DPW-8/AePW-4

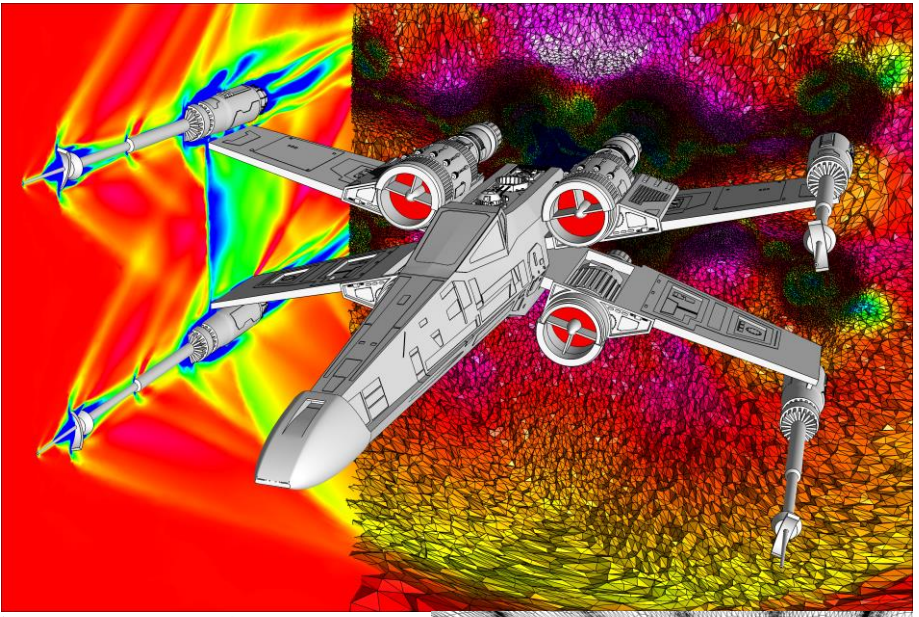
Helden Aerospace

Summary of HeldenMesh Grids Generated for the AIAA 8th Drag Prediction Workshop / 4th Aeroelastic Prediction Workshop

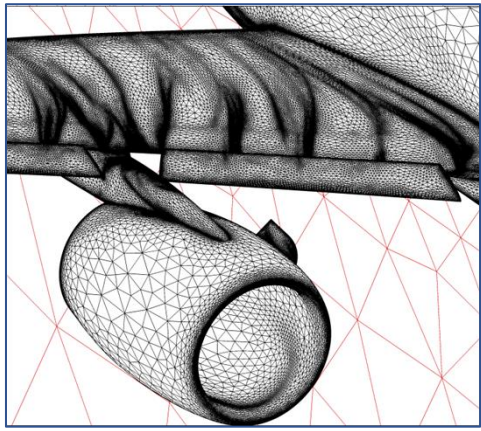
June 6-7 2026

Andrew Wick **Rick Hooker**

HeldenMesh – Overview



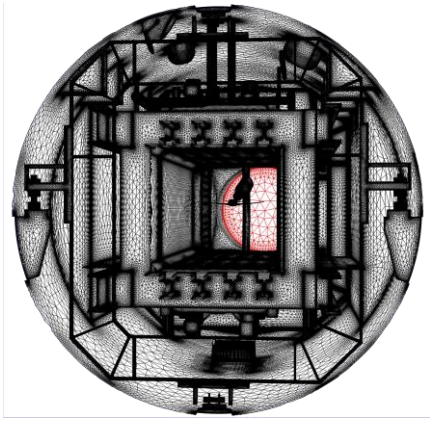
- High Quality Unstructured Mesh Generator
  - Mixed element meshes (prisms, pyramids, tets, hexes, and quads)
  - Prismatic / hex elements built from surface to resolve the boundary layer
  - Smooth transition to inviscid outer mesh



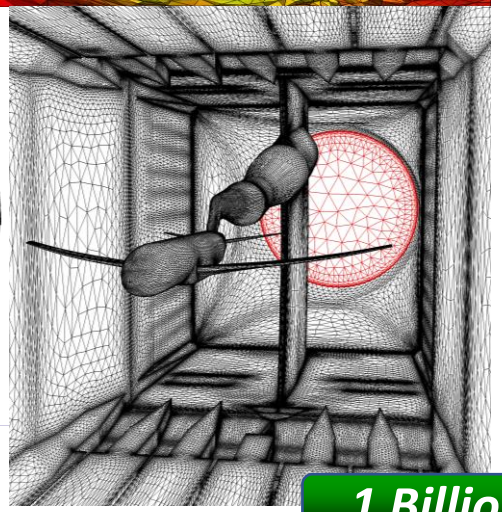
- Efficient
  - Anisotropic stretching on the surface and volume
  - Automated wake and shock volume resolution
  - Reduced run times with higher accuracy

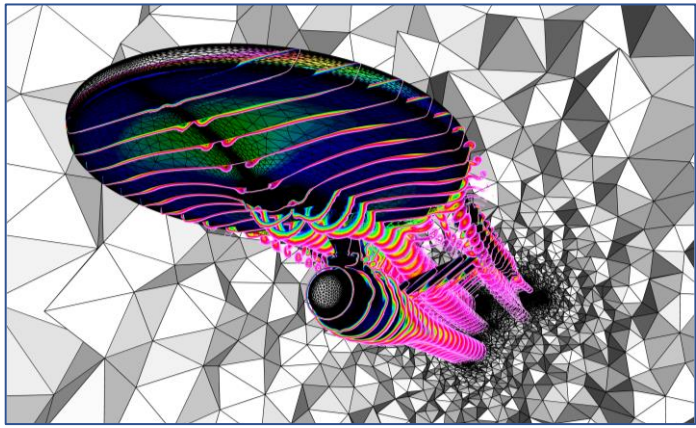
- Automated & Robust
  - Automated geometry pre-processing on complex configurations
  - Simplified input file automates mesh spacing
  - Enables rapid grid density studies

- Advanced Capabilities
  - Surface and volume mesh deformation
  - Design / optimization capability
  - Solution adaptation capability



CRM in the NTF
> 10k Surfaces





1 Billion cells in under 10 minutes on a laptop!

HeldenMesh – DPW8 Summary

- **18 unique geometries were used for this workshop**
  - JAXA CRM wing body tail = 4 unique wing deflections
  - CRM LoQ wing body = 8 unique wing deflections
  - CRM JIG wing body + tail + nacelle = 3 variations
  - OATA15 2D airfoil
  - DPW3 Wing 1 & Wing 2
- **87 total HeldenMesh grids delivered to committee in multiple formats and multiple coordinate scales**
  - 62 3D CRM meshes (multiple formats and multiple coordinate scales)
  - 13 2D meshes
  - 14 3D for DPW3 Wing1 / Wing2
- **843 total HeldenMesh grids generated as part of the design process**
  - Over 1.4 Trillion cells total!

HeldenMesh – CRM Meshes

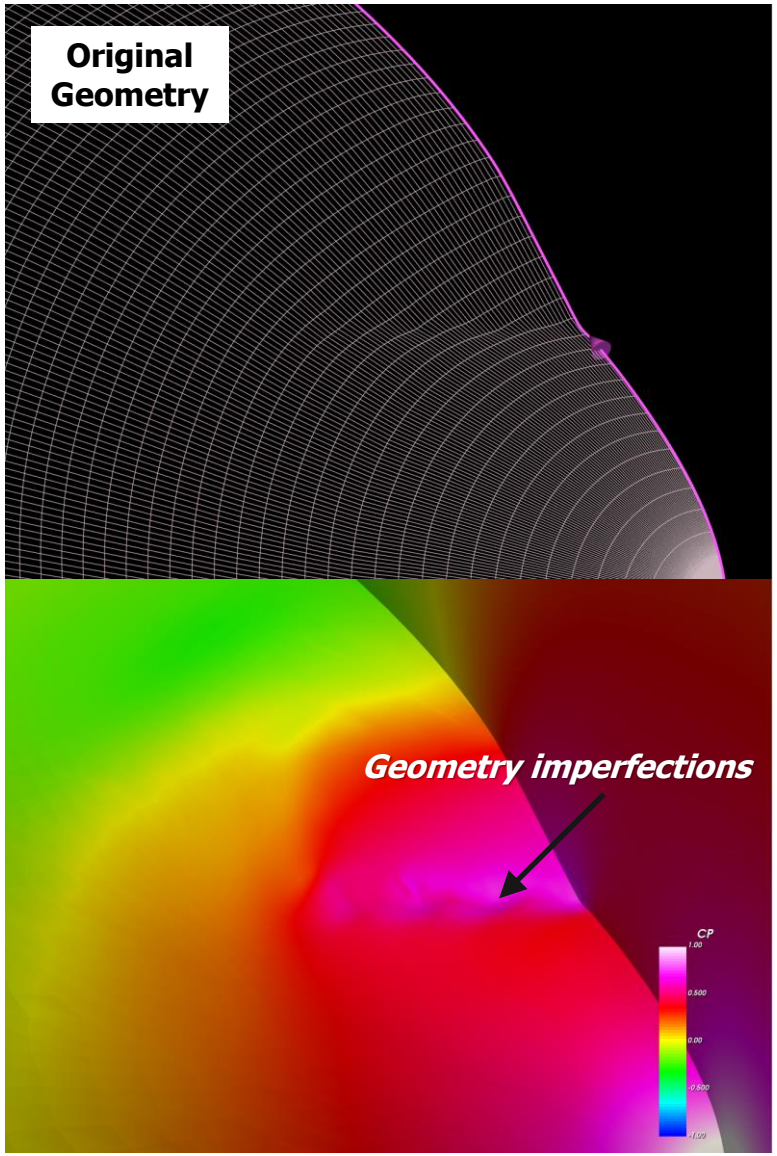
- **Using process from AIAA HLPW5 to develop best meshing characteristics**
  - Spatial adaption was used to identify regions for refinement (surface and volume) & then a fixed mesh series was created to match it
  - Detailed meshing refinement studies for Wing/Body/Tail at 4.84 alpha

