Fundamental Aeronautics Program

High Speed Project

Three-Stream Jet Test Plans
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Acoustics Technical Working Group
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Objectives of Study

• Develop baseline for future third-stream concepts
• Determine noise reduction potential of “stair-stepping” velocity
• Guide future third-stream designs
  – Offset stream concepts
  – Ejectors
  – Inverted velocity concepts
• Develop prediction tools for three-stream jets
Previous Three-Stream Investigation

90°

Simulated 2-Stream Jet, $BPR_{fan/core} = 4.7$
Simulated 2-Stream Jet, $BPR_{fan/core} = 6.3$

$A_b/A_c = 2.82$
$A_t/A_c = 0.56$

NPR = Nozzle Pressure Ratio
NTR = Nozzle Temperature Ratio

150°

$NTR_c = 3.2$
Plan for 2014 Study

- Study will use a three-stream, externally mixed, convergent nozzle system
- Existing core nozzles will be used
- Core and fan streams will be subsonic
- Third stream will include subsonic and supersonic operating conditions
- Study will investigate the impact of area ratios and operating conditions on resulting far-field acoustics
Existing Dual-Stream Nozzle System

- Core-nozzle trailing edges and plugs are replaced to go from externally plugged to internally plugged.
- Dual-stream nozzle system mounts on externally mixed model.
- Three-stream model required for current experiments mandates the manufacture of new fan nozzles.
Target Investigation

- Use existing core internally and externally plugged trailing edge pieces and plugs
- Manufacture new fan and third-stream trailing edge pieces
- Baseline (no flow) nozzle for third stream
- Operating conditions of interest
  - \( 2.5 \leq \text{BPR}_{\text{tot}} \leq 5.5 \)
    - \( \text{BPR}_{\text{tot}} = (\text{fan} + \text{third}) / \text{core} \)
  - \( 1.5 \leq \text{NPR}_{f,c} \leq 1.8 \)
  - \( 1.3 \leq \text{NPR}_t \leq 2.4 \)
  - \( 1.0 < \text{NTR}_c < 3.2 \)
  - \( \text{NTR}_f = \text{NTR}_t = 1.25 \)
  - Range of area ratios
Proposed Experiments

\[0.6 \leq \frac{U_b}{U_c} \leq 1\]
\[0.6 \leq \frac{U_t}{U_b} \leq 1.2\]
\[1.0 \leq \frac{T_c}{T_a} \leq 3.2\]
Proposed Model

- Model will benefit from PIV measurements
Status

- Core and fan nozzle flow lines complete
- Preliminary CFD complete

- \( \frac{A_b}{A_c} = 1.0 \)
  \( \frac{A_t}{A_c} = 1.0 \)

- \( \frac{A_b}{A_c} = 1.75 \)
  \( \frac{A_t}{A_c} = 1.0 \)

- \( \frac{A_b}{A_c} = 2.5 \)
  \( \frac{A_t}{A_c} = 1.0 \)

TKE
Equal Thrust

- Dual Stream Jet
- Three-Stream Jet

- Core and fan nozzle flow lines complete
- Preliminary CFD complete
Next Steps

- Complete co-annular nozzle-system RANS solutions for all area ratios and use JENO to predict far-field noise
- Design and manufacture hardware
- Conduct RANS investigations of offset stream concepts
- Conduct RANS investigations for ejector concepts
- Complete noise experiments for co-annular and possibly offset stream concepts – Feb. 2014
- Complete follow-on PIV experiments – Spring 2014