

Jet-Surface Interaction Noise Models Comparison to TMP17 and Next Steps

Cliff Brown *

NASA Glenn Research Center

April 10, 2018

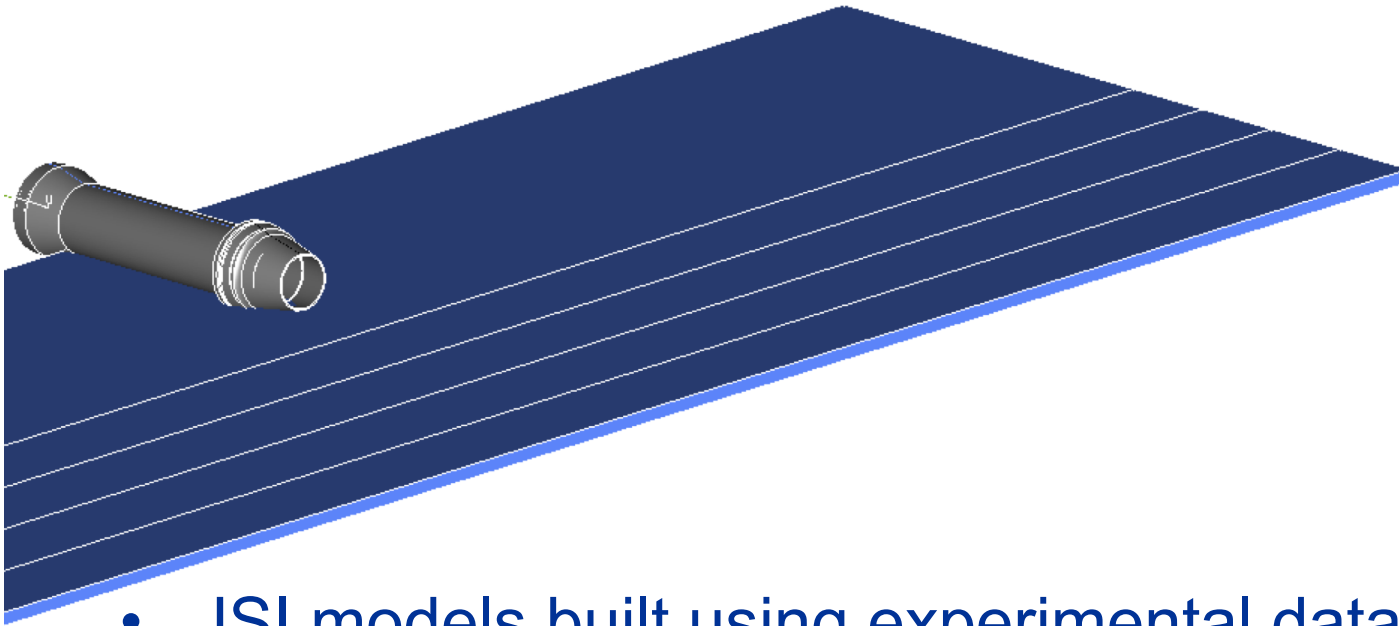
Supported by the CST Project

* Clifford.A.Brown@NASA.gov

Outline

- Part 1 – Where we are
 - Simple-Single-Stream (SSS) jet-surface interaction (JSI) noise models
 - Top-Mounted Propulsion (TMP17) test setup
 - Limitations of SSS models applied to TMP17
- Part 2 – Moving forward and improving
 - Problem statement and constraints
 - How can we use existing tools / methods for more realistic flows and geometries?

