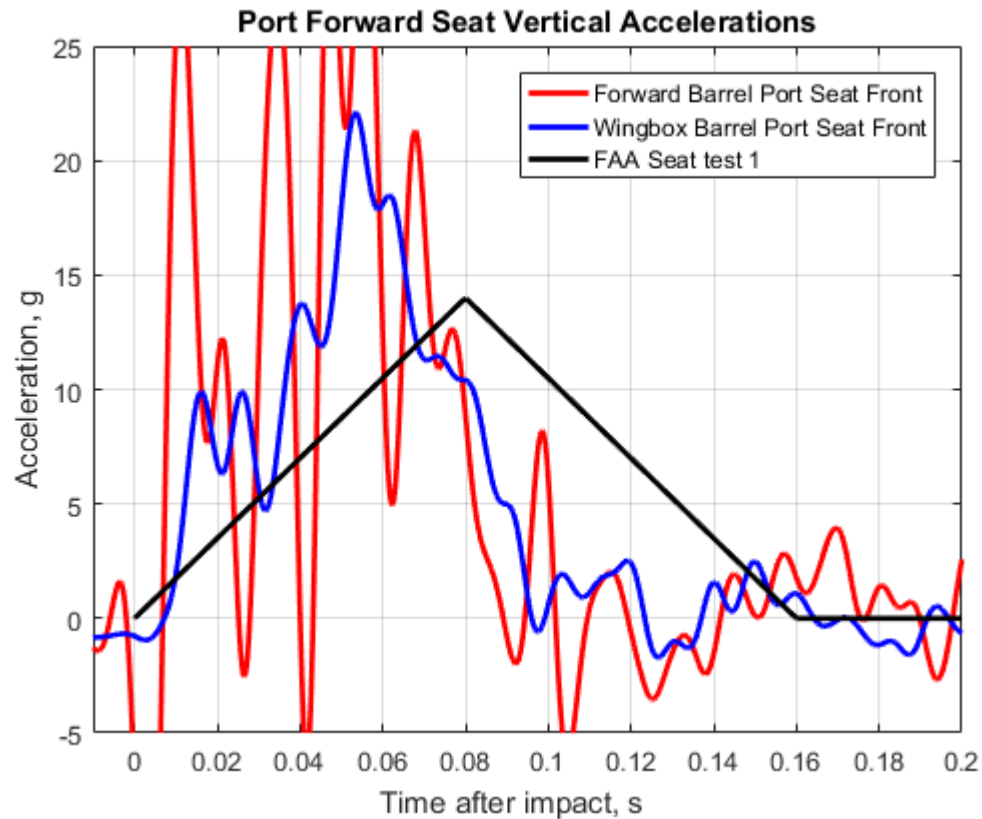


Port seat z accelerations

- 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

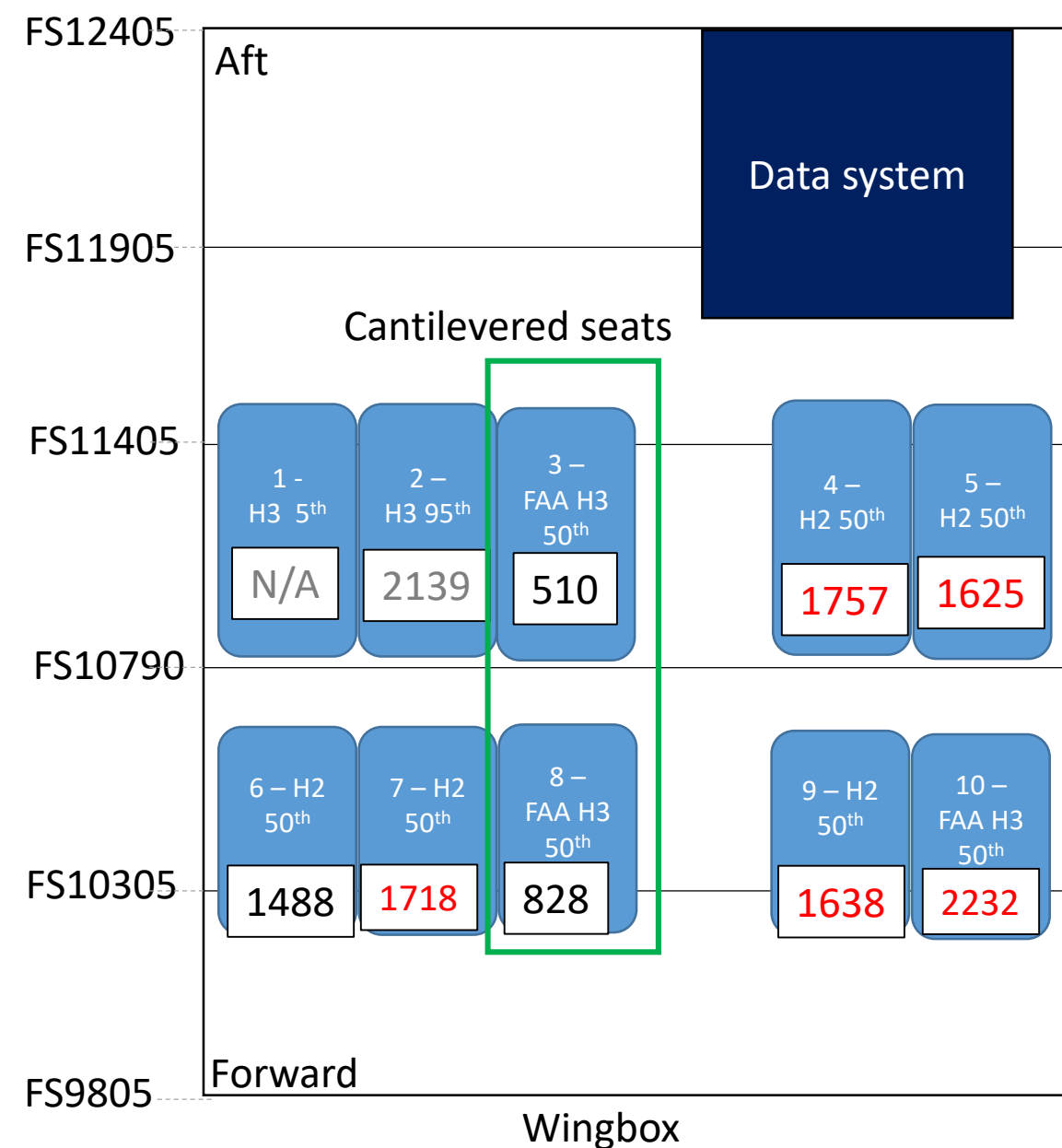
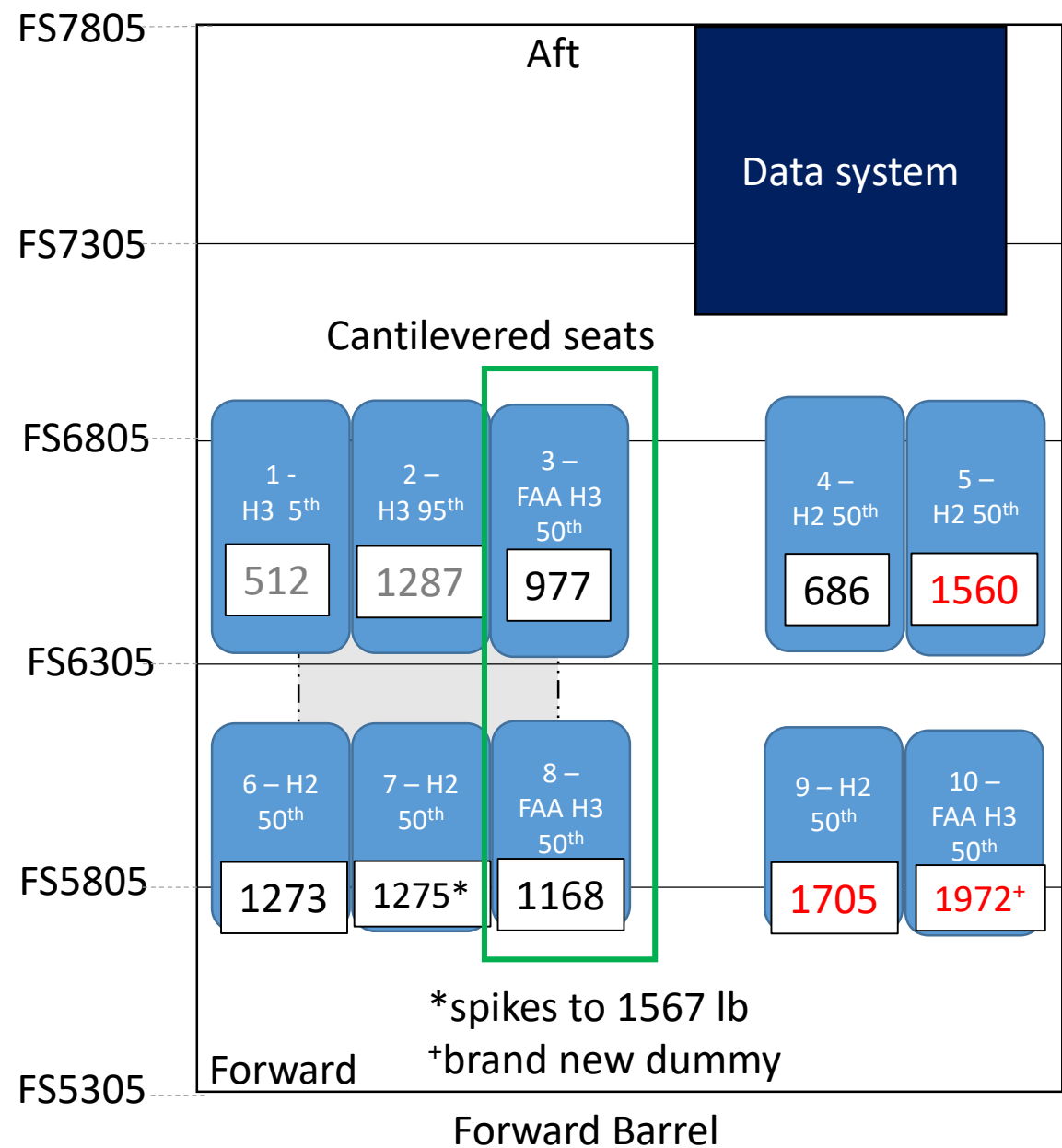
Double seat video comparisons