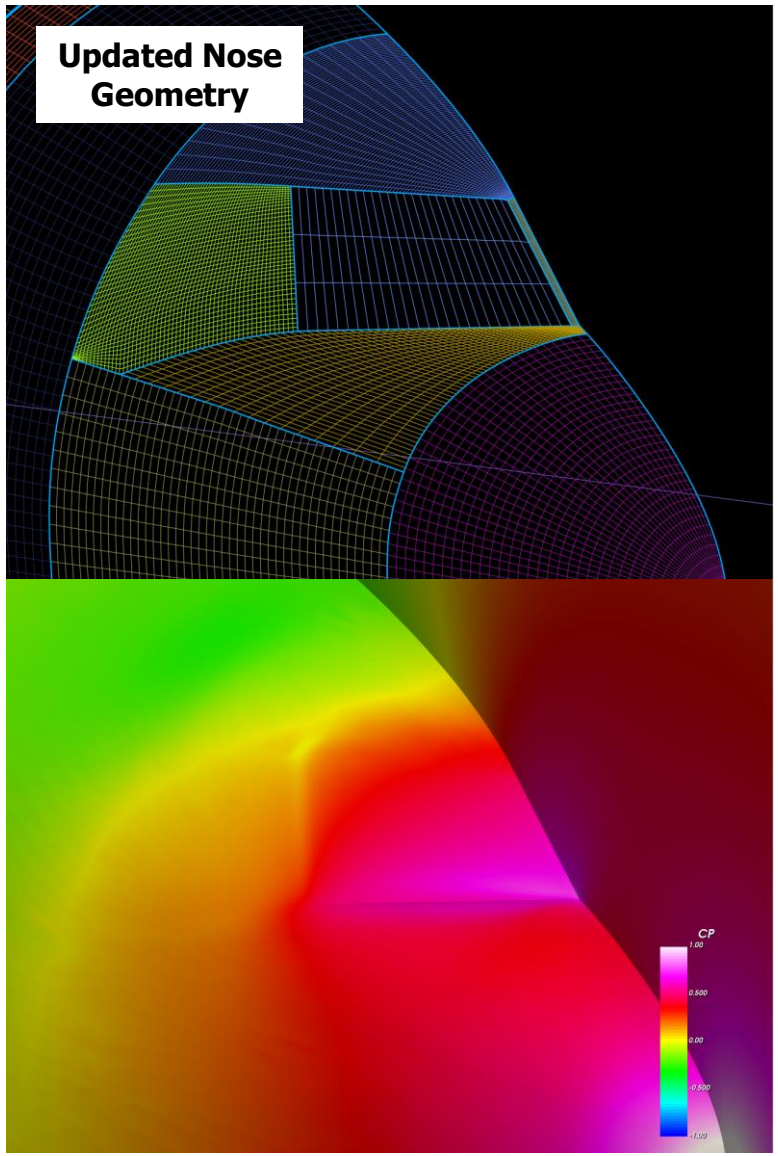
DPW-8 / AePW-4 Grid Matrix

						Grid Density						Grid Scale		
	WG	Configuration	Wing Loading	Rey#	Delivery	L1: Tiny	L2: Coarse	L3: Medium	L4: Fine	L5: eXtra	L6: Ultra	Full (inch)	Model	Units
1	All	OAT15A (2D airfoil)	N/A	TBD	Summer '24	X	X	X	X	X	X	X	-	inch
2	Sctr	Wing/Body	2.50 Alpha LoQ	5M (Cref=275.8)	(Spring) '25	?	?	X	?	?	?	X	-	inch
3	Sctr	Wing/Body	2.75 Alpha LoQ	5M (Cref=275.8)	(Spring) '25			X				X	-	inch
4	Sctr	Wing/Body	3.00 Alpha LoQ	5M / 20M?	Nov/Dec '24	X	X	X	X	X	X	X	-	inch
5	Sctr	Wing/Body	3.25 Alpha LoQ	5M (Cref=275.8)	(Spring) '25			X				X	-	inch
6	Sctr	Wing/Body	3.50 Alpha LoQ	5M (Cref=275.8)	(Spring) '25			X				X	-	inch
7	Sctr	Wing/Body	3.75 Alpha LoQ	5M (Cref=275.8)	(Spring) '25			X				X	-	inch
8	Sctr	Wing/Body	4.00 Alpha LoQ	5M (Cref=275.8)	(Spring) '25	?	?	X	?	?	?	X	-	inch
9	Sctr	Wing/Body	4.25 Alpha LoQ	5M (Cref=275.8)	(Spring) '25			X				X	-	inch
10	Bft	Wing/Body/Tail(iH=0)	4.84 Alpha JAXA	5M (Cref=275.8)	Nov/Dec '24	X	X	X	X	X	X	X	2.16%	mm
11	Bft	Wing/Body/Tail(iH=0)	5.89 Alpha JAXA	5M (Cref=275.8)	Nov/Dec '24			X				X	2.16%	mm
12	Def	Wing/Body	Jig (no load)	5M (Cref=275.8)	Nov/Dec '24	X	X	X	X	X	X	X	2.70%	inch
13	Bft	Wing/Body/Tail(iH=0)	Jig (no load)	5M (Cref=275.8)	(TBD)			X				X	2.16%	mm
14	Def	Wing/Body/Nacelle/Pylon	Jig (no load)	5M (Cref=275.8)	(Spring) '25	X	X	X	X	X	X	X	2.70%	inch

This case was used to define mesh family characteristics

CRM-Nose Geometry Modifications

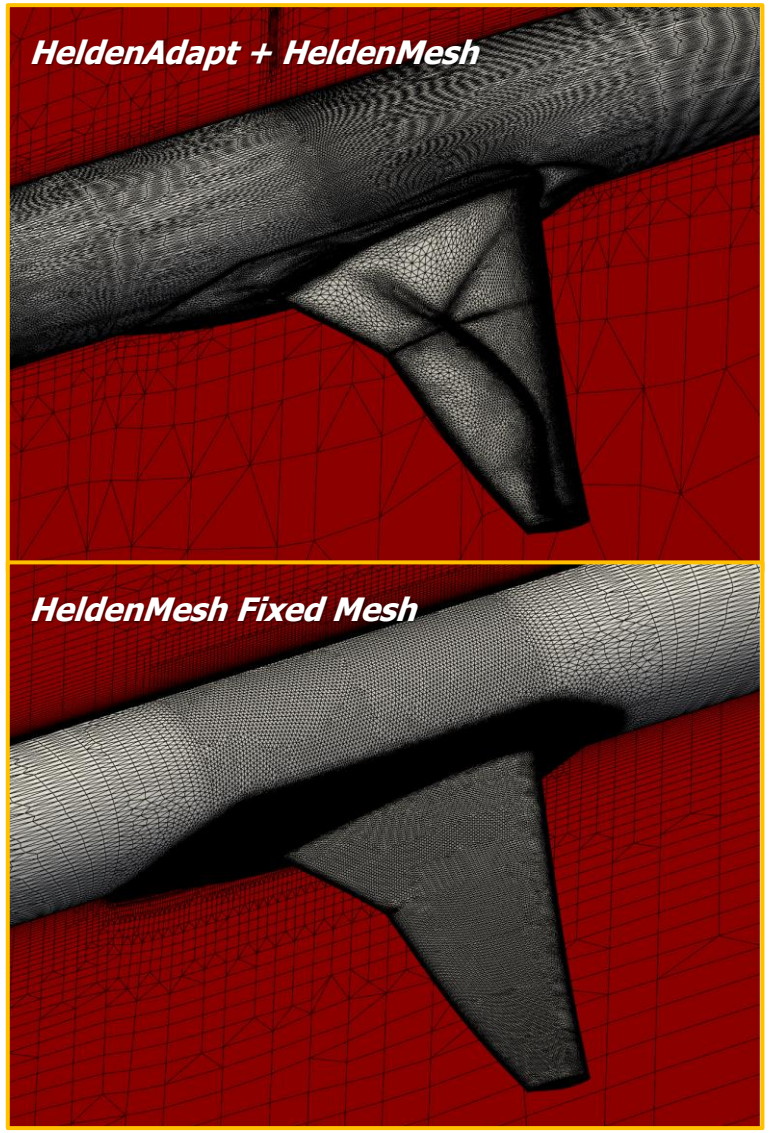




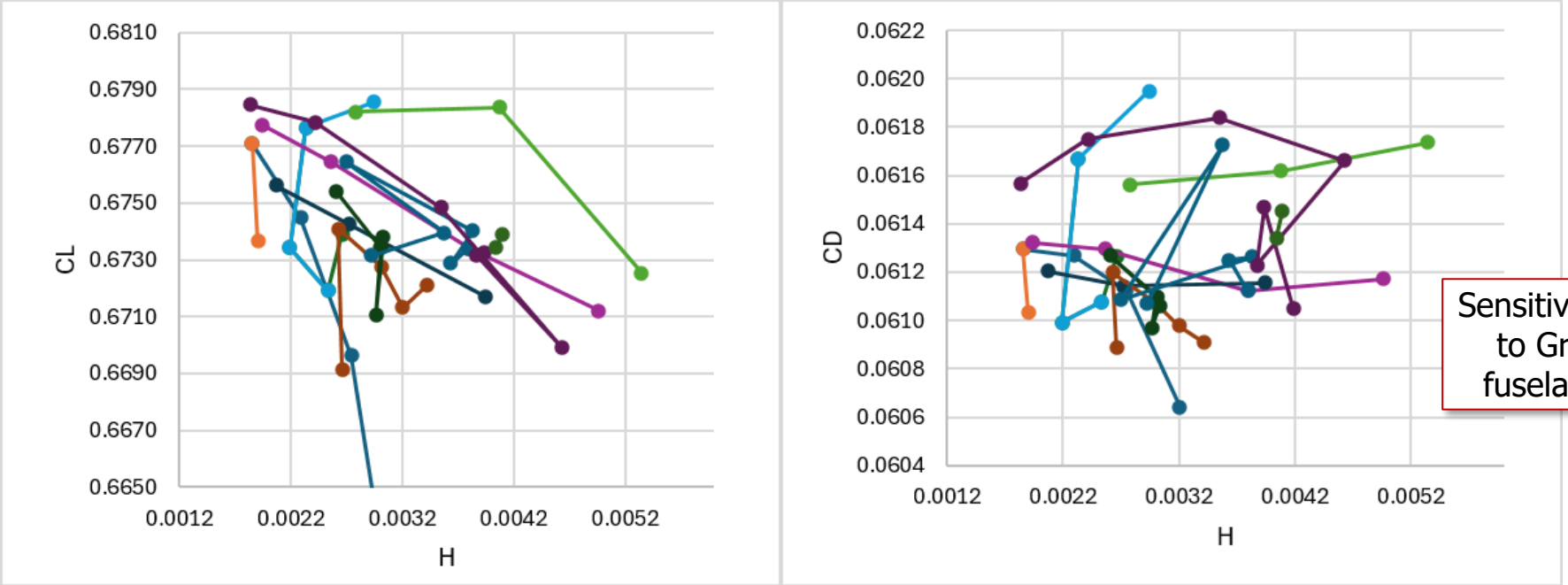
- **CRM geometry has had a geometry imperfection near the windshield for years.**
  - Rippled surface is Likely the result of a CAD simplification process results
  - Worth at least 1 count of drag
- **This unsmooth CAD model is not representative of what was manufactured for testing.**
  - Manufactured CAD model was not available.
- **Helden updated the CAD loft based on previous CRM lofts.**
  - wbh_aoa487_buffet_deformed_updatednose.iges
  - wbh_aoa592_buffet_deformed_updatednose.iges