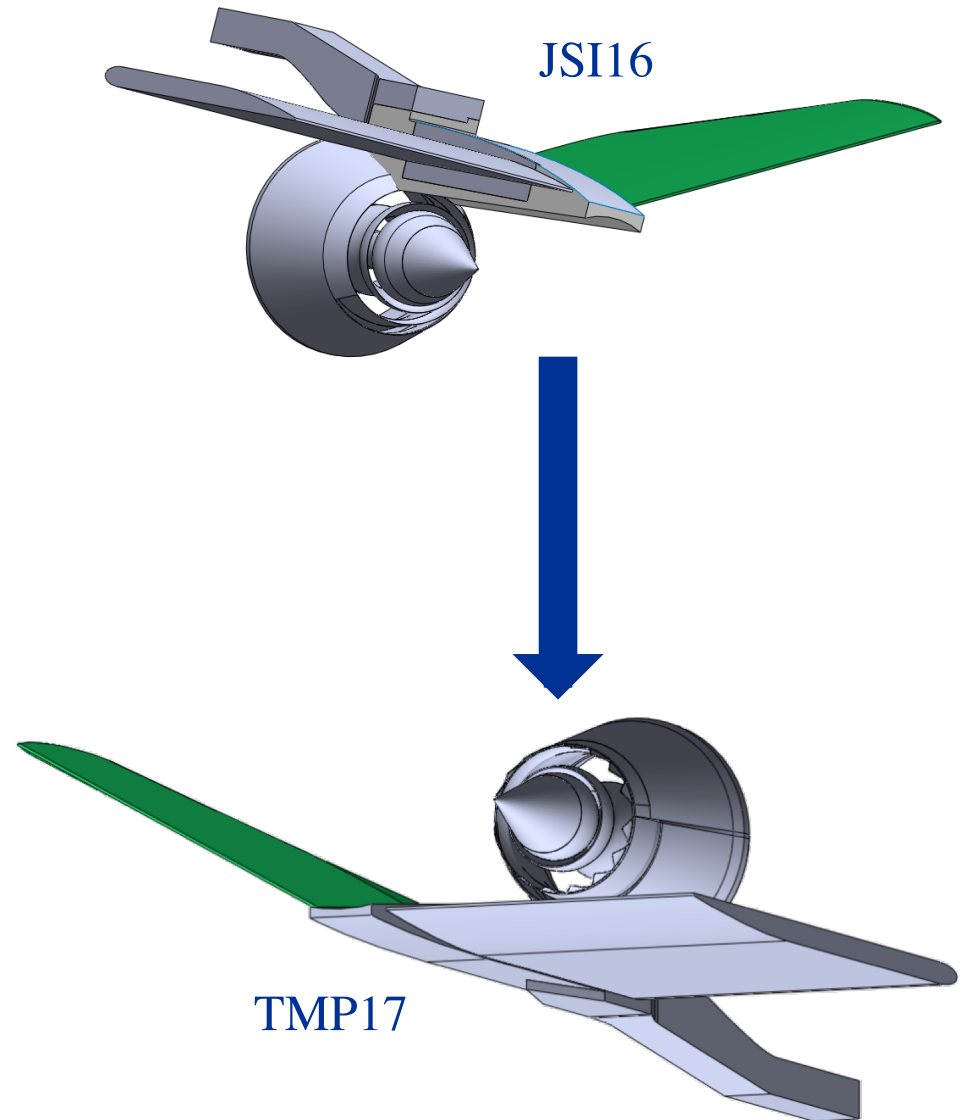
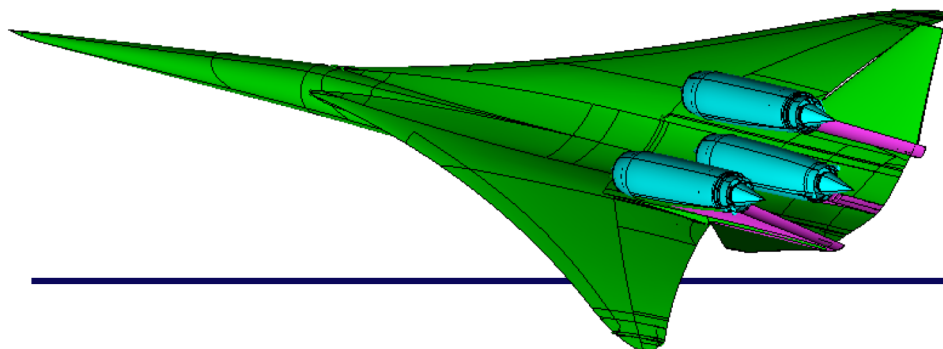
Simple-Single-Stream (SSS) JSI Models



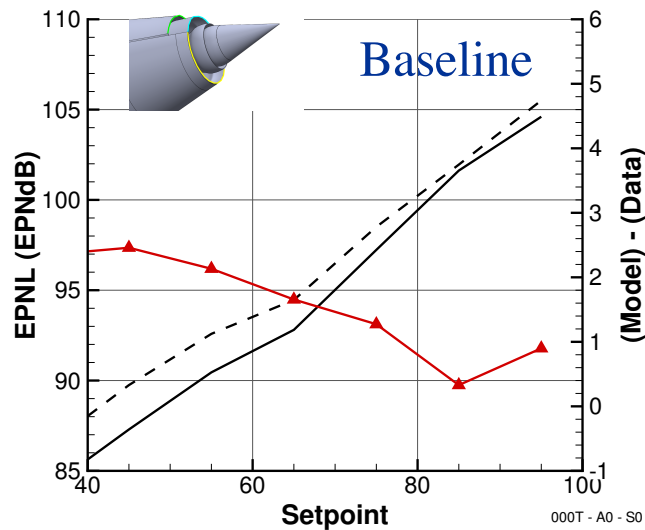
- JSI models built using experimental data where:
 - Single-stream subsonic jet (no plug) – no flight effects
 - Flat surface semi-infinite in 3 directions
 - Surface length and standoff distance, jet Mach and temperature vary
- JSI models assume:
 1. Velocity and TKE axial profile collapses with jet potential core (x_C)
 2. Peak source distribution collapses with x_C

Top Mounted Propulsion Test - 2017 (TMP17)