Forward Barrel

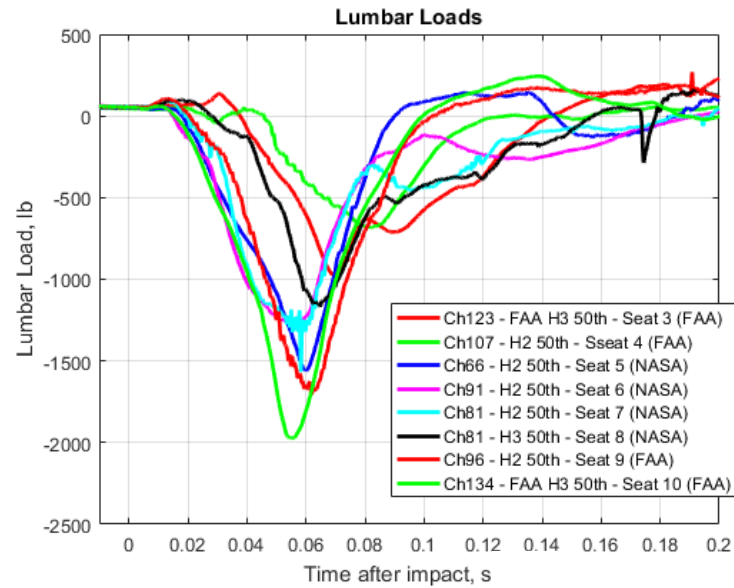
Wingbox

Lumbar loads - Peak values (lb.)

