High-Speed Airframe Integration Workshop

Transonic Performance

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8-FOOT TRANSONIC PRESSURE TUNNEL

Temperature = 120 deg. F

- H. P. Limit
- Flow Quality Limit
- Compressor Limit
- Flow Quality Limit

- q, psi: 9.0
- P, atm: 2.00 (Shell Pressure Limit)
- R/ft

- M
### Transonic CFD Capabilities/Methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Analysis</th>
<th>Design</th>
<th>Wing/Body</th>
<th>Complex</th>
<th>Viscous</th>
<th>Aeroelastic</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSD</td>
<td>X</td>
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<td>X</td>
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<tr>
<td>FP</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>*</td>
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<tr>
<td>Euler</td>
<td>X</td>
<td>*</td>
<td>X</td>
<td>*</td>
<td></td>
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</tr>
<tr>
<td>NS</td>
<td>X</td>
<td>*</td>
<td>X</td>
<td>*</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

*X = Current  * = Planned*
Planned Test of HSCT in 8-Foot TPT

- 0.01-scale models
- Square and curved tips
- Force, moment and wing pressure data
- Lateral data for stability and control group
- Scheduled for Fall 1989
Transport Wing Geometry

- Lower Surface Channels
- Upper Surface Channels
- Inboard Flaps
- Outboard Flap

22.5 in.
Effect of Static Aeroelastic Deflections on Wing Pressures

<table>
<thead>
<tr>
<th>Theory/Experiment</th>
<th>$\alpha$</th>
<th>$\eta$</th>
<th>$q$, psf</th>
<th>$R \times 10^{-6}$</th>
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</thead>
<tbody>
<tr>
<td>Theory</td>
<td>4.00</td>
<td>0.56</td>
<td>536</td>
<td>1.58</td>
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<tr>
<td>Theory</td>
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<td>0.56</td>
<td>1613</td>
<td>4.87</td>
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<td>2.63</td>
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</tbody>
</table>

(FLAGGED SYMBOLS DENOTE LOWER SURFACE)
Aeroelastic Design Procedure

Start

Flow conditions
Initial geometry

Aerodynamic
analysis module

Pressure distribution
current geometry

Design cycle
limit

Yes

No

Target pressures

New geometry

Design module

Stop
HIGHLY SWEPT FIGHTER WING GEOMETRY

$\eta = 0.52$

0.77
HIGHERLY-SWEPT FIGHTER WING CASE

\[ M = 0.85 \]
\[ \eta = 0.52 \]

\[ C_p \]

\[ C_p^* \]

--- Initial
--- Final
..... Target

\[ x/c \]
Transonic CFD Strengths and Weaknesses

• Strengths:
  o Potential codes are fast and have built-in grid generation
  o Extensive experience base with potential codes
  o Good prediction of lift and pressures for attached flow
  o Design and aeroelastic modules are portable

• Weaknesses:
  o Potential codes are not geared to low-AR, highly-swept configurations
  o Euler and NS codes are relatively slow and expensive
  o Limited experience with Euler and NS codes
  o Drag predictions are questionable
Advanced Technologies Applicable to HSCT

- Induced drag reduction:
  - Tip blowing
  - Winglets
  - Tip shape

- Viscous drag reduction:
  - Hybrid LFC
  - Transonic and supersonic design
HSCT Geometry

design station
Supersonic Wing Design Results

Mach = 3.0 \quad \alpha = 1.5

$C_p$ vs. $2y/b$ graph with three different lines:
- **initial**
- **final**
- **target**
Interdisciplinary Interface Requirements

- **Input:**
  - Detailed geometry descriptions
  - Transonic cruise/climb flight conditions
  - Wing structural characteristics
  - Design constraints

- **Output:**
  - Longitudinal aerodynamic characteristics
  - Wing air loads
  - Modified geometry
Transonic Research Goals

- Develop experience base with advanced methods
- Develop capability to analyze and design low-AR configurations
- Calibrate codes using transonic data for HSCT
- Apply induced drag reduction technologies