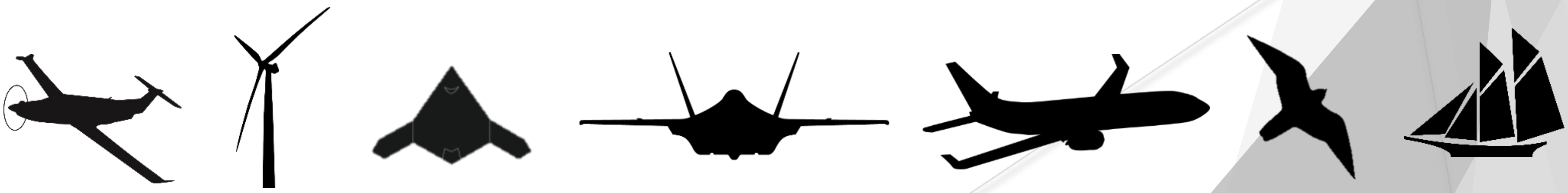
Research In Flight

FLIGHTSTREAM



The Research in Flight Company

- Established 2012
- Primary functions are the development, marketing and service of FlightStream and the development of aerodynamic solutions
- Key Personnel and Contact Information:
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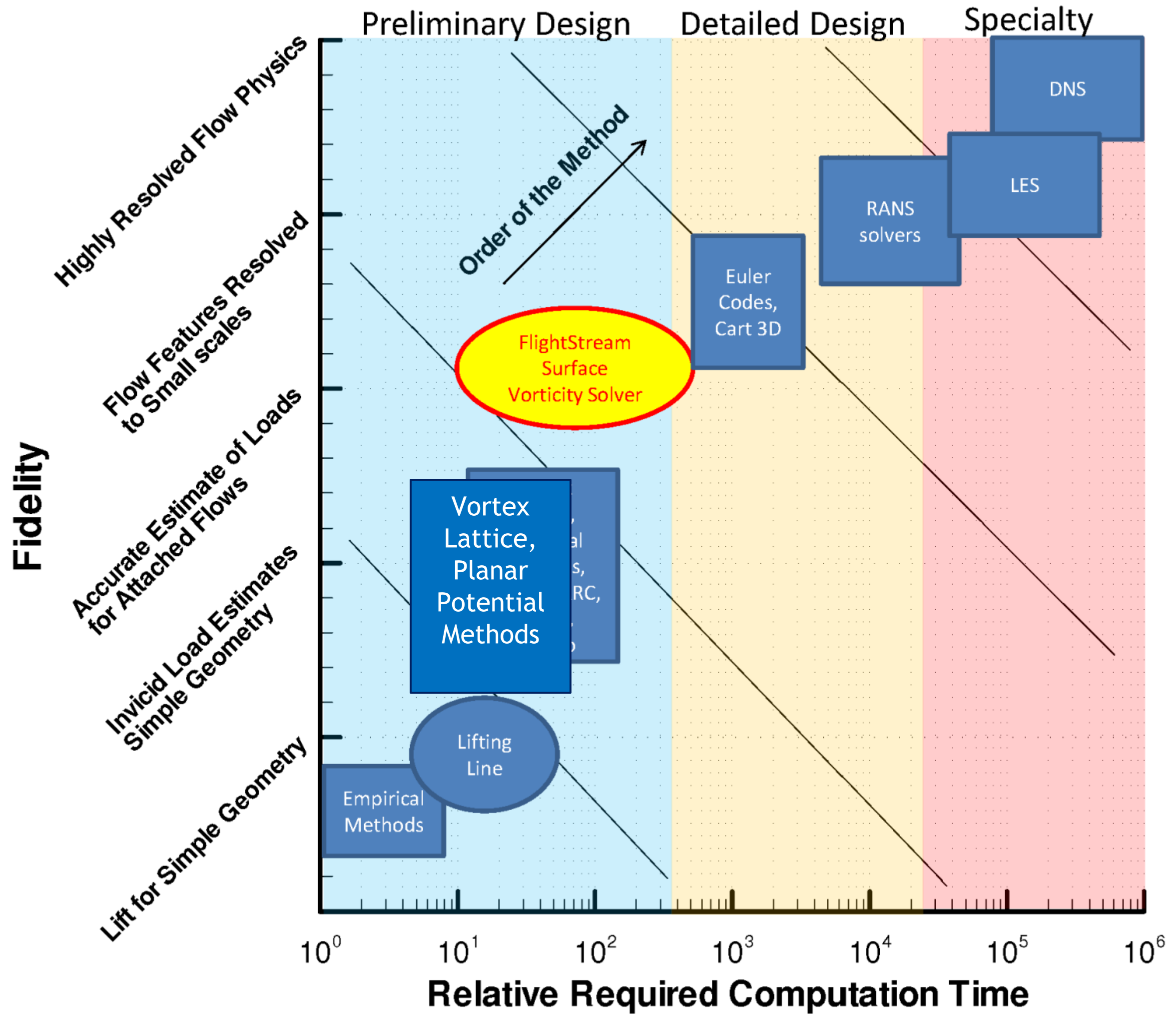
NASA SBIRs and other activities

- Evaluation of the D8.5 configuration
- Development of engine integration capability (SBIR 2015-I NNX15CL92P)
- Maximum Lift Estimation
- An advanced solution to vortex shedding for high lift modeling (SBIR 2016-I NNX16CL39P)

FlightStream Characteristics

- FlightStream is a highly efficient subsonic inviscid solver
- Capabilities:
  - Flow Field parameters with approximately the fidelity of a well implemented Euler solver except that FlightStream offers time resolved solutions, preservation of trailing vorticity, and solutions with close proximity aerodynamic lifting surfaces.
  - High Fidelity Inviscid Load Calculations for Airplanes of a wide variety of configurations including blended bodies, canard configurations, and nearly any nonconventional geometry.
  - FlightStream is fully integrated with a range of geometry inputs.
  - Viscous drag estimates are provided via a Reynolds analogy based approach.

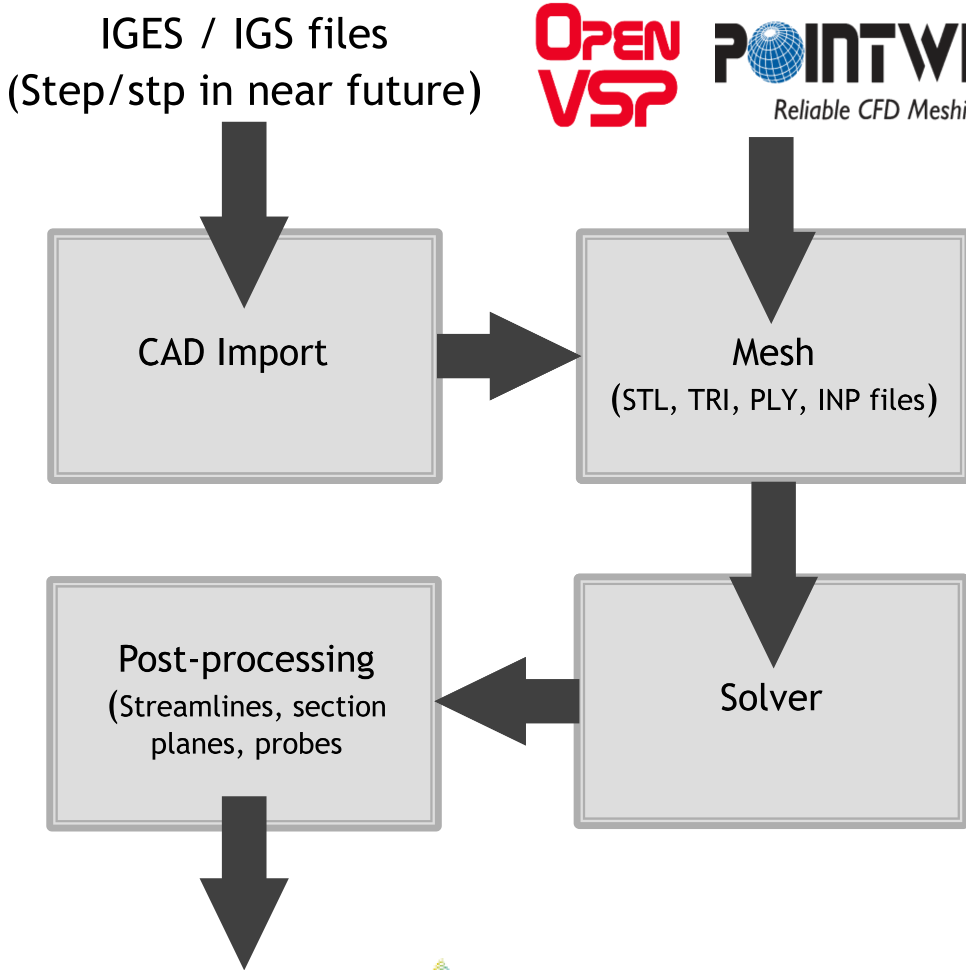
FlightStream Characteristics



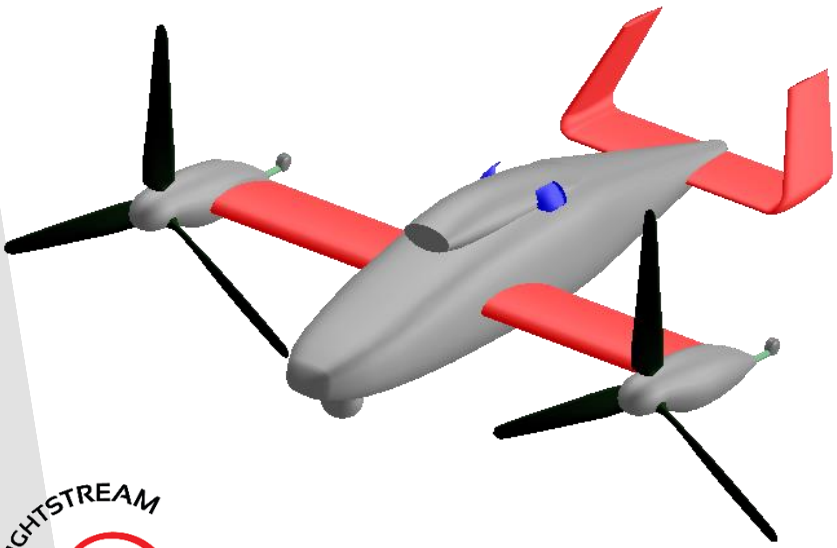
FlightStream Capabilities Overview

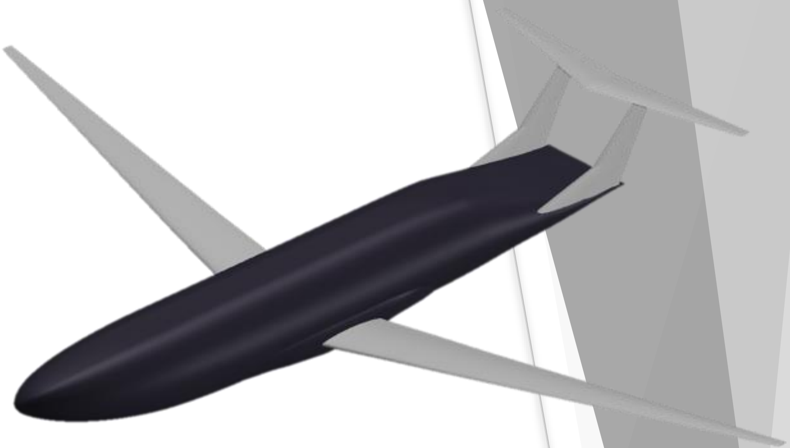
- All primary aerodynamic loads are calculated using a proprietary inviscid surface based method.
- Field variables are available on demand through efficient post processing.
- Surface pressures are available with appropriate solver settings
- Seamless geometry input:
  - Fully integrated with NASA's OpenVSP
  - Commercial surface mesh generators such as Pointwise
  - For missiles, missile lab and other stl or key geometry inputs are usable
  - Limited CAD interface capability
- Highly intuitive UI & High Quality native graphical post processing
- Built in Optimization using OpenVSP for geometry and a Real coded GA
- Propeller analysis using direct blade analysis or actuator disk models.
- Gas Turbine based engine integration through NPSS, inlet definition, and exhaust modeling

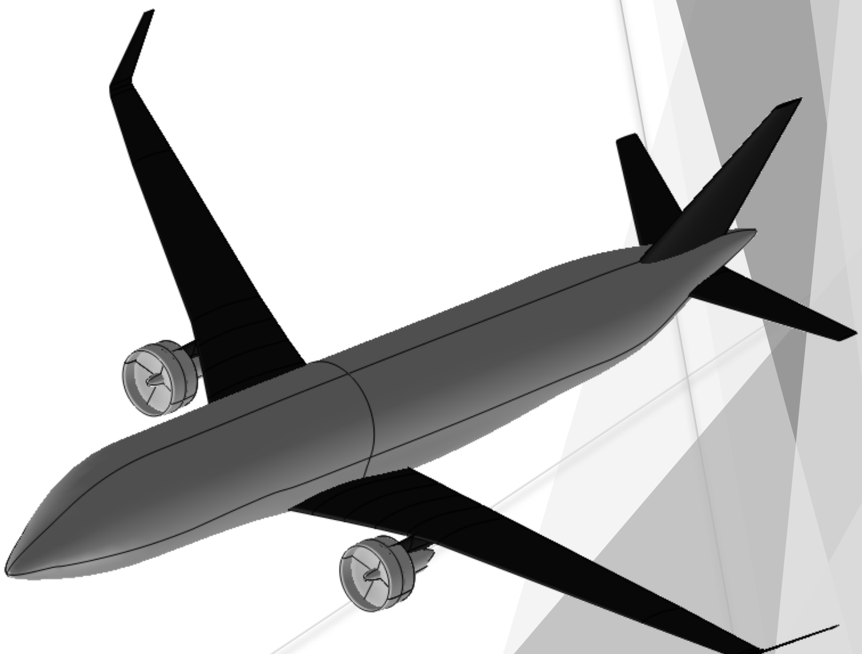
FlightStream Geometry Pre-processing: Overview