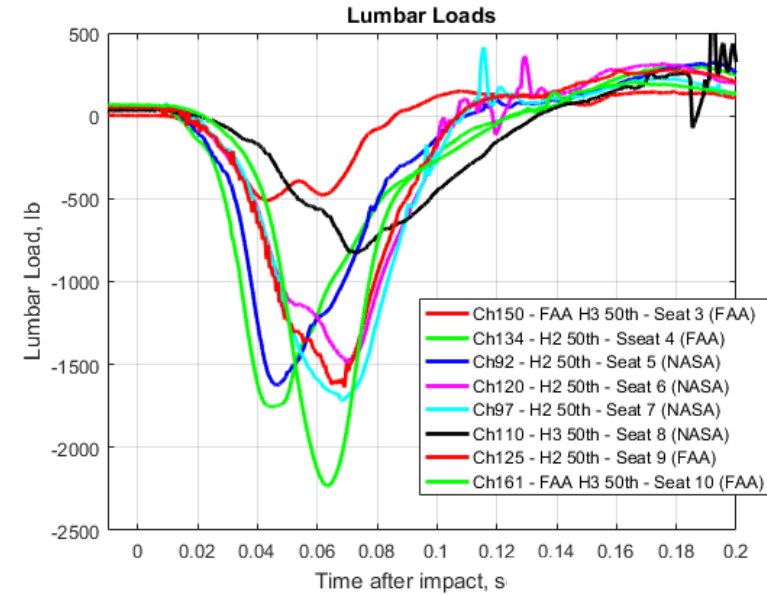


Lumbar loads peaks occur ~ 0.060 s

Forward barrel

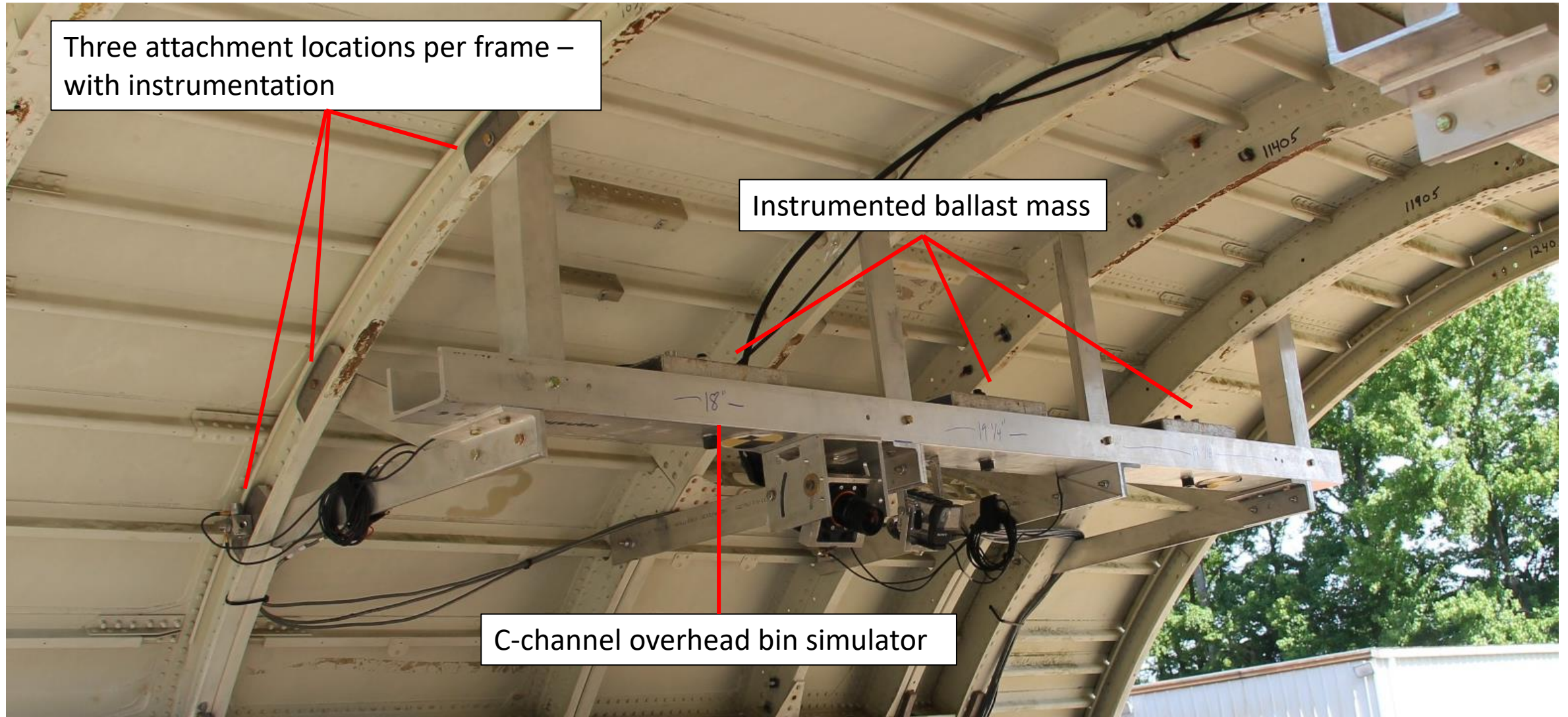


Wingbox



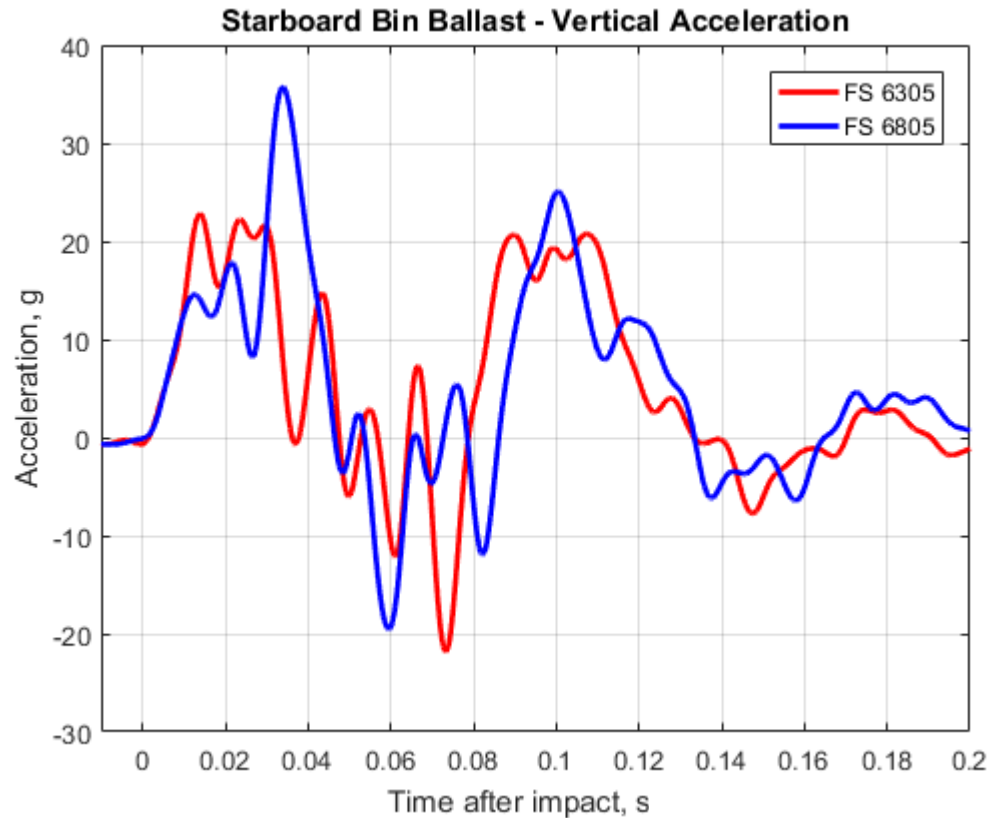
Frame at $t+0.060$ sec

Overhead bin attachment configuration ~116 lb per side

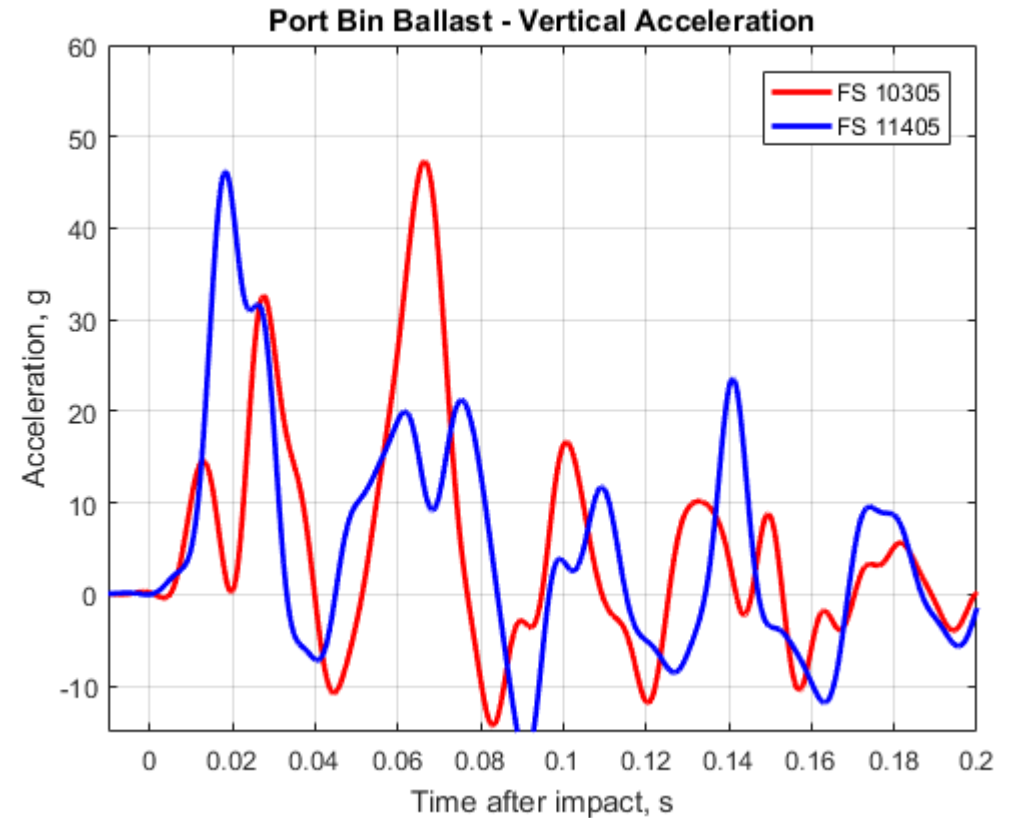


Overhead bin attachment results

Forward Barrel

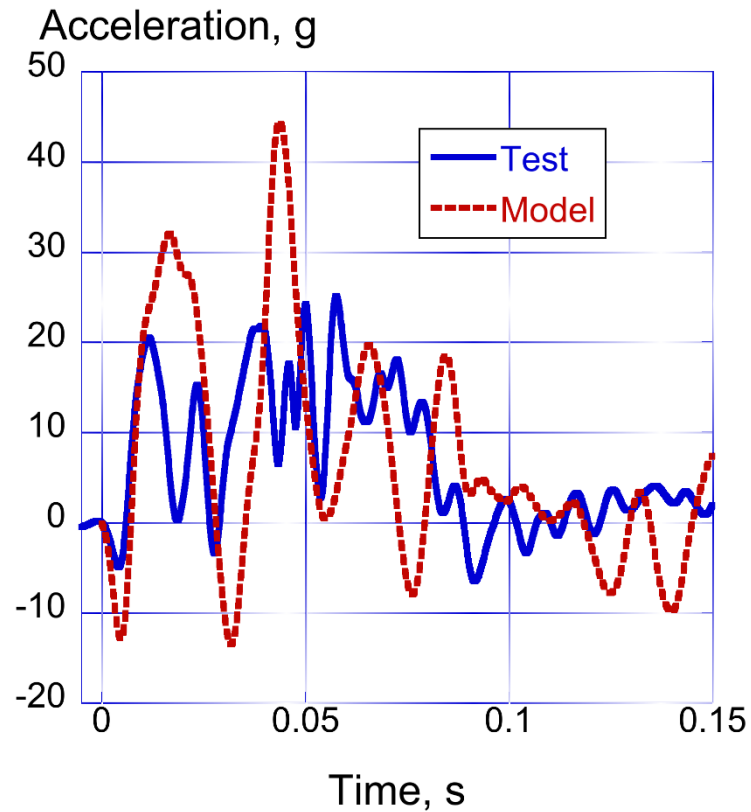
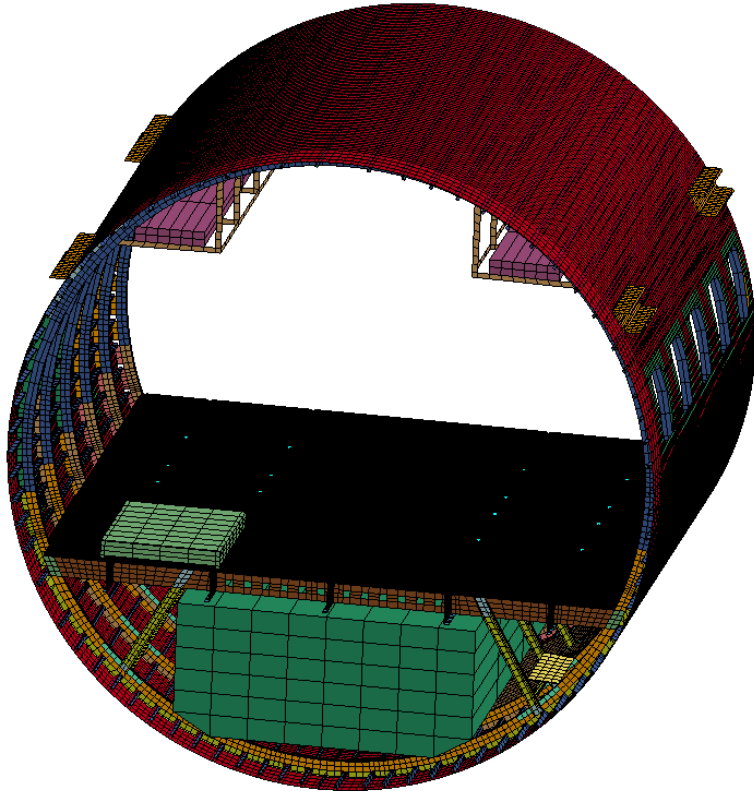


Wingbox

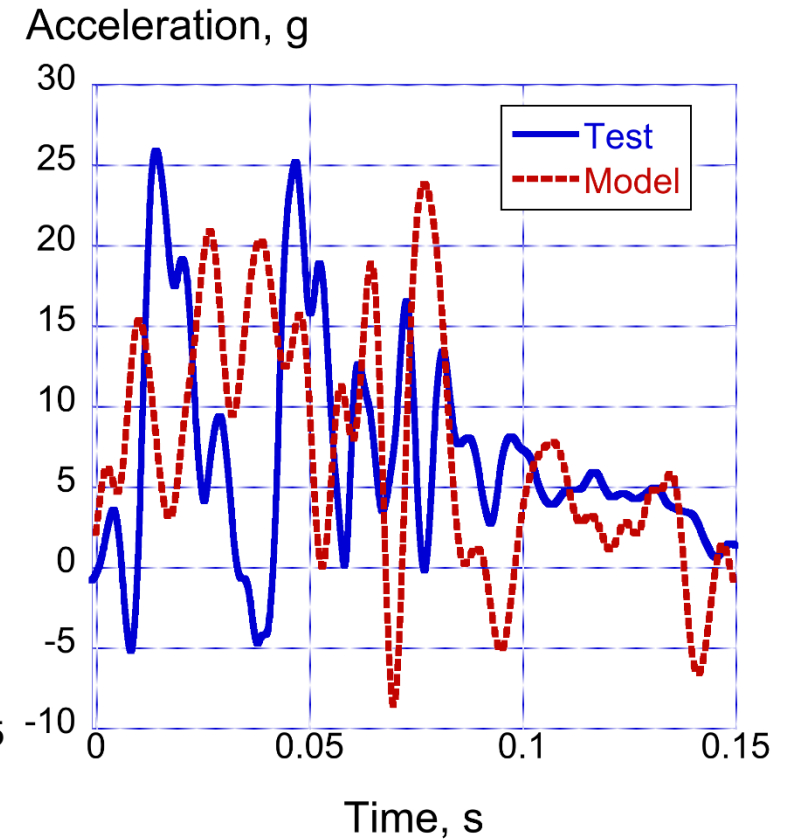


- Peaks (20 to 35 g) x bin mass = 2,320 to 4,060 lb dynamic load on attachments forward barrel
- Peaks (47 to 53 g) x bin mass = 5,452 to 6,148 lb dynamic load on attachments wingbox
- Equivalent static to dynamic loading?

