

**Best in class CFD meshing
for the aerospace sector**

Vangelis Skaperdas

physics on screen

ANSA evolution

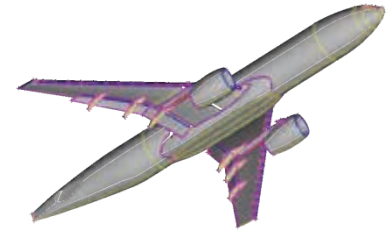
Born in the automotive industry back in the early 90s, for FEA meshing



In the late 90s it becomes widespread for CFD meshing in motorsports teams and OEMs



In the late 2000s it enters the CFD aerospace sector and is growing ever since



What is the recipe of success of a pre-processing software?



Recipe:

INGREDIENTS:

Quality

Speed

Automation

User Control

Feedback

Efficiency

Wide range

of functionality

Discipline and

solver independent

Support!!!

DIRECTIONS:

Geometry and flow features - Mesh quality - Consistency

Minimum to no user involvement

No black box approach

GUI guidance, preview, reporting...

Most accurate result with least cell count

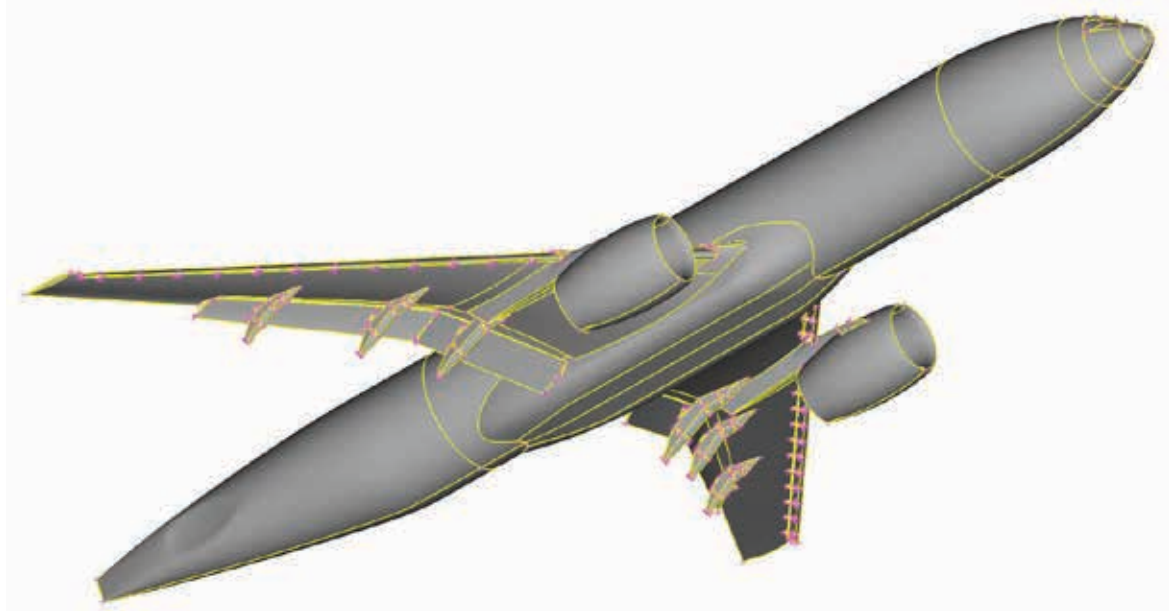
Geometry, Mesh, Morph, Model update ...

A common yet adaptable approach to all

CAE problems

Case study description

- Demonstrate ANSA pre-processing capabilities on the geometry of the CRM model from the 4th High Lift Prediction Workshop



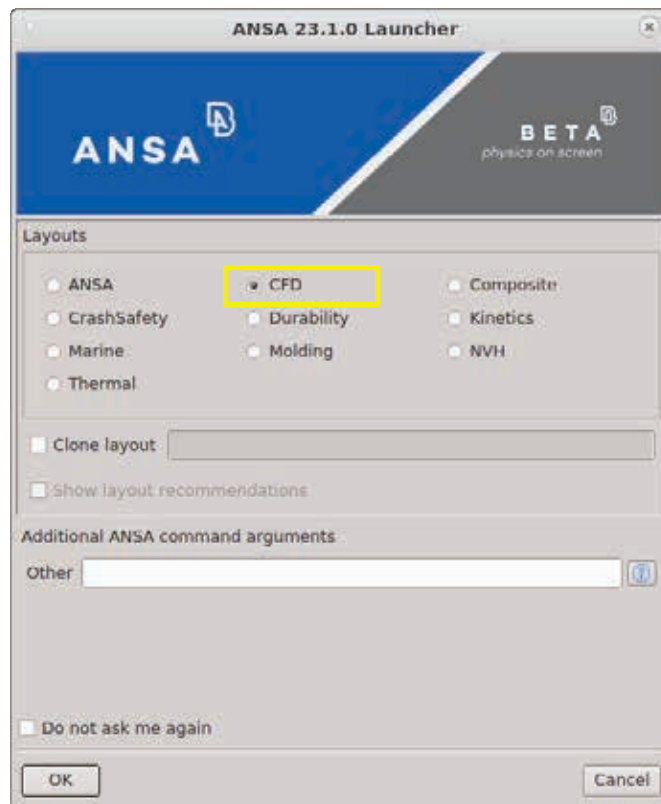
- ANSA v23.1.2

- Linux workstation with AMD Ryzen Threadripper 3970X with 32 cores (64 threads) and 256Gb RAM

ANSA steps to high fidelity mesh generation

- 1- Start ANSA in CFD layout and select your meshing profile
- 2- Read the CAD and check its topology
- 3- Create the domain
- 4- Assign correct orientation
- 5- Assign PIDs and BC types
- 6- Detect and manage Features
- 7- Setup Batch Mesh
- 8- Setup Size Field
- 9- Execute Batch Mesh
- 10- Check Mesh quality
- 11 – Output mesh

Launching ANSA for CFD



Selecting a Meshing Profile

The screenshot displays the ANSA v23.1.2 - CFD software interface. A dialog box titled "Select your meshing profile" is open, showing the following settings:

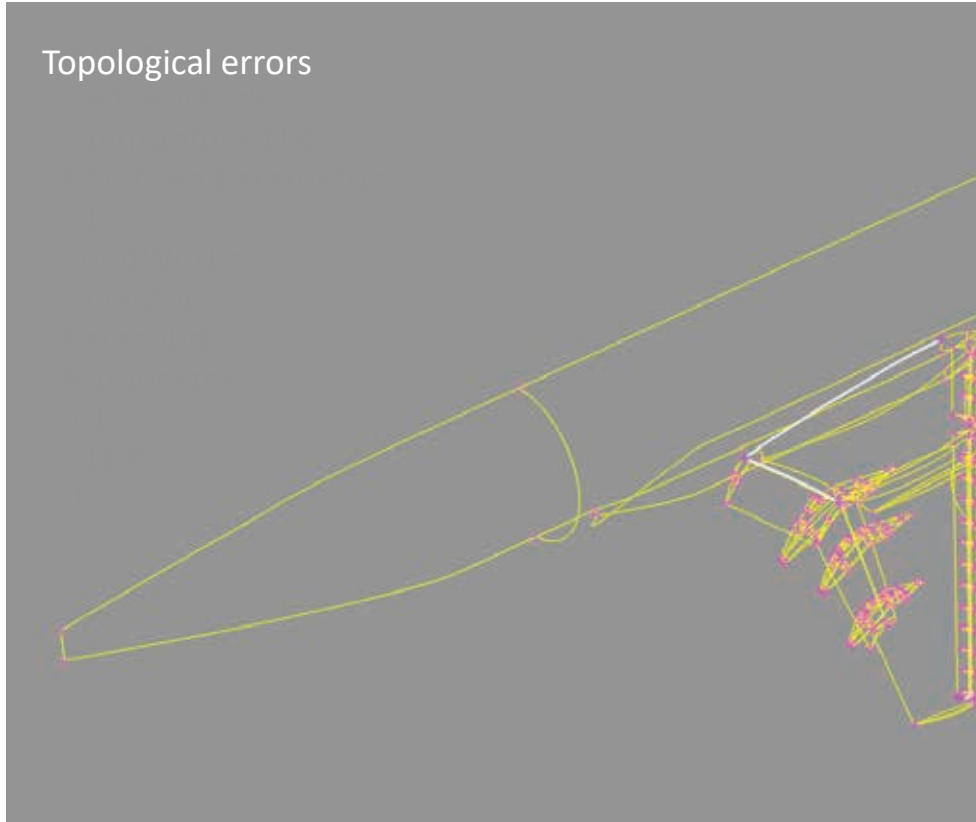
- Application: Aerospace
- Solver: TAU
- Surface mesh: Mixed
- Layers: y+ 1
- Volume mesh: HexInterior

There is an unchecked checkbox labeled "Do not show on ANSA startup" and "Apply" and "Skip" buttons at the bottom of the dialog.

A blue callout box at the bottom right of the image contains the text: **USB>CFD Meshing Profile**

Geometry import and check

Topological errors



Checks Manager Unmtr/aid_disk/titanas/ANSA_2001-eae/unife/Ansa_v23.1.7/config/Checks/CFD_Templ

Back Geometry Run

Type	Message Code	Entity ID	Description	Auto Fix
Warning	E4074	CONS_1982187	Single Cons	
Warning	E4074	CONS_1881451	Single Cons	
Warning	E4074	CONS_1058850	Single Cons	
Warning	E4074	CONS_1019837	Single Cons	
Warning	E4074	CONS_1011830	Single Cons	
Warning	E4074	CONS_1011830	Single Cons	

Show Show Only Hide Open in Window Create SETs

total 12 selected 12

Name	Value
Sharp Edges	<input type="checkbox"/>
Unmeshed Macros	<input type="checkbox"/>
Unchecked Faces	<input checked="" type="checkbox"/>
Collapsed Cons	<input checked="" type="checkbox"/>
Triple Cons	<input checked="" type="checkbox"/>
Needle Faces	<input checked="" type="checkbox"/>
Overlap Faces	<input checked="" type="checkbox"/>
Cracks	<input checked="" type="checkbox"/>
Single Cons	<input checked="" type="checkbox"/>

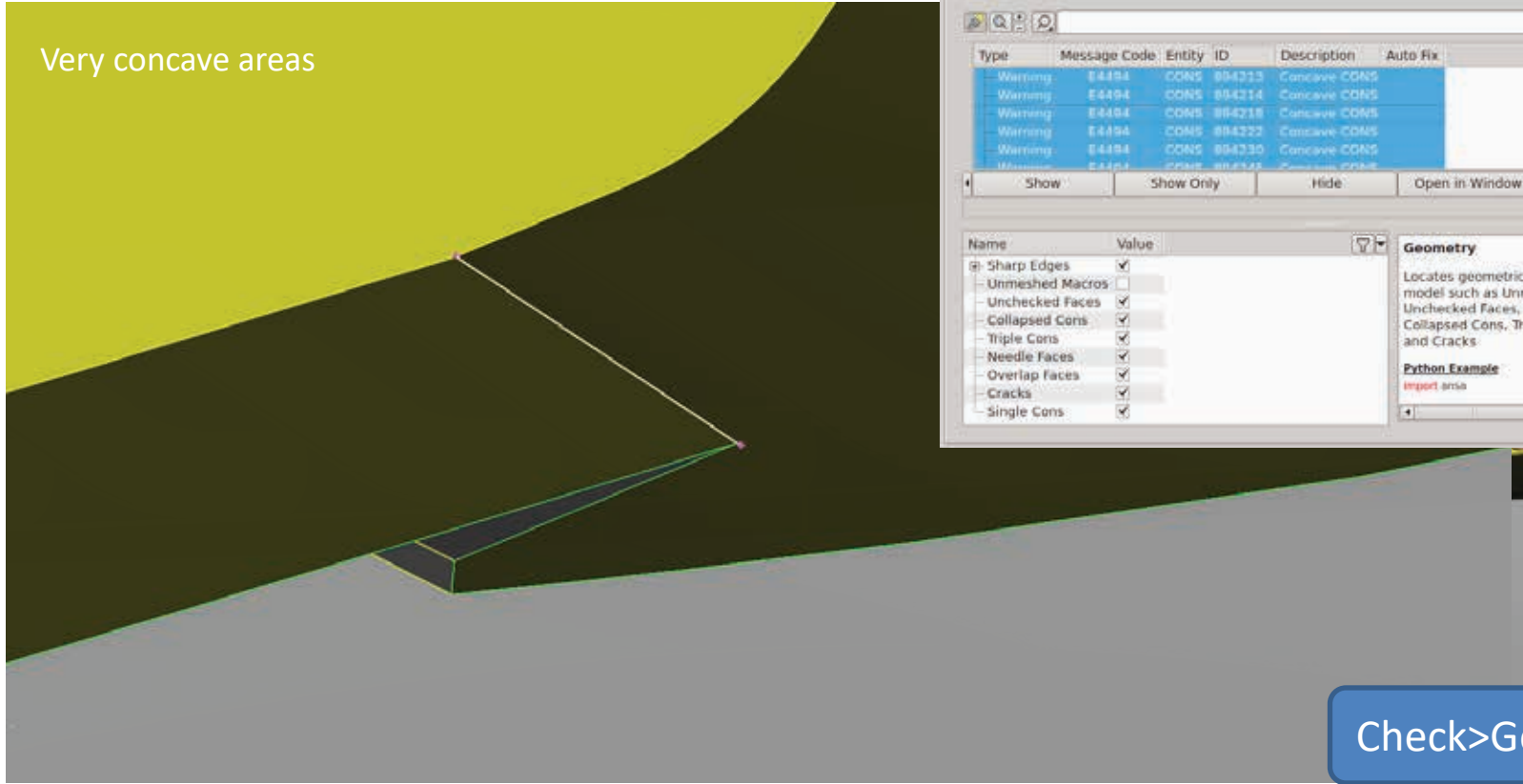
Geometry
Locates geometrical problems of the model such as Unmeshed Macros, Unchecked Faces, Needle Faces, Collapsed Cons, Triple Cons, Overlaps and Cracks

Python Example
`import ansa`

Check>Geometry

Geometry import and check

Very concave areas



Checks Manager Unmtr/aid_disk/titanas/ANSA_2001-ene/unifite/Ansa_v23.1.7/config/Checks/CFD_Templ...

Back Geometry Run

Type	Message Code	Entity ID	Description	Auto Fix
Warning	E4494	CONS 884213	Concave CONS	
Warning	E4494	CONS 884214	Concave CONS	
Warning	E4494	CONS 884218	Concave CONS	
Warning	E4494	CONS 884223	Concave CONS	
Warning	E4494	CONS 884230	Concave CONS	
Warning	E4494	CONS 884231	Concave CONS	

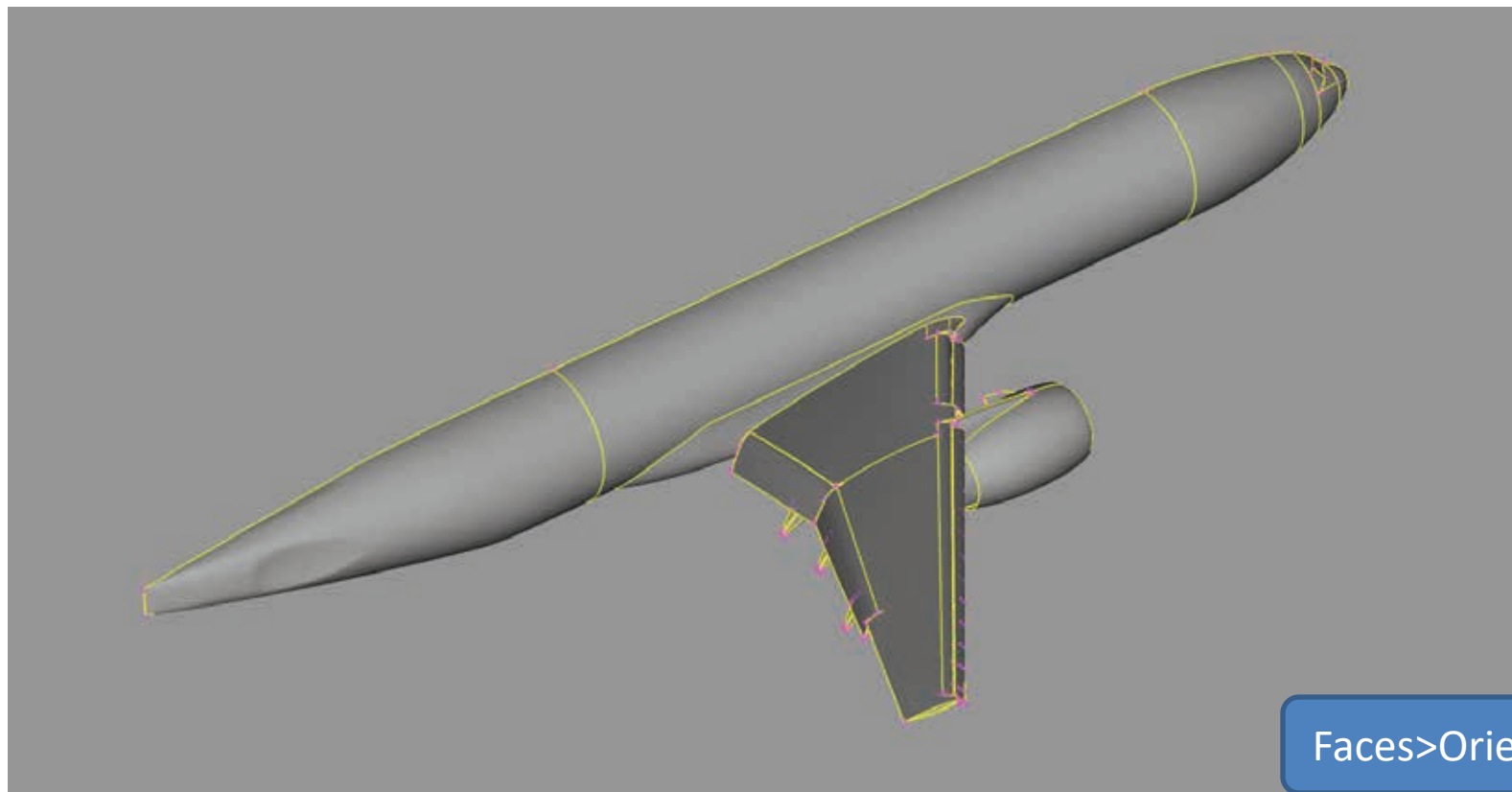
Show Show Only Hide Open in Window Create SETs total 10 selected 10

Name	Value
Sharp Edges	<input checked="" type="checkbox"/>
Unmeshed Macros	<input type="checkbox"/>
Unchecked Faces	<input checked="" type="checkbox"/>
Collapsed Cons	<input checked="" type="checkbox"/>
Triple Cons	<input checked="" type="checkbox"/>
Needle Faces	<input checked="" type="checkbox"/>
Overlap Faces	<input checked="" type="checkbox"/>
Cracks	<input checked="" type="checkbox"/>
Single Cons	<input checked="" type="checkbox"/>

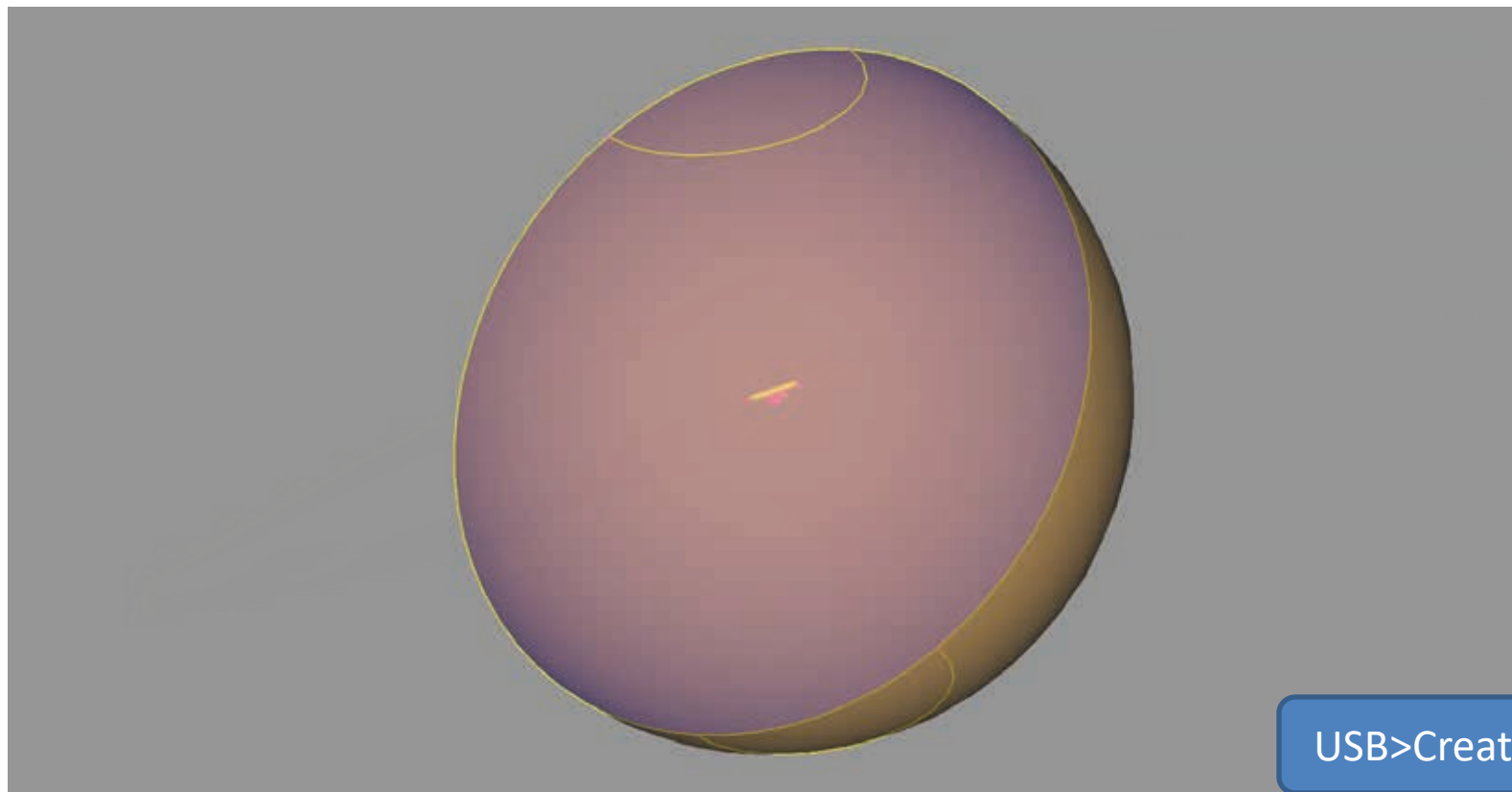
Geometry
Locates geometrical problems of the model such as Unmeshed Macros, Unchecked Faces, Needle Faces, Collapsed Cons, Triple Cons, Overlaps and Cracks

