National Aeronautics and Space Administration

Fundamental Aeronautics Program

High Speed Project

Three-Stream Jet Test Plans

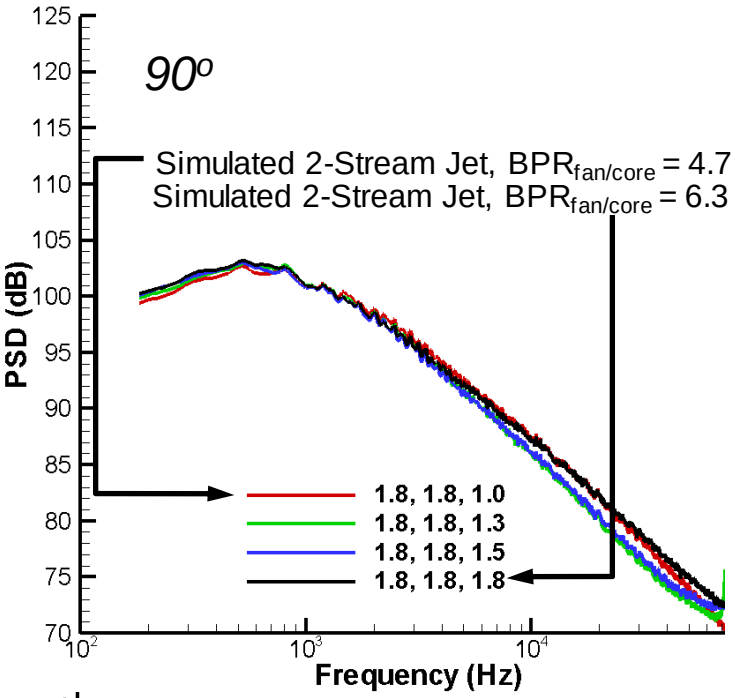
Brenda Henderson, NASA Glenn Research Center

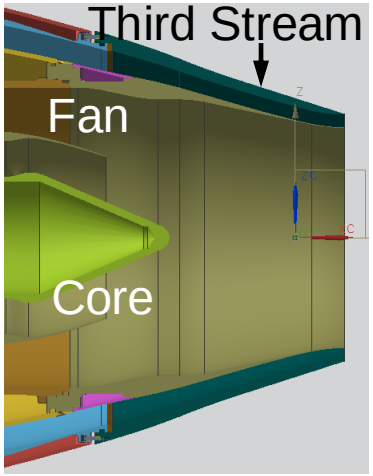
Acoustics Technical Working Group
April 23 – 24, 2013
Cleveland, Ohio