Forward barrel model/test comparison



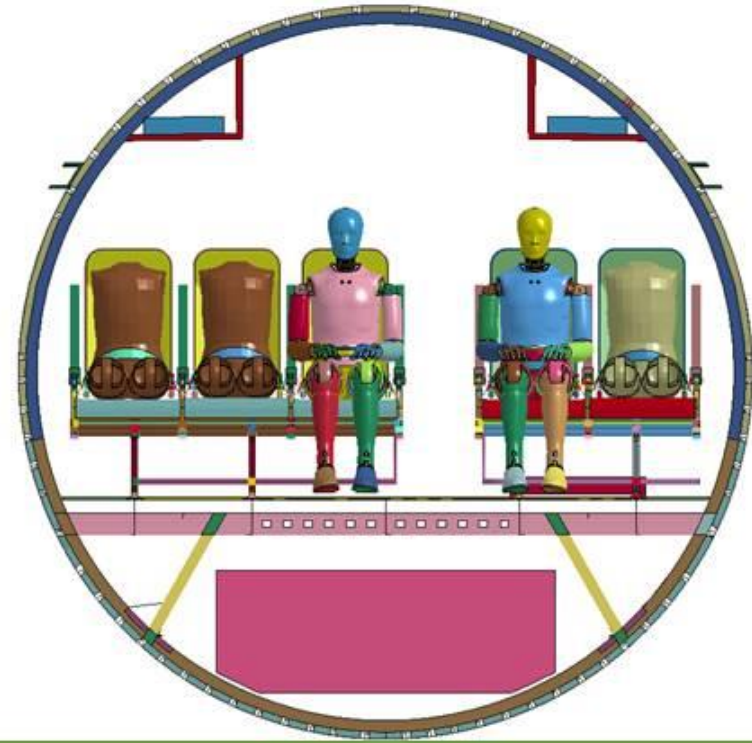
Left Side Window
at FS 5805



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

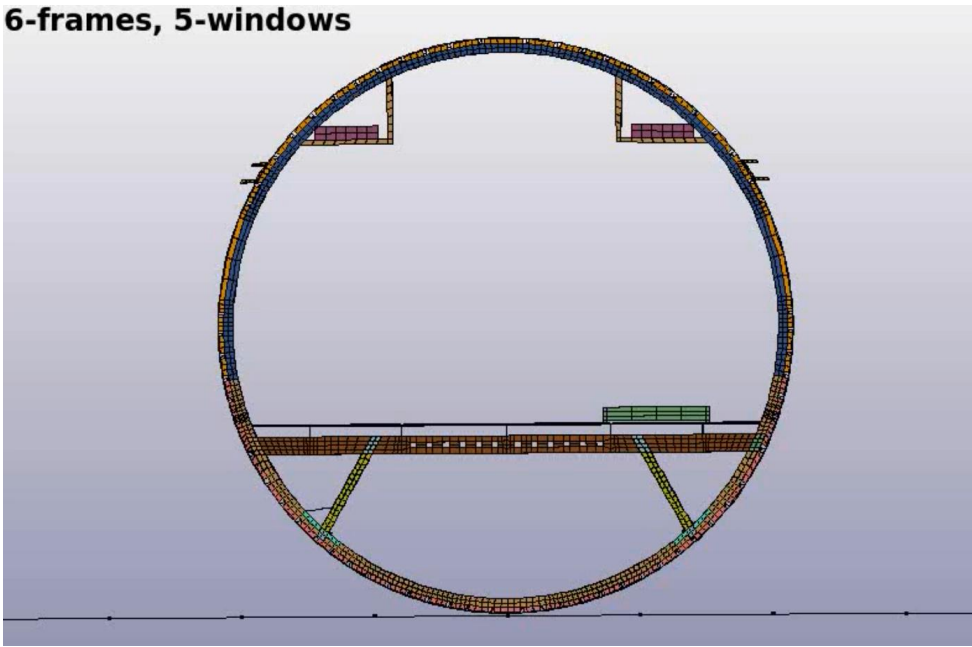


Model terminates at 0.090 sec due to contact instabilities between ATD pelvis and seat foam

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

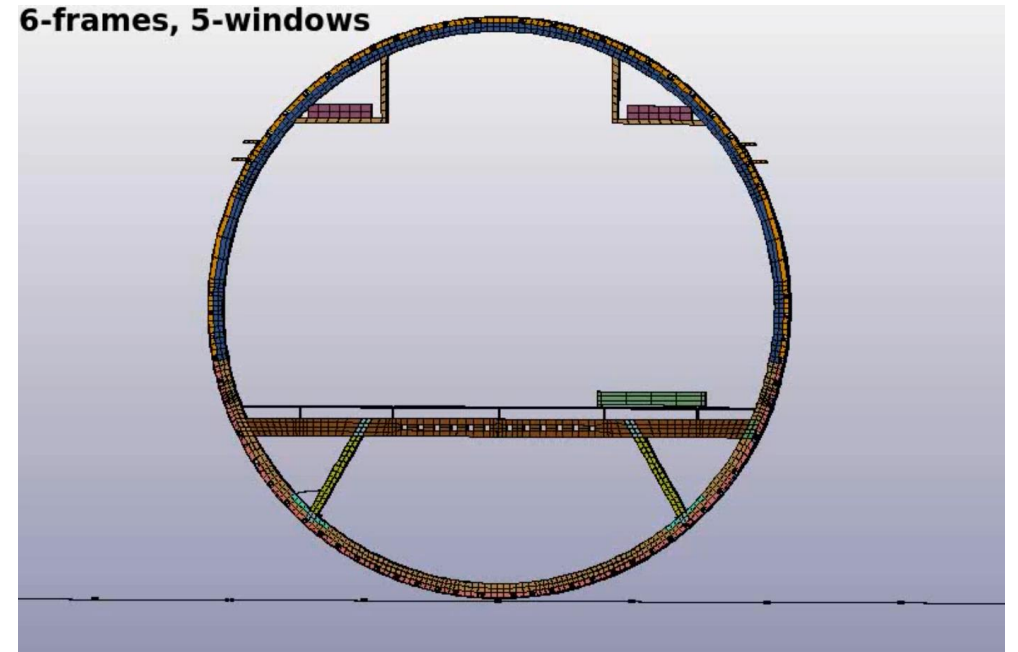
18 fps

6-frames, 5-windows

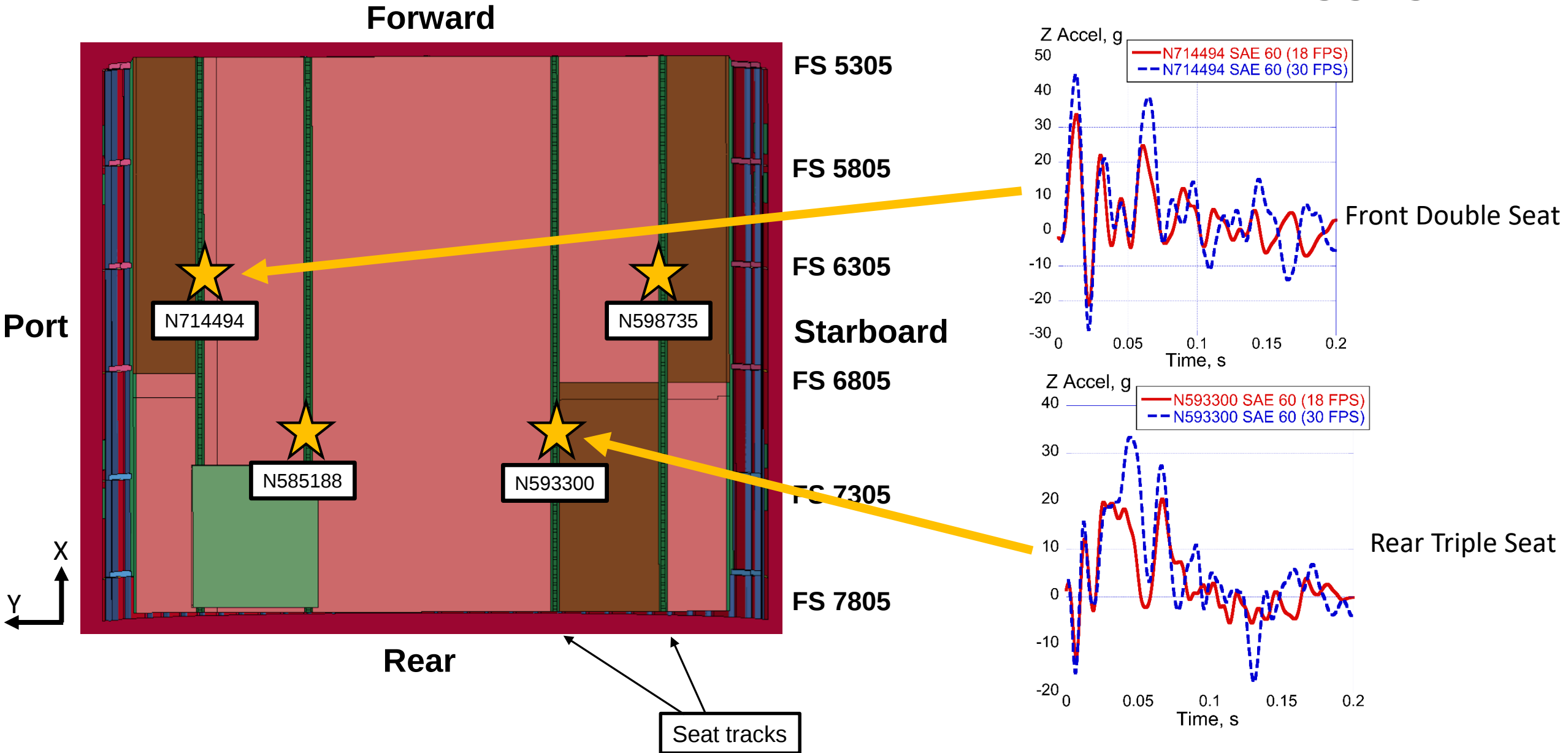


30 fps (2002 test condition)