Python Example
`import ansa`

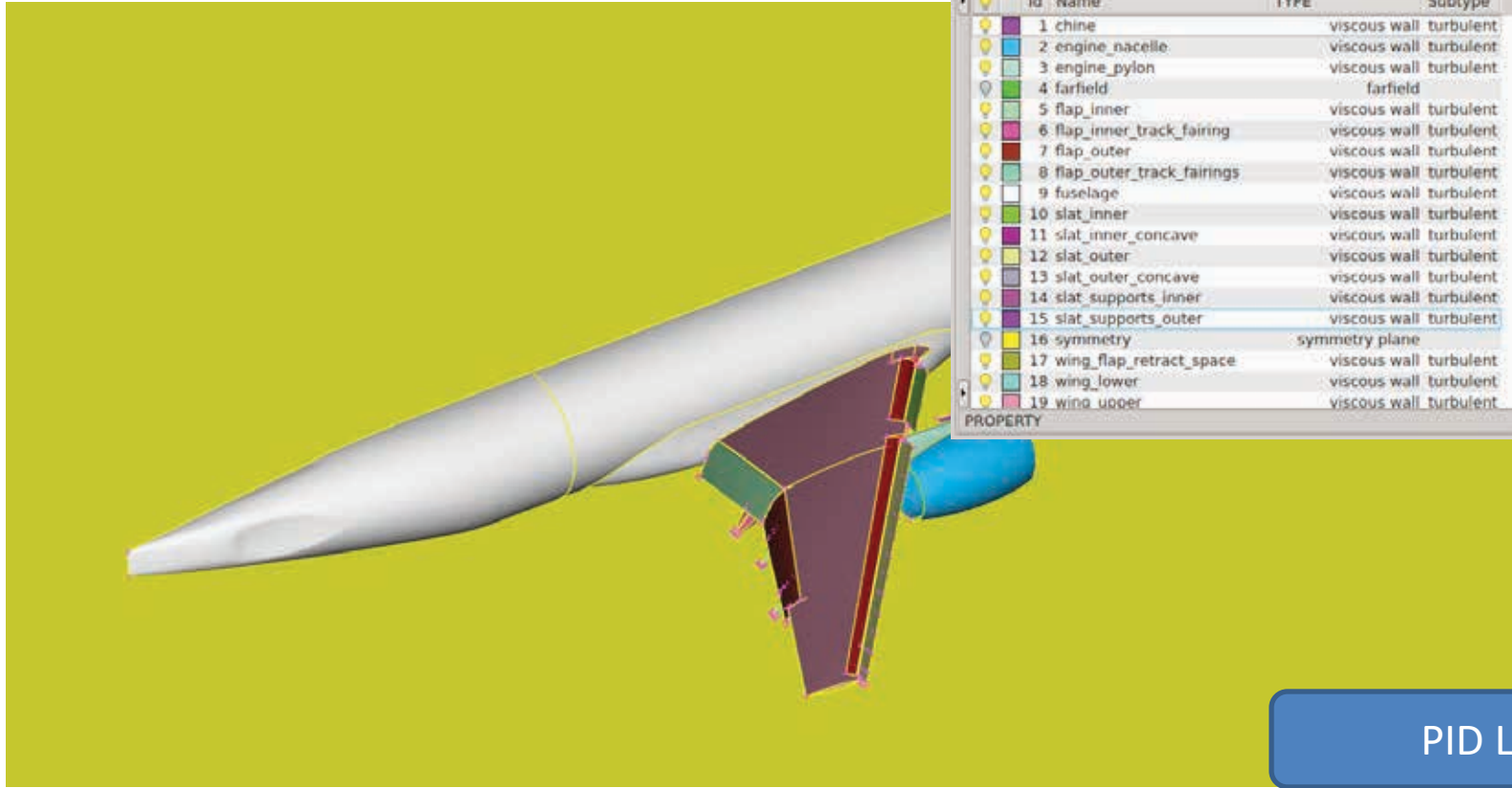
Correct orientation



Domain creation



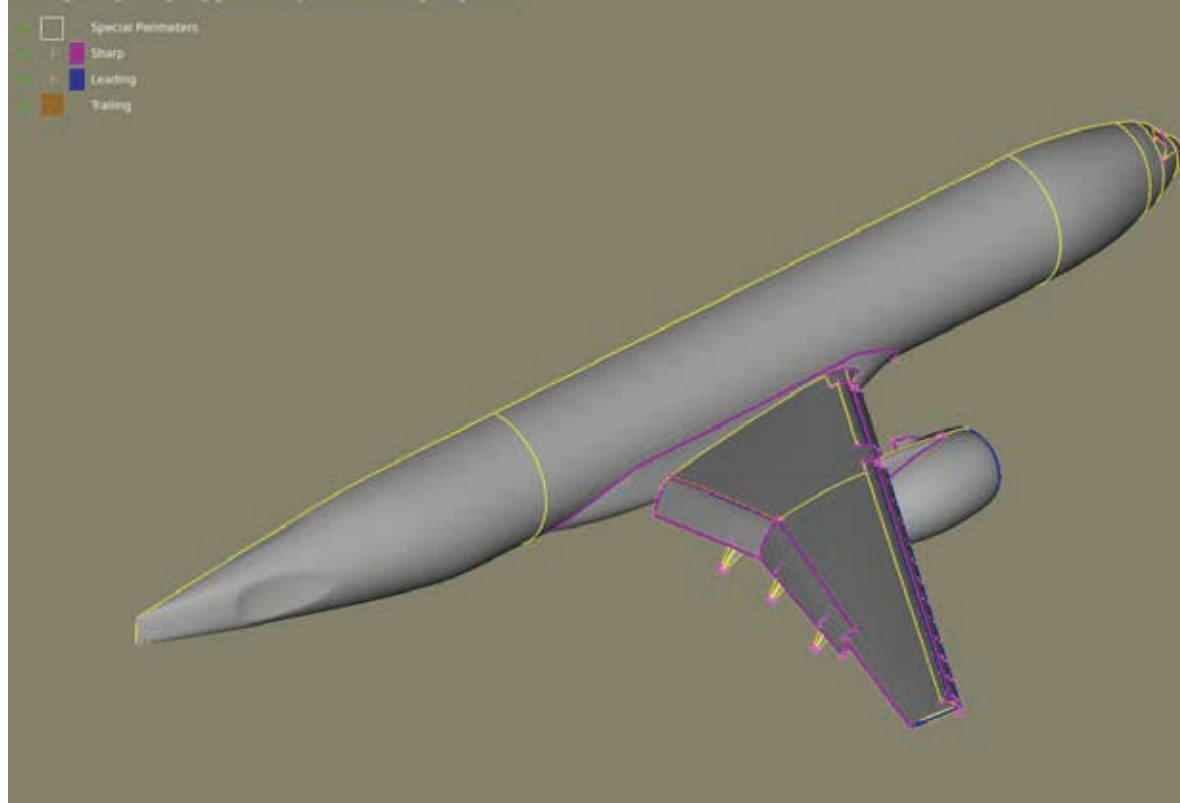
Assigning PIDs and BC type




PID List

Detection and Management of geometrical Features

D:\Case2a_HUMW-4_CRM46_Level_C_FINAL2.ansys.gl - Current Part: size_boxes_AoA.sweep



Special Perimeters 

Sharp

Leading


Free

FE break angle

Geom. break angle

Leading min. angle

Leading max. width

Trailing 

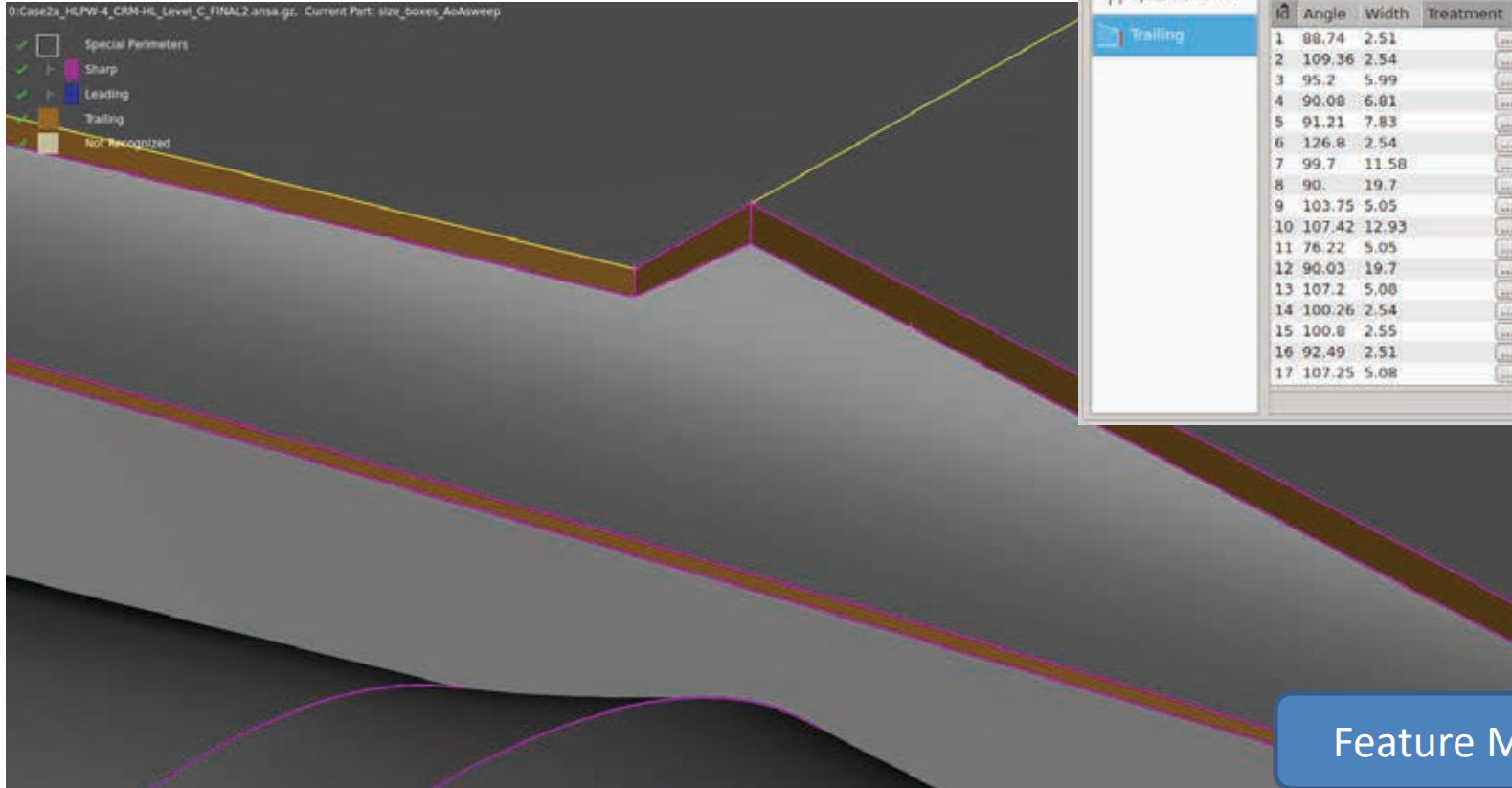
Min. angle

Min. width

Max. width

Feature Manager

Detection and Management of Features

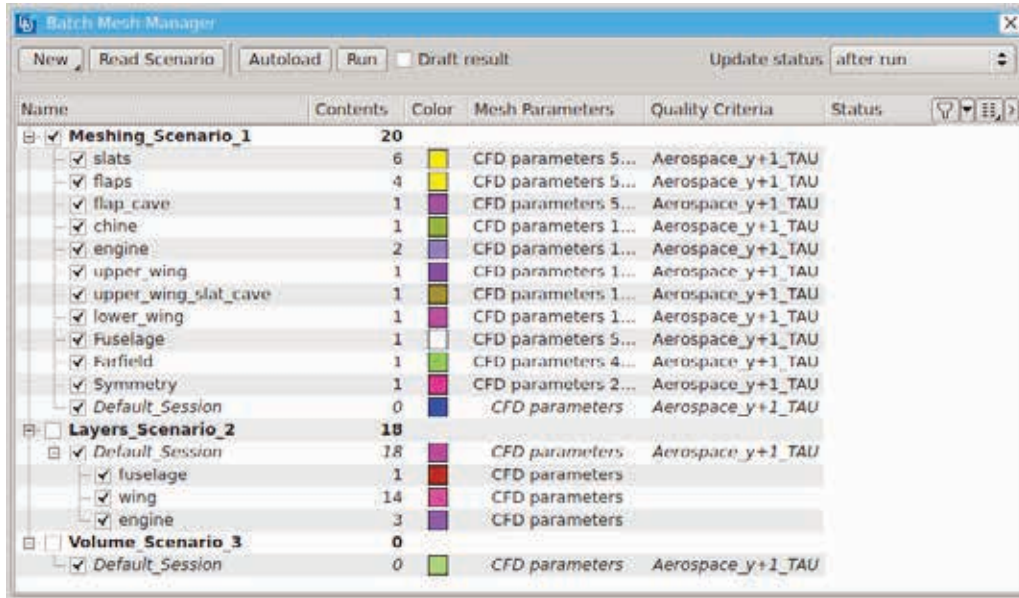


Feature Manager

Batch Mesh tool

Batch Mesh tool in ANSA performs fully automatic surface and volume meshing, ensuring:

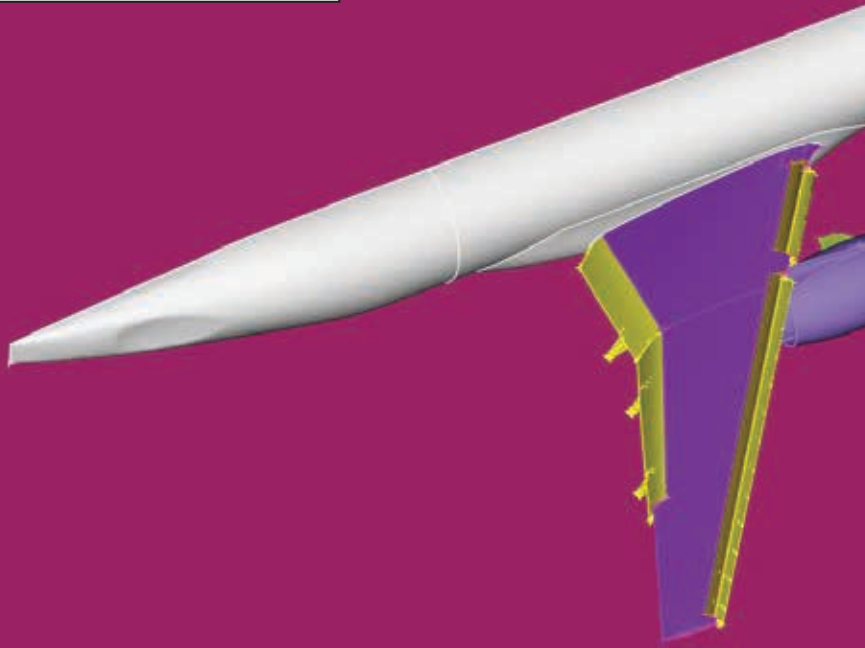
- Automation
- Reusability of scenario templates for new geometries
- No user interaction and hence consistency in meshing
- Facilitates mesh refinement studies
- Mesh specs traceability as template is saved in ANSA file



Setup of Batch Mesh tool

D:\Case2\HLPW-4_CRM-HI_Level_C_FINAL2_amsa.gz - Current Part: size_boxes_AoAweep

Batch Session colors

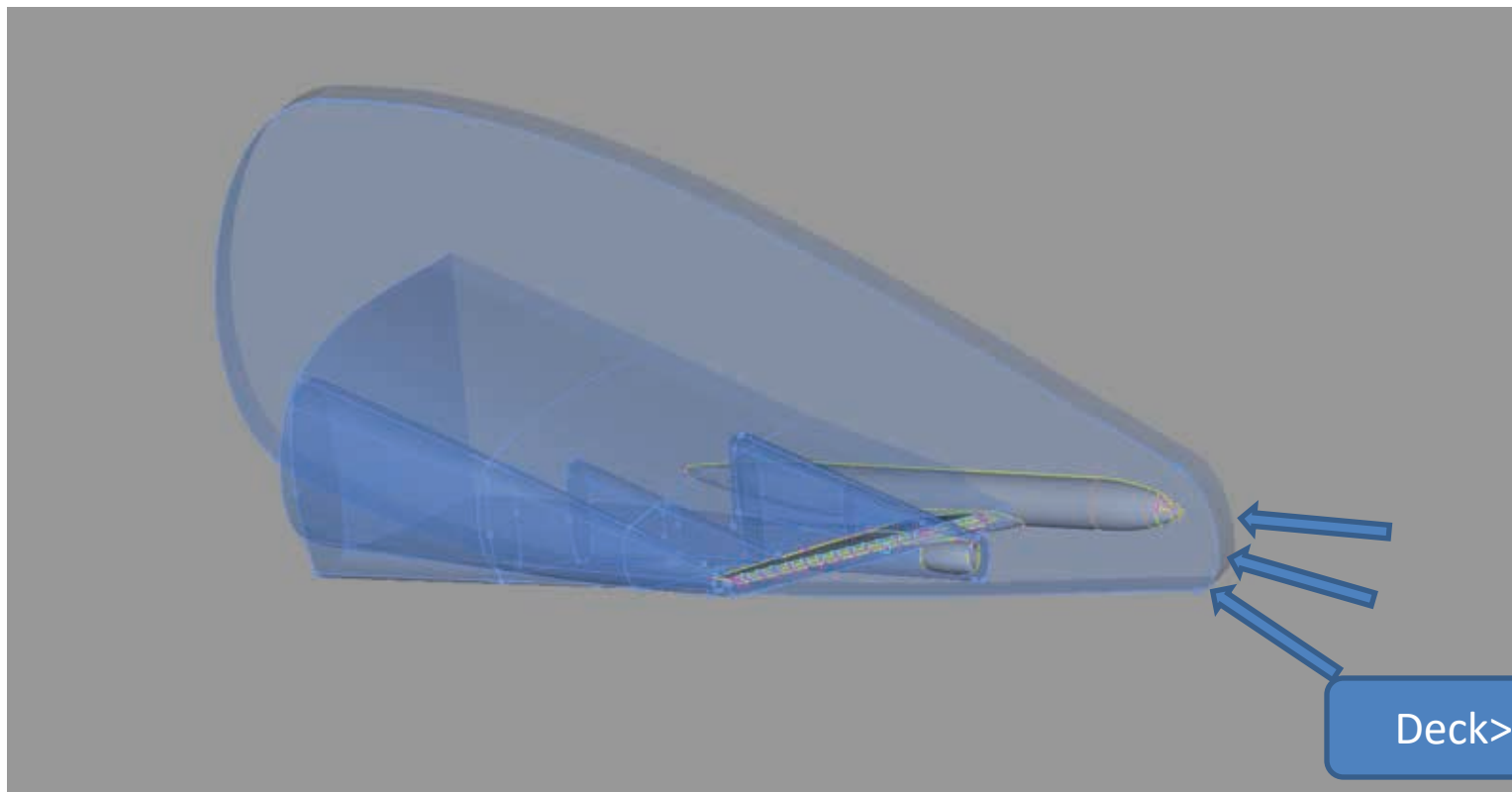


Name	Contents	Color	Mesh Parameters	Quality Criteria	Status
Meshing_Scenario_1	20				
✓ slats	6	Yellow	CFD parameters 5...	Aerospace_y+1_TAU	
✓ flaps	4	Yellow	CFD parameters 5...	Aerospace_y+1_TAU	
✓ flap_cave	1	Purple	CFD parameters 5...	Aerospace_y+1_TAU	
✓ chine	1	Green	CFD parameters 1...	Aerospace_y+1_TAU	
✓ engine	2	Purple	CFD parameters 1...	Aerospace_y+1_TAU	
✓ upper_wing	1	Purple	CFD parameters 1...	Aerospace_y+1_TAU	
✓ upper_wing_slit_cave	1	Purple	CFD parameters 1...	Aerospace_y+1_TAU	
✓ lower_wing	1	Purple	CFD parameters 1...	Aerospace_y+1_TAU	
✓ fuselage	1	White	CFD parameters 5...	Aerospace_y+1_TAU	
✓ Farfield	1	Green	CFD parameters 4...	Aerospace_y+1_TAU	
✓ Symmetry	1	Pink	CFD parameters 2...	Aerospace_y+1_TAU	
✓ Default_Session	0	Blue	CFD parameters	Aerospace_y+1_TAU	
Layers_Scenario_2	10				
✓ Default_Session	18	Purple	CFD parameters	Aerospace_y+1_TAU	
✓ fuselage	1	Red	CFD parameters		
✓ wing	14	Pink	CFD parameters		
✓ engine	3	Purple	CFD parameters		
Volume_Scenario_3	0				
✓ Default_Session	0	Green	CFD parameters	Aerospace_y+1_TAU	

- Curvature refinement
- Sharp edge feature refinement
- Leading and trailing edges anisotropic meshing
- Proximity refinement

Setup of additional size refinement zones

Creation of flexible Size Boxes to control the wake refinement



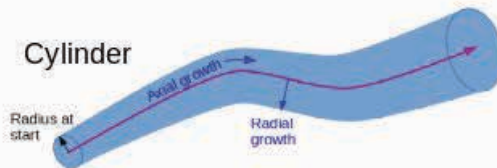
Setup of additional size refinement zones