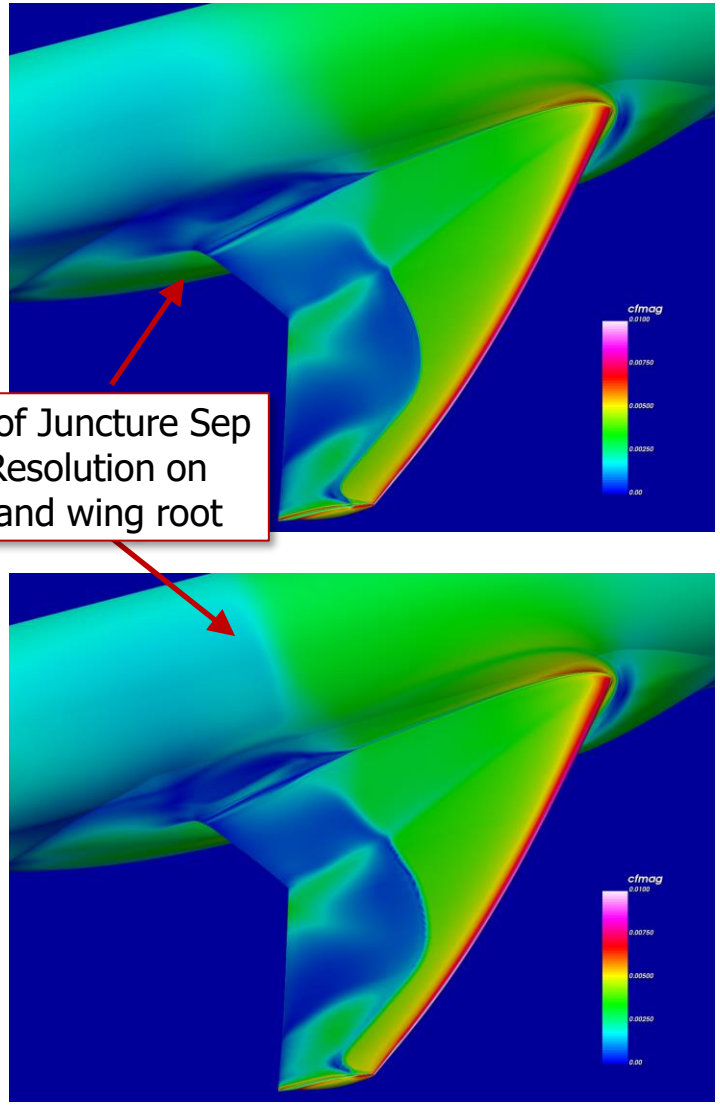
Using Adaptation to Inform Mesh Development

- **HeldenAdapt process used to generate solution adaptive grids**
  - Process takes an existing flow solution and converts it to mesh spacing
    - Uses Mach Hessian, so you are adding grid wherever the 2nd derivative of Mach is high
  - New mesh built from scratch using HeldenMesh with hybrid elements in boundary layer and high anisotropic stretching
  - These grids were used to study sensitivity to CL and CD and to inform the fixed mesh design process
    - Where to put mesh and to what levels
- **Fixed mesh refinement series were created for all CRM geometry variations required by Static Deformation, Buffet, and Scatter Group**
  - Built without adaption but refined in generalized regions
    - Areas of curvature
    - Leading edges / trailing edges
    - Wing upper surface
    - Wing/fuselage fairing
  - Adapted meshes are impractical for Jig Wing (where wing shape and shock location is variable)



Using Adaptation to Inform Mesh Development



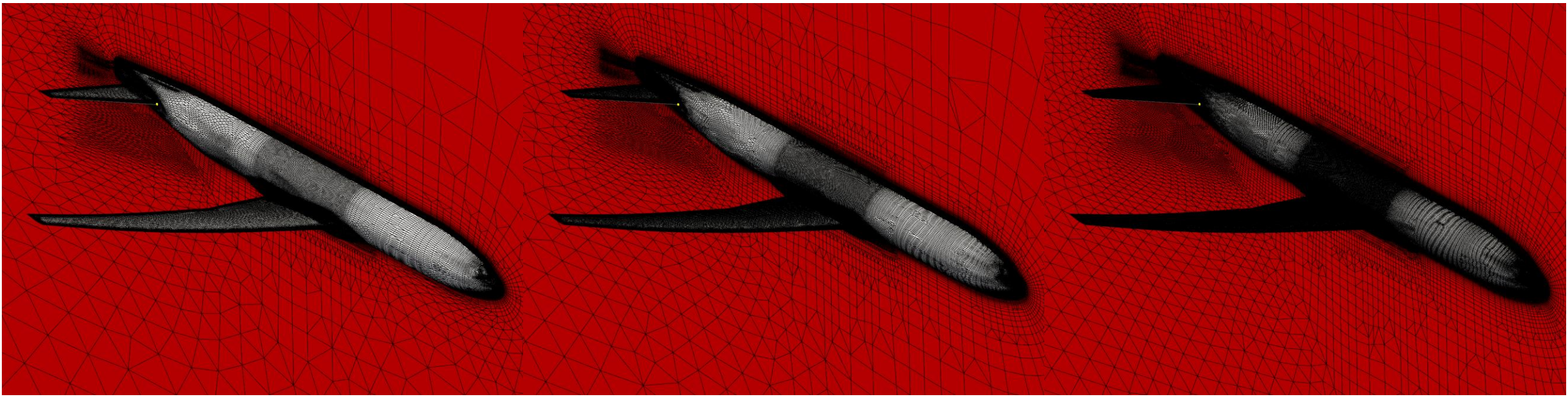


Sampling of HeldenMesh / HeldenAdapt Data
JAXA Mach 0.85, 1.5M RE *, Alpha 4.84

*NOTE: JAXA test data was taken at 1.5M RE, but workshop participants were asked to run this case at 5M RE

CRM Fixed HeldenMesh Design

- **Mesh Refinement Series were generated by linearly scaling up and down all the mesh spacings equally**
  - Including the boundary layer normal spacing
  - 6 mesh levels(A-F) with sizes ranging from 10M up to 1B cells