6-frames, 5-windows

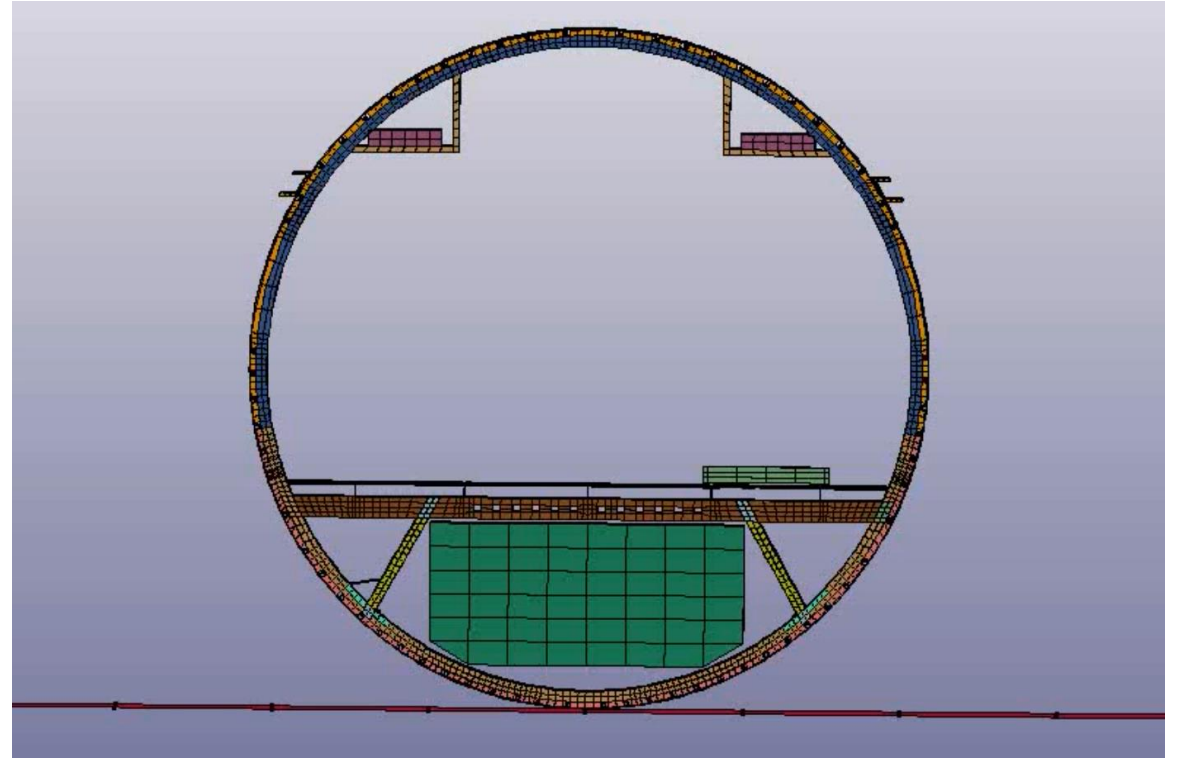
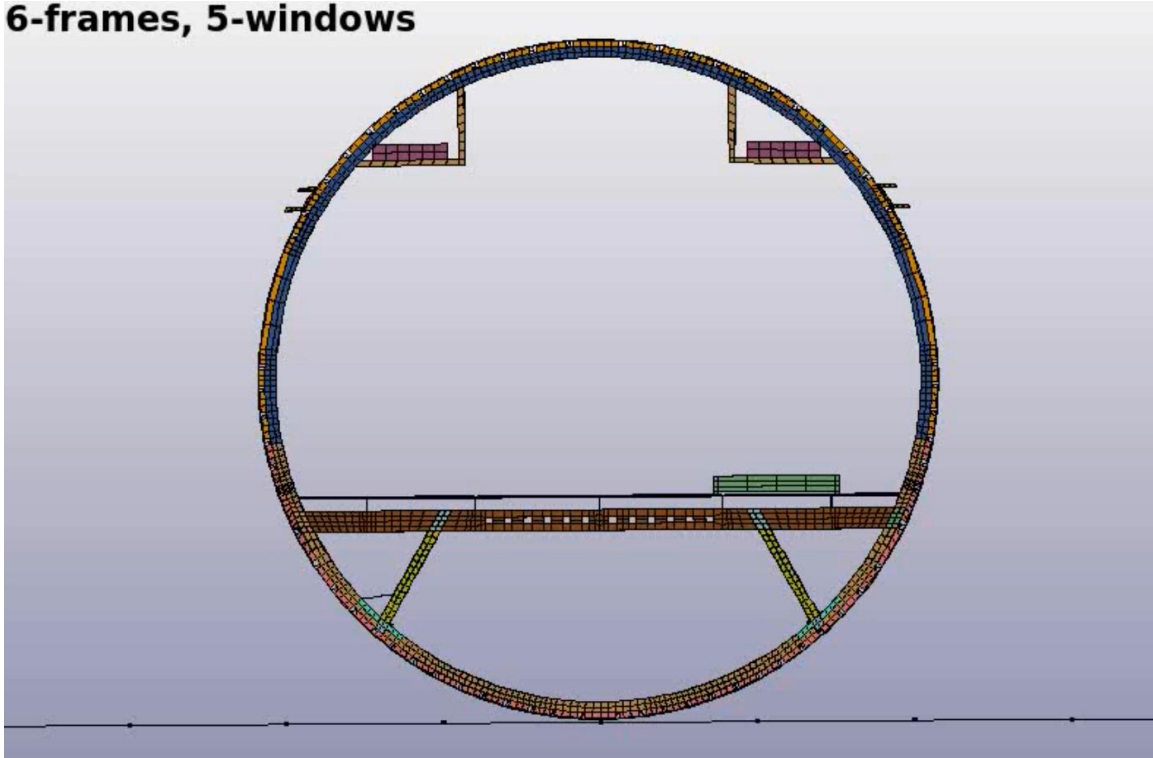


Model differences - 18 ft/sec vs. 30 ft/sec – no luggage

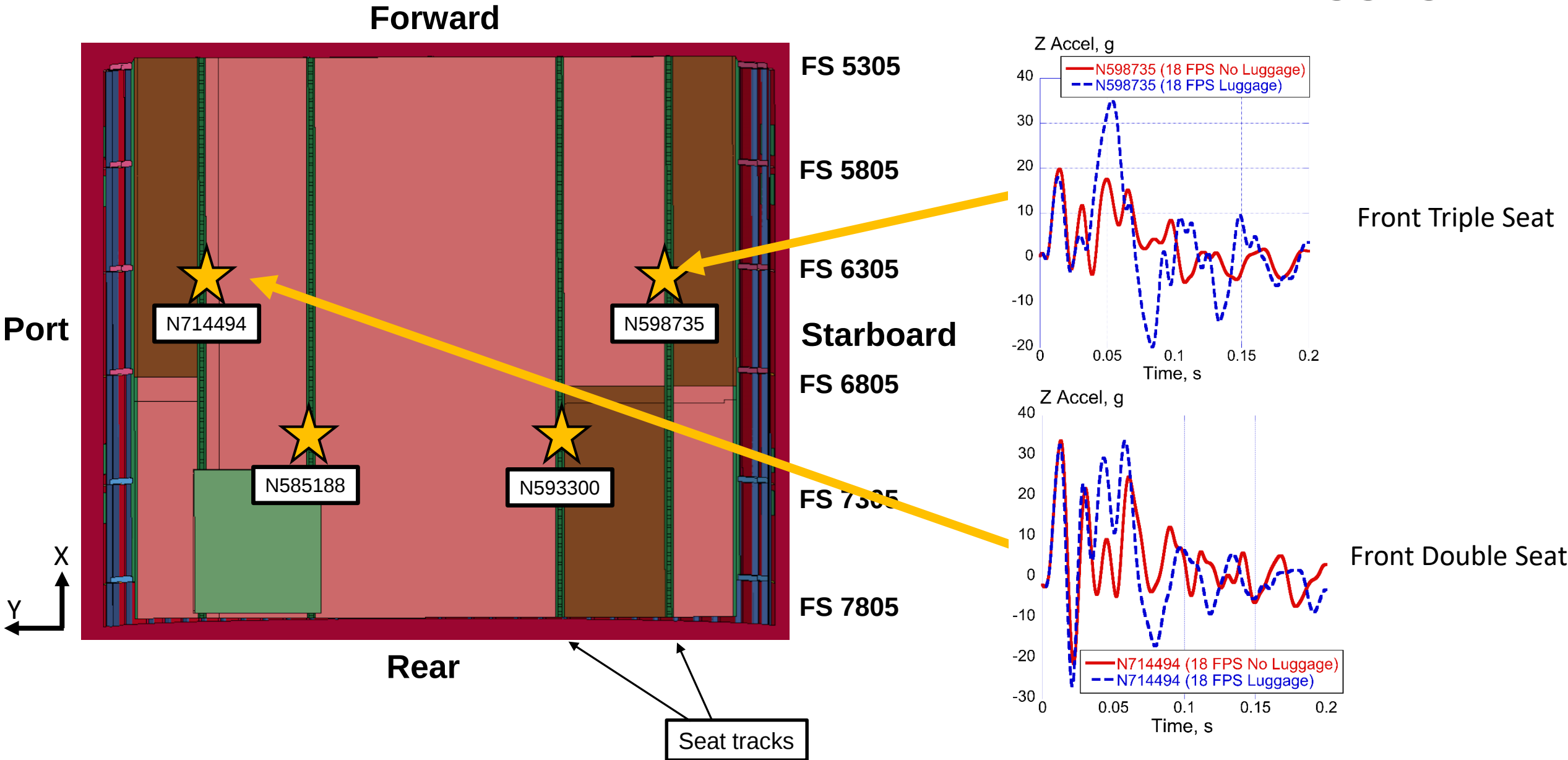


Model differences - 18 ft/sec vs. 18 ft/sec with luggage

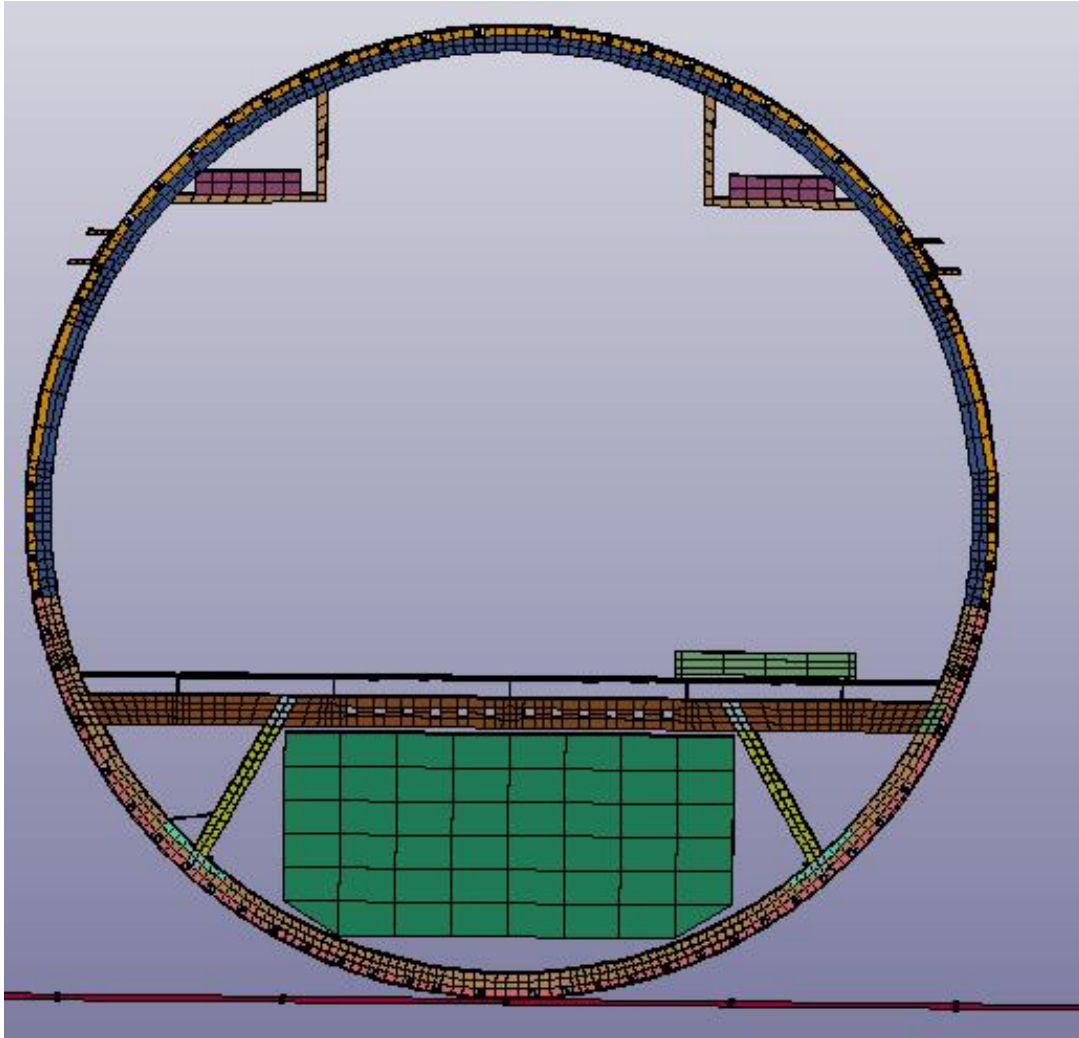
6-frames, 5-windows



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



Variations on a Theme: F-28 Forward Section Model Impacting a Rigid Surface at 18-ft/s