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

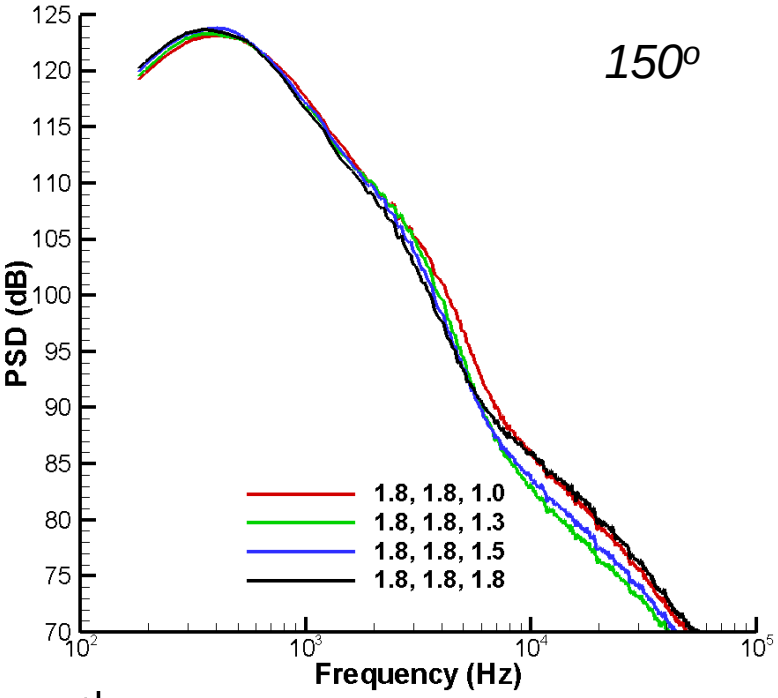
Previous Three-Stream Investigation

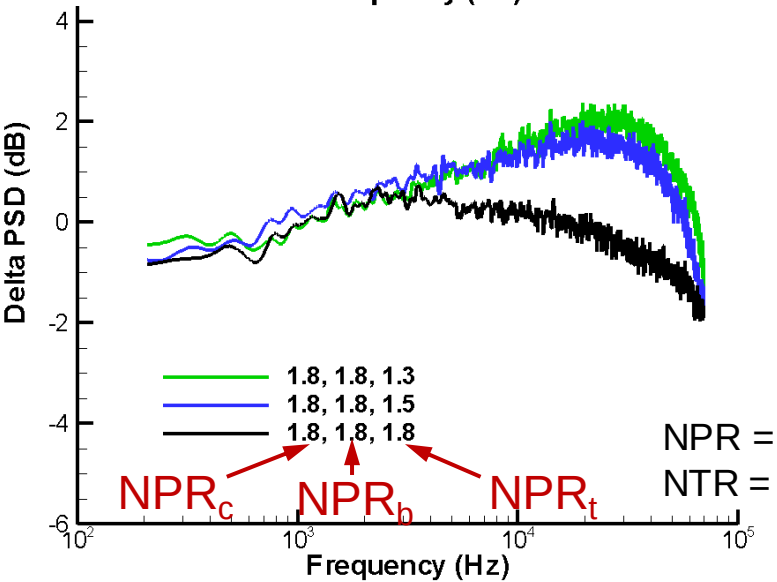




A_b/A_c = 2.82

A_t/A_c = 0.56

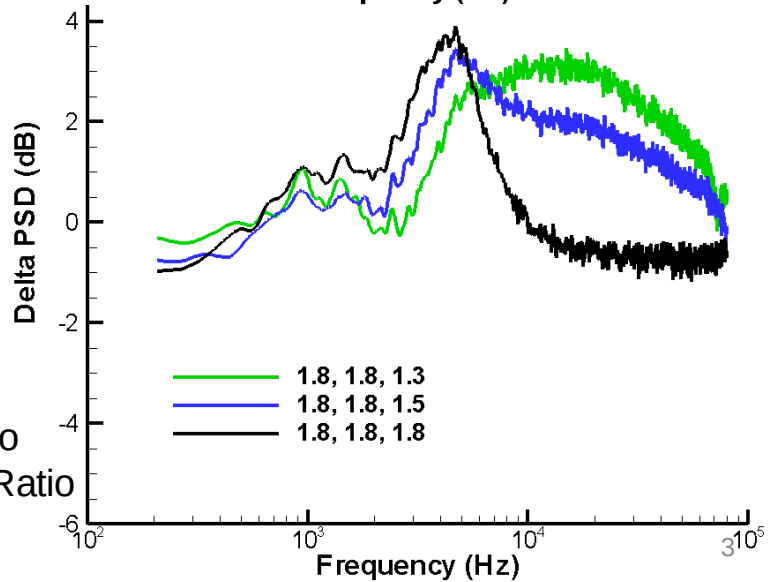




NTR_c = 3.2

NPR = Nozzle Pressure Ratio

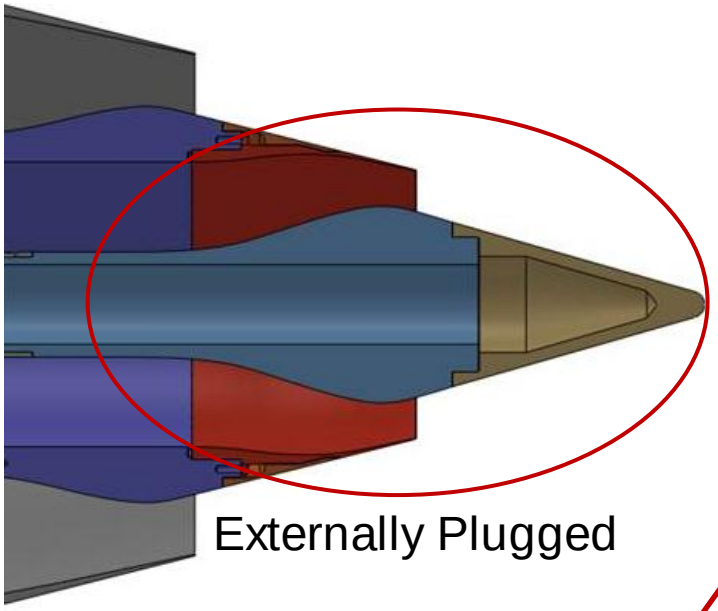
NTR = Nozzle Temperature Ratio

