HiLiftPW-3
JSM wind tunnel experiment
Overview

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Outline

- **JSM wind tunnel experiment**
  - Overview
  - Influence of standoff height
  - Influences of HLDs support brackets
  - Slat Static Pressure Tubes treatment
  - Flap Static Pressure Tubes treatment

- **Data for HiLiftPW-3**
  - Conditions for HiLiftPW-3
  - CAD model modification
  - Forces, Moment Data
  - Pressure Coefficient Data
  - Oil Flow Images
  - Transition Information
**JSM Overview (1/2)**

- **JSM J**axa highlift configuration **S**tandard **M**odel
  - Tested in 2005 ~ 2009
- **Model specification**
  - 17% of assumed aircraft (100 PAX)
  - 90% span slat
  - Inboard single- or double-slotted flap
  - Outboard single-slotted flap
  - Cylindrical flap
  - Pylon-mounted nacelle
  - FTFs
  - No trip dot
- **Test facility**
  - 6.5m by 5.5m JAXA low-speed wind tunnel (JAXA-LWT1)
    - Closed-circuit, atmospheric pressure
  - Estimated* tunnel turbulence intensity was Tu = 0.16 percent (via 2003 JAXA study)

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Standoff: 2.3 m
MAC: 0.529 m
Aspect ration: 9.42
Sweep angle at L.E.: 33°
• **Measurements**
  - Forces and moments (5-components balance)
  - Surface pressure distributions (456-taps on mainly 7-sections)
  - Surface flow pattern (oil-flow visualization)
  - Boundary layer transition location (china-clay visualization)
  - Model deformation (optical stereo measurement with target markers)

• **Tested cases in WTT**
  - High-lift setting effect
    ✓ Flap deflection study
      • Inboard single- or double-slotted flap: 30° or 35°
      • Outboard single-slotted flap: 30° or 35°
    ✓ Slat/flap position effect
  - Nacelle on/off effect
  - Nacelle chine effect
  - Influence of standoff height
Basic characteristics

- Laminar separation bubbles locate on the flap surface.
- Flow separation in the tip region occurs at higher AoA.
- Stall is caused by large separation in the wing-root region.

Case 2c
M=0.172 (60m/s) with nacelle, single-slotted flap in 30°
A standoff height of 60 mm (≈ twice of the displacement thickness) was selected based on wind tunnel tests and extensive CFD studies.
Influences of HLDs support brackets

- Flow separation near wing tip appears due to slat support
- Slat support causes flow separation on the main wing near the wing-tip
- Local flow separation appears on flap due to FTF
Slat Static Pressure Tubes

- Pulled in the main wing along the slat supports circled by red
- Wrapped by aluminum tape
- Tubes are not included in the CAD model this time
Flap Static Pressure Tubes

- Pulled in the main wing along flap supports #1 (magenta) and #2 (blue)
- Covered by FTFs
- Tubes are not included in the CAD model this time.

1. Static pressure tubes for flap are pulled in main wing along flap supports.
2. The flap support and static pressure tubes are covered by FTF.
3. Protruded pressure tubes are covered by tape.
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Conditions for HiLiftPW-3 Data

- Re = 1.93 million per MAC (mean aerodynamic chord)
- M = 0.172 (60 m/s)
- Nacelle-on/off configurations with minimal standoff effect
  - Flap
    - Inboard/outboard single-slotted flaps with 30° deflection
    - 35° deflection & inboard double-slotted flap induced larger flow separation over the flap and it caused large scattering of CFD in a 2006 workshop in JAPAN.
    - Gap between the flaps was continuously connected.
  - Slat
    - Nominal 25° deflection setting for both nacelle on/off configurations
As-built CAD model provided by JAXA was modified for CFD studies by HiLiftPW-3 committee.

- To fill small gaps and smooth out small bumps in junctions between parts.
- Detail information is shown in the Appendix.
Balance data was measured in the “pitch & pause” mode

Wind tunnel wall interferences correction
- Model blockage and downwash were corrected by the method based lifting liner theory which is proposed by Alan Pope et all.

Pressure measurement was done at the same time without the tube interference (tare)

Repeatability in three test campaigns

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<th>AoA [deg]</th>
<th>Deviation from the mean value</th>
<th>Balance Accuracy</th>
<th>Recommended (*)</th>
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<td>±0.0150</td>
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</tbody>
</table>

(*) F. M. Payne, AIAA Paper 99-0306,
“Low Speed Wind Tunnel Testing Facility Requirements: A Customer’s Perspective”
Pressure Coefficient Data

- Cp distribution from 436 taps
  - Main-wing, slat, flap, fuselage and nacelle upper surface
- 6 AoA conditions
- Pressure data is not corrected
difference is about 1%

![Diagram showing pressure coefficients at various sections](image)

- e.g. C-C section @ AoA=10°
Oil Flow Images

- Surface flow visualization with fluorescence oil and UV-light
- 4 AoA conditions

(*) The nacelle-pylon OFF conditions were taken with standoff of 30 mm height while all other data for this workshop used 60 mm standoff height. However, the differences in aerodynamic forces between the 30 mm and 60 mm standoff was small.
Transition Information

- Transition detection with china clay visualization
- 3 AoA conditions only for Case 2c (Nacelle-on)
- Transition location on the upper surface was digitized by the visual survey
  - The wing lower surface, nacelle, and pylon were also evaluated, but transition was extremely complex, so they have not been similarly digitalized. The boundary layer on the fuselage became fully turbulent well ahead of the wing.

![China clay picture](image1)

AoA=10.47 °

![Digitized in CAD](image2)
References

- **Wind tunnel testing**

- **Wind tunnel interferences (standoff effect)**

- **CFD**

- **Nacelle-chine effect**
Appendix

CAD model modification
by HiLiftPW-3 committee
Inboard Edge of Inboard Slat

As-built CAD model
No changes

CFD CAD model
Outboard Edge of Inboard Slat

As-built CAD model

CFD CAD model

0.2648 mm

No gaps
Outboard Edge of Outboard Slat

As-built CAD model

CFD CAD model

No gaps

0.0389 mm
Inboard Edge of Aft Flap

As-built CAD model

CFD CAD model

Flap LE extended

Model overlapped

0.2555 mm
Main & Aft Flaps (2)

As-built CAD model

1 mm gap

CFD CAD model
Flap Connector

As-built CAD model

Slightly different

Model overlapped
Flap Track Fairings

As-built CAD model

CFD CAD model

Fillet added

Slightly different fillet
Gap between Nacelle & Pylon
Wing Element Edge & Pylon

As-built CAD model

CFD CAD model
As-built CAD model

CFD CAD model

Model overlapped