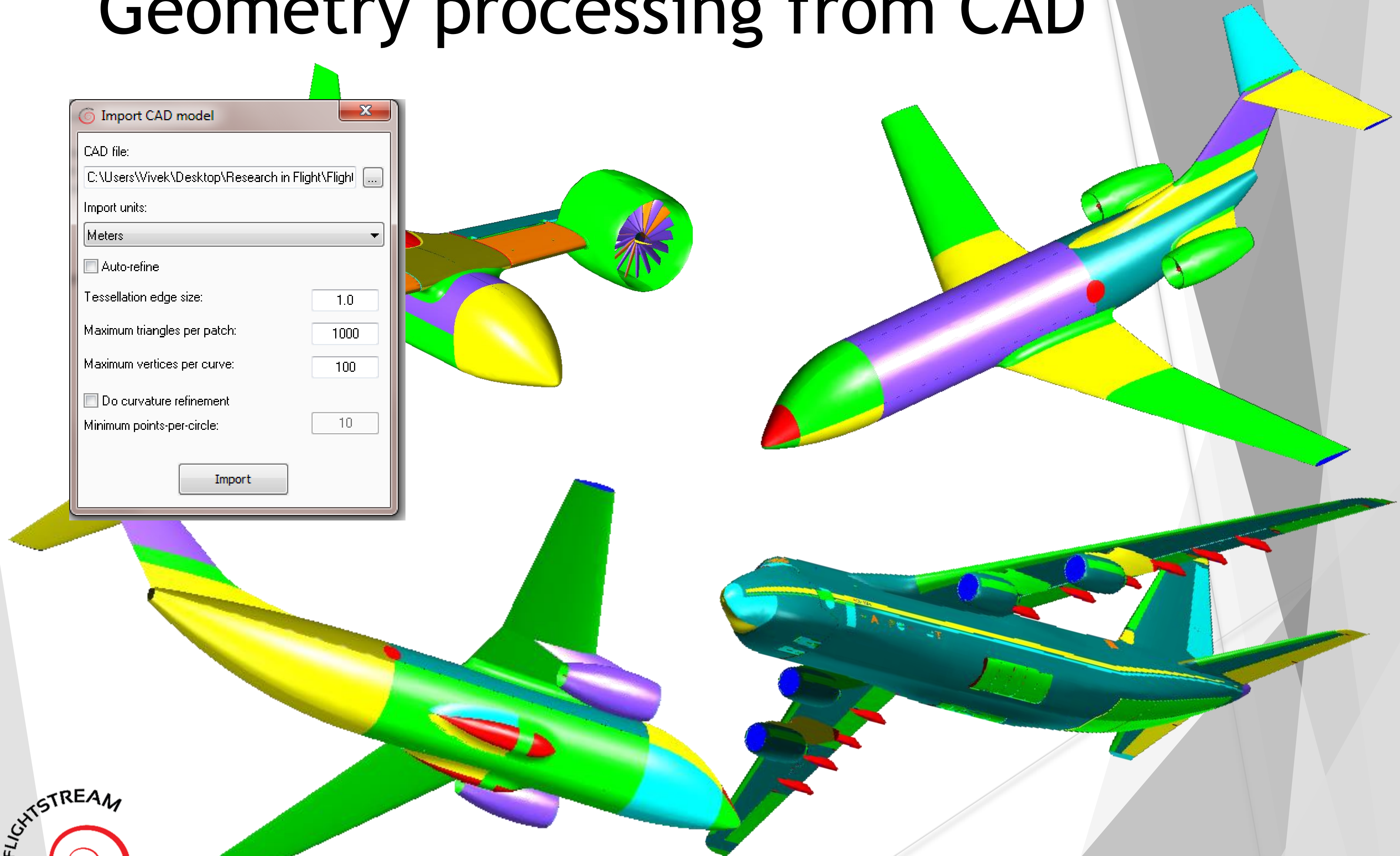
Geometry Pre-processing: VSP





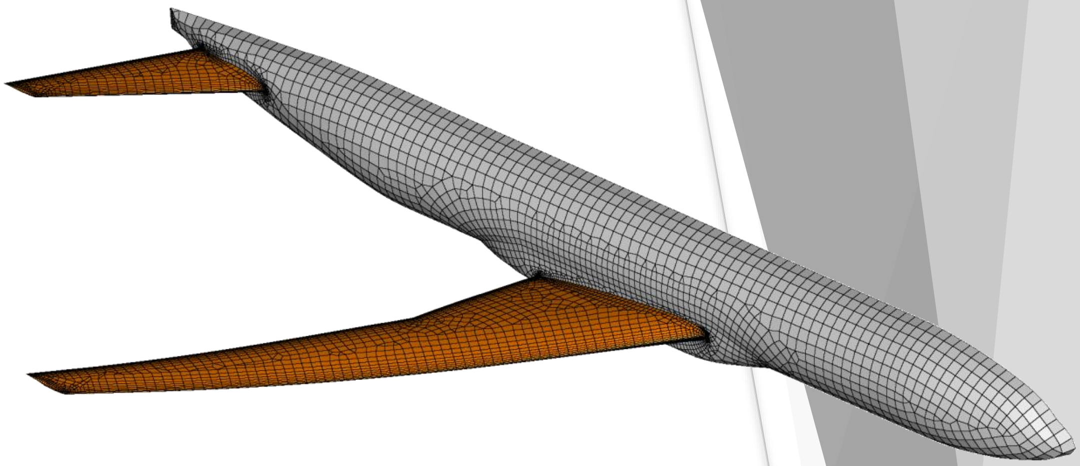


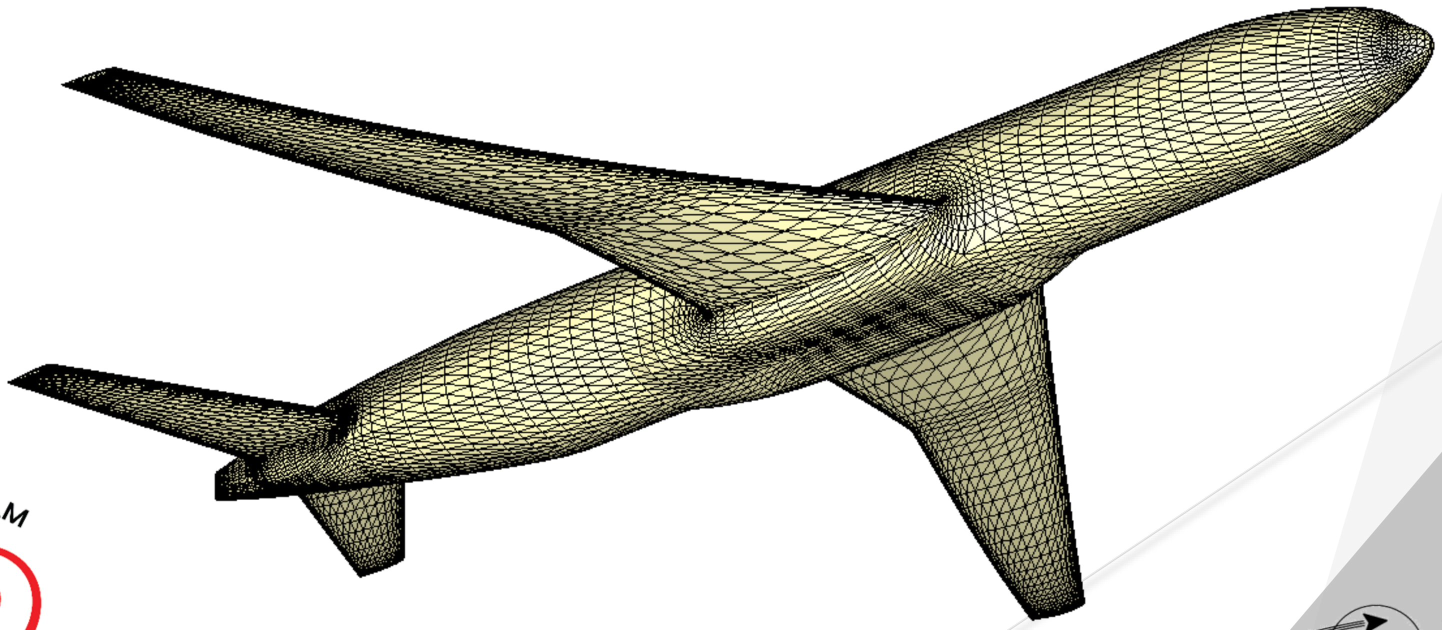
Geometry processing from CAD



Geometry Pre-processing: Pointwise® Meshes

- FlightStream is compatible with Pointwise® meshes
- Pointwise® can generate aligned structured and unstructured surface meshes
  - Both of these have been tested with FlightStream successfully

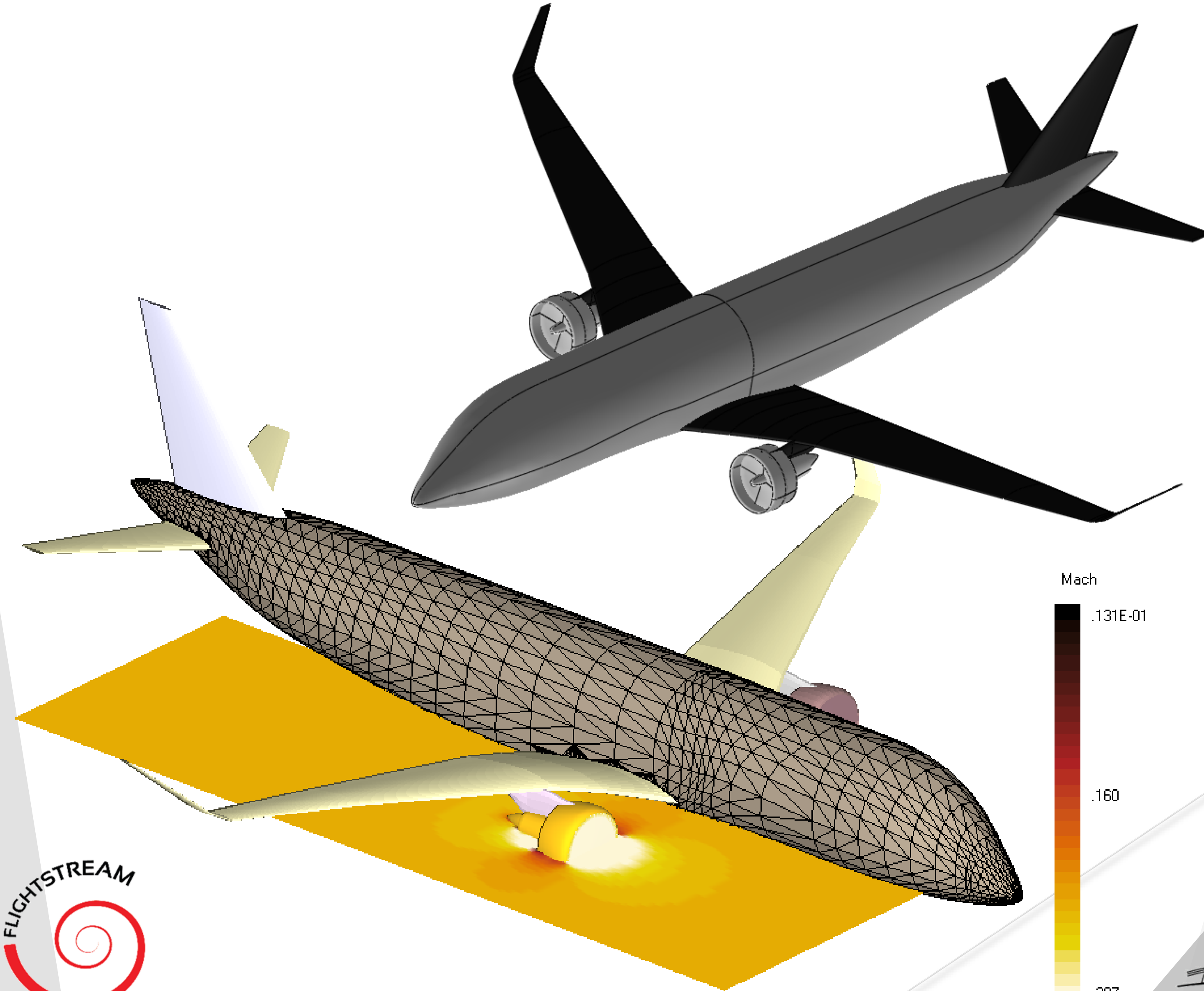




Engine Integration Modeling

- Modeling jet engines:
  - Velocity inlets for engine intakes
  - Actuator discs for engine exhaust flows
- Modeling propellers:
  - Actuator discs for propeller models in steady flow
  - Unsteady solver for time-dependent studies with full fidelity propeller modeling

Engine Integration Modeling: Velocity Inlets



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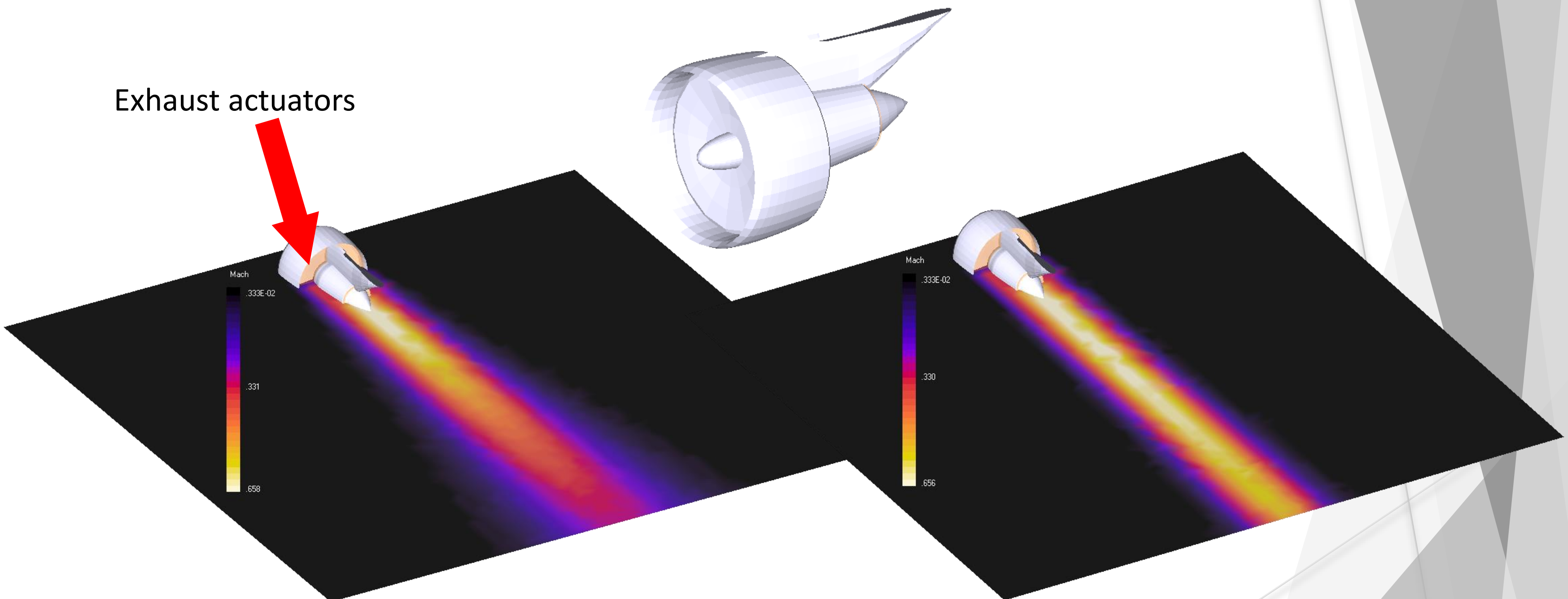
Engine Integration Modeling: Jet Exhausts

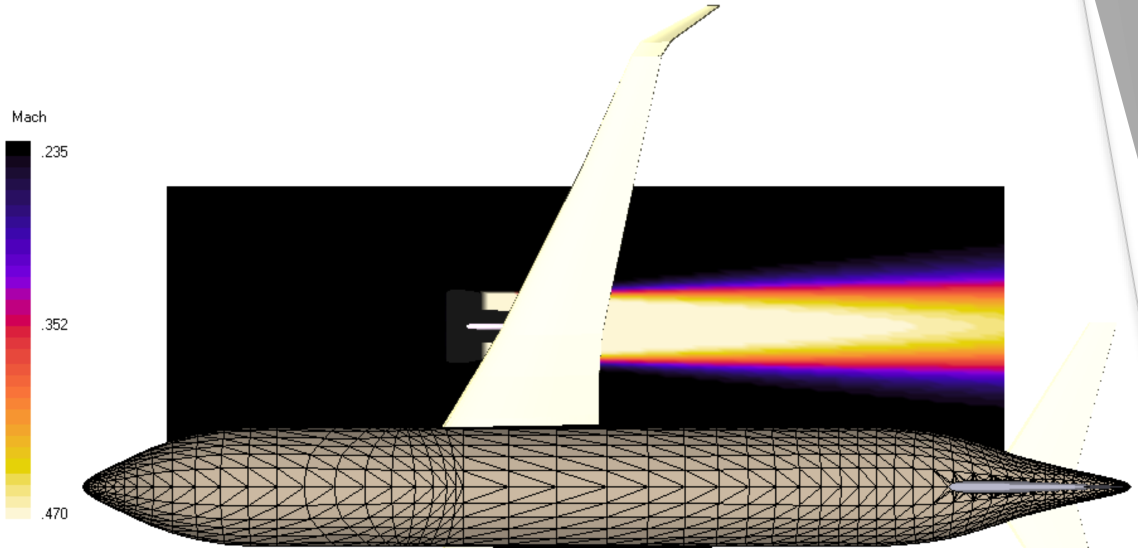
- Turbofan Example:
  - Two actuator exhausts. One for the fan and the other for core; Concentric cascading.
  - Free-stream velocity set to 1 m/sec.

