Mesh Generation Guidelines

Version: 11.3

3rd Geometry and Mesh Generation Workshop (GMGW-3)
4th High Lift Prediction Workshop (HLPW-4)

The following guidelines are provided for participants in the GMGW-3 and HLPW-4 workshops as a baseline set of recommendations for how to construct meshes for the test cases and challenges presented by both workshops. This document is not meant to be interpreted as a strict set of requirements but instead as a starting point for meshing the High Lift Common Research Model (CRM-HL) in its full-scale nominal landing configuration (with trailing edge (TE) flap deflections of 40°/37°). The material is provided specifically for those involved in generating mesh families.

If you identify problems implementing these guidelines or you adopt different guidelines during the course of preparing your submissions to the workshop please identify and explain the practices you adopt in your Participant Questionnaire (PQ) submission. In addition, if you are part of a Technology Focus Group (TFG), please ensure your TFG coordinator is aware of any difficulties you encounter or changes you adopt since they may create an opportunity for more general investigation and/or learning within the TFG.

Important: these guidelines are designed to try to achieve a "mesh family." This requires that the minimum spacing at the wall and boundary layer growth rate vary according to particular rules, as the mesh is refined. Here, we have chosen the D level mesh (and finer) to have minimum wall spacing that yields estimated y+ values less than one. Similarly, y+ values for the A, B, and C meshes are expected to be one or greater by design. Note, however, that the y+ values are only estimates; the actual levels will vary significantly over the vehicle.

Mesh Family

Surface Mesh

Surface mesh sizing and spacing guidelines are provided below in Table 1 and are based on **C_{REF}= 275.8 in** and a **wing semi-span = 1156.75 in** for the CRM-HL geometry.

Table 1 Recommended Surface Mesh Characteristics

Mesh	Fuselage Cell Size* (Body, Nose, Tail)	Chordwise Spacing† (@Slats, Wing, Flaps LE/TE)	Spanwise Spacing‡ (@Slats, Wing, Flaps Root/Tip)	Cells (Points) on TE§	Mesh Factor
A	≤ 2.25% C_{REF}	≤ 0.225% Local chord	≤ 0.225% Semi-span	4(5)	
B	≤ 1.5% C_{REF}	≤ 0.15% Local chord	≤ 0.15% Semi-span	6(7)	2/3
C	≤ 1.0% C_{REF}	≤ 0.1% Local chord	≤ 0.1% Semi-span	9(10)	2/3
D	≤ 0.75% C_{REF}	≤ 0.075% Local chord	≤ 0.075% Semi-span	12(13)	3/4
E	≤ 0.5% C_{REF}	≤ 0.05% Local chord	≤ 0.05% Semi-span	18(19)	2/3
F	≤ 0.33% C_{REF}	≤ 0.033% Local chord	≤ 0.033% Semi-span	27(28)	2/3

Construct surface Mesh Level A based on the guidelines in Table 1.

Create the next member of the mesh family (Mesh Level B) by consistently applying changes to surface mesh sizing characteristics by a Mesh Factor of 2/3. Examples of other surface mesh characteristics that would typically be scaled by this factor include node counts, edge lengths, stretching ratios, decay rates and source terms (as possible and/or applicable in your toolset).

* Fuselage Cell Size is the maximum edge length recommended for the entire fuselage surface mesh (nose, body, tail) for that mesh level.
† Streamwise chordwise spacings are based on the local chord of each element (slats, wing, and flaps). Use the local slat-element, wing-element, and flap-element chords respectively in your calculations. Chordwise spacings are upper limits on the grid point spacing at the LE/TE of each element.
‡ Spanwise spacings are upper limits on the grid point spacing at the Root/Tip of each element.
§ A minimum of 5 nodes (4 cells) should be placed across the minimum thickness trailing edge for the coarsest mesh (Mesh Level A).

Note when creating Mesh Level D, a variance in the factor applied to surface mesh sizing characteristics (3/4 instead of 2/3) is recommended to keep the cell sizes on the trailing edges proportional throughout the mesh family. This factor is applied throughout Mesh Level D's other surface and volume mesh characteristics for consistency.

Continue creating progressively finer members of the mesh family by repeating this process.

Farfield

Meshes generated for the workshop should have a minimum distance of 1000 C_{REF} between the Outer Mold Line (OML) and the farfield mesh boundary. A hemispherical farfield mesh boundary shape is recommended but not required.

If you are creating a mesh family, use the same farfield distance for all refinement levels in the family.

Volume Mesh

Principal volume mesh characteristics for the mesh families to be generated are included in Table 2.

Table 2. Recommended Volume Mesh Characteristics

Mesh	Initial Wall Spacing Δy^{**}	Estimated Wall y+	Boundary Layer Growth Rate	Required	Mesh Factor
A	0.00239	2.25	1.25	Yes	
B	0.00160	1.5	1.16	Yes	2/3
C	0.00106	1.0	1.10	Yes	2/3
D	0.00080	3/4	1.07	Yes	3/4
E	0.00053	1/2	1.05	No	2/3
F	0.00035	1/3	1.03	No	2/3

Participants are encouraged to create all levels (6) in Table 1. At a minimum, construct 4 levels and bias towards the finest mesh levels you can generate. If you are unable to generate all levels (6), please explain why (identifying and documenting the limiting factors) in your Participant Questionnaire submission.

Additional Considerations

Structured Meshes - Ensure that meshes are consistent as described above. Making your meshes multi-grid friendly is not a requirement. If you wish to do so, please try to ensure that each coordinate direction in every zone has a multi-griddable number of cells. The number of cells should be divisible by 2 at least 4 times. For example, if you have 192 cells in one coordinate direction for a zone, it will have 193 nodes (points) which is multi-griddable 6 times.

Unstructured Meshes - Any reference to spacings should be considered in the context of the solver for which the mesh family is constructed. If the solver is node-centered, spacings in this document refer to inter-nodal spacings. If the solver is cell-centered, the spacings refer to spacings between cell centers.

Wake Resolution – Resolving the wakes passing over the OML and those shed downstream in each mesh is of critical importance to the resulting accuracy of the flow solutions generated. As a result, our workshops are actively trying to learn which wake resolution mesh generation techniques are the most effective. The following wake resolution recommendations are based on past workshops and serve as a starting point for your meshes.

- Cells in wake regions should have an increased resolution compared to the normal gradation of cells away from the OML in the isotropic portion of the mesh.
- Wake clustering and refinement should be enforced over the full chord-length of both the wing and flap elements as well as a minimum of 2 wing chord-lengths downstream from the flap trailing edge.

Please identify and document any approaches and strategies that you use to treat and resolve the wake regions in your meshes in your Participant Questionnaire submission.

** Volume mesh initial wall spacing calculations were performed for the full-scale geometry model (in inches). Initial wall spacings were derived by computing the wall y+ value for mesh level C then scaling that value by each mesh level factor to calculate their respective wall spacings. The corresponding y+ values for each mesh level are estimated from flat plate theory, and are therefore only approximate.