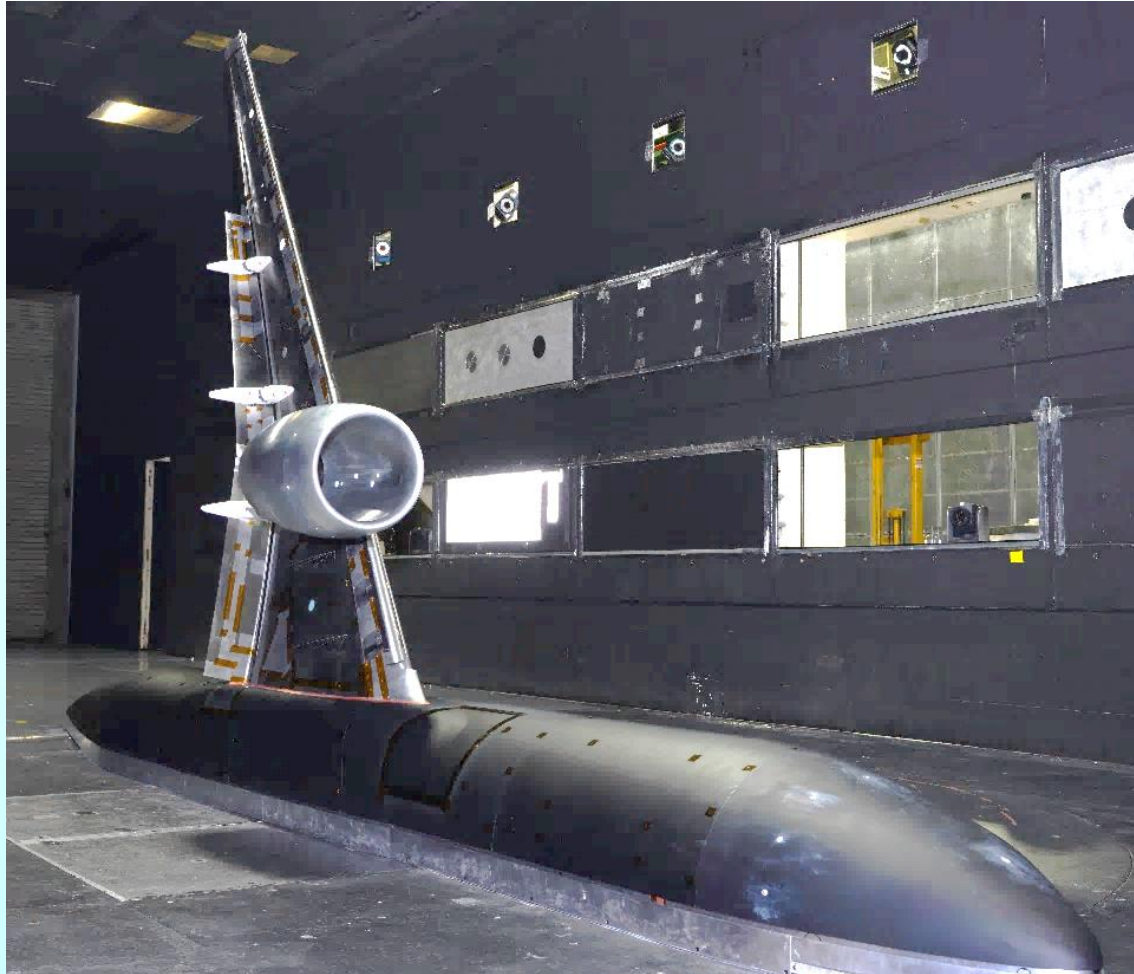




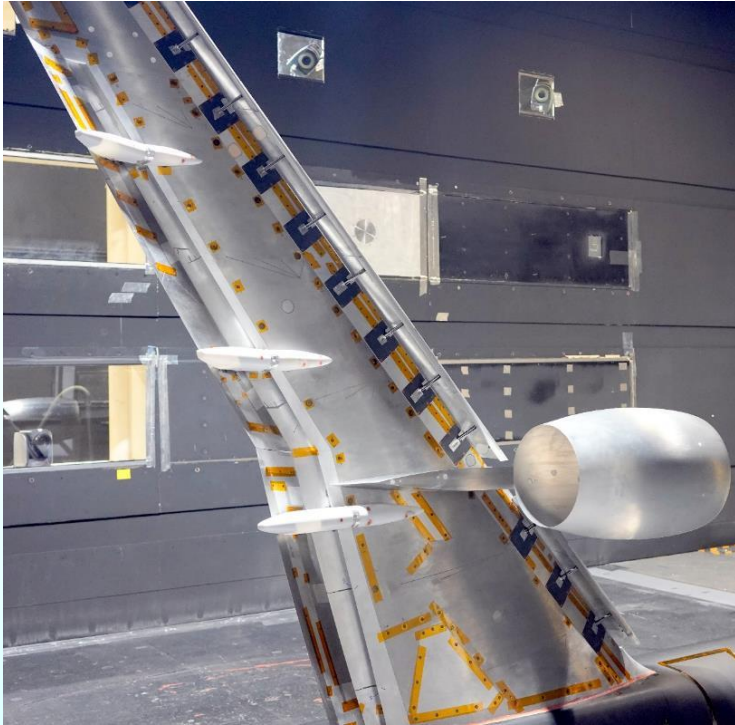
Slat Noise Reduction Devices for the High-Lift Common Research Model and Aeroacoustic Test Plans



David P. Lockard
Acoustics TWG Meeting, Oct 2019

Advanced Air Transport Technology
(AATT) Project

High-Lift Common Research Model (HL-CRM)

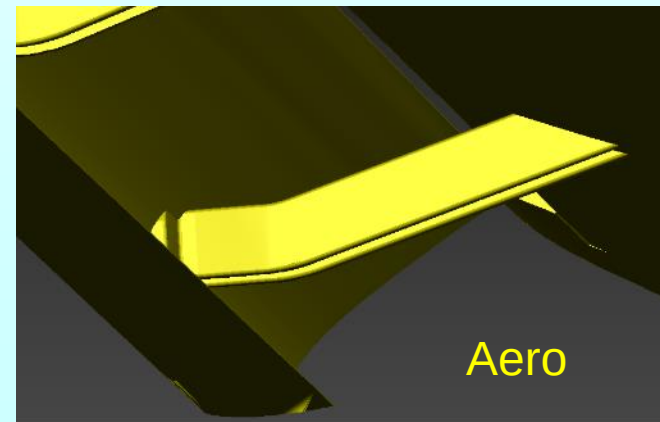
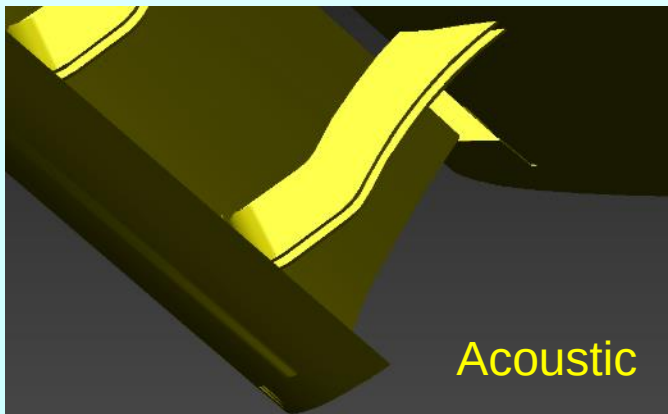


An open geometry high-lift configuration based on the high-speed CRM. Developed by Boeing® in 2015 using modern design practices