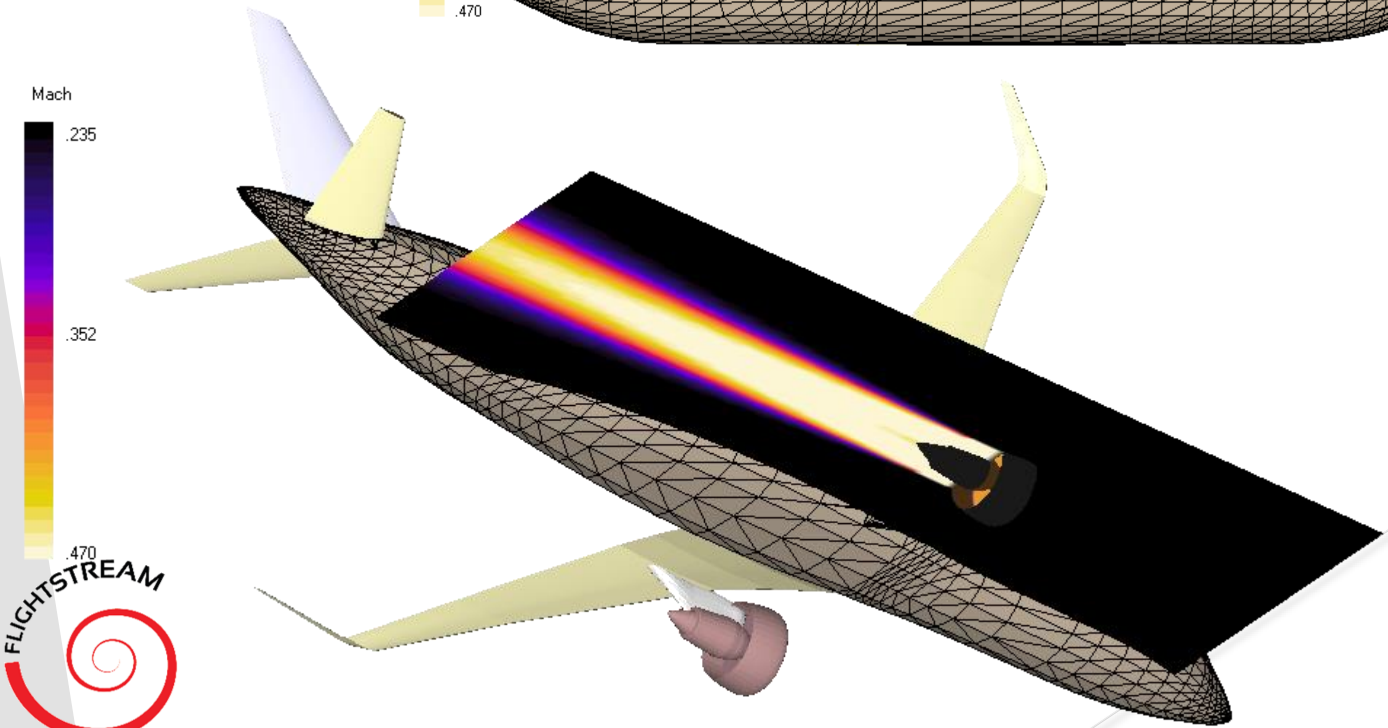


Jet spreading rate: 0.1000
Condition for high velocity gradient in the exhaust plane

Jet spreading rate: 0.0375
Condition for uniform exhaust velocity distribution

Engine Integration Modeling: Jet Exhausts (Contd.)





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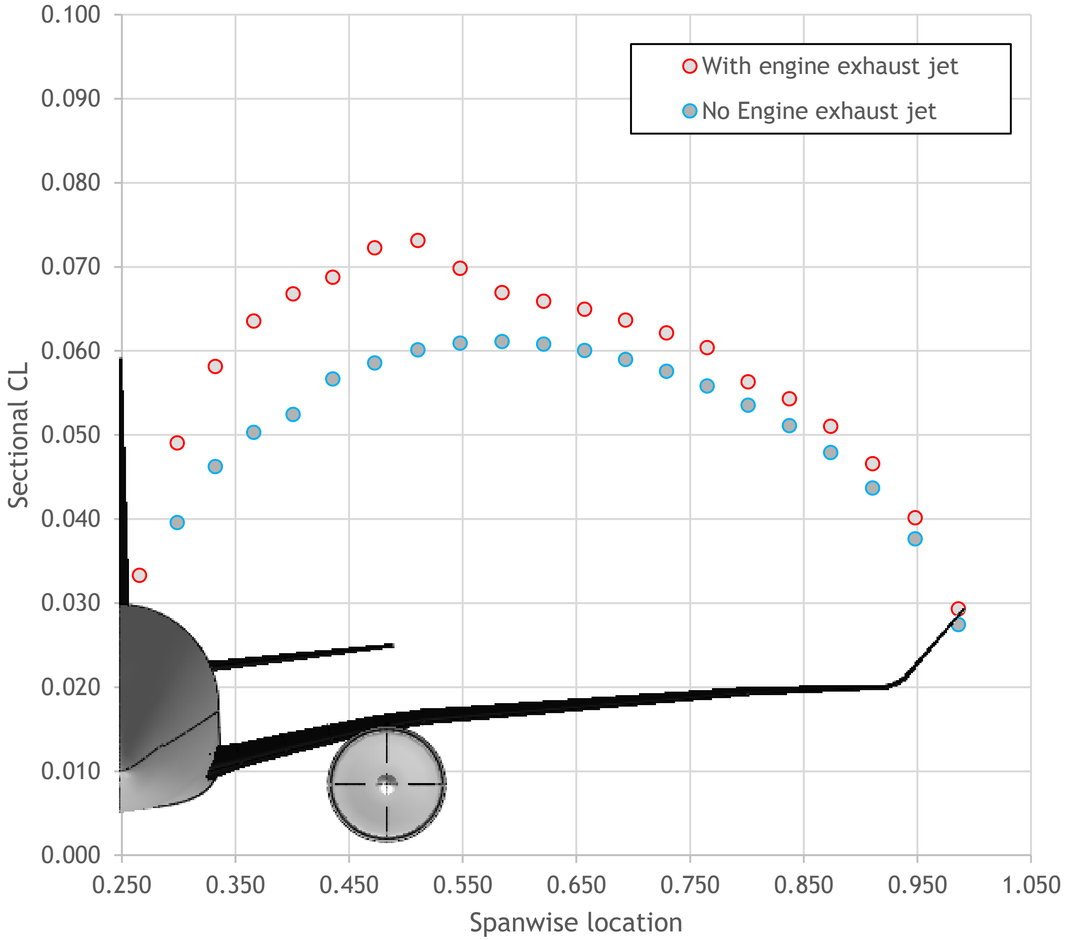
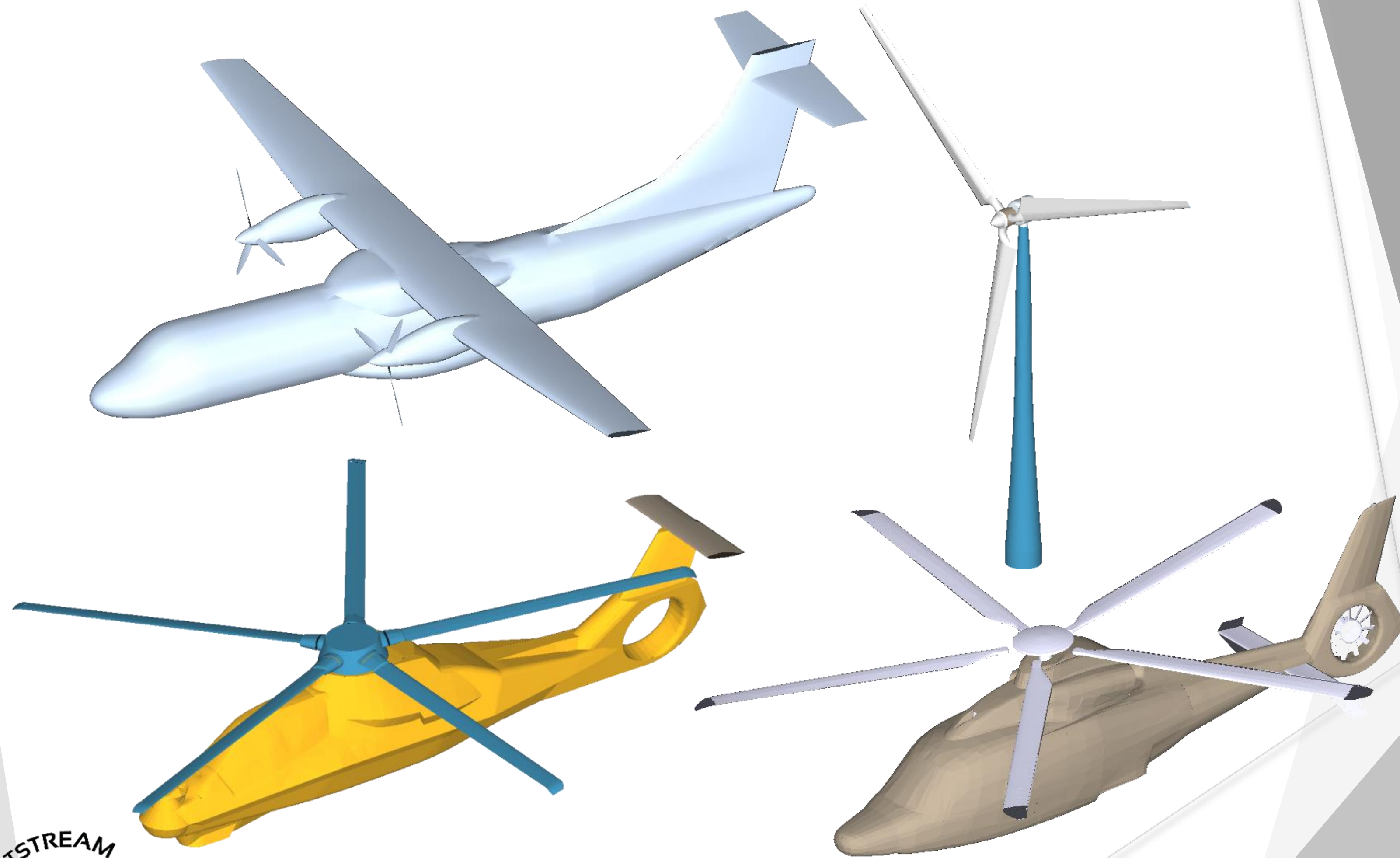
Engine Integration Modeling: Combined Inlets + Exhausts

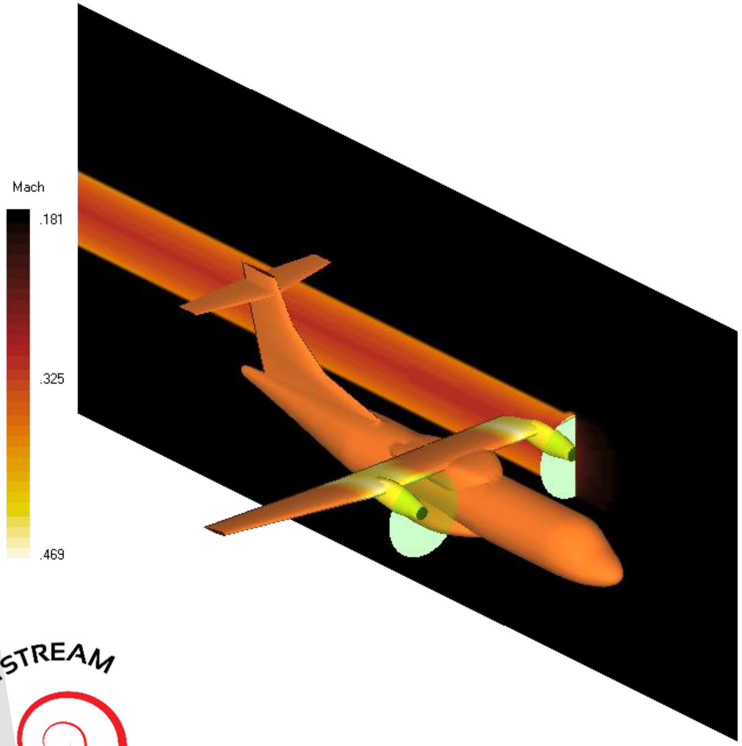


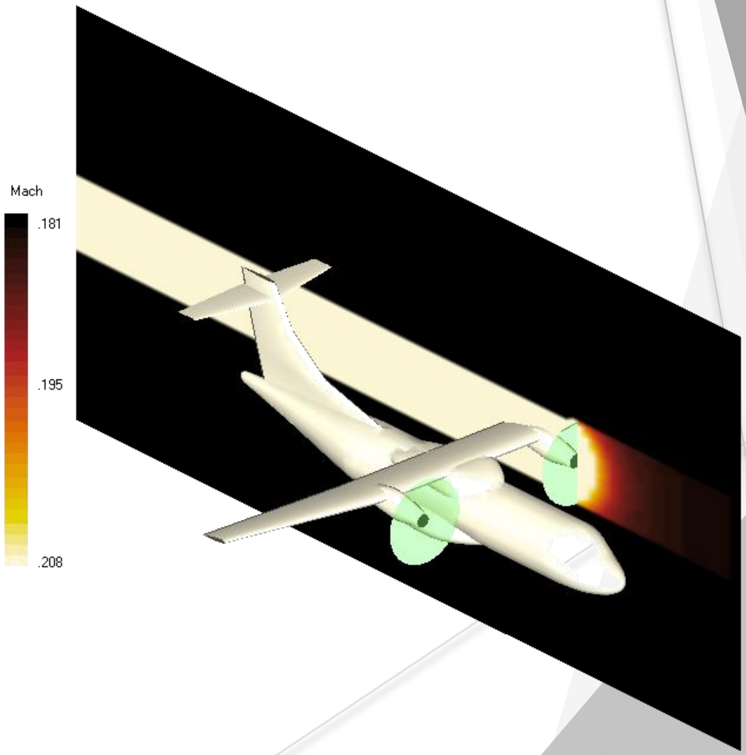
Modeling Propellers: Vehicle Sketch Pad Geometries



Modeling Propellers: Actuator discs for steady-flow

- Created using local coordinate systems in FlightStream.
- Need only radius, RPM, thrust and power coefficients as user inputs.
- Works within the FlightStream steady-state solver.
- Is used as a preliminary approach to modeling propeller effects on aircraft geometry.
- Extremely high computational efficiencies.
- Can be used to model large number of propellers on the same geometry.