Specification of advanced Size Field functions

Closed Surface



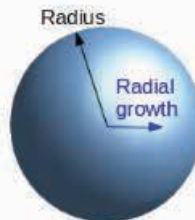
Cylinder



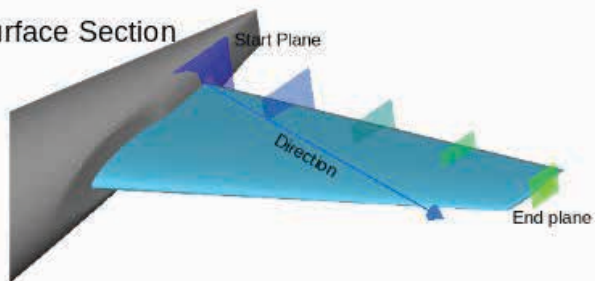
Surface Offset



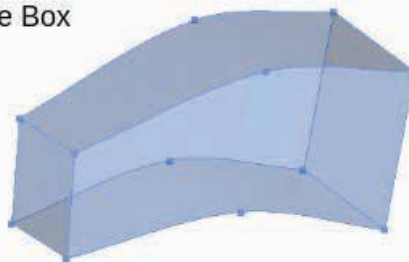
Sphere



Surface Section



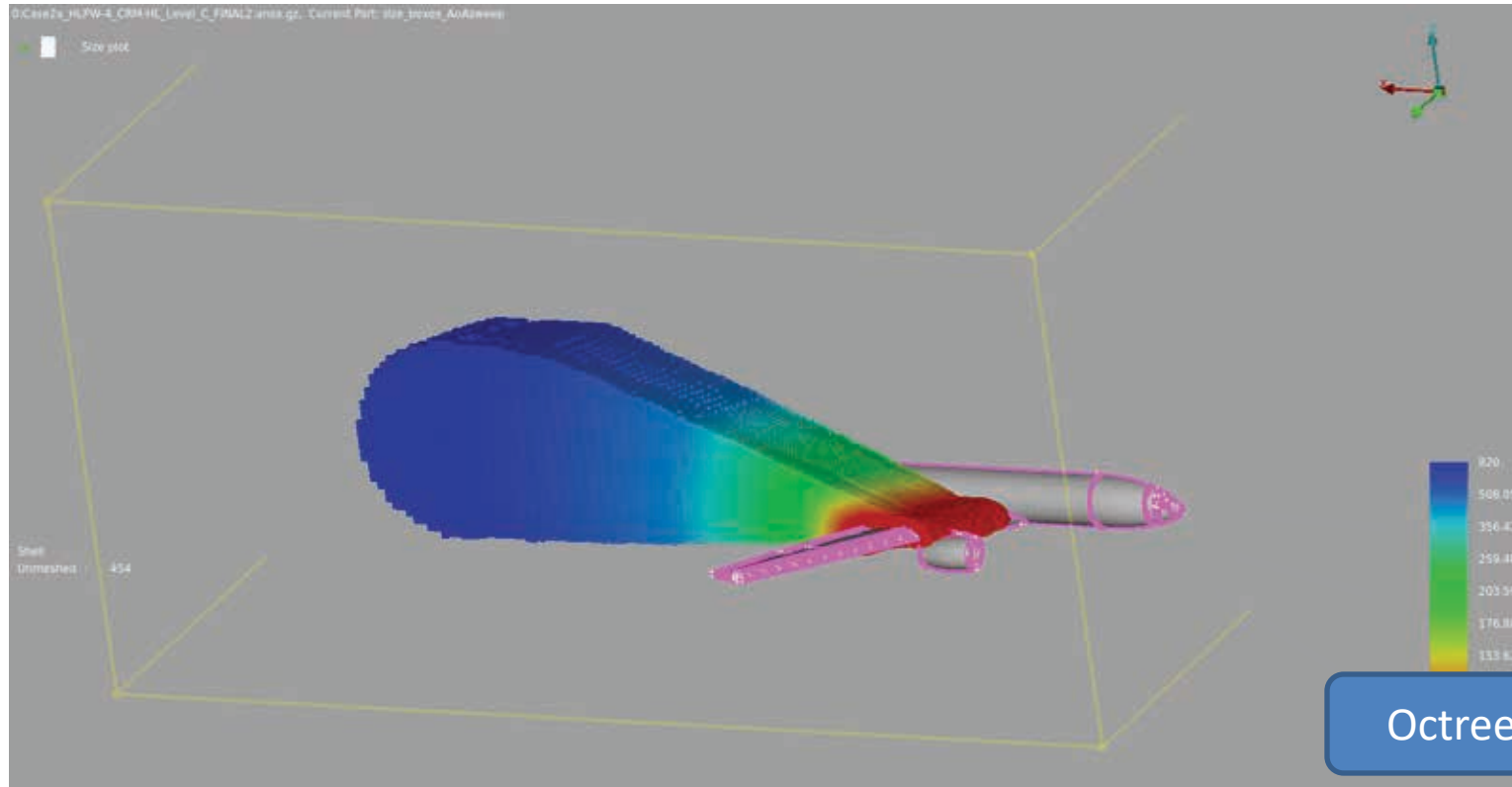
Size Box



Octree>Size Field

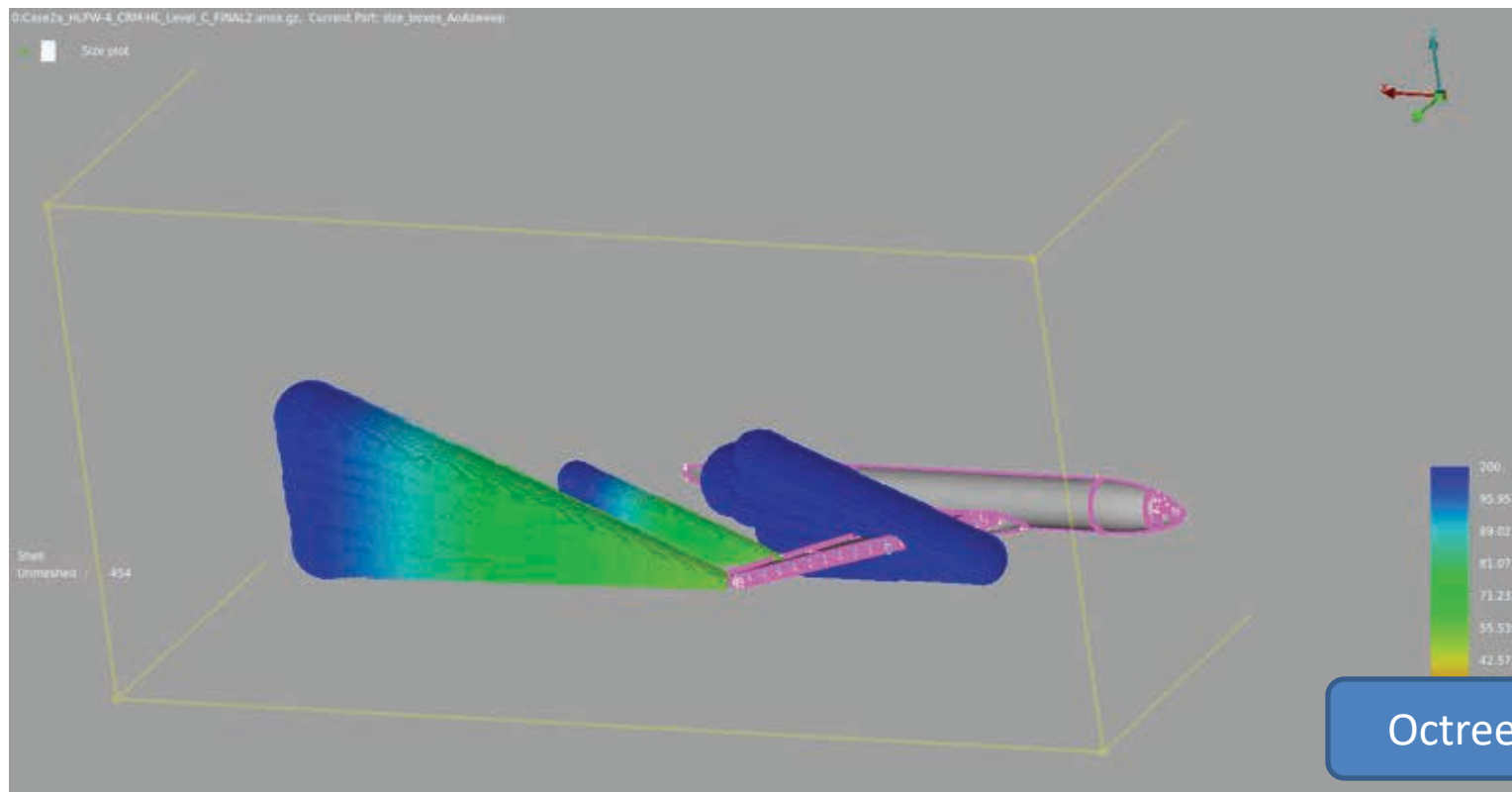
Setup of Size Field

Surface Offset Rule from selected PIDs along a user specified direction

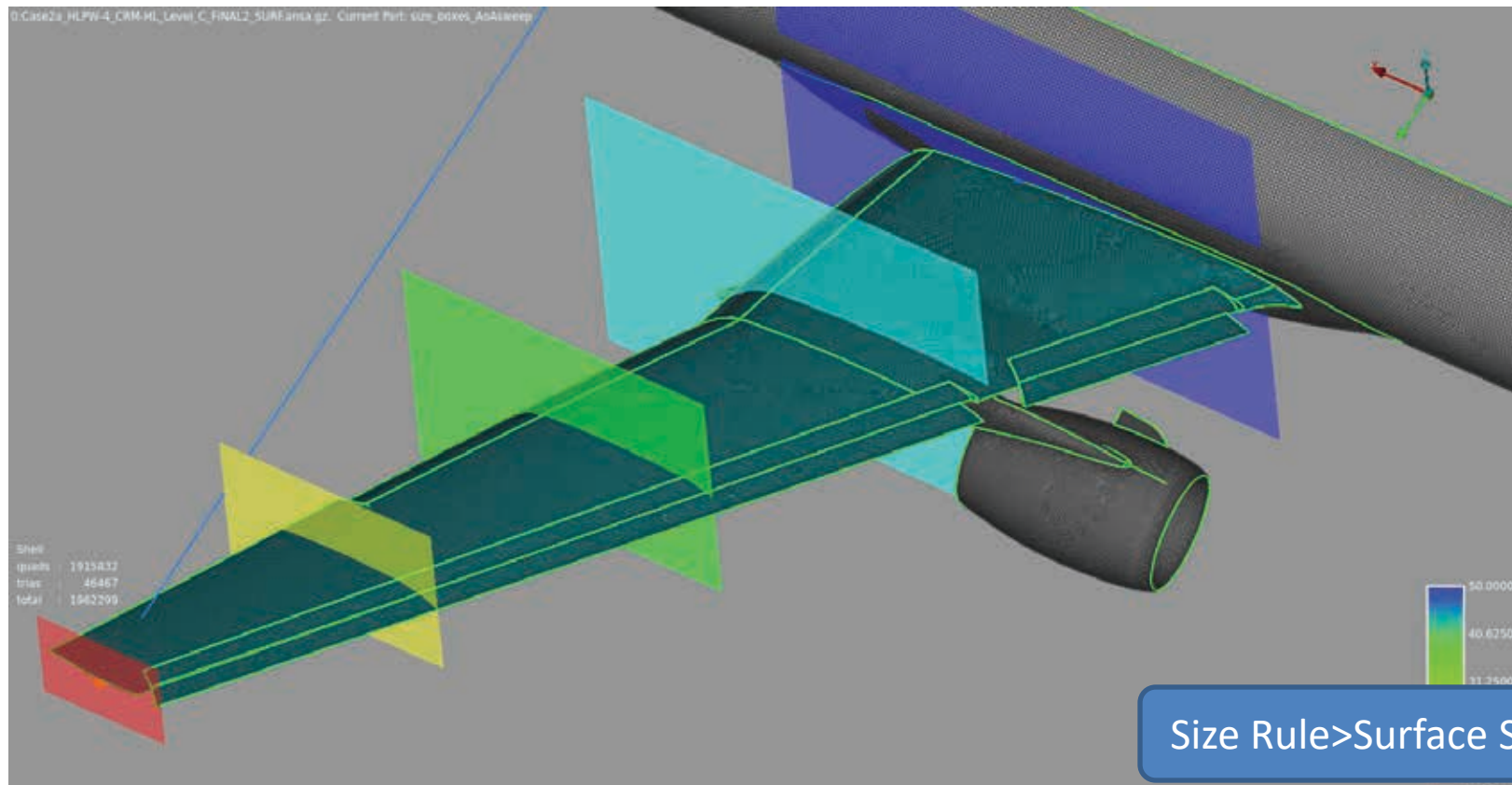


Setup of Size Field

Cylinder Rule along selected 3D Curves

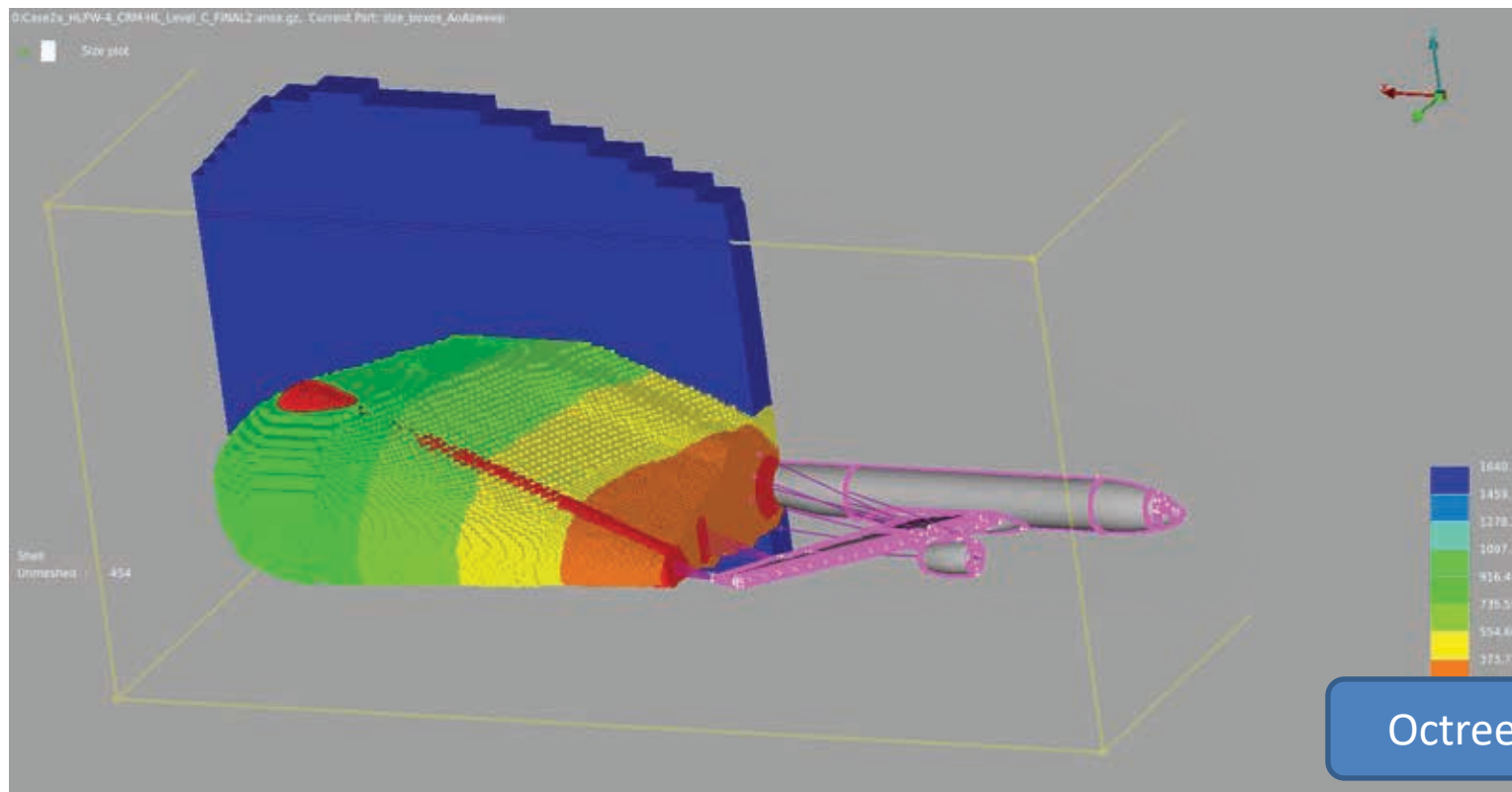


Main wing – Linear Variation of maximum length

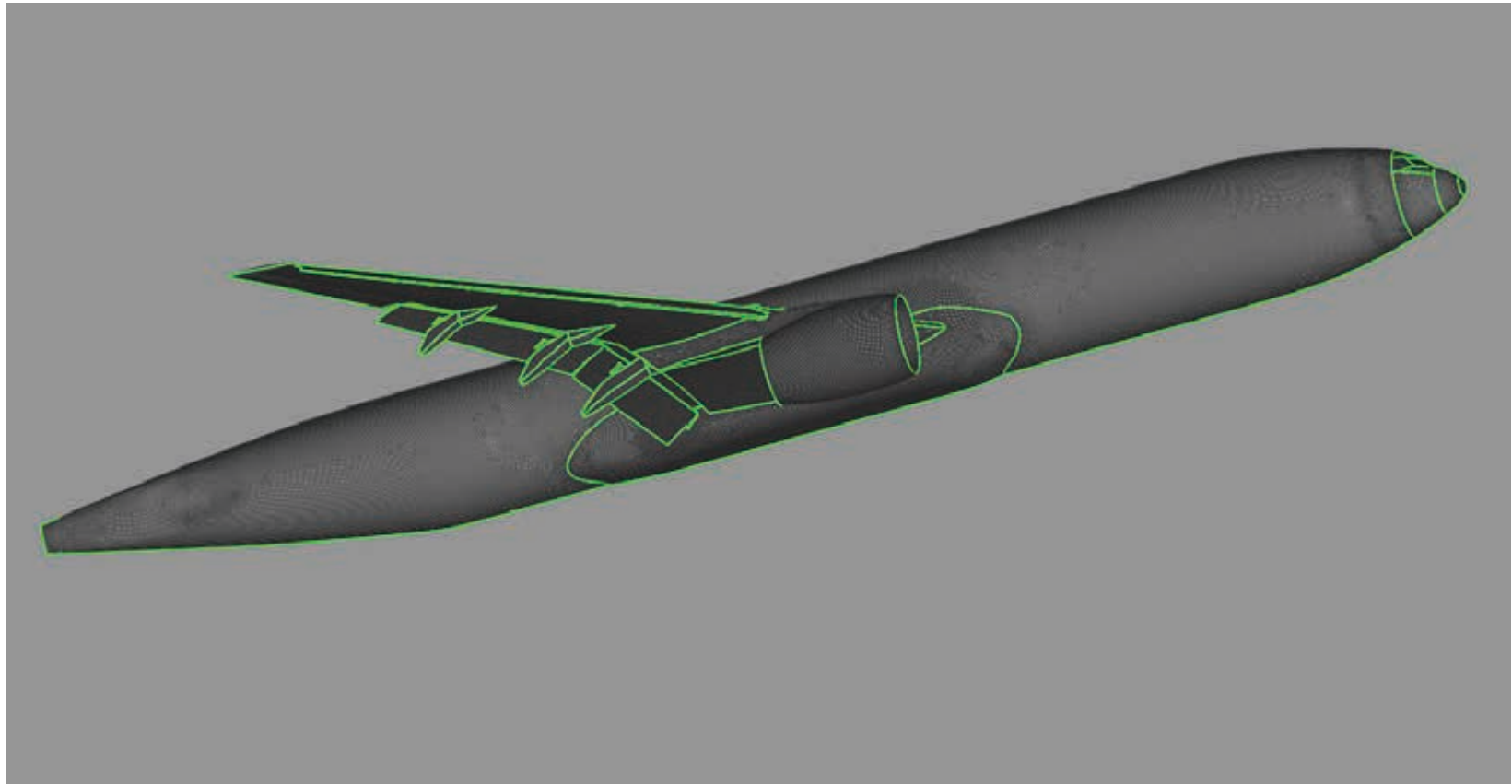


Setup of Size Field

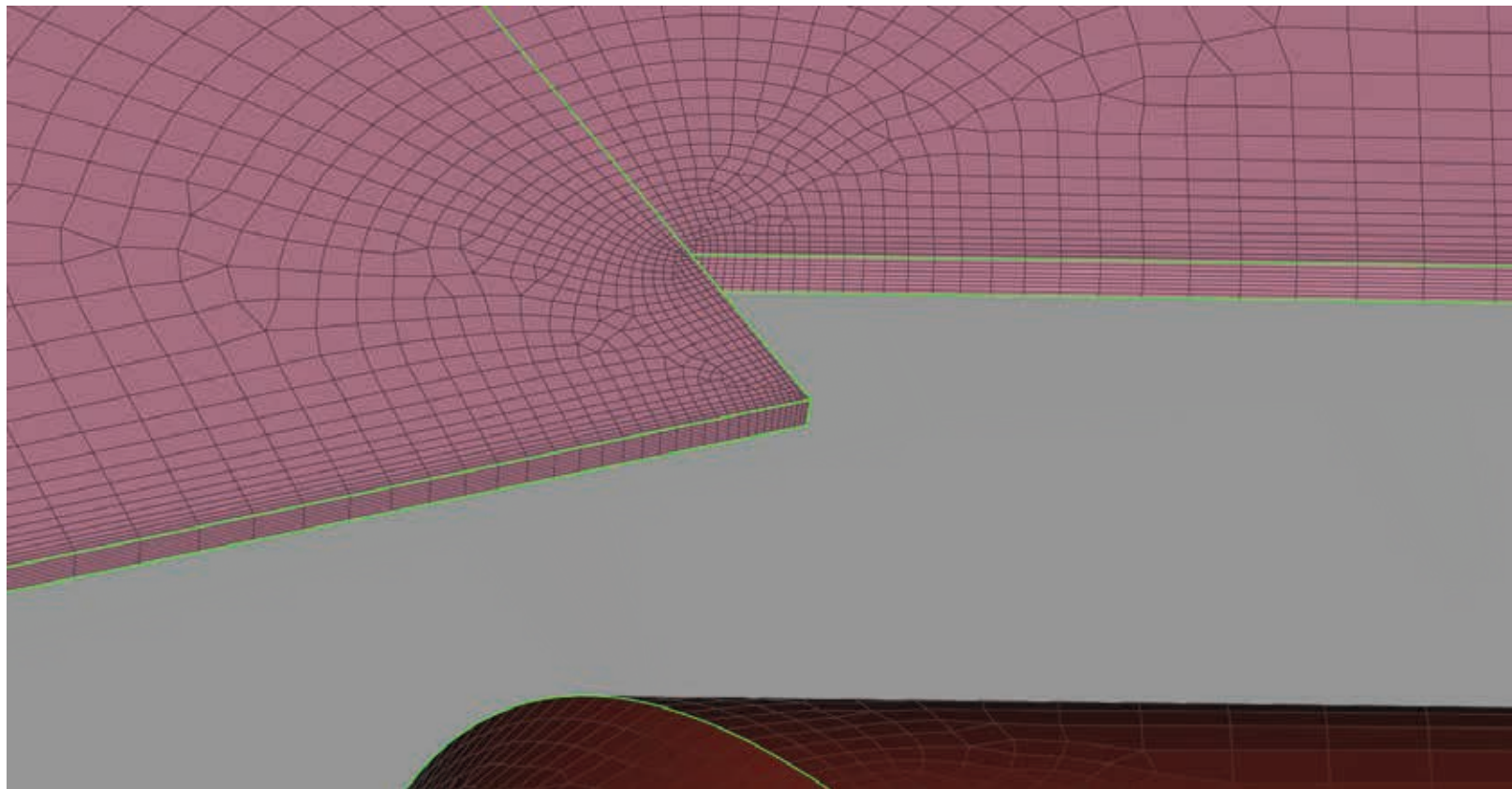
Final combined Size Field



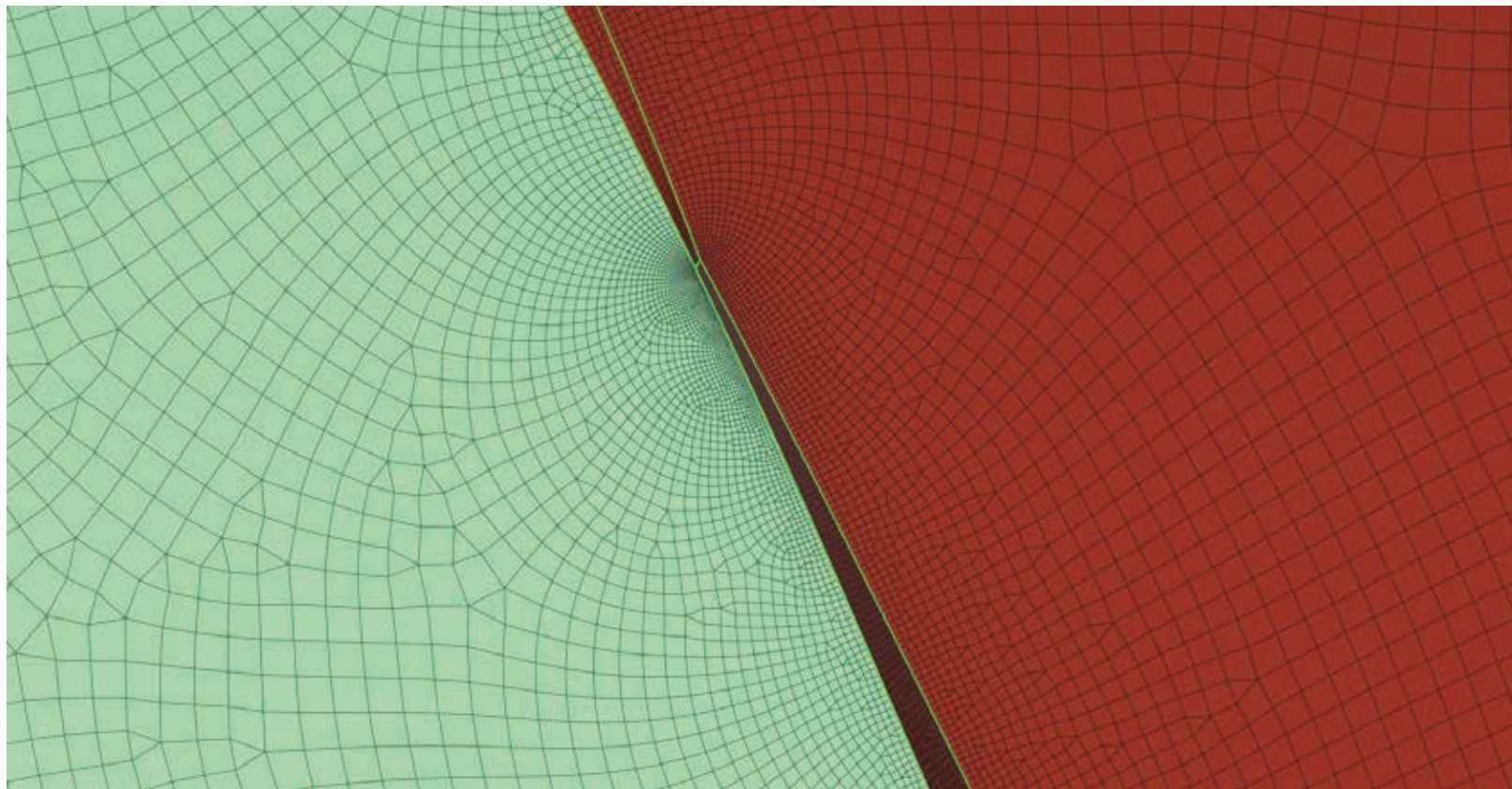
Surface mesh Level C refinement - 2 million shells