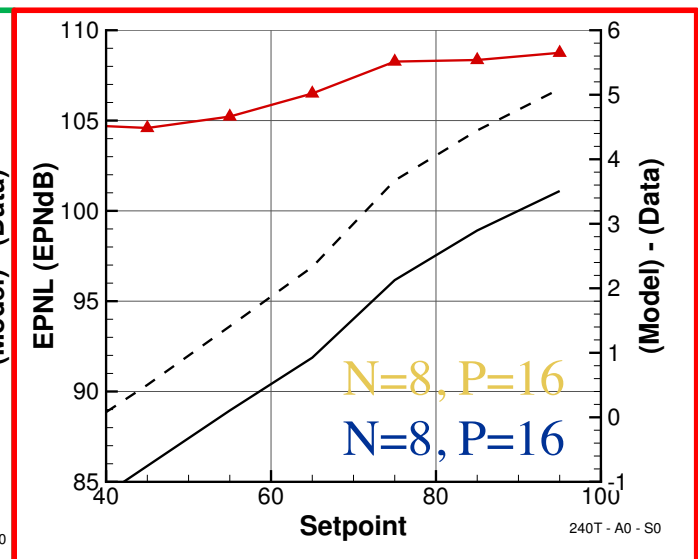
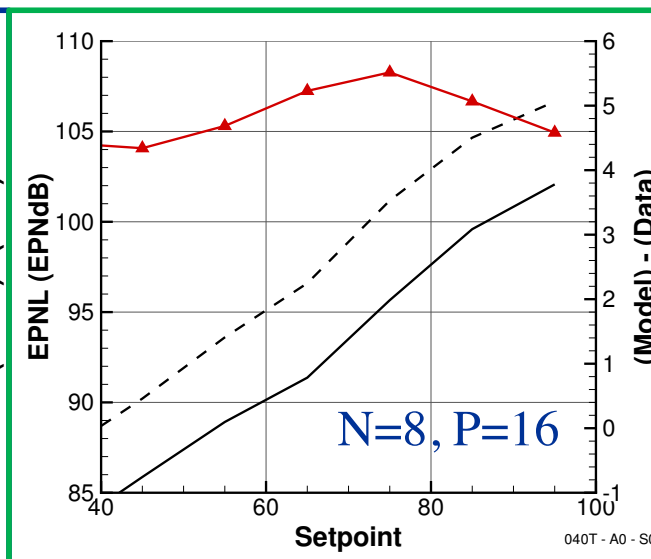
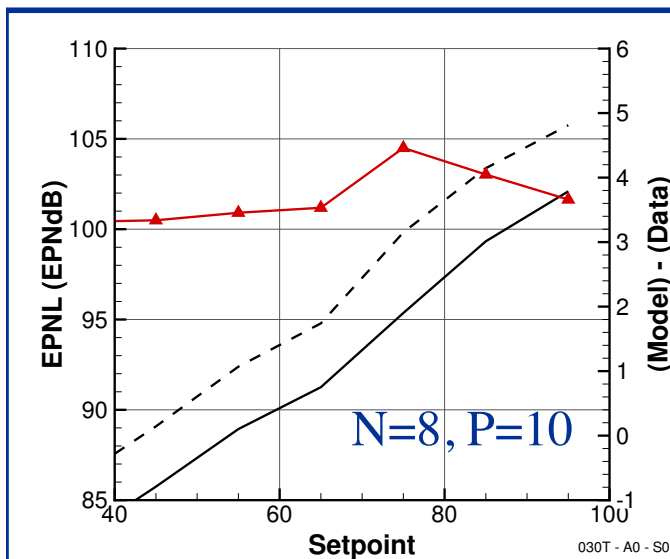
- JSI16 test showed:
 - Noise shielding for top-mounted center engine
 - Noise penalty for bottom-mounted outboard engines
- TMP17 test:
 - Move outboard engines to top of airframe for shielding
 - Add chevrons to improve shielding
 - How does SSS model perform?



EPNL – TMP17 Planform

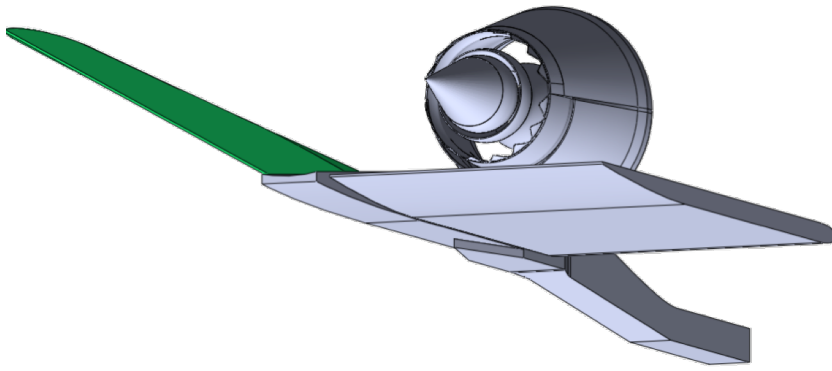


- Models do not account for chevrons
 - Prediction same in each case
- Baseline error is 1-2 dB at high setpoints
 - Represents "best case" for model
- Error increases:
 - Baseline chevrons (3-4 dB)
 - Aggressive chevrons (5-6 dB)
 - Aggressive chevrons on 2 streams (5-6 dB)