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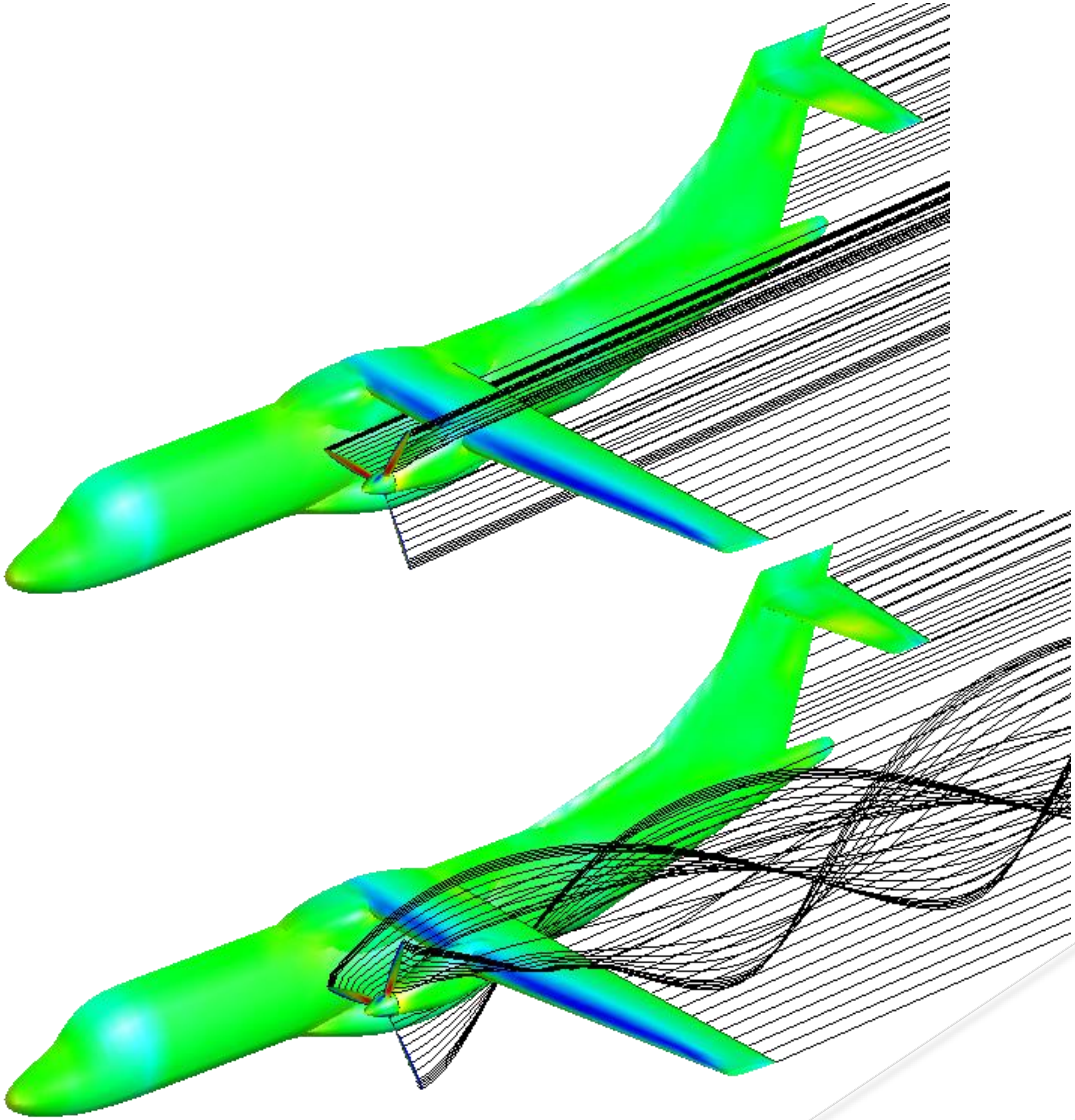
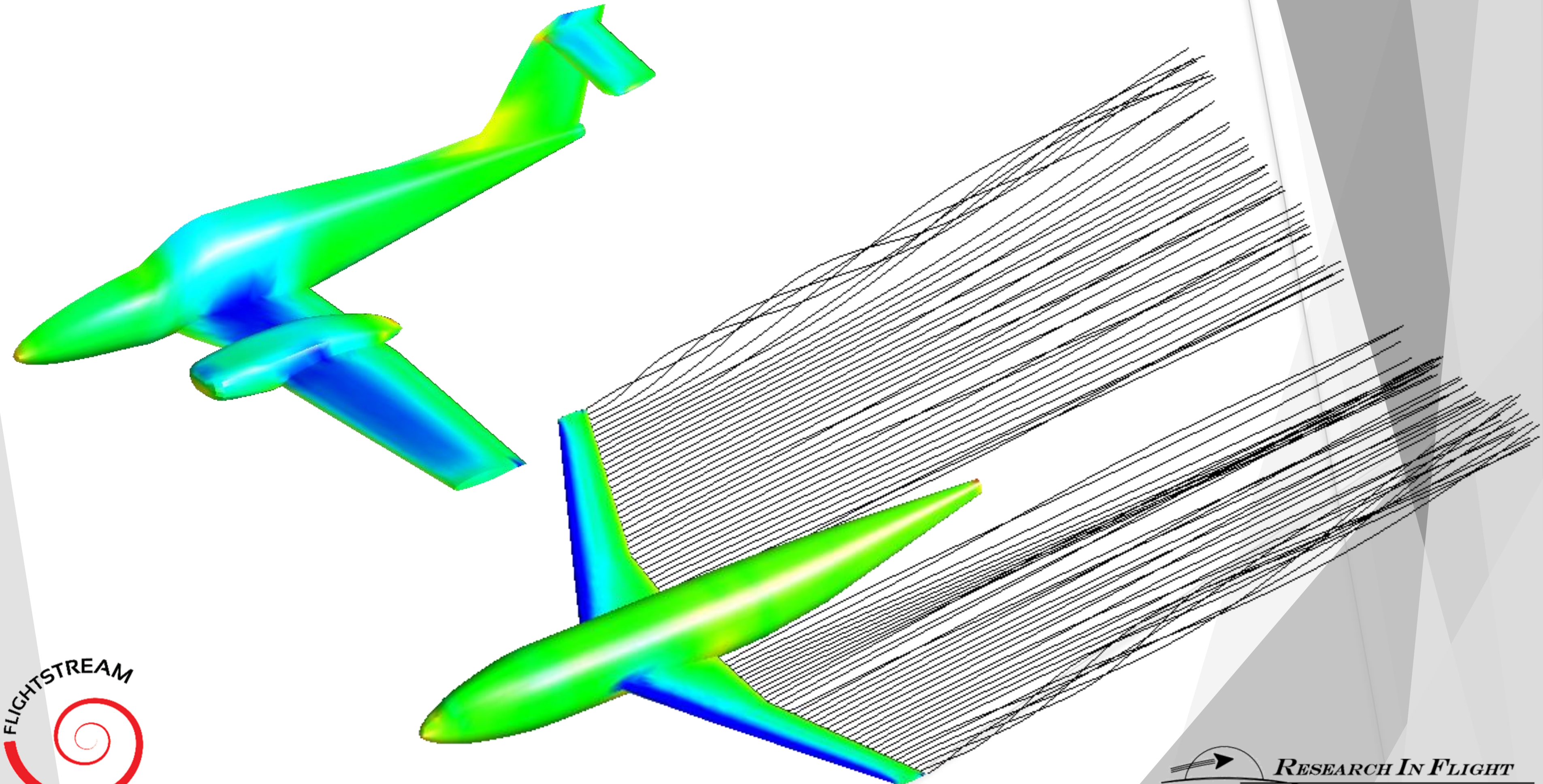
Modeling Propellers: Time-Dependent Solver



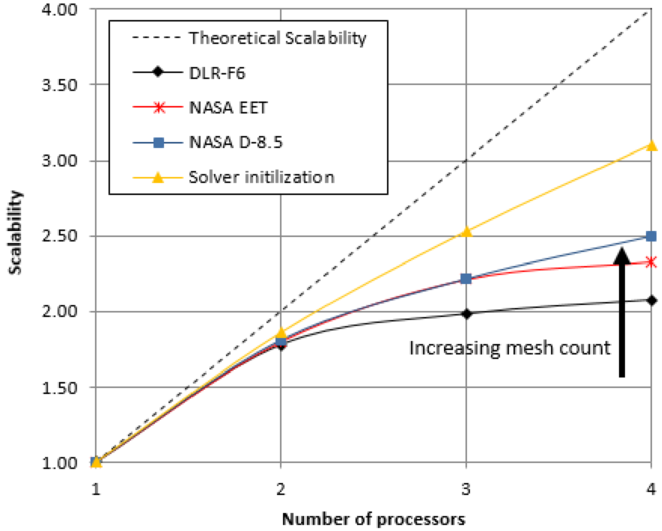
Surface Pressure Computations

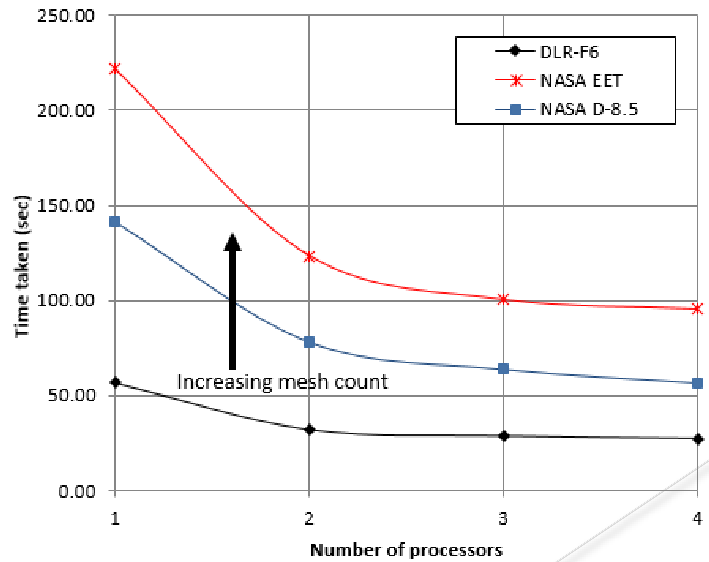
- Evaluated as a byproduct of the vorticity solution
- No computational penalties



Parallel Solver Scalability

- FlightStream flow solver is completely parallel-scalable





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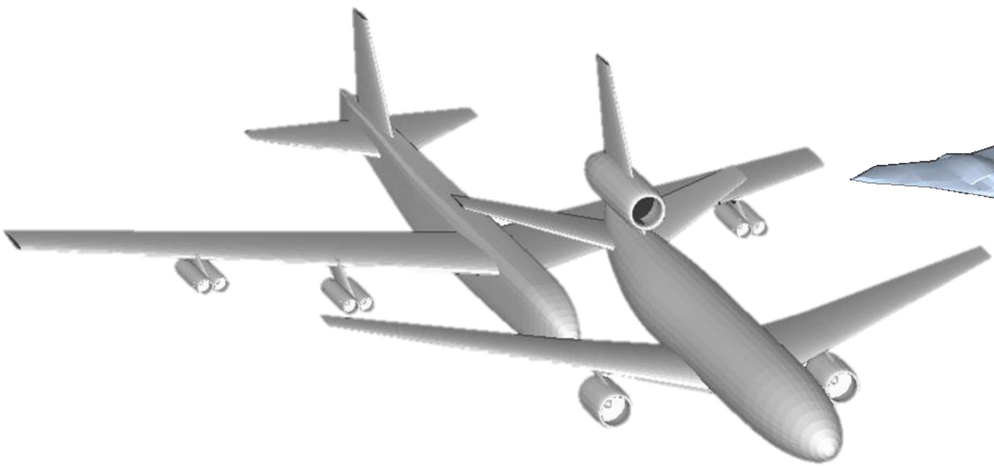
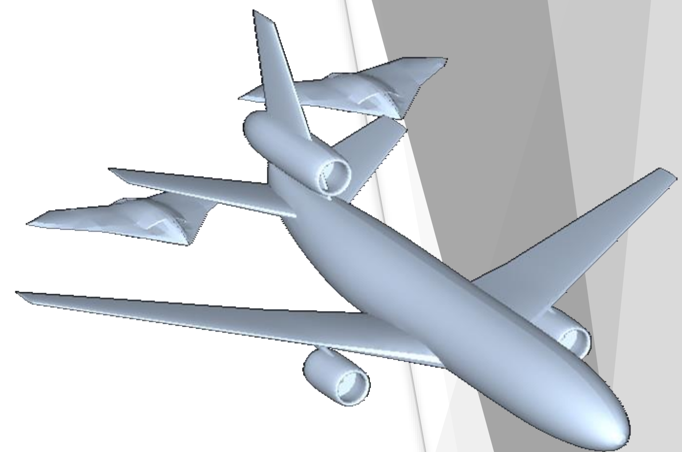
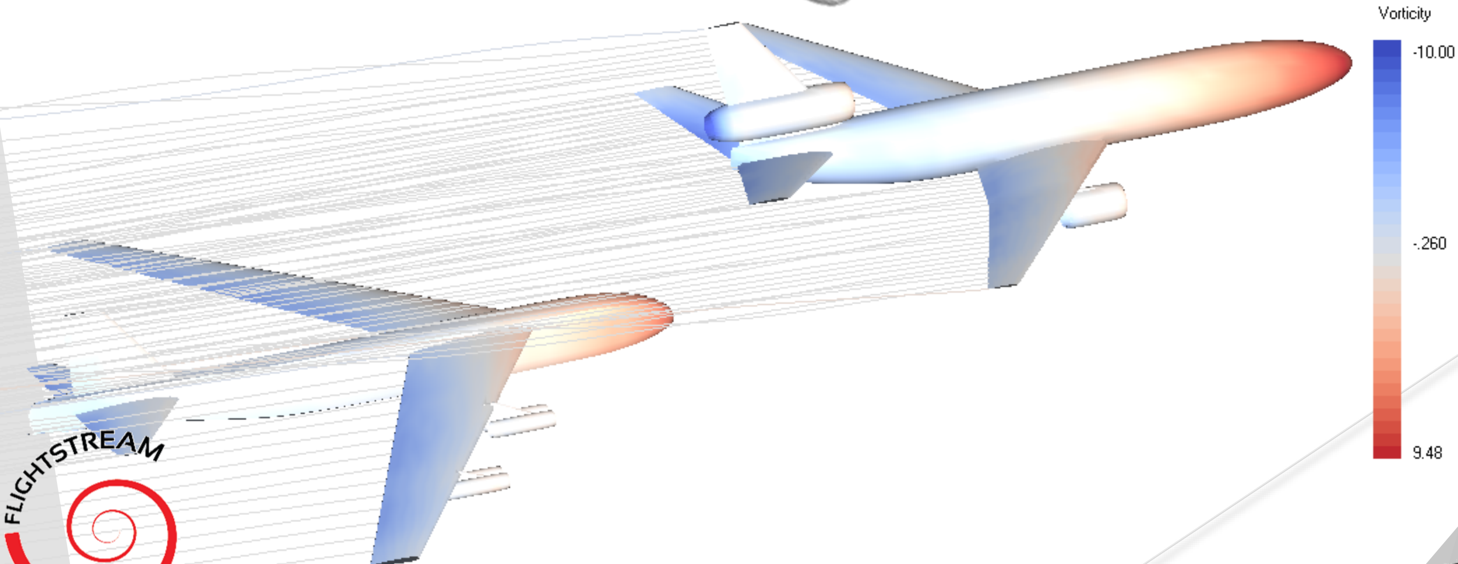
Special Applications: In-Flight Refueling Modeling

