COE CST Fifth Annual Technical Meeting

Optical Measurements of Rocket Nozzle Thrust and Noise

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Arlington, VA

Agenda

- Team Members
- Challenges and Motivation
- Task Description
- Test Facilities
- Schedule & Milestones
- Nozzle Design
- Future Work

Team Members

- Team
  - Rajan Kumar & Farrukh Alvi
  - Griffin Valentich
- Organizations Involved
  - FSU / FCAAP
  - Space Florida
  - SpaceX



FCAAP
FLORIDA CENTER FOR ADVANCED AERO-PROPULSION
TECHNOLOGIES FOR THE NEXT GENERATION

SPACE FLORIDA

SPACEX

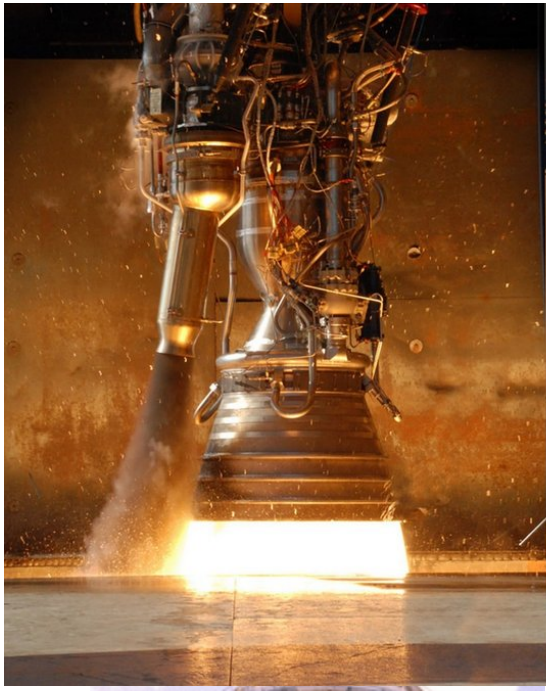
Challenges & Motivation

70% accidents in aerospace missions are due to engine malfunction or propulsion system failures!!

Rocket propulsion studies are limited (only National Labs. & big corporations)

- **High temperature and pressure environment**
- **Complex chemistry – unstable fuels**
- **Large scale tests are expensive & require specialized rigs**

- **Need to develop high temperature pressure sensors – activity initiated under COE-CST**
- **Measure steady and transient loading on the nozzle and ground surface – material characterization**
- **Jet plume development and flow field analysis**
- **Nearfield & farfield noise measurement and prediction tools**
- **Study of next generation hybrid fuels**



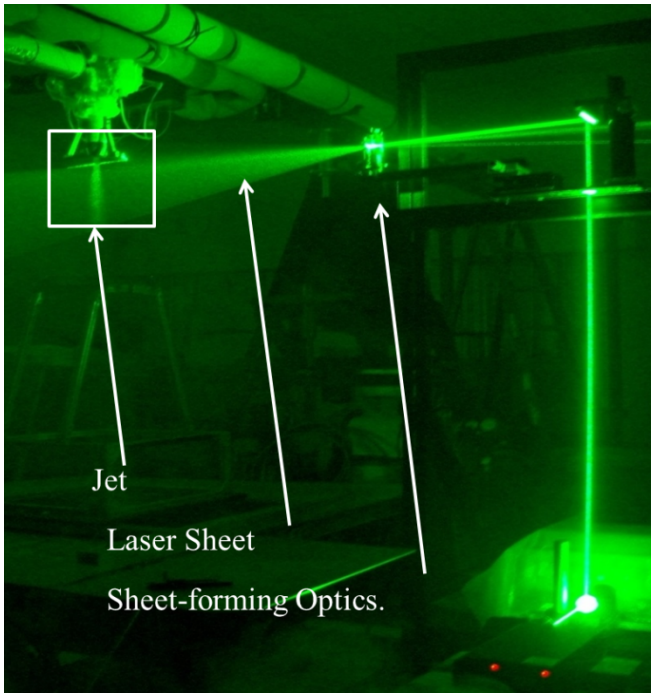
Tasks Description

- Development of a research plan based on state-of-art thrust and noise measurement techniques.
- Discussion with NASA /commercial launch engineers to ensure the transition of technology from laboratory to full-scale implementation.
- Design of a scaled nozzle and simulate realistic temperature and pressure conditions of the jet exhaust in the FSU jet facility
- Design and develop advanced optical techniques for thrust measurements and characterize its performance at controlled conditions.
- Refine and test the measurement techniques over a wide range of test conditions.

