ASCENT Project 075

Improved engine fan broadband noise prediction capabilities

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Cost Share Partner: BU, RTRC, AARC

Objective:

Improve low-order (LO) models for the prediction of fan broadband interaction noise by addressing gaps in existing methods using both computation and experimentation. The main gaps being considered are a LO model for the inflow to an exit guide vane and full-scale validation of the LO exit guide vane response.

Project Benefits:

Elimination of time-consuming, high-fidelity simulations or prototype development and testing in order to assess broadband noise levels created by high bypass turbofans.

Research Approach:

- Develop a surrogate model for a fan wake using machine learning. Create the necessary training data and compare different machine learning methods. Determine both the mean and turbulence wake profiles upstream of the exit guide vane using only rotor-based information.
- Test the current LO exit guide vane response method's ability to predict the broadband noise associated with a full-scale case using available experimental data.

Major Accomplishments (to date):

- Data set development started
- ML methods tested for mean wake on initial data
  - SDT data has been the focus
  - Method developed for unrolling the gap wake data so that ML can actually follow the wake shape (feature identification)

Future Work / Schedule:

- Summer: LO response tested on full-scale rig data
- Summer: ML
  - Turbulent wake profile
  - Multiple fans and more speeds

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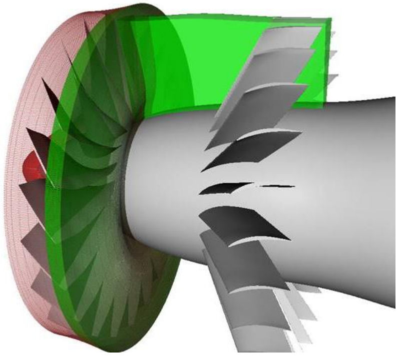
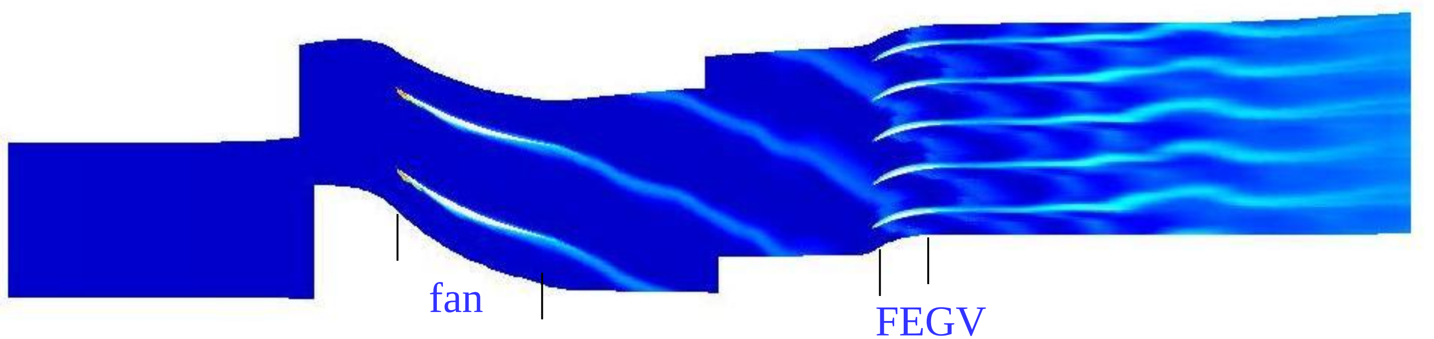
Basic Problem

