Aeronautical research in the State of São Paulo

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EESC • USP

FAPESP Week CHINA 2024, June 28 - 29

EMBRAER

Comercial
Bjets









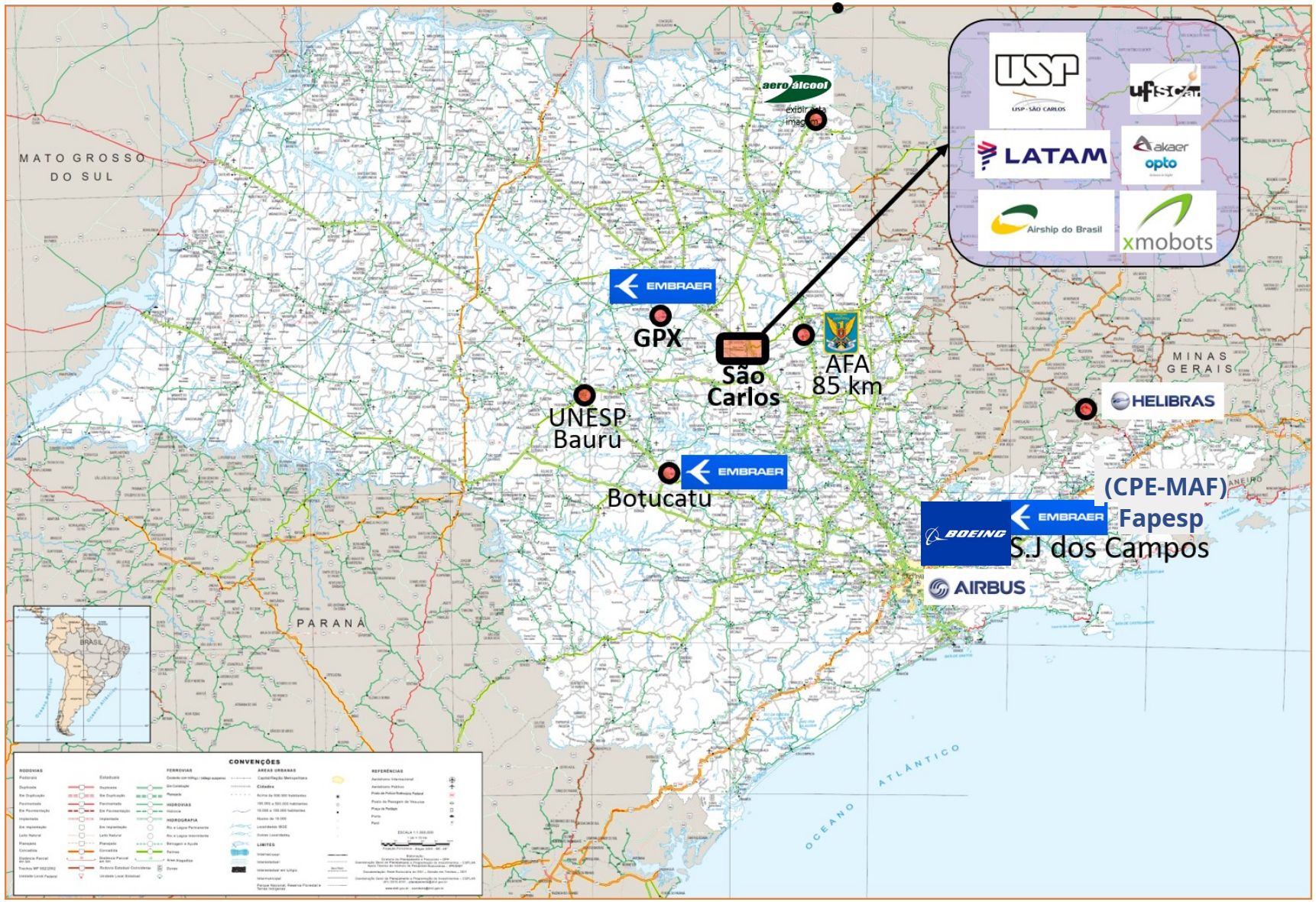


USP - SÃO CARLOS

Defense



An important state for Aerospace industry



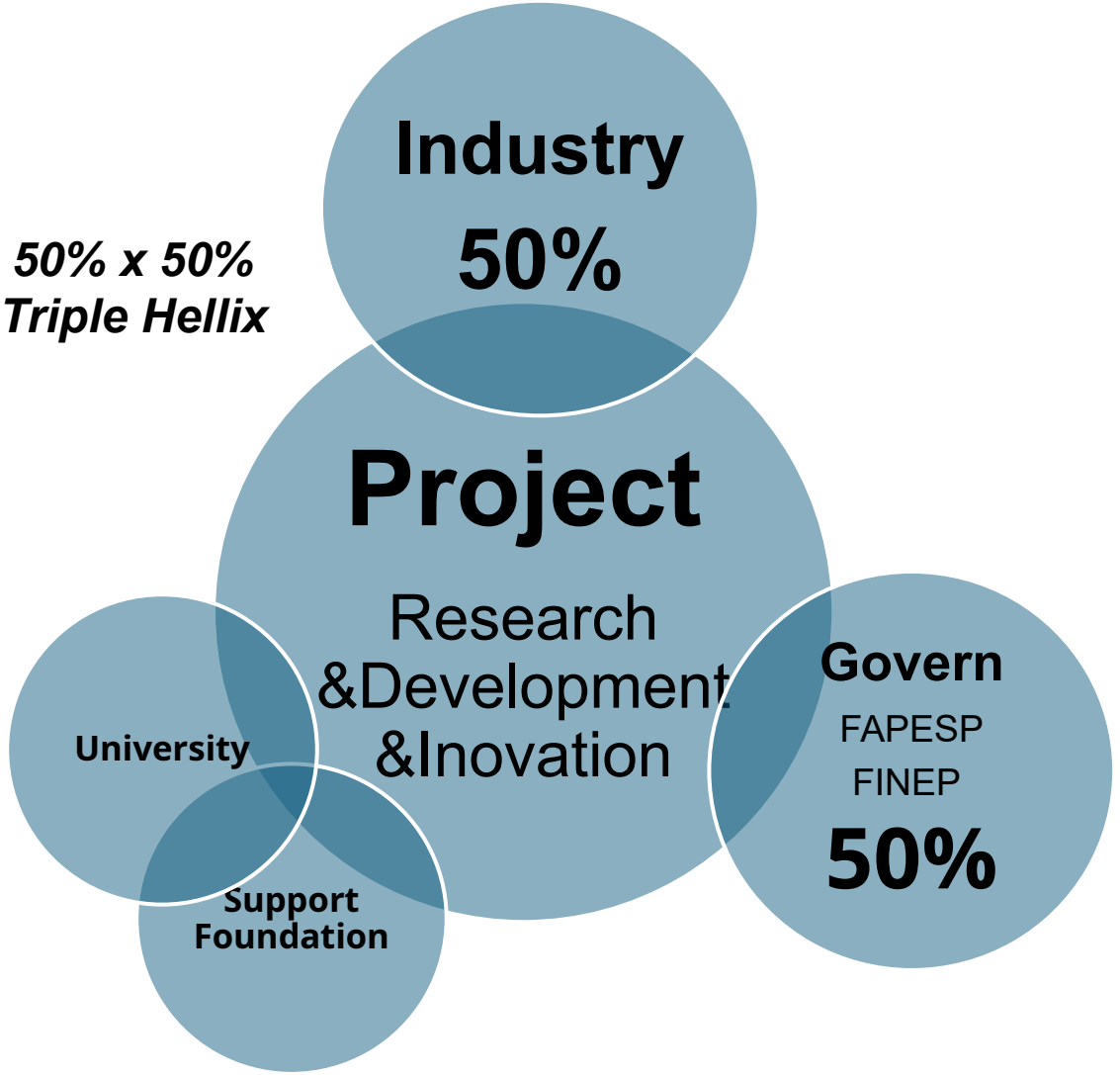




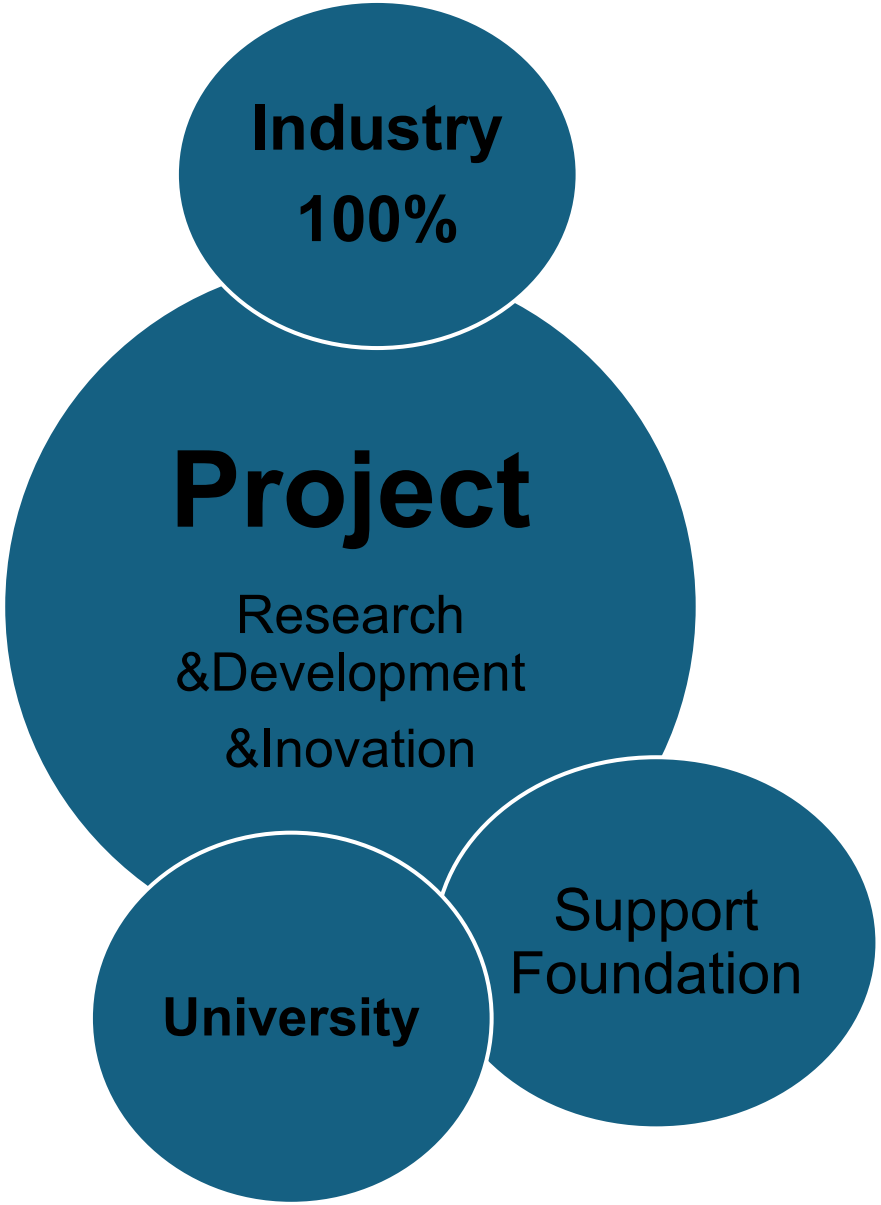
FAPESP Week CHINA 2024, June 28 - 29

Partnership systems:

50% x 50%
Triple Hellix

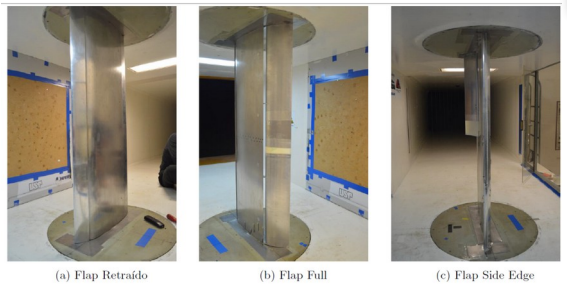


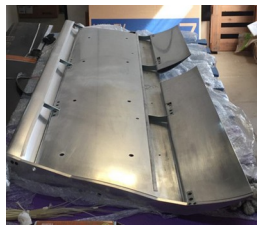
100%

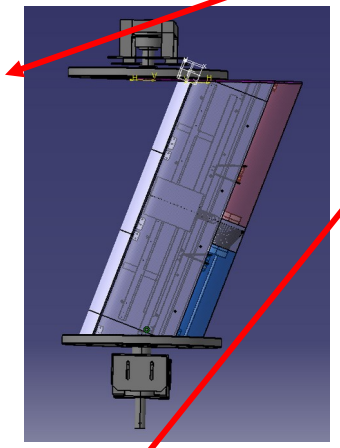


A E R O - SCIENCES

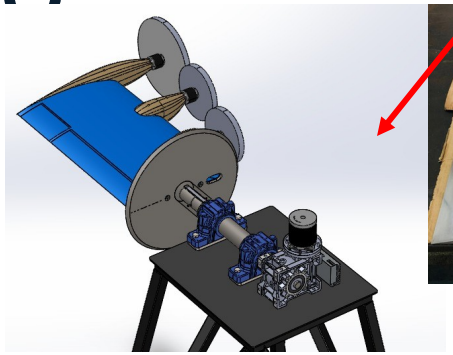
AROACUSTICS + APPLIED AERODYNAMICS
Testing capabilities


(a) Flap Retraído (b) Flap Full (c) Flap Side Edge





Porfolio

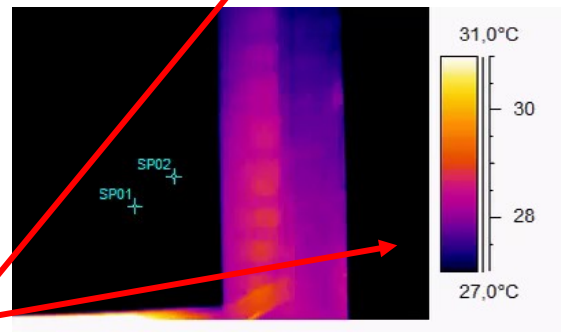


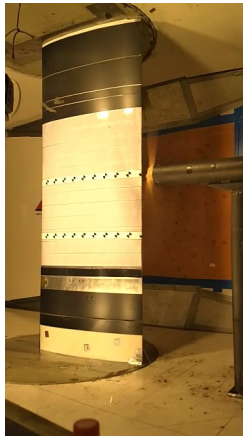


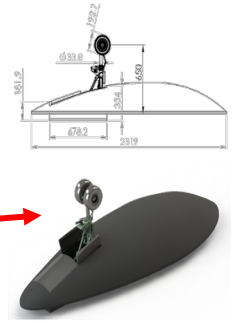
- High lift 2-D wings:
  - 170 slat +single flap
  - 30P30N slat+single+double Flap. Set of various bracktes
  - 190E2 Silence profile 4 sets of slats_cover fillets+single flap.
  - 190 E2 Silence sweep back model 23deg.
  - All models with pressure tapping's in all elements
- Distributed propulsion propeller model:
  - Three propeller + half wing model
  - All propeller with thrust and torque balance.
  - -100Deg to +100deg incidence angle
  - Propeller positioning at three forward and three upward positions.
  - Spanwise pressure tappings
  - Wing with flap and aileron with hinge moment balance.
- Laminar wing model:
  - Two chordwise pressure tappings
  - Two Lift and Drag imbedded balances
  - IF set-up with Flyr camera
  - Hot film system for skin friction.
- Single propeller rig for tractor or pusher configuration. (external Balance for thrust only)
- Complex Nose Landing Gear

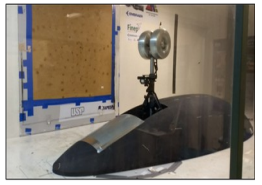




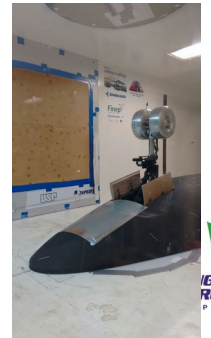










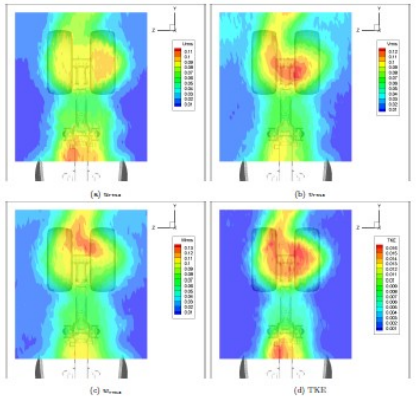


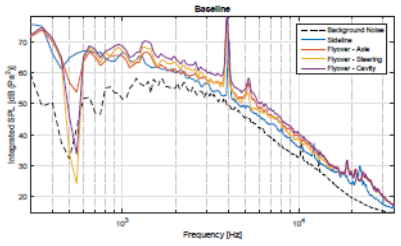
FAPESP Week
2024, June
28 - 29



AERO - SCIENCES

AROACUSTICS + APPLIED AERODYNAMICS
Testing instrumentation





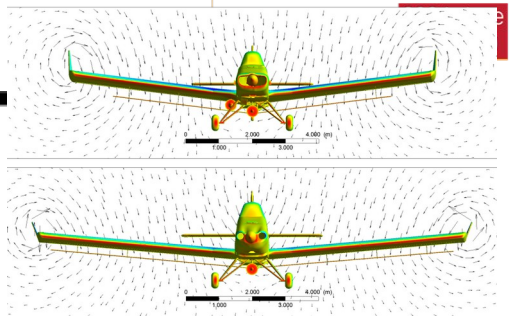


Hardware

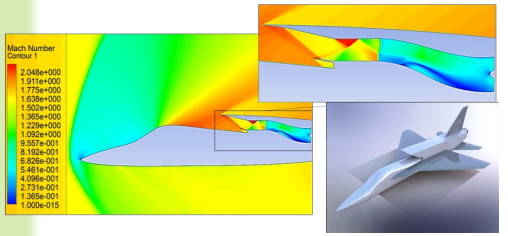
- National PXI for acoutic and modal analysis
- Hot wire 3 Channels CTA , Traverse 3-D
- Flow mapping
  - Hot wire
  - Multi-hole pitot (7, 14 and 5)
- Hot Film 16 Channels
- Scanivalve ZOC system 400 taps
- Aerodynamic Balances Sting 6DoF, external 3DoF, in house design of internal balances
- HBM system
- Additive Manufacturing (filamento and metal for small parts)

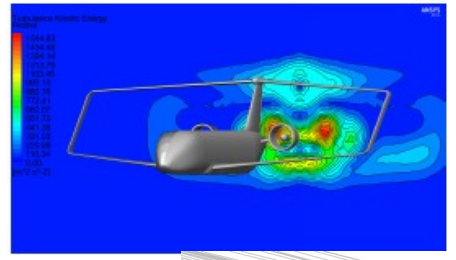
Software

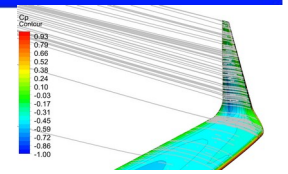
- CFD package
- CFX
- PowerFlow
- 2 Beanform software developed in house
- CLUSTER
- MathLab etc.

