Mesh Size Naming Conventions for GMGWx

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Typically, for the big aerodynamic workshops, meshing guidelines are given for different mesh levels, which are generally labeled as coarse, medium, fine, and extra-fine. For GMGW2, we intend to add another level (super-fine? ultra-fine? cluster-buster?). This short-term view of things neglects the long-term picture: that the nominal goal laid out in the CFD 2030 vision document is 10^{12} cells by 2030. By today's standards, that's something like XXXXXXXXXFine. CFD Vision 2030 foresees that running on 10-100 billion cell meshes will be normal in 2030, so running on 10^{12} cells will be something that is done fairly routinely to confirm grid convergence, as opposed to being an exceptionally rare hero calculation.

If we want to be able to track progress towards the CFD Vision 2030 goals, our premise about naming is wrong: instead of creatively naming finer and finer mesh levels, we need a new system that takes expected size growth into account.

Example: High-Lift Wing-Body Mesh Sizes

Currently, the typical workhorse (i.e., medium) mesh size (as inferred from the DPW6 and HiLPW3 mesh specifications) is around 150M-250M cells (measured as equivalent number of tets, for consistency; yes, this measure is unstructured-centric). I'm assuming geometric growth at a constant rate, and that the ratio between mesh sizes at any given time will be about a factor of 3 (as per DPW and HiLPW guidelines). [1] This suggests the following target sizes as time goes on:

Year	Miniscule	Tiny	XCoarse	Coarse	Medium	Fine	XFine	SuperFine	Hero
2018	3.16M	10M	31.6M	100M	316M	1B	3.16B	10B	31.6B
2021	10M	31.6M	100M	316M	1B	3.16B	10B	31.6B	100B
2024	31.6M	100M	316M	1B	3.16B	10B	31.6B	100B	316B
2027	100M	316M	1B	3.16B	10B	31.6B	100B	316B	1T
2030	316M	1B	3.16B	10B	31.6B	100B	316B	1T	3.16T

Note that this lands us squarely at 10B-100B cells for routine calculations in 2030, and assumes exponential growth in mesh size with time. Among other things, we get the convenient result that today's medium mesh is the coarse mesh of three years from now, and so on. Note that this is *not* the actual trajectory that DPW / HiLiftPW mesh sizes have historically taken, whether because of meshing challenges or solver challenges.

Naming these explicitly by size has some appeal. The easiest way to do this may be simply to use the $\log_{10}$ of mesh size, so that the 2024 Coarse mesh is a Class 9 mesh, and the 2030 XFine mesh is a Class

[1] To make the approximate sizes easily human readable and memorable, I'm going to use $\sqrt{10}$ instead of 3.

11.5 mesh, and so on. Applying non-numeric names gets us back into the XXXXXXXXXXXFine sort of nomenclature, or has names whose meaning changes with time.

Different applications, of course, will have different resolution requirements, both in terms of total mesh size and distribution of cells.

Typical Mesh Spacings

For workshops like DPW and HiLPW, the medium mesh is meant to be a typical production mesh size. Currently, the cell sizes specified for these meshes is something like:

Location	Spacing
Normal to surface	$y^+ = 1$
Wing LE/TE	0.1% of local chord^2
Cells on blunt TE	8
Spanwise @ root/tip	0.1% of semispan
Fuselage nose/tail	1% of MAC

To keep pace with the growth in cell count describes above — an order of magnitude every six years — typical cell dimensions must drop by $\sqrt[3]{10}$ in the same span. This means that dimensions must change like, for instance:

Year	y^+								
	Miniscule	Tiny	XCoarse	Coarse	Medium	Fine	XFine	Superfine	Hero
2018	4.6	3.2	2.2	1.5	1	0.68	0.46	0.32	0.21
2021	3.2	2.2	1.5	1	0.68	0.46	0.32	0.21	0.15
2024	2.2	1.5	1	0.68	0.46	0.32	0.21	0.15	0.1
2027	1.5	1	0.68	0.46	0.32	0.12	0.15	0.1	0.068
2030	1	0.68	0.46	0.32	0.21	0.15	0.1	0.068	0.046

Scaling of the other reference spacings given above is easy to do by inspection.

The number of cells across a blunt TE is subject to serious rounding issues, because an integer number of cells is required. Working from the same size ratios as for other quantities, and rounding as necessary, we get:

Year	Number of cells across a blunt TE								
	Miniscule	Tiny	XCoarse	Coarse	Medium	Fine	XFine	SuperFine	Hero
2018	2	3	4	6	8	12	17	25	37
2021	3	4	6	8	12	17	25	37	55
2024	4	6	8	12	17	25	37	55	80
2027	6	8	12	17	25	37	55	80	117
2030	8	12	17	25	37	55	80	117	172