- Multi-aircraft simulations
- Geometry modeled using VSP







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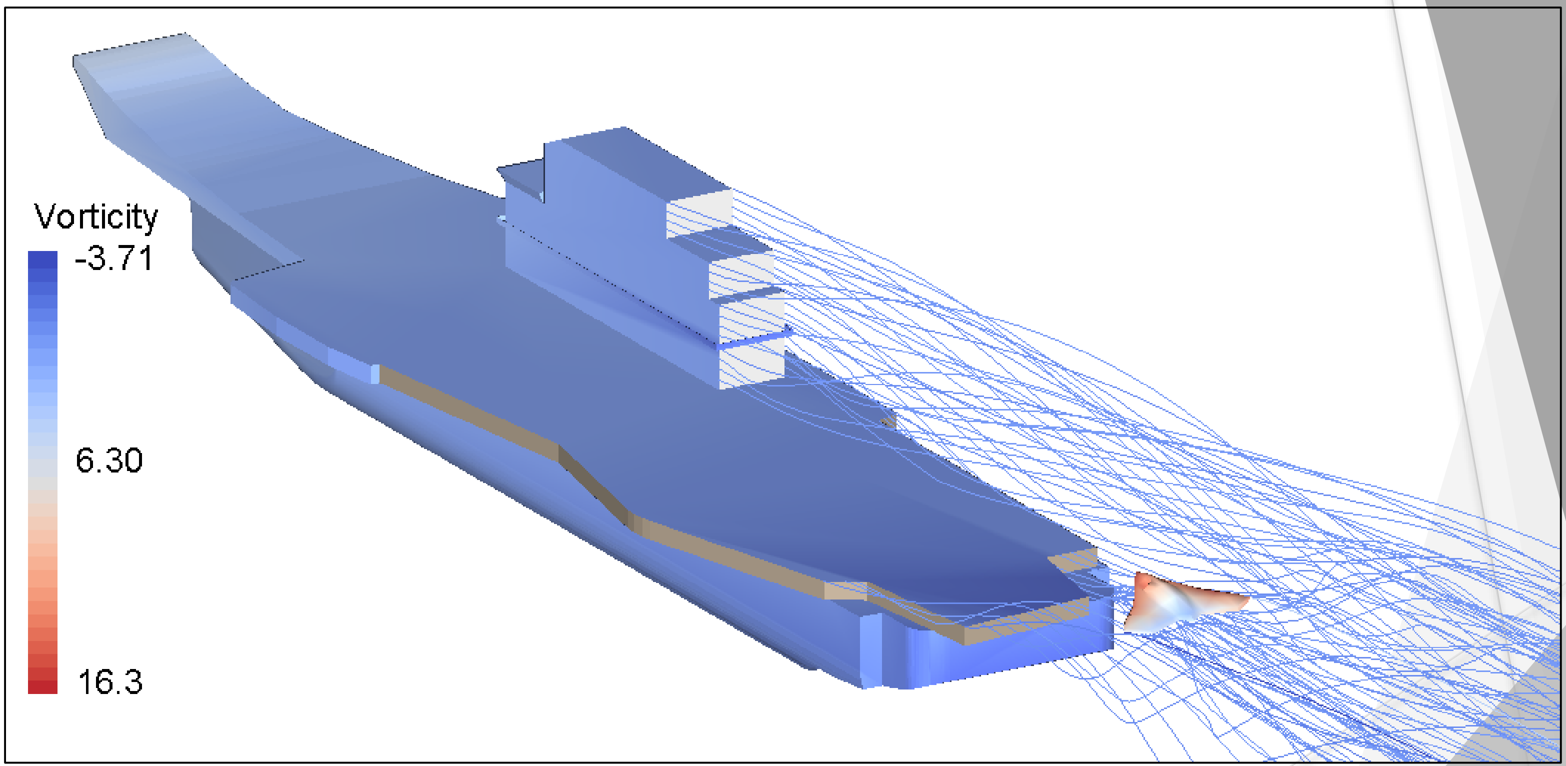
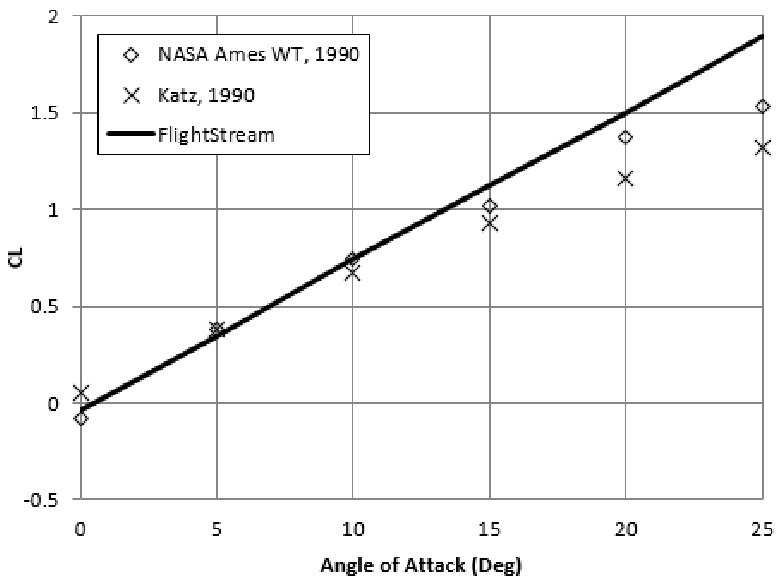
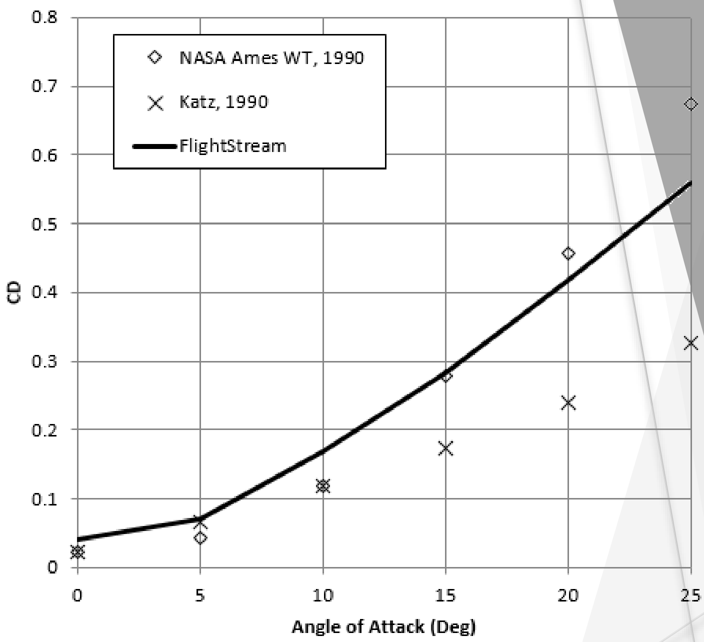
Special Applications: Proximity to surroundings

- Carrier landings
- Wind-Tunnel flow with modeled ducts



Validation cases: Boeing F-18A





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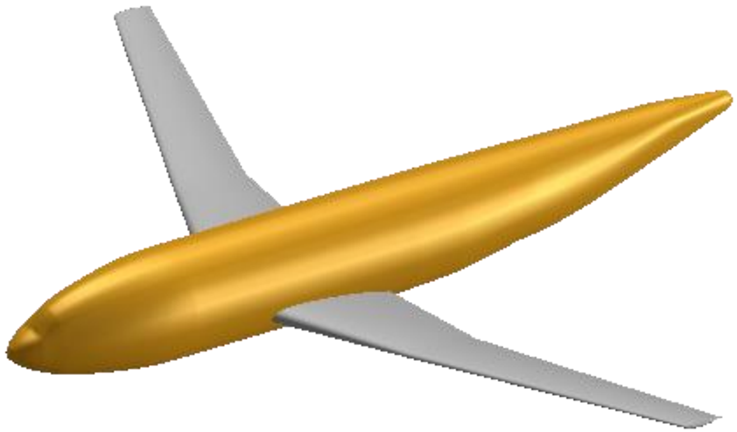
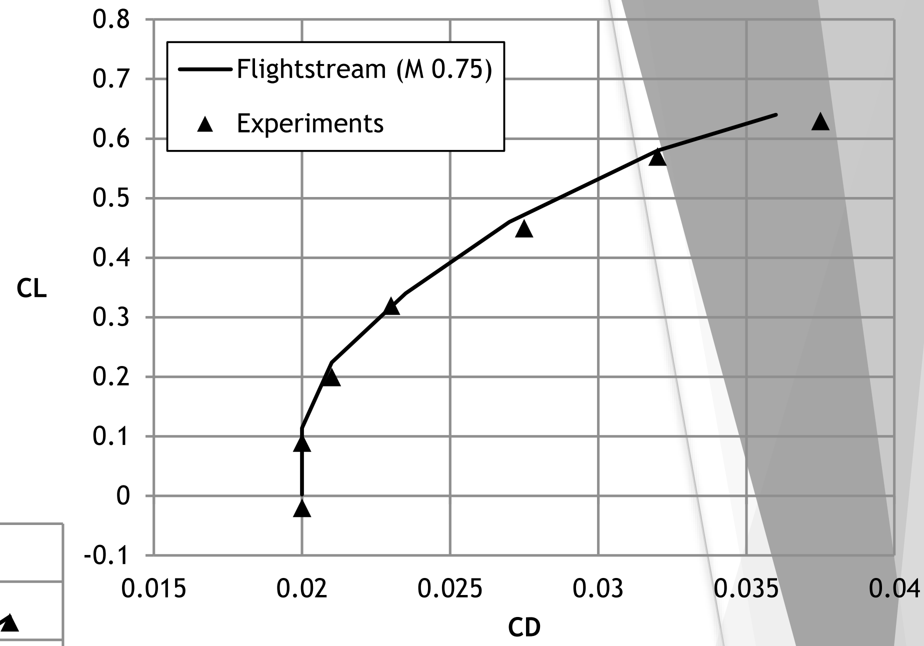
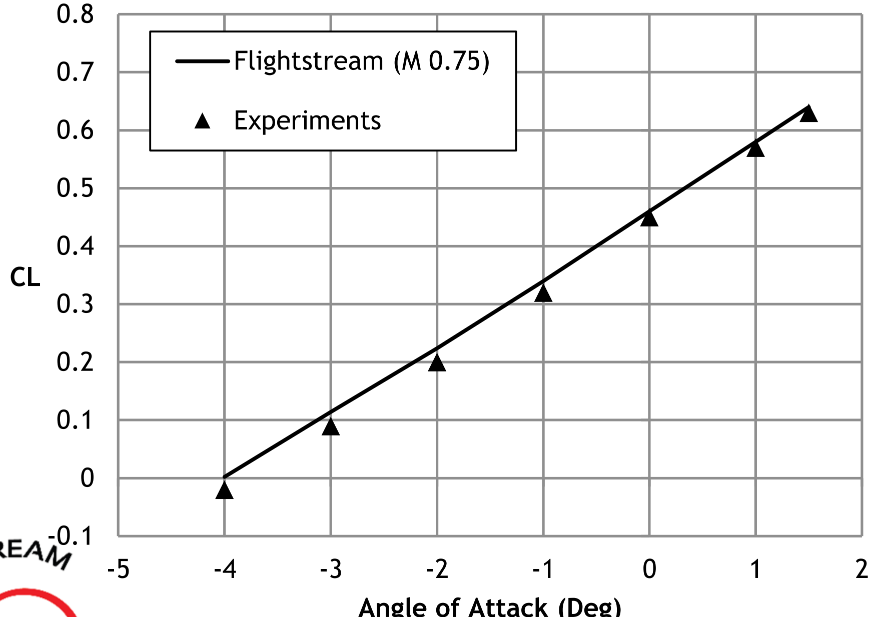
Validation cases: DLR-F4







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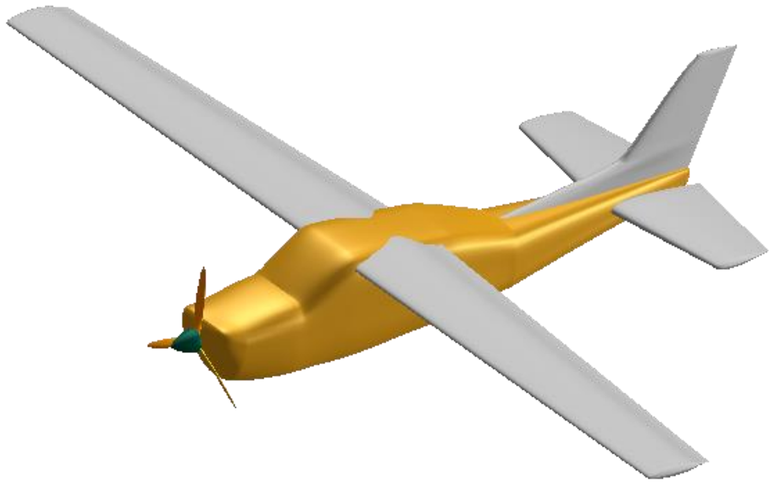
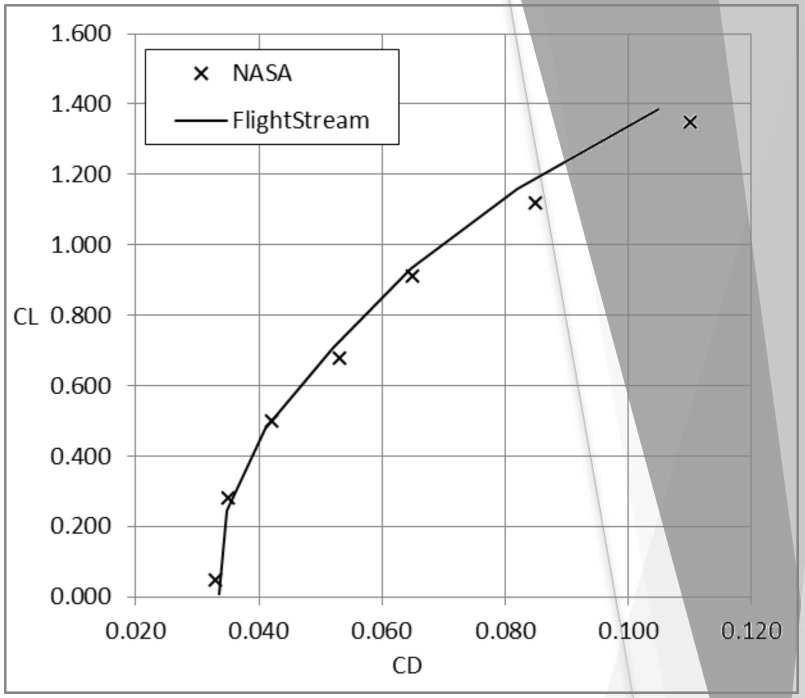
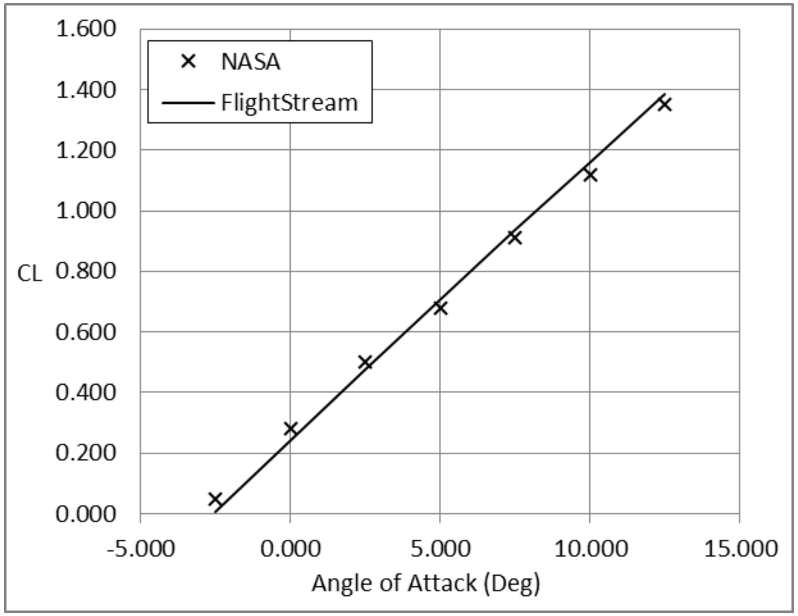
Validation cases: Cessna 210