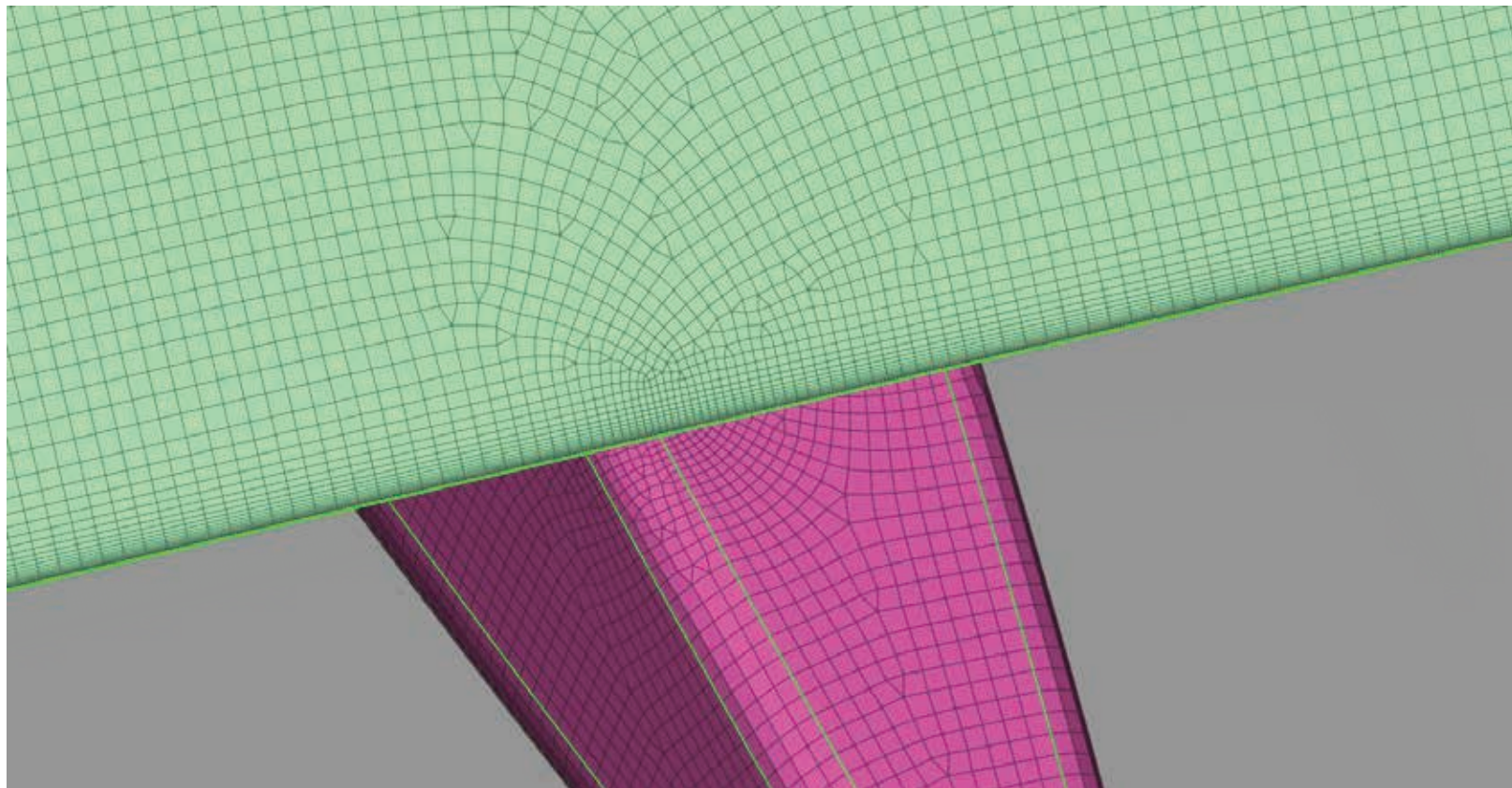
Flaps area



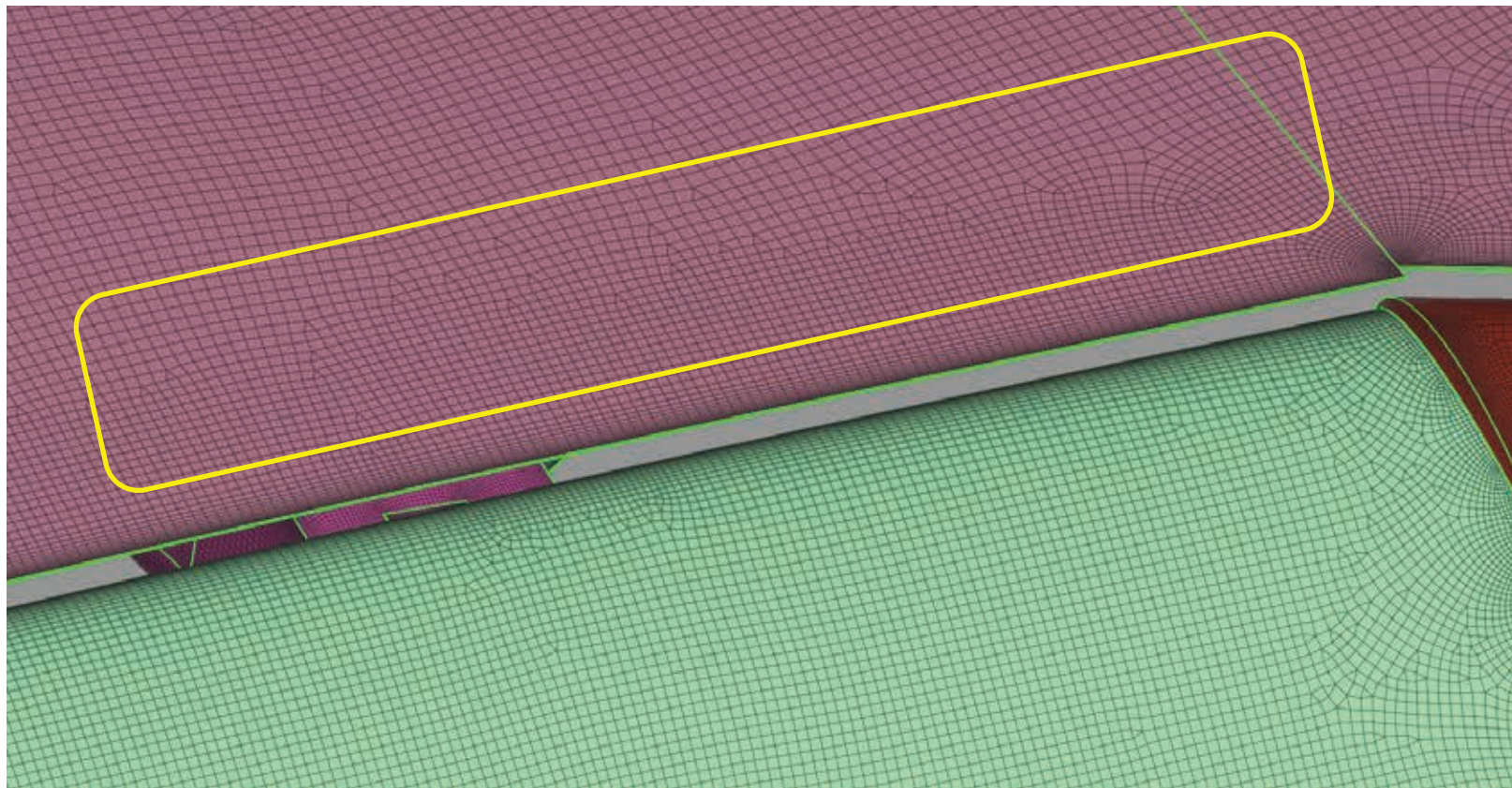
Flaps area



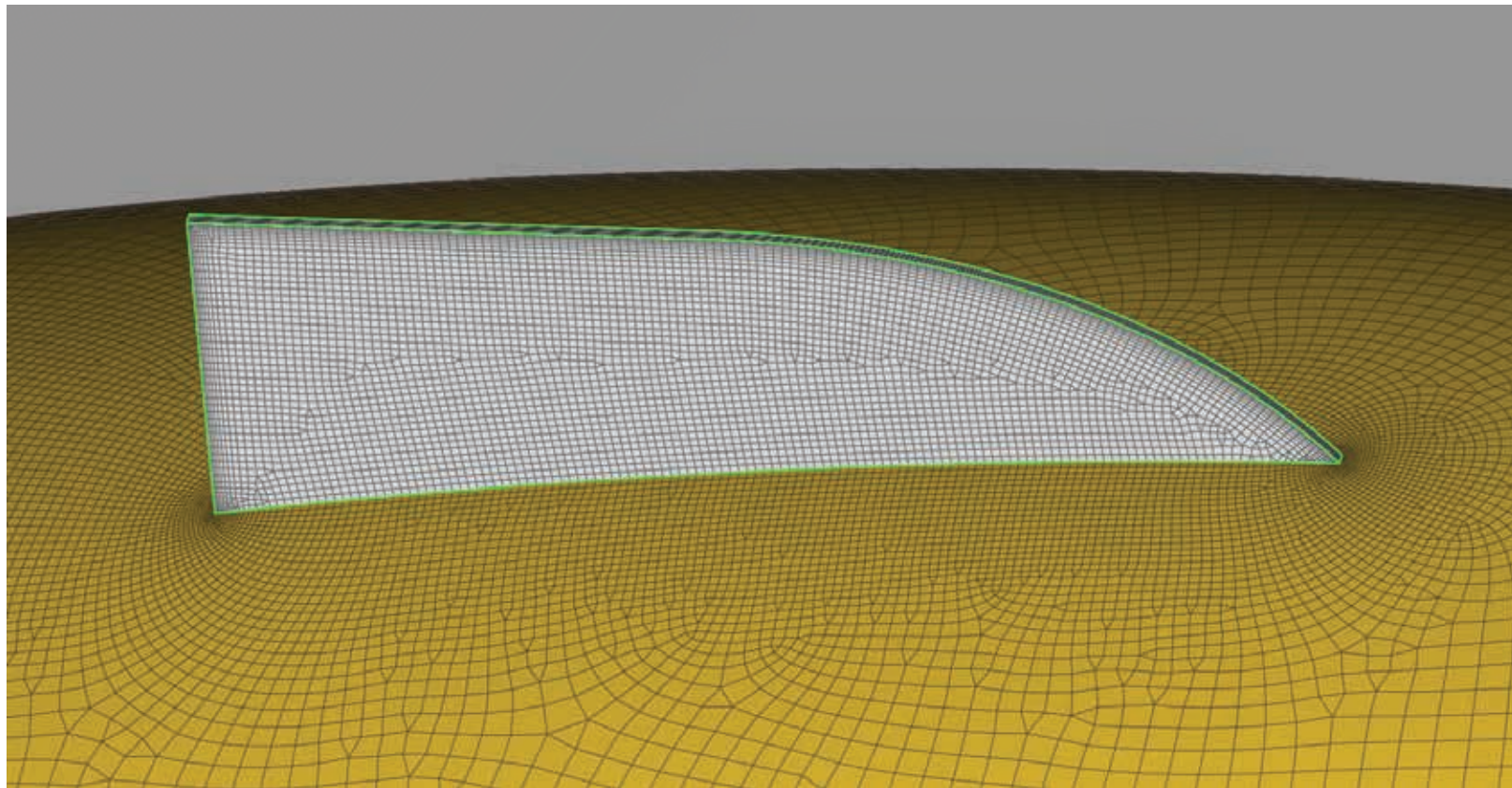
Flaps area



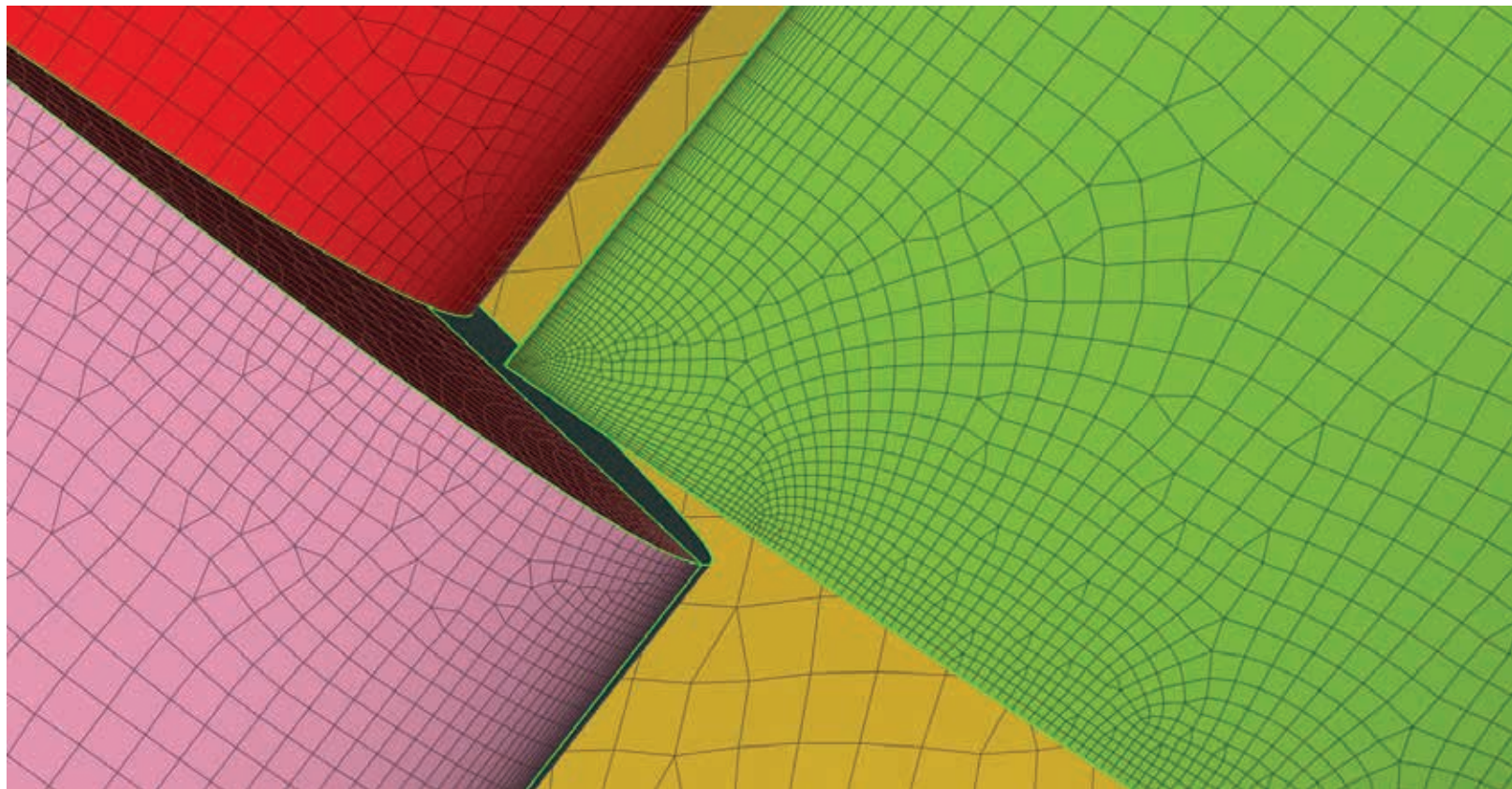
Flaps area



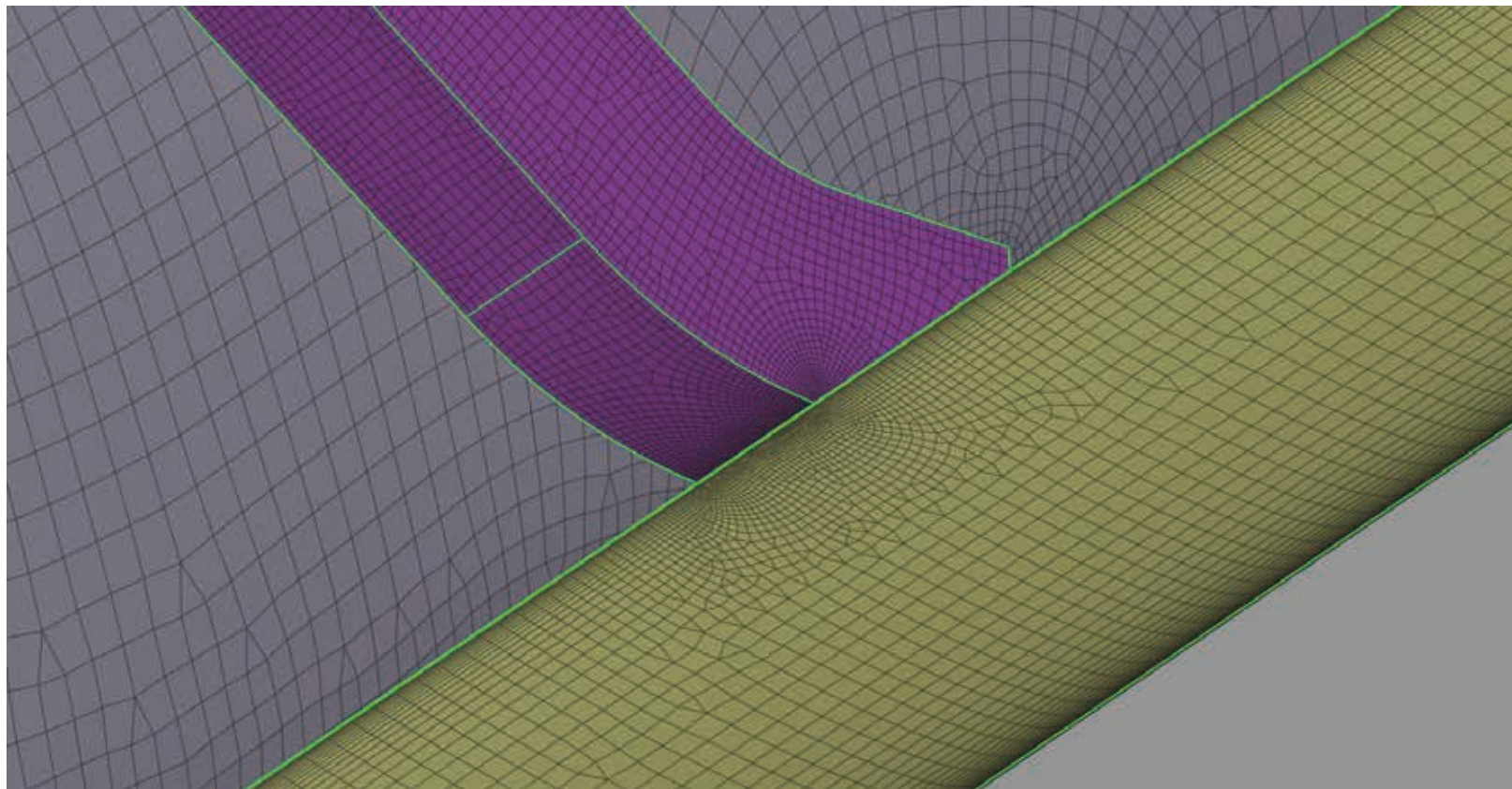
Engine nacelle area



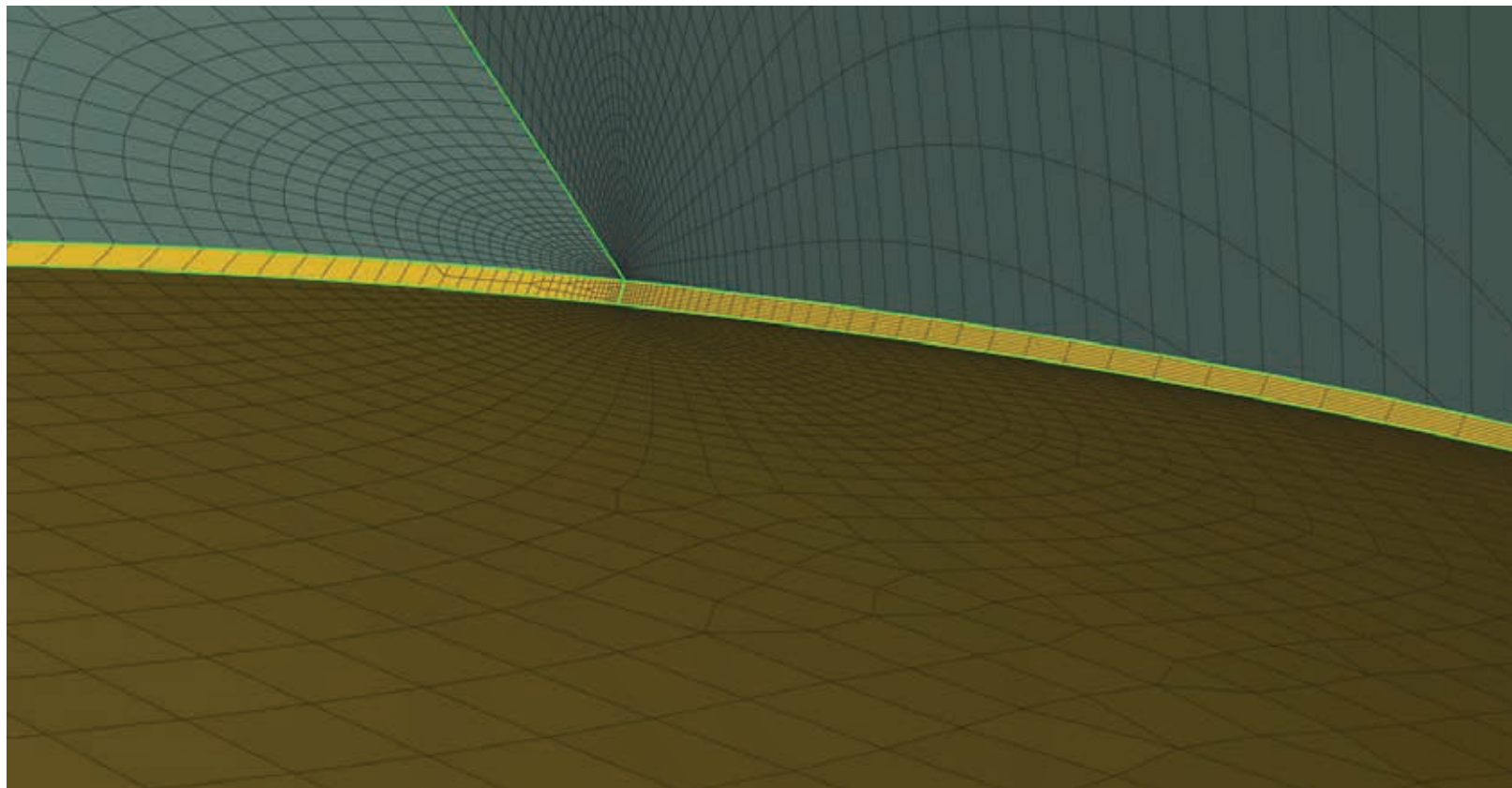
Engine nacelle area



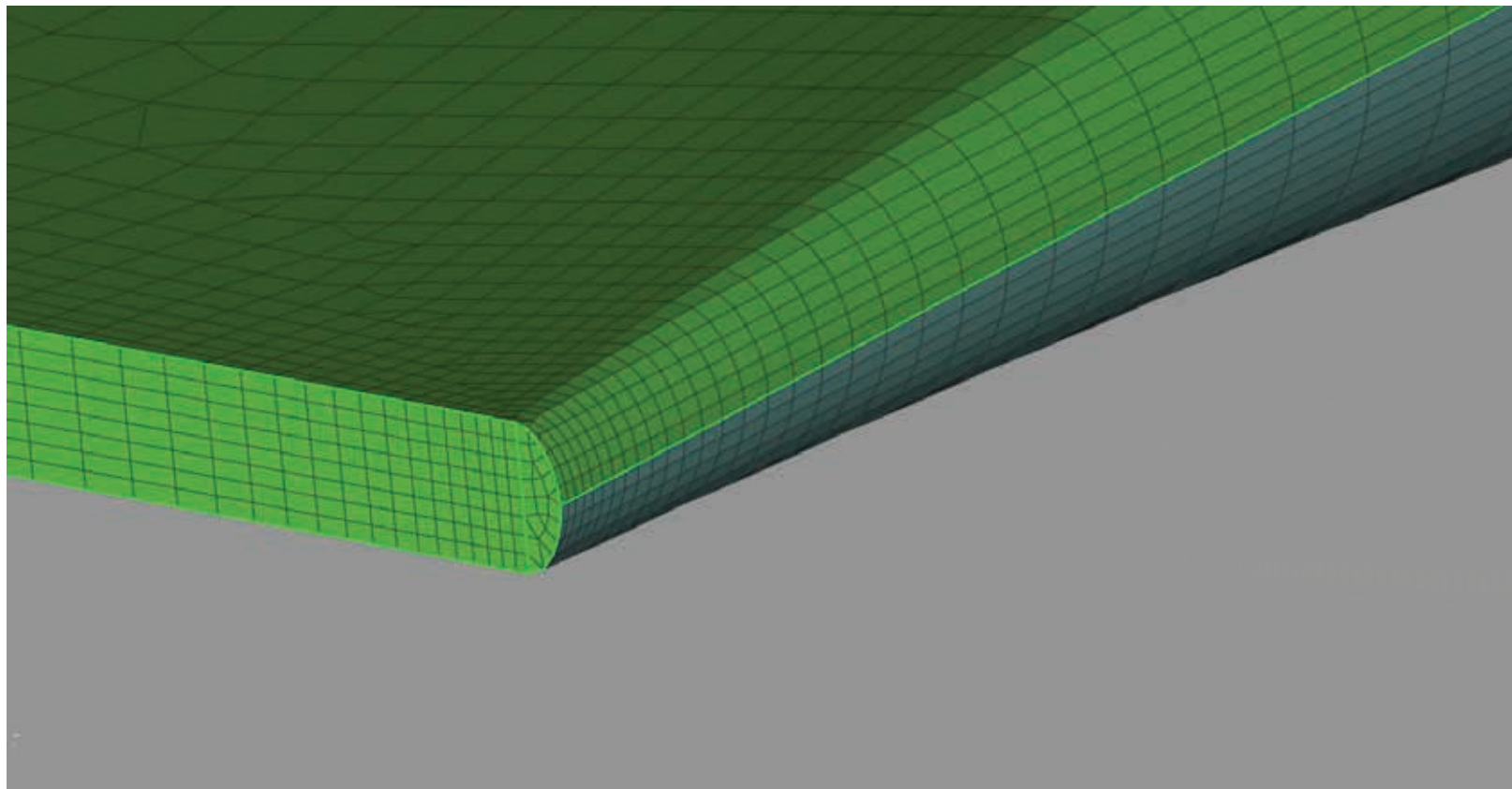
Underside area



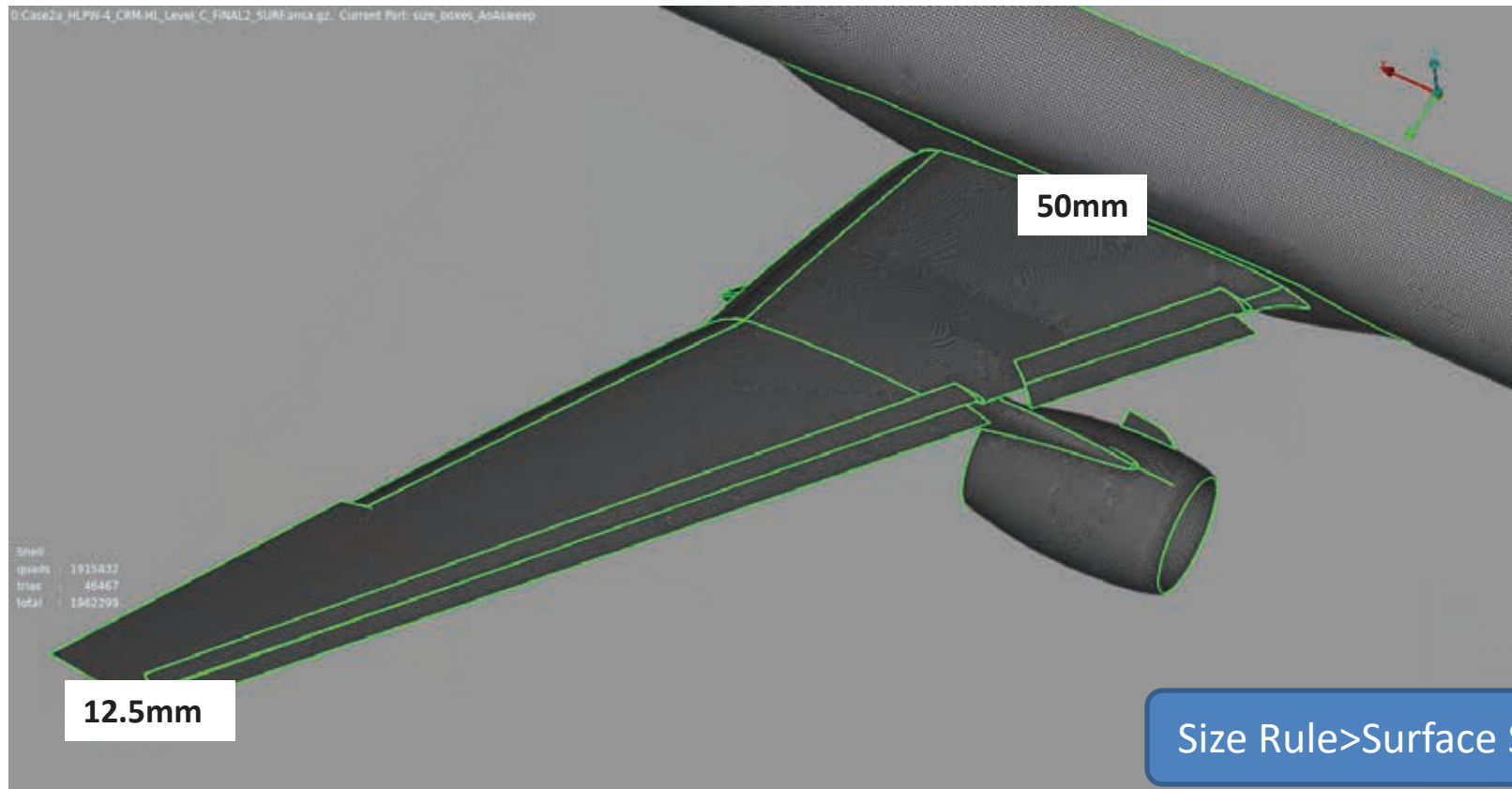
Underside area



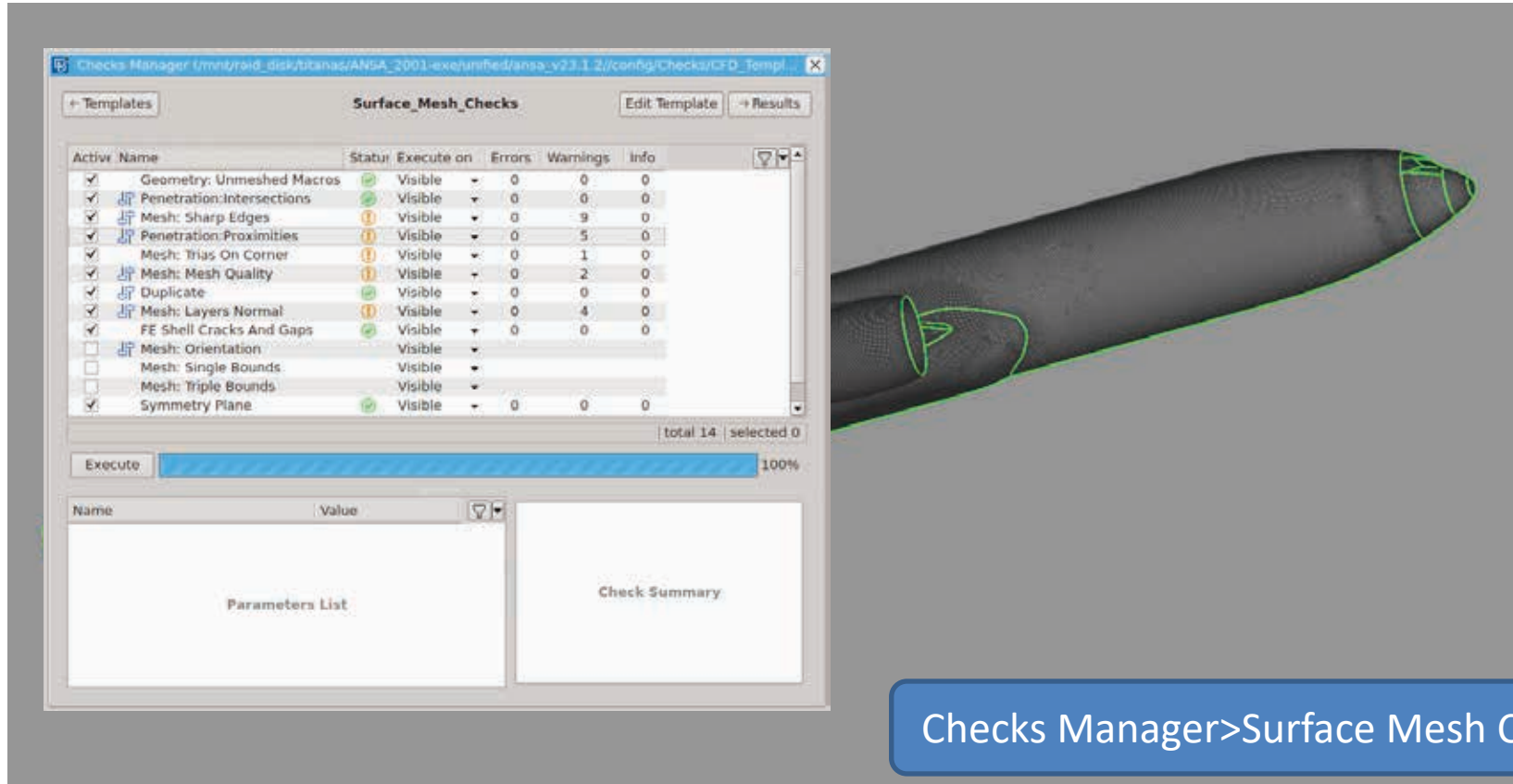
Wingtip area



Main wing – Linear Variation of maximum length



Surface Mesh Checks



The screenshot shows the ANSYS Checks Manager interface for Surface Mesh Checks. The window title is "Checks Manager /mnt/raid_disk/titanas/ANSA_2001-exe/umhed/ansa_v23.1.2/config/Checks/CFD_Templ...". The "Surface_Mesh_Checks" template is active. A table lists 14 checks with their status, visibility, and counts of errors and warnings. A progress bar shows the execution is 100% complete. Below the table are sections for "Parameters List" and "Check Summary". To the right, a 3D model of a rocket nozzle is shown with green outlines highlighting areas where mesh quality checks failed, such as sharp edges and proximity penetrations.