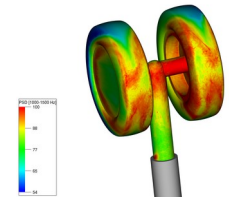


Supercritical condition









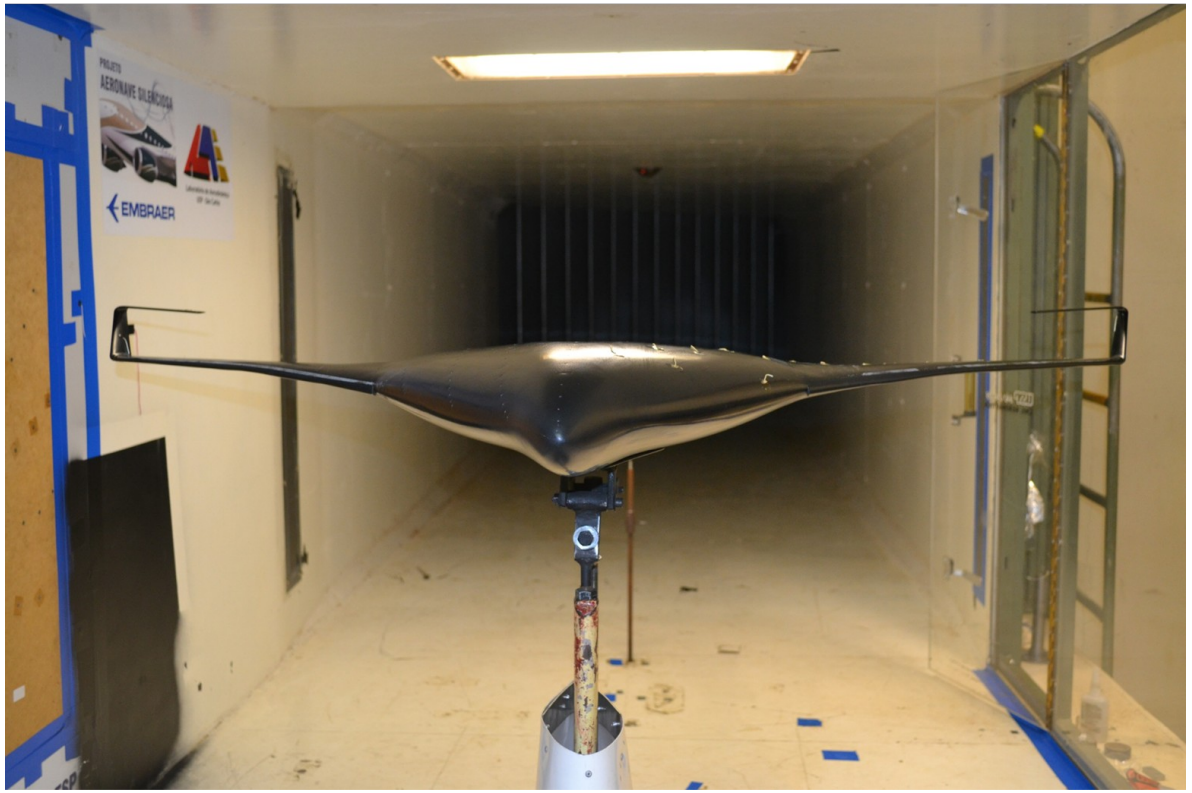
ENGENHARIA AERONÁUTICA
USP - SÃO CARLOS

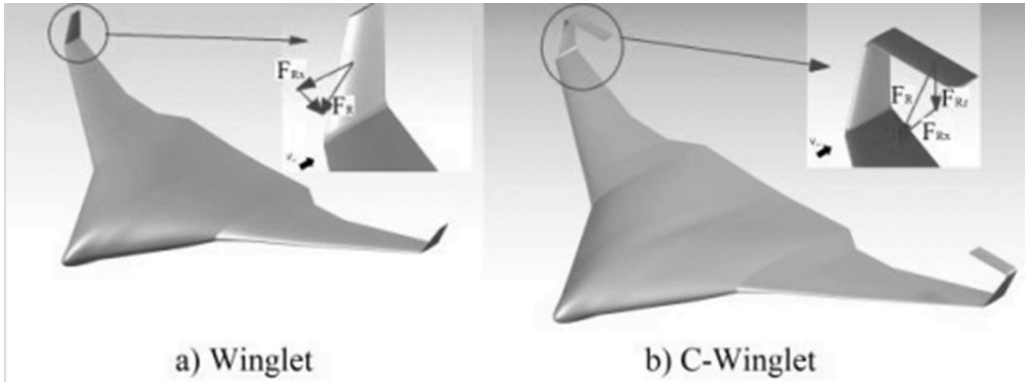
Background

- New configurations studies
  - Blended wingbody



Ceron-Muñoz, H. D, Catalano F.M. The Aerodynamic Interference of power plant system on a Blended Wing Body. 27T H International Congress of the Aeronautical Sciences, Nice, France, 2010.

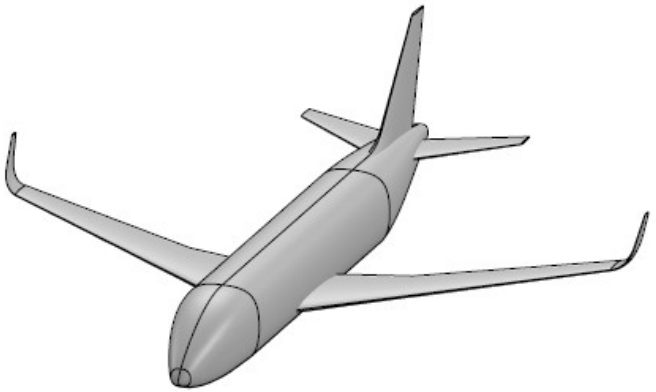




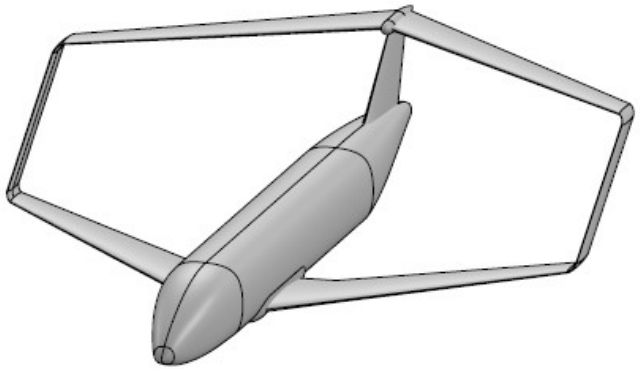
AERODYNAMIC INTERFERENCE OF WINGTIP AND WING DEVICES ON BWB
H. D. Ceron-Muñoz * , D. O. Diaz-Izquierdo, J. Solarte-Pineda, F. M. Catalano *

Design, aerodynamic optimization and experimental assessment of a next generation commercia

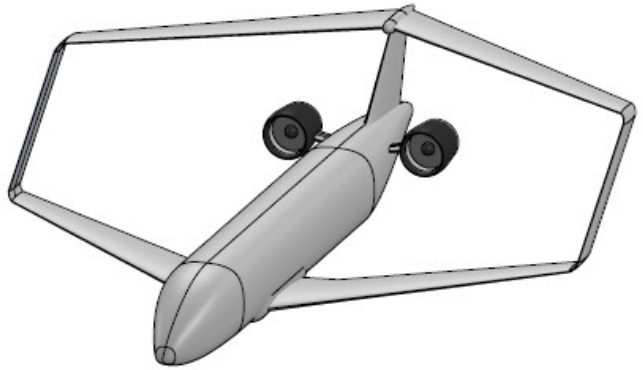
- Focused on the combination of two revolutionary technologies: Box-wing and BLI ingestion
- Single-aisle category
- Conceptual-level MDO studies



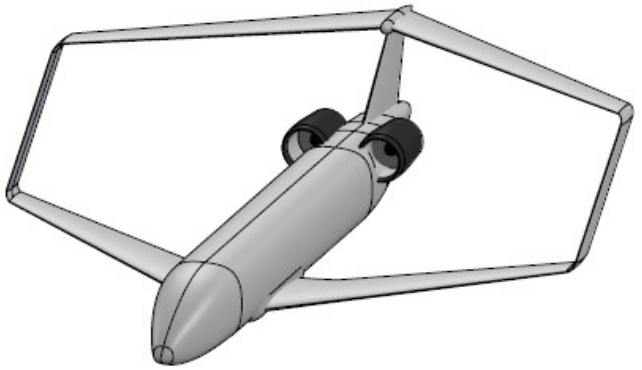
(a) Conventional reference.



(b) Unpowered configuration.



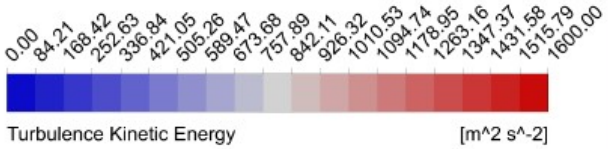
(c) Non-BLI configuration.

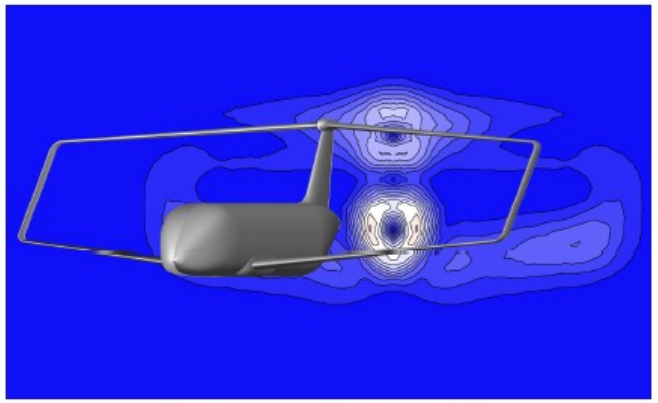


(d) BLI configuration.

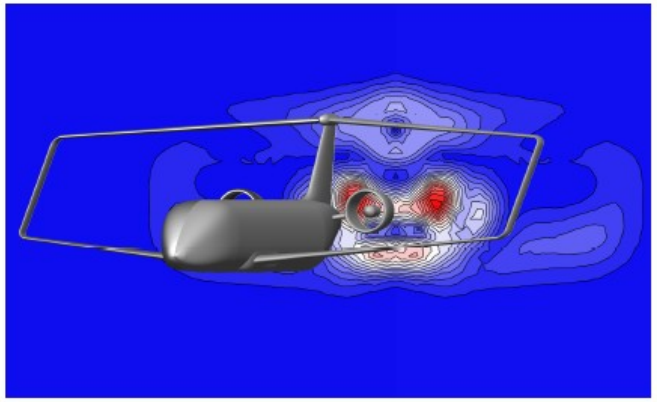
CFD analysis

- Mach 0.78, optimum cruise altitude
- Propulsion modeled as an actuator disk

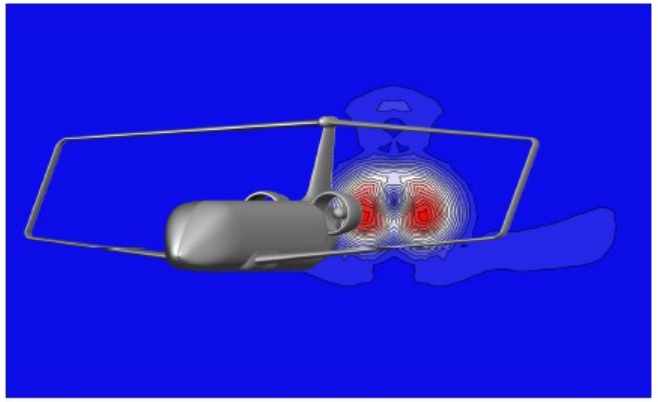




(a) Unpowered configuration.

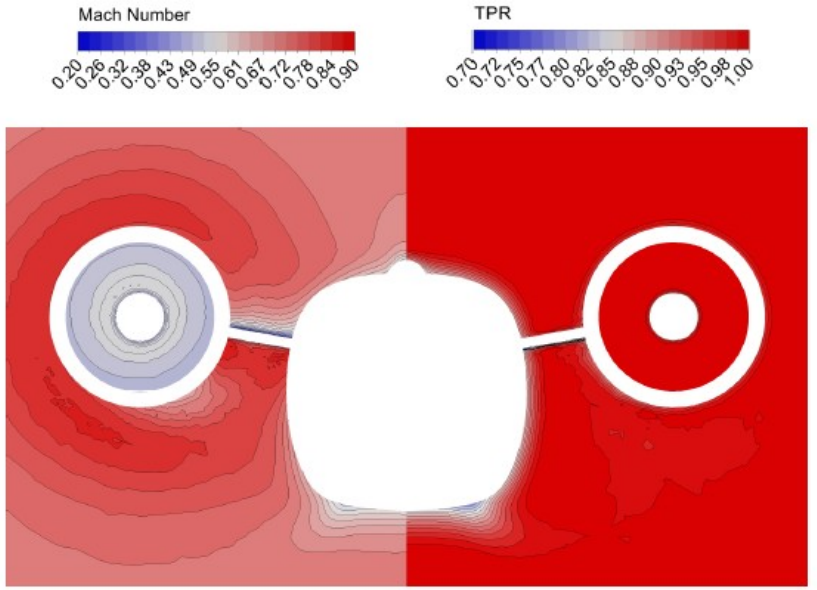


(b) Non-BLI configuration.

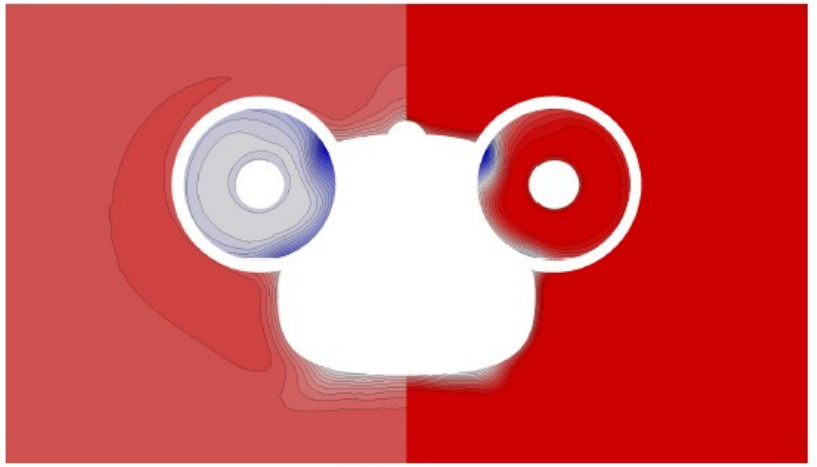


(c) BLI configuration.

- Power saving 6.55%
- Fuel-burn benefits of about 15%



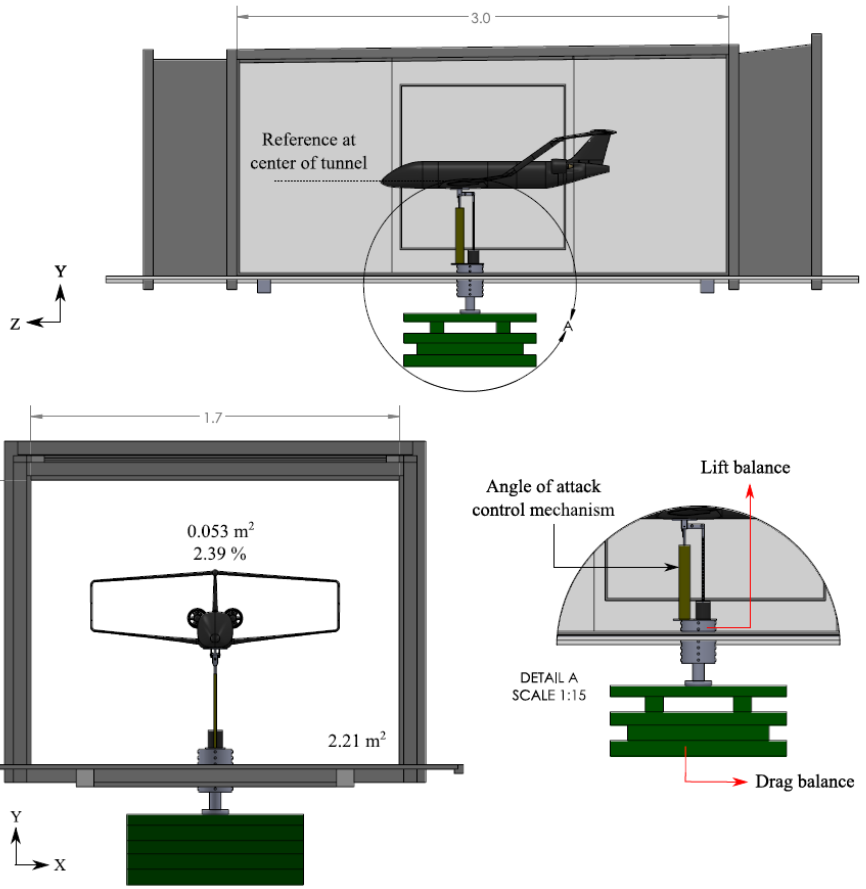
(a) Non-BLI version.



(b) BLI version.

Subsonic wind-tunnel experiments

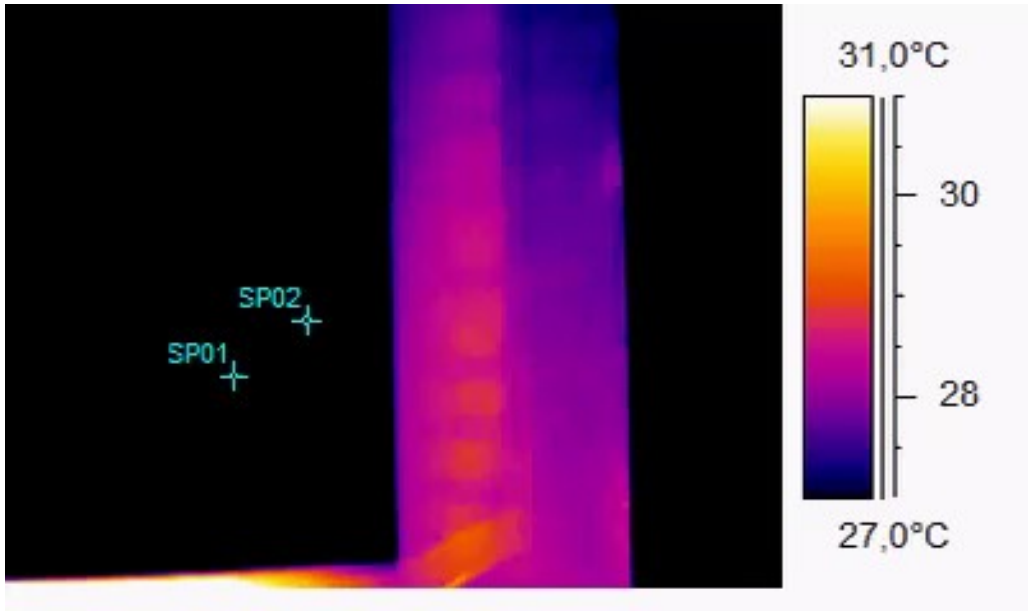
- Conventional force balance and power balance measurements
- 7-hole probe measurements to visualize the flow
- Total pressure surveys using a distortion rake