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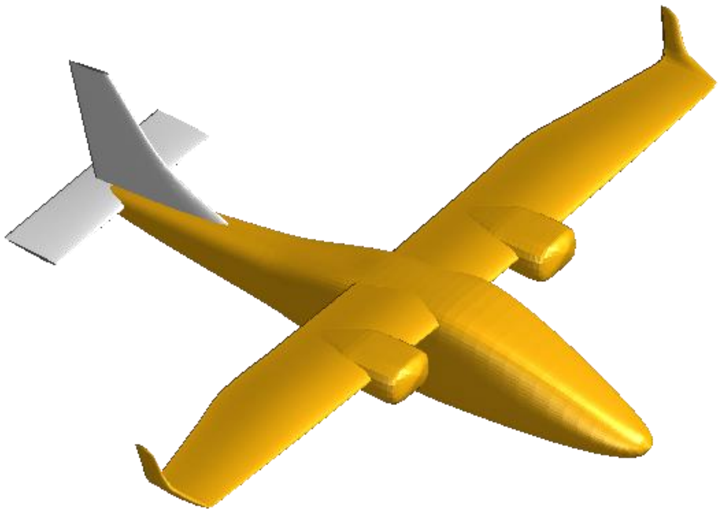
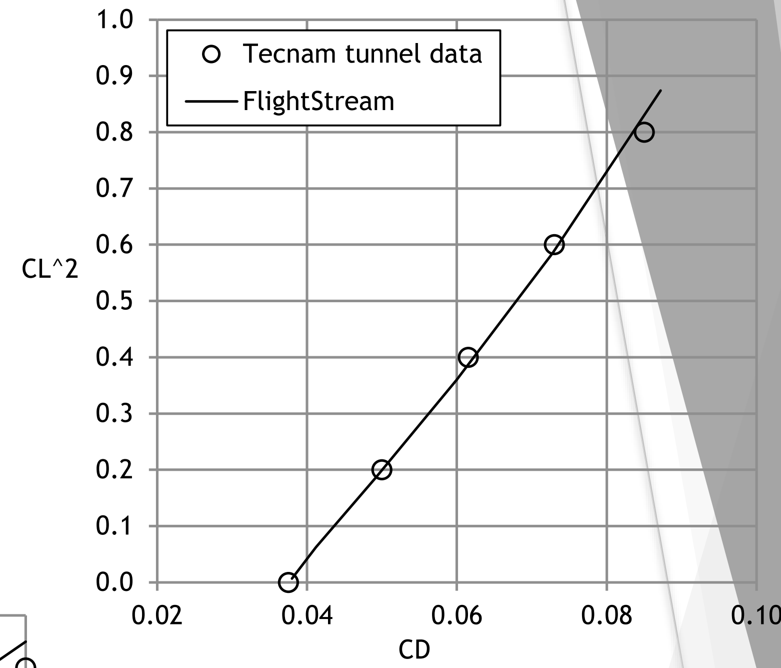
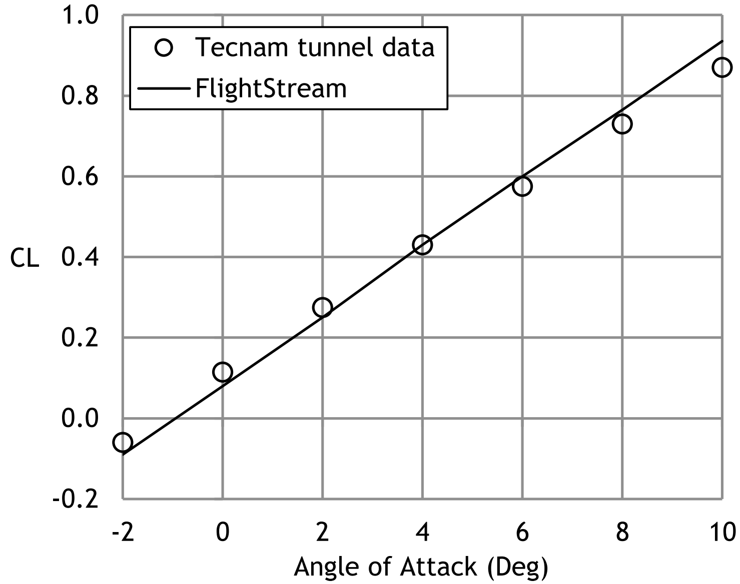
Validation cases: Tecnam P2006T







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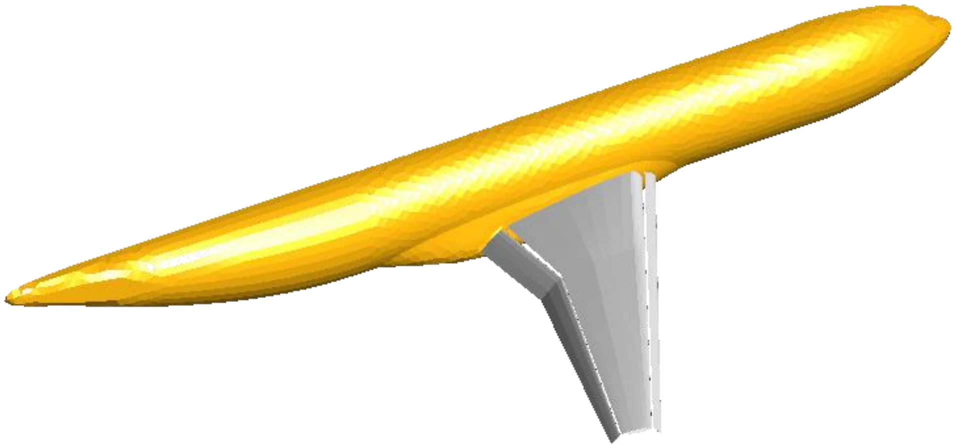
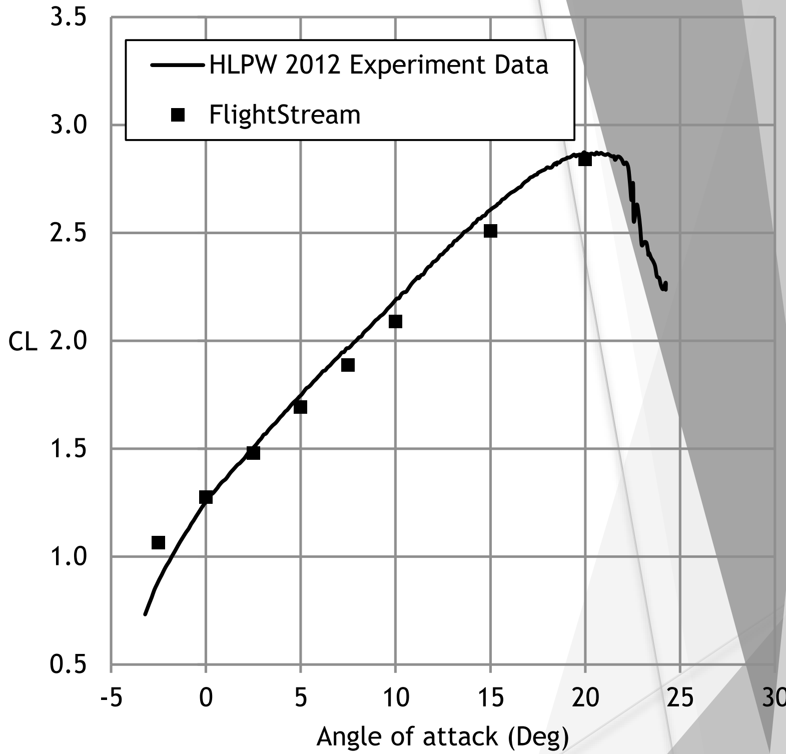
Validation cases: HLPW-2 (With Slats & Flaps)





Modeling Separation

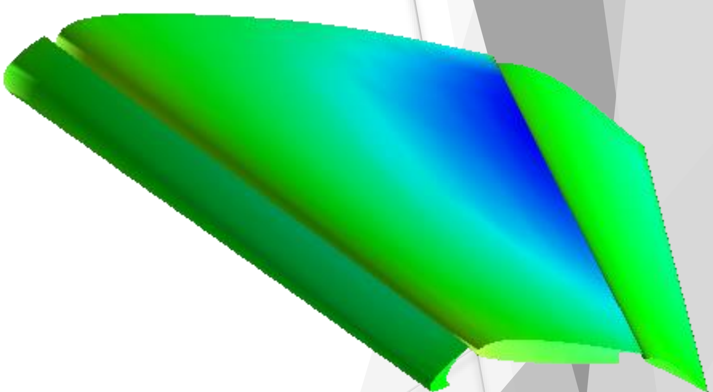
- Clmax computations for each spanwise section
- Formulation based on the Valarezo and Chin Pressure Difference rule
- Reformulated into vorticity

Output of CL-max computations in the Analysis tab

Surface loads | Separation | Sectional Plots | Probes

Boundary	X	Y	Z	Force	Status	...	...	..
Slat	.6195	-.2415	-.0112	.0126	Active	...	...	..
Slat	.7100	-.3740	-.0120	.0181	Active	...	...	..
Slat	.8005	-.5065	-.0128	.0222	Active	...	...	..
Slat	.8909	-.6389	-.0136	.0261	Active	...	...	..
Slat	.9814	-.7714	-.0143	.0298	Active	...	...	..
Slat	1.0...	-.9038	-.0151	.0330	Separated	...	...	..
Slat	1.1...	-1.0...	-.0159	.0359	Separated	...	...	..
Slat	1.2...	-1.1...	-.0167	.0382	Separated	...	...	..
Slat	1.3...	-1.3...	-.0175	.0400	Separated	...	...	..
Slat	1.4...	-1.4...	-.0183	.0411	Separated	...	...	..
Slat	1.5...	-1.5...	-.0191	.0416	Separated	...	...	..
Slat	1.6...	-1.6...	-.0199	.0412	Separated	...	...	..
Wing	1.6...	-.2526	.0064	.1369	Active	...	...	..
Wing	1.6...	-.4071	.0054	.1413	Separated	...	...	..
Slat	1.7...	-1.8...	-.0206	.0397	Separated	...	...	..
Wing	1.7...	-.5617	.0043	.1425	Separated	...	...	..
Wing	1.7...	-.7162	.0032	.1416	Separated	...	...	..
Slat	1.7...	-1.9...	-.0214	.0360	Separated	...	...	..
Wing	1.8...	-.8708	.0021	.1385	Separated	...	...	..
Slat	1.8...	-2.0...	-.0222	.0274	Separated	...	...	..
Wing	1.9...	-1.0...	.0011	.1335	Separated	...	...	..
Flap	1.9...	-.2530	-.1793	.0683	Separated	...	...	..
Wing	1.9...	-1.1...	-.0000	.1269	Separated	...	...	..
Flap	1.9...	-.4094	-.1716	.0643	Separated	...	...	..
Wing	2.0...	-1.3...	-.0011	.1186	Separated	...	...	..

Status of individual elements



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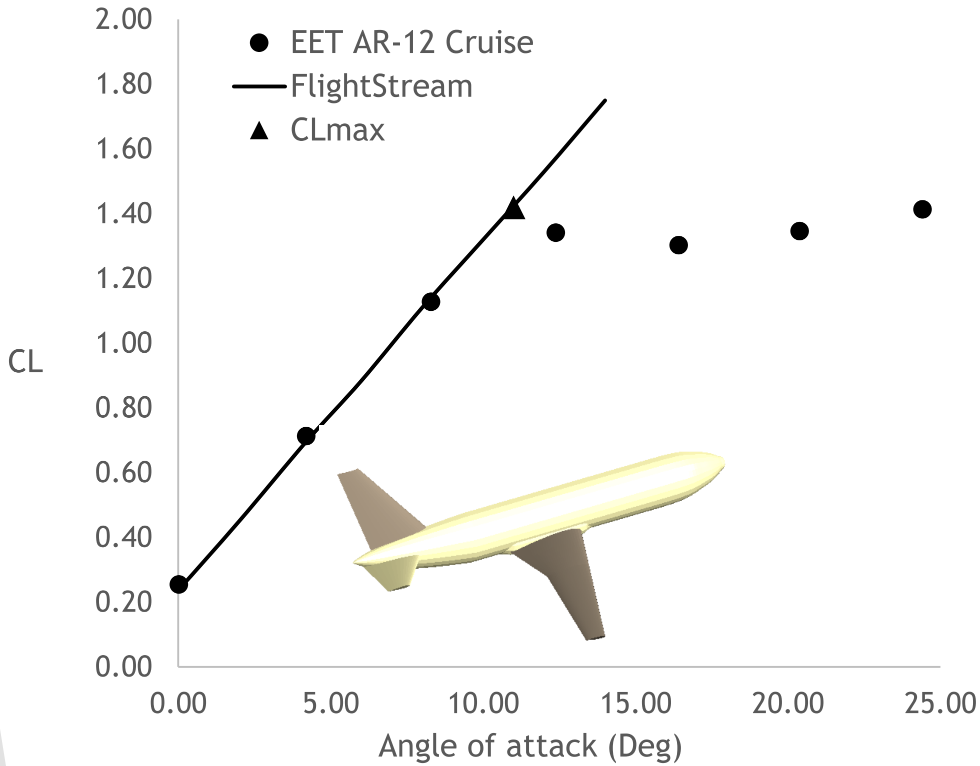
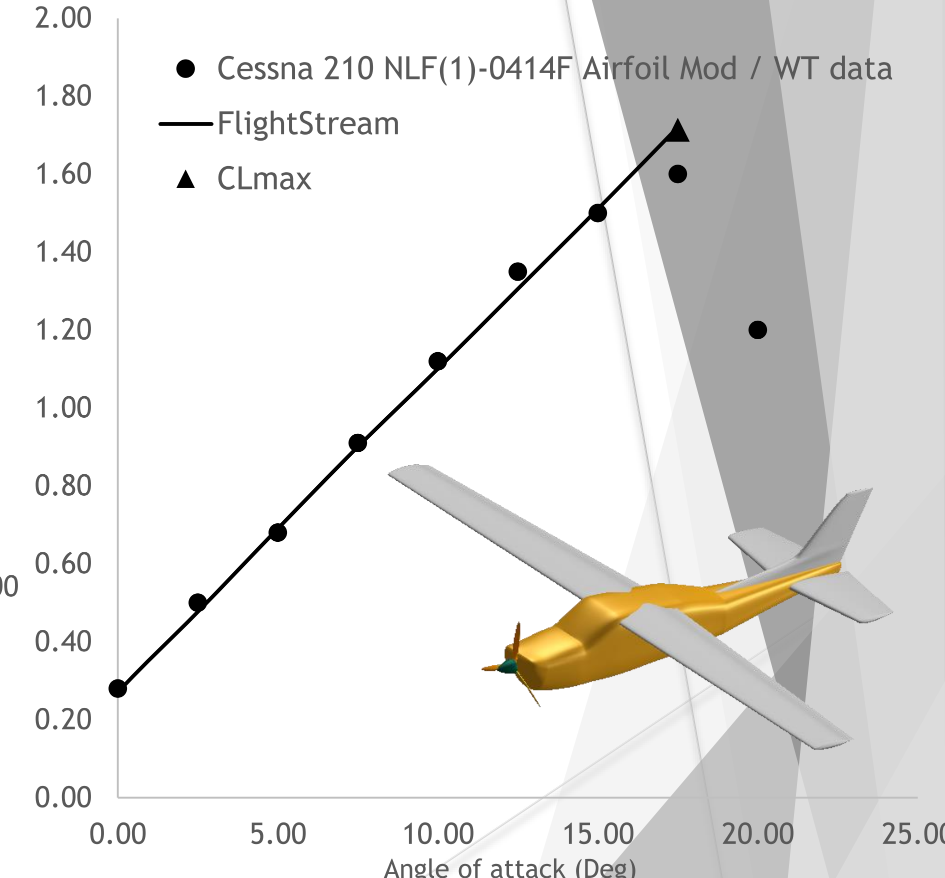
Validation cases: Flow Separation