Active	Name	Status	Execute on	Errors	Warnings	Info
<input checked="" type="checkbox"/>	Geometry: Unmeshed Macros		Visible	0	0	0
<input checked="" type="checkbox"/>	Penetration: Intersections		Visible	0	0	0
<input checked="" type="checkbox"/>	Mesh: Sharp Edges		Visible	0	9	0
<input checked="" type="checkbox"/>	Penetration: Proximities		Visible	0	5	0
<input checked="" type="checkbox"/>	Mesh: Trias On Corner		Visible	0	1	0
<input checked="" type="checkbox"/>	Mesh: Mesh Quality		Visible	0	2	0
<input checked="" type="checkbox"/>	Duplicate		Visible	0	0	0
<input checked="" type="checkbox"/>	Mesh: Layers Normal		Visible	0	4	0
<input checked="" type="checkbox"/>	FE Shell Cracks And Gaps		Visible	0	0	0
<input type="checkbox"/>	Mesh: Orientation	Visible				
<input type="checkbox"/>	Mesh: Single Bounds	Visible				
<input type="checkbox"/>	Mesh: Triple Bounds	Visible				
<input checked="" type="checkbox"/>	Symmetry Plane		Visible	0	0	0

total 14 | selected 0

Execute 100%

Name Value

Parameters List Check Summary

Checks Manager > Surface Mesh Checks

Variable First Layer height specification

0:Case2a_HLPW-4_CRM-HI_Level_C_FINAL2_SURFansa.gz. Current Part: size_edges_AoAsteep

Variable first height definition

Variability type: Boundary layer theory

Preview: First height

Direction: User defined

Definition: 2 Points

Vector: 1. 0. 0.

Type of flow: Flat plate

Velocity (m/s): 12.

Density (kg/m³): 1.225

Dynamic viscosity (kg/ms): 1.789E-5

Reference length (m): 5.

Target y⁺: 0.5

Reynolds number: 4.1e+06

Estimated first cell centre (m): 1.6e-05

Estimated first layer height (m): 3.2e-05

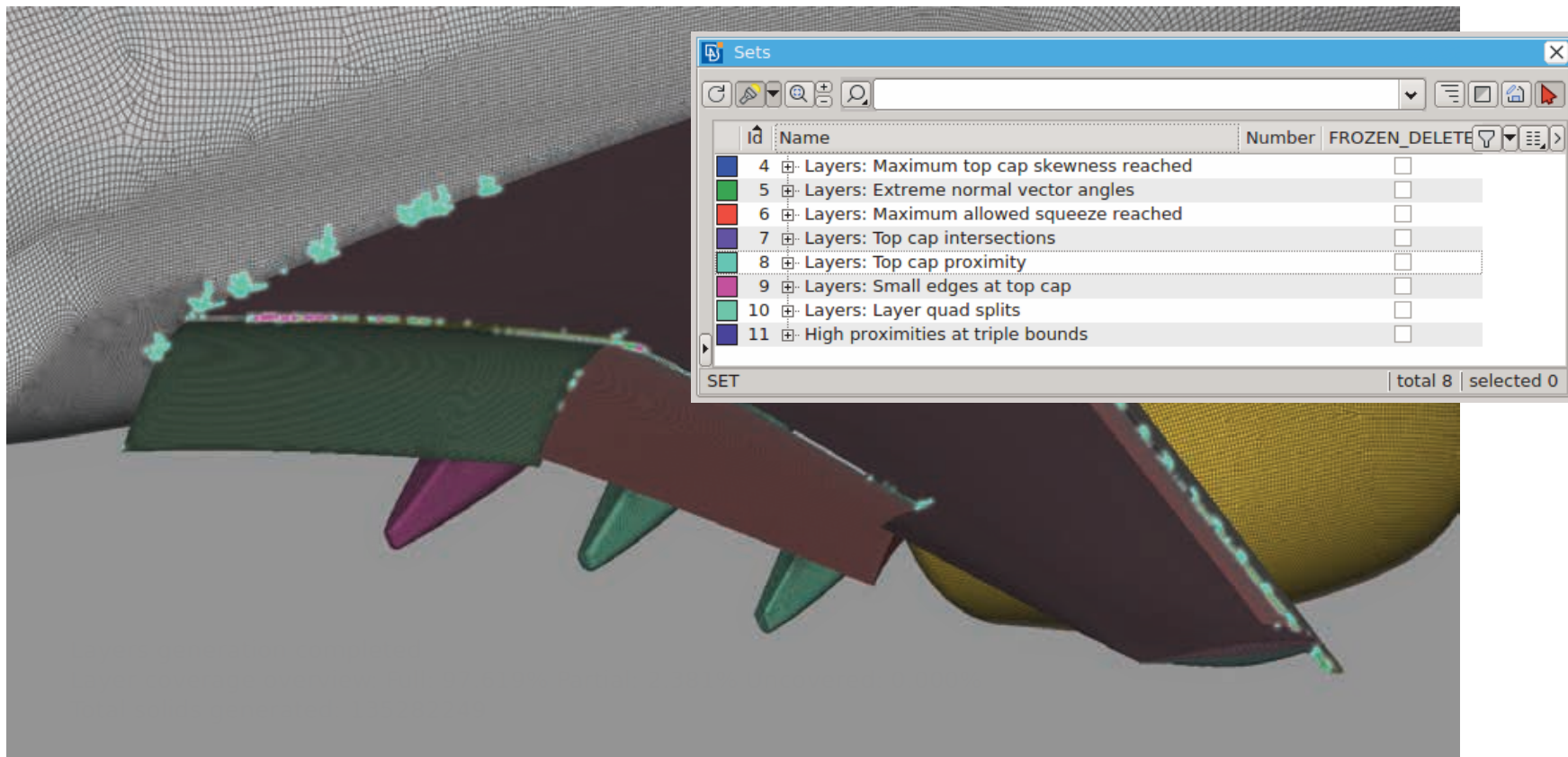
Total boundary layer thickness (m): 8.8e-02

OK

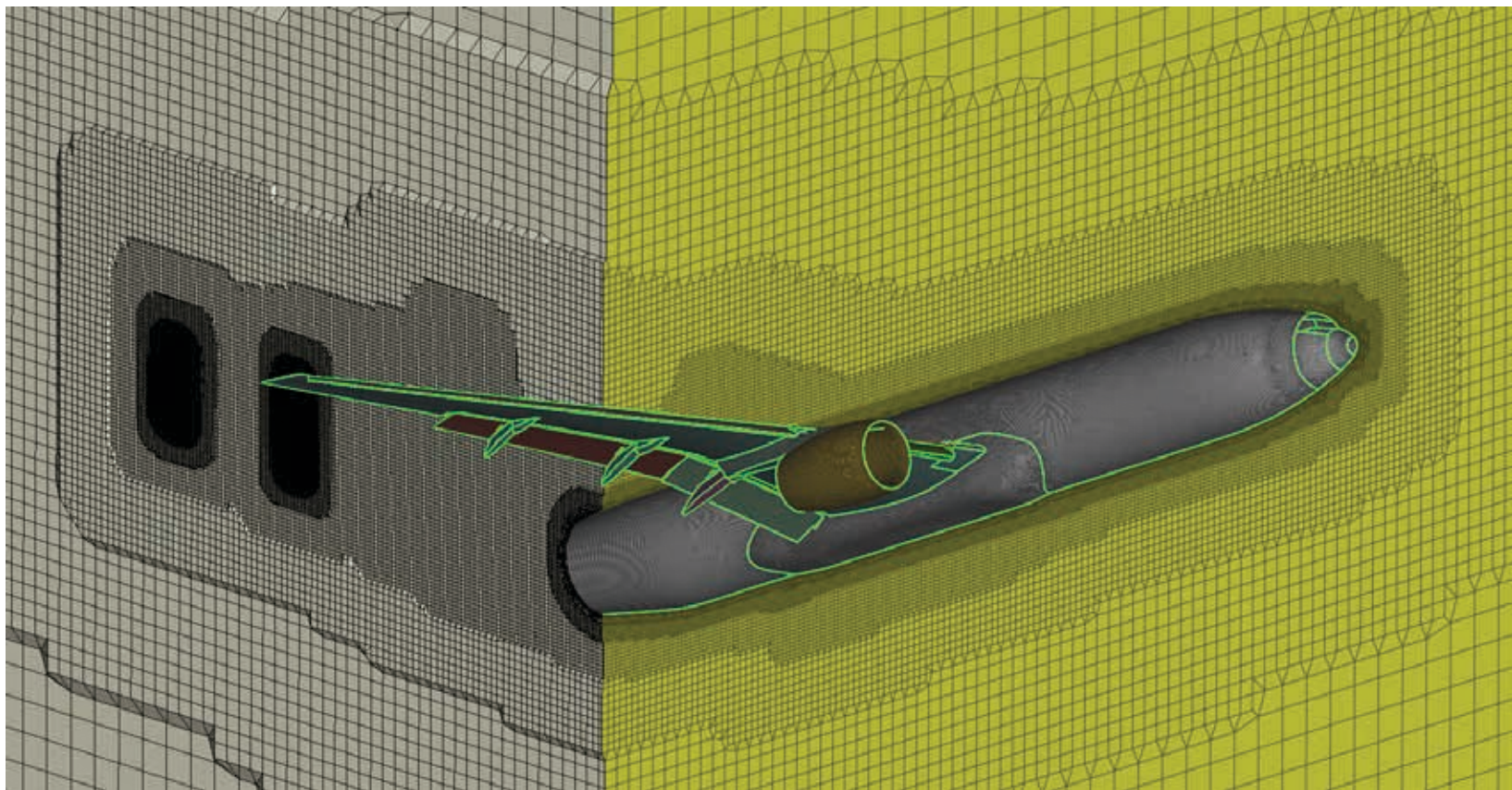
0.0349
0.0333
0.0317

Batch Mesh>Layer Areas

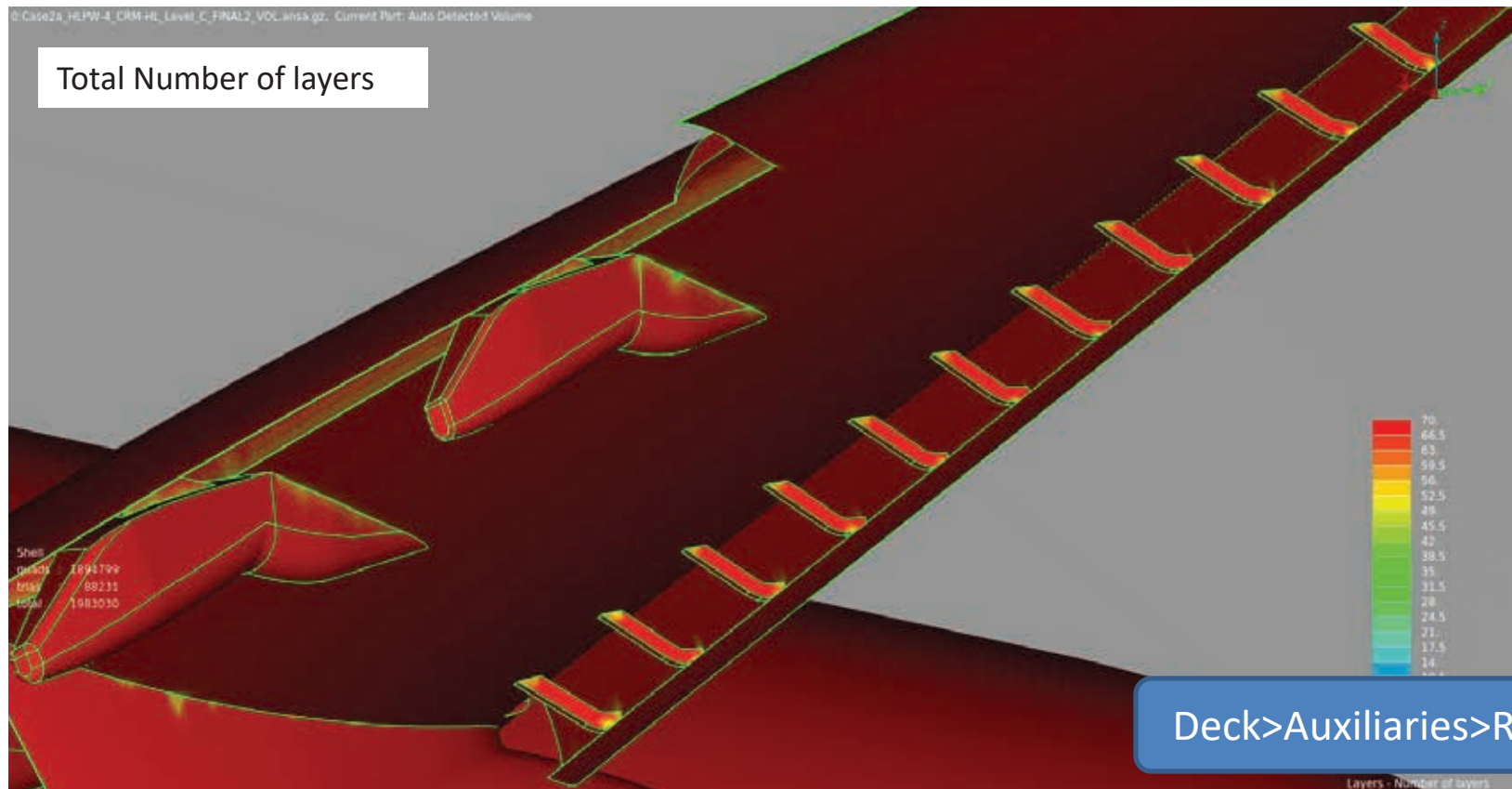
Layers generation – 70 layers variable first height and growth rate



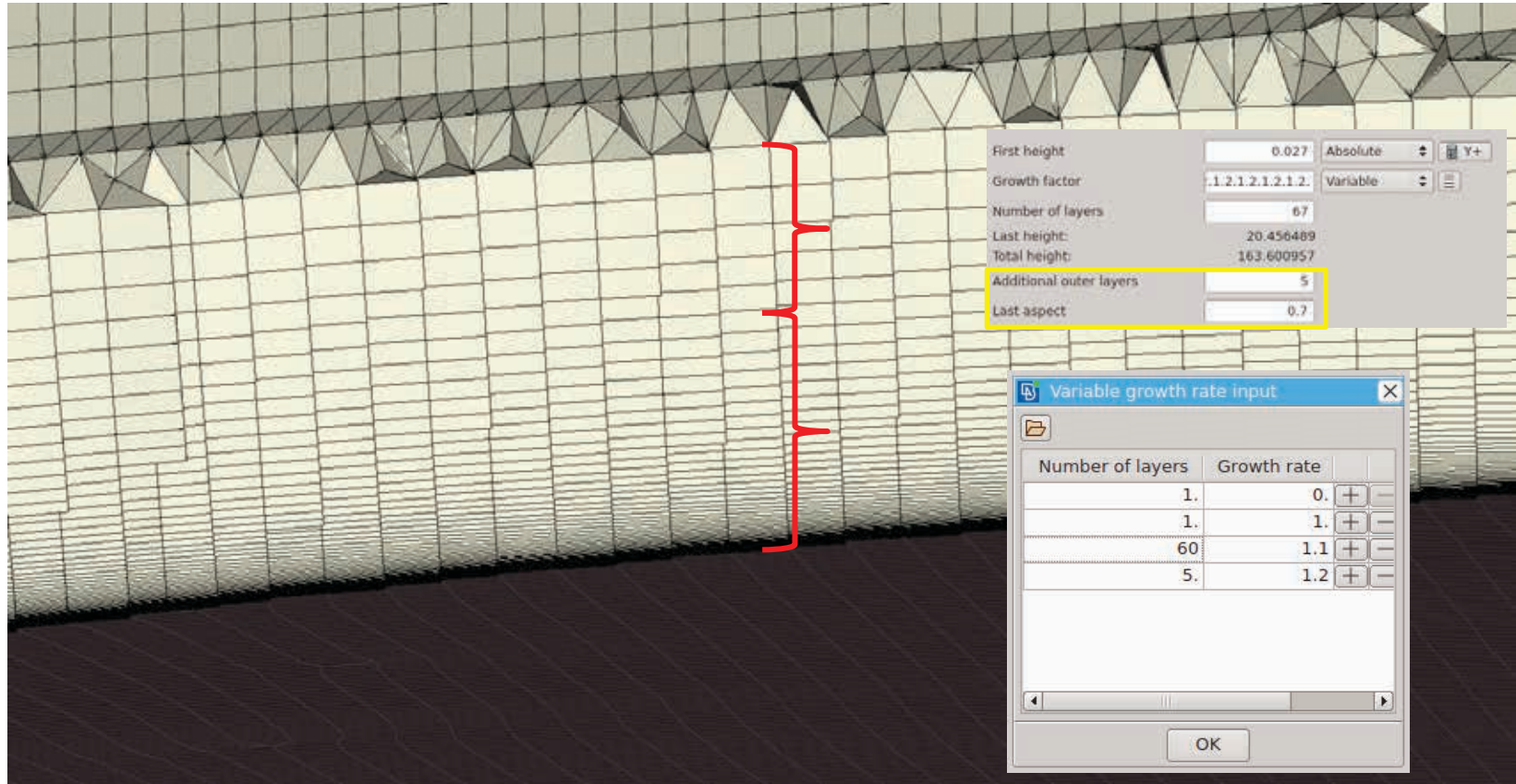
Volume mesh Level C refinement - 211 million cells (188 million nodes)



