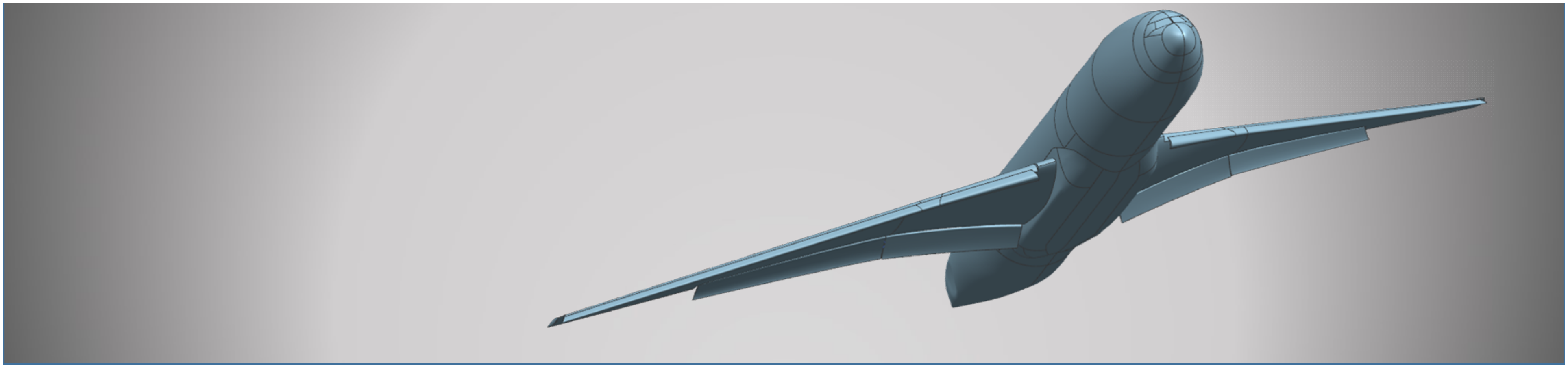

# GMGW-2

## Case 3: Participant P&Q – Initial Analysis

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# Outline

- Introduction
- The Participant Questionnaire (PQ)
- Synthesis of Responses
- Closing Remarks

# Intro: (1/2) Context & Objectives

- The human effort and expertise involved in Geometry and Mesh Generation remains crucial to the successful deployment of CFD
- In order to address the associated challenges posed by the 2030 Vision, it will be necessary to identify which aspects of current practice work well and to understand why others are problematic
- To this end, following the practices established in GMGW-1, each Participant in GMGW-2 Case 3 was required to complete a Participant Questionnaire (PQ)
- These slides summarise the findings of an initial analysis of the responses received
    - A more considered report will be presented at AIAA AVIATION in the summer

# Intro: (2/2) Scope & Approach

- The following slides present select findings of an initial analysis of the responses
  - This analysis has been undertaken independently of all other workshop information (geometry; mesh quality; flow solutions)
    - No feedback had been sought from the originators at the time of preparing these slides
  - Rather than attempting to focus on the details, a broad brush approach has been adopted
    - Much of the detail will have been addressed during the individual Participant Presentations

# The Questionnaire

- Consisted of 48 questions arranged in the following sections:
  - Geometry (Creation, Import, Preparation for Meshing);<br>Meshing (Type, Surface Meshing, Validity & QA, Volume Meshing, Validity & QA);<br>I/O; Miscellaneous
- General themes addressed:
  - Tooling; Process Overview; Problems Encountered; Resource & Expertise Required
  - Intended to address those aspects that would not necessarily be identified via direct analysis of the meshes themselves
- In the event, 9 PQs were received
  - Anonymous completion – not all originators clearly identifiable
  - It is thought that 2 PQs are from Participants who have subsequently withdrawn (...)