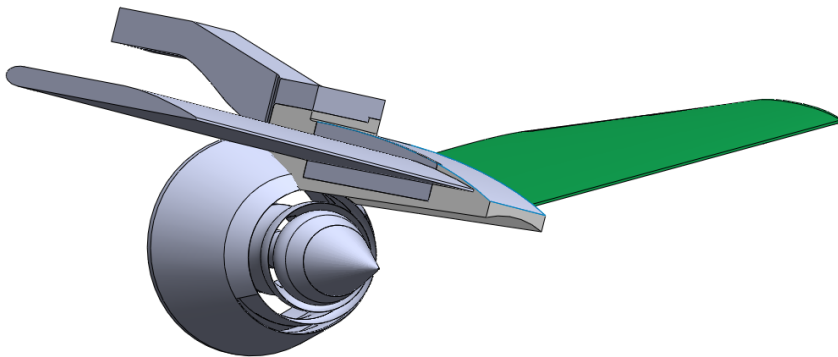


Next Steps: Usage Example CST Concept Aircraft

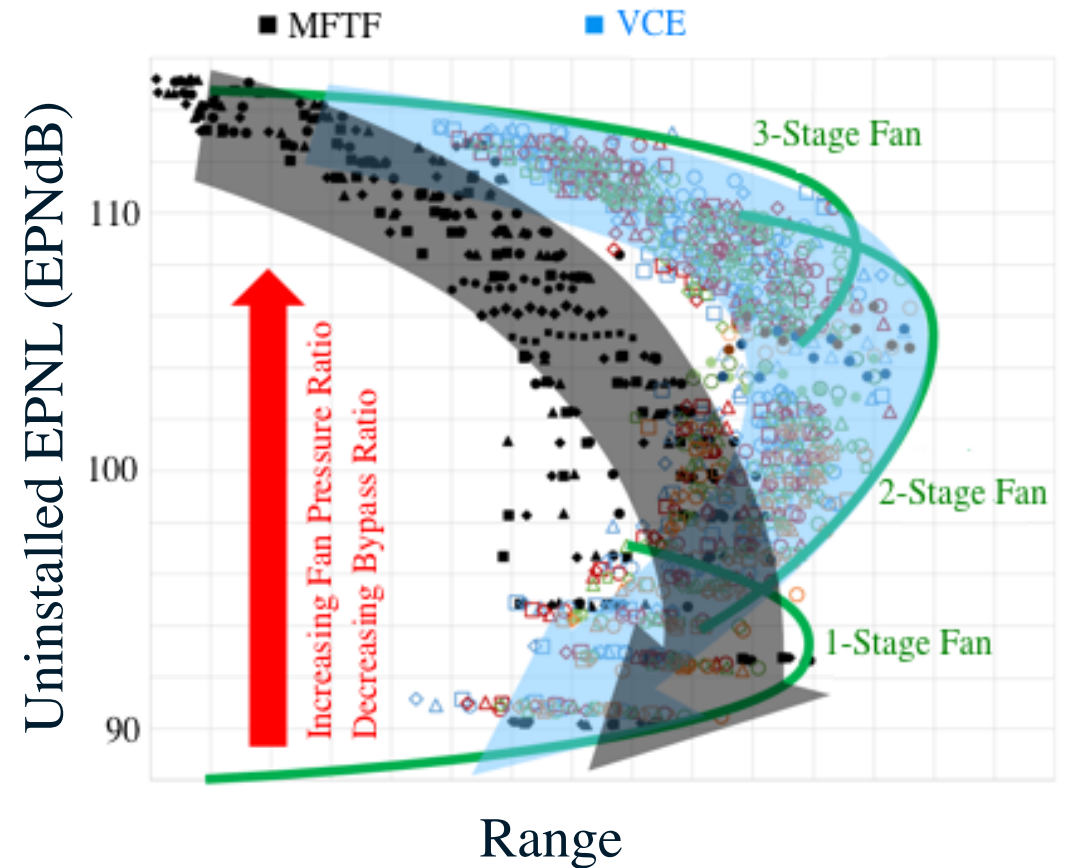
Top-Side Installation



Under-Side Installation



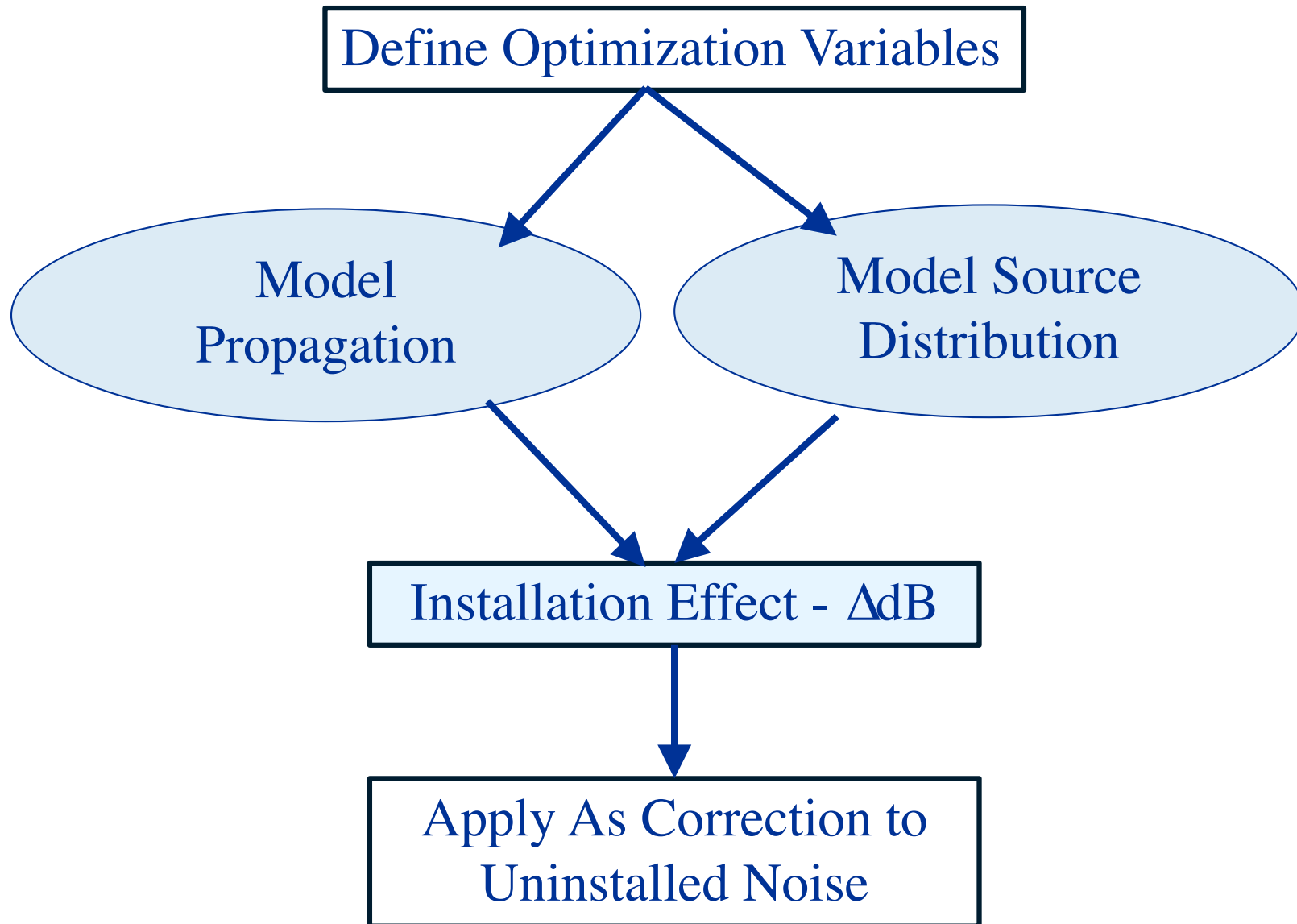
Many Potential Engines



Improved Installation Modeling Concept

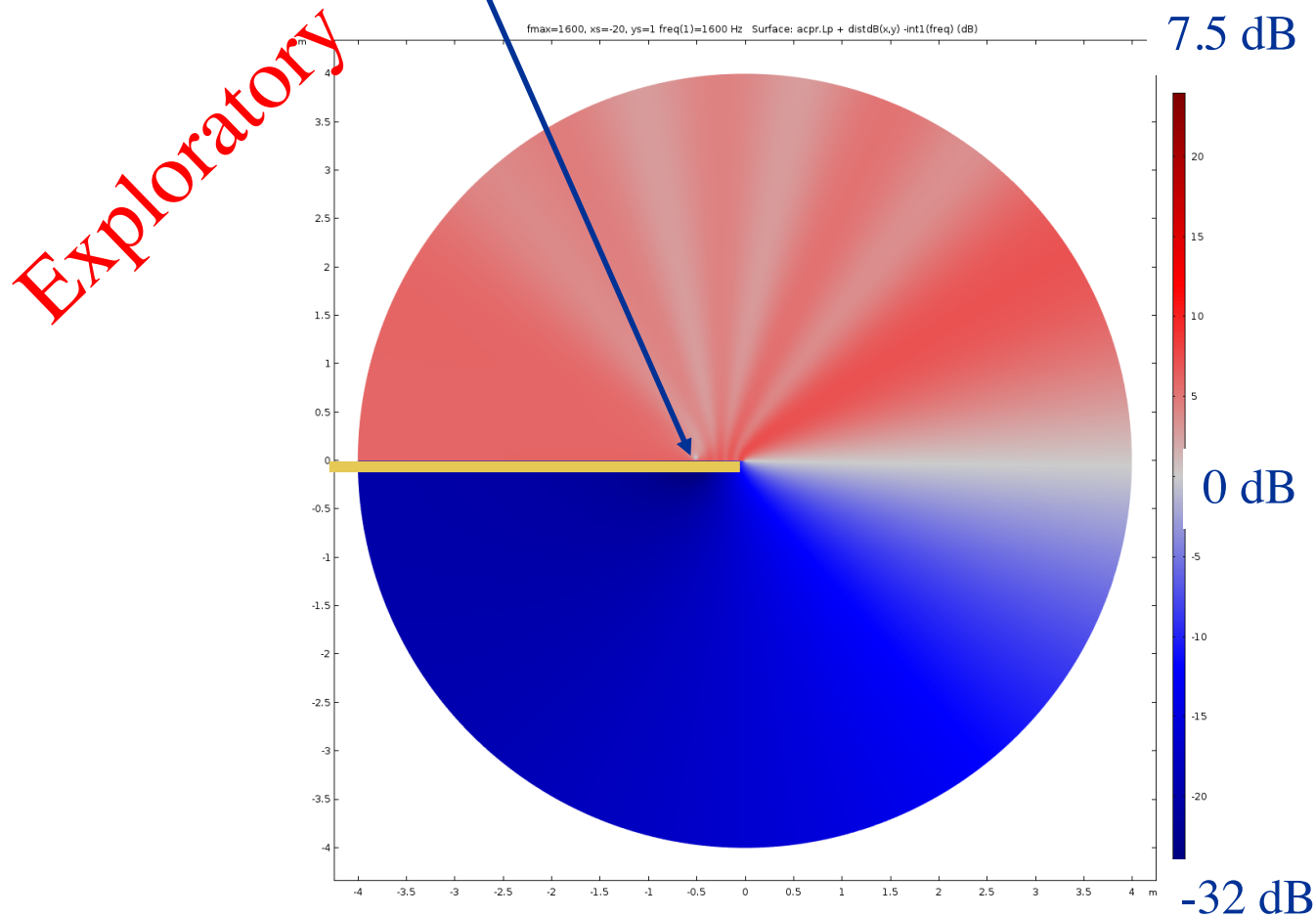
- Constraints:
 1. Limit to “low- to mid-level” simulations
 - e.g. RANS, FEM, BEM, Maekawa
 - LES too time consuming for realistic optimization space
 - Experiments too costly (time and money) for specific models
 2. Retain computation speed of empirical models in ANOPP
 - Implies meta-models for “mid-level” simulations (RANS, FEM, BEM)
- Proposed Concept:
 1. Use existing jet-mixing noise prediction (e.g. Stone Jet in ANOPP)
 2. Calculate/Model a 1-D geometry dependent source distribution
 3. Pair with a geometry dependent propagation to calculate installation effect as Δ dB from uninstalled jet noise
 4. Evaluate the error from simplifying assumptions