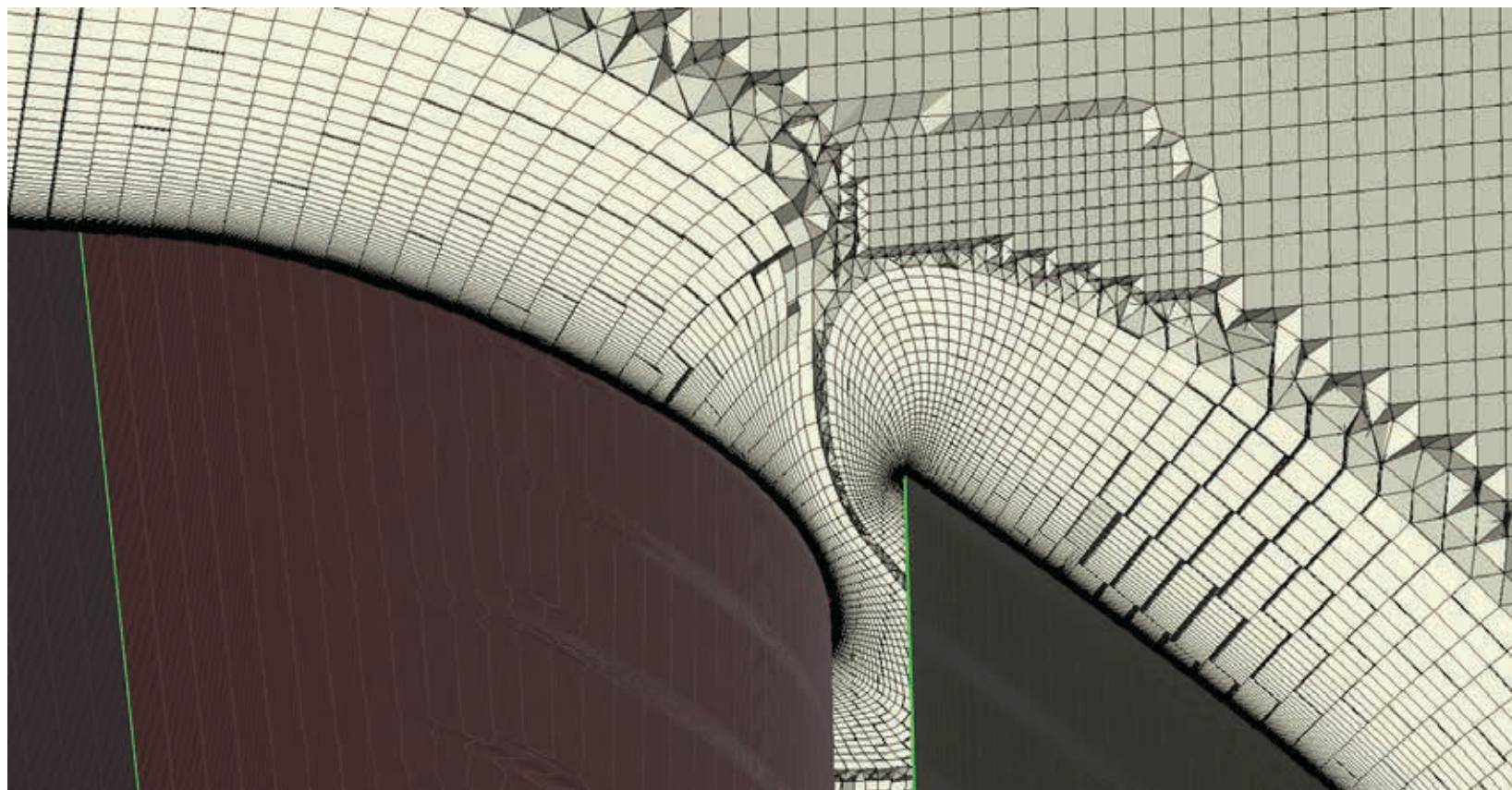
Boundary Layer coverage display



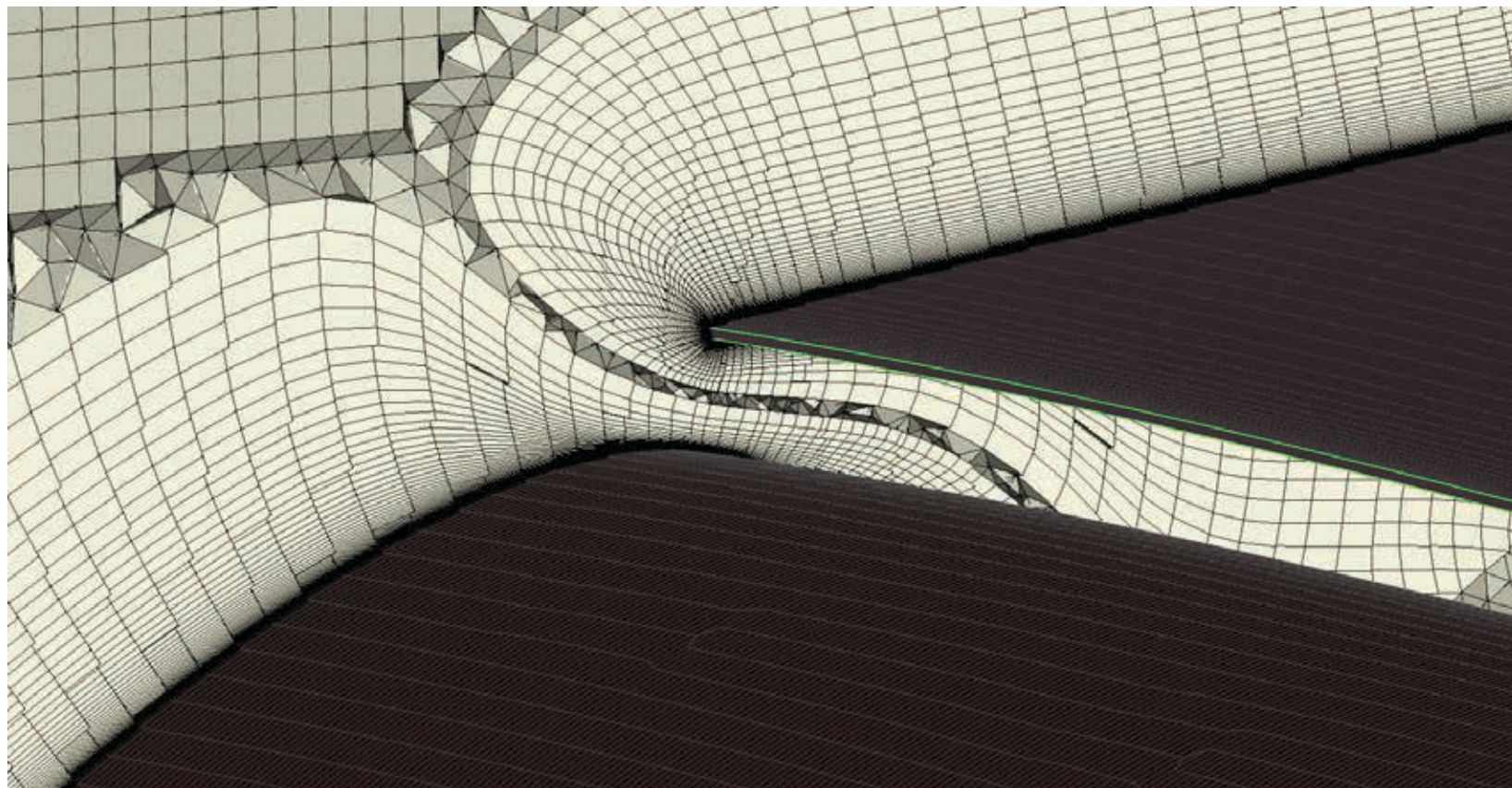
Layers on wing section



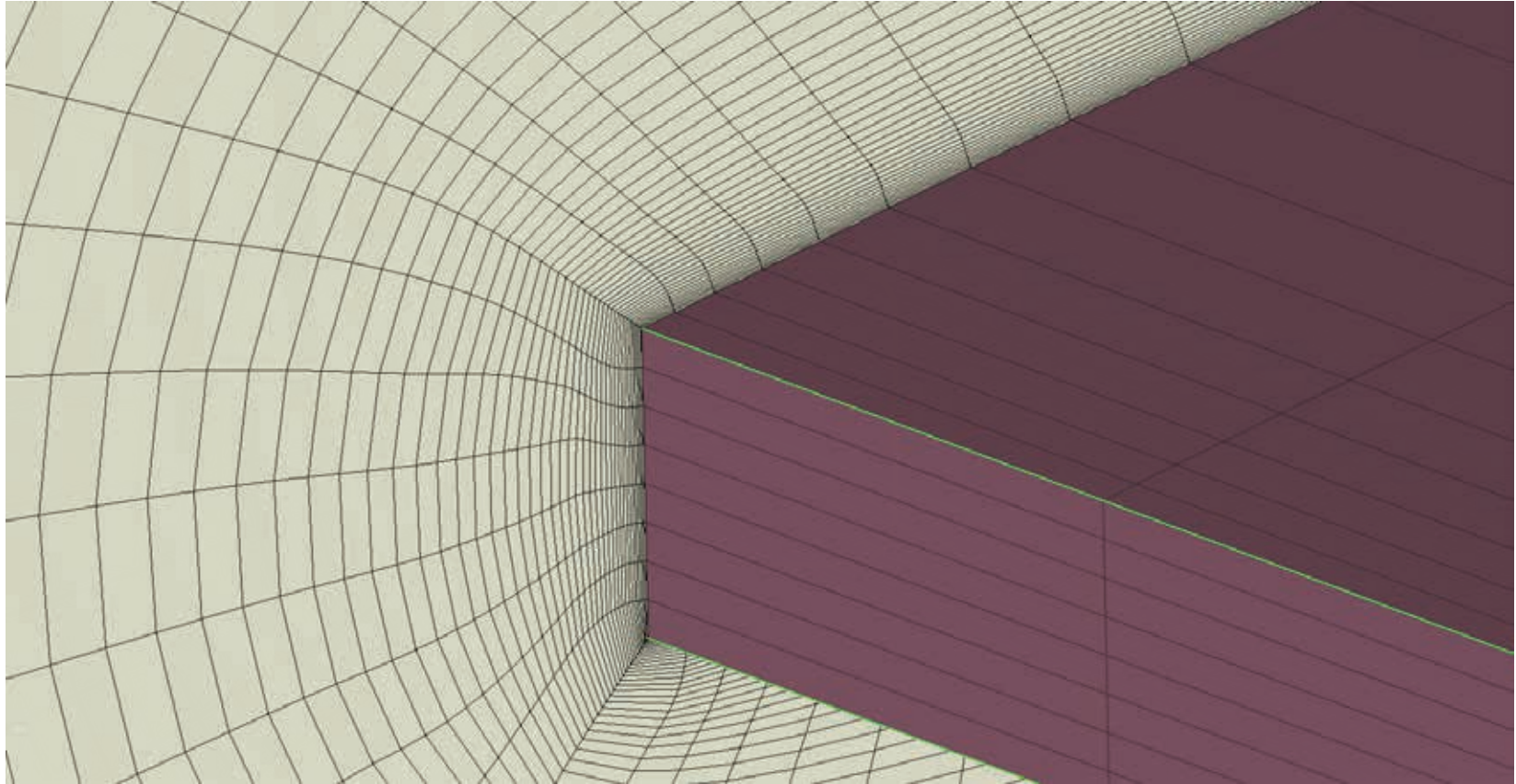
Layers on wing section



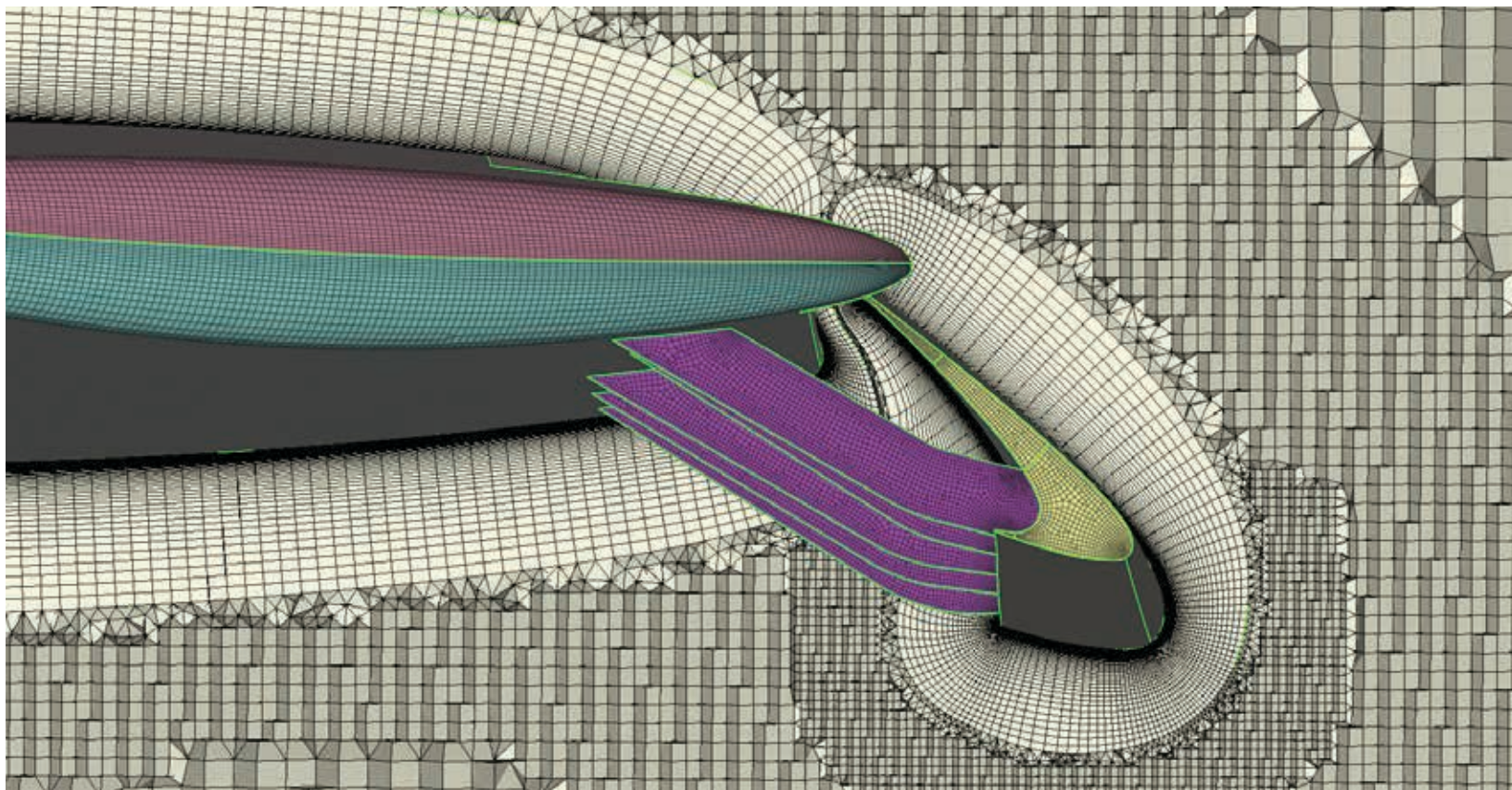
Layers on wing section



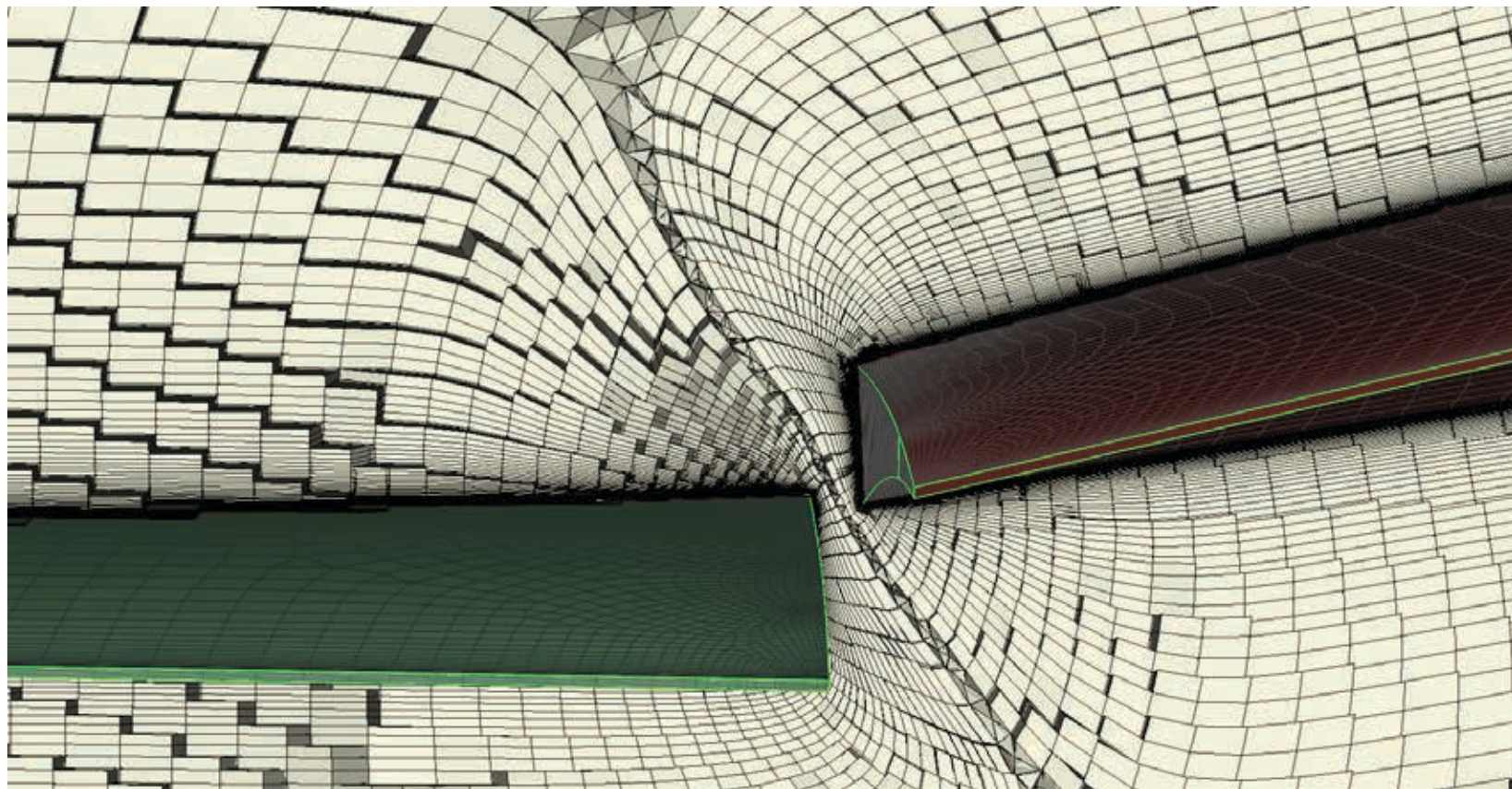
Orthogonality near the wall



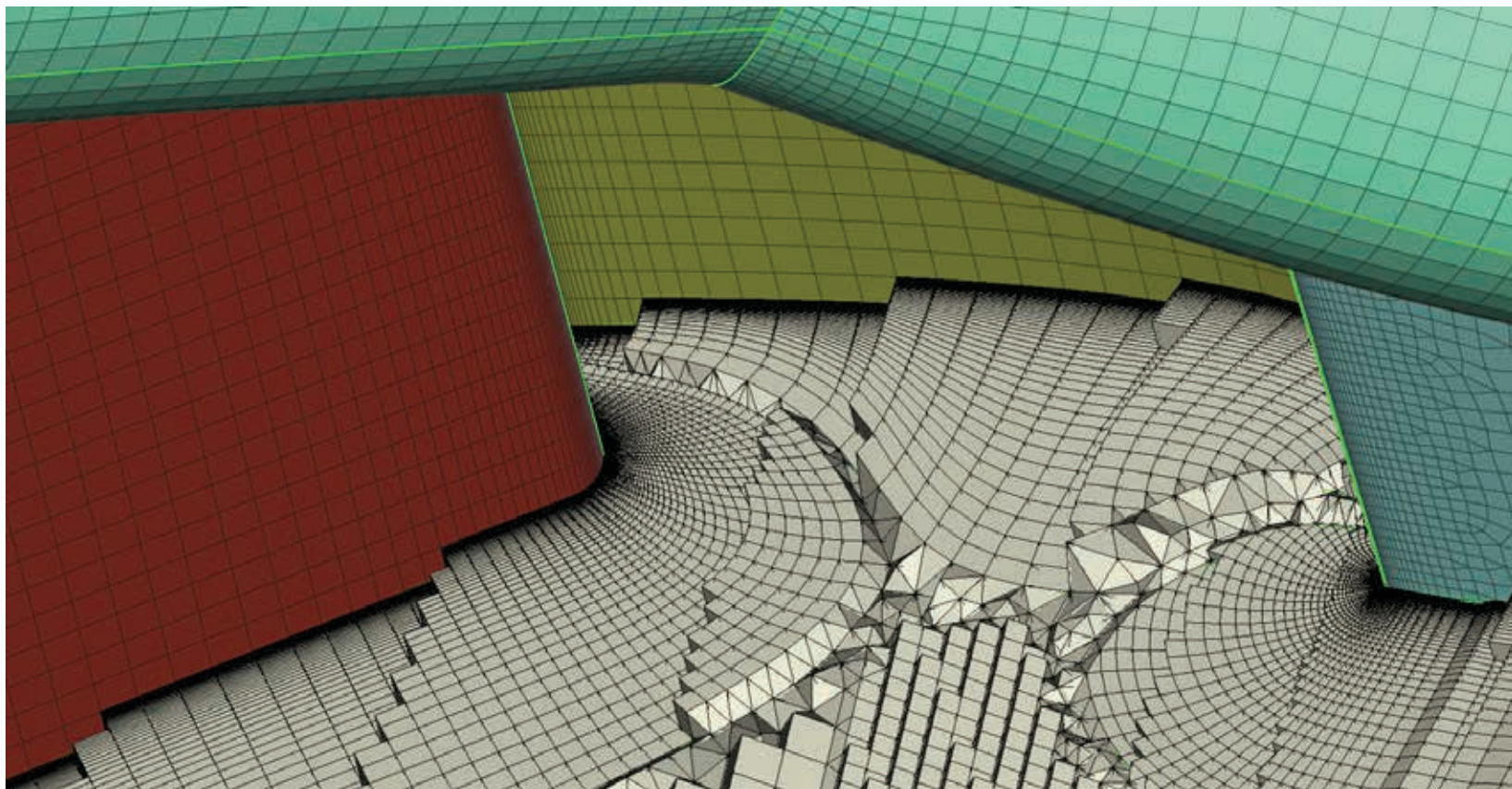
Slat area



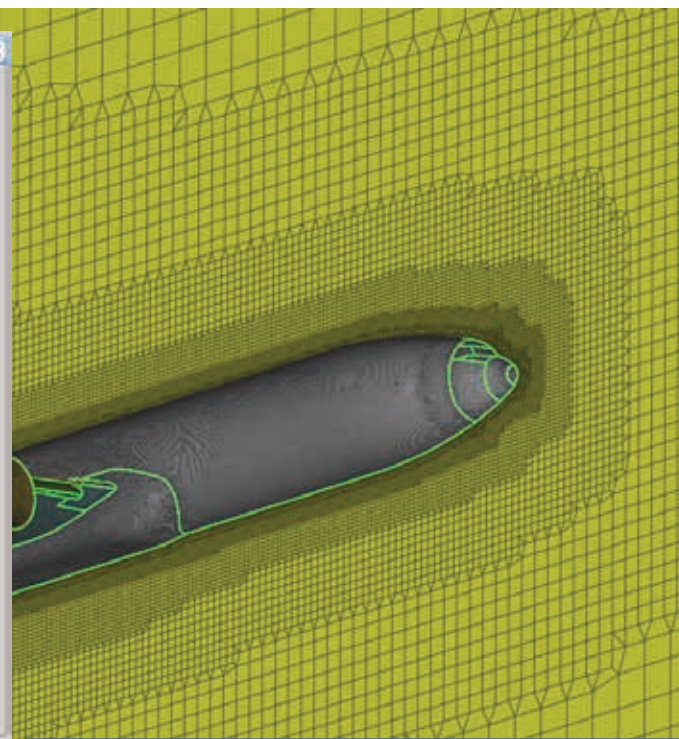
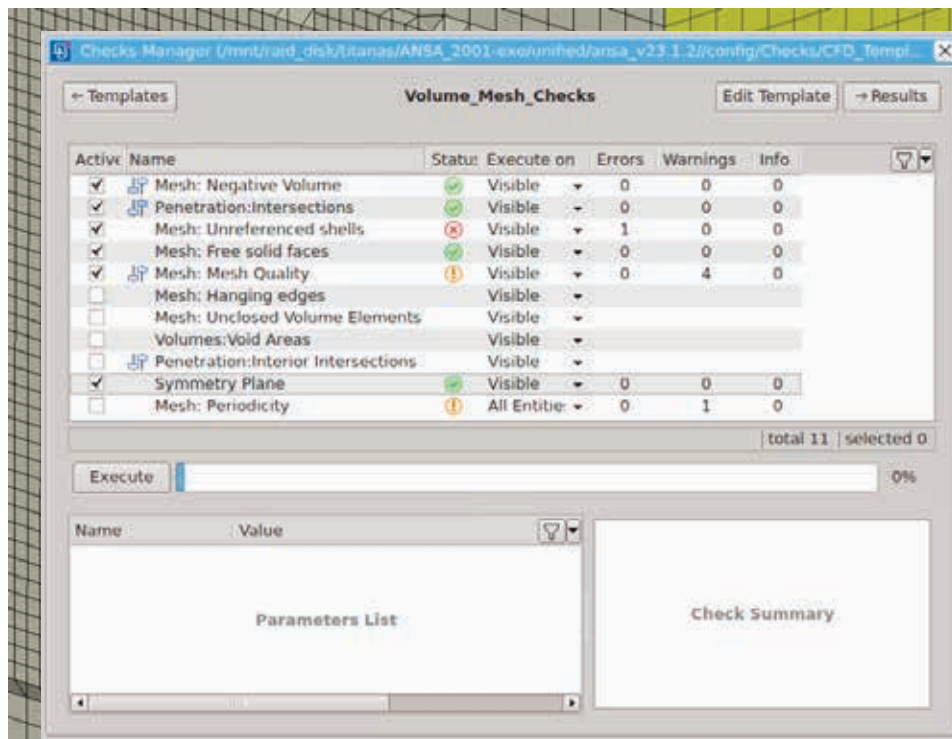
Gap between the two flaps



Flap underside area



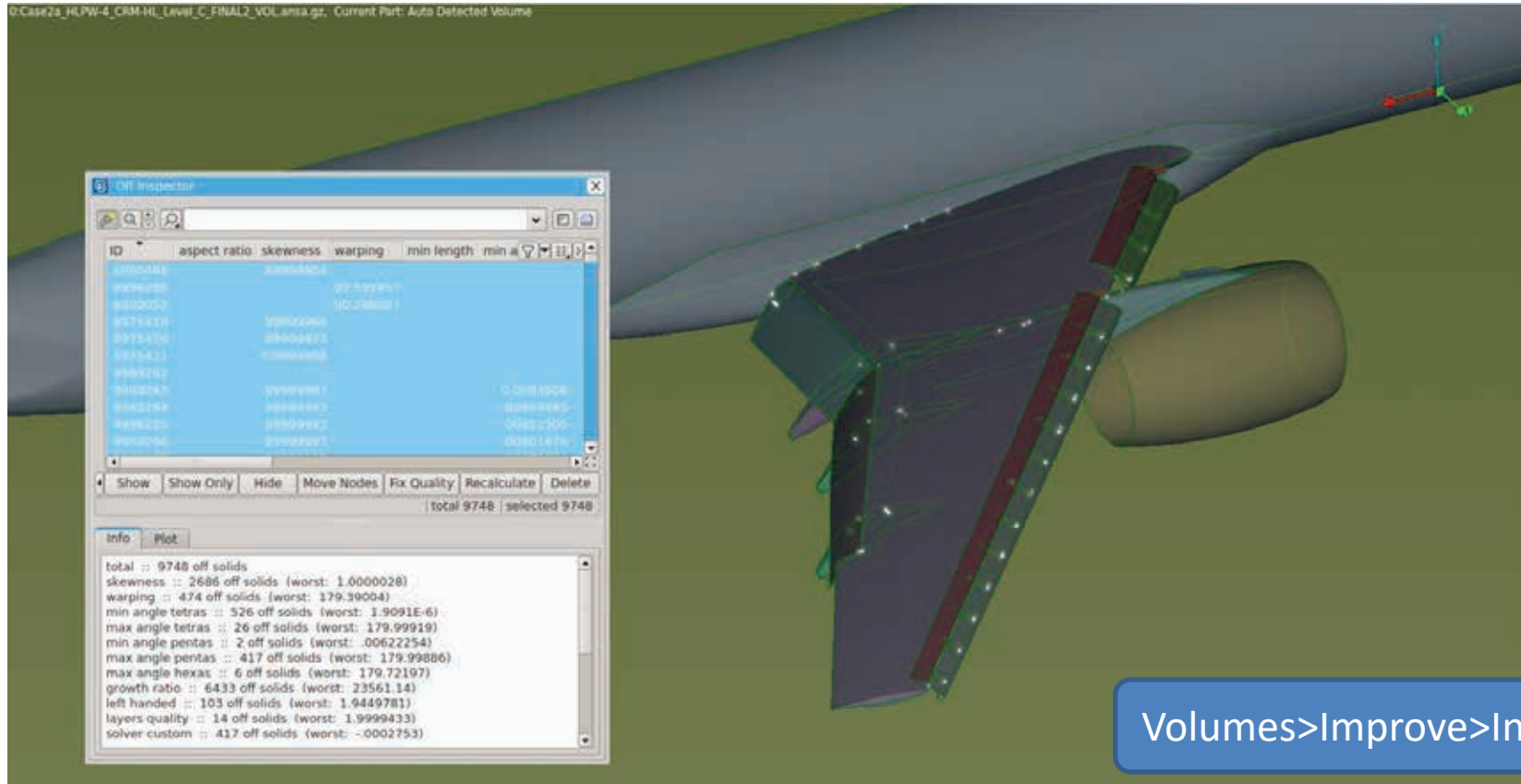
Volume mesh Checks



Checks Manager>Volume Mesh Checks

Inspecting mesh quality violations

©Case2a_HLPW-4_CRM-HI_Level_C_FINAL2_VOL.ansys.gt. Current Part: Auto Detected Volume



ID	aspect ratio	skewness	warping	min length	min a
80000488		0.00000004			
80000489		0.00000004	0.00000001		
80000490		0.00000004	0.00000001		
80000491		0.00000004	0.00000001		
80000492		0.00000004	0.00000001		
80000493		0.00000004	0.00000001		
80000494		0.00000004	0.00000001		
80000495		0.00000004	0.00000001		
80000496		0.00000004	0.00000001		

Show Show Only Hide Move Nodes Fix Quality Recalculate Delete
total 9748 | selected 9748