# Responses: Geometry Creation (1/3)

- 5/9 Participants generated Outer Mould Lines (OML) from the supplied parameterisation data
- Tools used:
  - BOXERmesh
  - Engineering Sketch Pad (ESP)
  - “in-house” (PID7)
  - NASA Chimera Grid Tools (CGT)
  - RBF Morph (perturbations of Case 3a only)

# Responses: Geometry Creation (2/3)

- Time required to create the OML:
  - BOXERmesh : 4hrs (3D transforms, FFD operations)
  - ESP : 2min (supplied input decks used)
  - “in-house” (PID7) : 2wks (to build IGES generator); “instant” execution time
  - NASA CGT : 120hrs (advanced user – fuselage, wing, tail) + 18days (novice – pylons, pods)
  - RBF Morph : 40hrs (setup RBF configurations)
- Wide variation of approaches adopted
  - From: application of “out-of-the-box” tools/processes
  - To: customised and/or exploratory

# Responses: Geometry Creation (3/3)

- What made the task difficult:
  - BOXERmesh : indirect interpretation of original parameters (eg “pod diameter”)
  - ESP : -
  - “in-house” (PID7) : lack of robust intersection procedure
  - NASA CGT : inconsistencies between supplied parameterisation and STEP file OML
  - RBF Morph : impact of large meshes on “normal operations”
- Expertise required:
  - Novice : ESP
  - Intermediate : BOXERmesh
  - Advanced: “in-house”, CGT, RBF Morph

# Responses: Geometry Import (1/5)

- 8/9 Participants provided responses
  - ESP effectively N/A
  - Some OML creators used supplied STEP data as a point of reference only
- Tools used:
  - ANSYS ICEMCFD
  - ANSYS Space Claim
  - Beta/CAE ANSA
  - BOXERMesh
  - CADfix
  - CREATE-MG Capstone
  - Pointwise
  - NASA CGT

# Responses: Geometry Import (2/5)

- All 8 used supplied STEP file(s), bar PID7 (locally generated IGES)
- Preferred format:
  - ANSYS ICEMCFD : STEP; IGES (“familiarity”)
  - ANSYS Space Claim : STEP
  - Beta/CAE ANSA : STEP, IGES ...
  - BOXERMesh : Parasolid (smoother, more accurate representation of underlying surfaces that IGES or STEP) NB uses STL-like tesselations internally
  - CADfix : ACIS (cf Parasolid [1000m scale limit])
  - CREATE-MG Capstone : STEP
  - Pointwise : “CATIA” (for consistent surface naming practice)
  - NASA CGT : STL (via CADfix) -> .tri (for CGT)

# Responses: Geometry Import (3/5)

- Problems reported:
  - ANSYS ICEMCFD : None; [STEP more segmented – incl. duplicated/triplicated entities – than in-house IGES]
  - ANSYS Space Claim : None
  - Beta/CAE ANSA : None
  - BOXERMesh : None
  - CADfix : Add far-field boundary (via IMIME)
  - CREATE-MG Capstone : 3e default collapse of very thin face on pylon
  - Pointwise : None
  - NASA CGT : inconsistencies with supplied parameterisation

# Responses: Geometry Import (4/5)

- Import timings:
  - ANSYS ICEMCFD : Inexpensive; [seconds]
  - ANSYS Space Claim : Inexpensive
  - Beta/CAE ANSA : 6min
  - BOXERMesh : seconds
  - CADfix : 5min
  - CREATE-MG Capstone : 1min
  - Pointwise : seconds
  - NASA CGT : -

# Responses: Geometry Import (5/5)

- Expertise required:
  - ANSYS ICEMCFD : Novice; [Intermediate]
  - ANSYS Space Claim : Novice
  - Beta/CAE ANSA : Novice
  - BOXERMesh : Novice
  - CADfix : Intermediate (initial setup to handle trailing edges)
  - CREATE-MG Capstone : Novice
  - Pointwise : Novice
  - NASA CGT : Intermediate to Expert

# Responses: Prep for Meshing (1/4)

- Post-import actions required:
  - ANSYS ICEMCFD : Creation of surfaces and curves to support mesh blocking topology; Clean-up randomly generated entites
  - ANSYS Space Claim : see above
  - Beta/CAE ANSA : Divide OML into meaningful PIDs; cut in half (symmetry plane); create far-field boundary; assign spacing; cut sharp conic end of engine
  - BOXERMesh : Modification (renaming/grouping faces)
  - CADfix : Create far field boundary; setup to handle trailing edges
  - CREATE-MG Capstone : Sizing attribution
  - Pointwise : None
  - NASA CGT : N/A