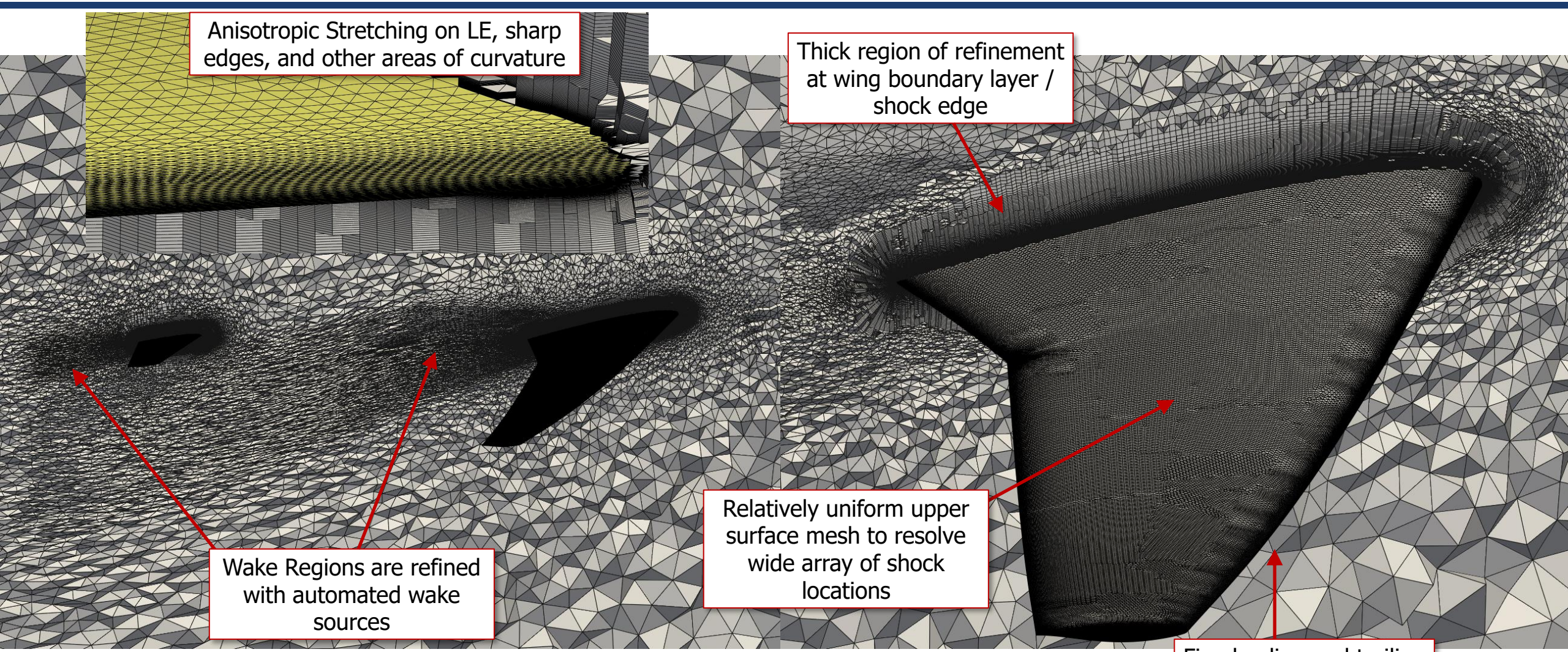


EPW4_A484_v55_A
10M Cells

EPW4_A484_v55_B
22M Cells

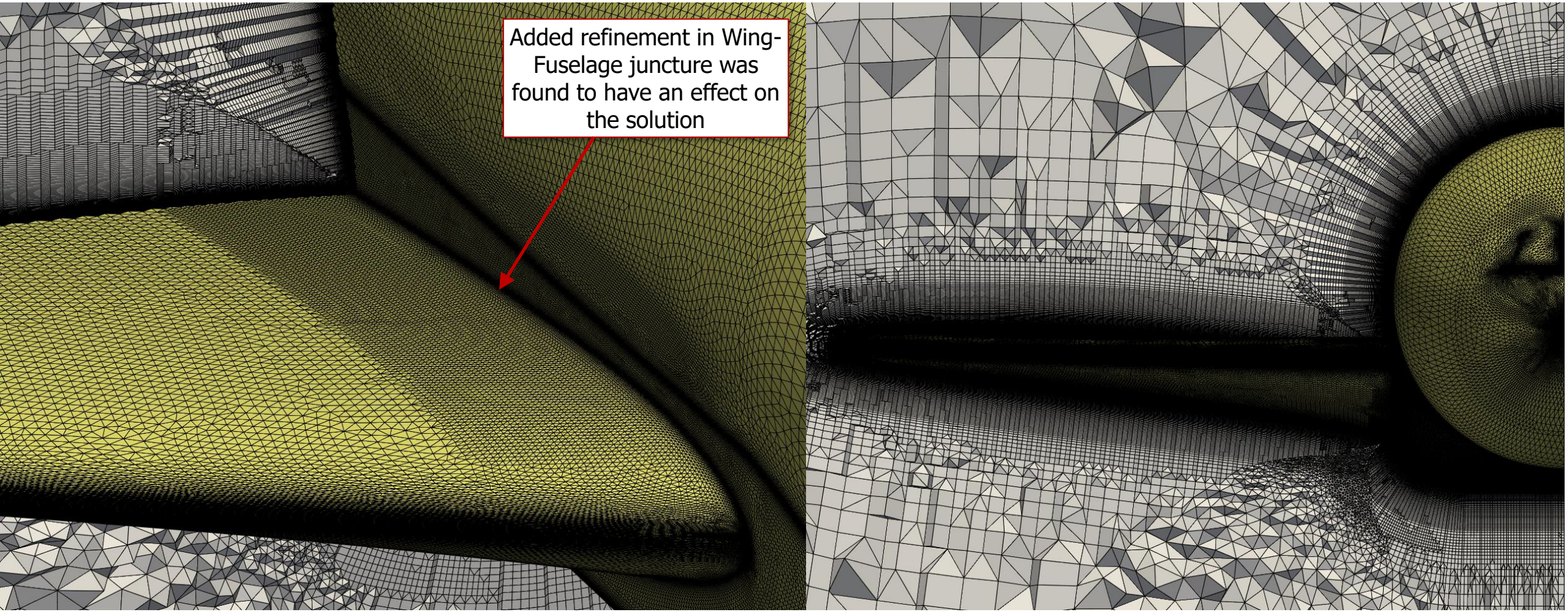
EPW4_A484_v55_C
69M Cells

CRM Fixed HeldenMesh Design



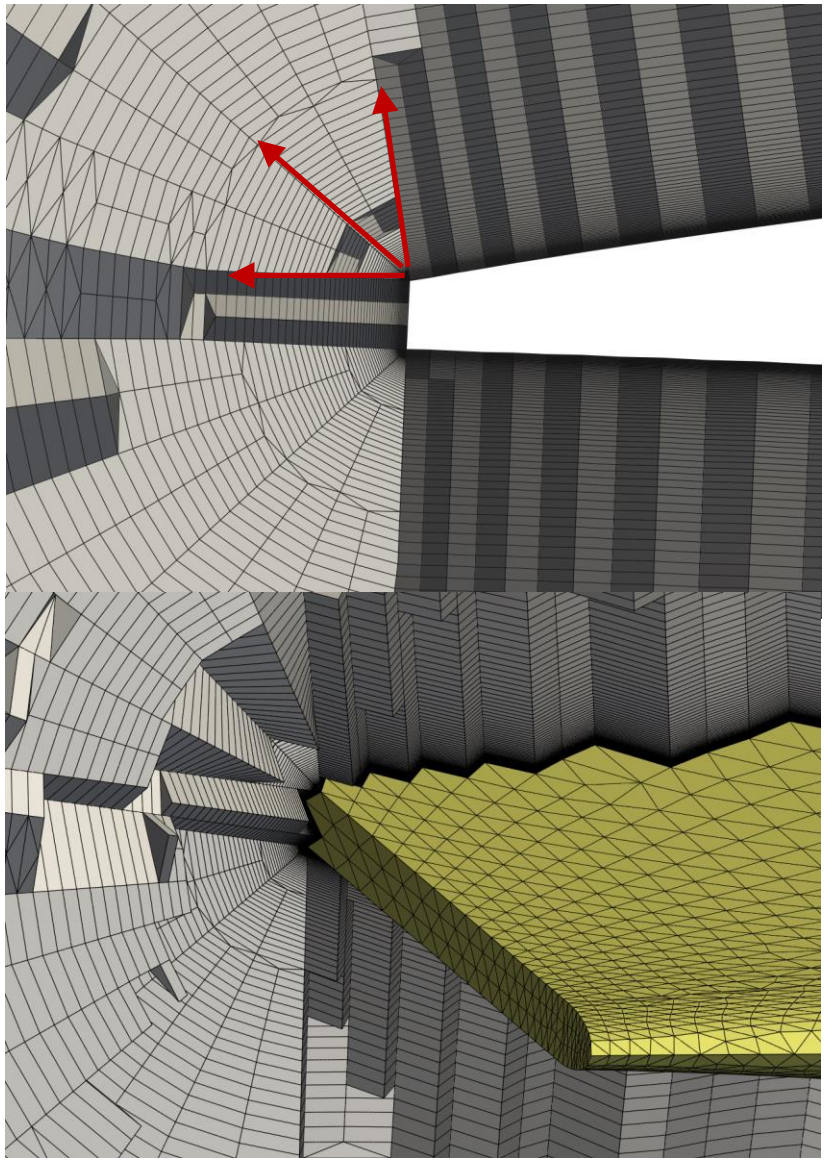
EPW4_A484_v55_C, 69M Cells

CRM Fixed HeldenMesh Design



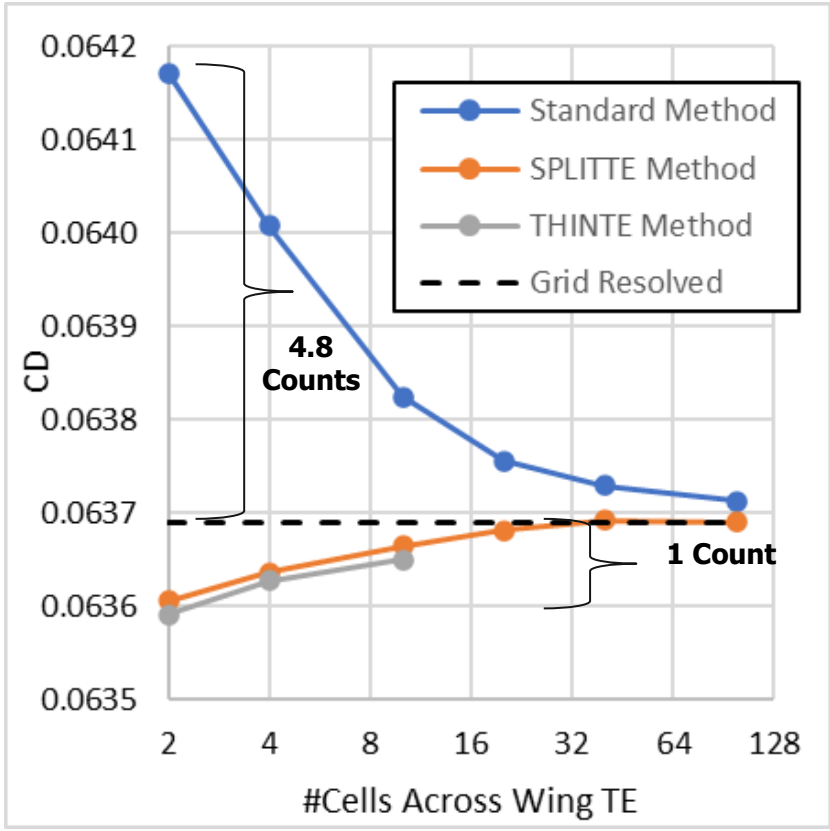
EPW4_A484_v55_C, 69M Cells

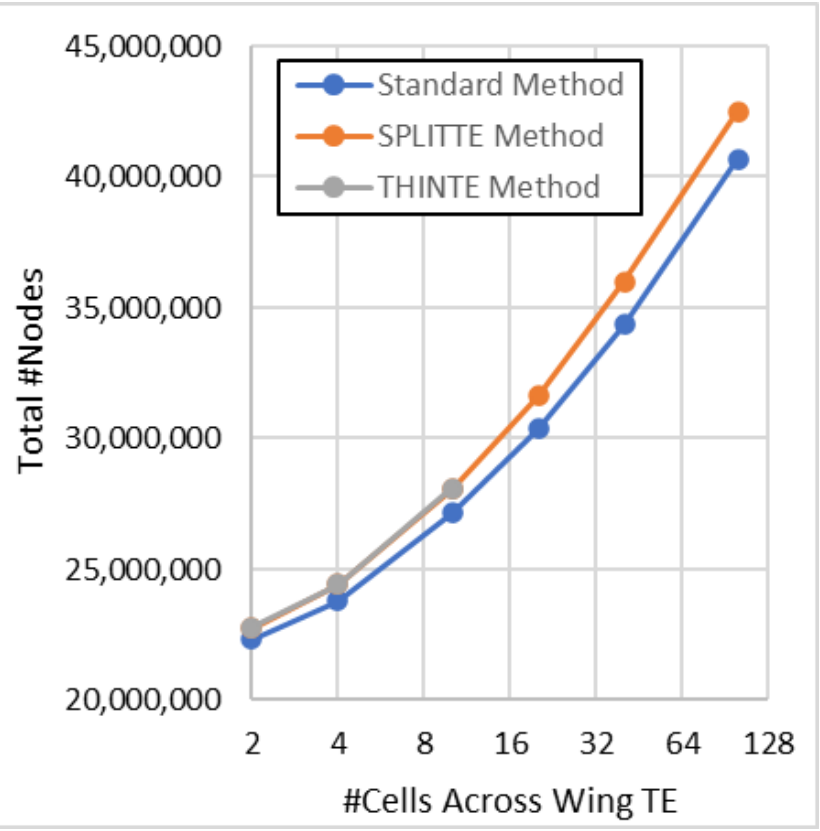
CRM Fixed HeldenMesh Design



- Growing the boundary layer elements from multiple vectors along sharp edges eliminates the need for super-fine trailing edges which have been the traditional "best practice" for DPW

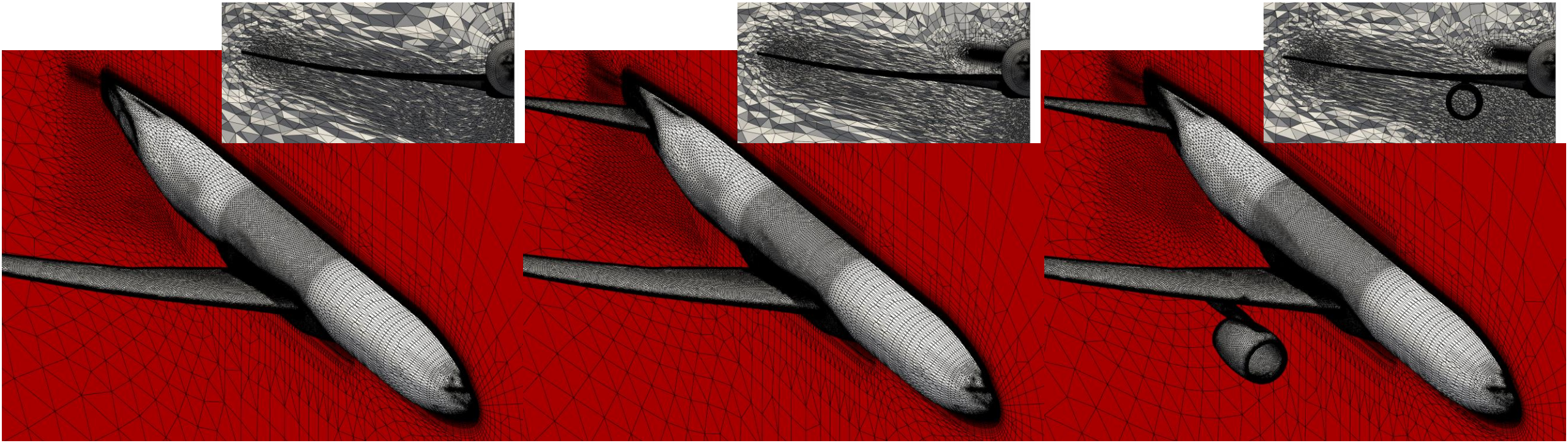
HLPW5 Results (AIAA 2025-0683)