Model Work Flow



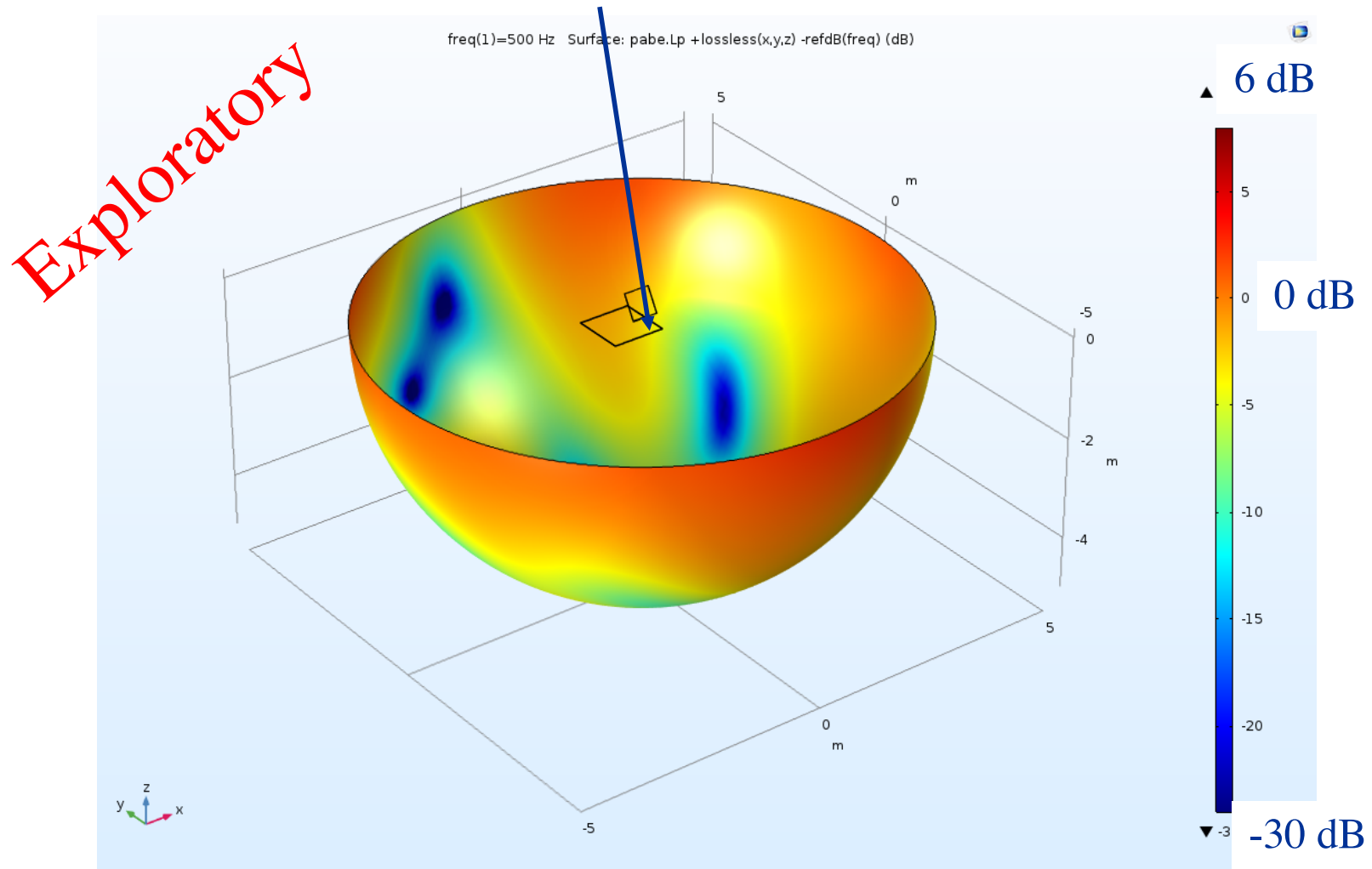
Propagation – COMSOL FEM (2D)

Point Source - 1600 Hz at $x_E - 20''$



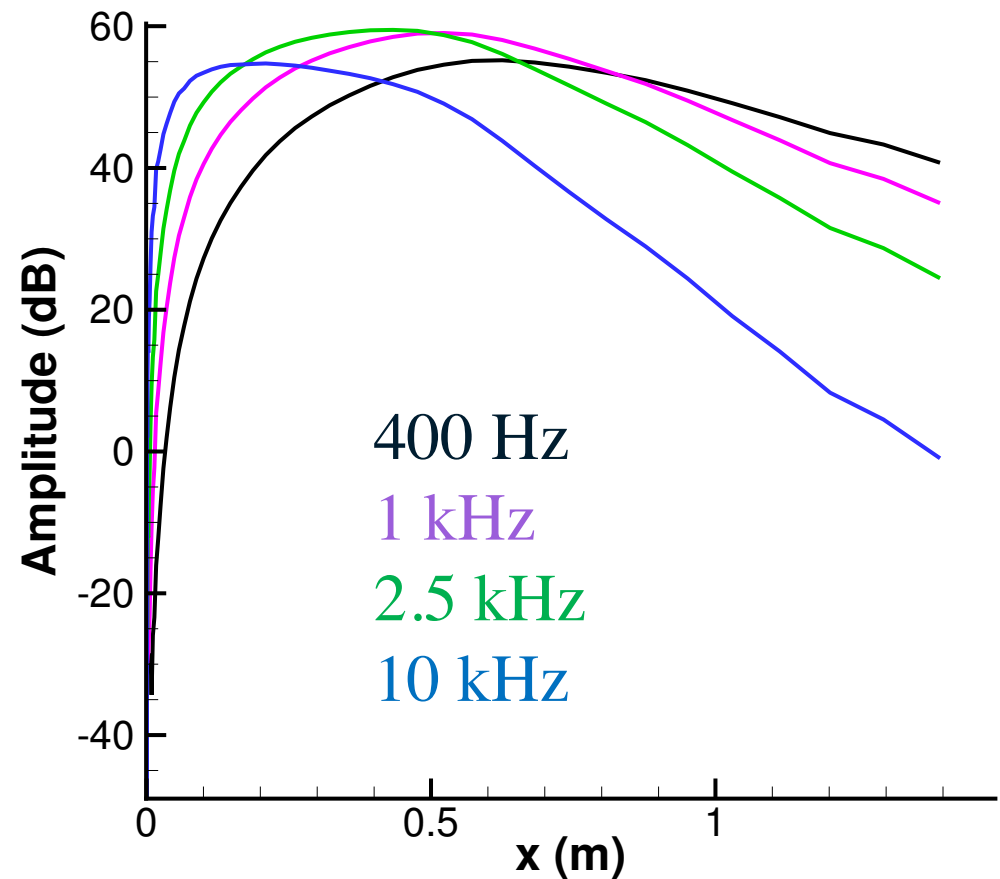
Propagation – COMSOL FEM (3D)