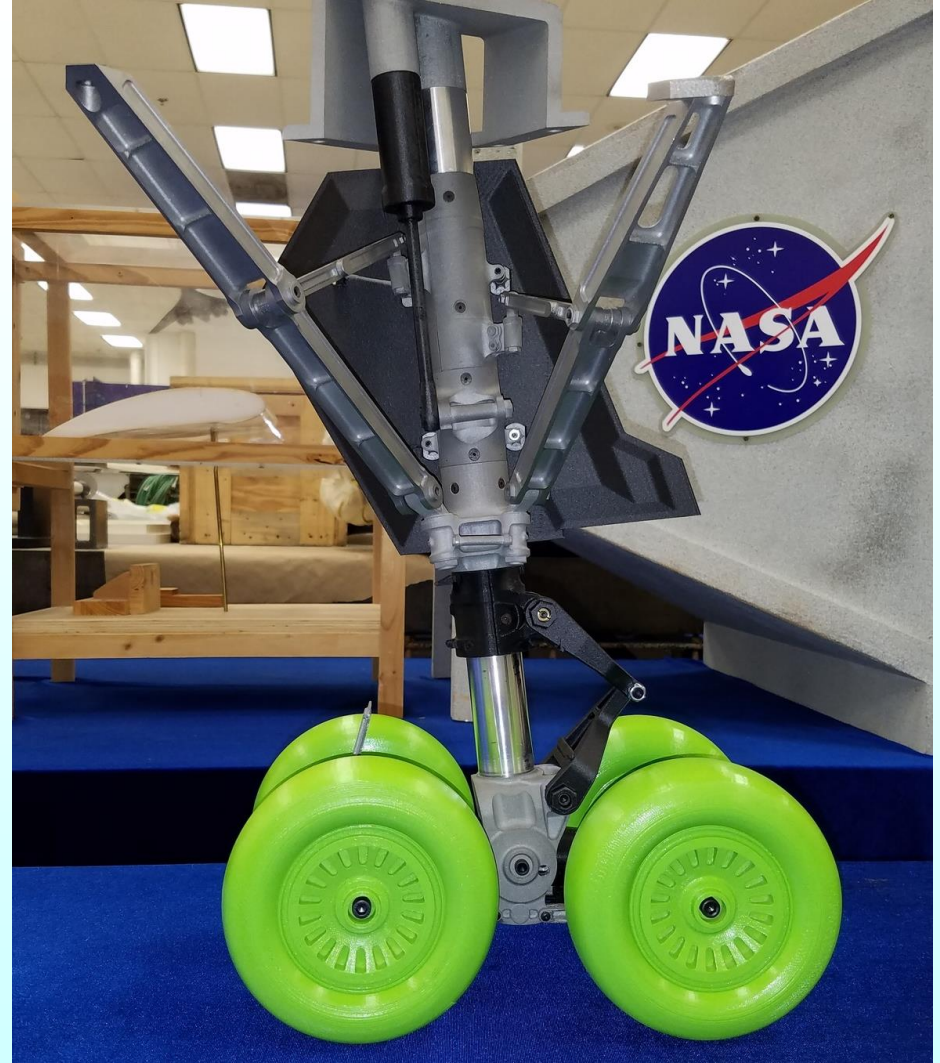
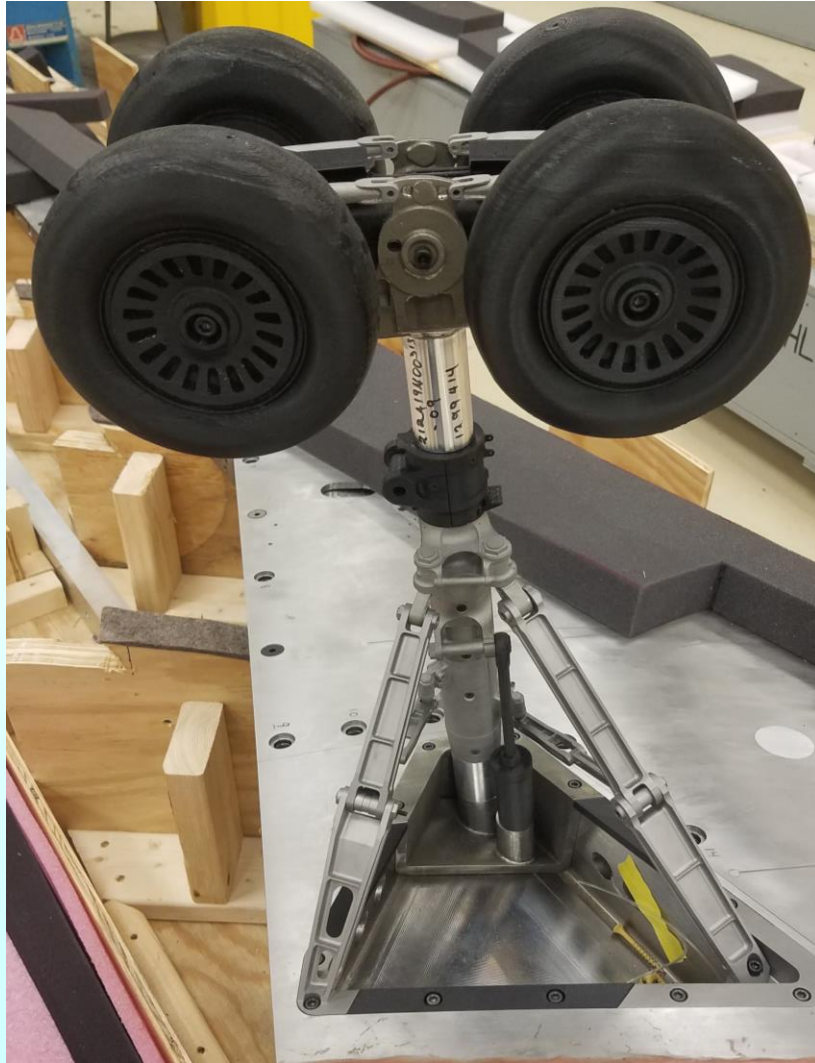


- HL-CRM model tested in the NASA Langley Research Center 14- by 22-Foot Subsonic Tunnel (14x22) in 2018
 - Aerodynamic and acoustic data collected with a closed test section
 - Model has a 9.7 ft span and 2.3 ft mean aerodynamic chord
 - Approximately 10% scale of a large twin-aisle aircraft
 - Baseline model currently being tested in the UK QinetiQ tunnel
 - Optimization of gaps and overhangs for stall

- Aeroacoustic testing of noise reduction devices scheduled for April 2020
 - Open-jet test section with a traversing array outside of the shear layer
- Test priorities
 - Baseline with acoustic (realistically shaped) brackets, unsteady pressure transducers on the slat, and three removable slat brackets
 - Landing Gear
 - Baseline with aero brackets (to compare with 2018 closed-wall test)
 - Slat-cove and slat-gap fillers
 - Various side-edge treatments (porosity, continuous link)
 - Alternative gap-filler designs (porosity, shape, location)



Landing Gear

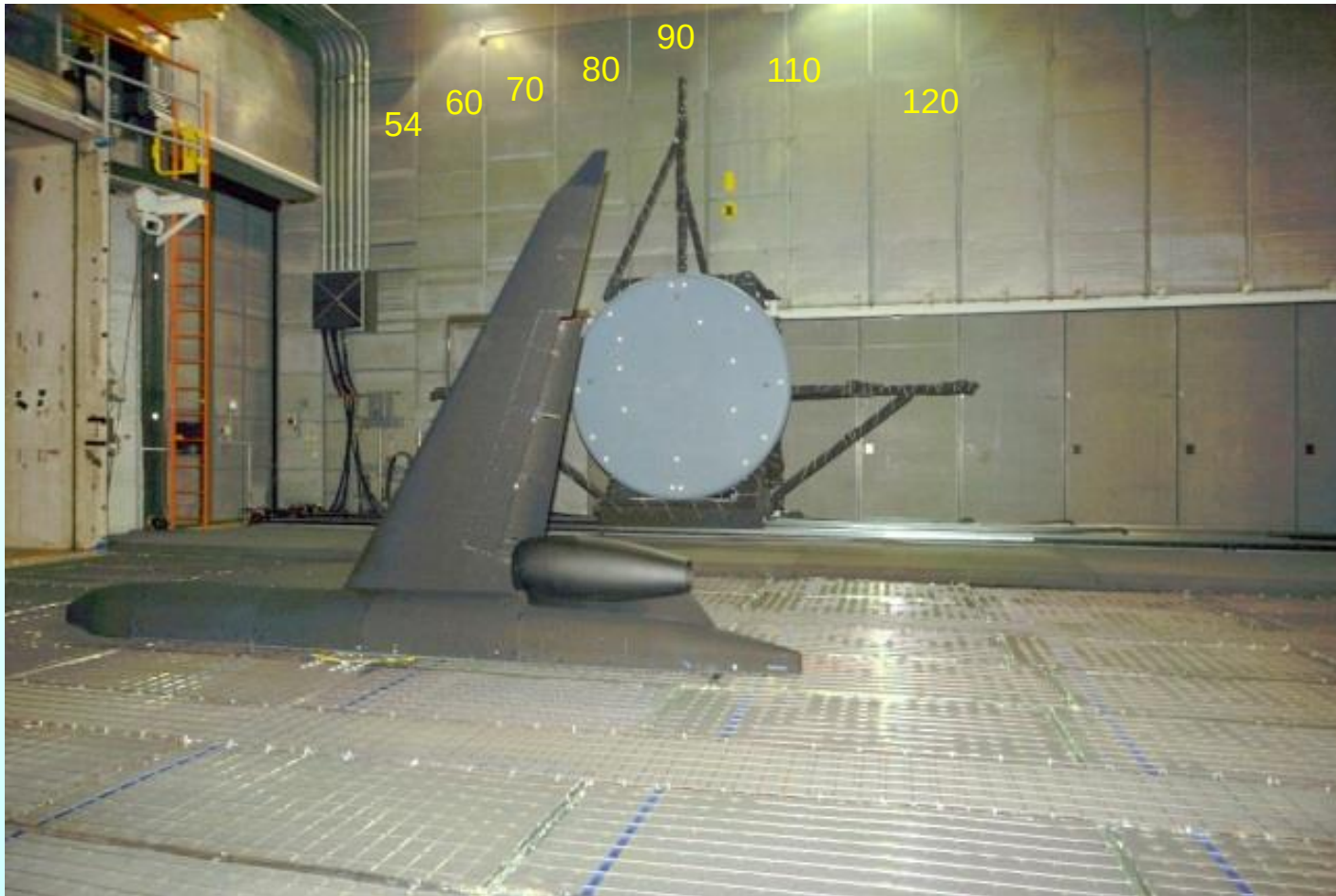


- Cavity is not realistic
- Small-scale features will be added using 030 tubing

14x22 Acoustic Measurements



- Similar acquisitions to Gulfstream semi-span model test



Microphone array will traverse on the pressure side of the model

Acoustic Measurement Hardware



97 Channel Array



Traverse, cabling

Same array, traverse, cabling, power supplies

New data acquisition system that was used in 2018 test

14x22 Extraneous Noise Sources



- The collector and the grating holding the foam in the baskets generated extraneous noise during previous tests