CRM Fixed HeldenMesh Design

- **The same HeldenMesh input file was used to generate each geometry variation**
  - Mesh spacings are not exact from one grid to another but consistent
  - Mesh spacing automatically recomputed for changed or added geometry
  - Automated wake volume sources are generated from trailing edges



LoQ Wing Body
8M Cells

JAXA Alpha 4.84
10M Cells

Jig Wing + Nacelle + Tail
14M Cells

Buffet Meshes – Test Case 2 (JAXA Alphas)

Mesh Name		#Nodes	#Cells (M)	y+ (5M)	Y+ (1.2M)	First Layer DZ	Target Layer Height	DZ at Height	#LAYERS within Height	Max Arate	Geo Growth	SEDGE & SMIN ALL	SBASE WING FUSE	SBASE WING	SBASE ALL
EPW4_A122_v55_A	A	4,406,756	10.001684	1	0.24	0.00140995	35	2	75	0.1898	0.4	0.4	4	8	200
EPW4_A122_v55_B	B	9,936,241	22.091038	0.75	0.18	0.00105746	35	1.5	100	0.1395	0.3	0.3	3	6	150
EPW4_A122_v55_C	C	31,914,272	69.761406	0.5	0.12	0.00070498	35	1	150	0.09119	0.2	0.2	2	4	100
EPW4_A122_v55_D	D	74,021,330	160.402817	0.375	0.09	0.00052873	35	0.75	200	0.06771	0.15	0.15	1.5	3	75
EPW4_A122_v55_E	E	244,483,675	524.955383	0.25	0.06	0.00035249	35	0.5	300	0.0447	0.1	0.1	1	2	50
EPW4_A122_v55_F	F	618,653,876	1319.81189	0.1875	0.045	0.00026437	35	0.375	400	0.0233	0.075	0.075	0.75	1.5	37.5

Mesh Name		#Nodes	#Cells (M)	y+ (5M)	Y+ (1.2M)	First Layer DZ	Target Layer Height	DZ at Height	#LAYERS within Height	Max Arate	Geo Growth	SEDGE & SMIN ALL	SBASE WING FUSE	SBASE WING	SBASE ALL
EPW4_A229_v55_A	A	4,405,824	9.995524	1	0.24	0.00140995	35	2	75	0.1898	0.4	0.4	4	8	200
EPW4_A229_v55_B	B	9,938,239	22.090891	0.75	0.18	0.00105746	35	1.5	100	0.1395	0.3	0.3	3	6	150
EPW4_A229_v55_C	C	31,903,273	69.777008	0.5	0.12	0.00070498	35	1	150	0.09119	0.2	0.2	2	4	100
EPW4_A229_v55_D	D	74,003,781	160.199127	0.375	0.09	0.00052873	35	0.75	200	0.06771	0.15	0.15	1.5	3	75
EPW4_A229_v55_E	E	244,405,745	523.686584	0.25	0.06	0.00035249	35	0.5	300	0.0447	0.1	0.1	1	2	50
EPW4_A229_v55_F	F	619,160,721	1318.425781	0.1875	0.045	0.00026437	35	0.375	400	0.0233	0.075	0.075	0.75	1.5	37.5

Mesh Name		#Nodes	#Cells (M)	y+ (5M)	Y+ (1.2M)	First Layer DZ	Target Layer Height	DZ at Height	#LAYERS within Height	Max Arate	Geo Growth	SEDGE & SMIN ALL	SBASE WING FUSE	SBASE WING	SBASE ALL
EPW4_A484_v55_A	A	4,408,892	10.026572	1	0.24	0.00140995	35	2	75	0.1898	0.4	0.4	4	8	200
EPW4_A484_v55_B	B	9,915,444	22.114828	0.75	0.18	0.00105746	35	1.5	100	0.1395	0.3	0.3	3	6	150
EPW4_A484_v55_C	C	31,897,574	69.829788	0.5	0.12	0.00070498	35	1	150	0.09119	0.2	0.2	2	4	100
EPW4_A484_v55_D	D	73,911,244	160.337845	0.375	0.09	0.00052873	35	0.75	200	0.06771	0.15	0.15	1.5	3	75
EPW4_A484_v55_E	E	243,943,734	524.0271	0.25	0.06	0.00035249	35	0.5	300	0.0447	0.1	0.1	1	2	50
EPW4_A484_v55_F	F	617,746,312	1319.564087	0.1875	0.045	0.00026437	35	0.375	400	0.0233	0.075	0.075	0.75	1.5	37.5

Mesh Name		#Nodes	#Cells (M)	y+ (5M)	Y+ (1.2M)	First Layer DZ	Target Layer Height	DZ at Height	#LAYERS within Height	Max Arate	Geo Growth	SEDGE & SMIN ALL	SBASE WING FUSE	SBASE WING	SBASE ALL
EPW4_A592_v55_A	A	4,400,417	9.982527	1	0.24	0.00140995	35	2	75	0.1898	0.4	0.4	4	8	200
EPW4_A592_v55_B	B	9,935,219	22.093996	0.75	0.18	0.00105746	35	1.5	100	0.1395	0.3	0.3	3	6	150
EPW4_A592_v55_C	C	31,945,058	69.842552	0.5	0.12	0.00070498	35	1	150	0.09119	0.2	0.2	2	4	100
EPW4_A592_v55_D	D	73,939,997	160.129272	0.375	0.09	0.00052873	35	0.75	200	0.06771	0.15	0.15	1.5	3	75
EPW4_A592_v55_E	E	244,310,293	525.039795	0.25	0.06	0.00035249	35	0.5	300	0.0447	0.1	0.1	1	2	50
EPW4_A592_v55_F	F	618,987,810	1319.631714	0.1875	0.045	0.00026437	35	0.375	400	0.0233	0.075	0.075	0.75	1.5	37.5

- **Refinement series generated for each of the 4 alphas**
  - Alpha 1.22
  - Alpha 2.29
  - Alpha 4.84
  - Alpha 5.92
- **All mesh spacings were scaled linearly at the same rate to create mesh series**
  - Including in boundary layer
- **Mesh sizes ranged from 10M to 1.3B cells**
- **24 meshes total**

Static Deformation – Test Case 2 (Jig)

Mesh Name		#Nodes	#Cells (M)	y+ (5M)	Y+ (1.2M)	First Layer DZ	Target Layer Height	DZ at Height	#LAYERS within Height	Max Arate	Geo Growth	SEDGE & SMIN ALL	SBASE WING FUSE	SBASE WING	SBASE ALL
EPW4_jig_v55_A	A	3,717,353	8.380057	1	0.24	0.00140995	35	2	75	0.1898	0.4	0.4	4	8	200
EPW4_jig_v55_B	B	8,373,318	18.525145	0.75	0.18	0.00105746	35	1.5	100	0.1395	0.3	0.3	3	6	150
EPW4_jig_v55_C	C	26,949,913	58.528137	0.5	0.12	0.00070498	35	1	150	0.09119	0.2	0.2	2	4	100
EPW4_jig_v55_D	D	62,233,075	133.698593	0.375	0.09	0.00052873	35	0.75	200	0.06771	0.15	0.15	1.5	3	75
EPW4_jig_v55_E	E	206,553,305	440.886322	0.25	0.06	0.00035249	35	0.5	300	0.0447	0.1	0.1	1	2	50
EPW4_jig_v55_F	F	521,143,266	1112.661011	0.1875	0.045	0.00026437	35	0.375	400	0.0233	0.075	0.075	0.75	1.5	37.5

Mesh Name		#Nodes	#Cells (M)	y+ (5M)	Y+ (1.2M)	First Layer DZ	Target Layer Height	DZ at Height	#LAYERS within Height	Max Arate	Geo Growth	SEDGE & SMIN ALL	SBASE WING FUSE	SBASE WING	SBASE ALL
EPW4_jig_tail_v55_A	A	4,432,335	10.07573	1	0.24	0.00140995	35	2	75	0.1898	0.4	0.4	4	8	200
EPW4_jig_tail_v55_B	B	9,968,155	22.236223	0.75	0.18	0.00105746	35	1.5	100	0.1395	0.3	0.3	3	6	150
EPW4_jig_tail_v55_C	C	32,060,307	70.188438	0.5	0.12	0.00070498	35	1	150	0.09119	0.2	0.2	2	4	100
EPW4_jig_tail_v55_D	D	74,049,035	160.309525	0.375	0.09	0.00052873	35	0.75	200	0.06771	0.15	0.15	1.5	3	75
EPW4_jig_tail_v55_E	E	244,872,925	529.85144	0.25	0.06	0.00035249	35	0.5	300	0.0447	0.1	0.1	1	2	50
EPW4_jig_tail_v55_F	F	619,601,890	1333.449097	0.1875	0.045	0.00026437	35	0.375	400	0.0233	0.075	0.075	0.75	1.5	37.5

Mesh Name		#Nodes	#Cells (M)	y+ (5M)	Y+ (1.2M)	First Layer DZ	Target Layer Height	DZ at Height	#LAYERS within Height	Max Arate	Geo Growth	SEDGE & SMIN ALL	SBASE WING FUSE	SBASE WING	SBASE ALL
EPW4_jig_pylon_tail_v55_A	A	5,922,726	13.910611	1	0.24	0.00140995	35	2	75	0.1898	0.4	0.4	4	8	200
EPW4_jig_pylon_tail_v55_B	B	13,249,099	30.366856	0.75	0.18	0.00105746	35	1.5	100	0.1395	0.3	0.3	3	6	150
EPW4_jig_pylon_tail_v55_C	C	42,198,671	94.234574	0.5	0.12	0.00070498	35	1	150	0.09119	0.2	0.2	2	4	100
EPW4_jig_pylon_tail_v55_D	D	96,836,822	213.678574	0.375	0.09	0.00052873	35	0.75	200	0.06771	0.15	0.15	1.5	3	75
EPW4_jig_pylon_tail_v55_E	E	319,076,719	698.253906	0.25	0.06	0.00035249	35	0.5	300	0.0447	0.1	0.1	1	2	50
EPW4_jig_pylon_tail_v55_F	F	813,842,793	1767.563477	0.1875	0.045	0.00026437	35	0.375	400	0.0233	0.075	0.075	0.75	1.5	37.5

- **Refinement series generated for each of the 3 Jig configurations**
  - Wing-Body
  - Wing-Body + Tail
  - Wing-Body + Tail + Nacelle
- **All mesh spacings were scaled linearly at the same rate to create mesh series**
  - Including in boundary layer
- **Mesh sizes ranged from 8M to 1.8B cells**
- **18 meshes total**

Scatter Prediction – Test Case 2 (Low Q)