Info Plot

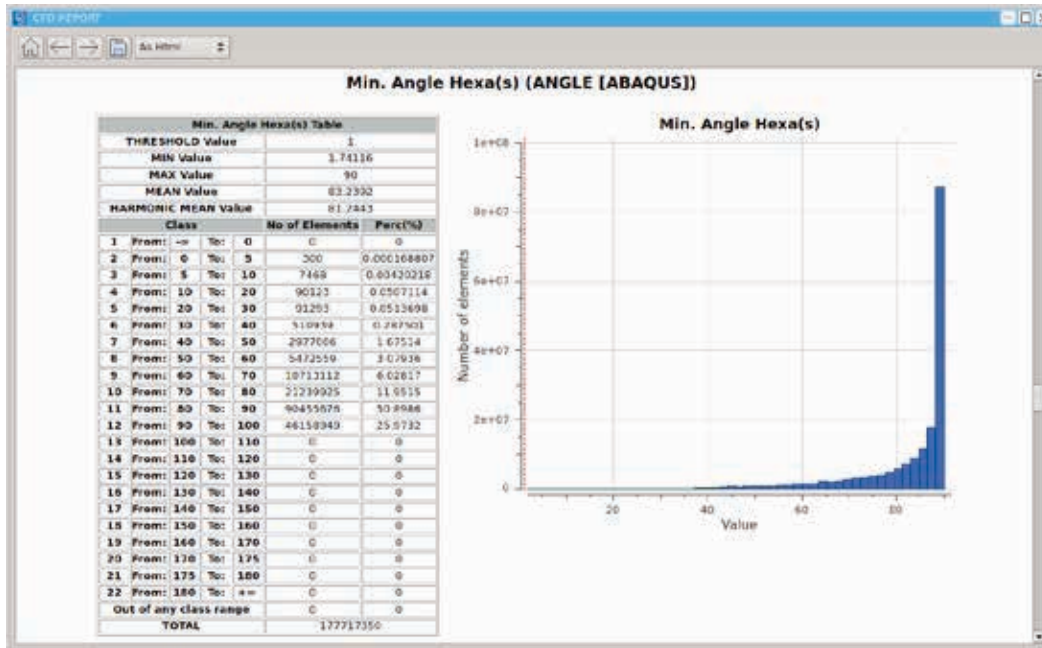
total :: 9748 off solids
skewness :: 2686 off solids (worst: 1.0000028)
warping :: 474 off solids (worst: 179.99004)
min angle tetras :: 526 off solids (worst: 1.9091E-6)
max angle tetras :: 26 off solids (worst: 179.99919)
min angle pentas :: 2 off solids (worst: .00622254)
max angle pentas :: 417 off solids (worst: 179.99886)
max angle hexas :: 6 off solids (worst: 179.72197)
growth ratio :: 6433 off solids (worst: 23561.14)
left handed :: 103 off solids (worst: 1.9449781)
layers quality :: 14 off solids (worst: 1.9999433)
solver custom :: 417 off solids (worst: -.0002753)

Volumes>Improve>Inspect

Quality Metrics Reporting

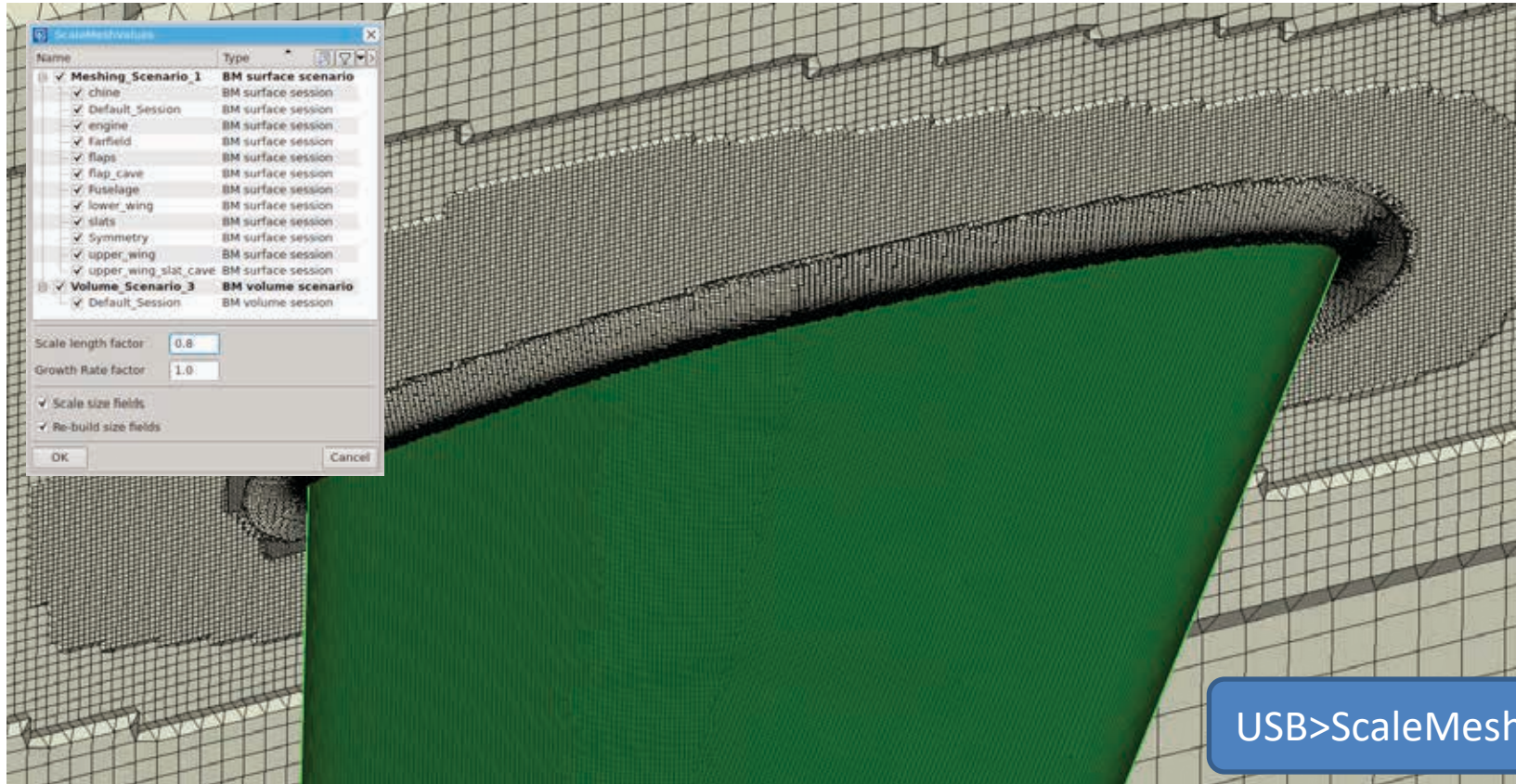
Html creation of mesh statistics

- Mesh quality criteria histograms
- Nodes, Elements, Facets number
- Element type percentages



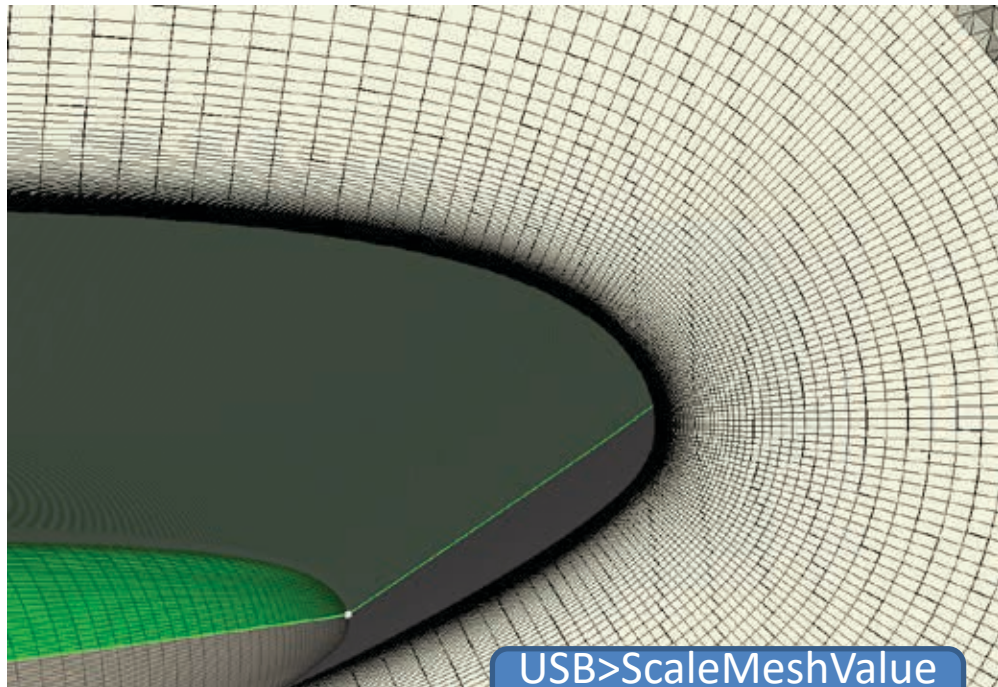
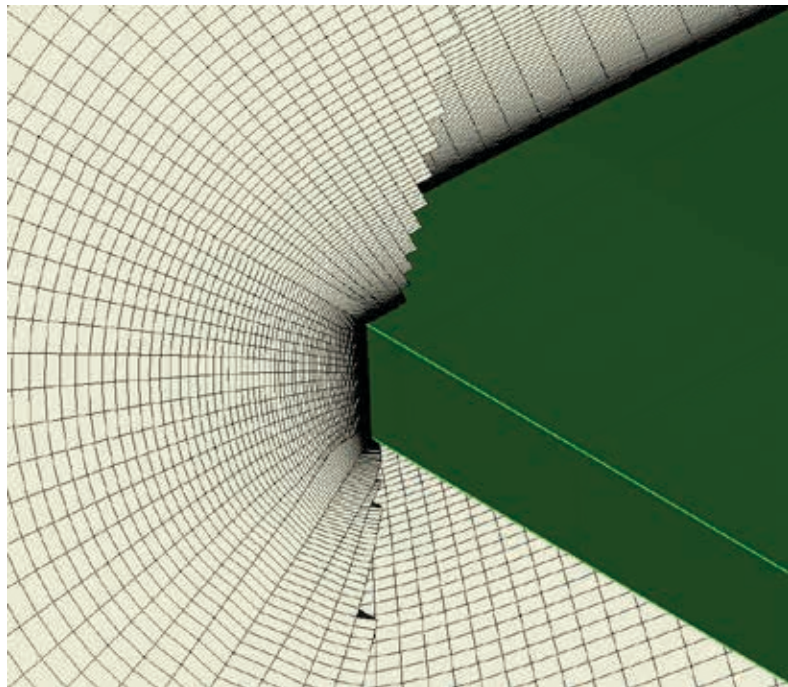
Report Tool

Mesh Refinement Studies on Case 1 of HLPW-5 - five mesh levels



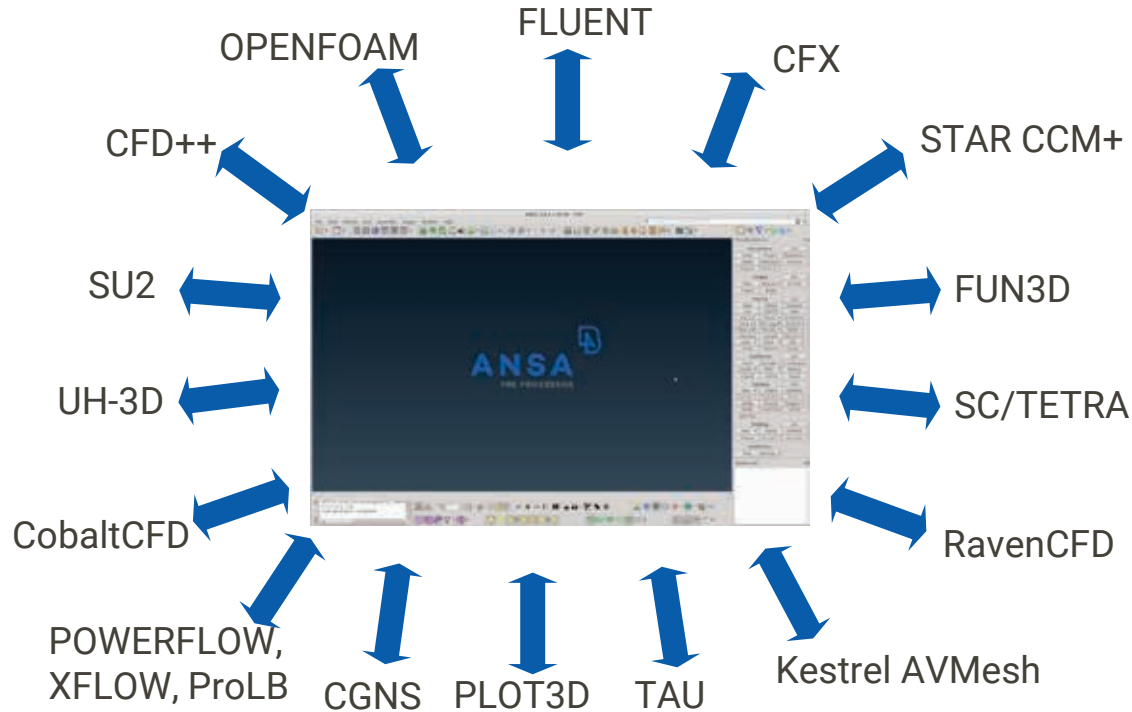
Mesh Refinement Studies on Case 1 of HLPW-5 - five mesh levels

Functionality to automatically scale all length values of Batch Mesh



USB>ScaleMeshValue
S

Mesh output in multiple CFD mesh formats



Performance - Memory

211 million cells

Peak memory usage 92 Gb RAM

0.44 Gb/million cells

GENERAL		
	Number	Perc(%)
Grids	190019251	
Surface elements	2137201	
Quads	2034023	95.172
Trias	103178	4.828
Polygons	0	0.000
Volume elements	211426919	
Hexas	177717350	84.056
Pentas	7564111	3.578
Pyramids	5102918	2.414
Tetras	21042540	9.953
Polyhedrals	0	0.000
Faces	1214878005	
Properties	21	
Materials	1	

Performance – Speed

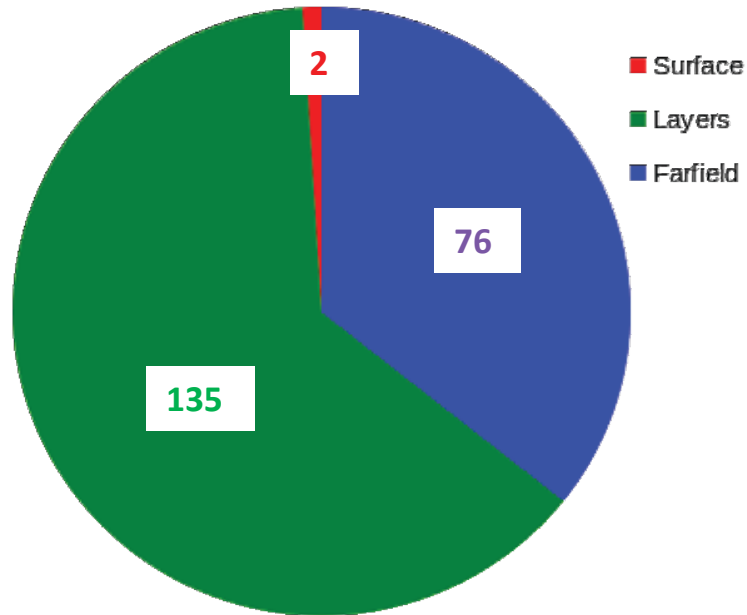
2 million shell elements in 11 min

211 million volume elements in 34 min

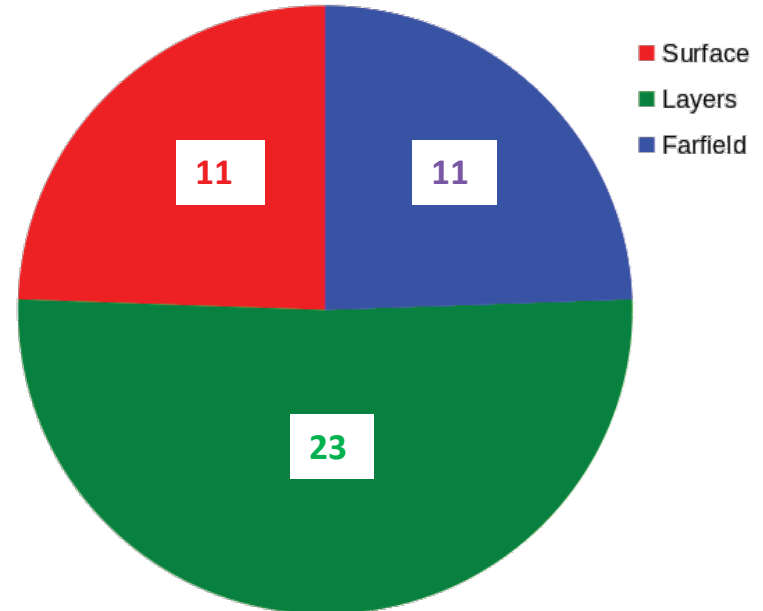
Surface mesh = 11 million shells/hour

Volume mesh = 372 million cells/hour

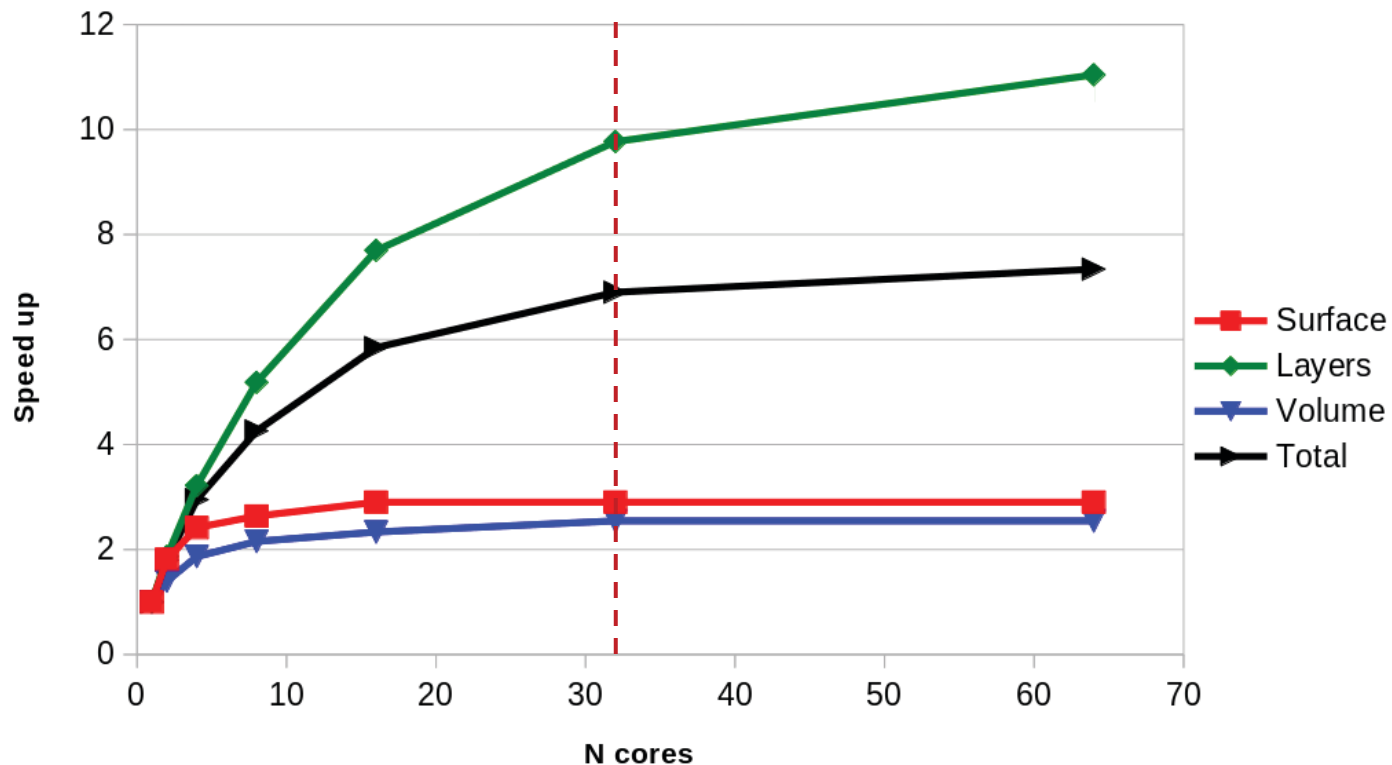
Number of elements (millions)



Meshing time (min)

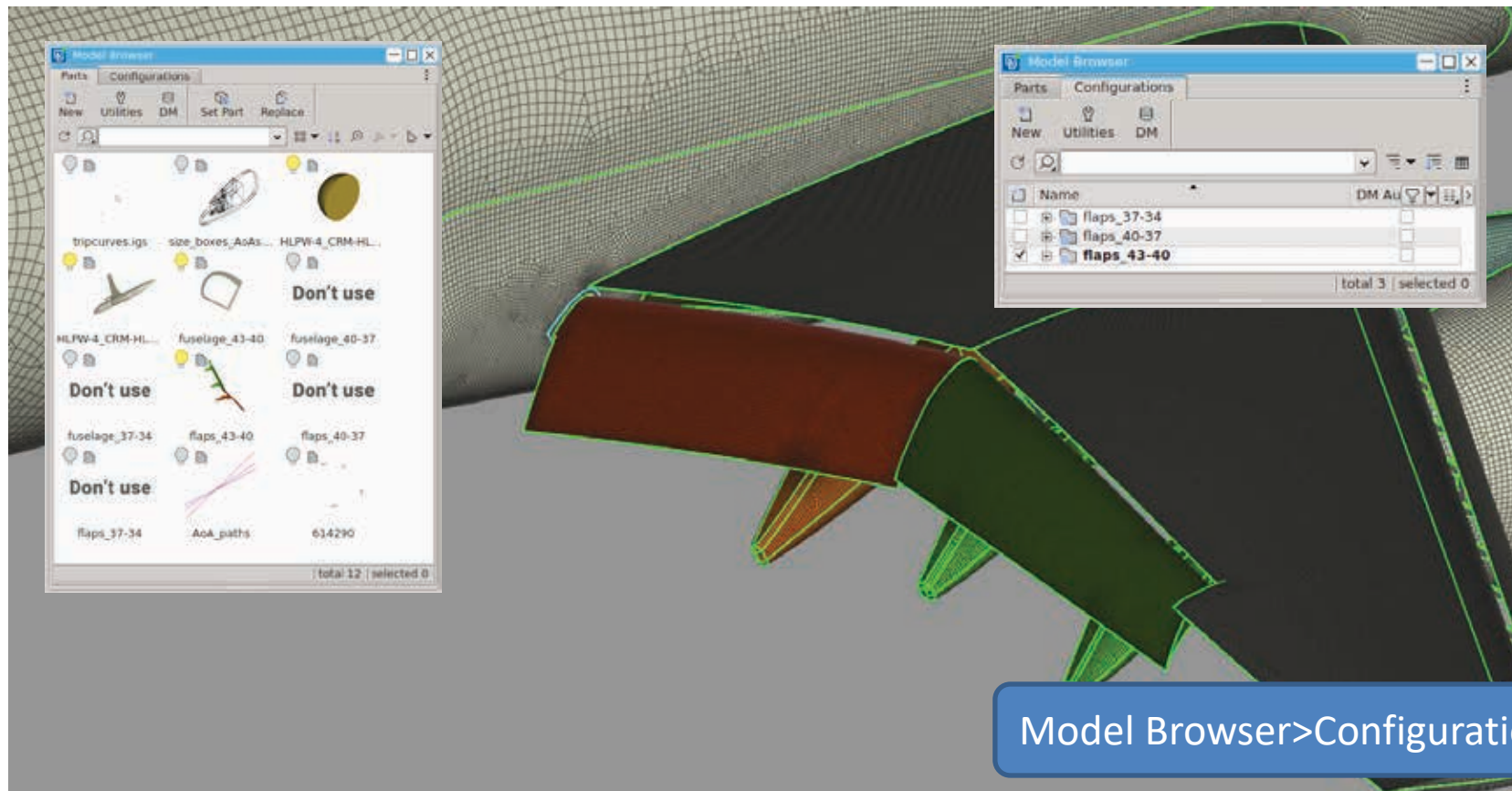


Speed performance scalability



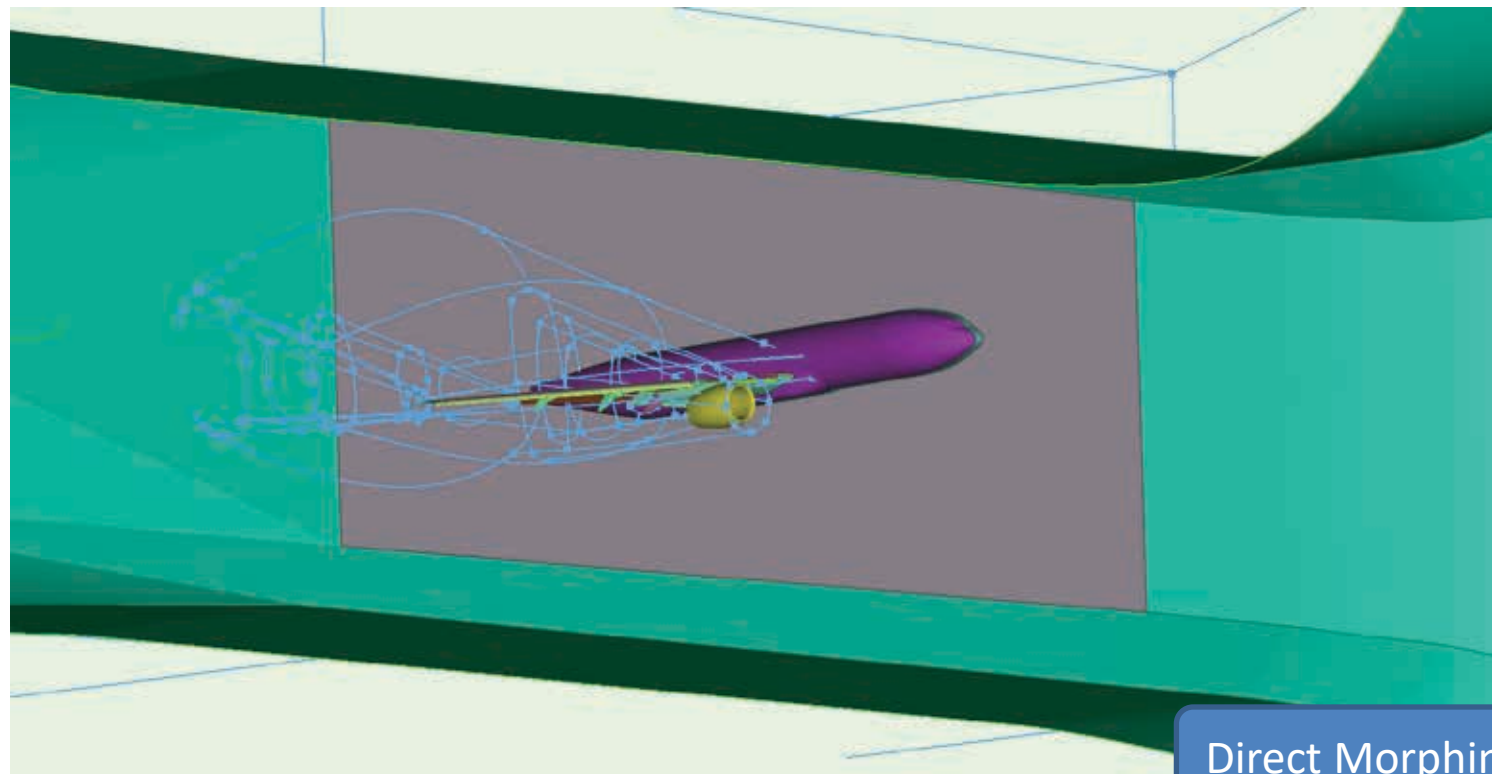
Hardware used has 32 cores (64 threads)