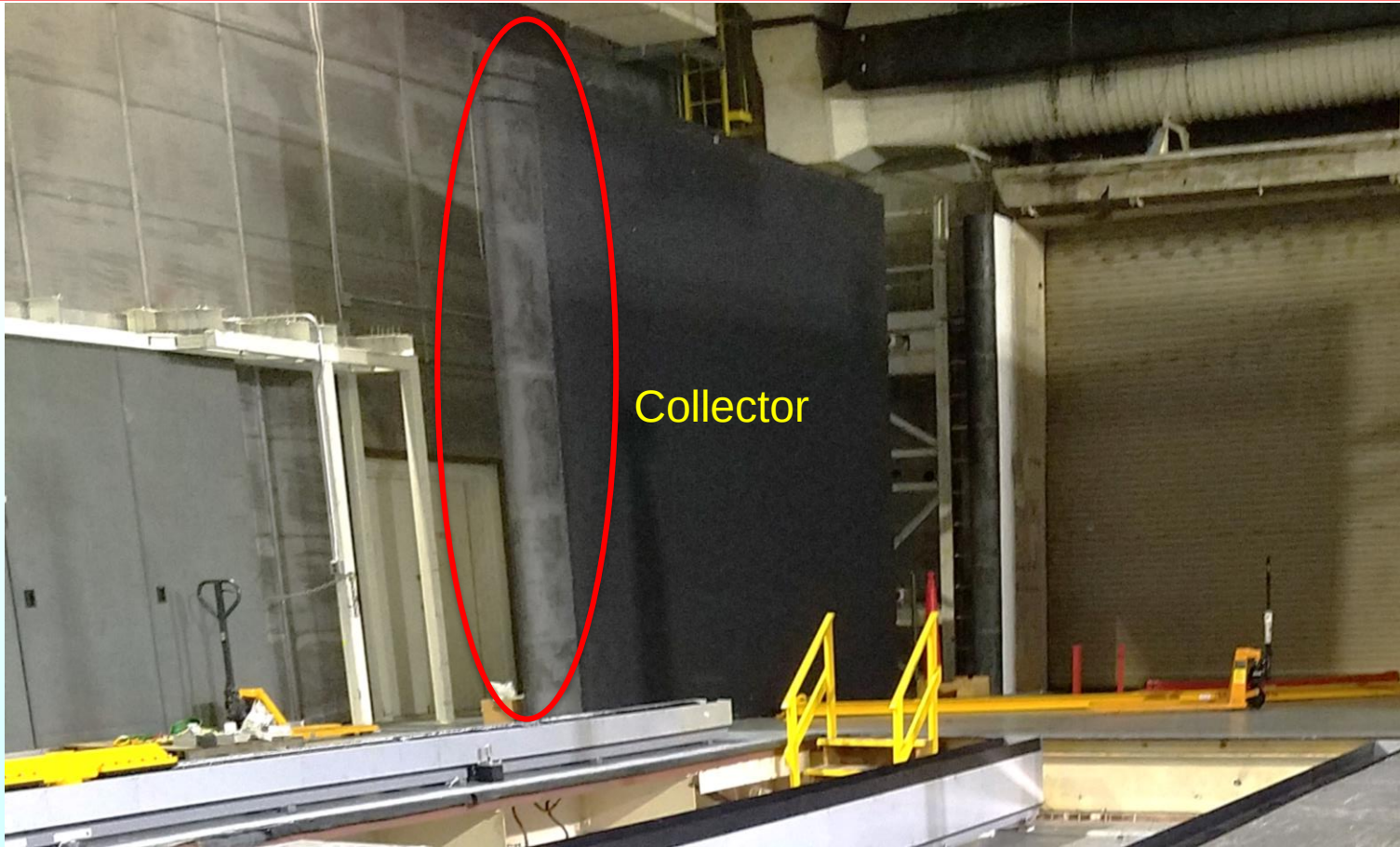
Basket grating

14x22 Upgrade - Baskets



- Foam baskets
 - Perforated sheets added to top
 - Weight added to bottom of baskets
 - New tie-down mechanism

14x22 Upgrade - Collector



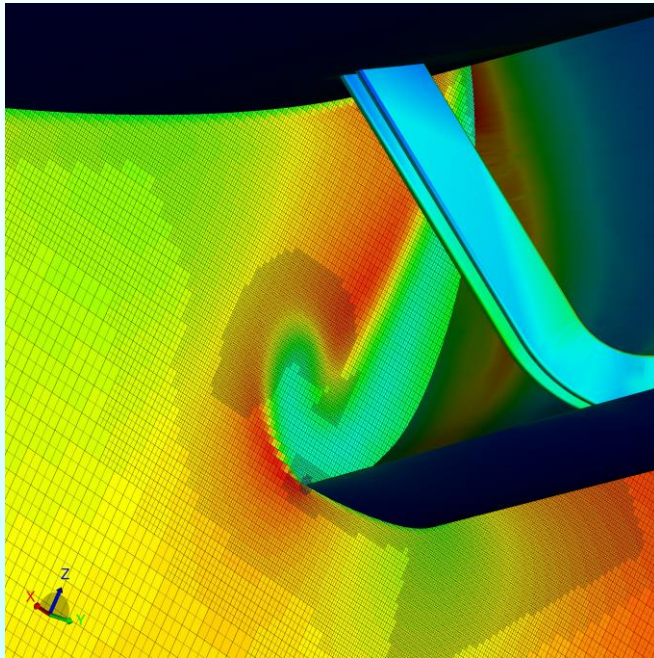
- Collector
 - Leading-edge made of perforated sheets
 - Filled with wrapped fiberglass

Slat-Cove Filler (SCF)

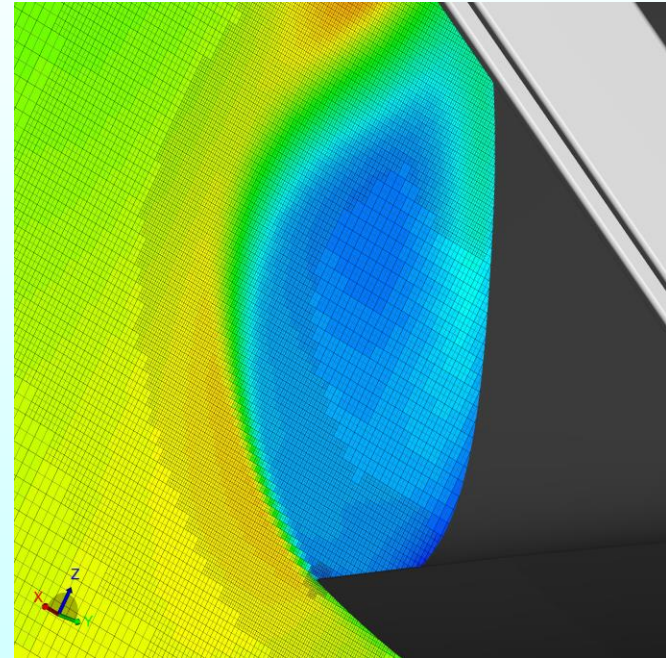


Only on the Outboard Slat

Velocity Magnitude Contours



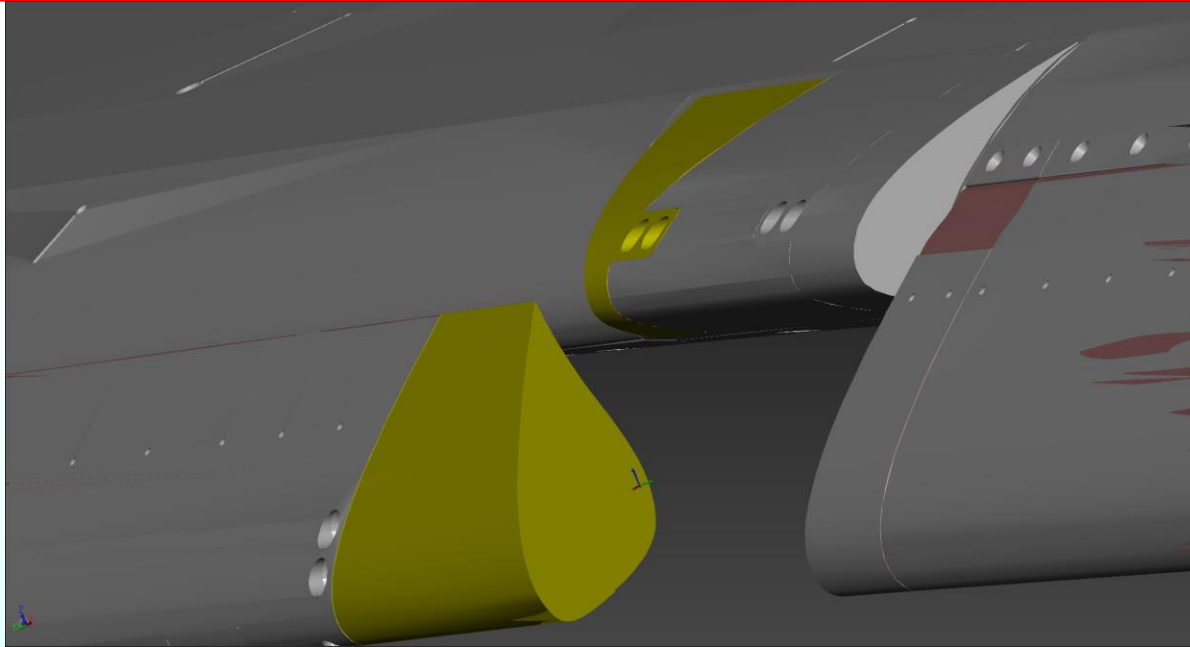
Near inboard end of slat



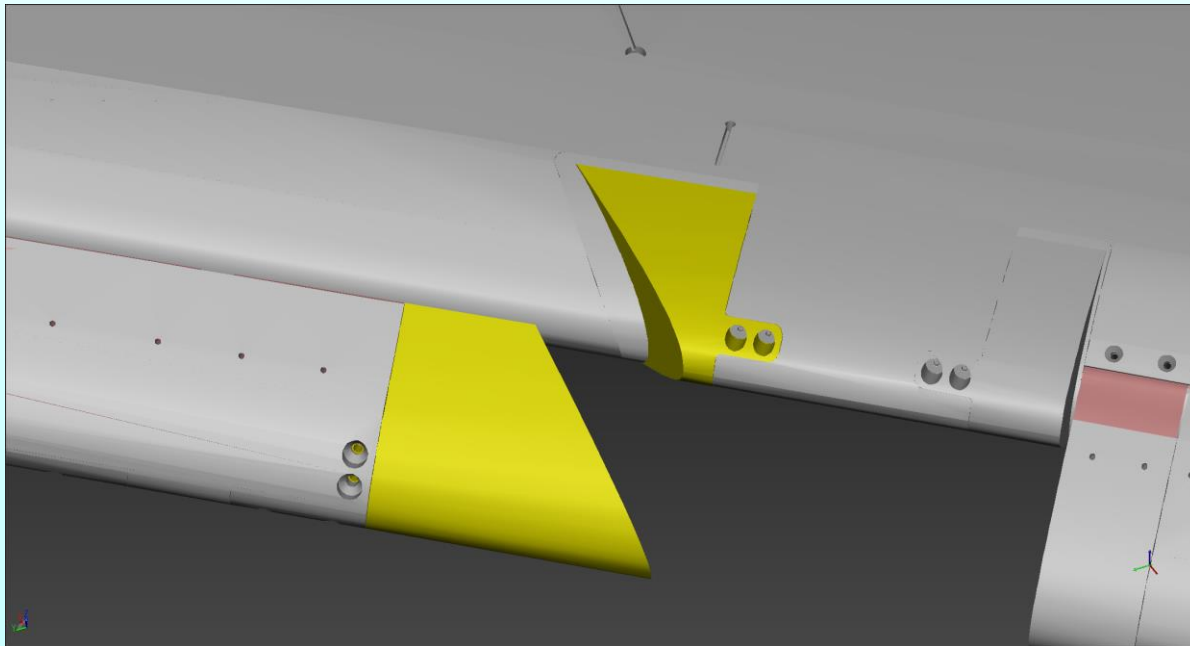
Near outboard end of slat

The shear layer trajectory is not conducive to a slat-cove filler near the inboard end of the slat.