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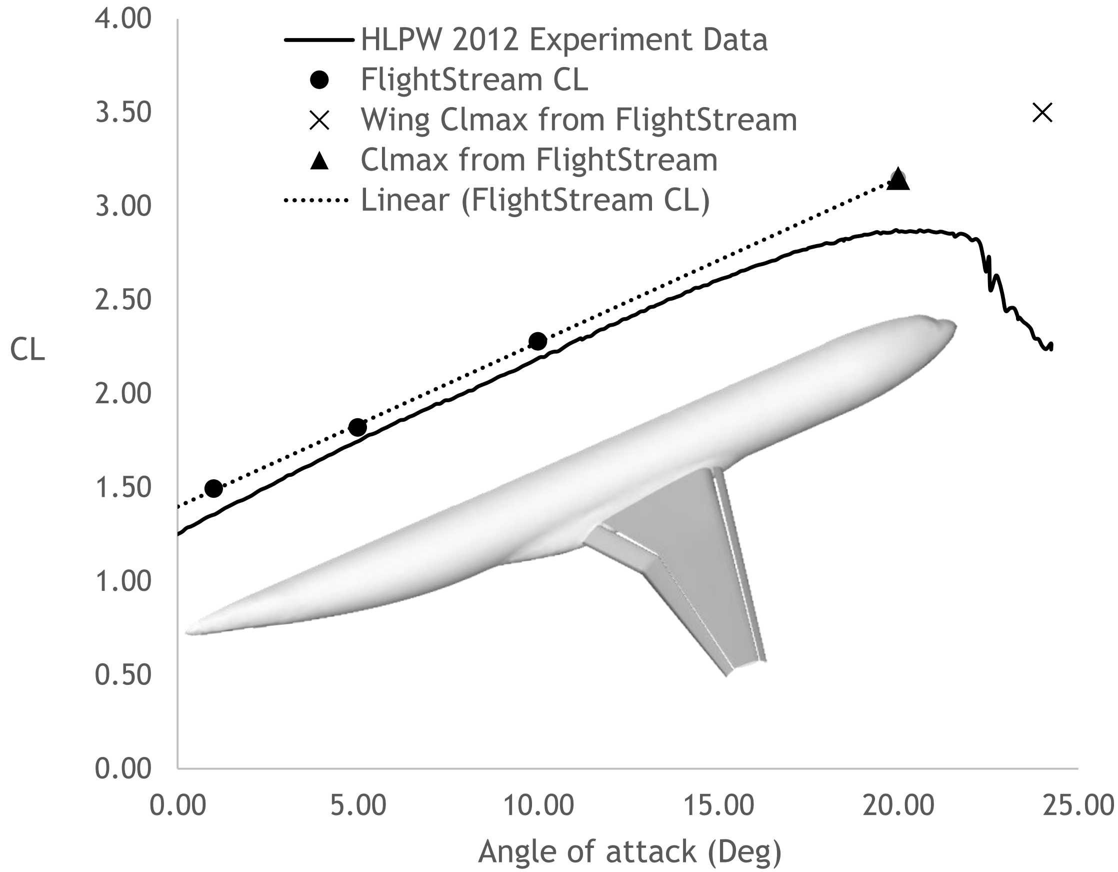
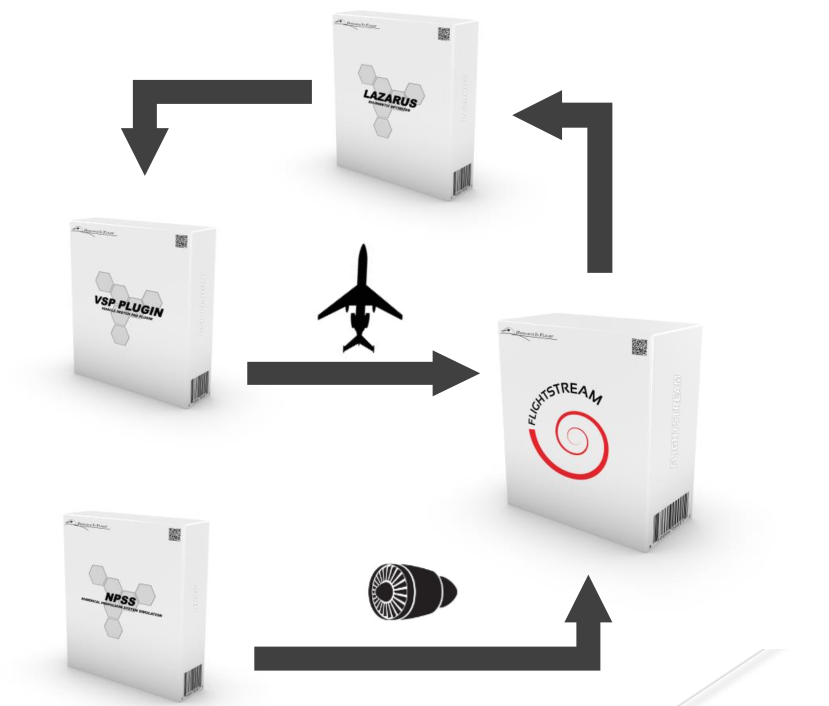
Validation cases: High-lift Prediction Workshop



FlightStream Toolboxes

- AOA and Mach sweeps
- VSP
- N.P.S.S. Turbofan/Turbojet model
- Aero-propulsive optimizer



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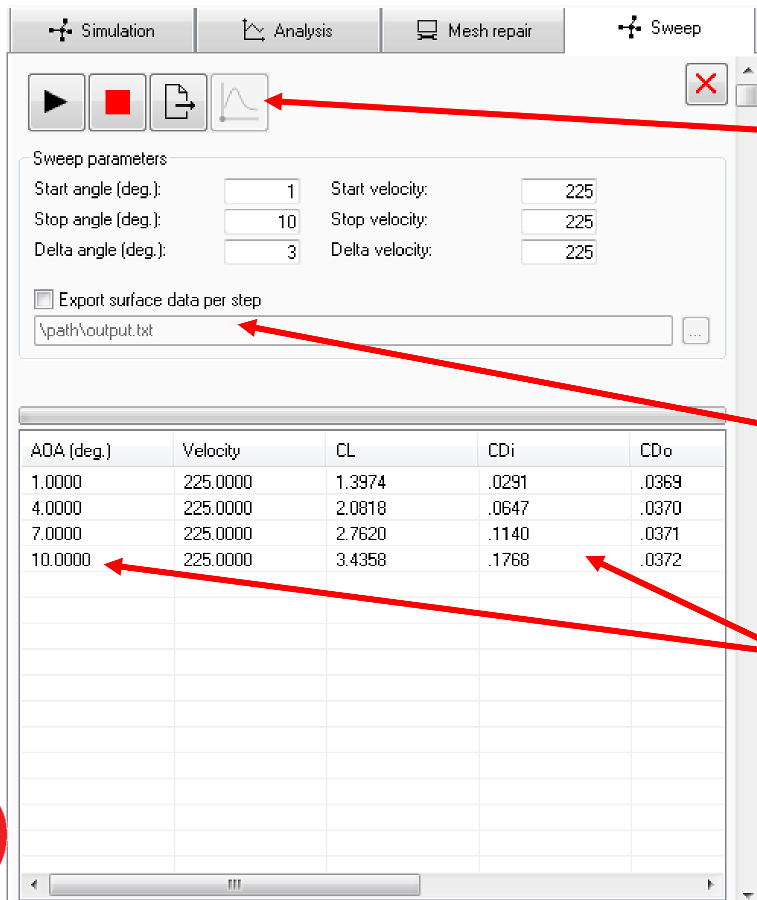
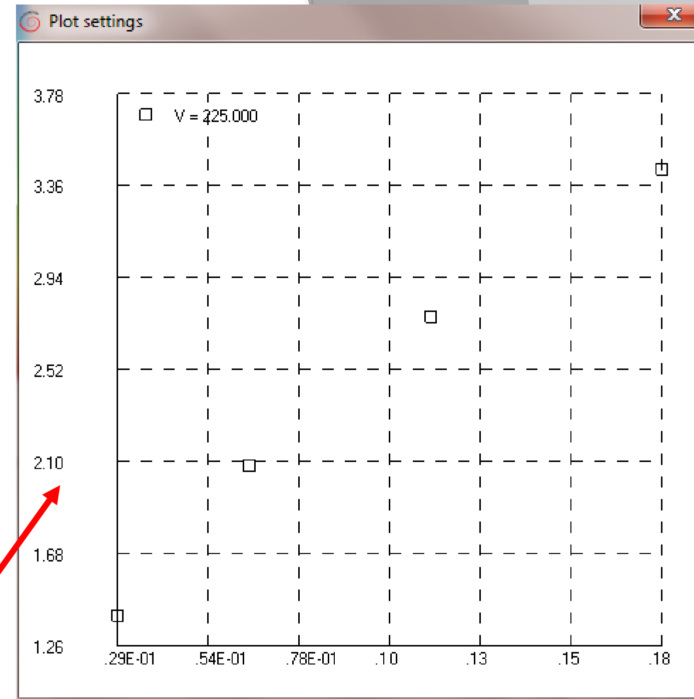
Toolbox: AOA and Mach Sweeps

- Automated solver runs to generate sweep data
- Export per-surface component loads
- Plot data directly in FlightStream





L/D plots

Export full analysis spreadsheets for each data point!

Loads per component and overall geometry

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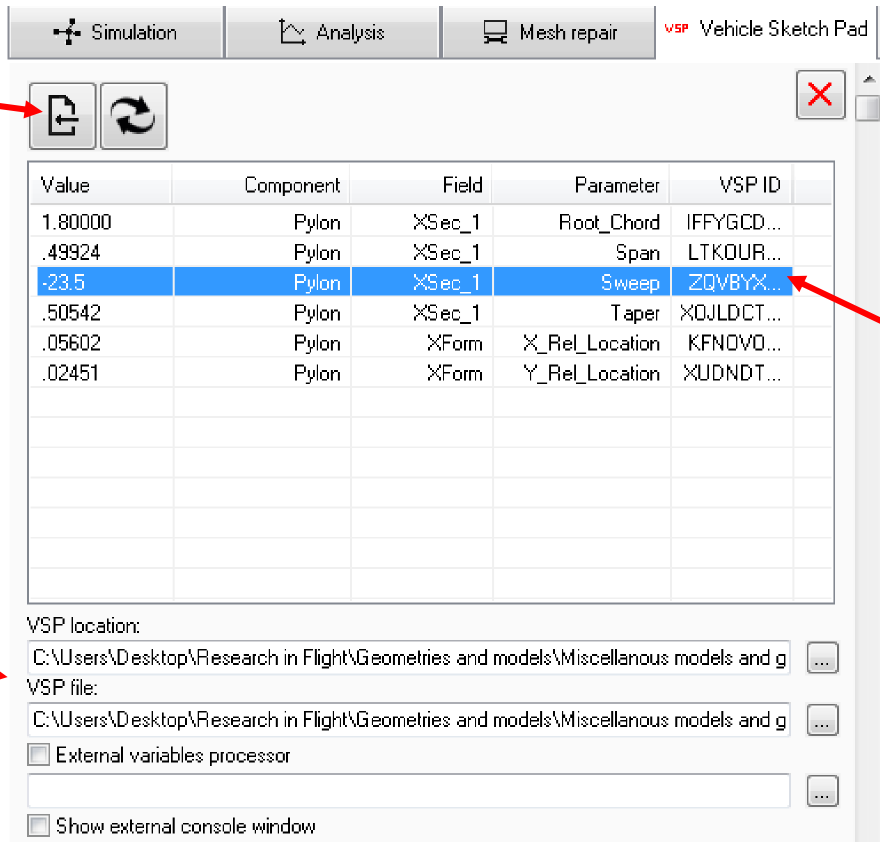
Toolbox: VSP

- Import VSP design parameters into FlightStream
- Integrate with the aero-propulsive optimizer
- Change parameters and automate import and solver setup

Import .des files and execute from within FlightStream



Change any design parameter here

Specify VSP location and model file

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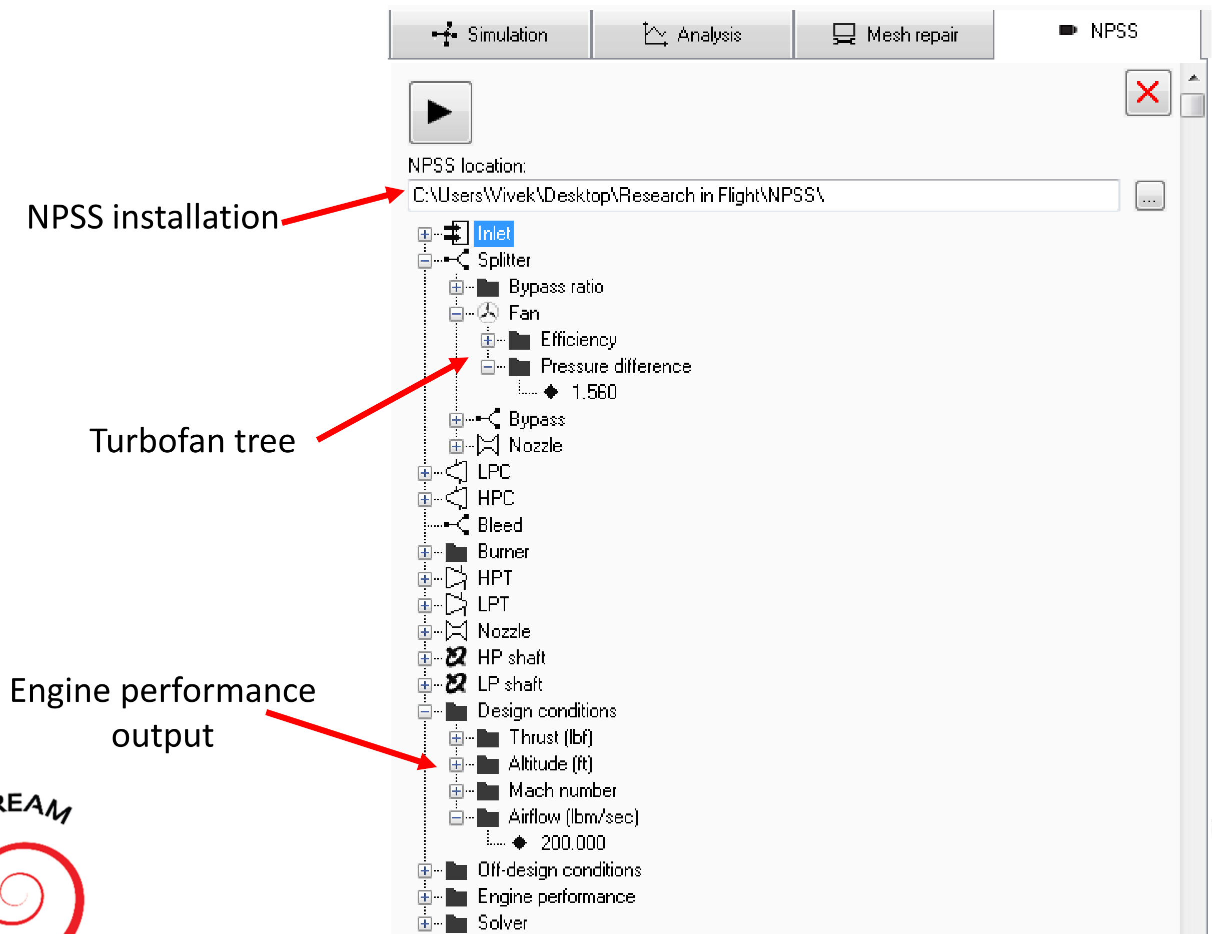
Toolbox: N.P.S.S. Turbofan / Turbojet modeling

- Connect to velocity inlet and exhaust boundaries on the mesh
- Generate design and off-design performance and boundary conditions
- User needs N.P.S.S. software to use this toolbox!