Point Source - 500 Hz



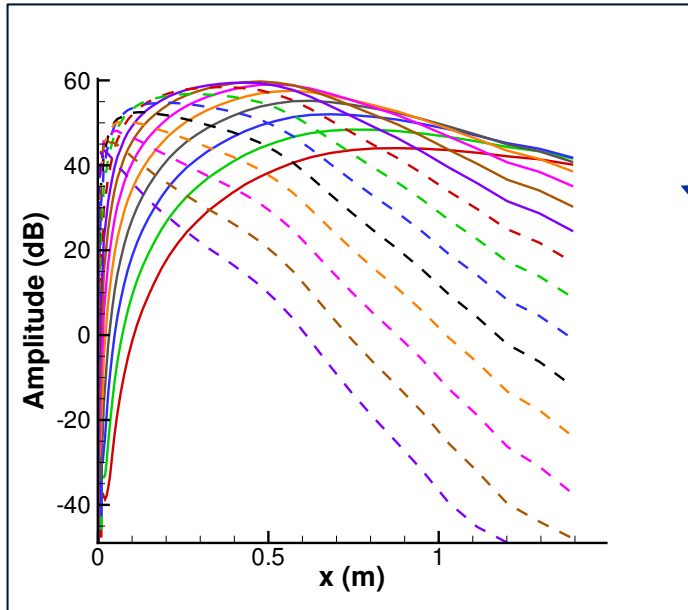
Source Locations – mSrc* Method

- Run RANS CFD
- Use result to compute source amplitude at each point
- Integrate in y-z at each x to get 1-D source distribution at each frequency

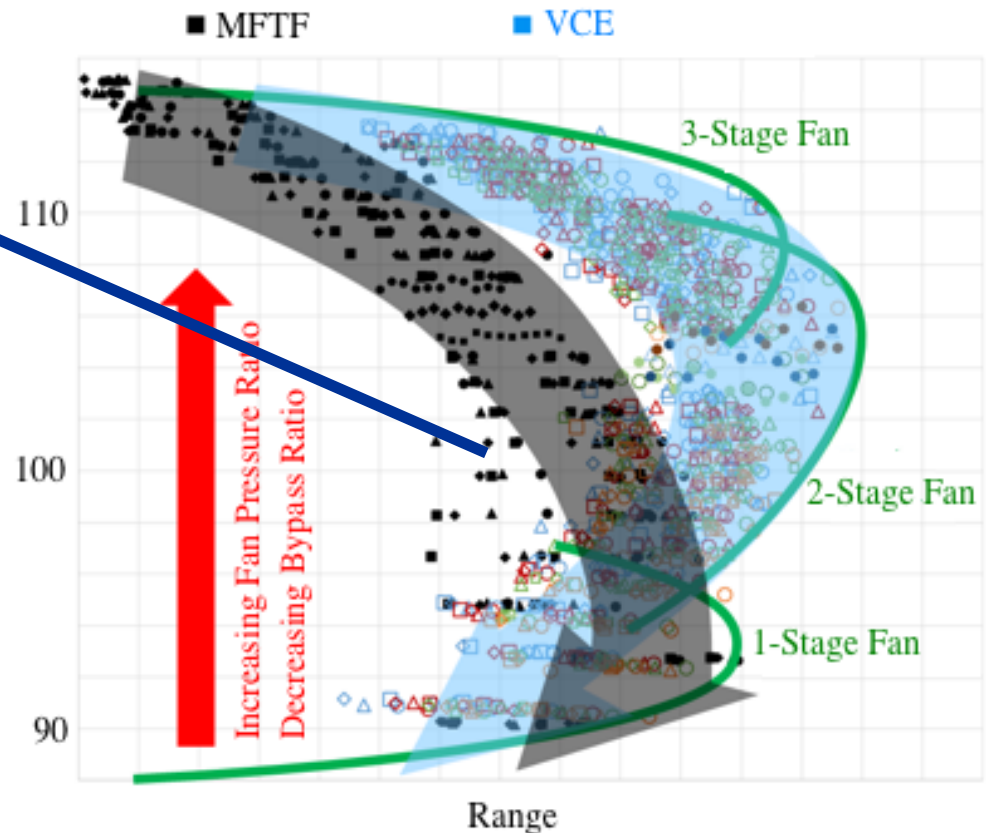


Source distribution generated using
SolidWorks Flow Solver and mSrc
(run time on the order of hours)

Source Locations – mSrc* Method



Uninstalled EPNL (EPNdB)