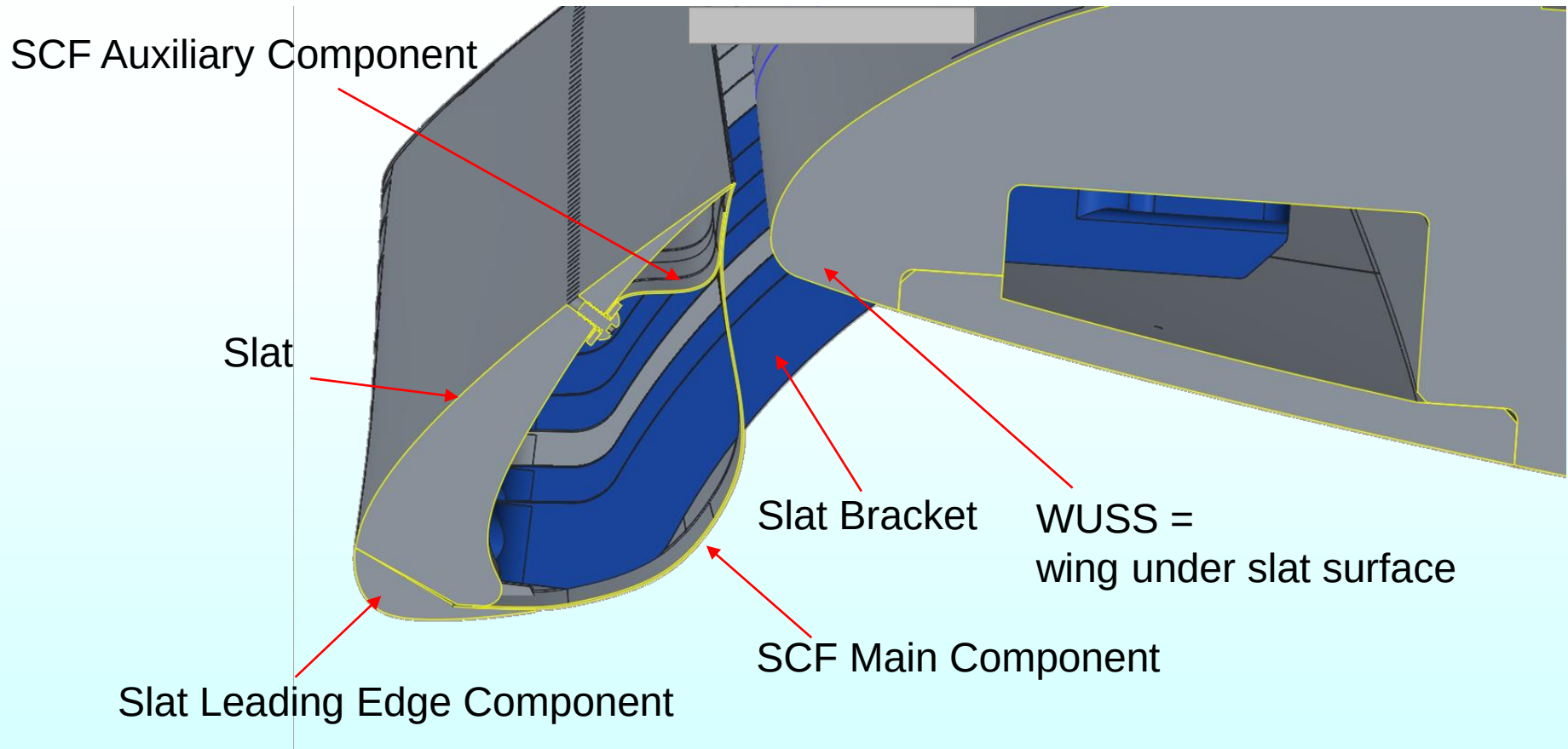
Slat-Cove Filler (SCF)



End pieces are solid

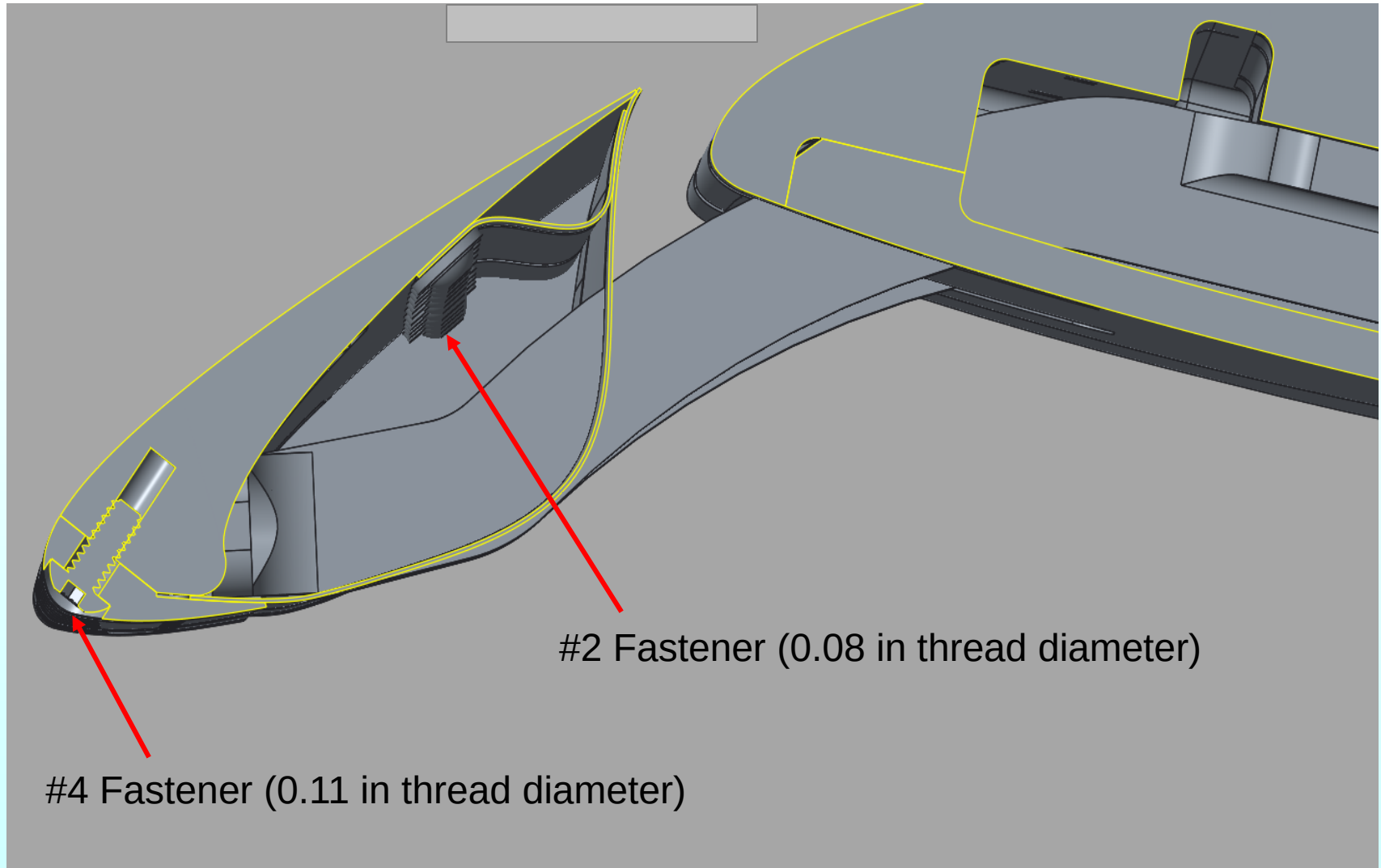


Both the slat end and mating part on the slatless WUSS are removable



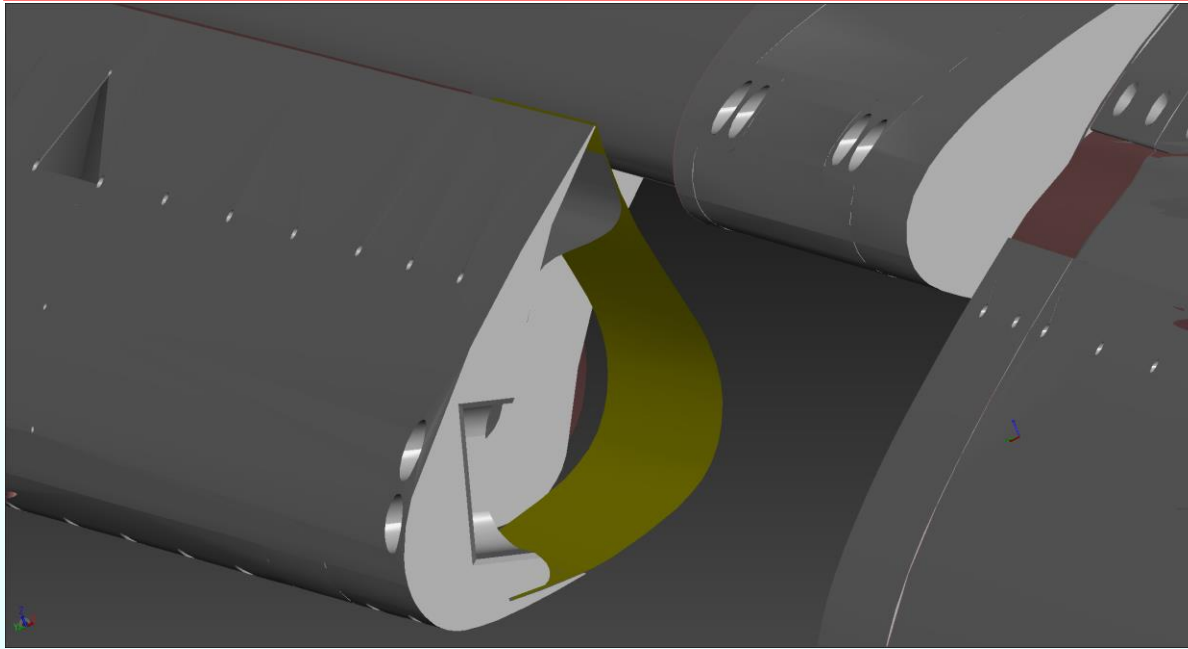
These parts look big on the screen, but they are small with tiny components. Building realistic parts at 10% scale is challenging. The SCF main component varies between 0.005 and 0.009 inches thick.