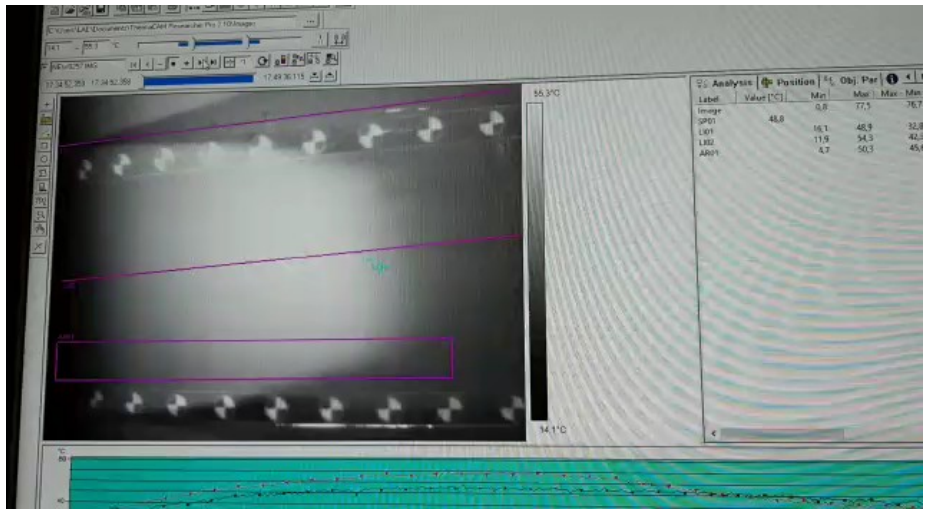


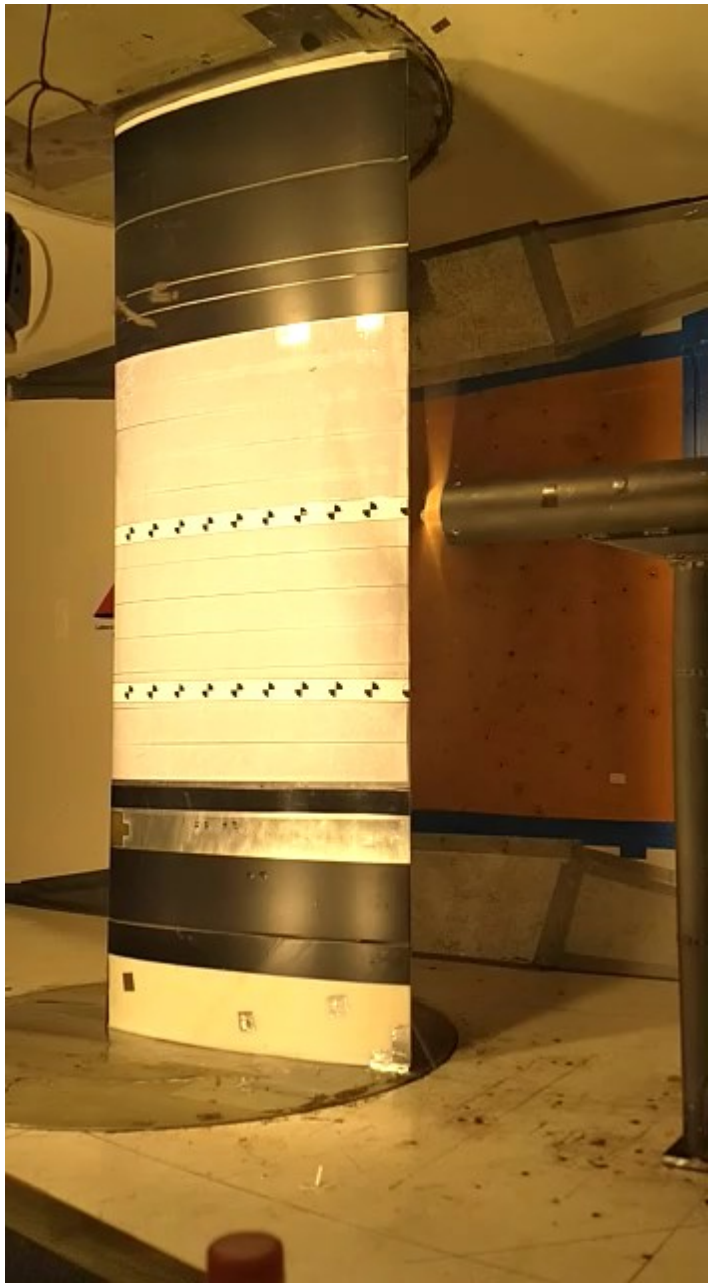


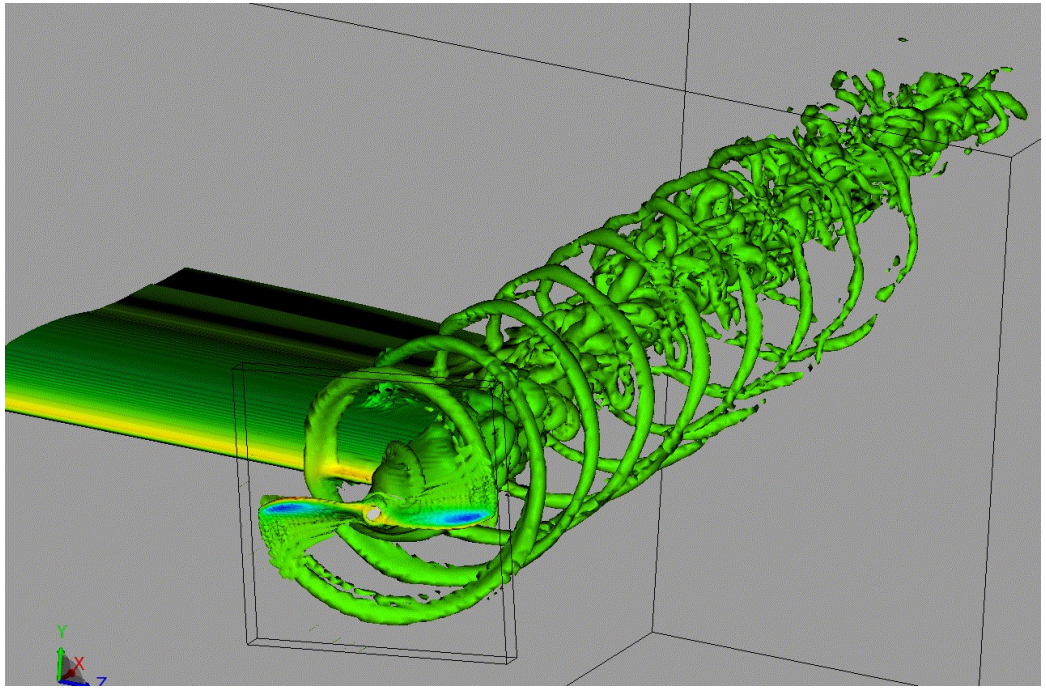


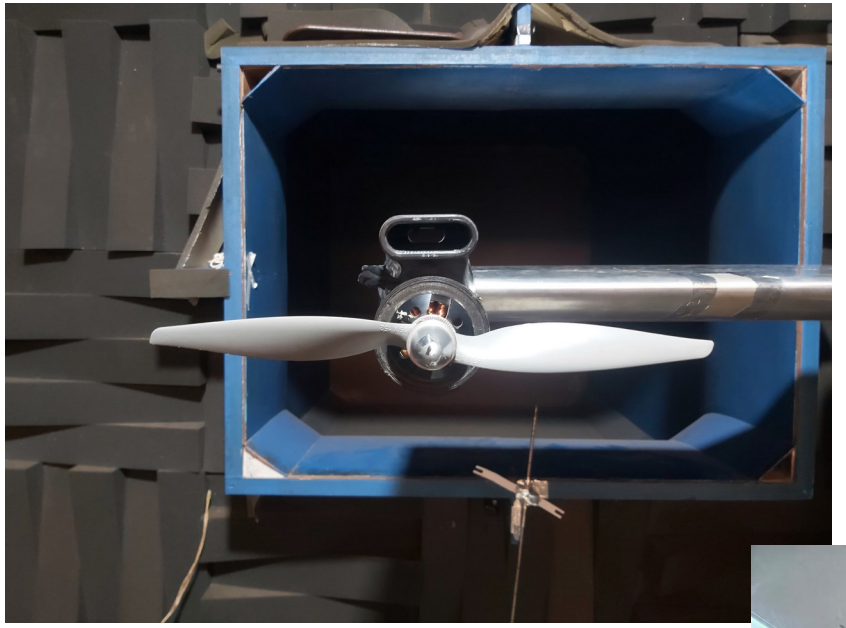
- Laminar wing testing Pusher propeller effect

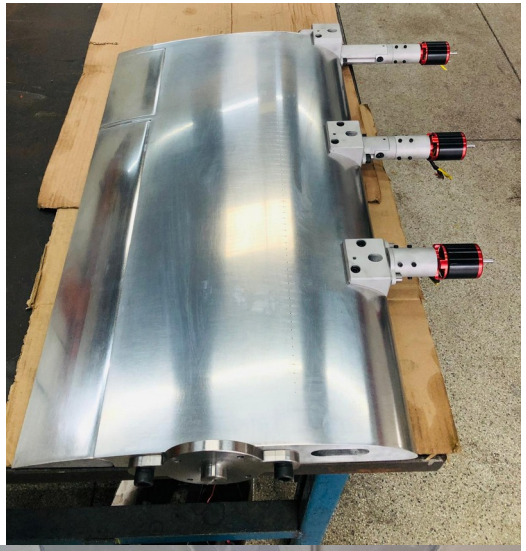






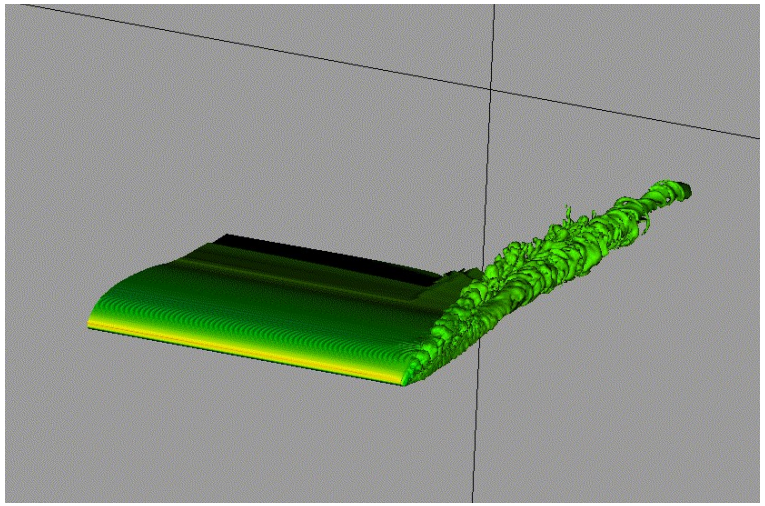


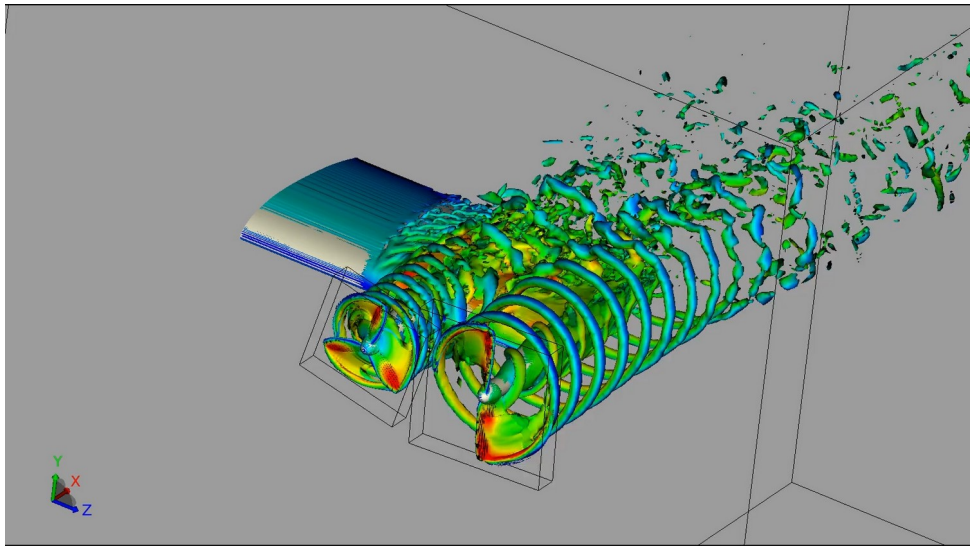






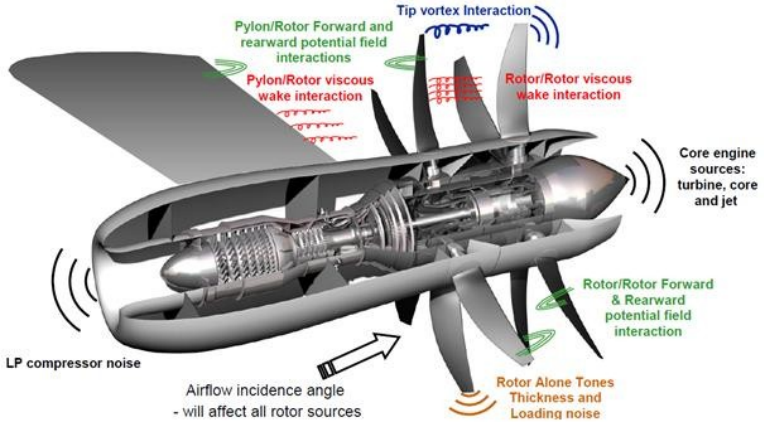
Distributed propulsion aerodynamics and aeroacoustics

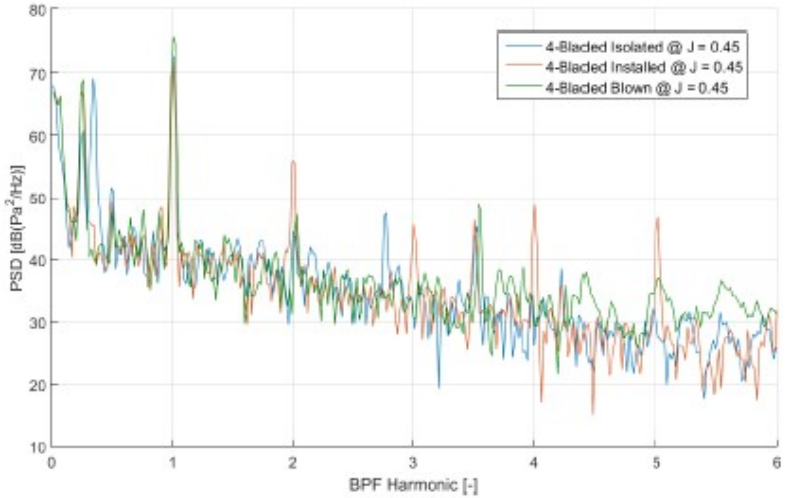


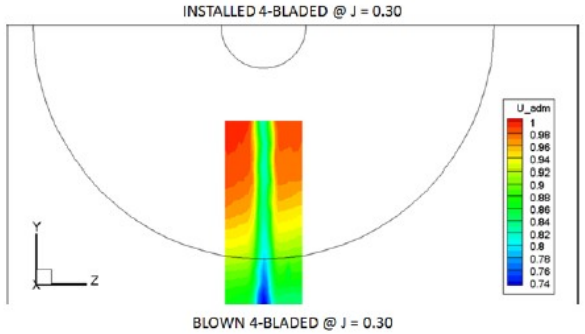


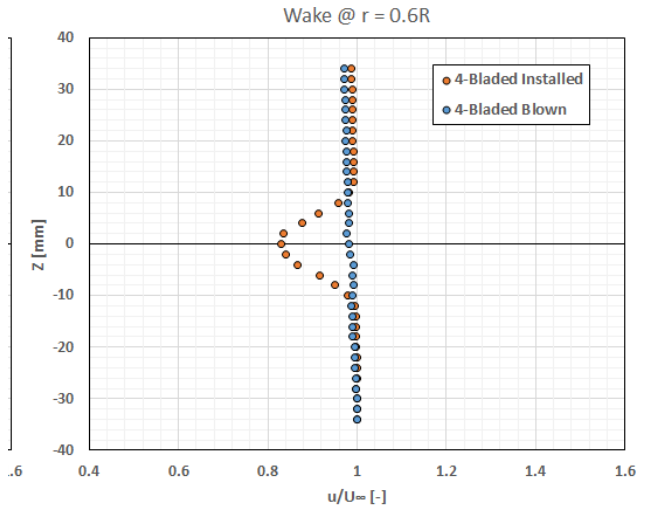
DEVELOPMENT OF A BLOWING SYSTEM FOR A PYLON-PUSHER PROPELLER CONFIGURATION WITH THE STUDY OF THE ASSOCIATED AERODYNAMIC AND AEROACOUSTIC PHENOMENA







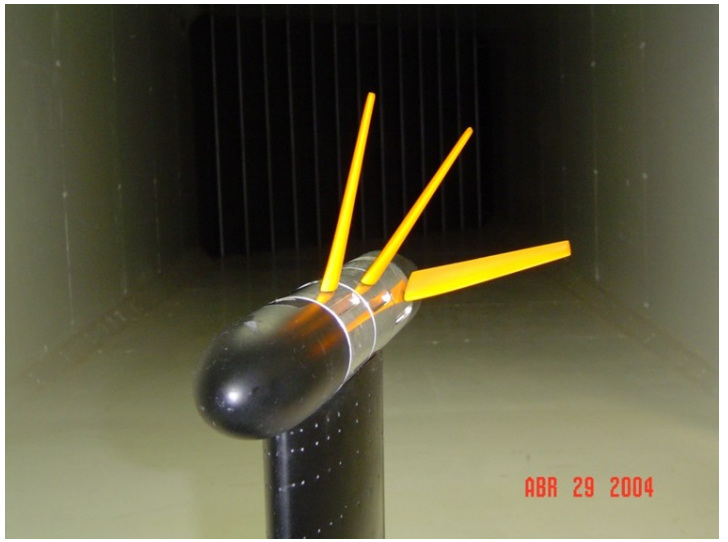


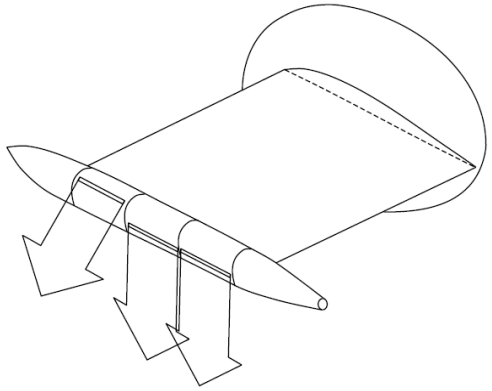


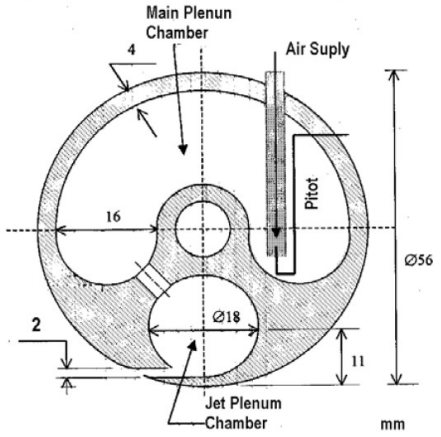
Noise Reductions on a Pusher Propeller Configuration through Pylon Tangential Blowing
LF Rego, LT Lima Pereira, F Catalano
2018 AIAA/CEAS Aeroacoustics Conference, 4194

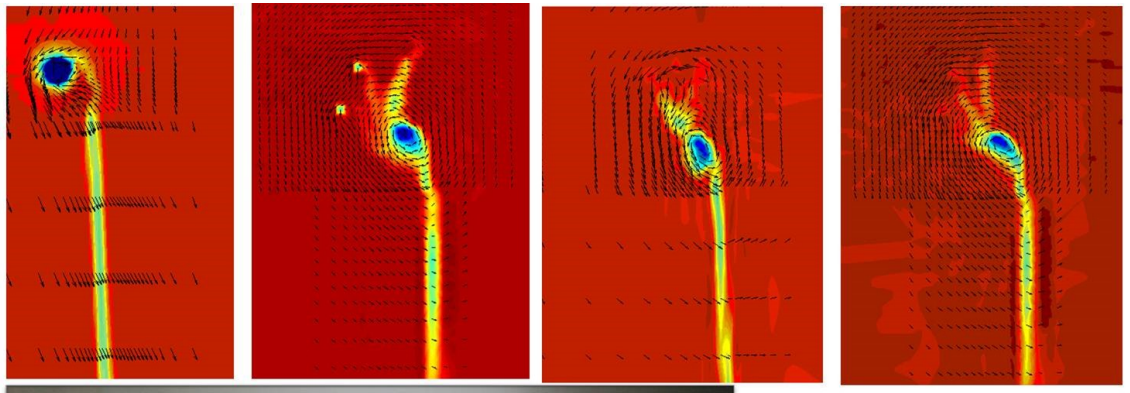
Experimental Investigation of Wing-Tip Devices on the Reduction of Induced Drag