# Responses: Prep for Meshing (2/4)

- Effort required:
  - ANSYS ICEMCFD : 4hrs; 1-2 days (write clean-up script)
  - ANSYS Space Claim : 4hrs
  - Beta/CAE ANSA : 0.5hr
  - BOXERMesh : 1hr
  - CADfix : N/A
  - CREATE-MG Capstone : 15min
  - Pointwise : None
  - NASA CGT : [OML generated analytically in 3 days]

- NB: Minutes required to edit ESP input files to create 5 different OPAM cases (no other action required)

# Responses: Prep for Meshing (3/4)

- IT requirements:
  - ANSYS ICEMCFD : Normal PC/laptop; 20 cores; 128GB RAM
  - ANSYS Space Claim : Normal PC/laptop
  - Beta/CAE ANSA : No significant requirements
  - BOXERMesh : 2cores; 500MB RAM
  - CADfix : Workstation/Laptop; little of available RAM used
  - CREATE-MG Capstone : PC
  - Pointwise : None
  - NASA CGT : Mixed resources used – not used to capacity

# Responses: Meshing (1/4)

- Wide variety of approaches taken
- Types:
  - 3 Structured multiblock (ANSYS ICEMCFD *2), ANSA
  - 1 Structured overset : CGT
  - 5 unstructured :
    - BOXERMesh
    - Prisms/Tets (IMIME, MARS, Pointwise)
    - All tet (CREATE-MG Capstone, Pointwise)
  - NB: PID9 ((ESP+)Pointwise) generated families of 3 different mesh types (all tet; tet/prisms; mixed – all four element types)
- Sizes: 10m – 414m DOF volume meshes
  - Files from 0.2 – 23GB (each output in order of minutes)
- Only select observations are reported in the following slides
  - Most details will have been covered in Participant presentations

# Responses: Meshing (2/4)

- Not all mesh generation software supported the requested Mesh Validity and Quality Assessments
  - e.g. Distance between surface mesh points and OML
- In some cases, metrics are hard-coded into the generation process and detailed output was not available to users
- Difficult to compare histograms with inconsistent dependent variable ranges
  - A lesson for next time or something to re-visit now?

# Responses: Meshing (3/4)

- Generation times:
  - 3 Structured multiblock
    - ANSYS ICEMCFD *2 : 100hrs, 200hrs(prep), then 3mins
    - ANSA 100hrs+50hrs
  - 1 Structured overset : CGT o(day(s))
  - 5 unstructured :
    - BOXERMesh 1hr / 2hrs 35min
    - Prisms/Tets (IMIME, Pointwise/MARS, Pointwise) 45min+4.25hrs, 30mins+1hr10mins, 3hrs 30min
    - All tet (CREATE-MG Capstone, Pointwise) 10min+4-15hrs, 3hrs 30min
- Expertise Required:
  - Novice : (ESP+) Pointwise (AutoMesh Glyph scripts); CREATE-MG (w/o bugs)
  - Intermediate : BOXERmesh, Pointwise/MARS, IMIME
  - Expert : ANSA, ANSYS ICEMCFD, CGT(mixed team), CREATE-MG (w bugs)

# Responses: Meshing (4/4)

- Various strategies were adopted to determine when (volume) meshing was completed, e.g.:
  - Once domain is gridded and orphan points reduced to as low as feasible (CGT)
  - Ballpark of expected number of elements (CREATE-MG)
  - Script completion (Pointwise)
  - Software notification (ANSYS ICEMCFD, BOXERmesh, IMIME)
- No post-solution revision of meshes was reported
- No case-specific problems assoiciated with mesh generation were reported

# Closing Remarks

- A wide range of approaches were adopted accross the group of Participants
- (Subject to the limited scope of the Case 3 activity – and the self-assessment inherrent in the PQ)
  - Tooling developed specifically for this type of activity exists and is available for Novice users
  - Bespoke processes can be developed, but these require time (upto O(month)) to establish
- Potential further PQ data requirements
  - There appear to be 2 missing PQs
  - Appetite for re-visiting (standardising) the V&QA metric reporting?

Thank you for your attention