SCF Attachment Design

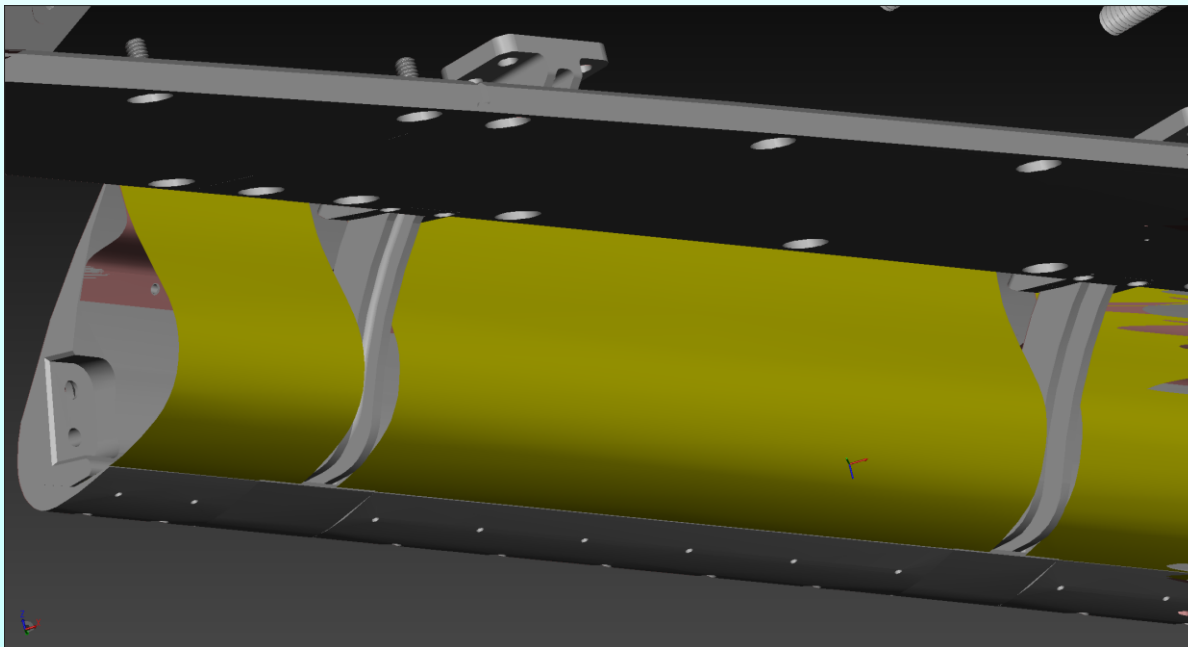


- The leading edge of the slat “clamps” down on the SGF
 - All ends securely fastened for tunnel safety

Slat-Cove Filler (SCF)



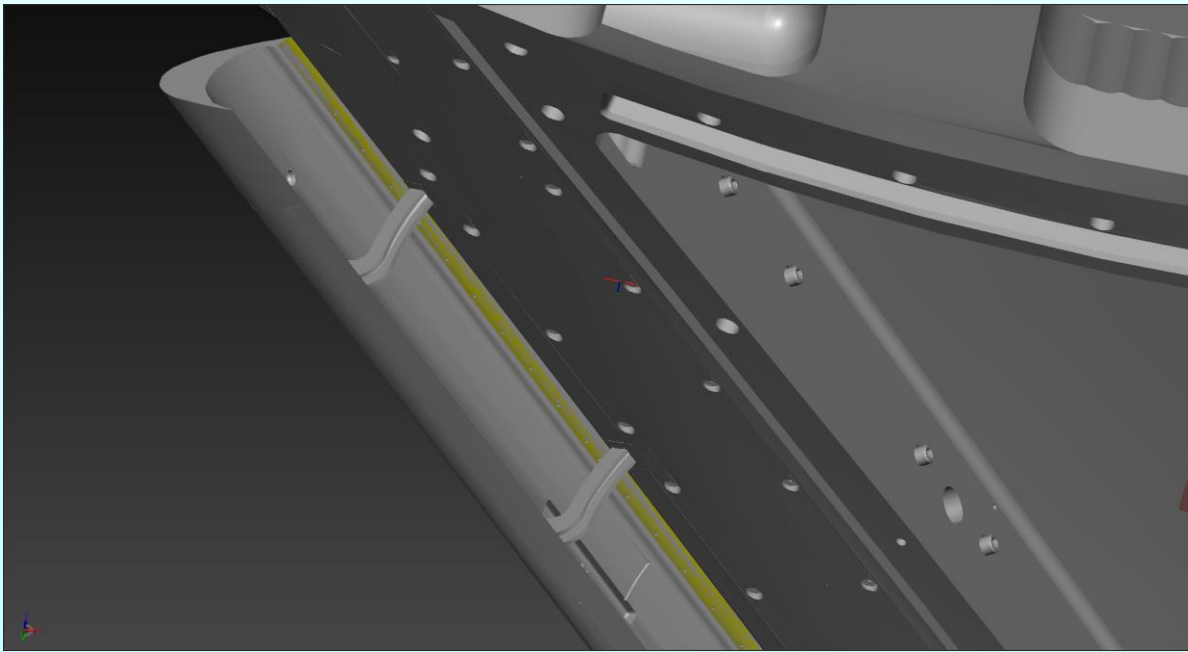
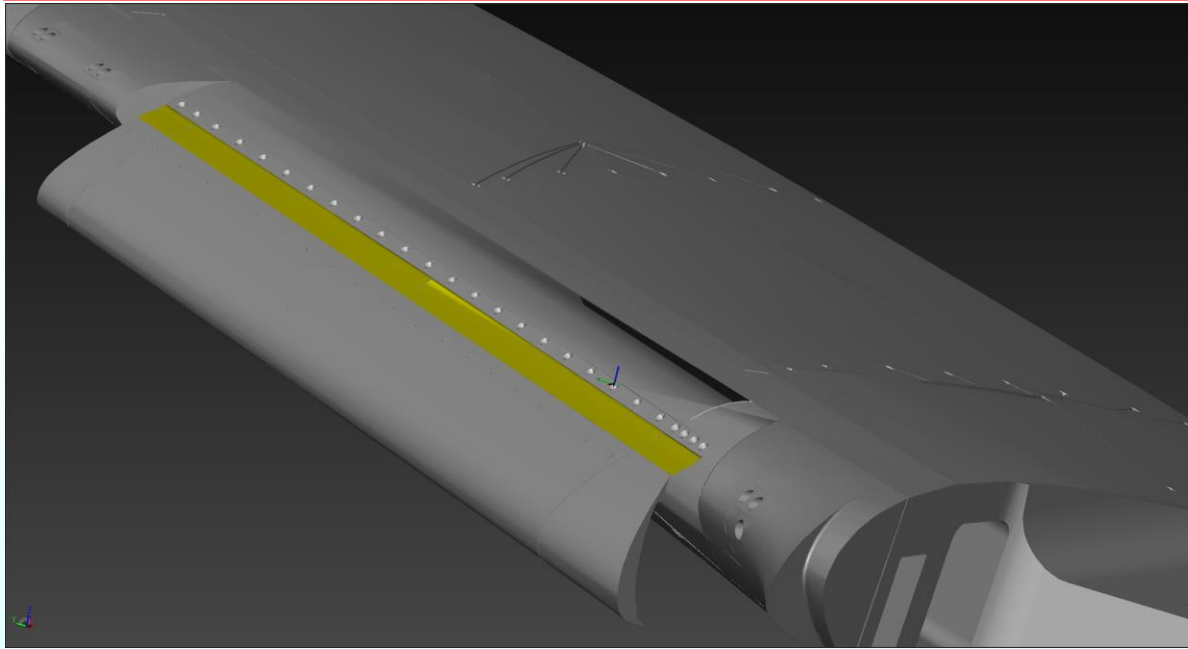
- Segments of SMA comprise the SCF
 - Breaks at brackets
 - SCF will be inserted into slots just above the slat cusp
 - Screws every inch





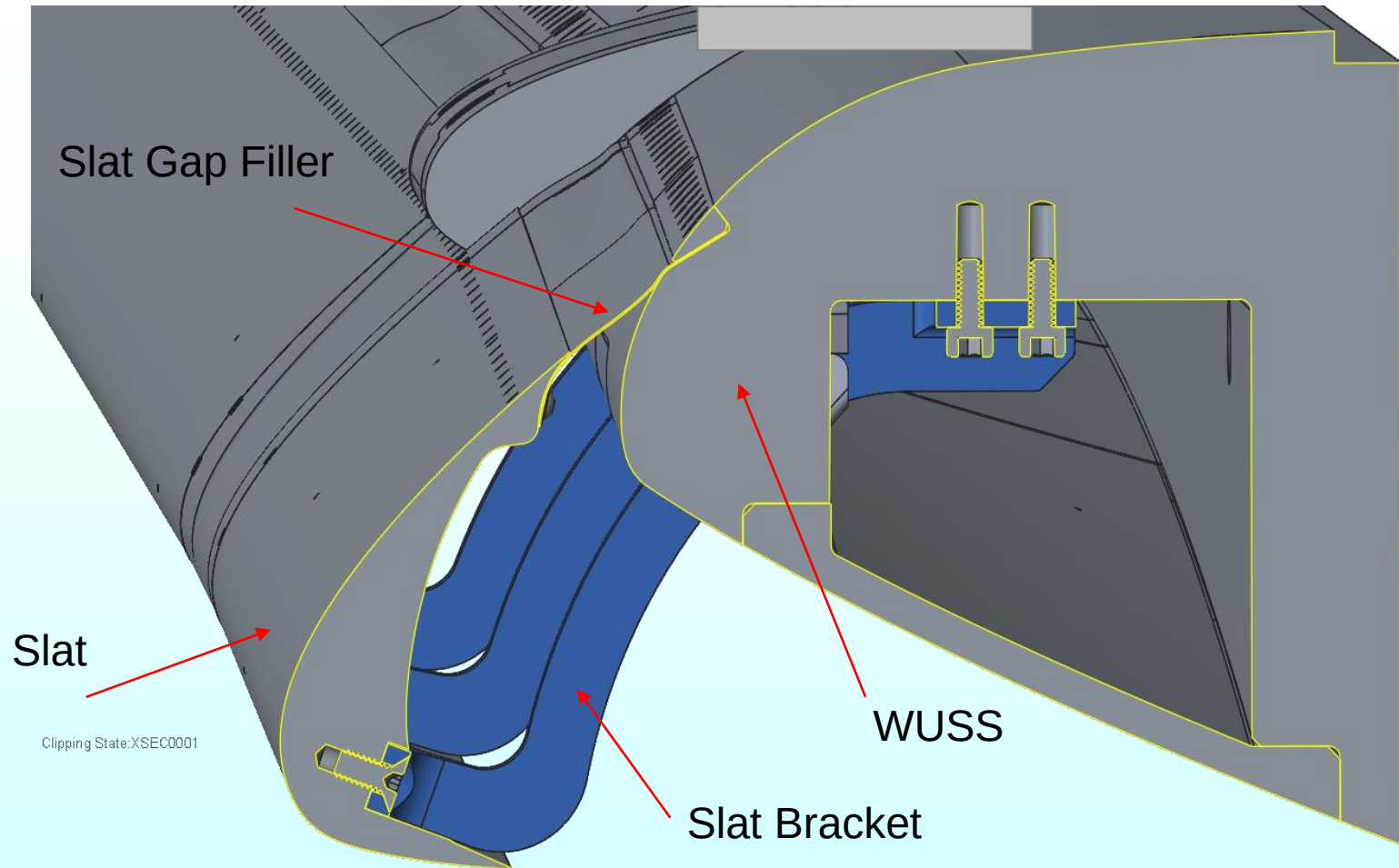
Slat-Gap Filler (SGF)