Test Facilities

Nozzle

Ground Plate with Transducer Block



Operational/Test Capabilities

- *Mach Number = 0.5 - 2.5*
- *T_o = 70 - 2000 F*
- *D_{Jet} = 25.4 – 76.2 mm*
- *NPR = Under-ideal-over expanded*
- *Anechoic chamber: 5.8 m x 5.2 m x 4.0 m, Calibrated to 100 Hz*

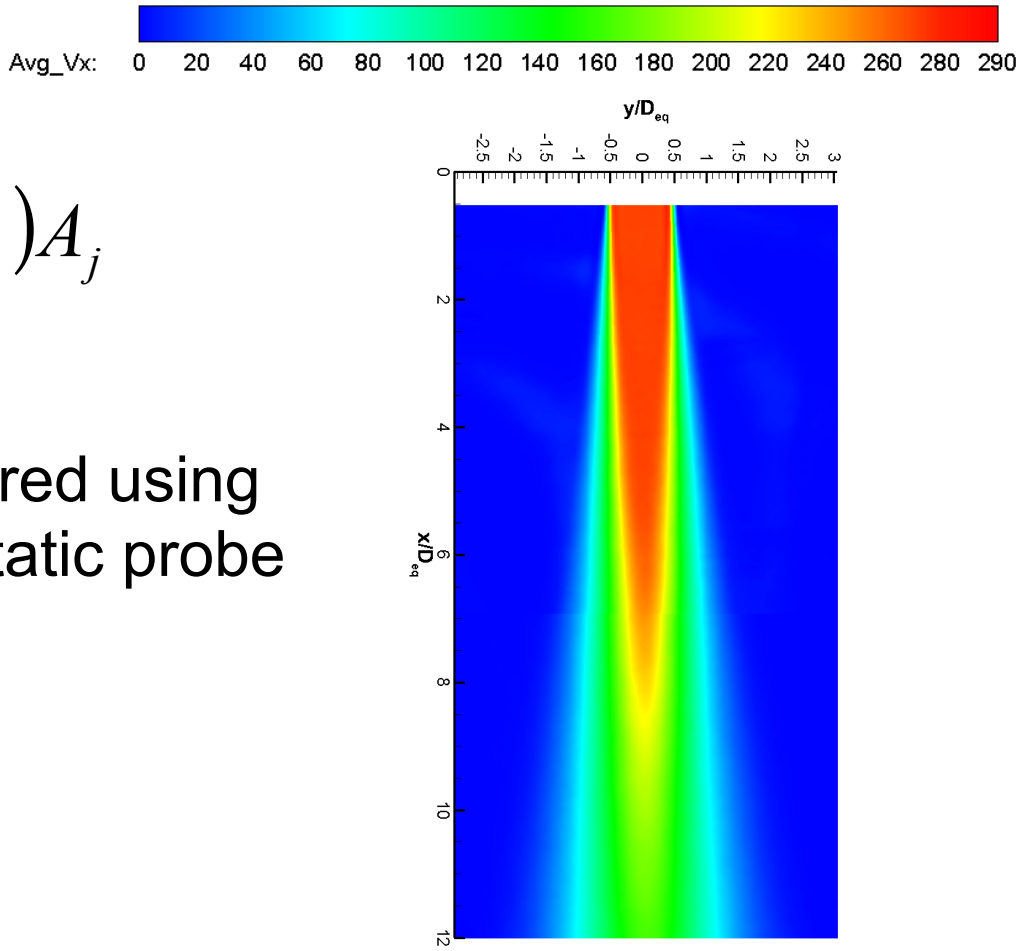