Use of Configurations for modifying flap angles – HLPW-4



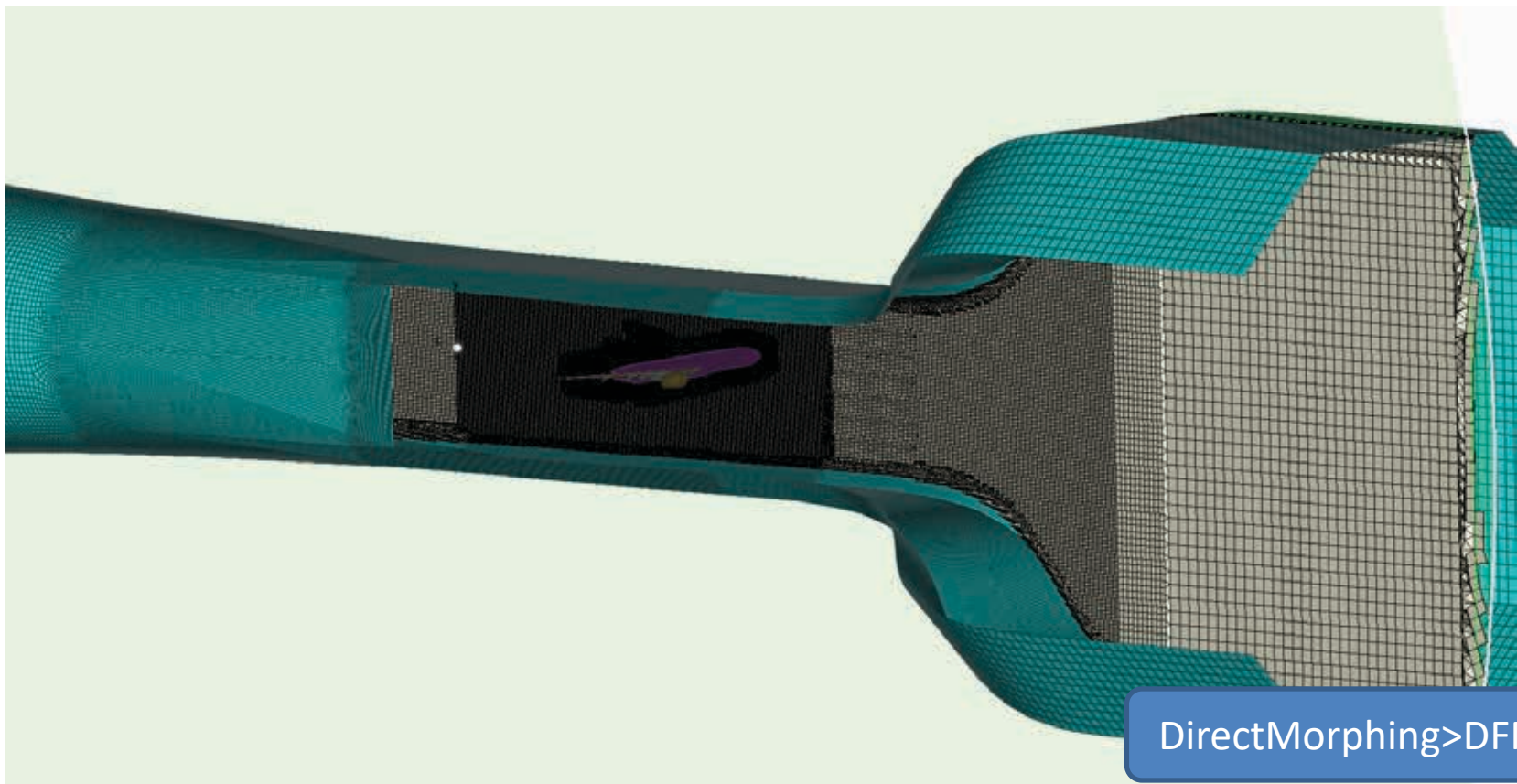
Model Browser>Configurations

Morphing to change the AoA of the model in a wind tunnel – HLPW-4

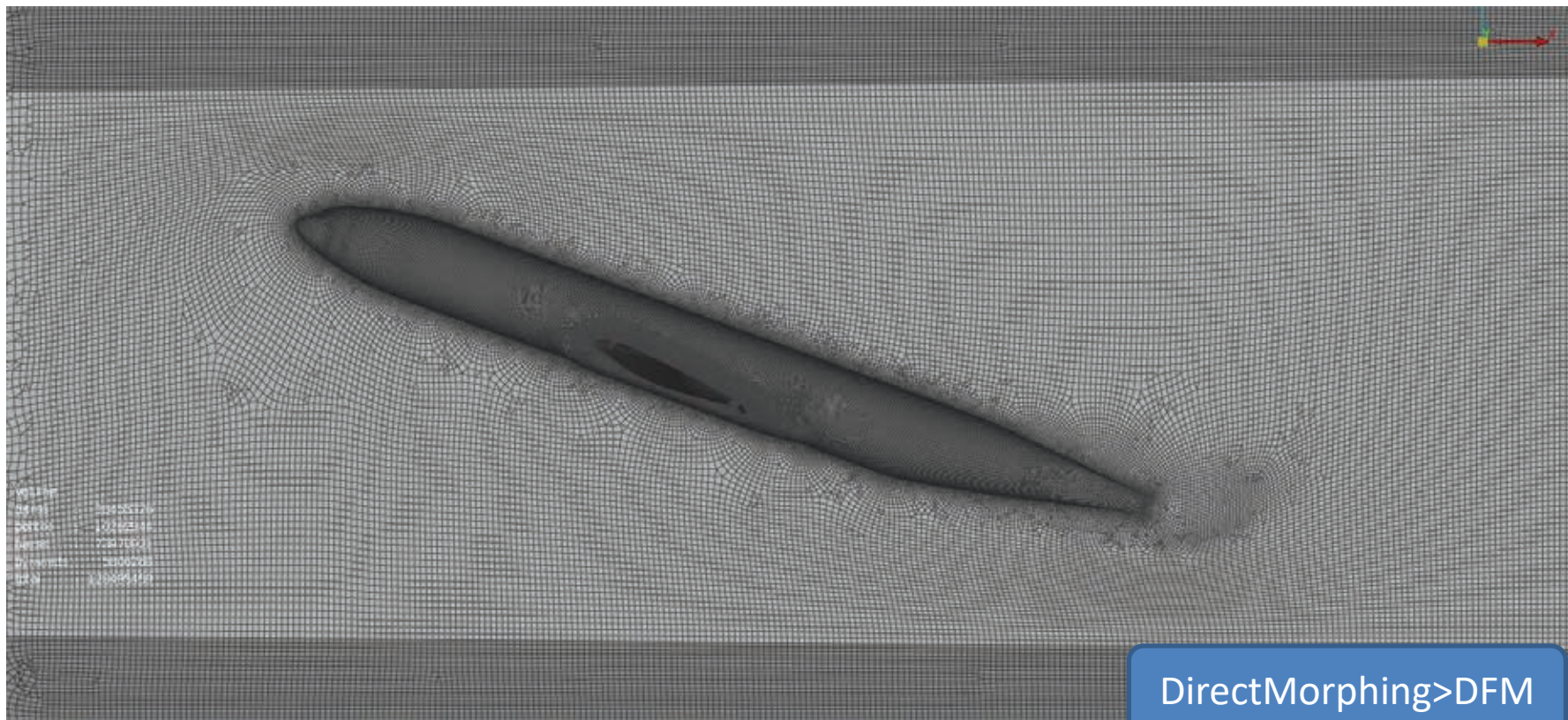


Direct Morphing>DFM

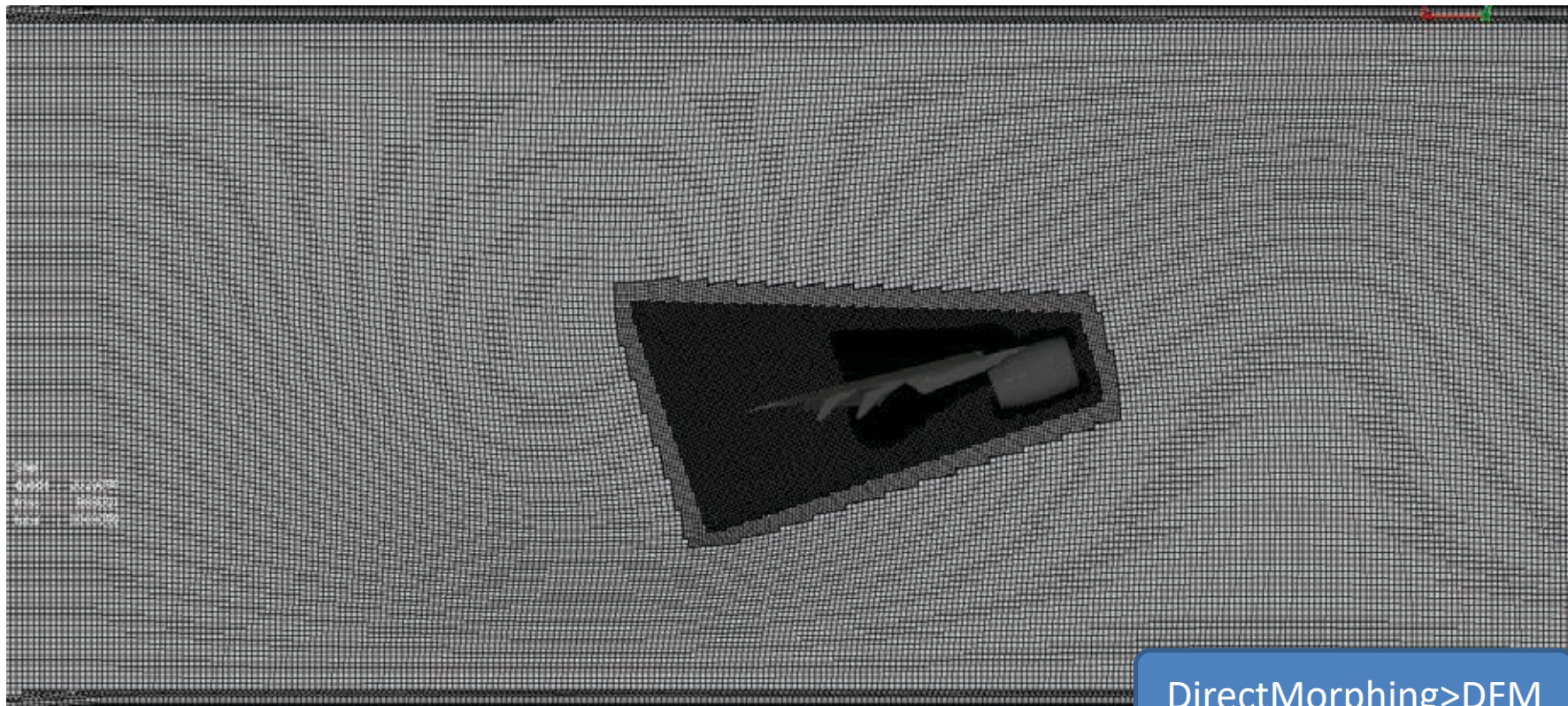
Morphing to change the AoA of the model in a wind tunnel – HLPW-4



Morphing to change the AoA of the model in a wind tunnel – HLPW-4

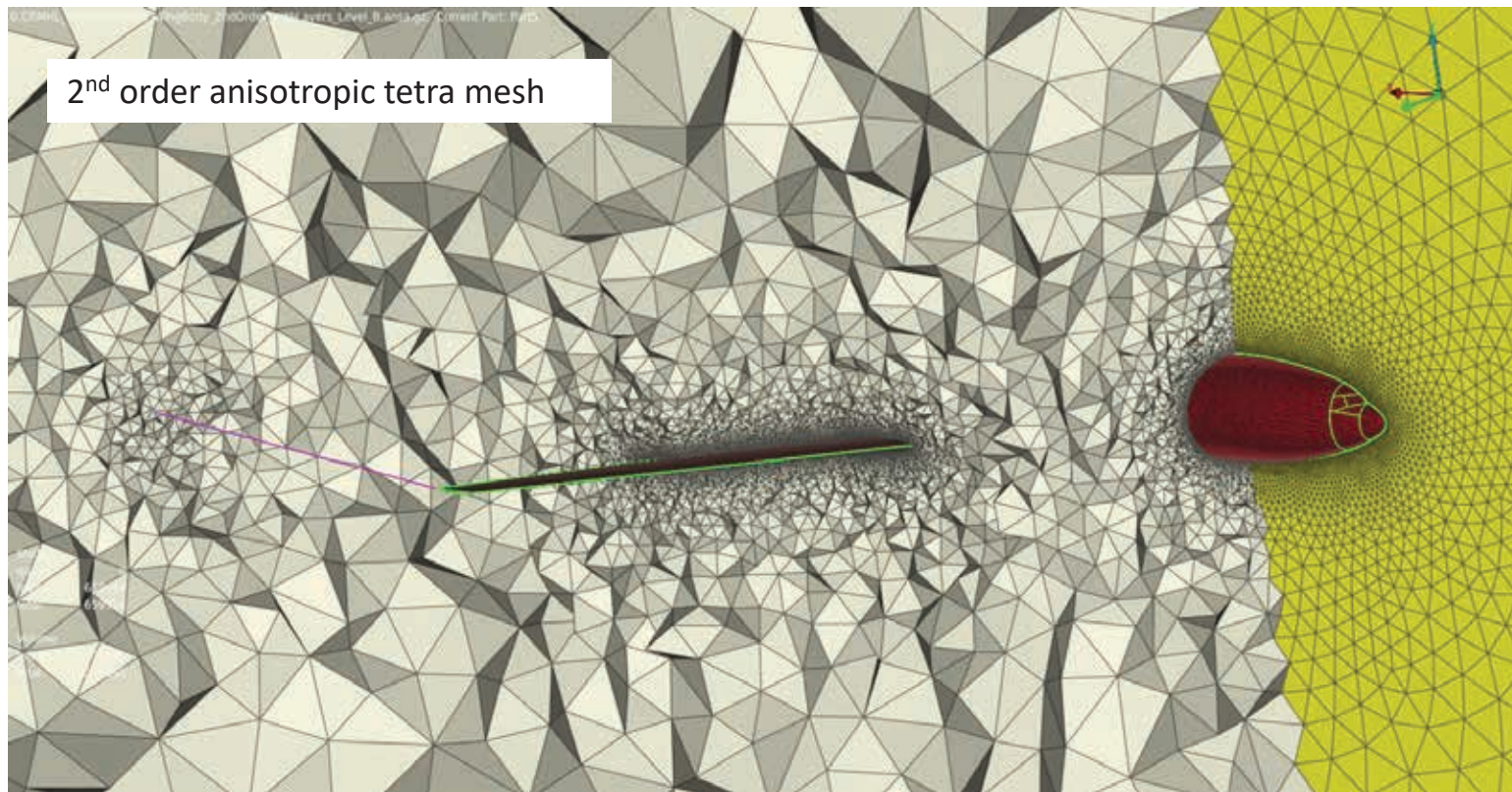


Morphing to change the AoA of the model in a wind tunnel – HLPW-4

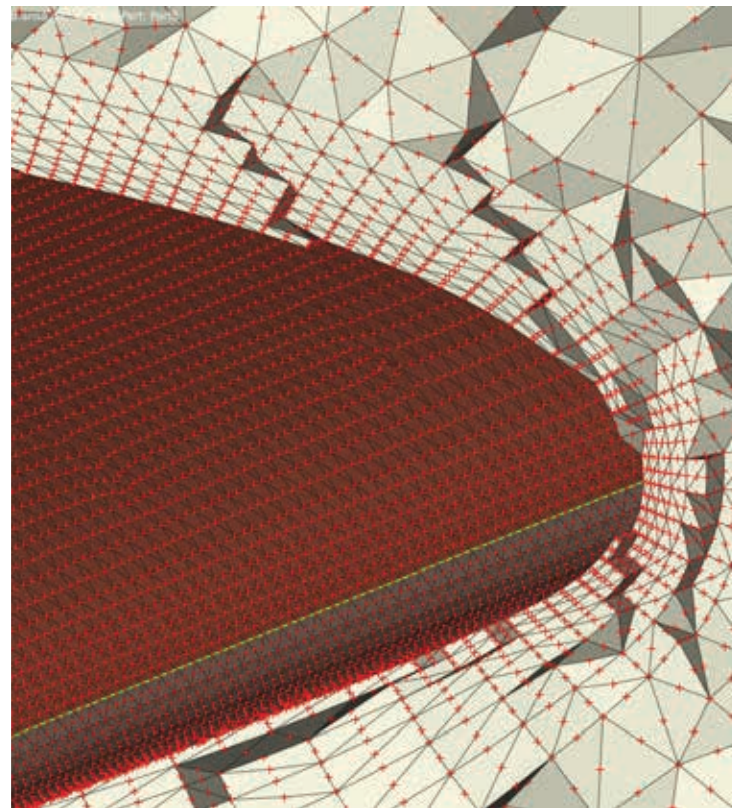
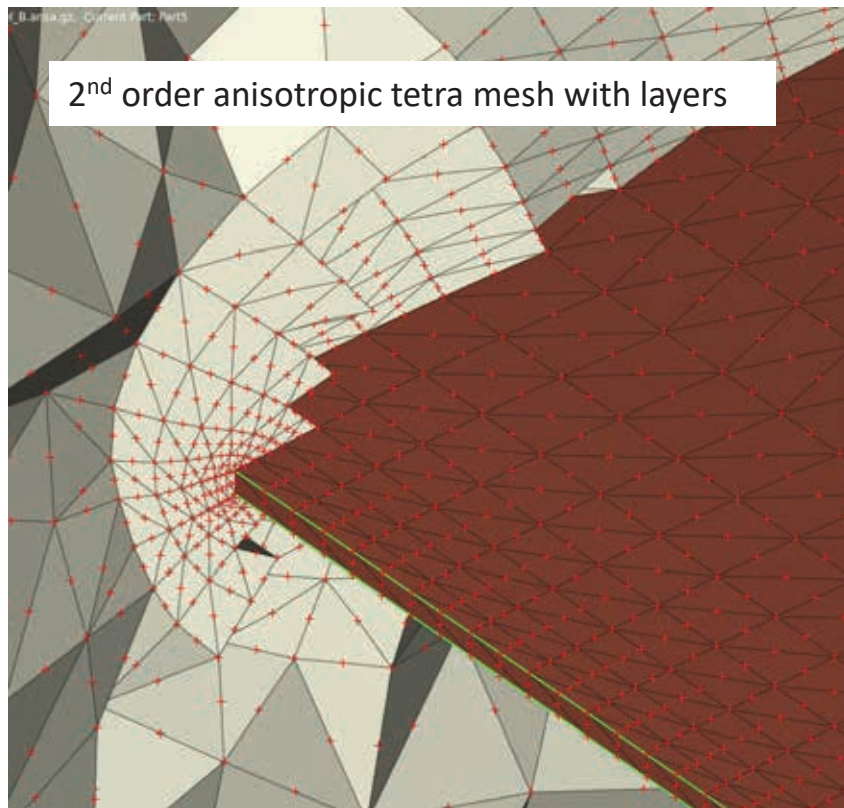


DirectMorphing>DFM

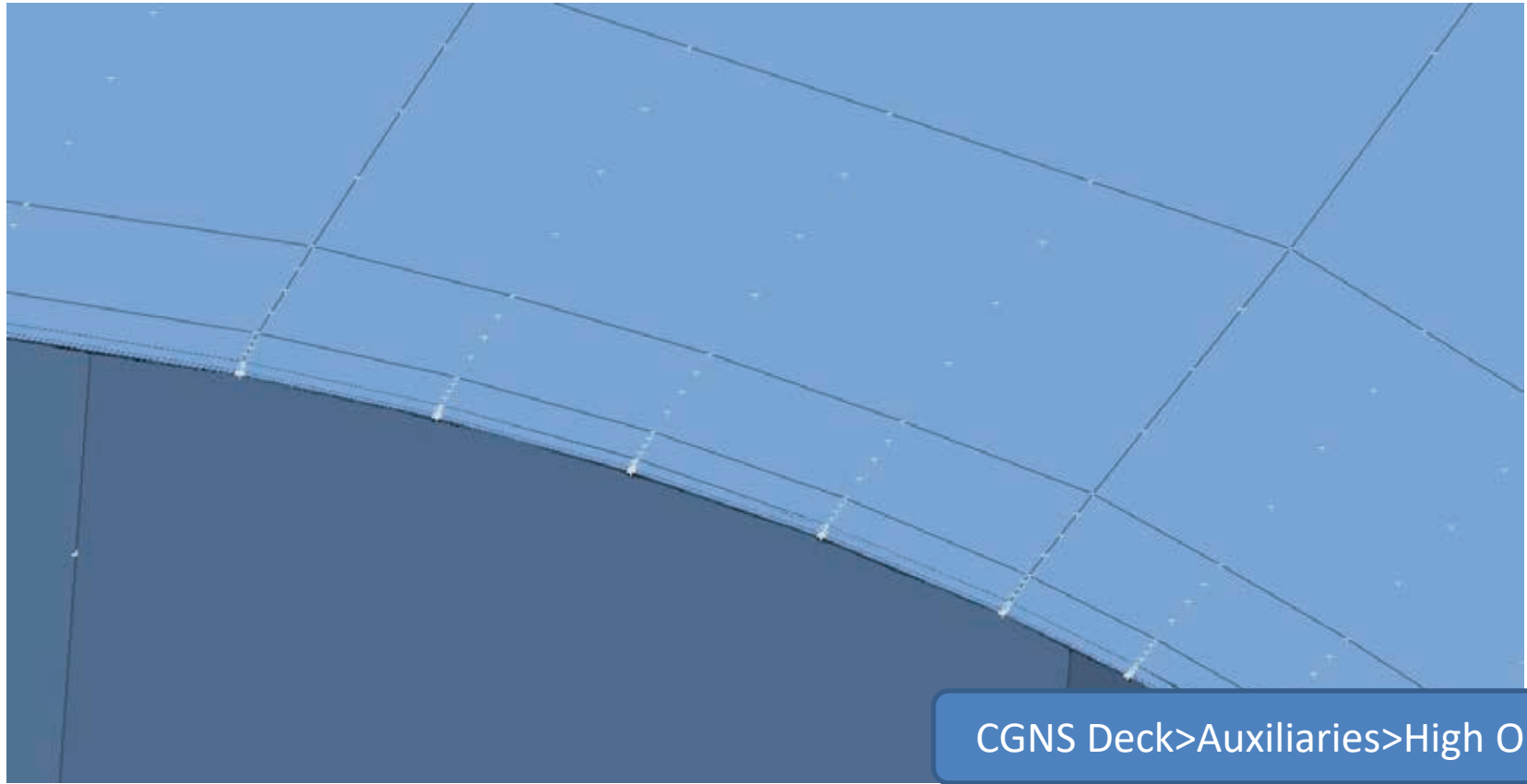
Meshing for CFD High Order methods – HLPW-5 Case 1 - WMLES methods



Meshing for CFD High Order methods – HLPW-5 Case 1 - WMLES methods



Mesh elevation to 3rd and 4th order



CGNS Deck>Auxiliaries>High Order

Recap



Recipe:

INGREDIENTS:

Quality

Speed

Automation

User Control

Feedback

Efficiency

Wide range

of functionality

Discipline and

solver independent

Support!!

DIRECTIONS:



Closing remarks

- ANSA can generate fully automatically high quality meshes for aerospace models, following precise user controls and specifications.
- ANSA presence is now widespread in the aerospace field (Industry, Academia, AIAA workshops..)
- We have achieved this by listening to our customers, working together and learning from them, in order to provide them with the optimum solutions for their work.
- We have done this since the beginning of BETA CAE and we have enjoyed every single moment of this journey.



Stay connected