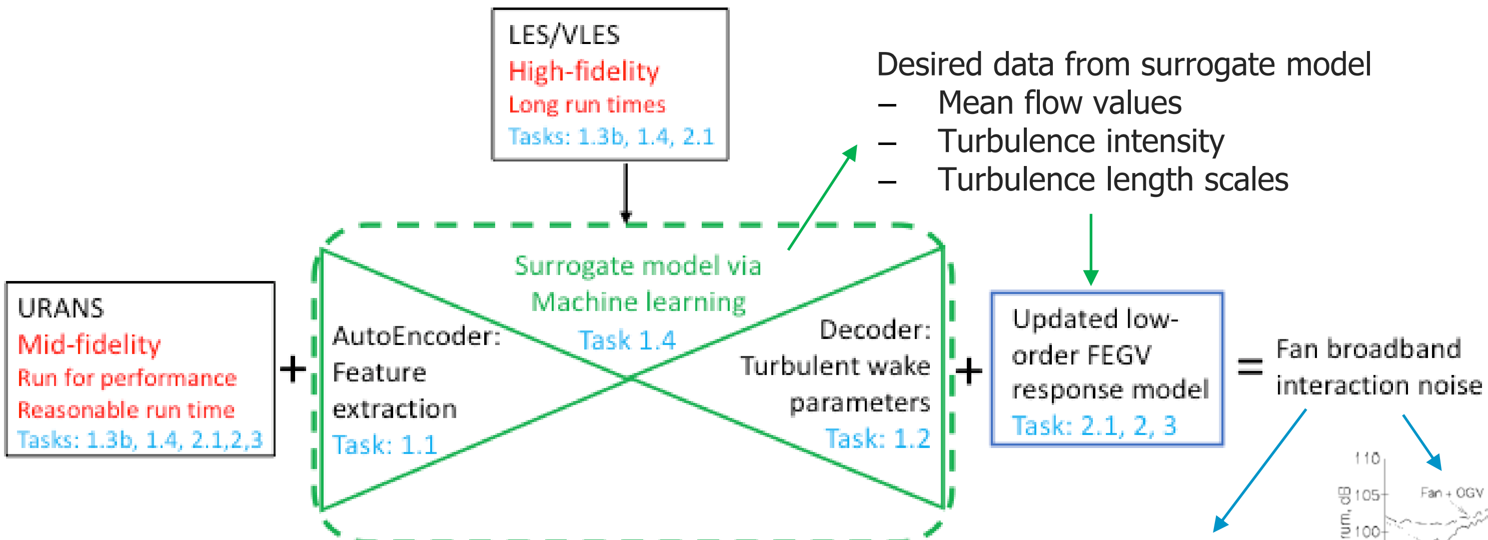


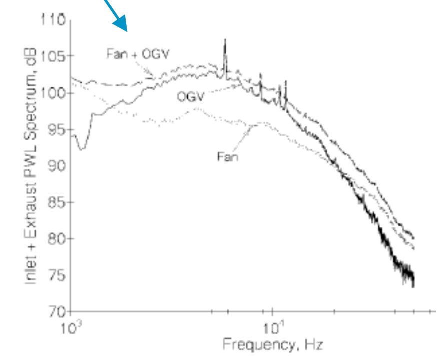


- Turbofan, fan-stage, interaction noise created by rotor wakes interacting with Fan Exit Guide Vanes (FEGV).
- Both tonal and broadband. For broadband, need to know about wake turbulence upstream of stator.

Wake surrogate model

- Create surrogate model via Machine Learning to provide the rotor wake data upstream of the stator.
- Use computational data to train the ML algorithm



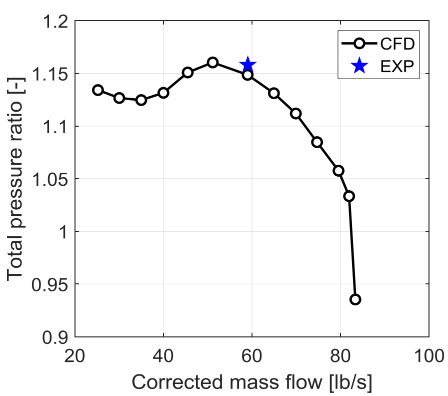


Desired outcome
Broadband spectrum
(from Nallasamy et. al.)

- Training data to consist of the
  – Gap velocity information (RANS type information)
  – Gap turbulence parameters (RANS type information)
  – Rotor basic spanwise geometry, spanwise force, trailing edge boundary layer quantity
  – Next level: Gap turbulence spectrum information (LES/VLES type information)

Training data

- URANS based on SDT at first
  - Add different mass flow rates, add rotor speeds
- Create new fans and run CFD for relevant map points
  - Morph geometry



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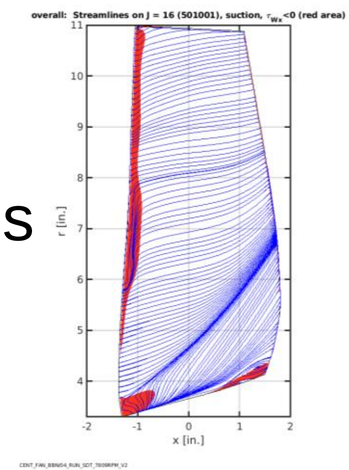

