ASCENT Project 076

Improved Open Rotor Noise Prediction Capabilities

Georgia Institute of Technology

PI: Dr. Dimitri Mavris

PM: Chris Dorbian

Cost Share Partner: GE Aviation

Objective:

- There is a major challenge in meeting noise targets while simultaneously meeting other design constraints.
- The open rotor concept has promising fuel benefits, but there is a need to quantify the impact of design parameters on open rotor noise.
- A study of design parameter sensitivity to CROR system noise responses will be conducted in order to identify impactful design parameters.

Project Benefits:

The study of CROR design parameter sensitivity will identify trends that can aid further research and provide insight to design tradeoffs

Research Approach:

This study is comprised of the following:

- Identification of Open Rotor noise-sensitive design parameters
- Parametric geometry model development
- Simulation campaign – unsteady aero & CAA
- Definition of sensitivity study methodology and its execution

Major Accomplishments (to date):

- Identification of open rotor design variables – from previous studies – classified in groups: rotor, pylon installation and airframe integration.
- Development of a parametric open rotor geometry

Future Work / Schedule:

- Down selection of design parameters for sensitivity study
- Validation – with experimental data – of simulation analysis; unsteady aerodynamics as well as computational aeroacoustics

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Study of Design Parameter Sensitivities

- Rotor parameters
- Installation Effects
- Frame Integration

Determining design parameters

- Effective Perceived Noise Level

Defining Responses

Sampling of design parameters.

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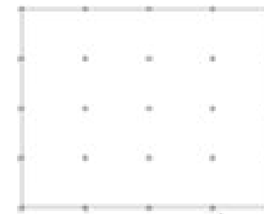
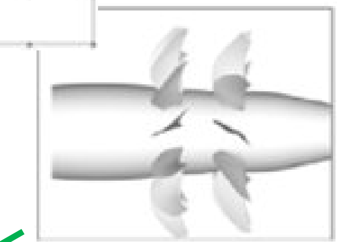
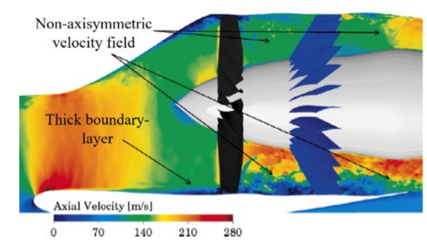


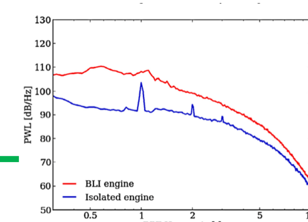


Simulation

- Unsteady Aerodynamics
- Computational Aeroacoustics



(c) $t/T = 7$



(a) *BLI and isolated engines*

Responses

Sensitivity Analysis

Outcome:

Ranking – by noise impact - of design parameters

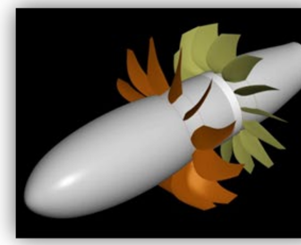
Term	Contrast		Lenth t-Ratio	Individual p-Value
Δx	0.012462		22.51	<.0001*
TE/LE	0.001700		3.07	0.0123*
PC	-0.001144		-2.07	0.0520
Δy	-0.000309		-0.56	0.5891
Δz	-0.000124		-0.22	0.8226
Δx*Δx	0.001559	*	2.82	0.0182*
Δx*TE/LE	-0.000192		-0.35	0.7329
Δx*PC	-0.000309		-0.56	0.5891
TE/LE*PC	0.000296		0.53	0.6068
PC*PC	0.000037	*	0.07	0.9475
Δx*Δy	0.000490		0.89	0.3469
TE/LE*Δy	-0.002367		-4.27	0.0023*
PC*Δy	0.000139		0.25	0.8048
TE/LE*Δz	-0.001682		-3.04	0.0127*
PC*Δz	-0.000429	*	-0.77	0.4078
Δx*Δx*TE/LE	-0.002138	*	-3.86	0.0043*
Δx*TE/LE*PC	0.000789		1.42	0.1523
TE/LE*PC*PC	0.000062	*	0.11	0.9118
Δx*TE/LE*Δy	-0.000821		-1.48	0.1394
TE/LE*PC*Δy	0.000746		1.35	0.1699
TE/LE*PC*Δz	-0.000234	*	-0.42	0.6777

Literature Review

- Objective:
  - ➢ Summarize the state of research on Open Rotor aeroacoustics
  - ➢ Define a super-set of design parameters shown to influence open rotor acoustics
  - ➢ **Down-selection** of design parameters from the super-set
- Design parameters are divided in three groups:
  - Rotor parameters
  - Pylon installation parameters
  - Airframe integration parameters
- **Review of publicly available open rotor literature has been completed**