Mesh Name		#Nodes	#Cells (M)	y+ (5M)	Y+ (1.2M)	First Layer DZ	Target Layer Height	DZ at Height	#LAYERS within Height	Max Arate	Geo Growth	SEDGE & SMIN ALL	SBASE WING FUSE	SBASE WING	SBASE ALL
EPW_loq_wb_a250_v55_A	A	3,683,140	8.298592	1	0.24	0.00140995	35	2	75	0.1898	0.4	0.4	4	8	200
EPW_loq_wb_a250_v55_B	B	8,333,026	18.429131	0.75	0.18	0.00105746	35	1.5	100	0.1395	0.3	0.3	3	6	150
EPW_loq_wb_a250_v55_C	C	26,772,535	58.138275	0.5	0.12	0.00070498	35	1	150	0.09119	0.2	0.2	2	4	100
EPW_loq_wb_a250_v55_D	D	61,997,914	132.980286	0.375	0.09	0.00052873	35	0.75	200	0.06771	0.15	0.15	1.5	3	75
EPW_loq_wb_a250_v55_E	E	205,726,073	440.792114	0.25	0.06	0.00035249	35	0.5	300	0.0447	0.1	0.1	1	2	50
EPW_loq_wb_a250_v55_F	F	520,108,133	1108.553467	0.1875	0.045	0.00026437	35	0.375	400	0.0233	0.075	0.075	0.75	1.5	37.5

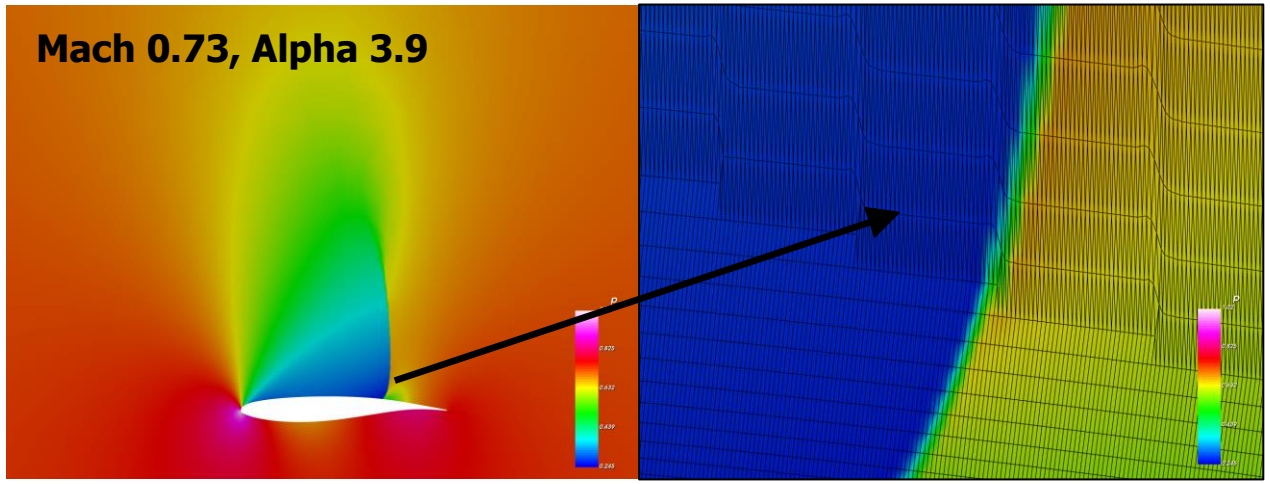
Mesh Name		#Nodes	#Cells (M)	y+ (5M)	Y+ (1.2M)	First Layer DZ	Target Layer Height	DZ at Height	#LAYERS within Height	Max Arate	Geo Growth	SEDGE & SMIN ALL	SBASE WING FUSE	SBASE WING	SBASE ALL
EPW_loq_wb_a300_v55_A	A	3,691,314	8.310528	1	0.24	0.00140995	35	2	75	0.1898	0.4	0.4	4	8	200
EPW_loq_wb_a300_v55_B	B	8,346,491	18.447027	0.75	0.18	0.00105746	35	1.5	100	0.1395	0.3	0.3	3	6	150
EPW_loq_wb_a300_v55_C	C	26,767,541	58.123772	0.5	0.12	0.00070498	35	1	150	0.09119	0.2	0.2	2	4	100
EPW_loq_wb_a300_v55_D	D	61,984,602	133.628601	0.375	0.09	0.00052873	35	0.75	200	0.06771	0.15	0.15	1.5	3	75
EPW_loq_wb_a300_v55_E	E	205,838,743	440.916626	0.25	0.06	0.00035249	35	0.5	300	0.0447	0.1	0.1	1	2	50
EPW_loq_wb_a300_v55_F	F	520,311,460	1106.400024	0.1875	0.045	0.00026437	35	0.375	400	0.0233	0.075	0.075	0.75	1.5	37.5

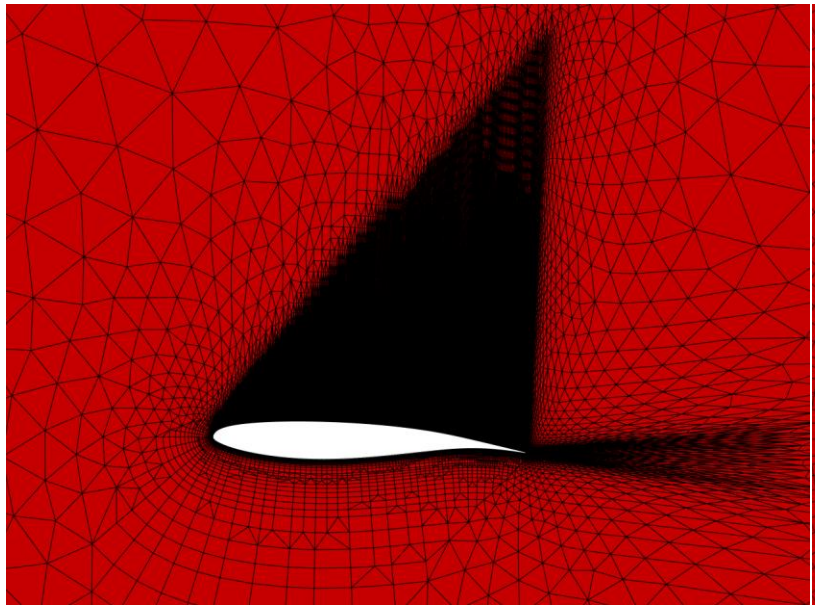
Mesh Name		#Nodes	#Cells (M)	y+ (5M)	Y+ (1.2M)	First Layer DZ	Target Layer Height	DZ at Height	#LAYERS within Height	Max Arate	Geo Growth	SEDGE & SMIN ALL	SBASE WING FUSE	SBASE WING	SBASE ALL
EPW_loq_wb_a250_v55_C	C	26,772,535	58.138275	0.5	0.12	0.00070498	35	1	150	0.09119	0.2	0.2	2	4	100
EPW_loq_wb_a275_v55_C	C	26,727,100	57.879189	0.5	0.12	0.00070498	35	1	150	0.09119	0.2	0.2	2	4	100
EPW_loq_wb_a300_v55_C	C	26,767,541	58.123772	0.5	0.12	0.00070498	35	1	150	0.09119	0.2	0.2	2	4	100
EPW_loq_wb_a325_v55_C	C	26,788,807	58.178665	0.5	0.12	0.00070498	35	1	150	0.09119	0.2	0.2	2	4	100
EPW_loq_wb_a350_v55_C	C	26,796,435	58.150978	0.5	0.12	0.00070498	35	1	150	0.09119	0.2	0.2	2	4	100
EPW_loq_wb_a375_v55_C	C	26,806,408	58.163616	0.5	0.12	0.00070498	35	1	150	0.09119	0.2	0.2	2	4	100
EPW_loq_wb_a400_v55_C	C	26,812,752	58.169086	0.5	0.12	0.00070498	35	1	150	0.09119	0.2	0.2	2	4	100
EPW_loq_wb_a425_v55_C	C	26,802,942	58.204247	0.5	0.12	0.00070498	35	1	150	0.09119	0.2	0.2	2	4	100

- **Refinement series generated for 2 Alphas**
  - Alpha 2.5
  - Alpha 3.0
- **Mesh sizes ranged from 8M to 1.1B cells**
- **Variation of 8 alphas at the C mesh level**
  - Alpha 2.5
  - Alpha 2.75
  - Alpha 3.0
  - Alpha 3.25
  - Alpha 3.75
  - Alpha 4.0
  - Alpha 4.25
- **20 meshes total**

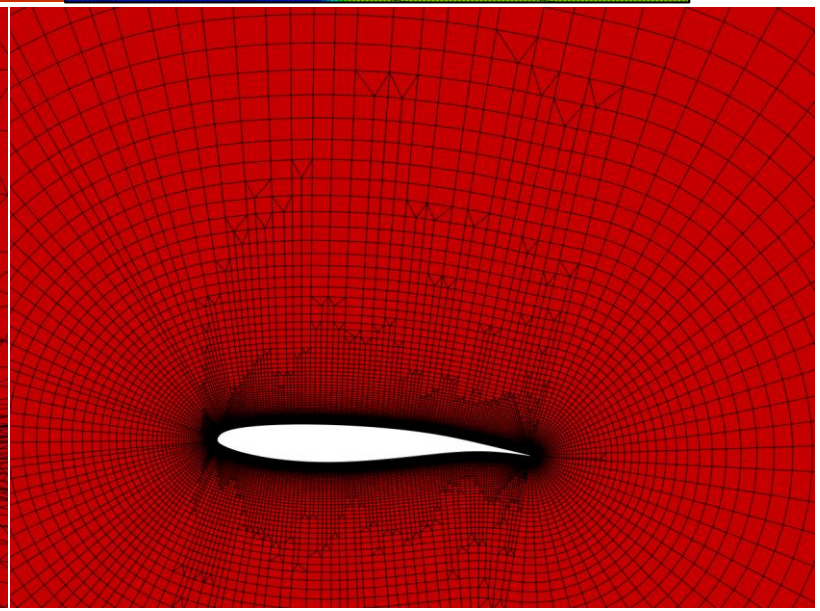
OAT15A Airfoil HeldenMesh Design

- **HeldenMesh's Q2D methodology was used to generate a 1 cell thick 3D mesh from a 2D geometry**
  - Chord = 230, Thickness = 23
- **An initial mesh series was generated with a triangular refinement zone on upper surface**
  - Refinement zone was intended to resolve shocks across a range of Alphas
  - Added resolution to wakes as well
  - **Many users reported difficulty running these grids!**
- **2nd mesh series was generated using a more traditional approach**
  - Farfield boundary was also significantly extended by request of the scatter group





Initial Series (2)



Final Series (4)

Scatter Prediction – Test Case 1A (OAT15A)