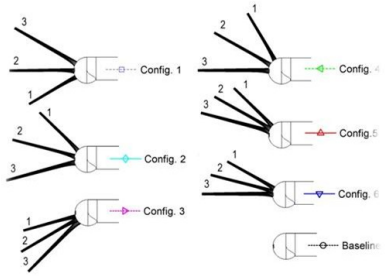






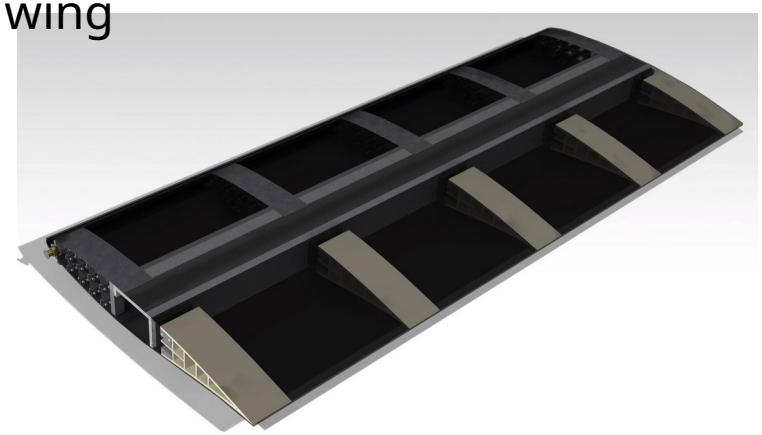


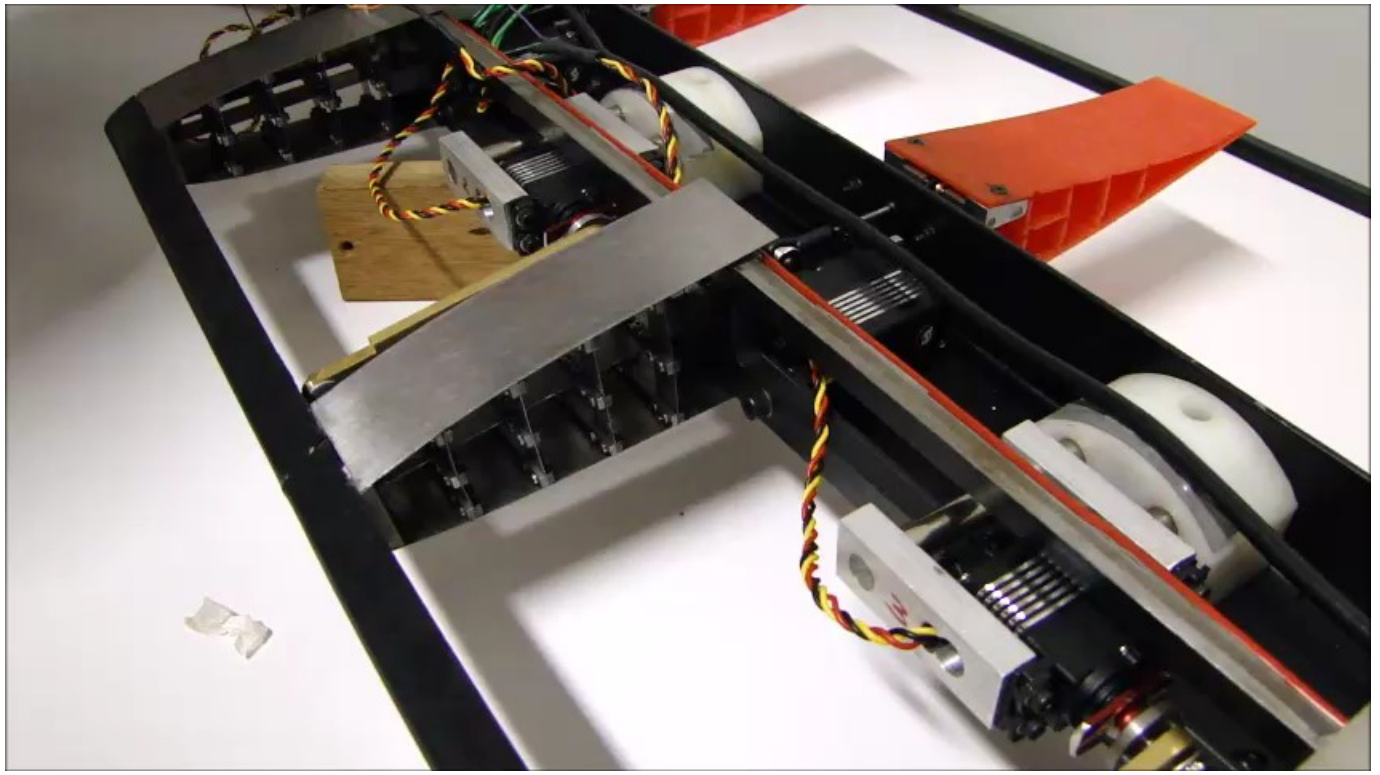


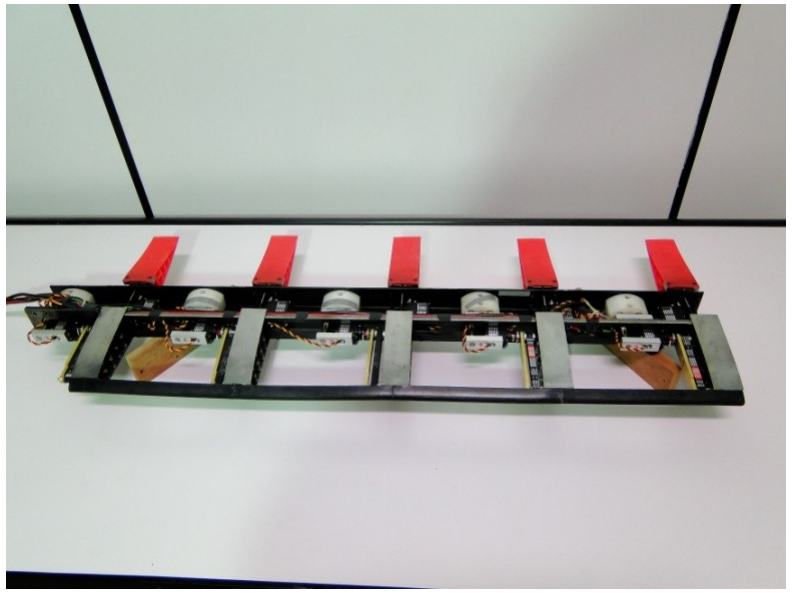


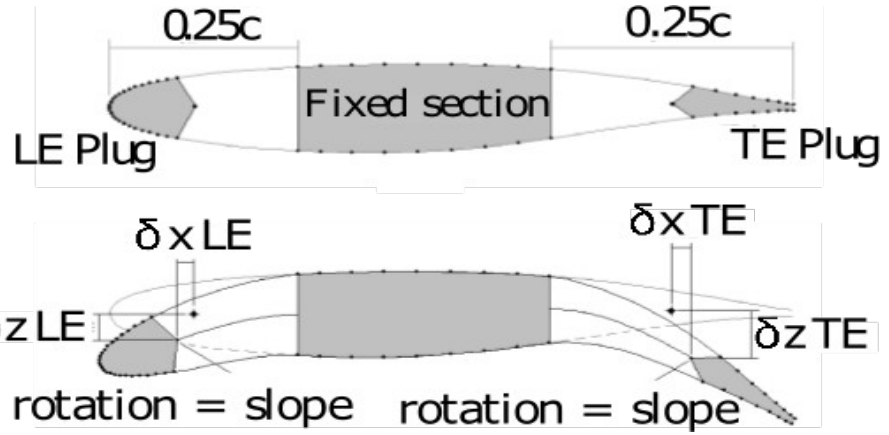
Experimental investigation of wing-tip devices on the reduction of induced drag
HD Céron-Muñoz, R Cosin, RFF Coimbra, LGN Correa, FM Catalano
Journal of Aircraft 50 (2), 441-449

Mophing wing or variable camber wing





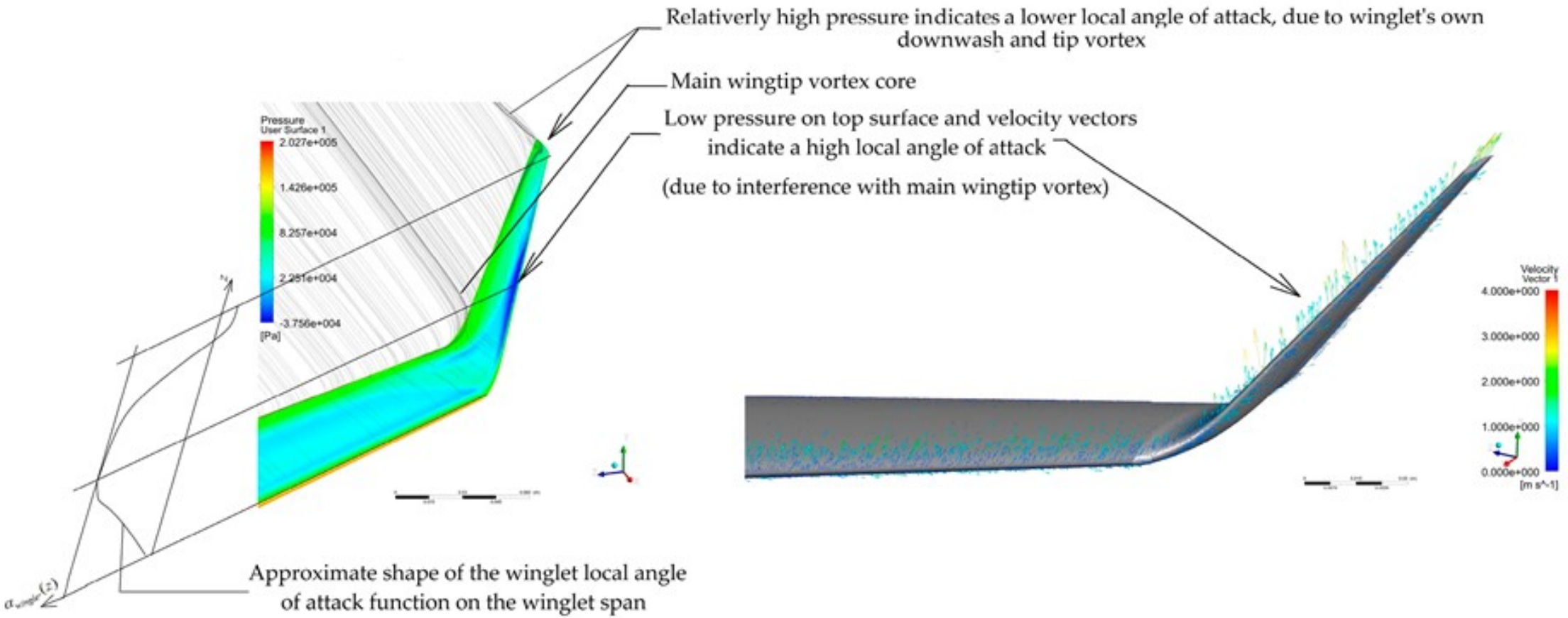




J. Braz. Soc. Mech. Sci. & Eng. vol.25 no.1 Rio de Janeiro Jan./Mar. 2003
http://dx.doi.org/10.1590/S1678-58782003000100001
Drag optimization for transport aircraft Mission Adaptive Wing
A. L. Martins; F. M. CatalanoI

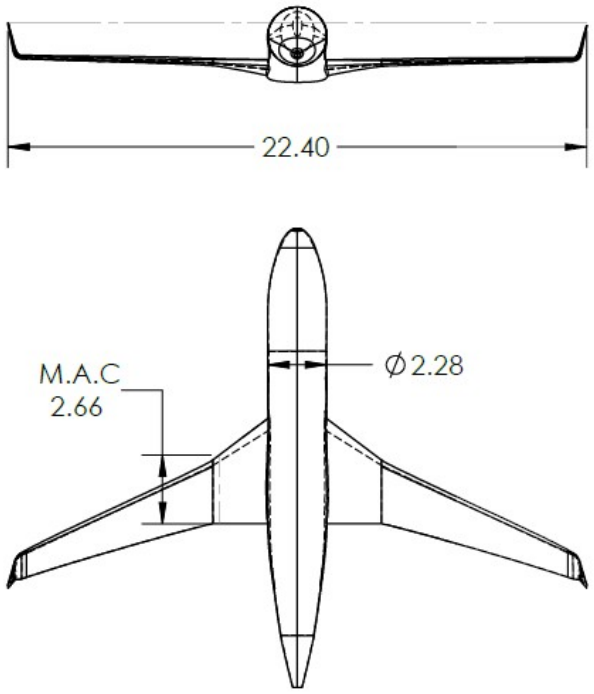
morphing systems to a wing let:

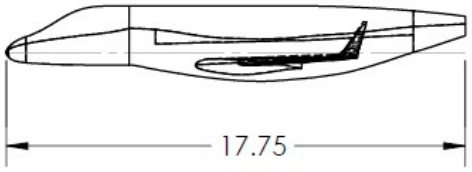
- Less critical component
- Small changes on overall configuration
- Performance improvement – Induced drag reduction

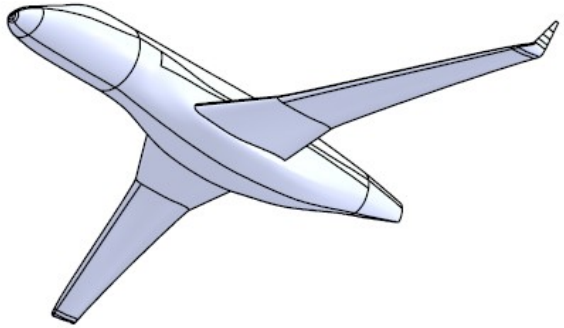

Relativerly high pressure indicates a lower local angle of attack, due to winglet's own downwash and tip vortex
Main wingtip vortex core
Low pressure on top surface and velocity vectors indicate a high local angle of attack
(due to interference with main wingtip vortex)
Pressure
User Surface 1
2.027e+005
1.426e+005
8.257e+004
2.251e+004
-3.756e+004
[Pa]
Velocity
Vector 1
4.000e+000
3.000e+000
2.000e+000
1.000e+000
0.000e+000
[m s^-1]
Approximate shape of the winglet local angle of attack function on the winglet span

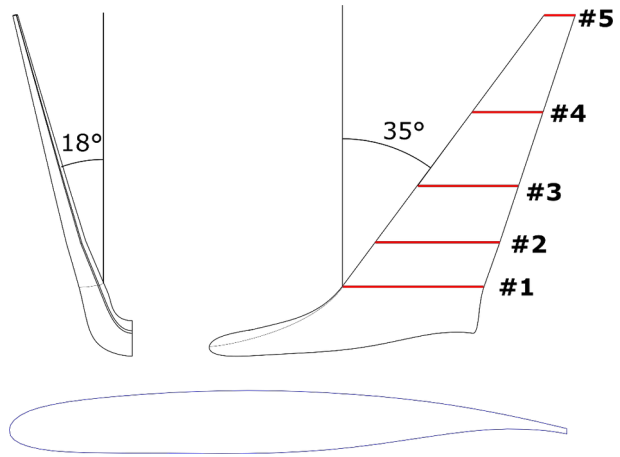
Concept evaluation

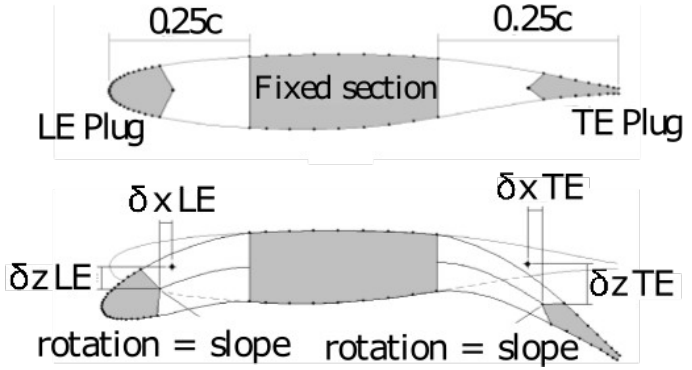
- Optimized fixed geometry winglet (FGW) x camber morphing winglet (CMW)



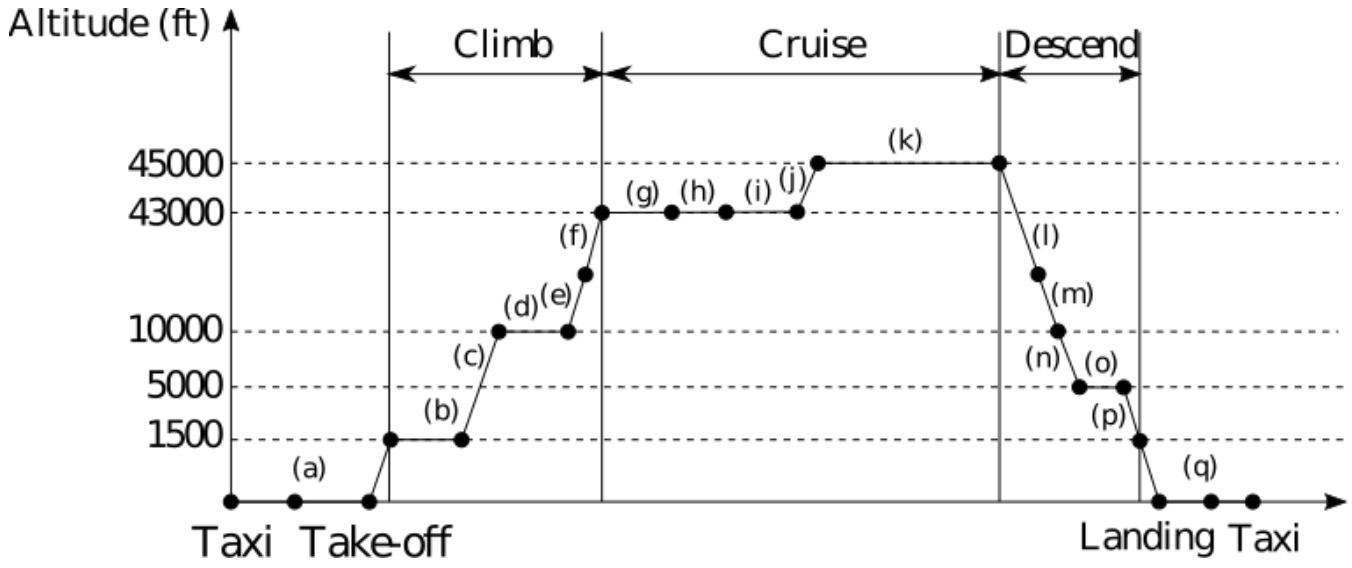








Mission profile



(a) Engine start, warm up, taxi, take-off and climb to 1500 ft. The weight at the end of this phase is considered to be $W_{to} = 0.98TOW$

(b) Acceleration from $Mach = 0.3$ to $IAS = 154\frac{m}{s}$ at $h = 1500$ ft.

(c) Climb at constant $IAS = 154\frac{m}{s}$ from 1500 ft to 10000 ft.

(d) Acceleration from $IAS = 154\frac{m}{s}$ to $IAS = 165\frac{m}{s}$ at $h = 10000$ ft.

(e) Climb at constant $IAS = 165\frac{m}{s}$ from 10000 ft until $Mach = 0.8$.

(f) Climb at constant $Mach = 0.8$ to $h = 43000$ ft.

(g) Cruise at $Mach = 0.8$ and $h = 43000$ ft.

(h) Acceleration from $Mach = 0.8$ to $Mach = 0.8124$ at $h = 43000$ ft.

(i) Cruise at $Mach = 0.8124$ and $h = 43000$ ft.

(j) Climb from $h = 43000$ ft to $h = 45000$ ft at $M = 0.8124$.

(k) Cruise at $Mach = 0.8124$ and $h = 45000$ ft.

(l) Descent from $h = 45000$ ft at constant $M = 0.8$ until $IAS = 165\frac{m}{s}$.

(m) Descent to $h = 10000$ ft at constant $IAS = 165\frac{m}{s}$.

(n) Descent to $h = 5000$ ft at constant $IAS = 154\frac{m}{s}$.

(o) Loiter at $h = 5000$ ft for $t_{loit} = 30$ min

(p) Descent from $h = 5000$ ft to $h = 1500$ ft at constant $IAS = 154\frac{m}{s}$.