Thrust Measurements

$$F = F_m + F_p$$

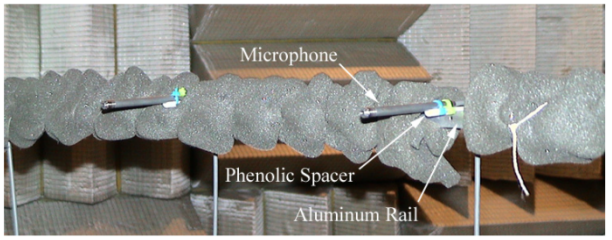
$$F = \dot{m}u_j + (p_e - p_a)A_j$$

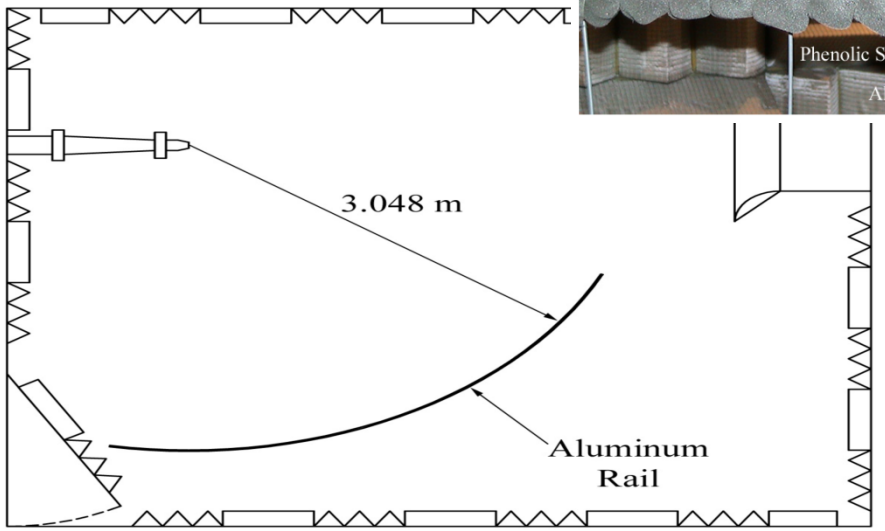
Measured using PIV

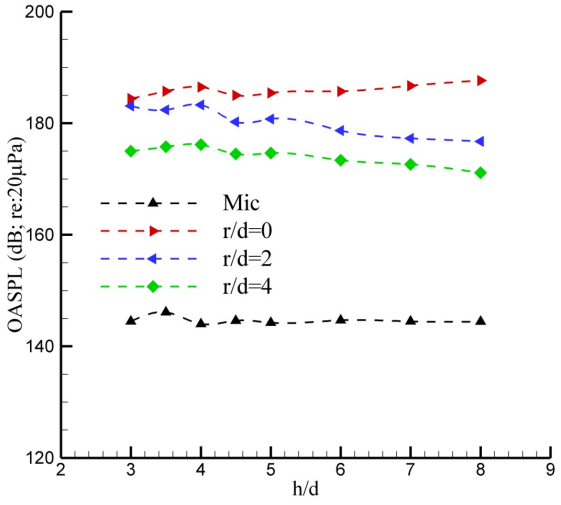
Measured using Pitot-static probe

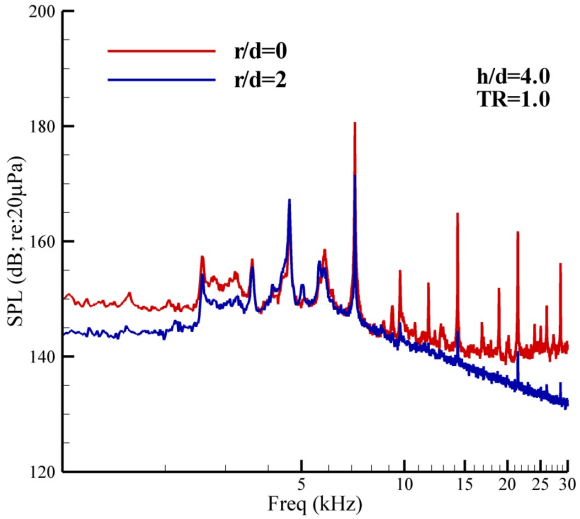