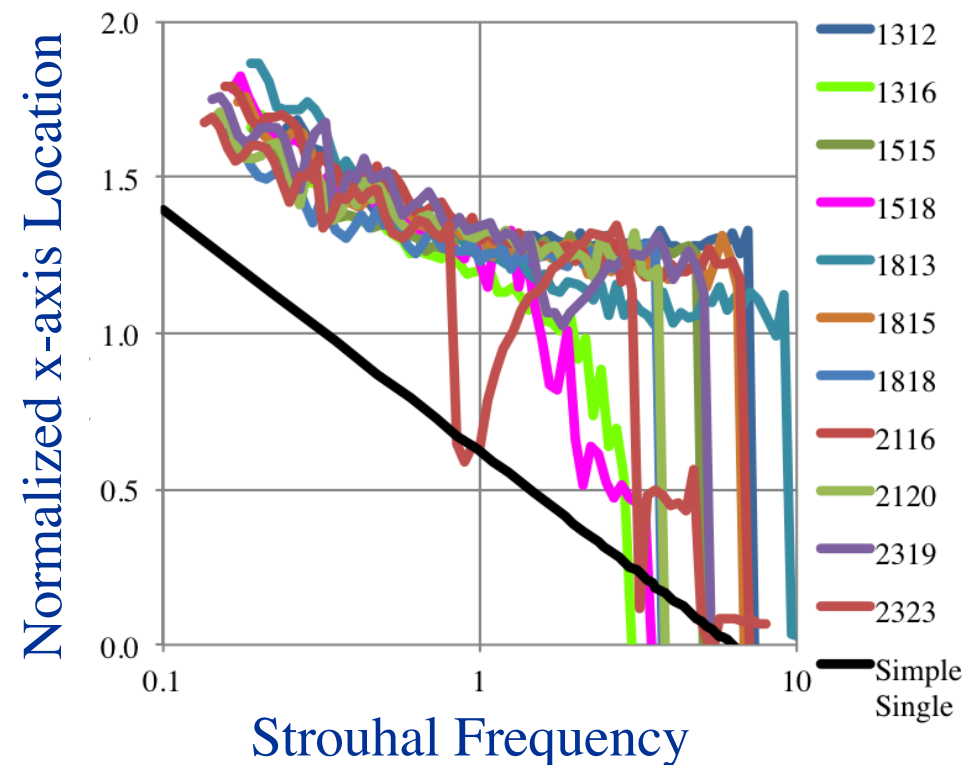


- Each engine has a source distribution
- May need a meta-model for source distribution depending on size of variable space

Aside: Meta-Model for Source Locations

Is it reasonable to model source location?

- Consider phased-array data for dual-stream jets
- Peak amplitude source location collapse with normalization of x-axis
- Discontinuity when source “jump” to nozzle exit – second source region to model
- Need to model at each frequency instead of peak amplitude only but this
- **Modeling seems reasonable based on experience**



Phased-Array Peak Source Location for Class of 2-Stream Jets (JSI16)

Combine Source and Propagation

Simple Surface Example – Semi-Infinite Flat Plate

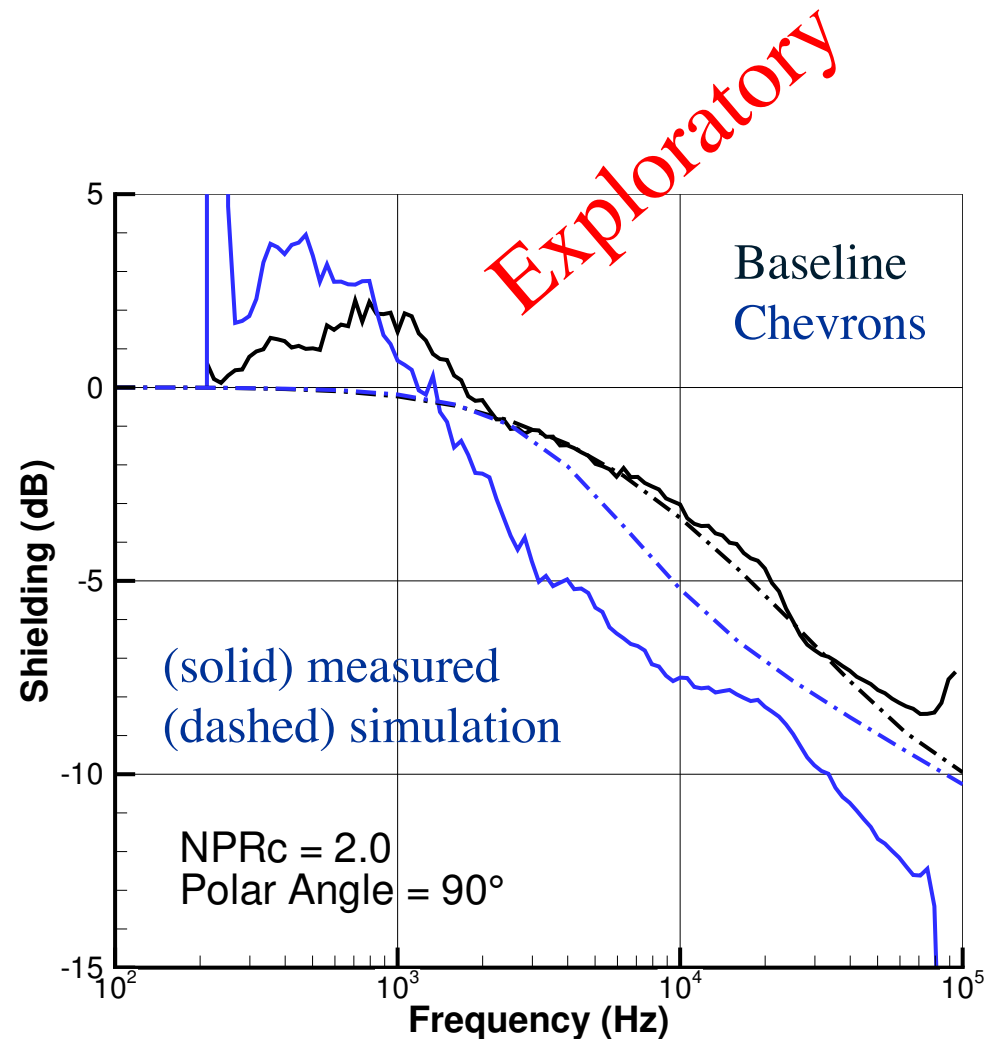
Shielding computed using

- mSrc source distribution
- Maekawa barrier theory

Results:

- Good agreement with baseline (no chevrons)
- Underpredict benefit with chevrons

Does RANS capture the full impact of chevrons?



Summary

1. TMP17 data shows limitations in current JSI models
 2. JSI models need to incorporate source location as function of frequency
 3. JSI models need to account for realistic surface geometries
 4. Want to retain computation speed of empirical models without requiring vast experimental database
 5. Propose using low- to mid-level simulation tools as basis for fast meta-models within a given variable space
- Have we captured all the constraints for a system-level model?
 - What simulations tools or methods should be considered?

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