Slat-Gap Filler (SGF)

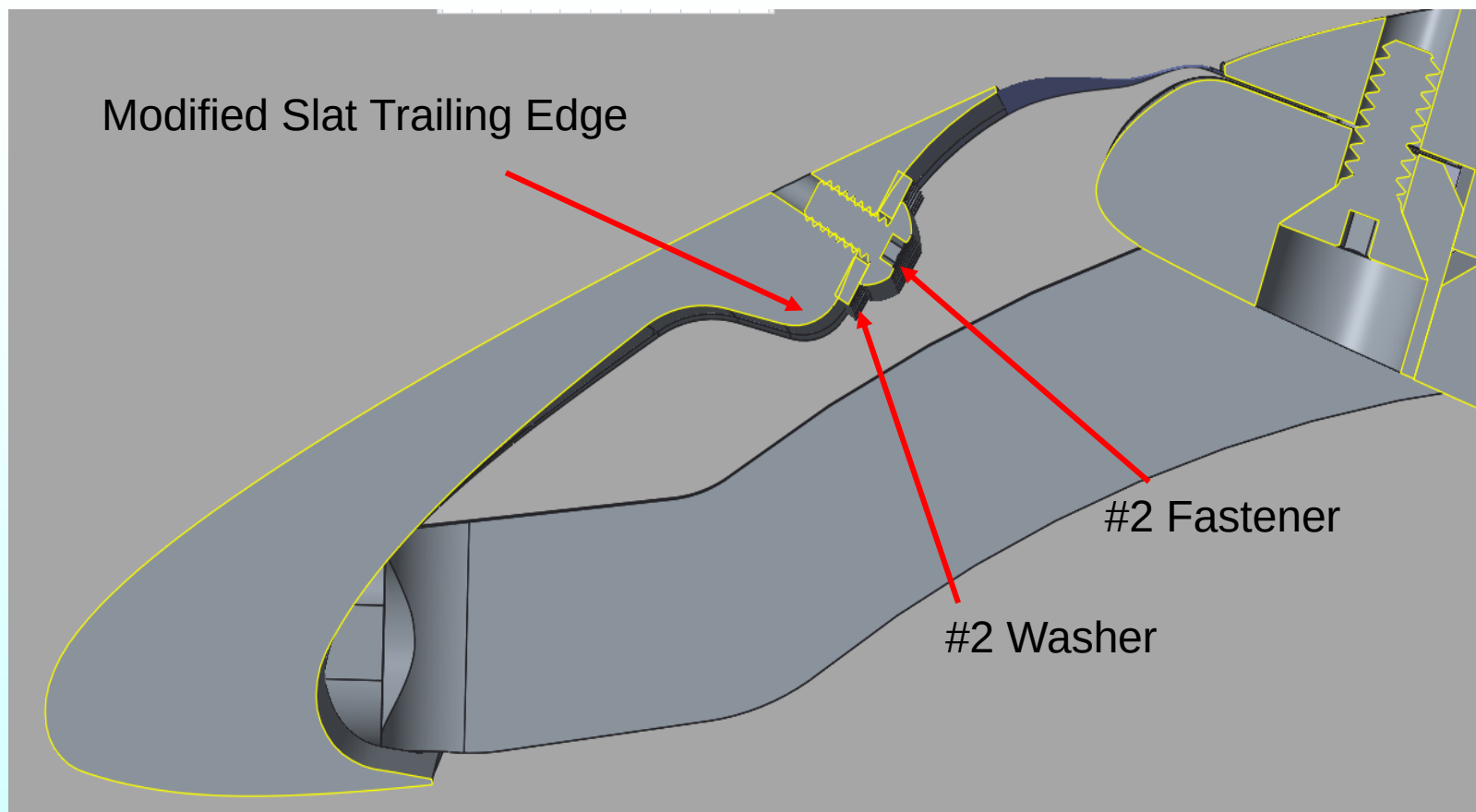


- Segments of SMA comprise the SGF
 - SGF dives into the WUSS with a stringer (wedge) that clamps it in place
 - Screws every inch
 - SGF attaches to a protrusion in the slat cove
 - Screws every inch

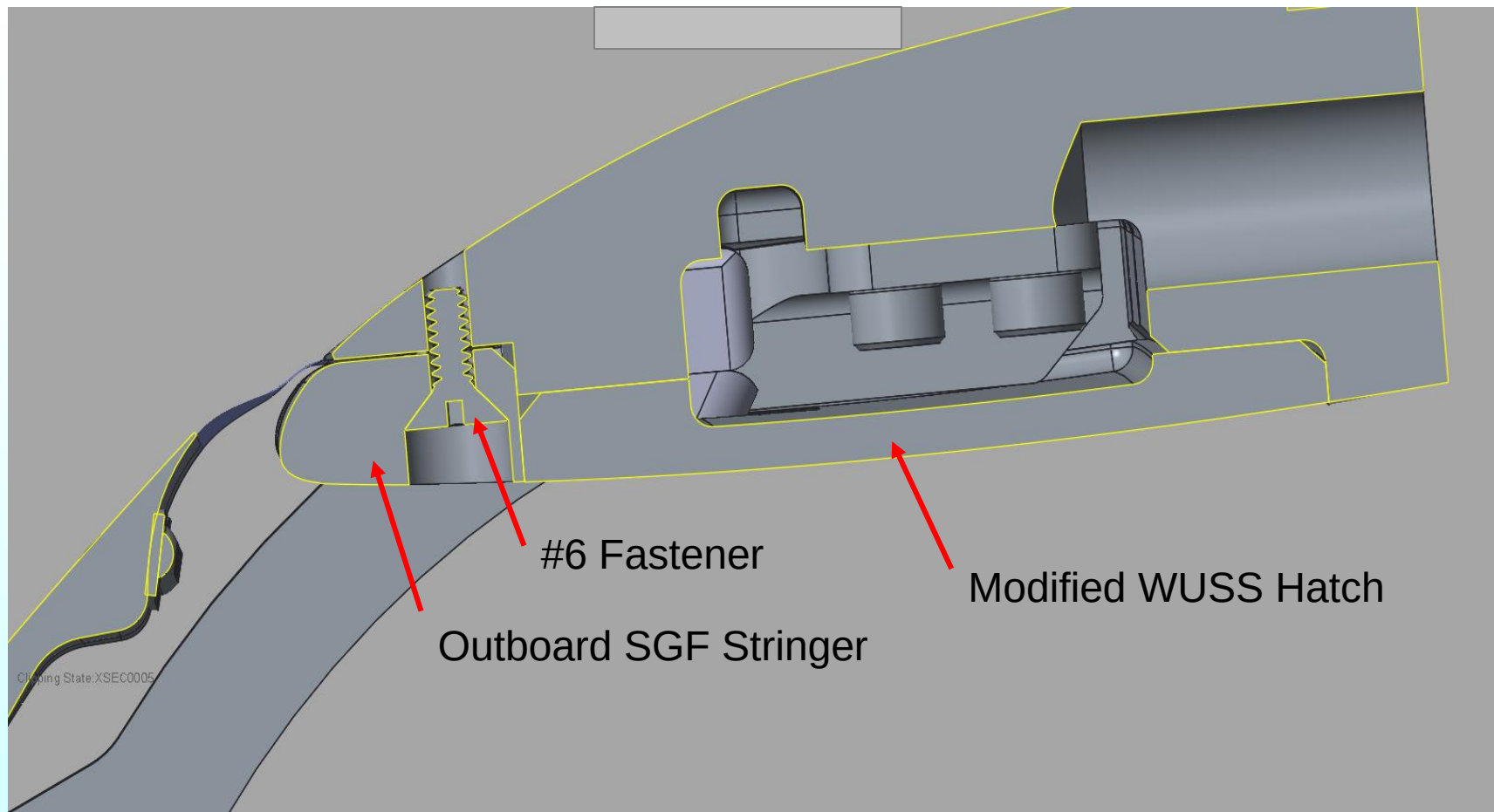
Slat-Gap Filler (SGF)