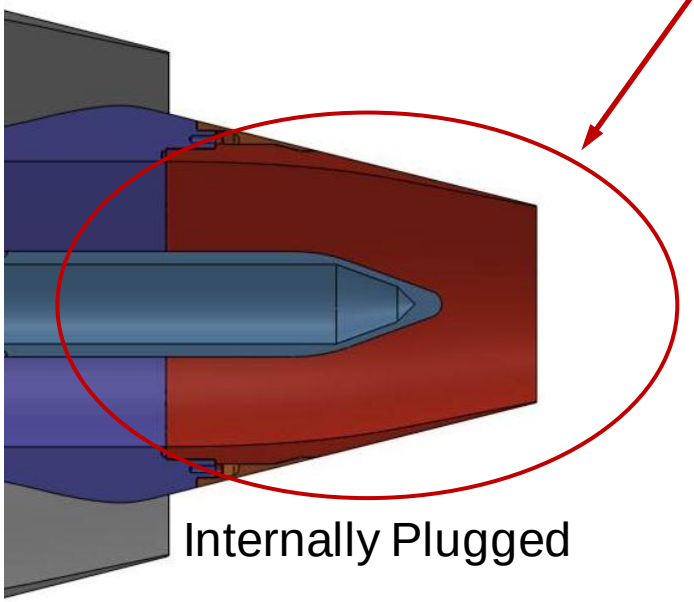


Plan for 2014 Study

- 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

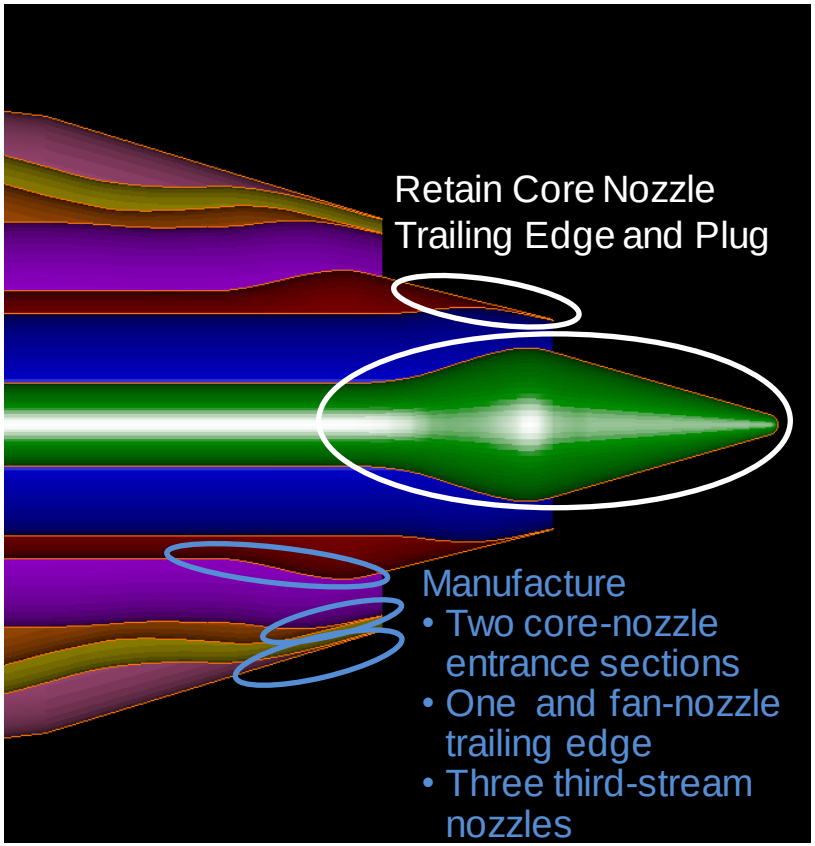
Existing Dual-Stream Nozzle System





- 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



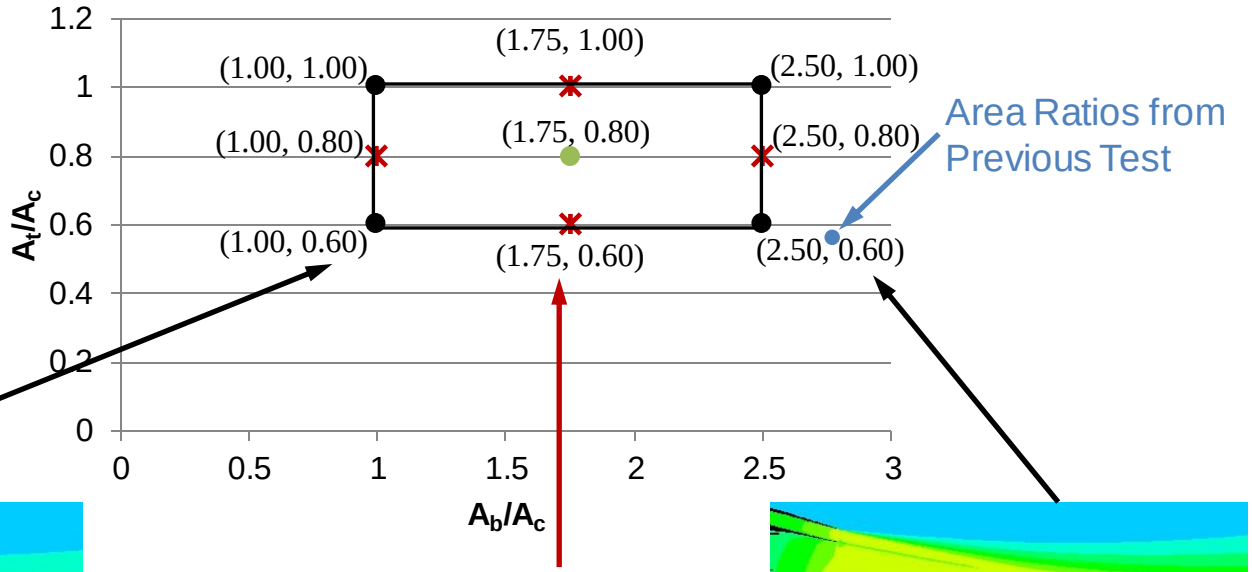
- Use existing core internally and externally plugged trailing edge pieces and plugs
- Manufacture new fan and third-stream trailing edge pieces
- Baseline (no flow) nozzle for third stream
- Operating conditions of interest
  - $2.5 \leq BPR_{tot} \leq 5.5$
    - BPR_{tot} = (fan+third)/core
  - $1.5 \leq NPR_{f,c} \leq 1.8$
  - $1.3 \leq NPR_t \leq 2.4$
  - $1.0 < NTR_c < 3.2$
  - $NTR_f = NTR_t = 1.25$
  - Range of area ratios