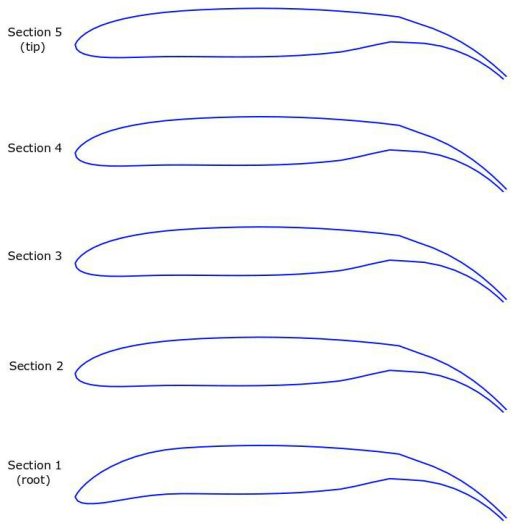
(q) Landing from 1500 ft, taxi and engine shut down. It is considered a weight at the end of the taxi as $W_{ld} = 0.992W_i$

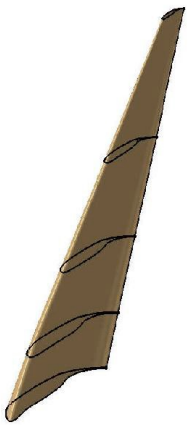
Performance improvement

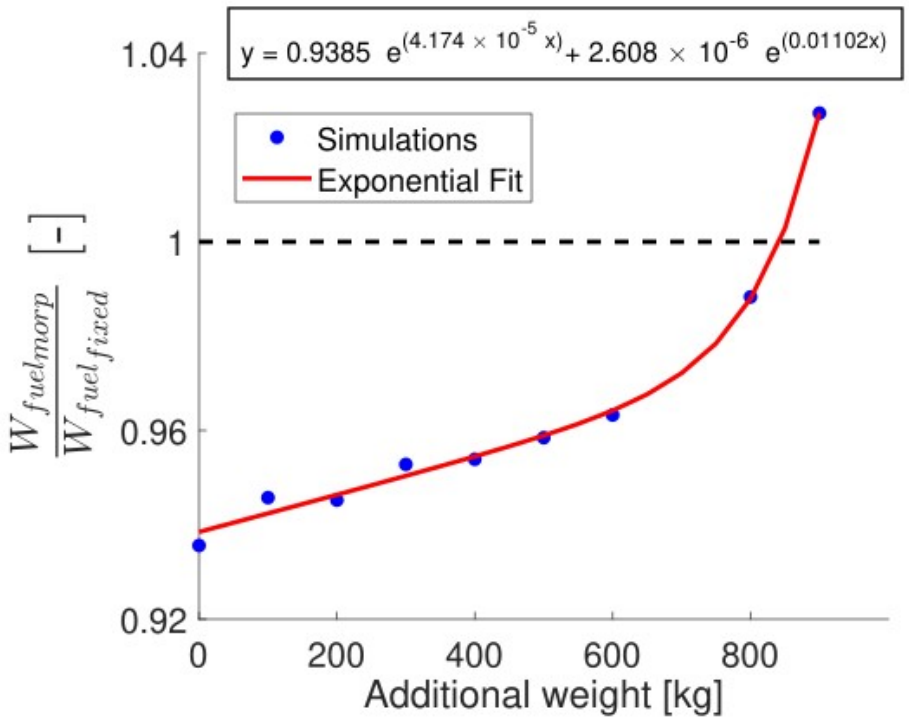
	FGW	CMW	Δ [%]
Time to climb (@ 430 FL) [min]	43	34	−20.9
Climb fuel consumption [kg]	540	445	−17.6
Cruise time [h]	6.25	6.25	0.0
Cruise fuel consumption [kg]	3590	3390	−5.9
Mission fuel consumption [kg]	4655	4355	−6.0



h = 1500 ft
IAS = 99.34 m/s
M = 0.30

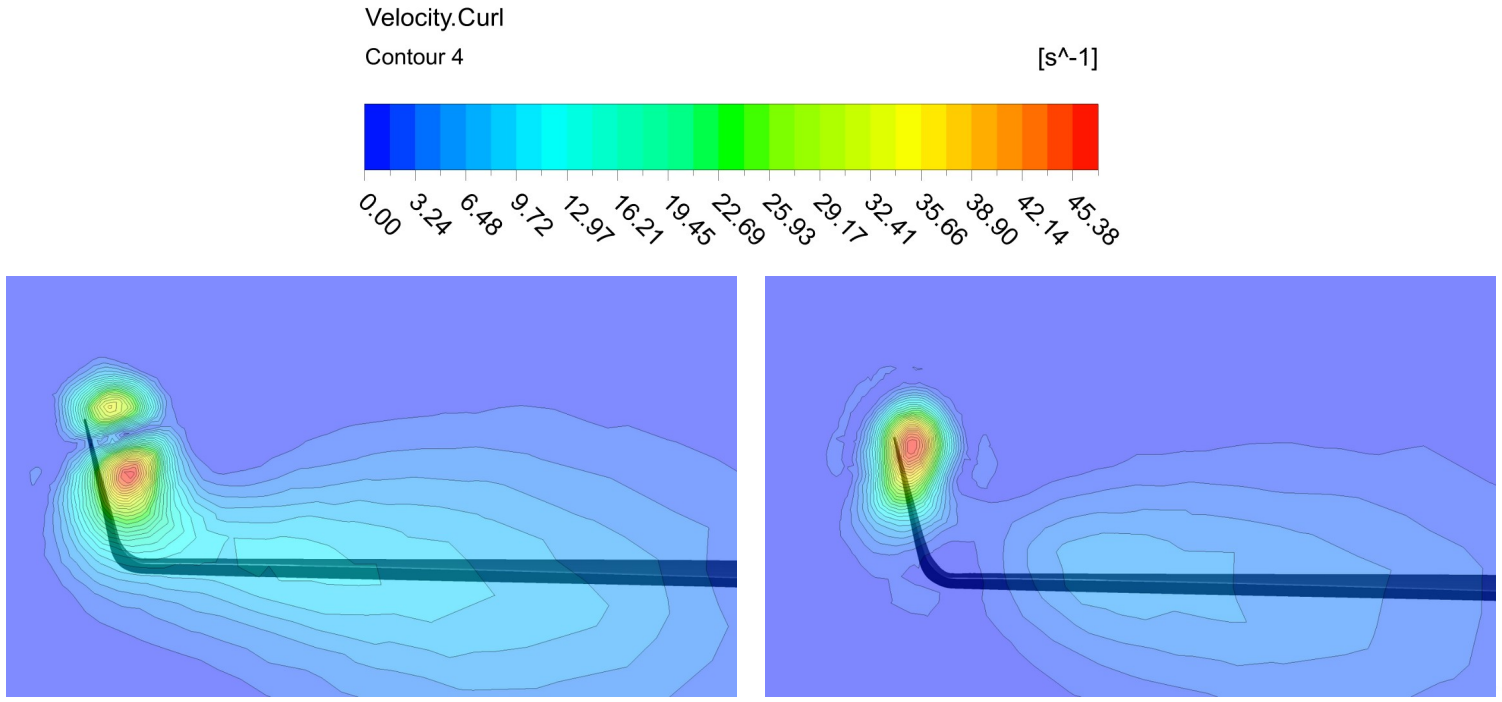






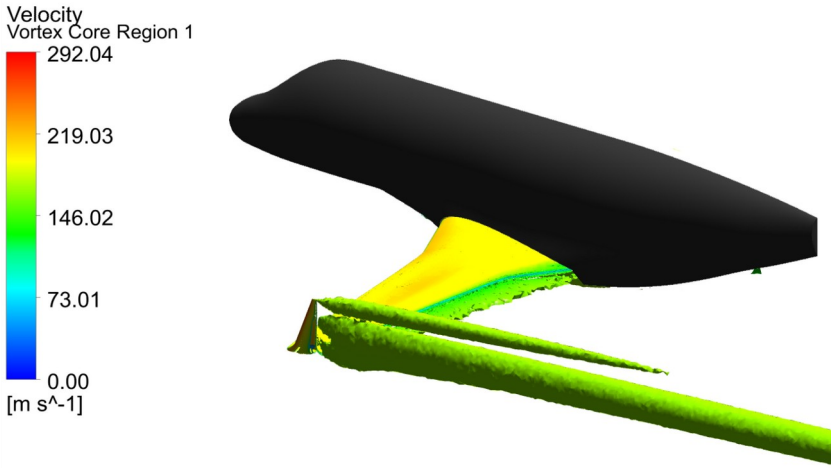
Vortex structure

- Data for climb condition.
- A similar behavior at cruise condition

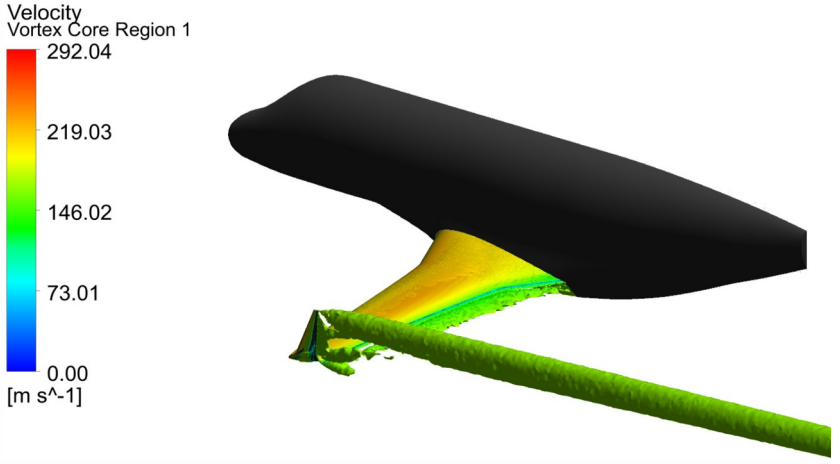


(a) Baseline winglet.

(b) Optimized winglet.



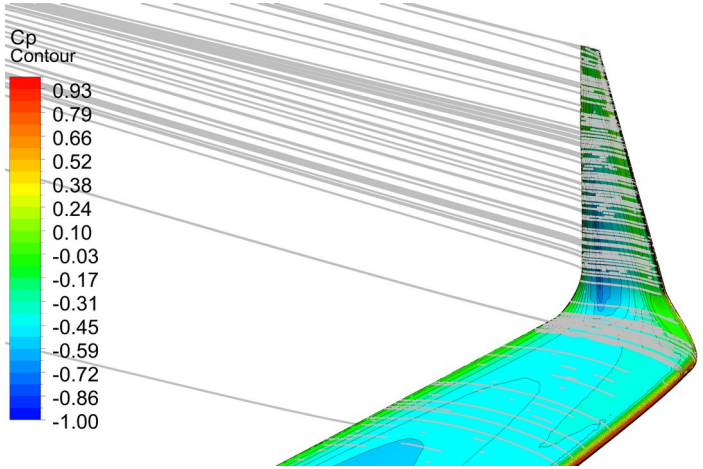
(a) Baseline winglet.



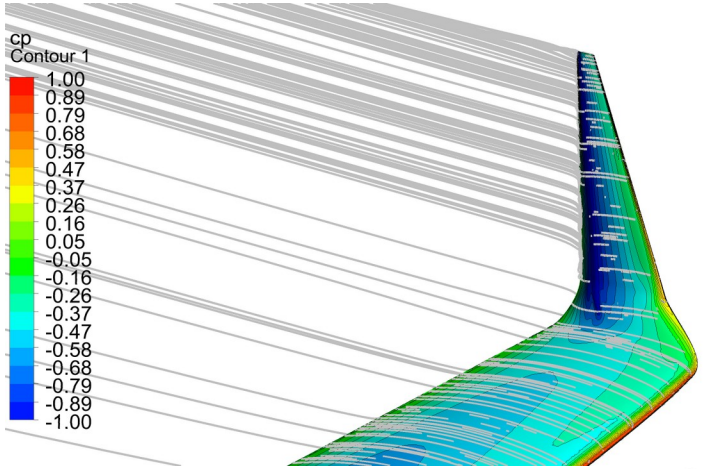
(b) Optimized winglet.

Streamlines

- Climb condition.

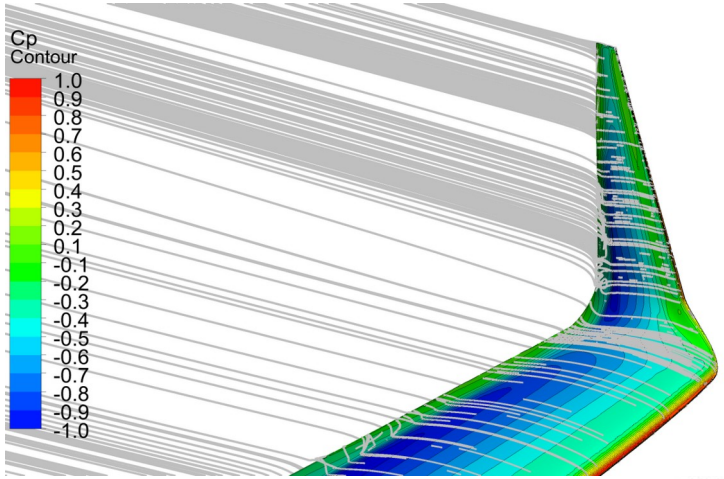


(a) Baseline winglet.

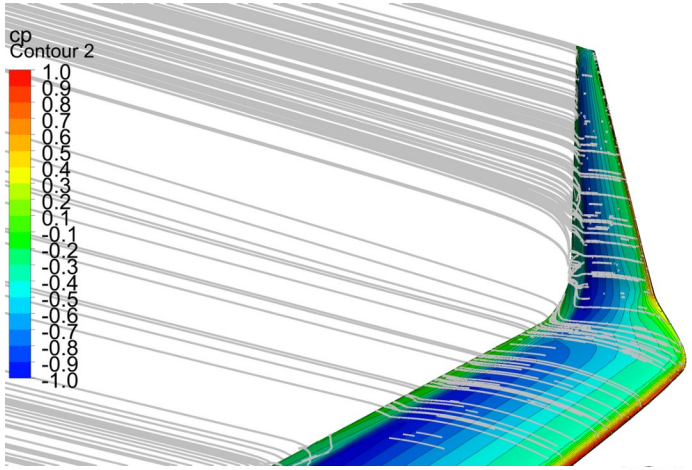


(b) Optimized winglet.

- Cruise condition



(a) Baseline winglet.



(b) Optimized winglet.