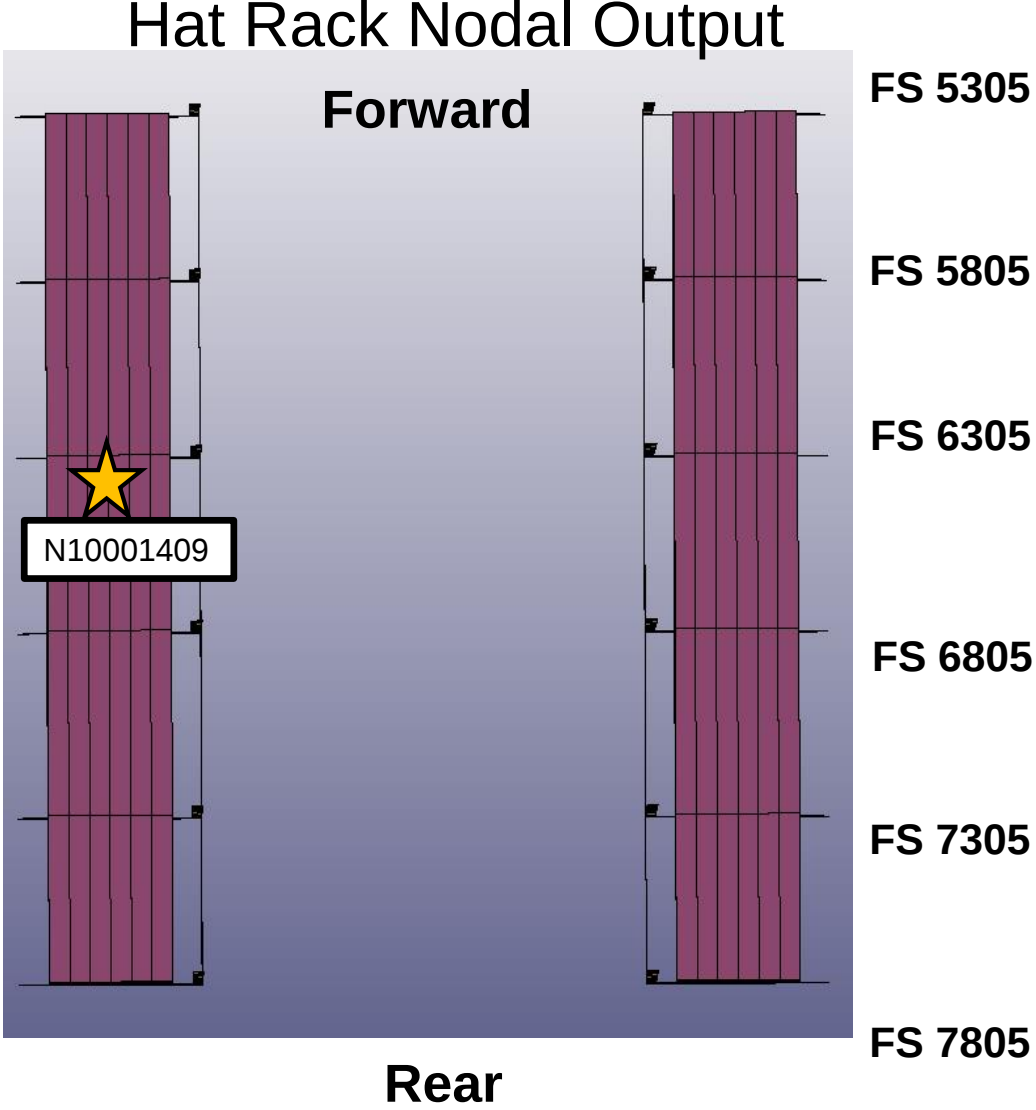
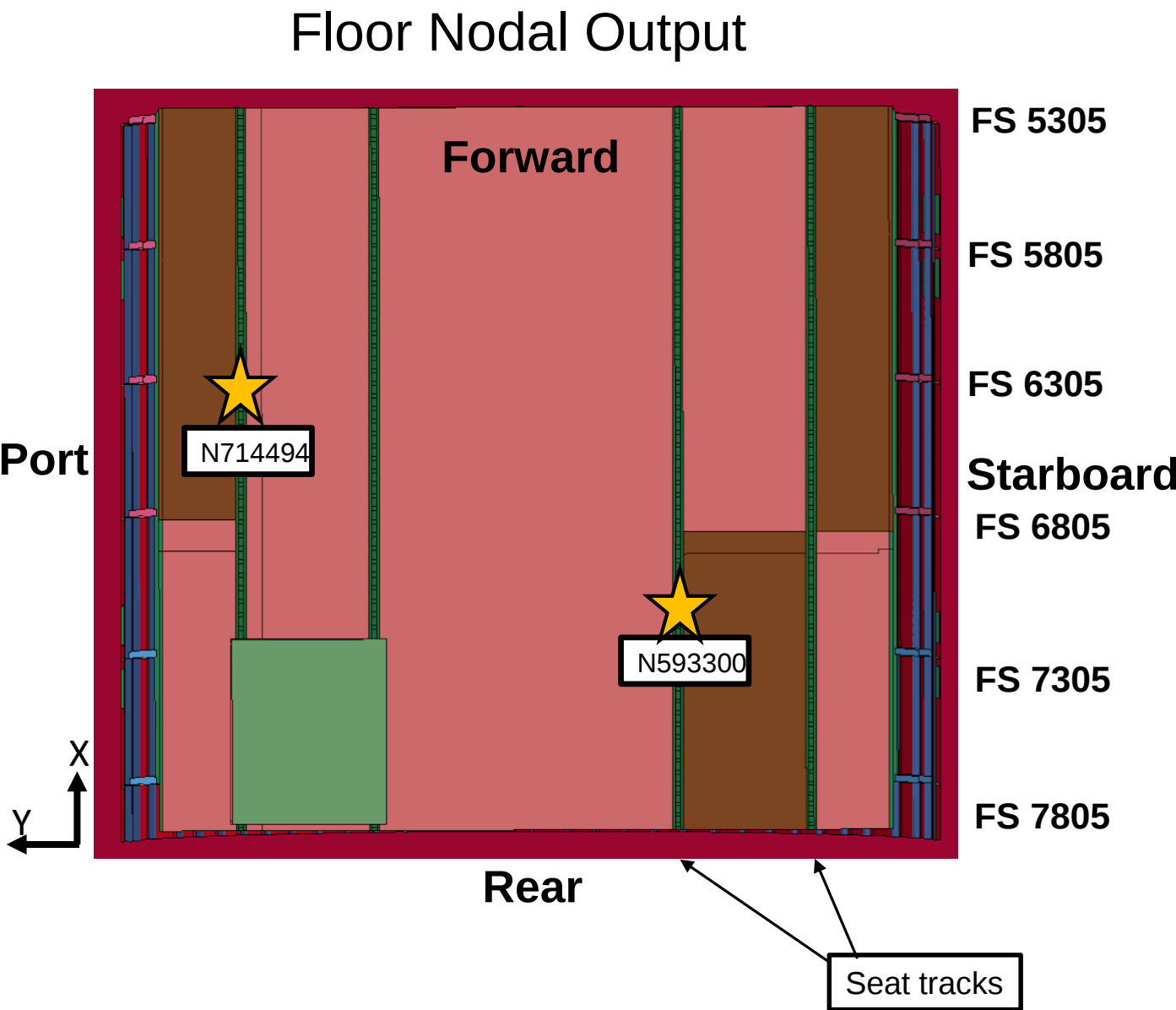
Baseline model (0° pitch, 0° roll)

Model Attributes

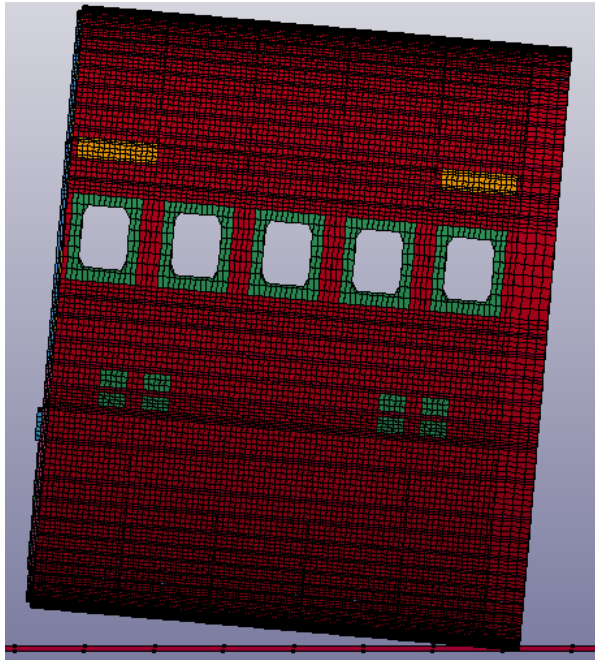
- With Luggage (922.8-lb)
- Impact Surface modeled as *RIGIDWALL_PLANAR
- Output from Local Coordinate Systems
- 8 Simulations were executed:
 - 5° pitch up
 - 5° pitch down
 - 5° right roll
 - 5° left roll
 - 5° pitch up and 5° left roll
 - 5° pitch down and 5° right roll
 - 5° right roll and 5° pitch up
 - 5° left roll and 5° pitch down