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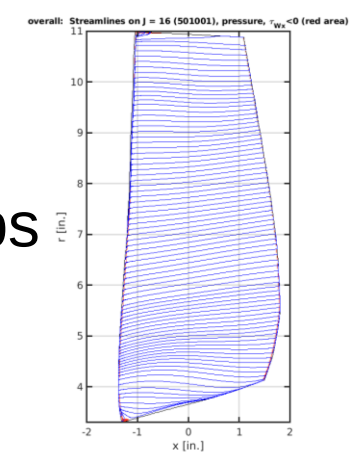
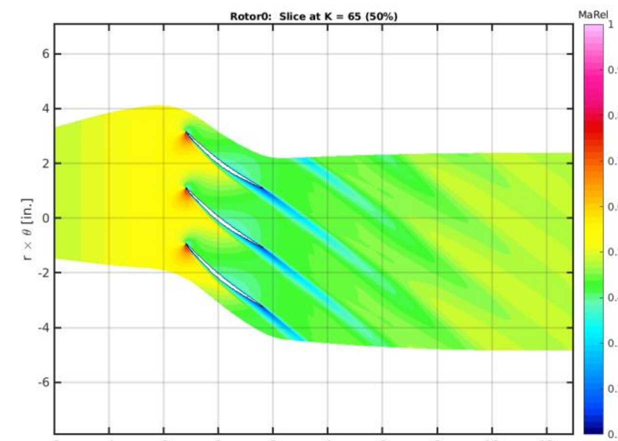
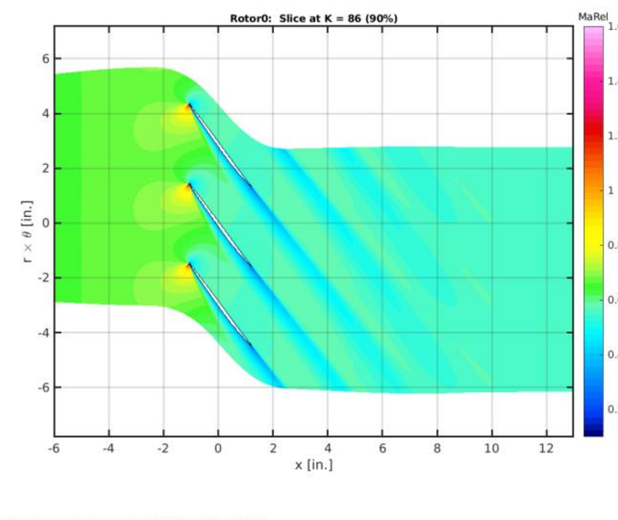


50% span



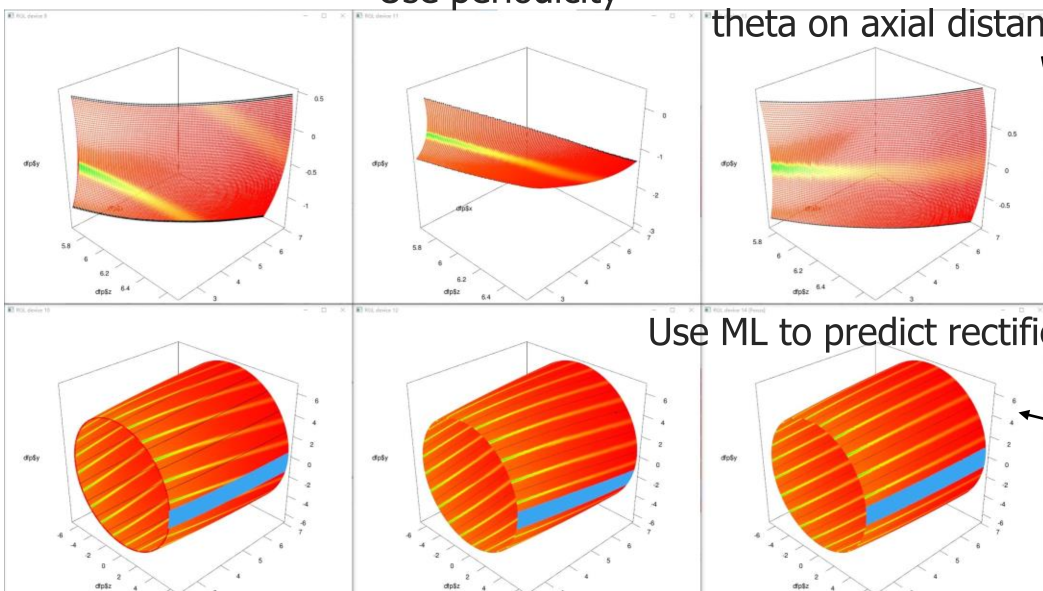
90% span



Preliminary ML results

- Focus on mean wake description at first
- Two transformations : r and theta to get wakes in center of ”grid”
  - Leading to “rectification” of the wake

Use periodicity → Find functional dependence of r and theta on axial distance (ML)



Use ML to predict rectified wake

Move back to original coordinates

Spline model working for prediction

Data from 3 SDT speeds

Some data used for training, other part used for prediction