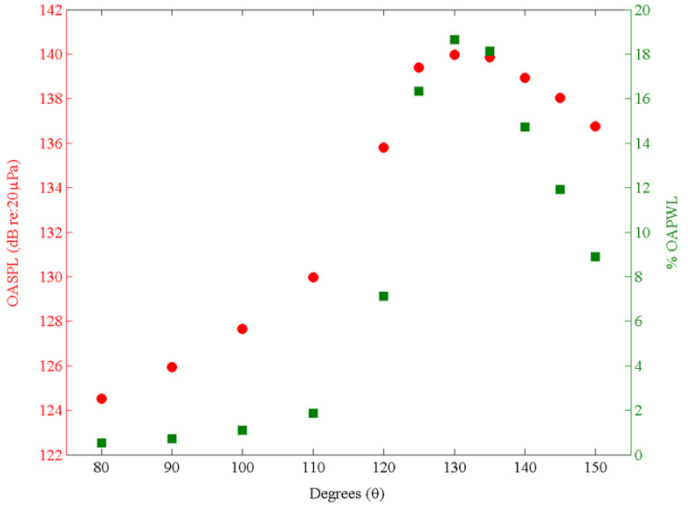
Noise Measurements



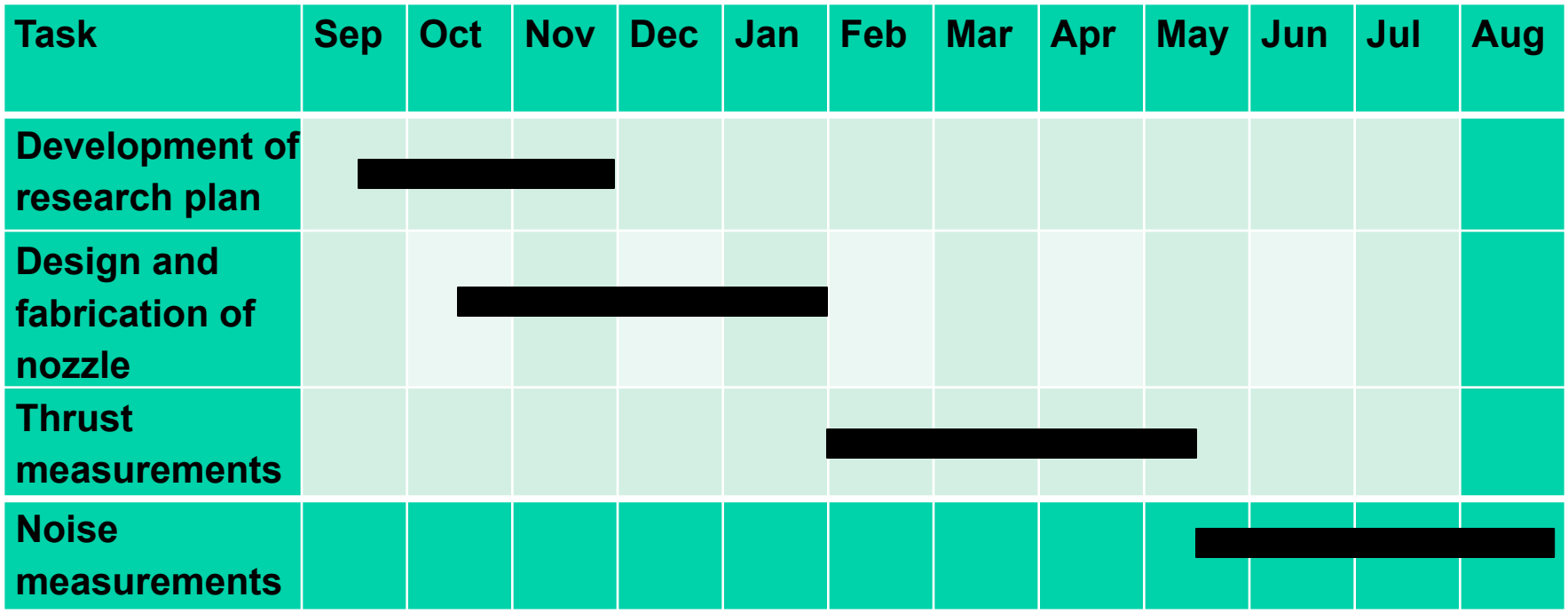




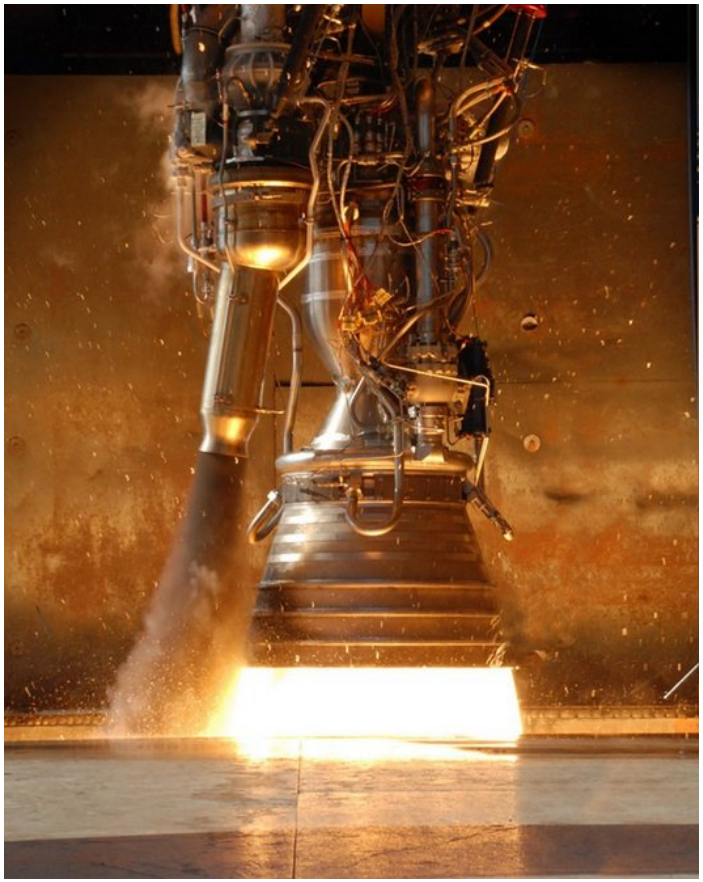


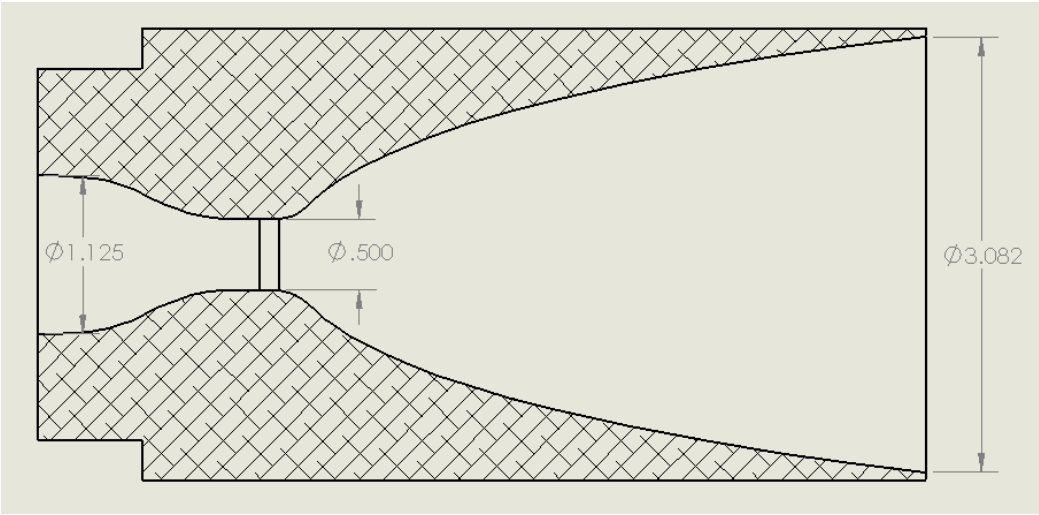


Schedule and Milestones



Preliminary Nozzle Design





Thrust optimized parabolic (TOP) contour nozzle
Design Mach Number: 5.6
A/A* = 38

Future Work

- Discussion with NASA / commercial launch manager (SpaceX).
- Detailed design to suit FSU jet facility and fabrication of TOP nozzle
- Instrumentation of jet facility to measure mass flow rate, exhaust velocity and pressure distributions at the nozzle exit