Design Parameters

Rotor



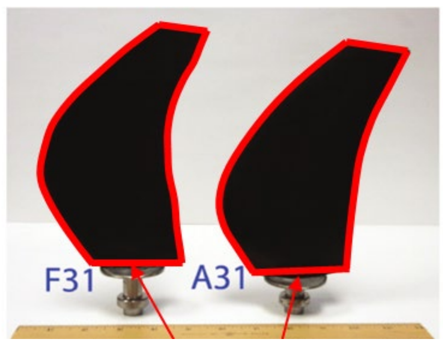
Pylon Installation

Airframe Integration

Development of Parametric Geometry

- To support the Sensitivity Analysis, we need a way to generate new geometries – **a parametric model** – from a Design of Experiments (DoE)
- Design parameters were identified during the literature review
- Parameterization is based on F31 A31 open rotor blades
- Parametric model is **complete** with a focus on **rotor and pylon installation design**

Rotors → Pylon → Nacelle



Planforms Extraction

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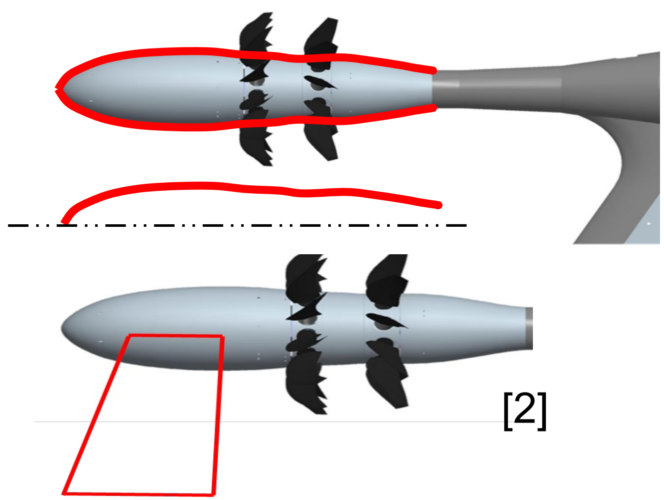


[2]

[2]

Parameter
Diameter of rotor
Aft rotor clipping
Rotor spacing
Pitch Angle
Number of blades
Blade Shape

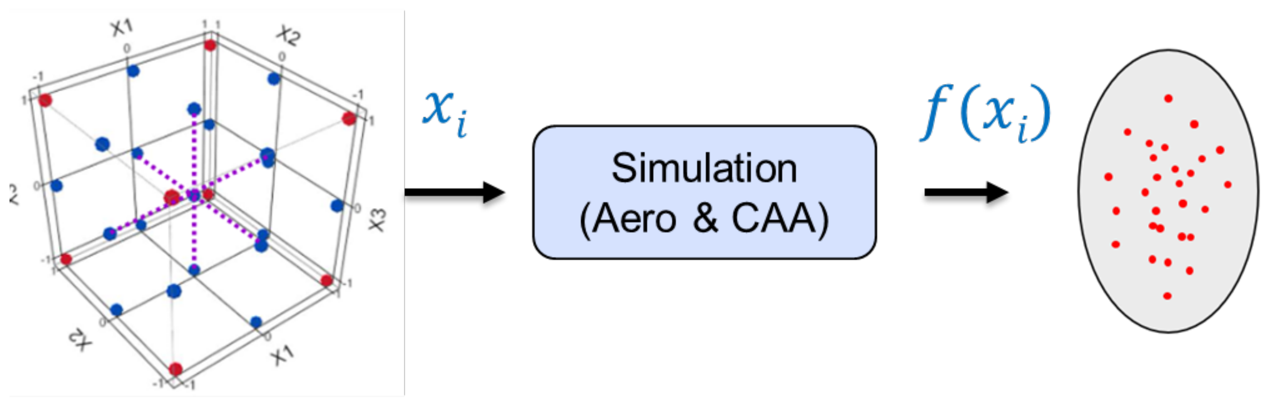
Parameter
Fuselage-Rotor Spacing
Pylon-Rotor Spacing
Angle of Attack (Twist)
Pylon Sweep

[1] Rizzi, S. A., et al., "Auralization of Flyover Noise from Open-Rotor Engines Using Model-Scale Test Data," Journal of Aircraft, Vol. 53, No. 1, 2016.
[2] Sree, D., "Near-Field Acoustic Power Level Analysis of F31/A31 Open Rotor Model at Simulated Cruise Conditions," NASA, 2015,

Procedure for Sensitivity Analysis

- **Seek to quantify the strength** of inputs (different designs) on the output (a noise metric)
- **Strength contribution** to output can be from **individual** inputs or from **interactions**
- Utilize a regression model for creating relationships between designs and noise metric
- Designs are described on a space of parameters, which in turn are represented by a sampling plan (discrete points)
- Work on this procedure is **in progress**

Regression Model



Sampling Plan

- Due to large simulation cost, selection of sampling plan (DOE's) is very important
- Would like to maximize information while minimizing sample points
- Currently, evaluating DOE type with lower sample size increase while accounting for desired effects

Resolution	Number of design variables	Effects Studied
III		
IV		
V		