Combo
Models

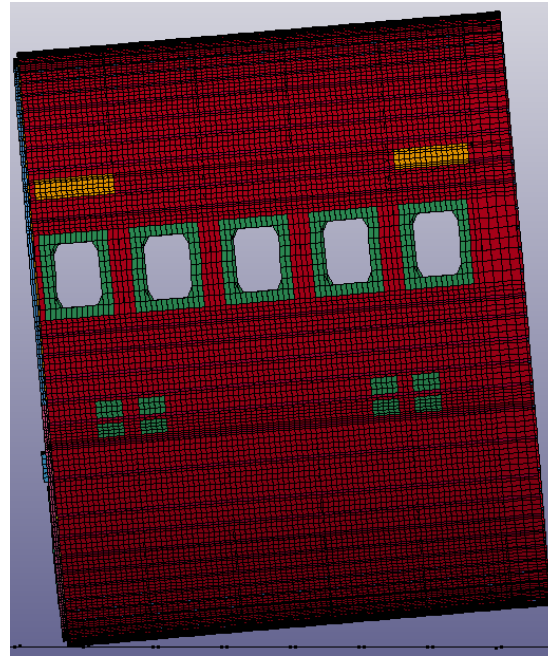
F-28 Forward Section Model at 18-ft/s: Data Comparison Locations



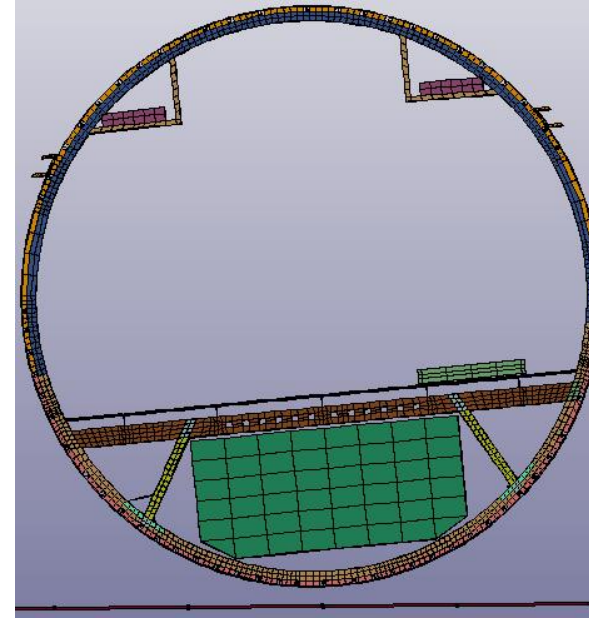
F-28 Forward Section Model at 18-ft/s: Models



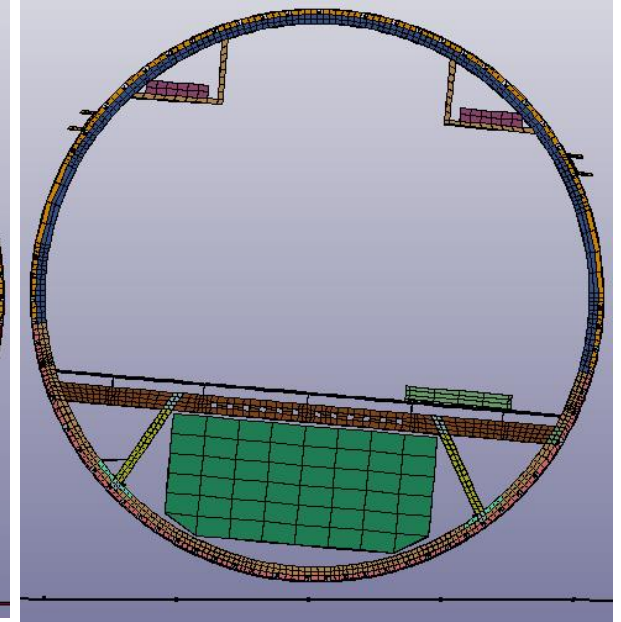
5° Pitch Up



5° Pitch Down

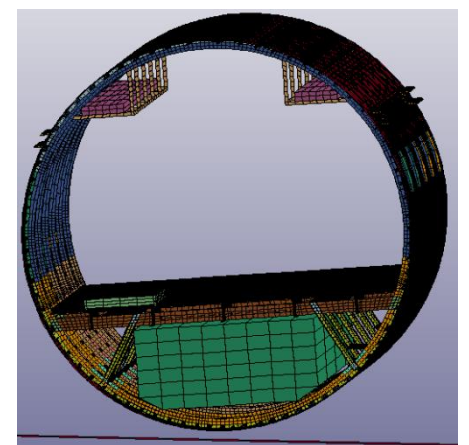
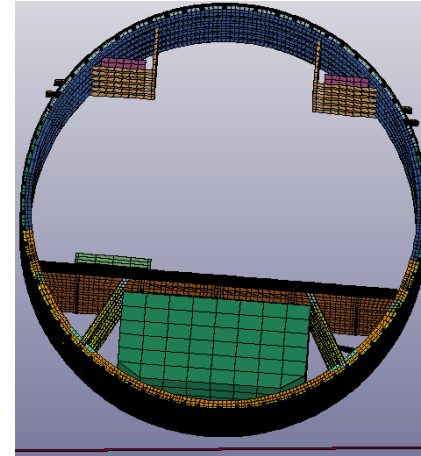
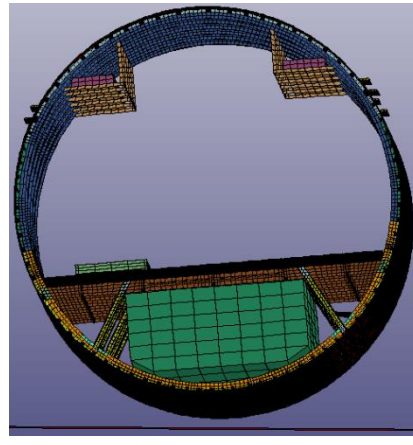
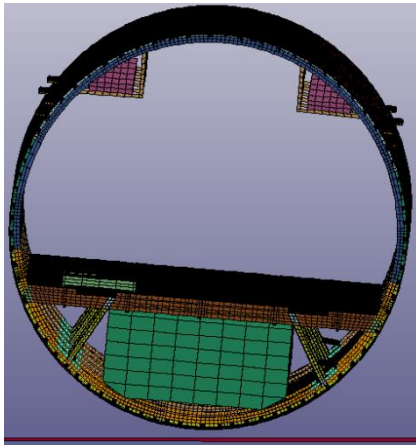
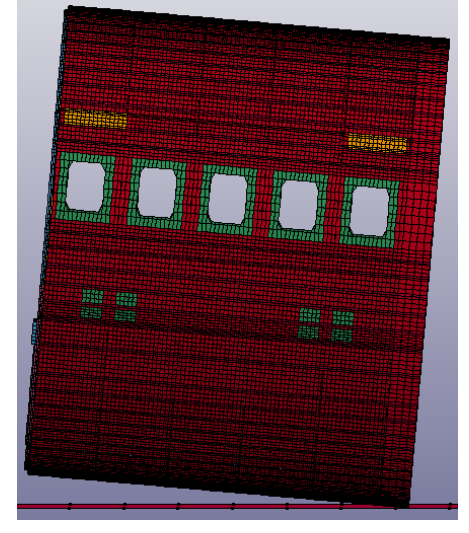
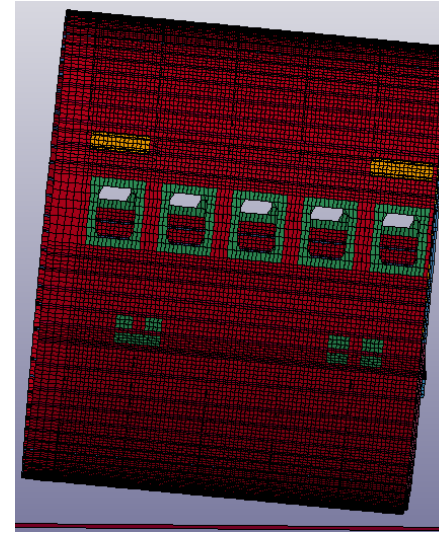
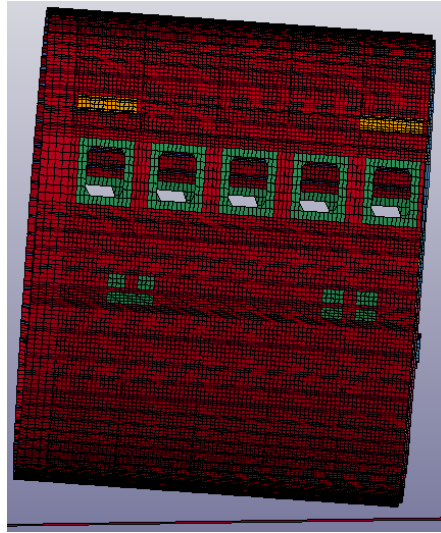
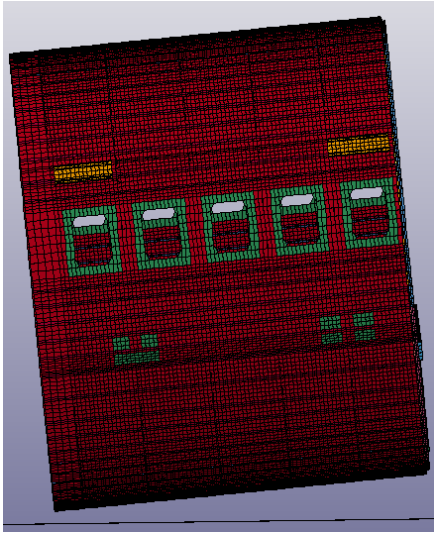