SGF Forward Attachment Method



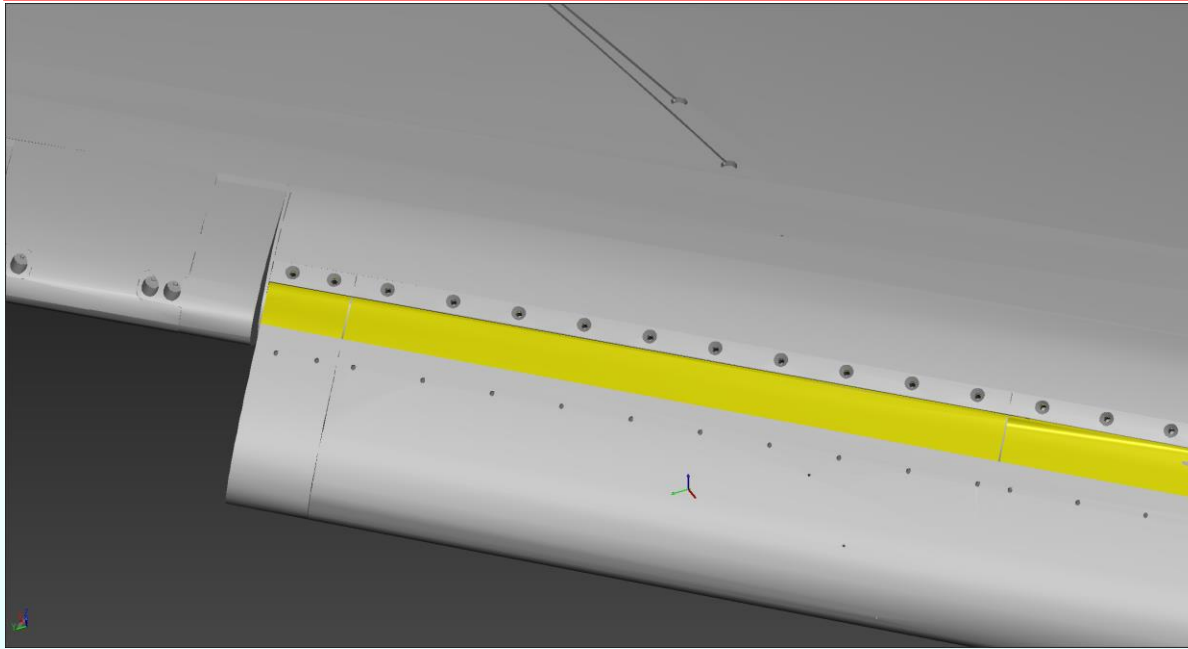
SGF Aft Attachment Method - Outboard



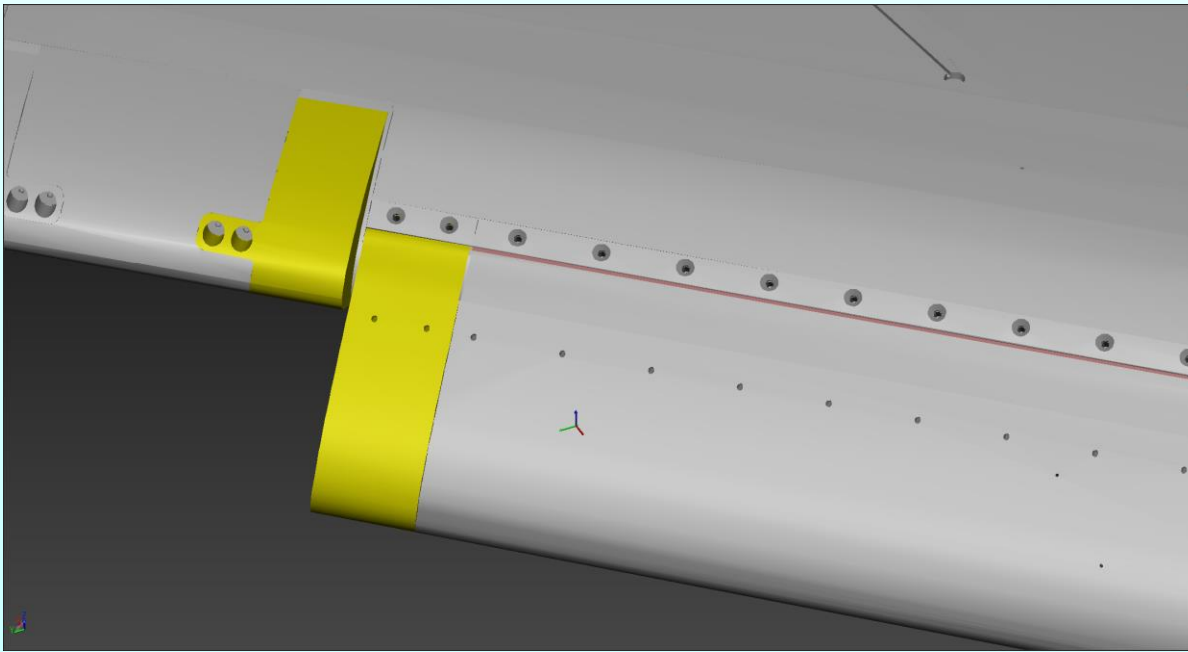
SGF Aft Attachment Method - Inboard



Slat-Gap Filler (SGF)



- Segments of SMA comprise the SGF
 - More frequent than bracket locations
- Multiple end treatments possible



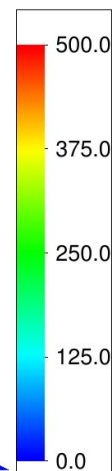
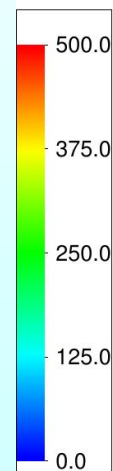
- Computations used to obtain loads for structural analyses and to examine the effectiveness of various means of reducing the noise coming from the slat
- Grid dimensions
 - With nacelle/pylon
 - 1.21 billion voxels (cells), 400 million fine equivalent
 - With full-span slat
 - 1.10 billion voxels (cells), 384 million fine equivalent
- Run time of around 6 days on 4000 cores
 - Most cases are still running