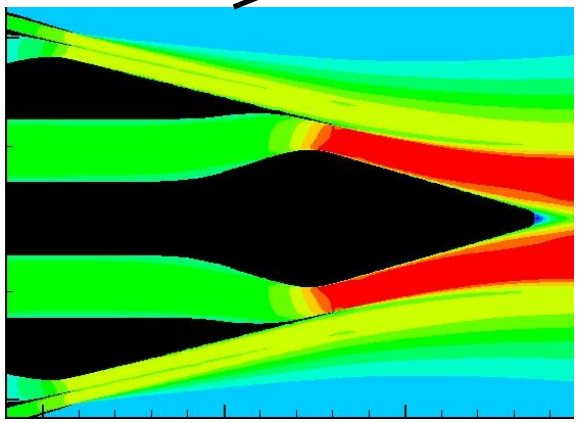
Proposed Experiments

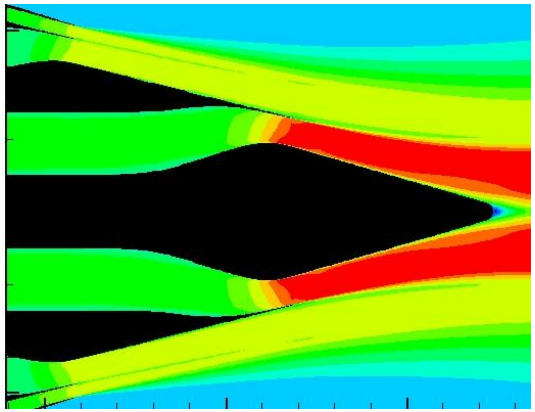
$0.6 \leq U_b/U_c \leq 1$

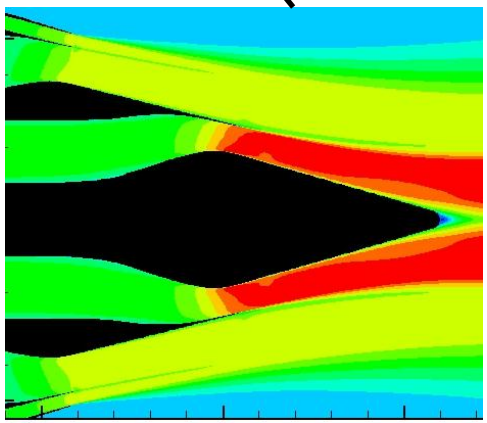
$0.6 \leq U_t/U_b \leq 1.2$

$1.0 \leq T_c/T_a \leq 3.2$

