HiLiftPW-2
Overview and Grid Systems

Jeffrey Slotnick
The Boeing Company

Mark Chaffin
Cessna Aircraft Company

2nd AIAA CFD High Lift Prediction Workshop
San Diego, California, USA
22-23 June 2013
Outline

• Organizing Committee
• Objectives
• Configuration
• Test Cases
• Agenda
• Participant Statistics
• Grid Systems
• AIAA Special Sessions
• Acknowledgments
Organizing Committee

• Jeffrey Slotnick and Tony Sclafani
  The Boeing Company

• David Levy* and Mark Chaffin
  Cessna Aircraft Company

• Ralf Rudnik and Kerstin Huber
  DLR – German Aerospace Center

• Thomas Wayman
  Gulfstream Aerospace Corporation

• Thomas Pulliam
  NASA Ames Research Center

• Chris Rumsey and Judi Hannon
  NASA Langley Research Center

• Carolyn Woeber
  Pointwise, Inc.

• Dimitri Mavriplis* and Michael Long
  University of Wyoming

* DPW organizing committee member
Objectives

• Assess the numerical prediction capability (meshing, numerics, turbulence modeling, high-performance computing requirements, etc.) of current-generation CFD technology/codes for swept, medium/high-aspect ratio wings in landing/take-off (high-lift) configurations

• Develop practical **modeling guidelines** for CFD prediction of high-lift flowfields

• Advance the understanding of **high-lift flow physics** to enable development of more accurate prediction methods and tools

• Enhance CFD prediction capability to enable practical **high-lift aerodynamic design and optimization**
Configuration

- DLR F11 wing/body high-lift configuration
  - Used for EUROLIFT I test campaigns
  - Rich set of low- and high-Re test data
  - CAD model made available
  - Representative of modern transport high-lift systems
Test Cases

Case 1 – Grid Convergence Study (REQUIRED)
DLR F11 “Config 2”
Slat 26.5 deg, Flap 32 deg (Wing/Body/HL system + SOB Flap Seal)

- Mach = 0.175
- Angles-of-attack to be computed (deg) = 7, 16 (OPTIONAL: 18.5, 20, 21, 22.4)
- Reynolds number = 15.1 million based on mean aerodynamic chord (MAC)
- RUN FULLY TURBULENT

33 Datasets
Case 2 – Reynolds Number Study

DLR F11 “Config 4”

Slat 26.5 deg, Flap 32 deg (Config 2 + Slat Tracks and Flap Track Fairings)

Flow solutions on comparable medium mesh density from Grid Convergence Study

Case 2a (REQUIRED) - Low Reynolds Number Condition

Mach = 0.175
Angles-of-attack to be computed (deg) = 0, 7, 12, 16, 18.5, 19, 20, 21
Reynolds number = 1.35 million based on mean aerodynamic chord (MAC)
RUN FULLY TURBULENT

19 Datasets

Case 2b (REQUIRED) - High Reynolds Number Condition

Mach = 0.175
Angles-of-attack to be computed (deg) = 0, 7, 12, 16, 18.5, 20, 21, 22.4
Reynolds number = 15.1 million based on mean aerodynamic chord (MAC)
RUN FULLY TURBULENT

20 Datasets

Case 2c (OPTIONAL) - Low Reynolds Number Condition with Transition

Mach = 0.175
Angles-of-attack to be computed (deg) = 0, 7, 12, 16, 18.5, 19, 20, 21
Reynolds number = 1.35 million based on mean aerodynamic chord (MAC)
RUN WITH SPECIFIED TRANSITION and/or TRANSITION PREDICTION METHODS

4 Datasets
Test Cases

Case 3 – Full Configuration Study (OPTIONAL)
DLR F11 “Config 5”
Slat 26.5 deg, Flap 32 deg (Config 4 + Slat Pressure Tube Bundles)
Flow solutions on comparable medium mesh density from Grid Convergence Study

Case 3a - Low Reynolds Number Condition
Mach = 0.175
Angles-of-attack to be computed (deg) = 0, 7, 12, 16, 18.5, 19, 20, 21
Reynolds number = 1.35 million based on mean aerodynamic chord (MAC)
RUN FULLY TURBULENT and/or RUN WITH TRANSITION

Case 3b - High Reynolds Number Condition
Mach = 0.175
Angles-of-attack to be computed (deg) = 0, 7, 12, 16, 18.5, 20, 21, 22.4
Reynolds number = 15.1 million based on mean aerodynamic chord (MAC)
RUN FULLY TURBULENT and/or RUN WITH TRANSITION

3 Datasets
3 Datasets
Test Cases

Case 4 – Turbulence Model Grid-Convergence Verification Study (OPTIONAL)

2-D bump from http://turbmodels.larc.nasa.gov/bump.html

The purpose of this case is to investigate the consistency in implementation of turbulence models in a controlled study. The grids supplied at the above website must be used.