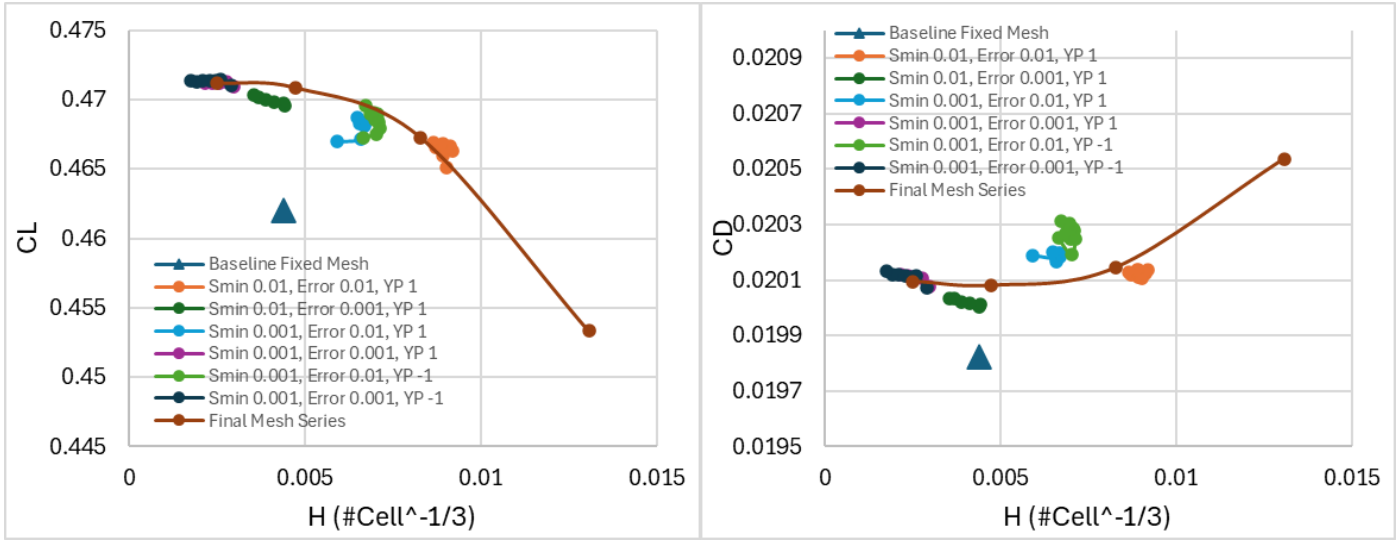
Mesh Name		#Nodes	#Cells (M)	Y+		First Layer DZ	Target Layer Height	DZ at Height	#LAYERS within Height	Geo Growth	SEDGE & SMIN ALL
EPW_2D2_v1	1	18,336	0.010451	4		0.007448	2.50906	1.2502292	10	1.2	0.4
EPW_2D2_v2	2	63,424	0.03583	2		0.003724	2.50906	0.6251146	20	0.6	0.2
EPW_2D2_v3	3	240,390	0.134113	1		0.001862	2.50906	0.3125573	40	0.3	0.1
EPW_2D2_v4	4	954,006	0.528276	0.5		0.000931	2.50906	0.1562786	80	0.15	0.05
EPW_2D2_v5	5	3,760,558	2.076273	0.25		0.0004655	2.50906	0.0781393	160	0.075	0.025
EPW_2D2_v6	6	14,926,966	8.208515	0.1875		0.00023275	2.50906	0.0390697	320	0.0375	0.0125

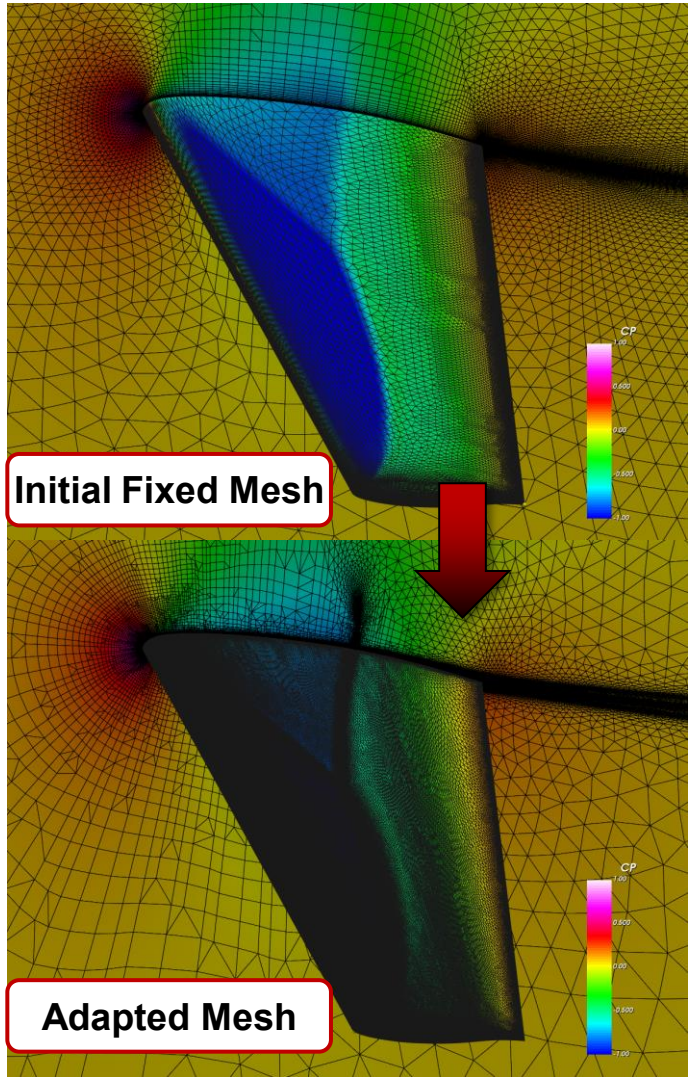
Mesh Name		#Nodes	#Cells (M)	Y+		First Layer DZ	Target Layer Height	DZ at Height	#LAYERS within Height	Geo Growth	SEDGE & SMIN ALL
EPW_2D4_v1	1	1,312	0.001256	4		0.007448	2.50906	1.2502292	10	1.2	0.4
EPW_2D4_v2	2	6,470	0.003352	2		0.003724	2.50906	0.6251146	20	0.6	0.2
EPW_2D4_v3	3	19,302	0.009847	1		0.001862	2.50906	0.3125573	40	0.3	0.1
EPW_2D4_v4	4	63,054	0.031887	0.5		0.001862	2.50906	0.3125573	40	0.3	0.1
EPW_2D4_v5	5	220,638	0.110856	0.5		0.000931	2.50906	0.1562786	80	0.15	0.05
EPW_2D4_v6	6	822,060	0.437438	0.25		0.0004655	2.50906	0.0781393	160	0.075	0.025
EPW_2D4_v7	7	3,952,952	2.085047	0.1875		0.00023275	2.50906	0.0390697	320	0.0375	0.0125

- 2 Refinement series generated
- Mesh sizes ranged from 1K to 8M cells
- 13 meshes total

DPW3 Wing 1 & Wing 2 HeldenMesh Design

- **HeldenAdapt process used to generate solution adaptive grids on Wing1 and Wing2**
  - Starts with a "fixed mesh" baseline grid and solution
  - Uses feature-based adaption to generate a new mesh based on improving the Mach field from the previous mesh/solution
  - Multiple adapt cycles performed to allow wake and shocks to develop
- **Final mesh series was generated from an adapted solution and coarsening/refining all length scales equally (including the boundary layer) to make a series**





Wing 1, Mach 0.76, Alpha 0.5

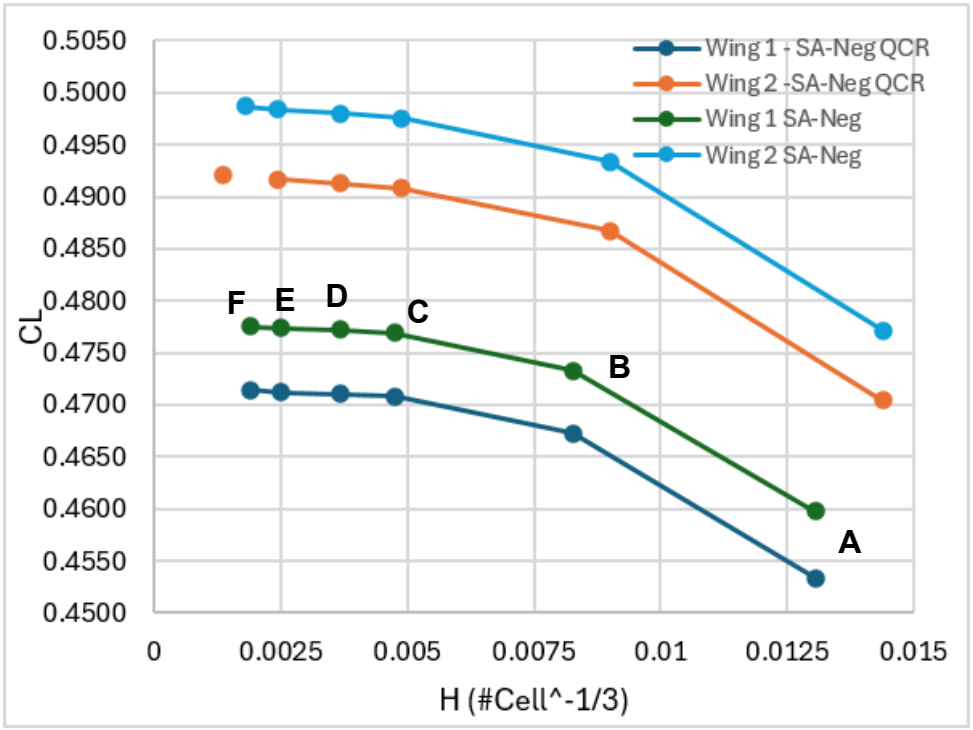
DPW3 Wing 1 & Wing 2 HeldenMesh Design

- **Final Mesh Series for Wing 1 & 2**
  - 7 Grids (A-G)
- **USM3DME run at Mach 0.76, Alpha 0.5, Reusm = 5M**
- **Results seem to indicate grid convergence**