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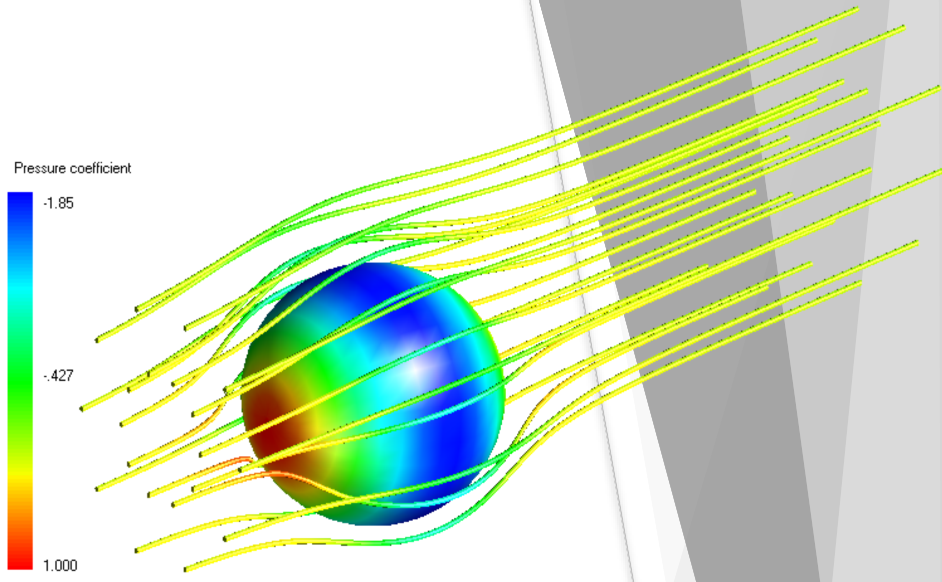
Post-processing enhancements

- Off-body streamlines
  - Stream tubes
  - Stream line distributions
  - 3D modeling of streamlines
  - Growing streamlines from probe points
  - Upstream/Downstream growth
  - Flow contours along streamlines



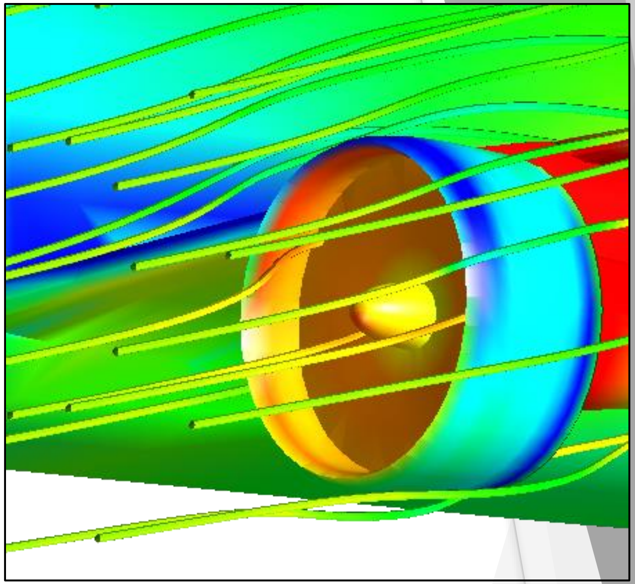
- Probe points
  - User-specified probing locations in 3D-space
  - Import/Export spreadsheet of probe point clouds

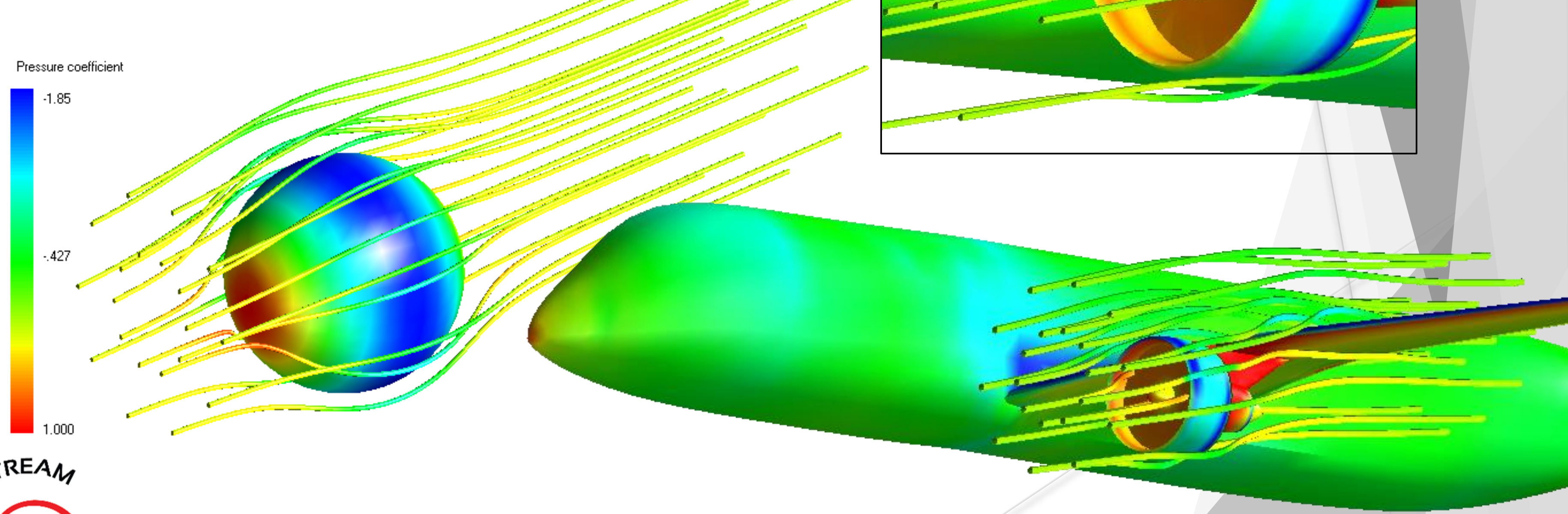
- Probe surfaces
  - Generate a cloud of probe points from individual components

- Sectional planes
  - Pressure and Mach number contours

Post-processing: Streamlines

- Stream tubes
- Stream line distributions
- 3D modeling of streamlines
- Growing streamlines from probe points
- Upstream/Downstream growth
- Flow contours along streamlines
- Import / Export streamlines





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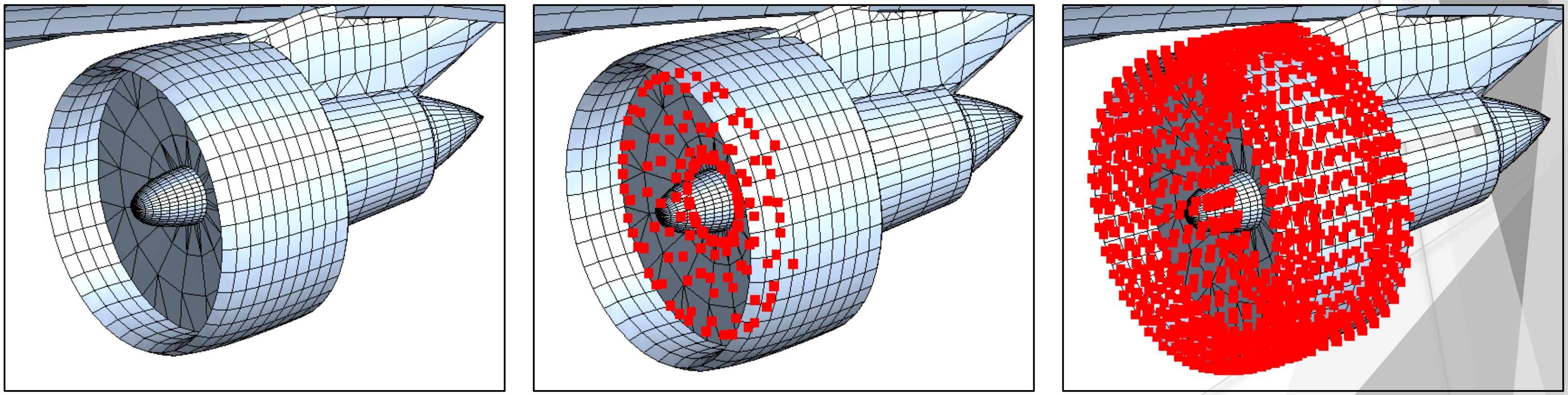
Post-processing: Probe Points & Surfaces

- User-specified probing locations in 3D-space
  - Import/Export spreadsheet of probe point clouds
  - Off-body specifications

- Probe surfaces
  - Generate a cloud of probe points from components



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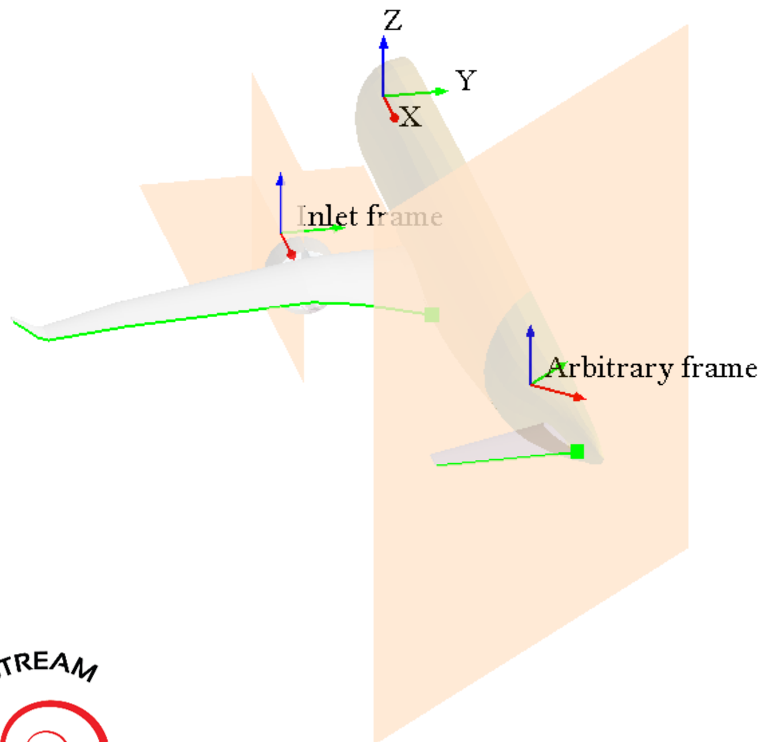
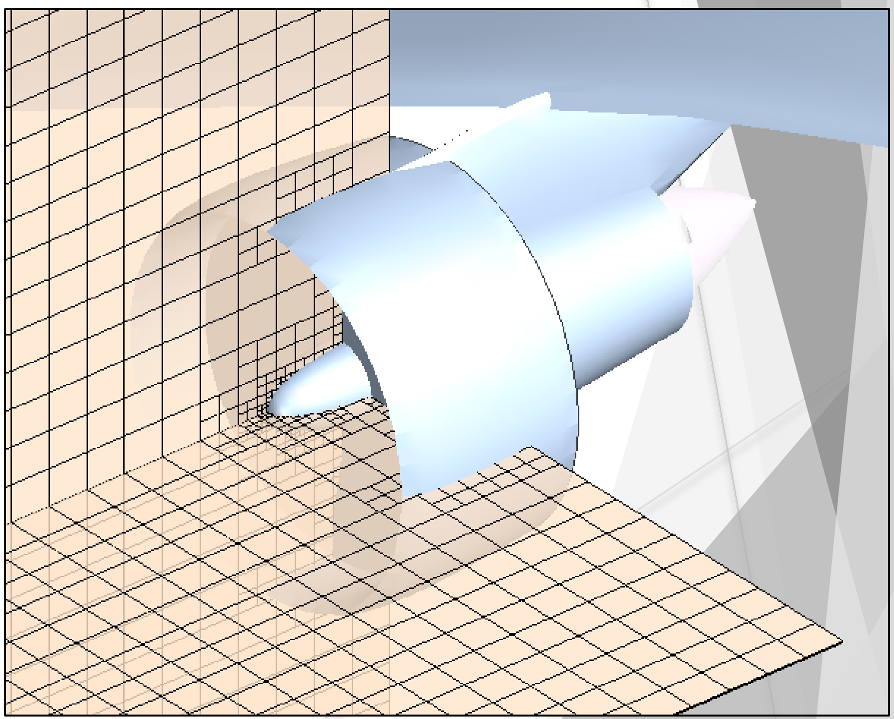
Post-processing: Sectional Planes

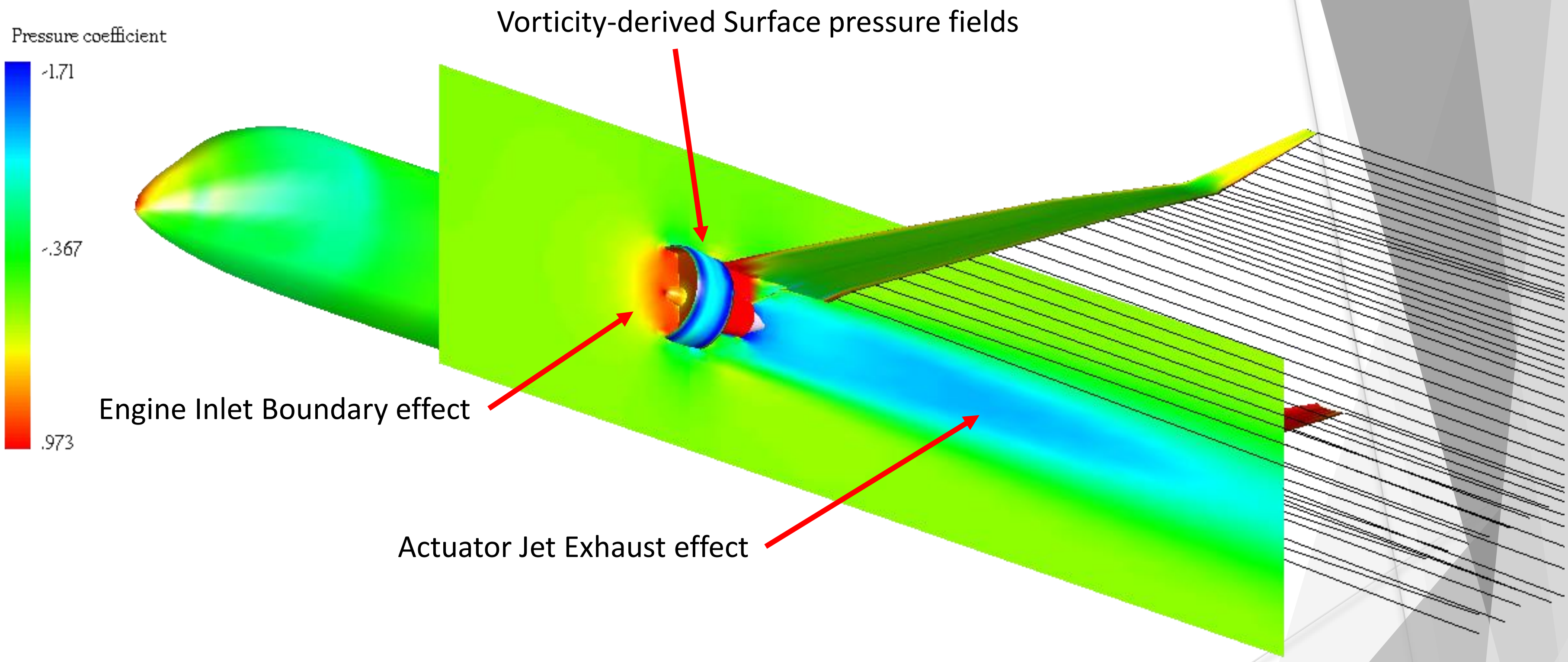
- Pressure and Mach number contours
- Sections in any arbitrary location and orientation
- Post-processing step only; No computational penalties for solver





Post-processing: Sectional Planes (Contd.)

Sectional plane example:



FlightStream Takeaways

- FlightStream offers the aircraft designer the opportunity to move high fidelity load calculations up into the preliminary design process with very high efficiency
- Integrates seamlessly with outer mold line tools such as VSP
- Engine integration capability at the conceptual and preliminary design level
- Time dependent solutions at this level
- High lift and maximum lift configuration analysis is possible at the preliminary design level
- Designs leaving the preliminary phase are much more mature, saving on development time

FLIGHTSTREAM

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