RMS of the Perturbation Pressure



Full-Span Slat

Lower (Compression)
Surface



Baseline

$M = 0.2$
 $AoA = 7 \text{ deg}$

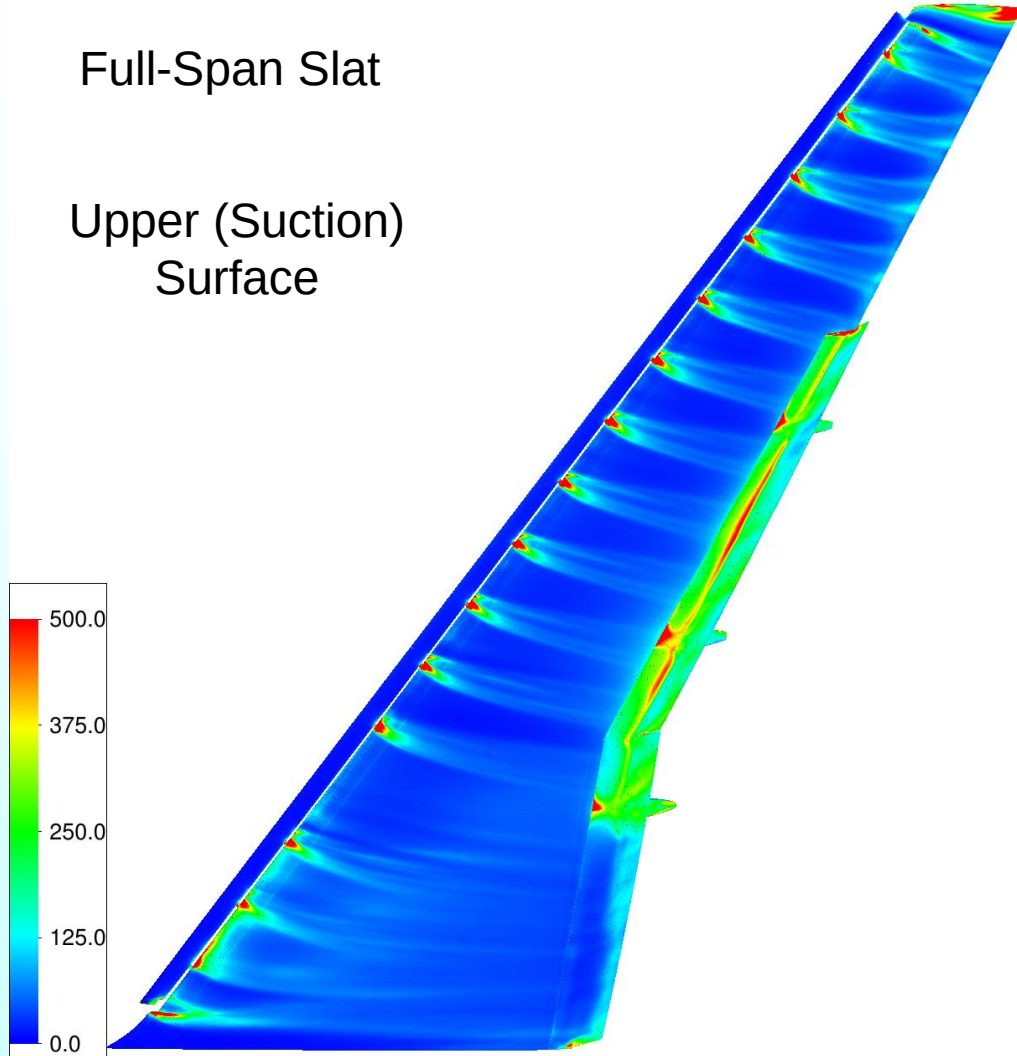
SGF

RMS of the Perturbation Pressure

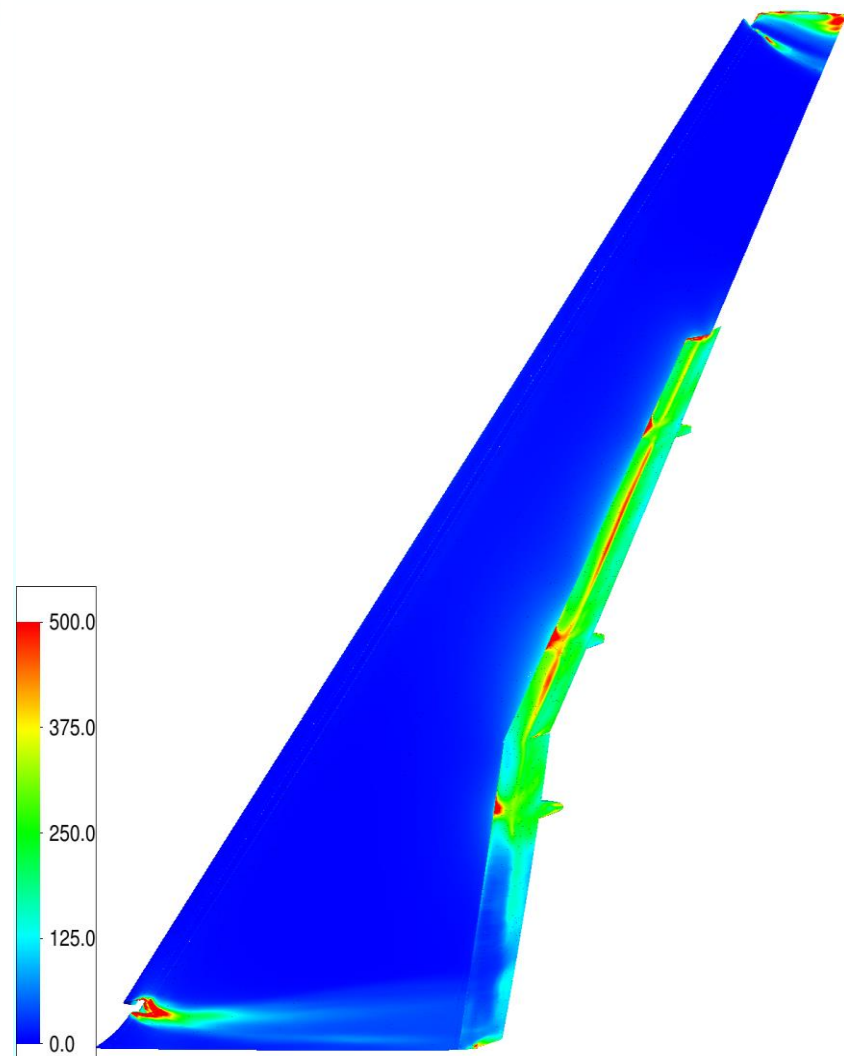


Full-Span Slat

Upper (Suction)
Surface



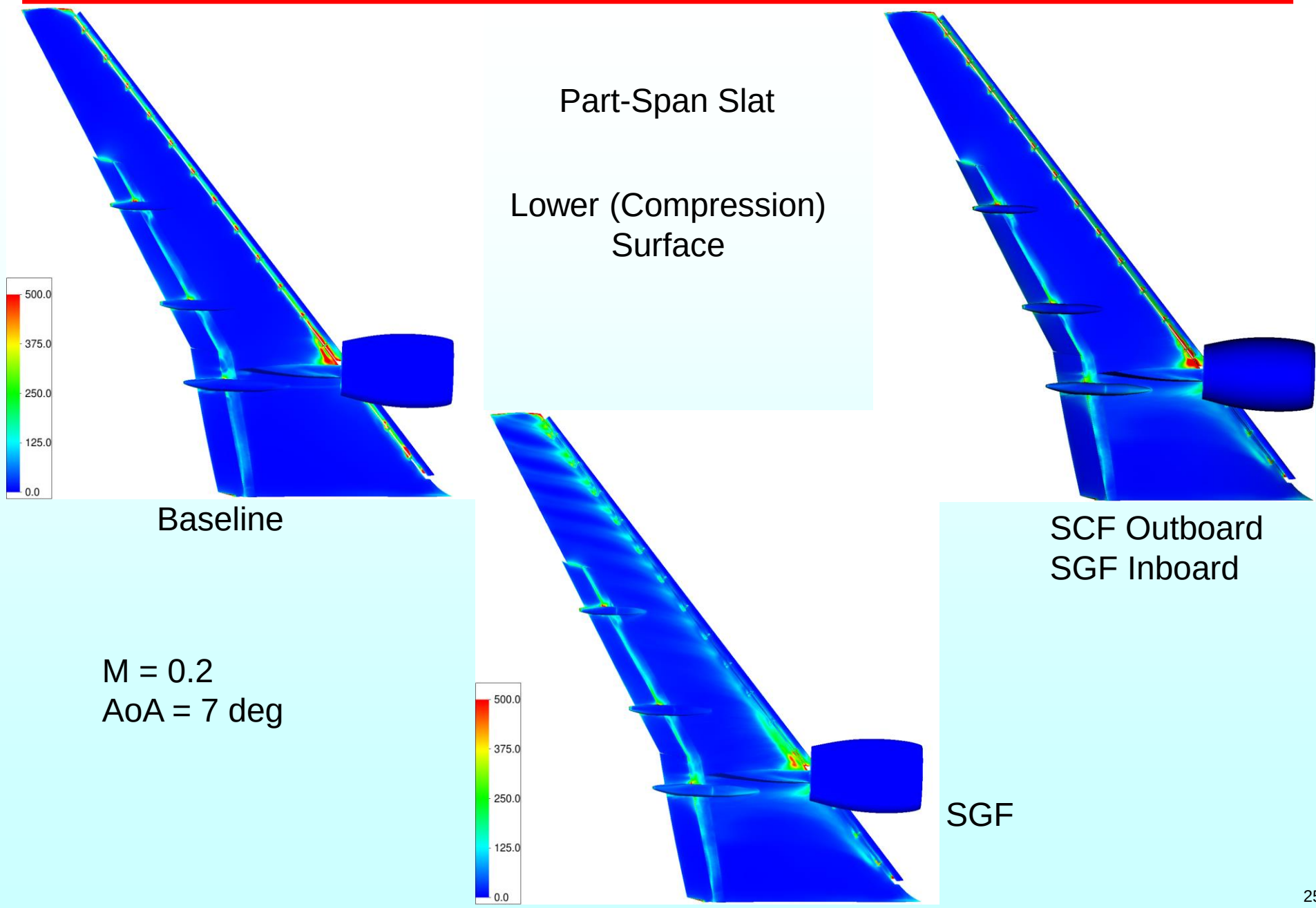
Baseline



SGF

$M = 0.2$
 $AoA = 7^\circ$

RMS of the Perturbation Pressure

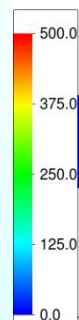


RMS of the Perturbation Pressure

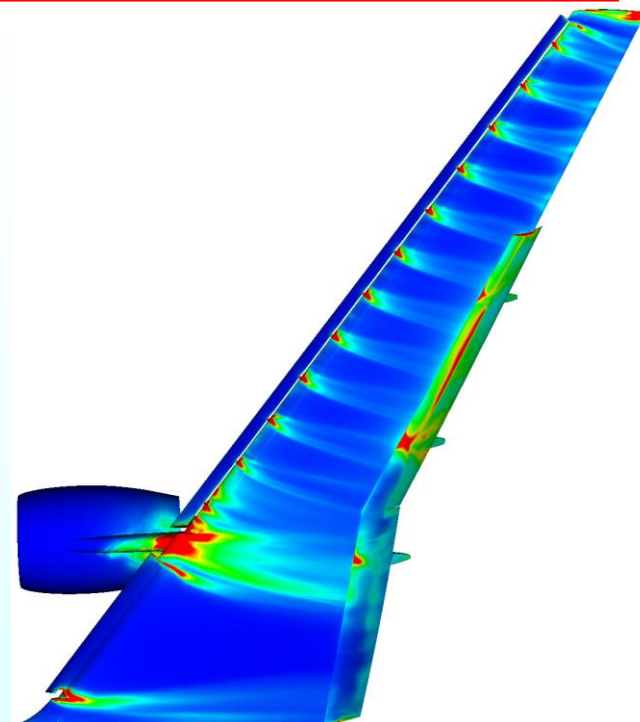


Part-Span Slat

Upper (Suction)
Surface



Baseline



SCF Outboard
SGF Inboard

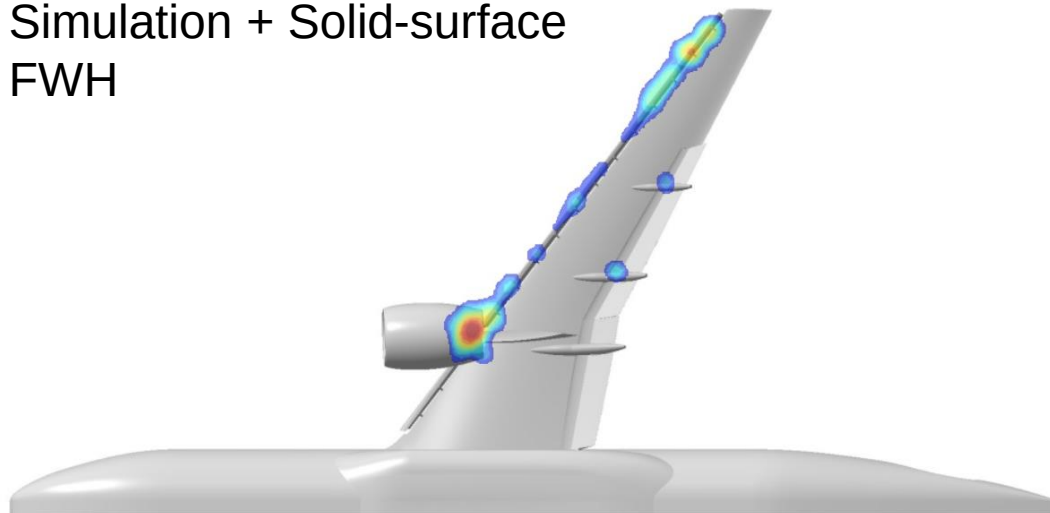
$M = 0.2$
 $AoA = 7^\circ$



SGF

Frequency = 5 kHz

Simulation + Solid-surface
FWH



- Sources seen “through” nacelle with the solid-surface FWH
 - Effect of the uniform convection assumption?
 - Simplified test cases being used to analyze the problem
- Porous-surface FWH prohibitively expensive for this problem
 - Solid-surface FWH file is 2.5 TB, and porous would be 5 times bigger

2018 14x22
Experiment



- SGF/SCF slat fabrication underway and delivery expected Feb, 2020
 - SGF and SCF parts will be attached at NASA LaRC
- 14x22 Conversion to open-jet mode begins in March, 2020
- Acoustic testing in the 14x22 begins in April, 2020 and ends July 28
 - Baseline with acoustic slat (Kulites + realistic slat brackets)
 - Full-span and part-span slat
 - Various slat end treatments
 - Three slat buckets removed and replaced with alternative designs
 - With and without Landing gear
 - Slat-gap filler with various end treatments
 - Baseline with aero slat (to compare with 2018 data)
 - Slat-cove filler with various end treatments
 - Alternative slat-gap filler treatments



Questions?