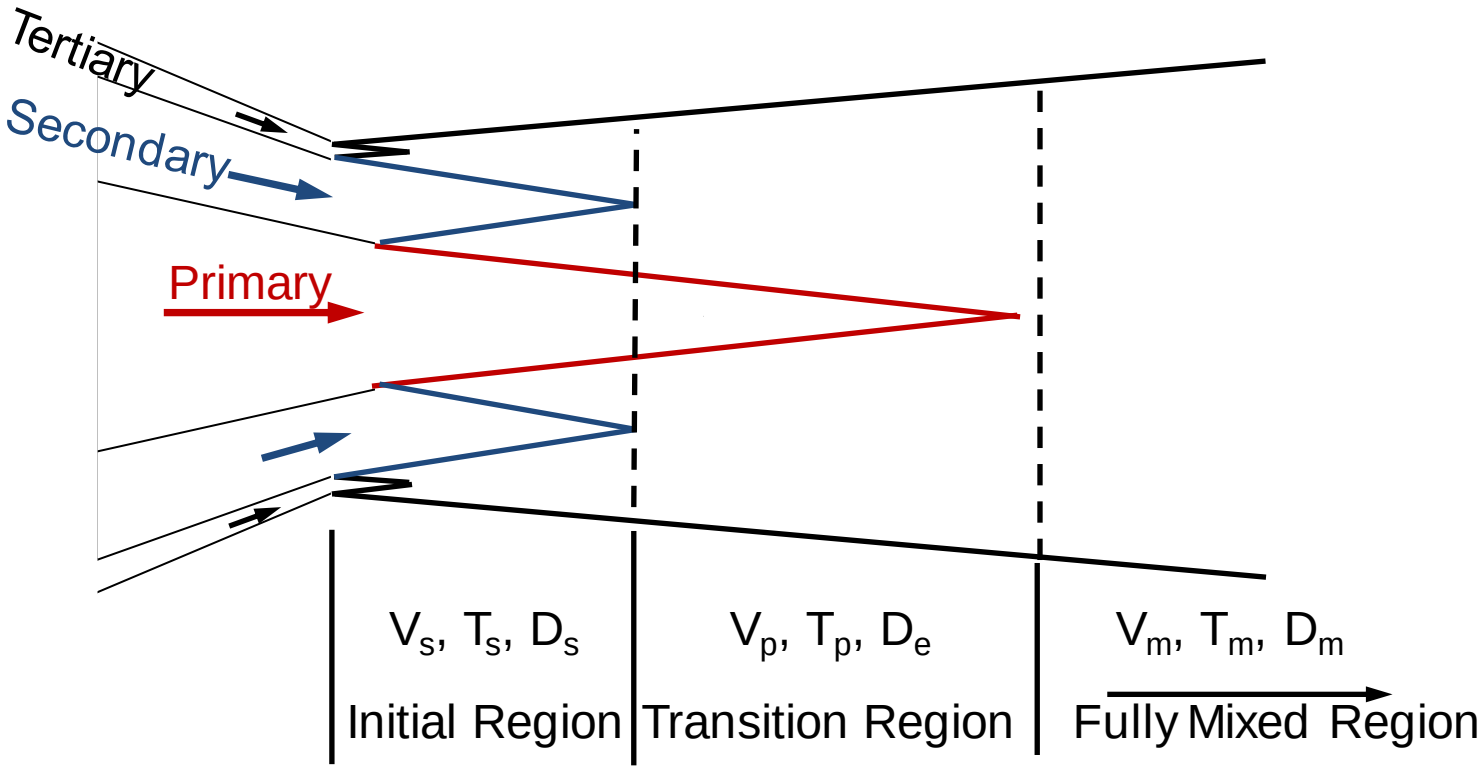








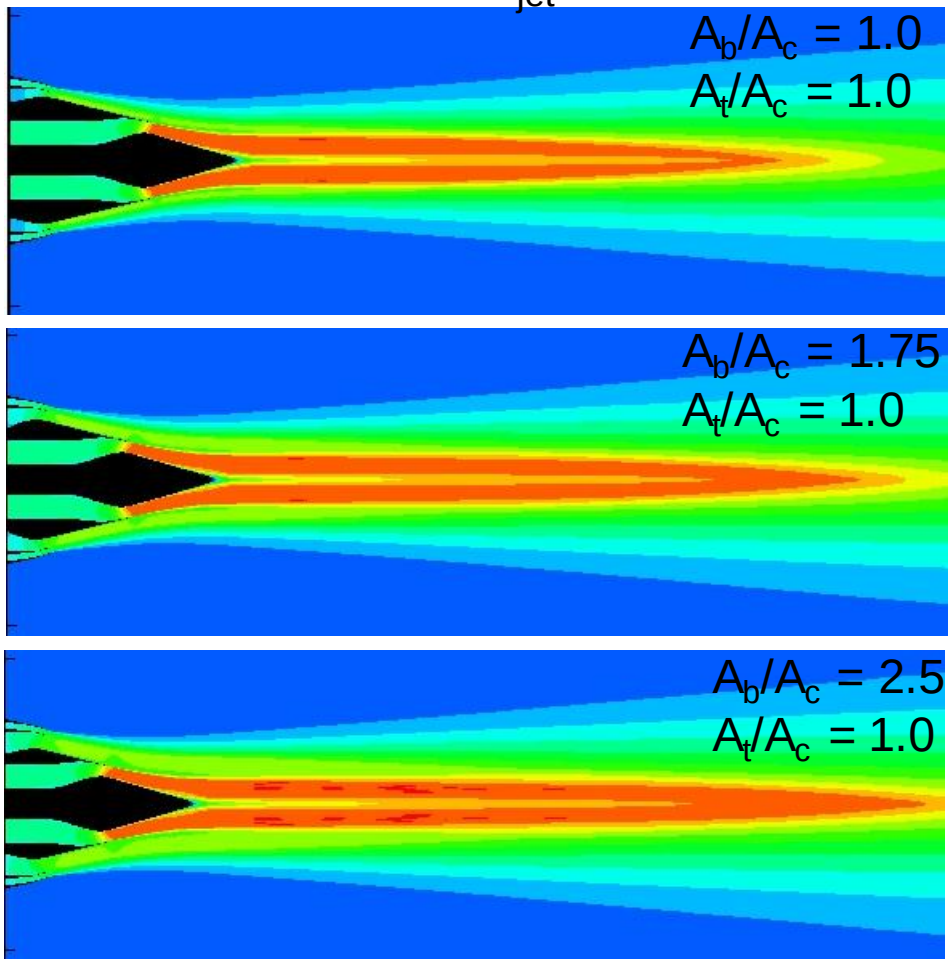
Proposed Model



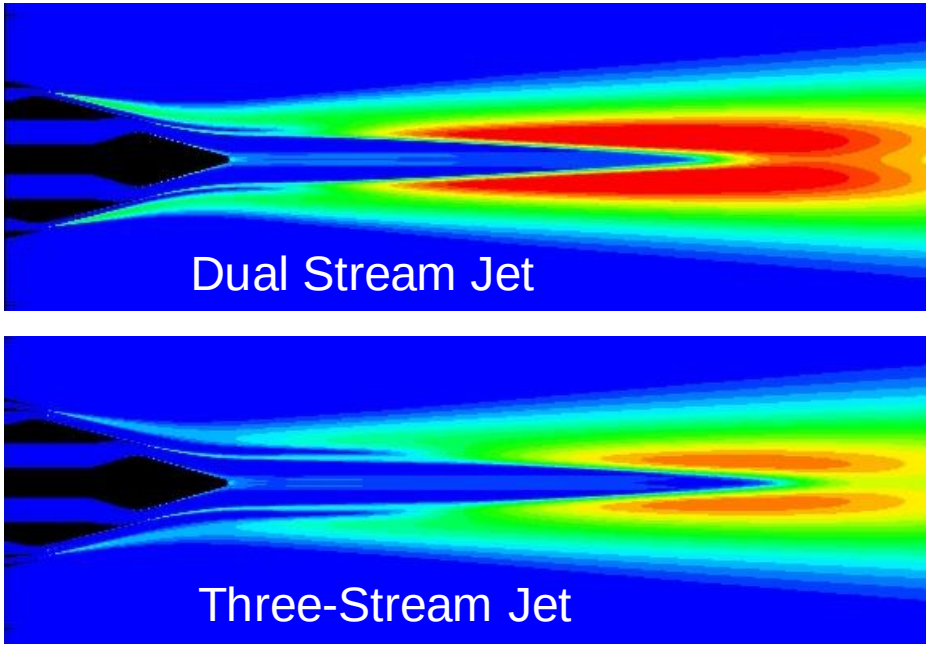
- Base on approach developed by Fisher et al. for dual-stream jets (Fisher, Preston, Bryce, AIAA-1993-4413 and Fisher, Preston, Mead, AIAA-1996-1666)
- Model will benefit from PIV measurements

Status

U/U_{jet}



TKE
Equal Thrust



- 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