BRAZILIAN SILENCE AIRCRAFT PROGRAM



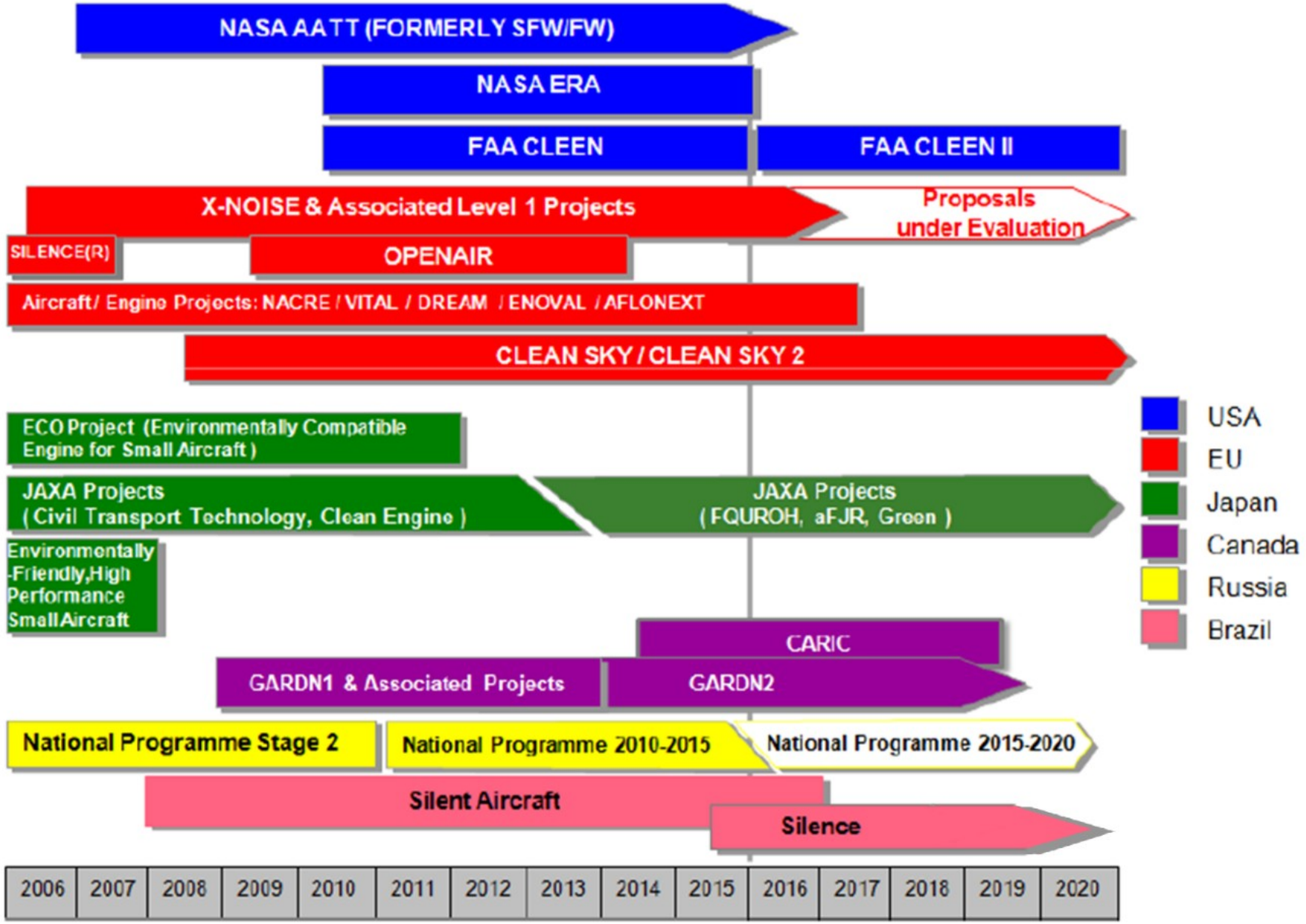








International Noise Technology Research Programmes





- The Team

Who is involved

MEMBERS

FAPESP - São Paulo Research Foundation

USP–University of Sao Paulo

EESC · USP
São Carlos School of Engineering

UFSC - Federal University of Santa Catarina

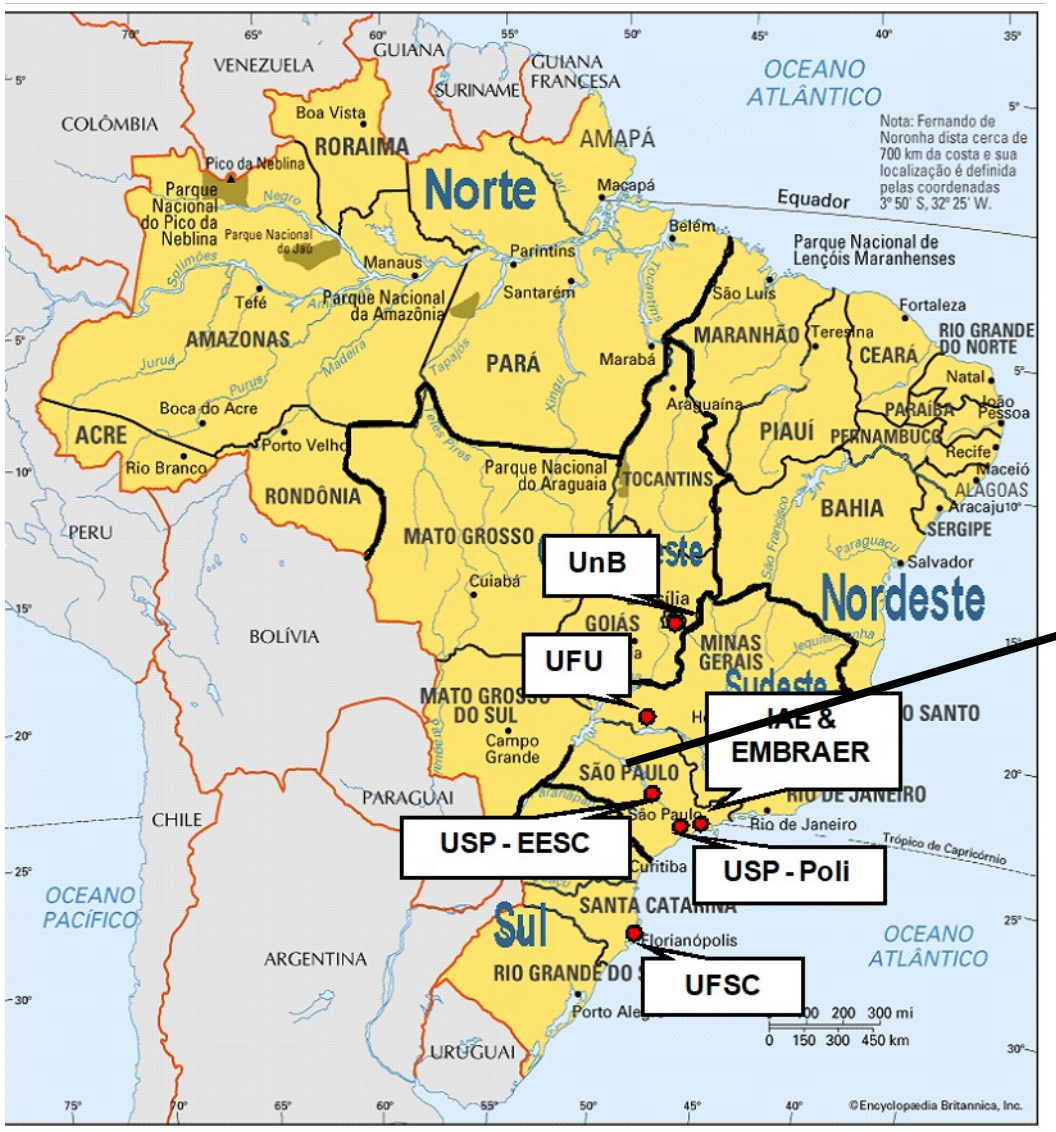
Poli – Polytechnic School

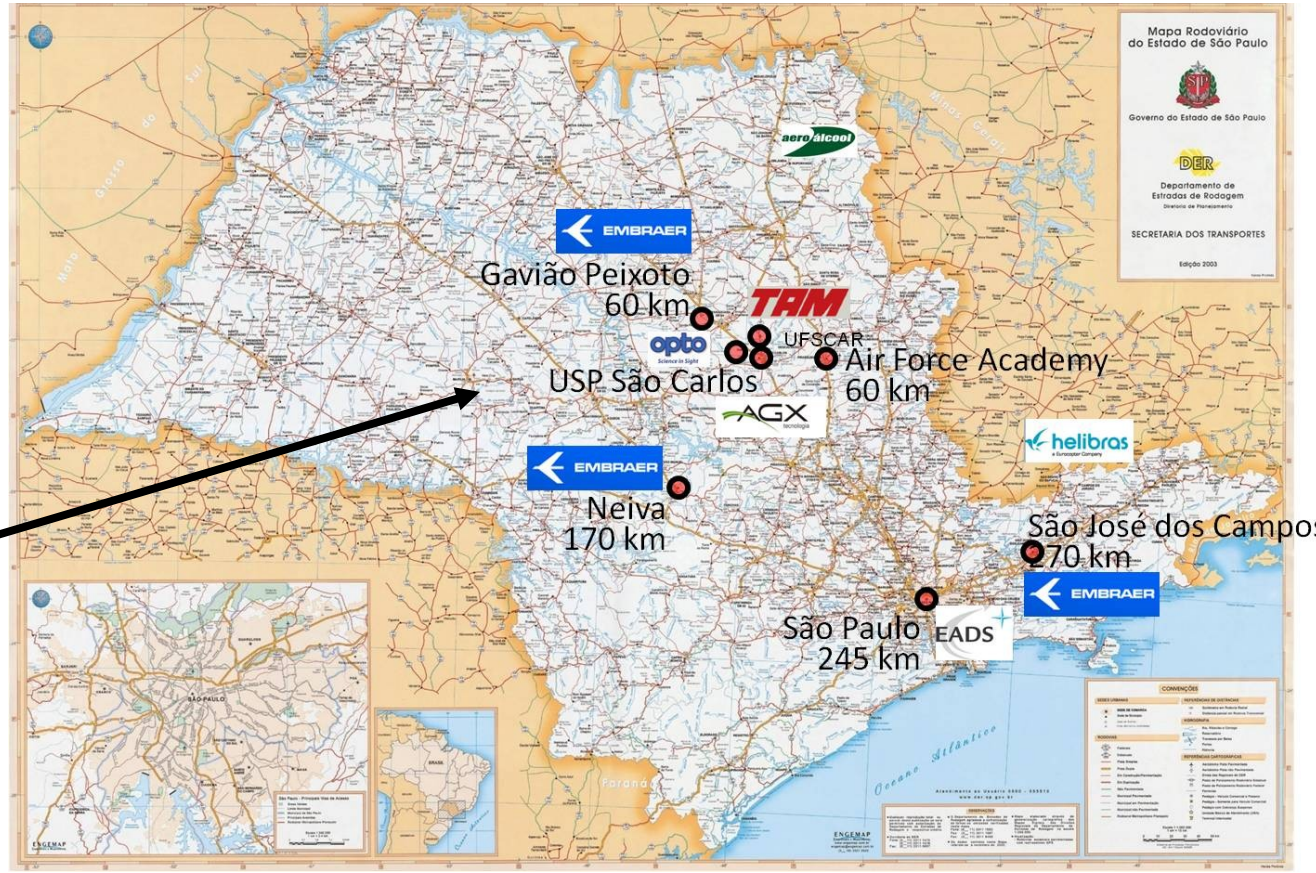
IAE - Brazilian Institute of Aeronautics and Space

UFU - Federal University of Uberlandia

UnB - University of Brasilia

Localization



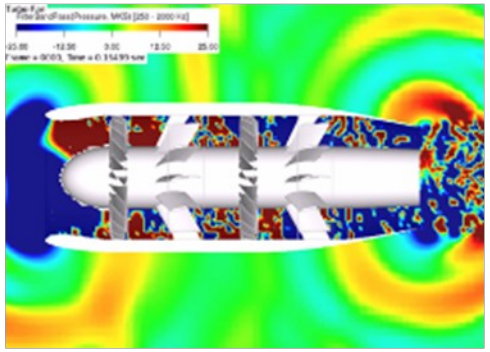


Jet noise prediction and testing



Fan Nosie prediction and testing





Finep

EMBRAER

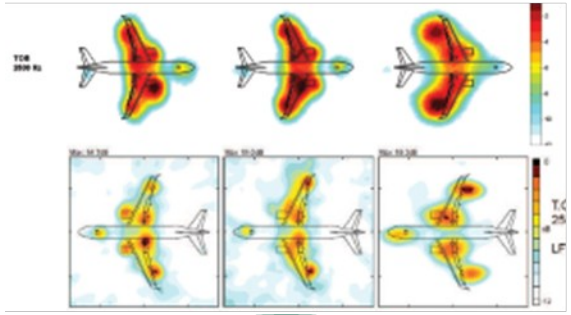
FAPESP

USP

USP–University of Sao Paulo

UFSC - Federal University of Santa Catarina

Poli – Polytechnic School

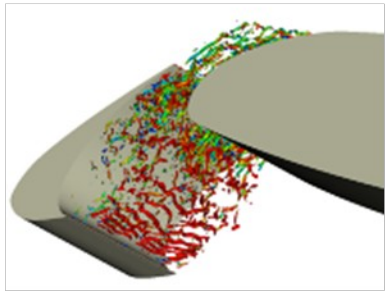


IAE - Brazilian Institute of Aeronautics and Space

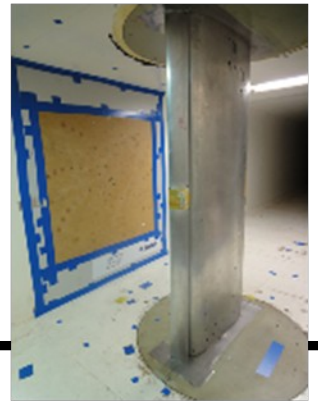
EESC · USP
São Carlos School of Engineering