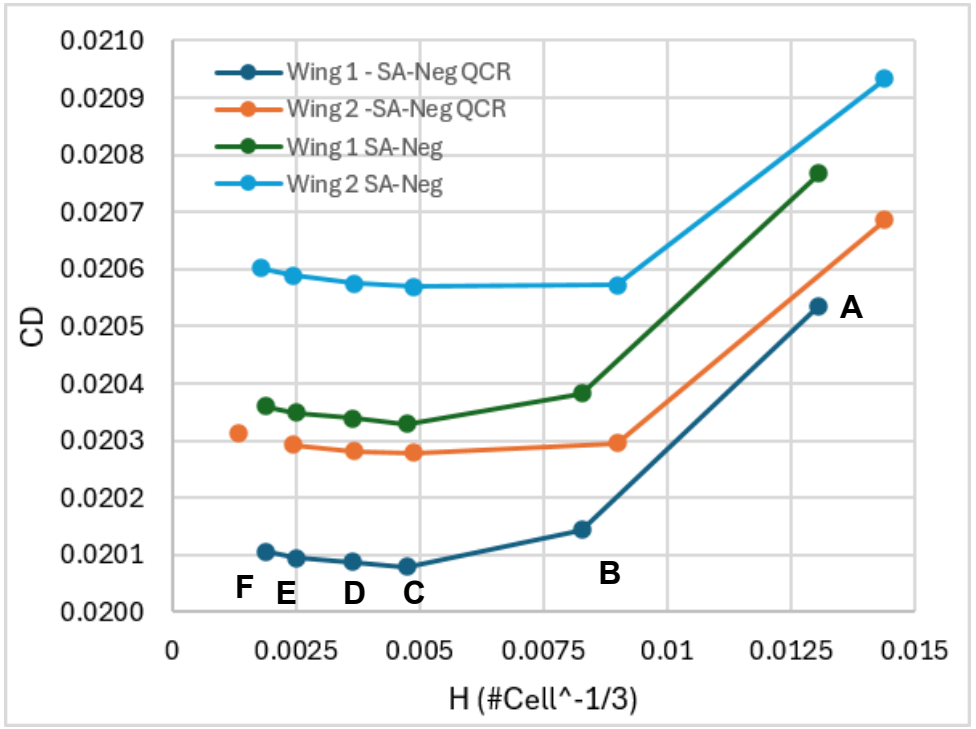
Label	Scale	#Nodes	#Cells
A	4	150,292	448,380
B	2	602,844	1,765,826
C	1	3,340,571	9,371,525
D	0.75	7,272,397	20,379,154
E	0.5	23,207,507	63,444,993
F	0.375	55,411,937	148,371,309
G	0.25	201,813,666	519,732,178

Label	Scale	#Nodes	#Cells
A	4	116,241	335,846
B	2	492,406	1,374,158
C	1	3,271,150	8,562,078
D	0.75	7,751,545	19,969,380
E	0.5	27,201,846	68,824,461
F	0.375	68,148,809	170,253,333
G	0.25	261,008,691	409,097,375

Wing 1



Wing 2



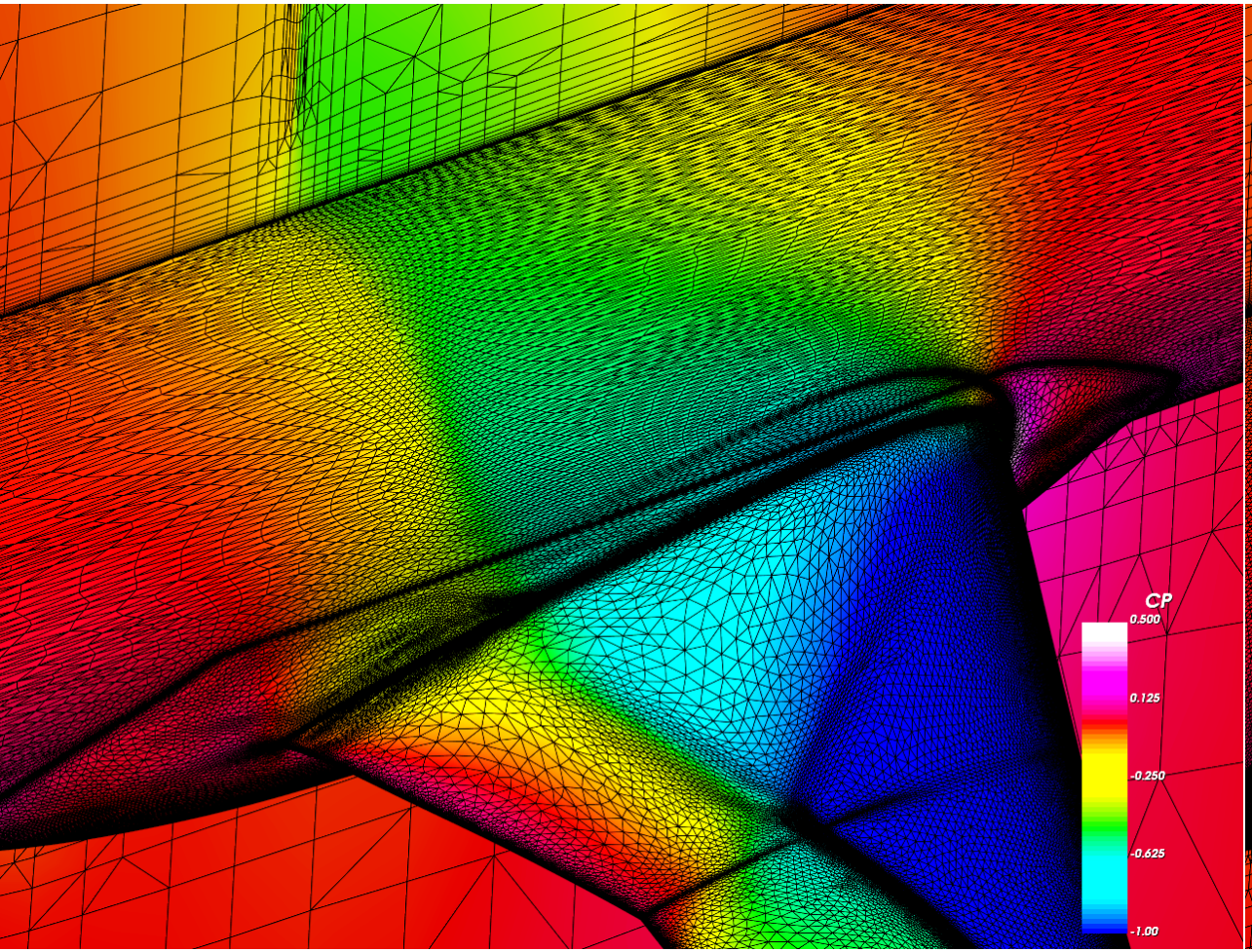
Scatter Prediction – Test Case 1B (DPW3)

Mesh Name		#Nodes	#Cells (M)	Scale	Smin
DPW8_W1_helden_A	A	150,292	0.44838	4	0.02
DPW8_W1_helden_B	B	602,844	1.765826	2	0.01
DPW8_W1_helden_C	C	3,340,571	9.371525	1	0.005
DPW8_W1_helden_B	D	7,272,397	20.379154	0.5	0.00375
DPW8_W1_helden_C	E	23,207,507	63.444993	0.5	0.0025
DPW8_W1_helden_B	F	55,411,937	148.371309	0.25	0.001875
DPW8_W1_helden_C	G	201,813,666	519.732178	0.1875	0.00125

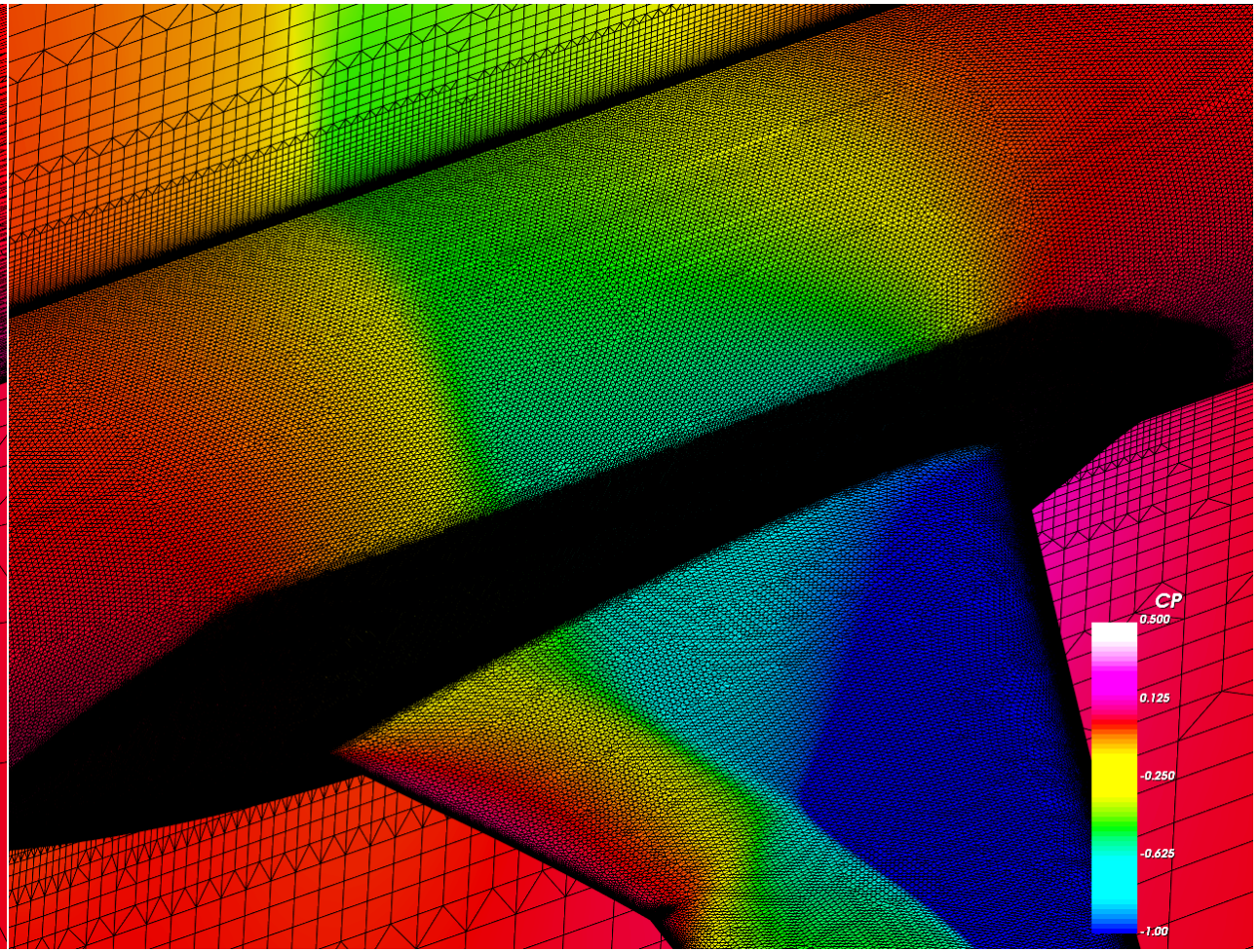
Mesh Name		#Nodes	#Cells (M)	Scale	Smin
DPW8_W2_helden_A	A	116,241	0.335846	4	0.02
DPW8_W2_helden_B	B	492,406	1.374158	2	0.01
DPW8_W2_helden_A	C	3,271,150	8.562078	1	0.005
DPW8_W2_helden_B	D	7,751,545	19.96938	0.5	0.00375
DPW8_W2_helden_A	E	27,201,846	68.824461	0.5	0.0025
DPW8_W2_helden_B	F	68,148,809	170.253333	0.25	0.001875
DPW8_W2_helden_A	G	261,008,691	409.097375	0.1875	0.00125

- Refinement series generated for Wing1 and Wing2
- Mesh sizes ranged from 330K to 520M cells
- All mesh spacings were scaled linearly at the same rate to create mesh series
- 14 meshes total

HeldenMesh – Questions?



HeldenAdapt



Fixed HeldenMesh