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Re=3 million per unit length
Tref=540°R
Participants must run at least the finest 3 supplied grids.
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Participant Guidelines & Information

• All participant presentations will be 15 minutes with 5 minutes Q/A (please wait until speaker is finished to ask questions)
• Presentations will be uploaded to the HiLiftPW website (http://hiliftpw.larc.nasa.gov) after the workshop
• Updates (if desired) to the datasets will be collected after the workshop
Participant Statistics

- **26** total presentations (24% increase from HiLiftPW-1)
- Representation from **11** countries (38% increase)
- ~**60%** non-US participation (50% increase)
Participant Statistics (2)

- Broad participation from aerospace community
- Significant increase in participation from academia compared to HiLiftPW-1
Participant Statistics (3)

- **37** total datasets (+2 compared to HiLiftPW-1)
- Most participants used committee-generated grid systems

![Pie chart showing the distribution of datasets generated by committee and participant.](chart.png)
Participant Statistics (4)

- More balanced use of structured or unstructured grids compared to HiLiftPW-1

![Pie chart](image)
Outline

- Organizing Committee
- Objectives
- Configuration
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- Grid Systems
- AIAA Special Sessions
- Acknowledgments
Gridding Guidelines

- Approximate initial spacing normal to all viscous walls ($Re=15.1M$ based on $CREF=MAC=347.09\text{ mm}$):
  - Coarse: $y+ \sim 1.0\ dy \sim 0.00055\ mm$
  - Medium: $y+ \sim 2/3\ dy \sim 0.00037\ mm$
  - Fine: $y+ \sim 4/9\ dy \sim 0.00024\ mm$
  - Extra-fine: $y+ \sim 8/27\ dy \sim 0.00016\ mm$

- Same grids to be used for low $Re$ ($1.35M$) cases
- Total grid size to grow ~3X between each grid level for grid convergence cases
  - For structured meshes, this growth is ~1.5X in each coordinate direction
- Growth rate of cell sizes in the viscous layer should be < 1.25
  - Include a region with constant cell spacing (growth rate = 1.0) to capture wakes from upstream elements
- Farfield located at ~100 $C_{REF}$’s for all grid levels
- For the Medium Baseline Grids:
  - Chordwise spacing for wing and tail leading edge (LE) and trailing edge (TE) ~0.1% local chord
  - Spanwise spacing at root and tip ~0.1% local semispan
  - Cell size near fuselage nose and after-body ~1.0% $CREF$

- Wing and Tail Trailing Edge Base:
  - Minimum of 4 cells across TE base for the coarse mesh
  - Minimum of 6 cells across TE base for the medium mesh
  - Minimum of 9 cells across TE base for the fine mesh
  - Minimum of 14 cells across TE base for the extra-fine mesh

- Be multi-grid friendly

No grid size targets specified
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* Case 1
Grid Systems

Committee-supplied Grids, HiLiftPW-2
Case 1

- X-C
- C
- M
- F
- X-F

E (str)  overset
D (uns)  tet or mixed
C (uns)  tet or mixed
B (uns)  mixed
A (uns)  hex
A (str)  1-to-1

N (number of grid points), millions
Grid Systems

Case 2 Medium Grid
Spanwise Cut at 750mm Wing

B SOLAR
C Pointwise
D VGRID
E Overset
Grid Systems

Case 2 Medium Grid
Spanwise Cut at 750mm
Wing

“Cell Volume” Metric

B SOLAR
C Pointwise
D VGRID
E Overset
Grid Systems

Case 2 Medium Grid
Spanwise Cut at 750mm Flap

B SOLAR
C Pointwise
D VGRID
E Overset
Grid Systems

Case 2 Medium Grid
Spanwise Cut at 750mm Flap

“Cell Volume” Metric
HiLiftPW Timeline

- **Chicago 2010** – HiLiftPW-1
  - SPECIAL SESSIONS – Orlando 2011
  - SPECIAL SESSIONS – New Orleans 2012

- **San Diego 2013** – HiLiftPW-2
  - SPECIAL SESSIONS (PLANNED) – National Harbor 2014
  - SPECIAL SESSIONS (PLANNED) – Atlanta 2014
### AIAA Special Sessions

#### January 2014 (SciTech - National Harbor, MD, USA)
- **13 Papers + Forum** (1 six- and 1 eight-paper session)

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#### Summer 2014 (APA – Atlanta, GA, USA)
- **14 Papers** (1 six- and 1 eight-paper session)

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Acknowledgments

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  Stefan Melber-Wilkending

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  Mike Rogers, Rich Wahls, Greg Gatlin

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- Alenia Aeronautica
- CASA
- CIRA
- Dassault Aviation
- ETW (European Transonic Windtunnel GmbH)
- DLR
- FOI
- IBK (Ingenieurbüro Dr. Kretschmar)
- INTA
- NLR
- ONERA

* EUROLIFT was co-funded by the European Commission
Back-Up
Grid Systems

Case 2 Medium Grid
Cut at X=1990mm
Wing

B SOLAR
C Pointwise
D VGRID
E Overset
Grid Systems

Case 2 Medium Grid
Cut at X=1990mm
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“Cell Volume” Metric

B SOLAR
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