5° Left Roll



5° Right Roll

F-28 Forward Section Model at 18-ft/s: Combo Models



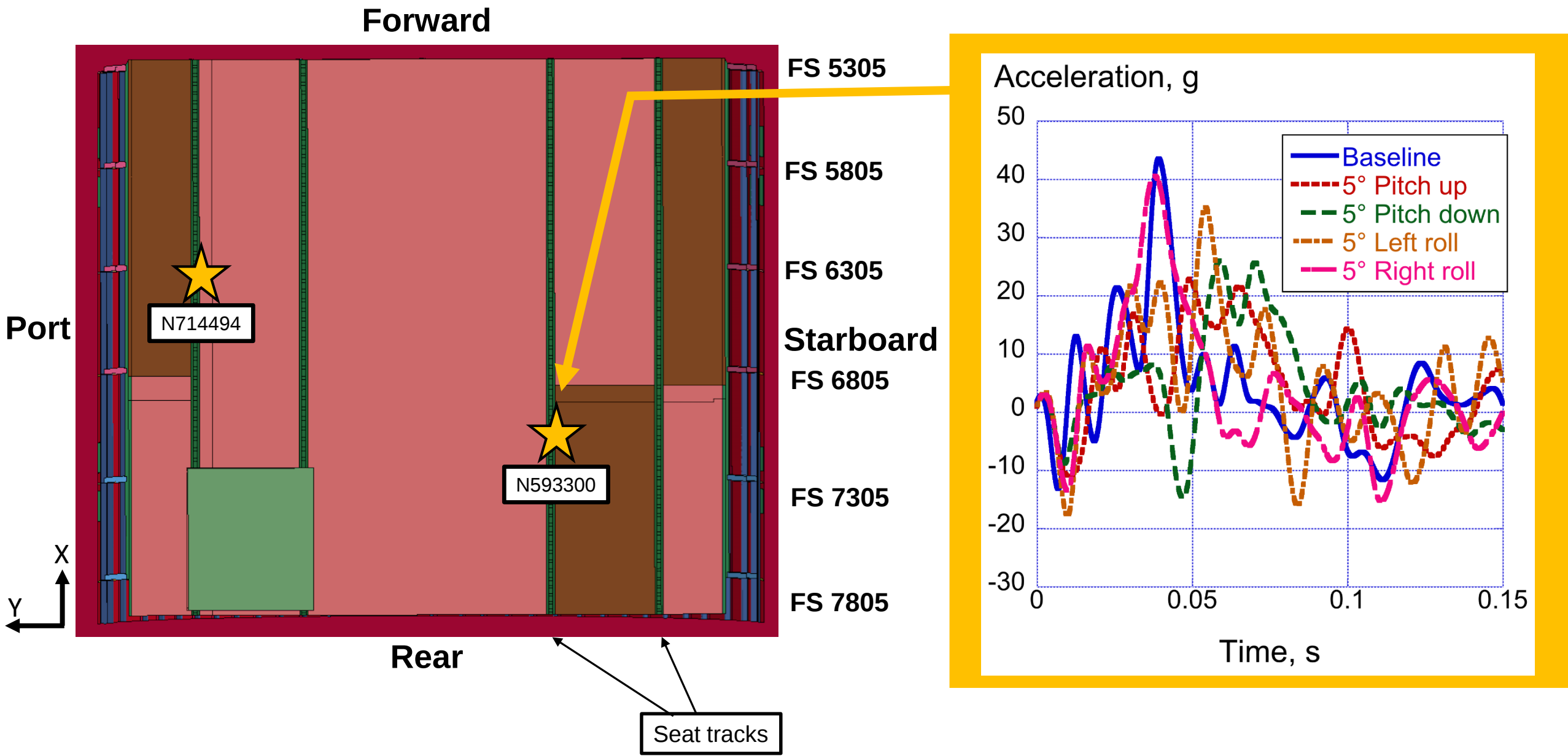
5° Pitch Up with
5° Left Roll

5° Pitch Down with
5° Right Roll

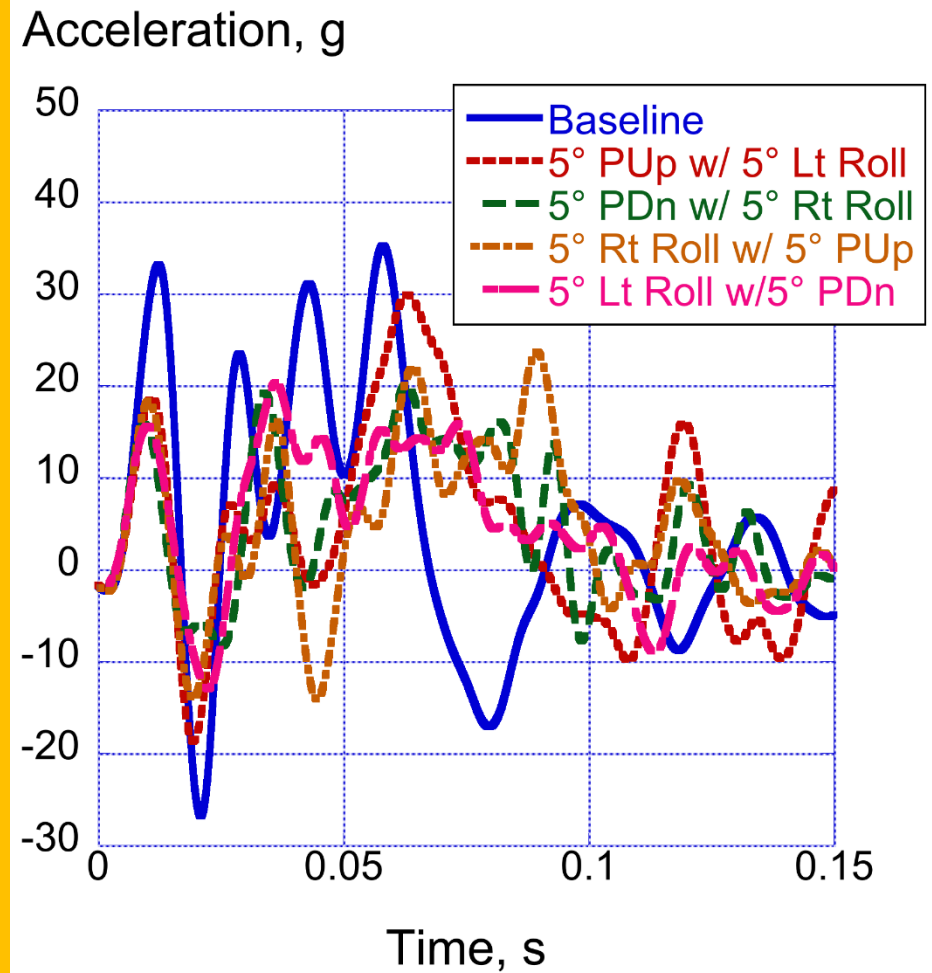
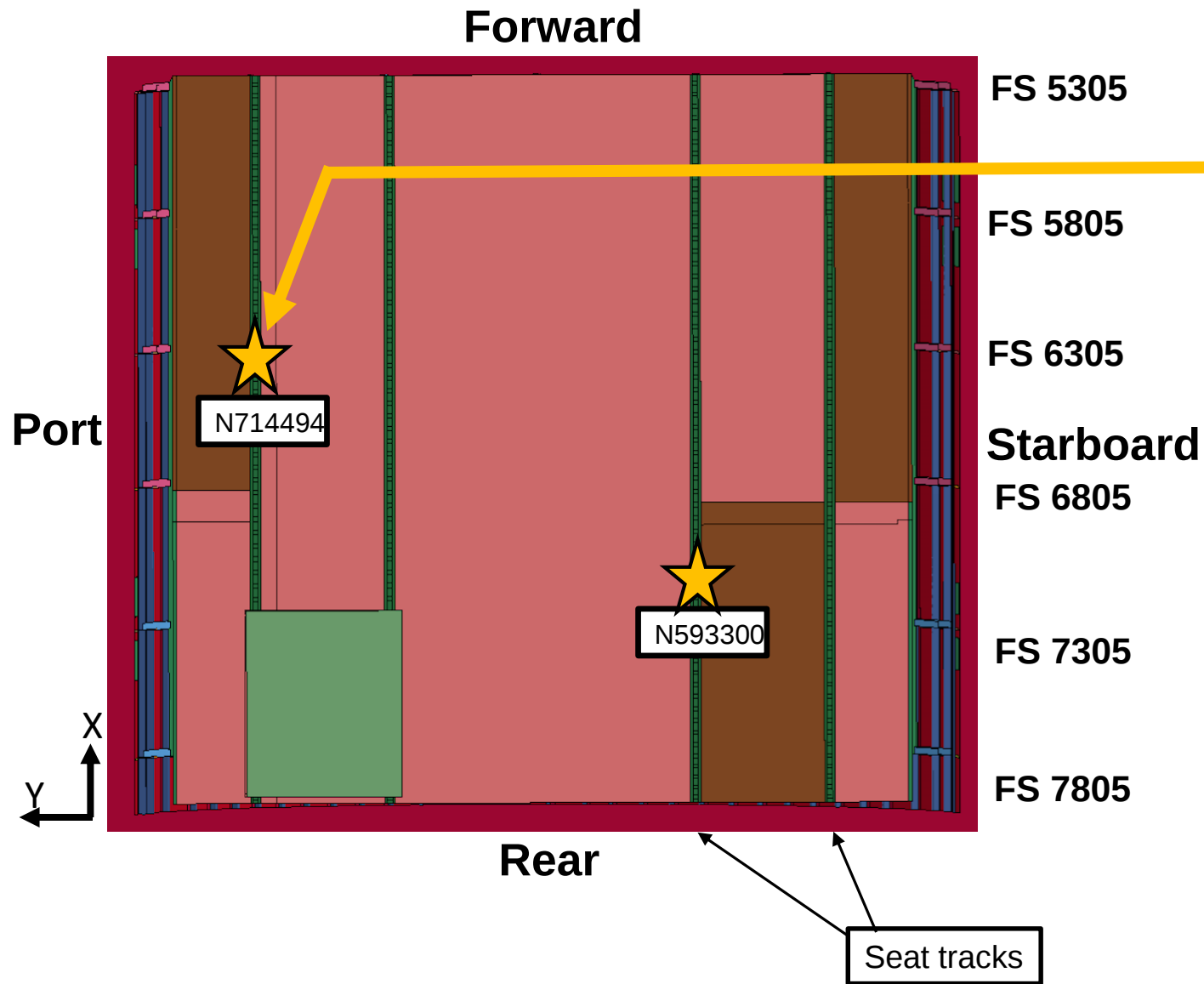
5° Left Roll with
5° Pitch Down

5° Right Roll with
5° Pitch Up

F-28 Forward Section Model at 18-ft/s: Output Comparisons



Results Combo Models: Port Side Outer Seat Track



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