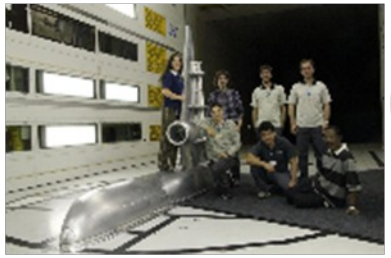
UnB - University of Brasilia

UFU - Federal University of Uberlandia



Wind tunnel and Flying testing and

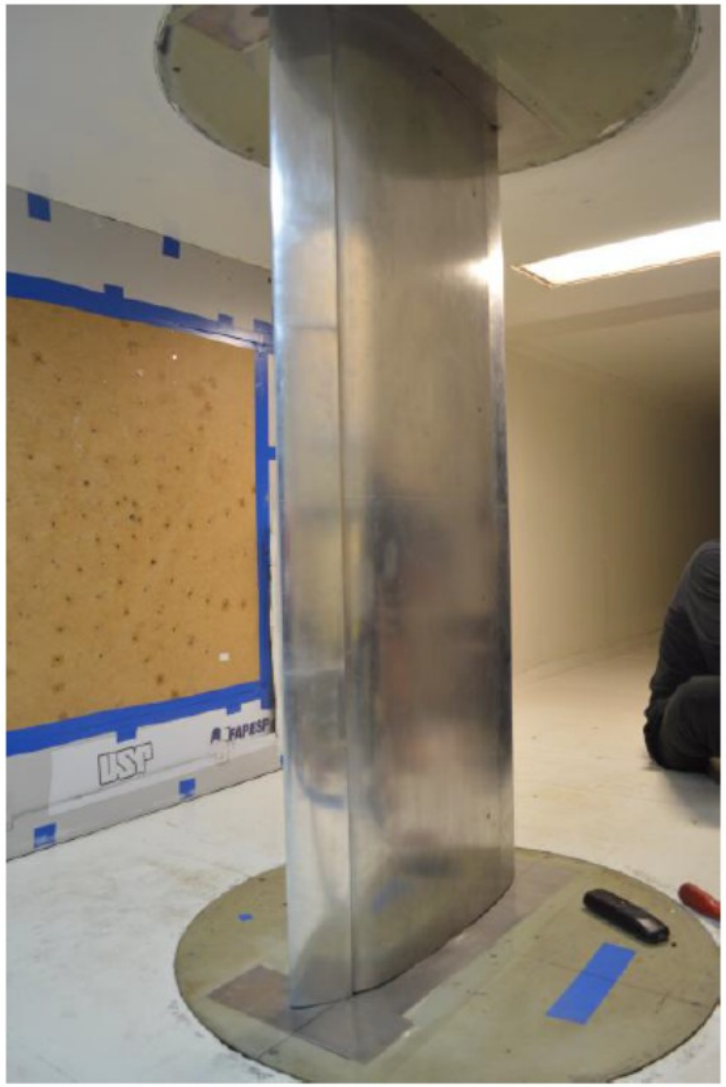




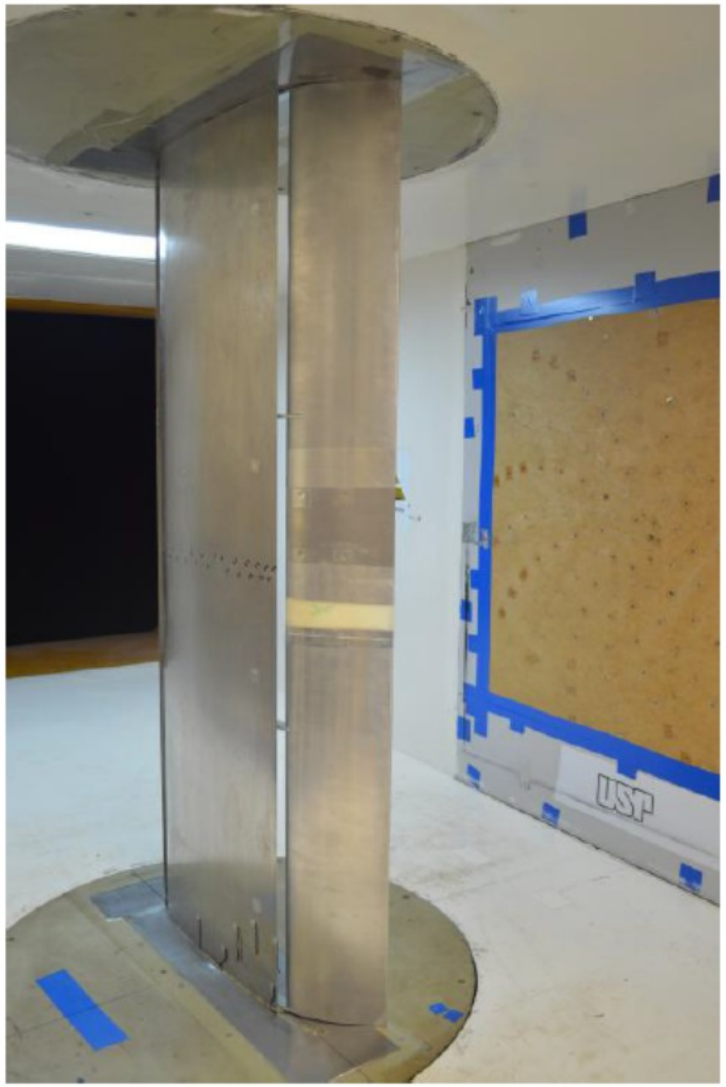
Airframe noise prediction and testing

Boeing Proprietary

AEROACOUSTIC WIND TUNNEL TESTS 2-D High lift model



(a) Flap Retraído

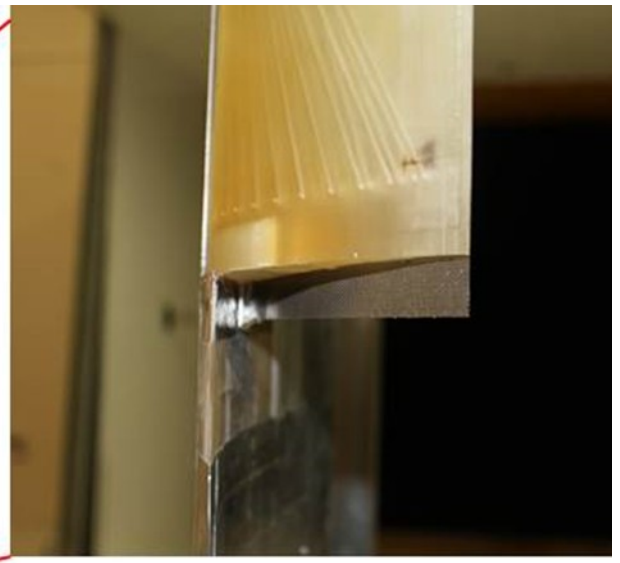


(b) Flap Full



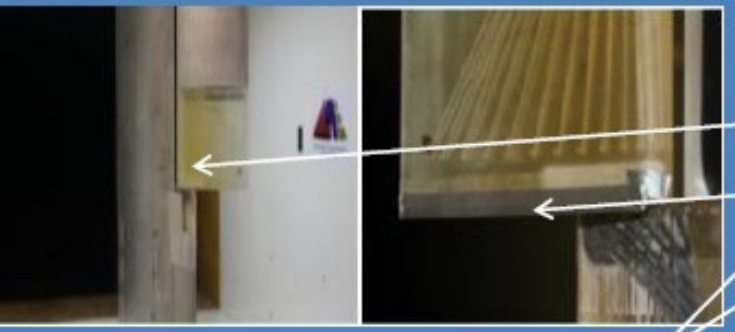
(c) Flap Side Edge

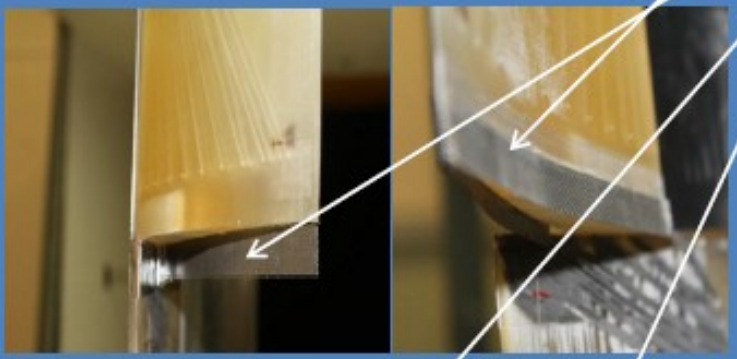




Flap side-edge noise reduction



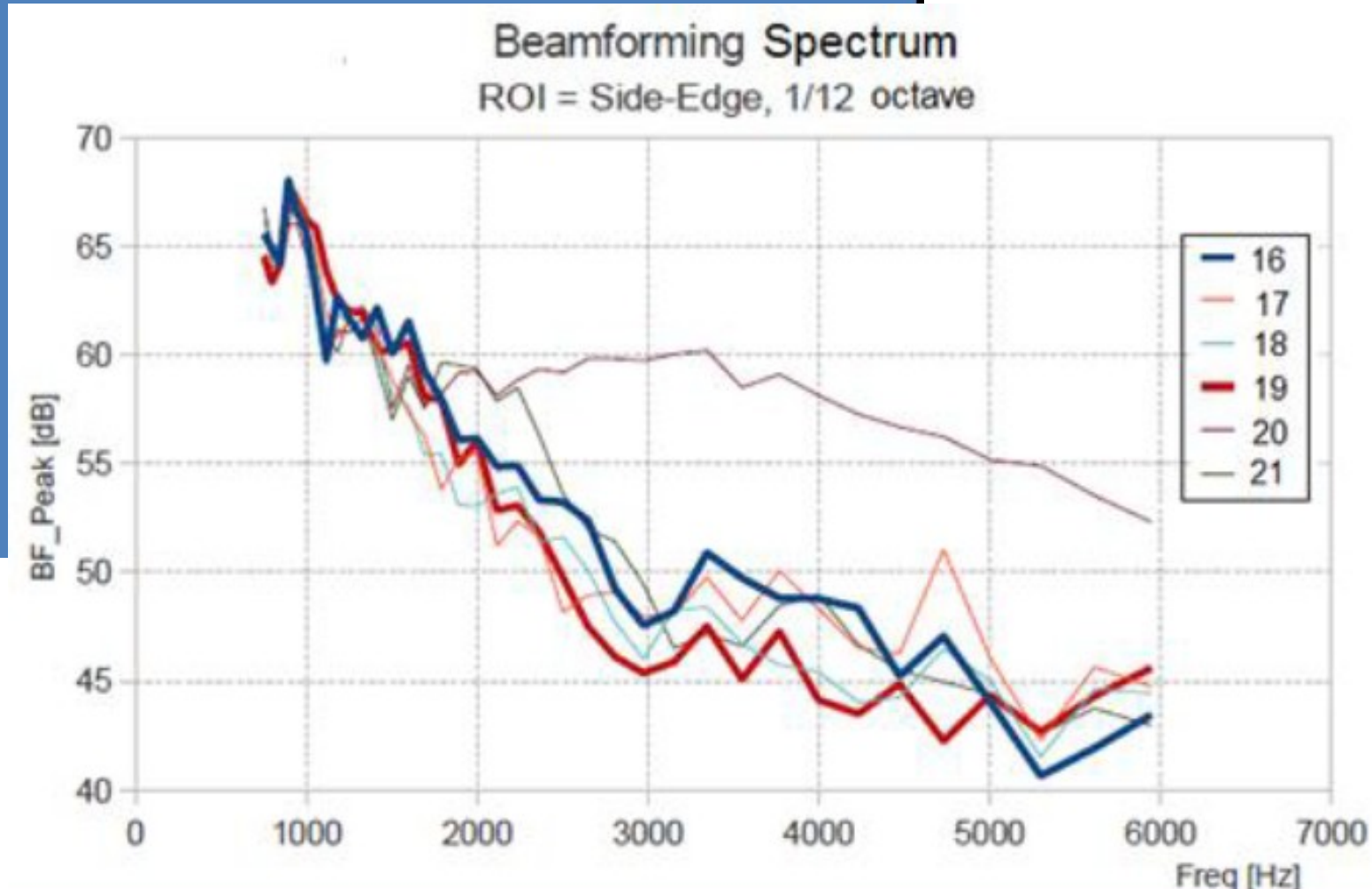




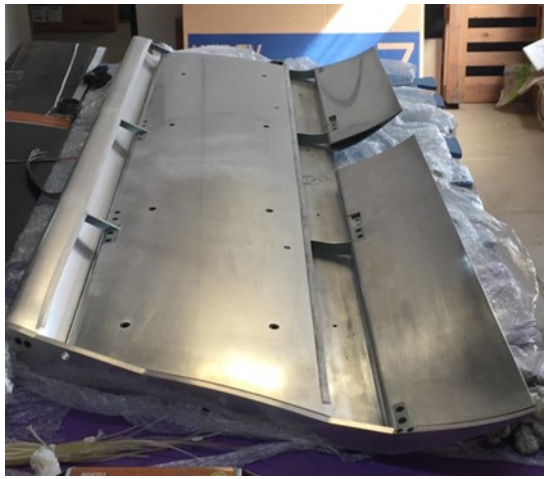


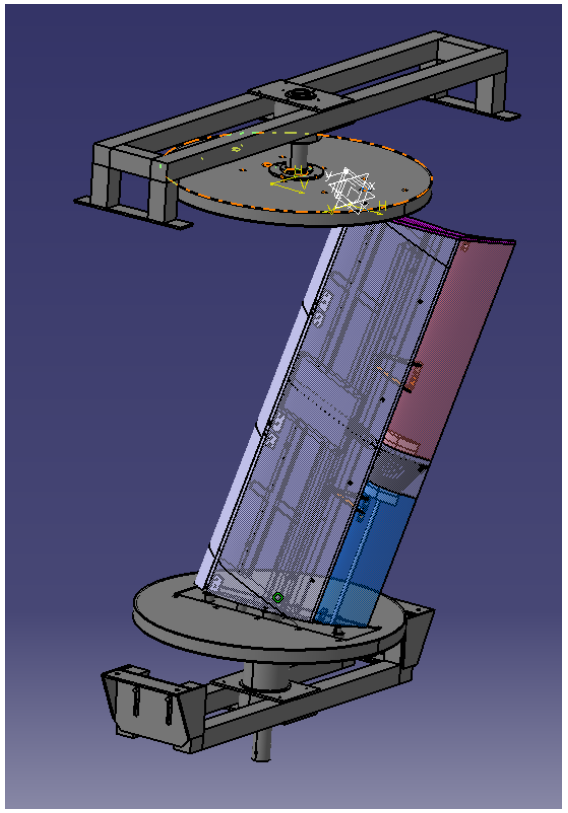


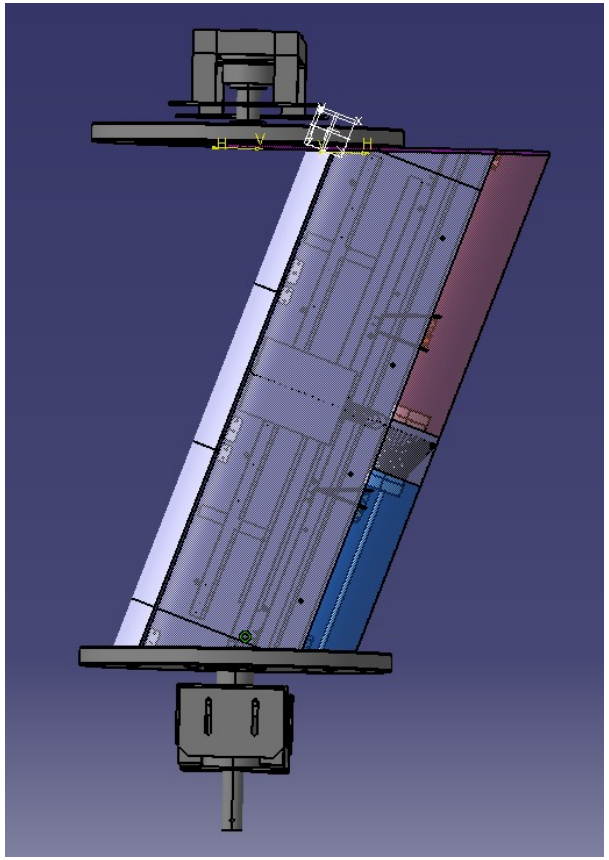
Test Number	Type Of Experiment	Location	Incidence Angle
16	Baseline		12º
17	Porous plate	Flap side edge bottom surface	12º
18	Porous plate	Flap side edge bottom and upper surface	12º
19	Porous plate	Flap side edge bottom surface (bigger plate, 15mm)	12º
20	Non porous plate	Flap side edge upper surface (bigger plate, 15mm)	12º
21	Split plate	Flap side edge	12º



Sweep back 2-D high lift wing model.

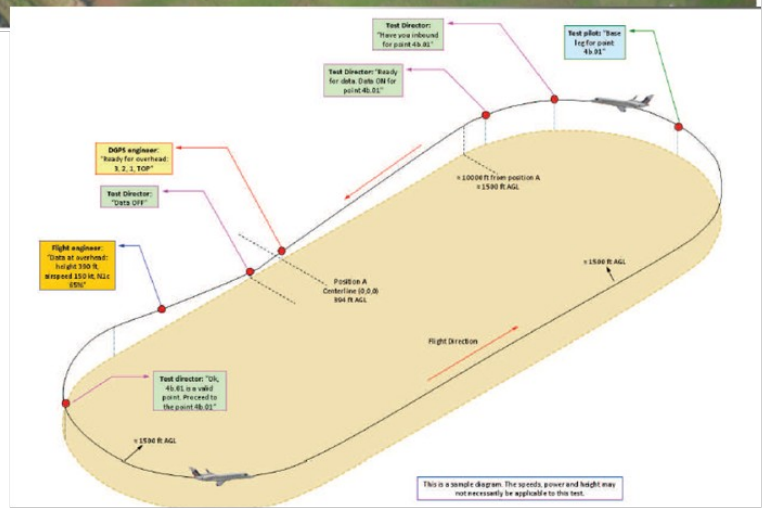




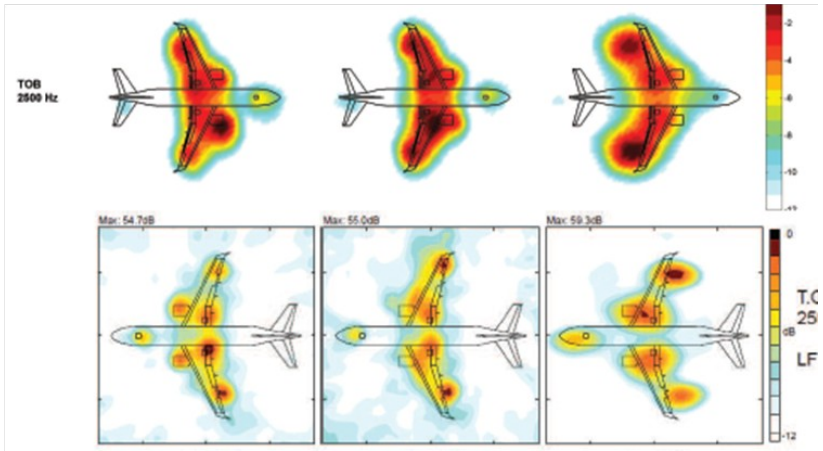


Flyover measurements

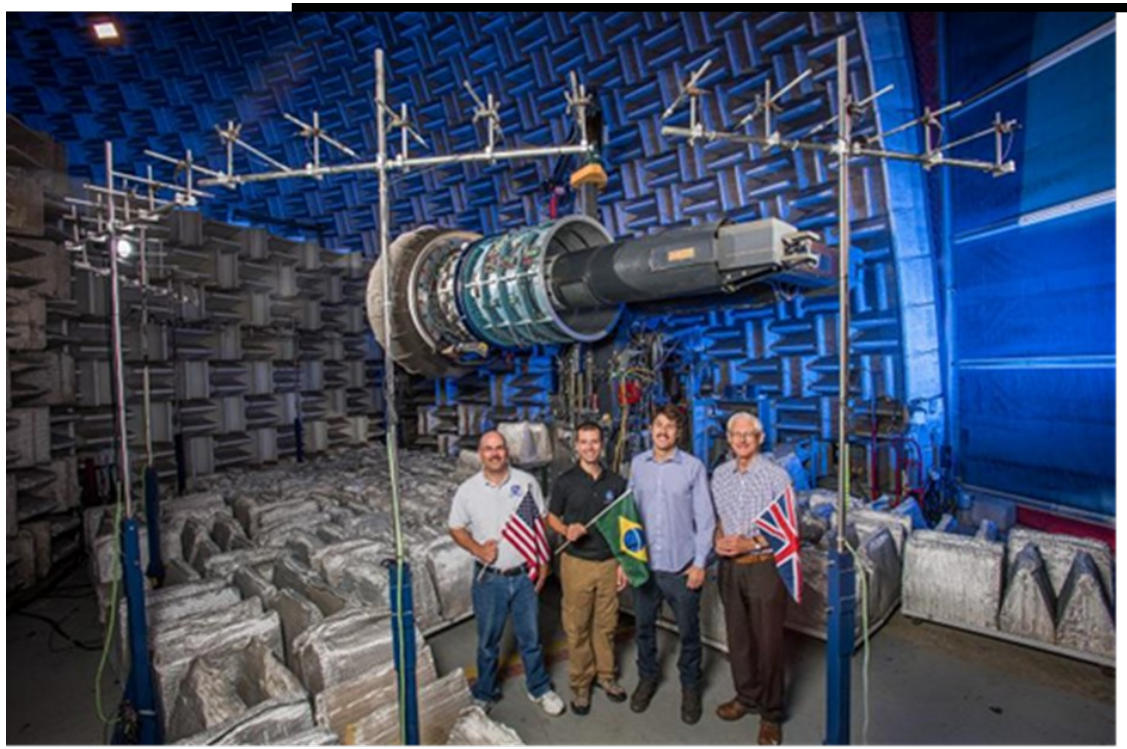




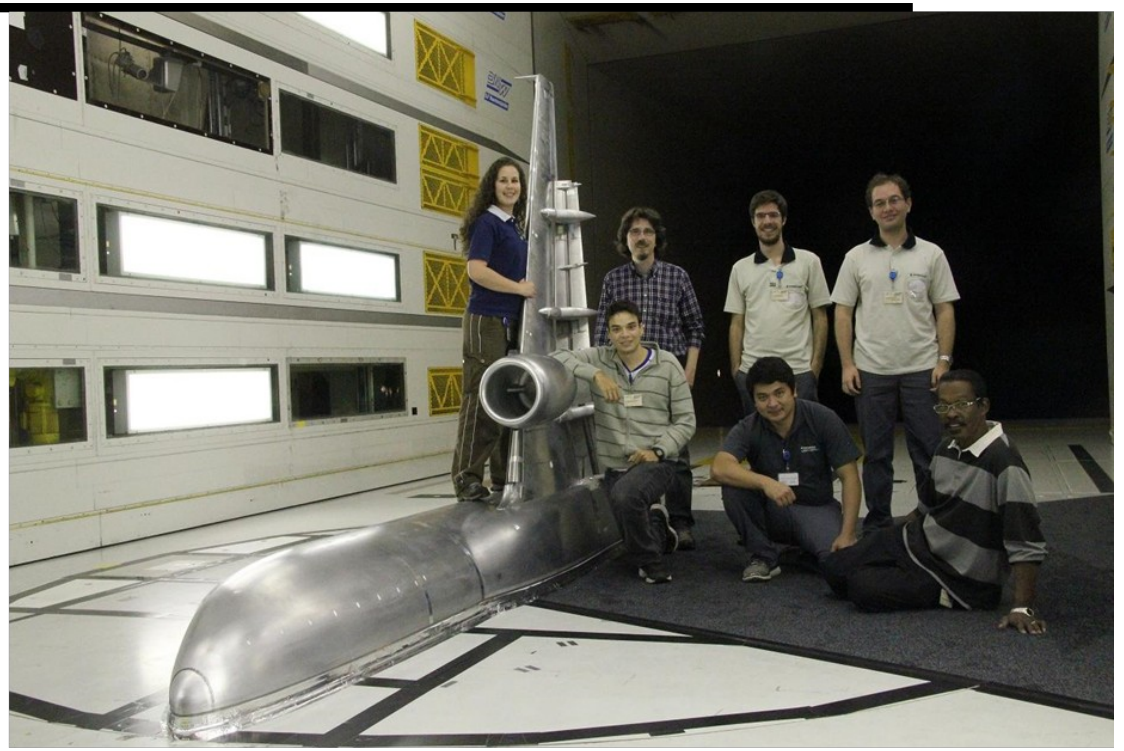




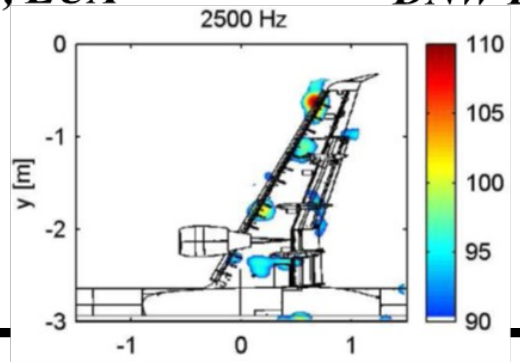
Large Scale Aeroacoustics Testing

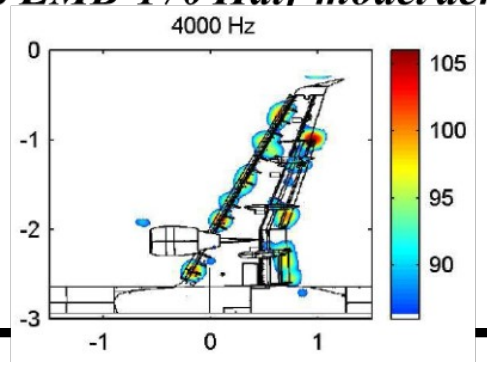


Testing at NASA Glen Fan Rig ANCF, EUA



DNW LLS EMB-170 Half-model aeroacustic testing.



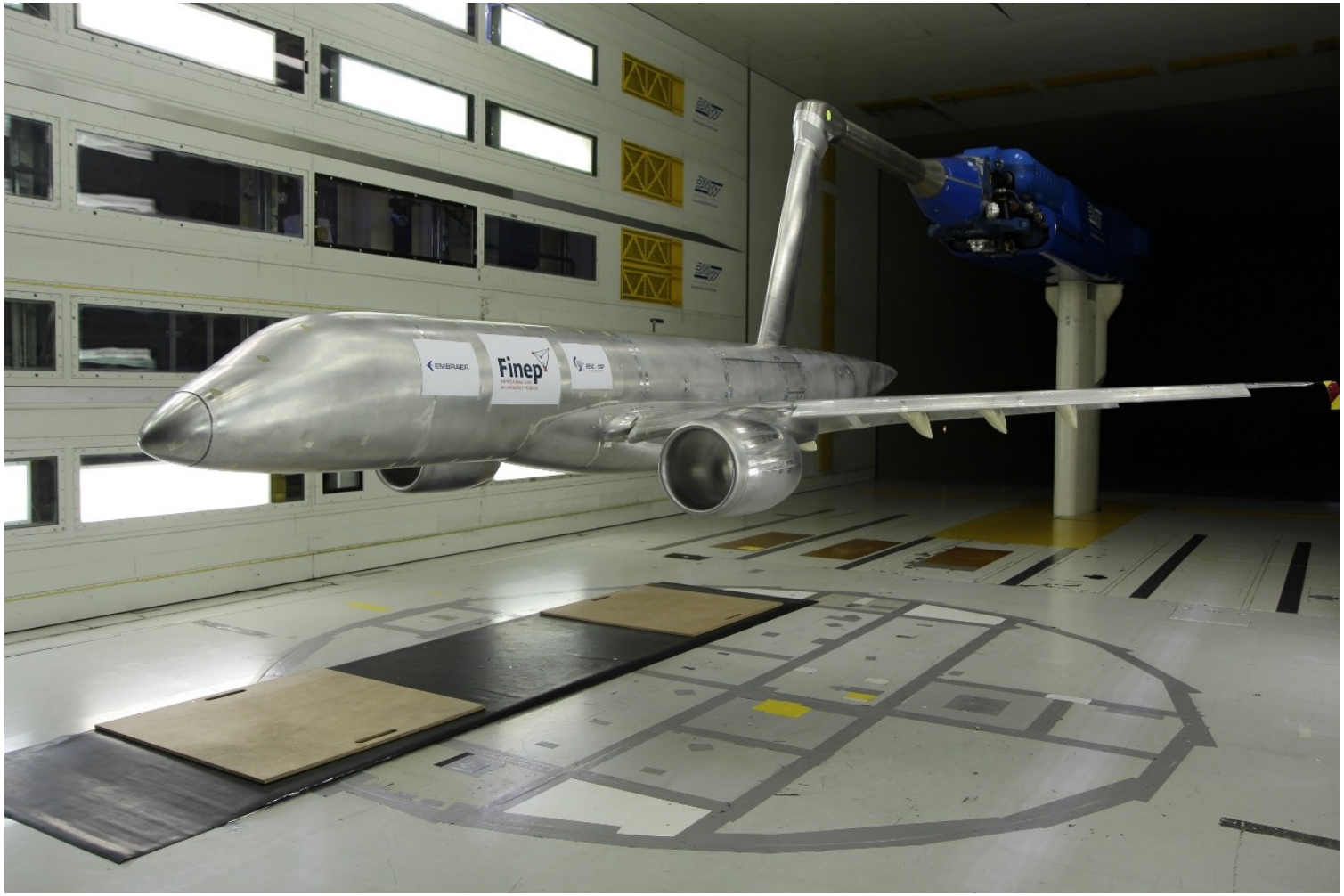


Large Scale Aeroacoustics Testing

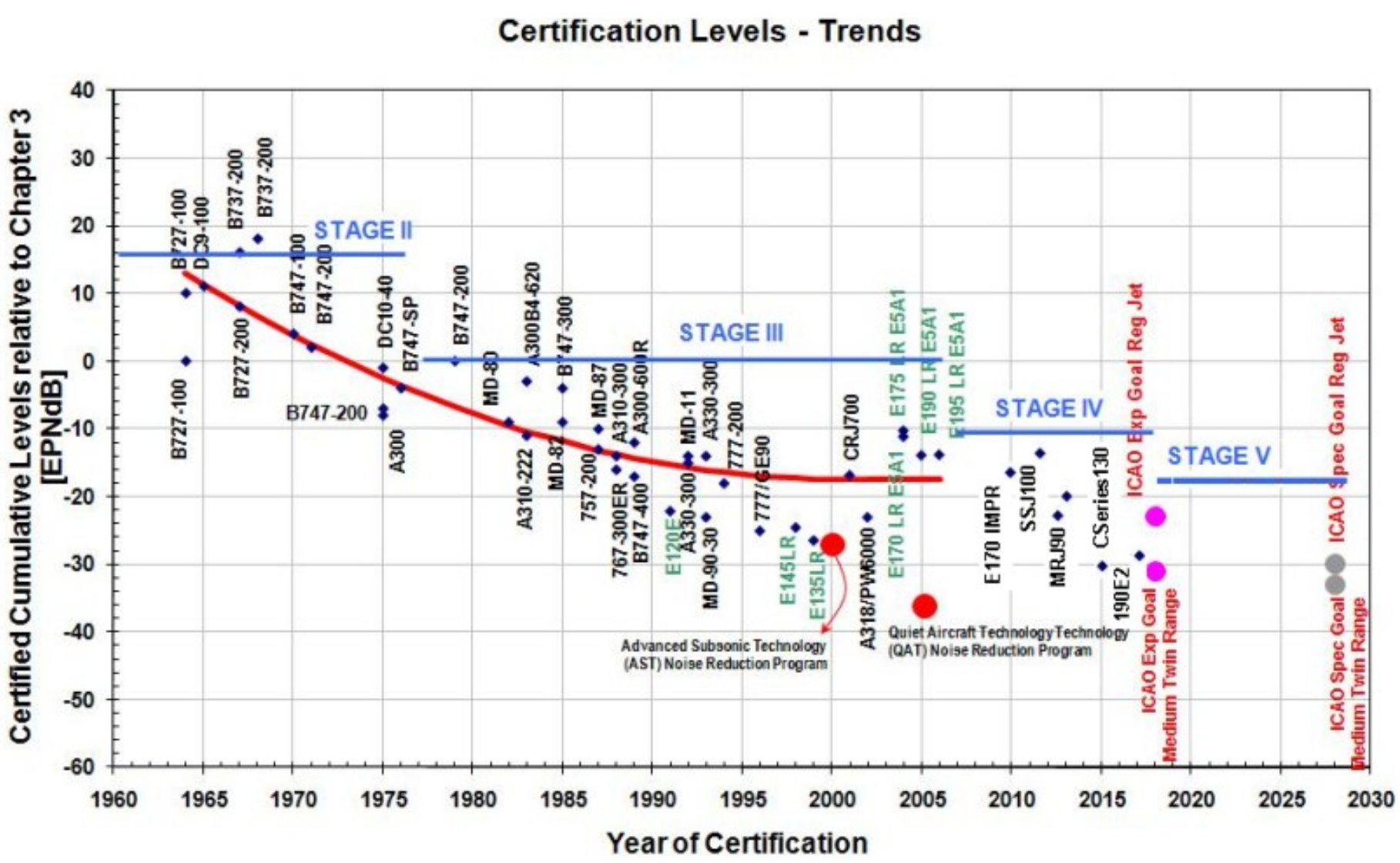
DNW LLF Wind Tunnel testing a full model Embraer 190E2

- 6m span model, M=0.15-0.33
- Single and double slotted flap, flap vane.
- 24 NRT for slat .
- 10 NRT for flap side-edge





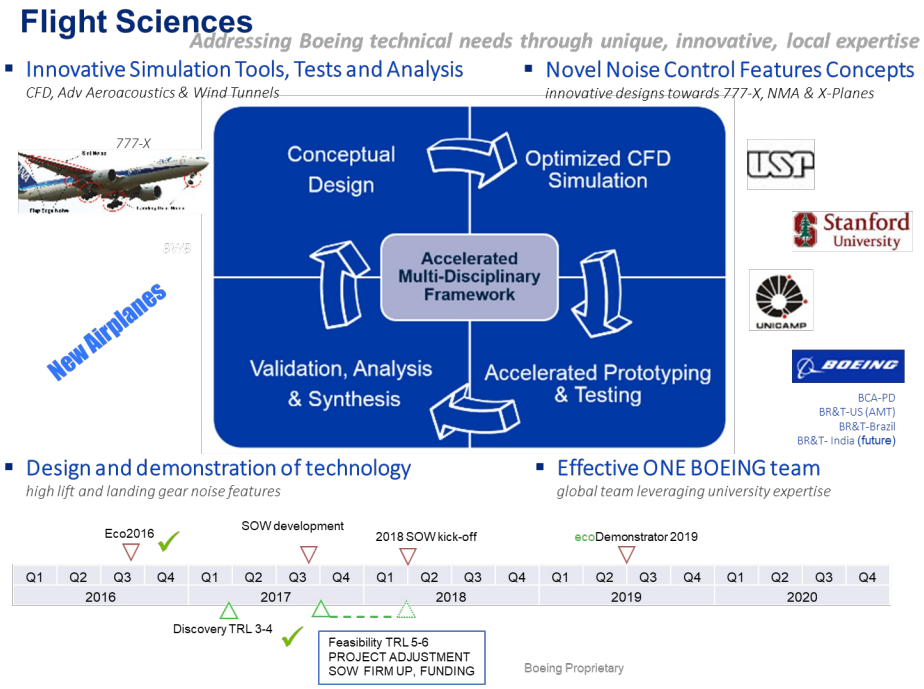
Results

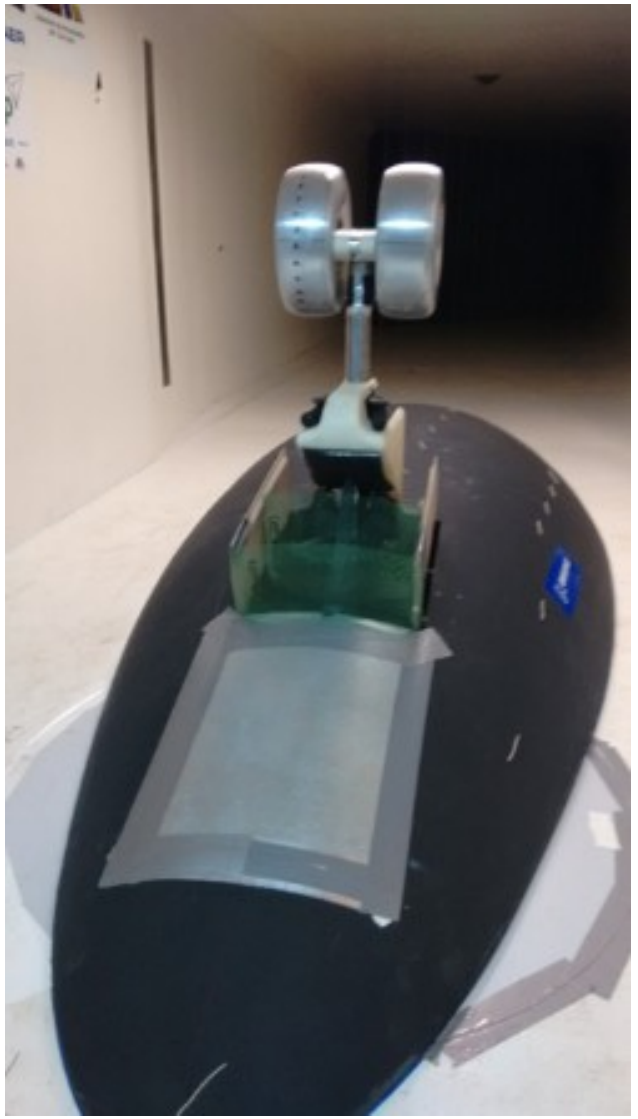


New Technologies have been produced significant noise reductions at noise source.



Complex NLG B777
model 1:6 scale

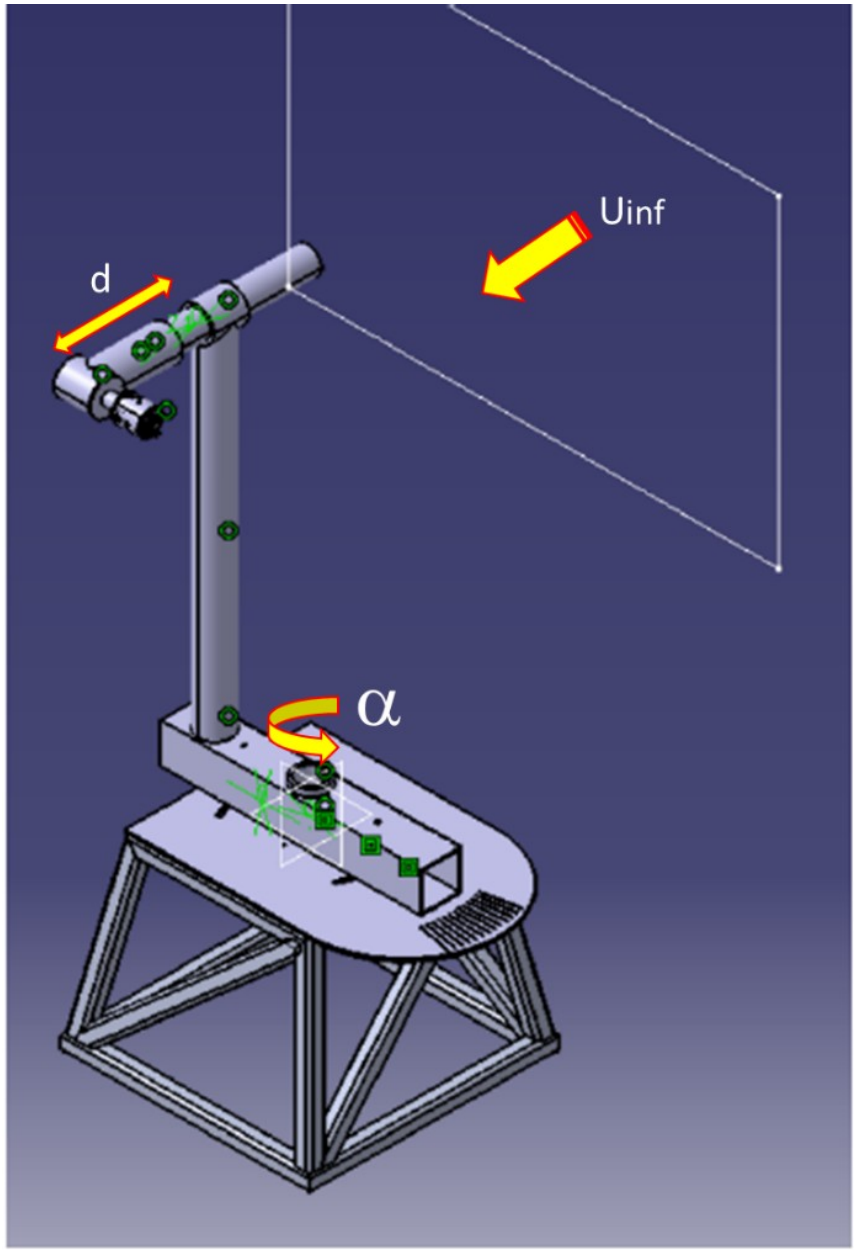


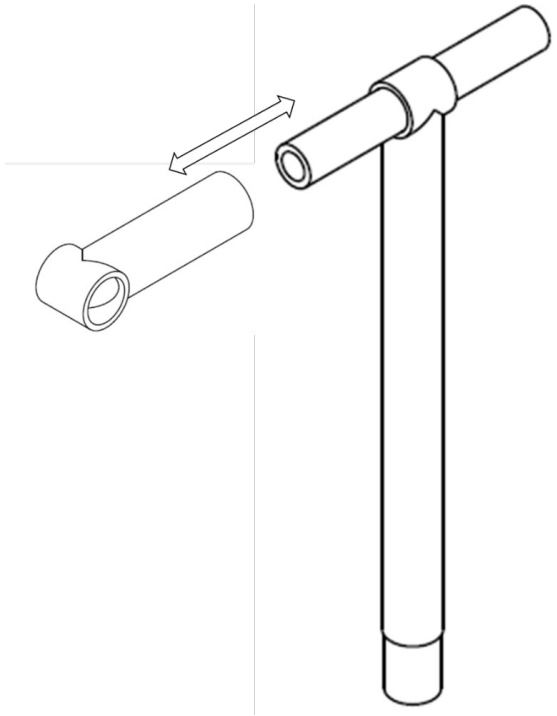


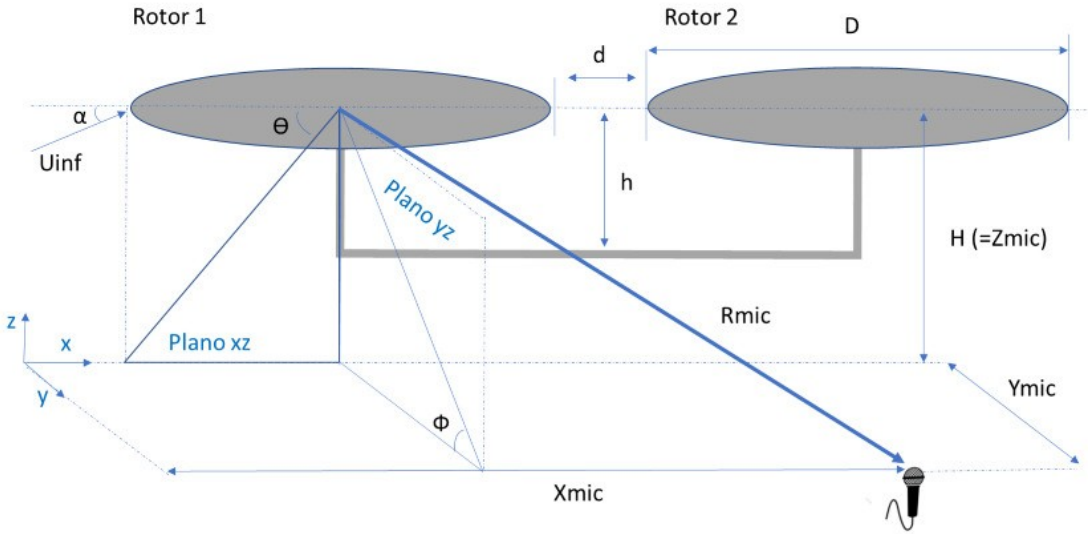
More than 100 hours of Wind tunnel testing both aeroacoustic and aerodynamics; 7 NRTs developed and tested with reductions up to 5 dB

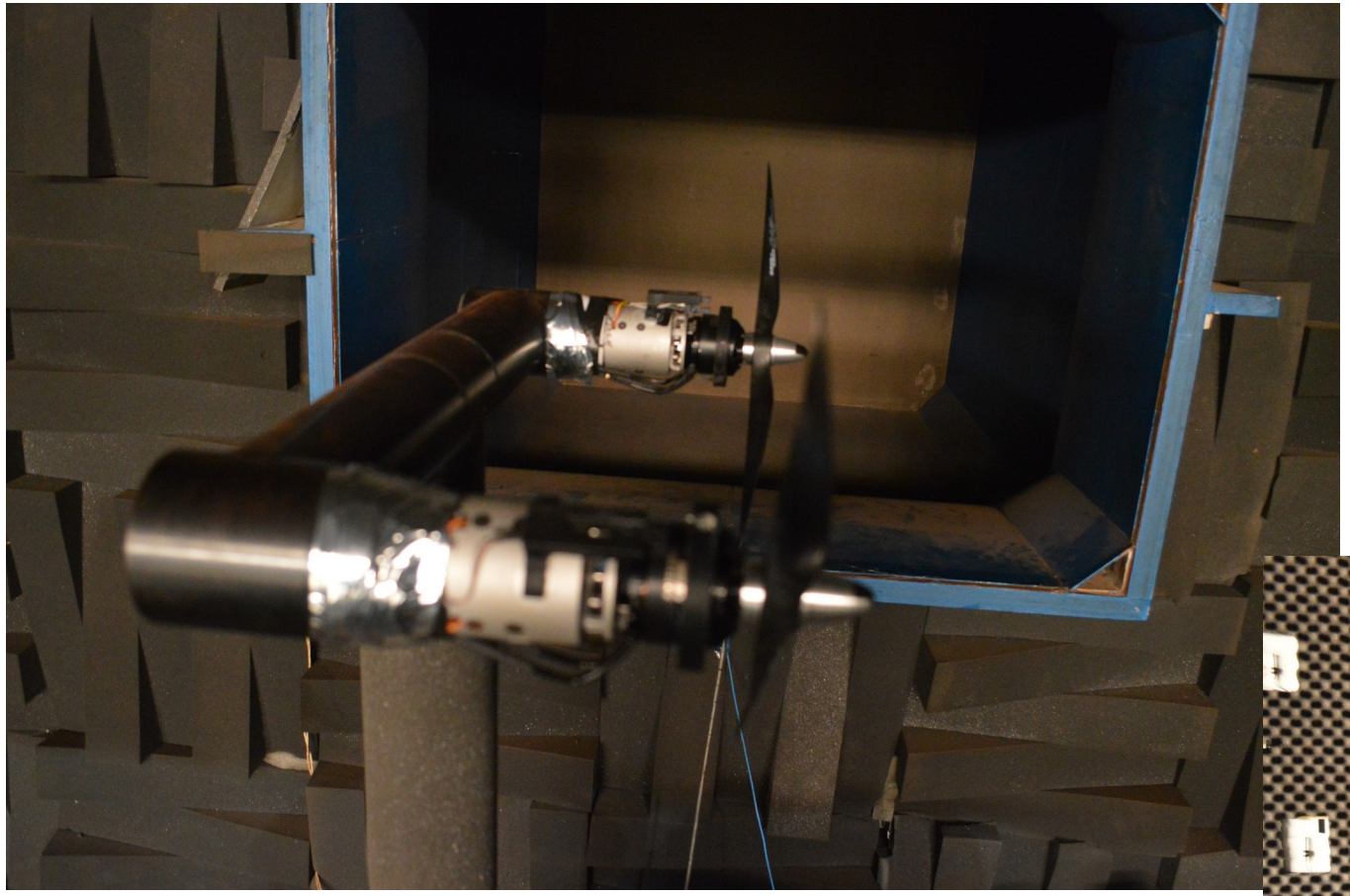
Boeing Proprietary

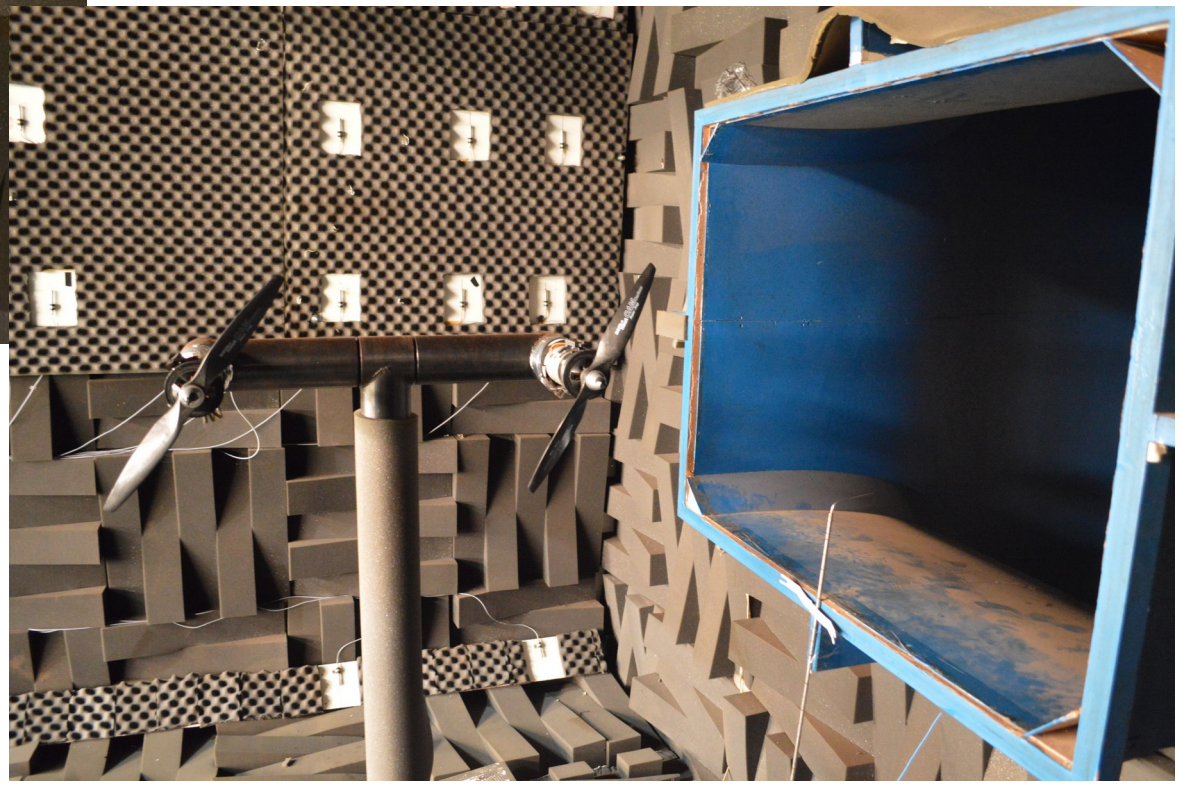
Rotor testing and Aeroacoustcs measurements



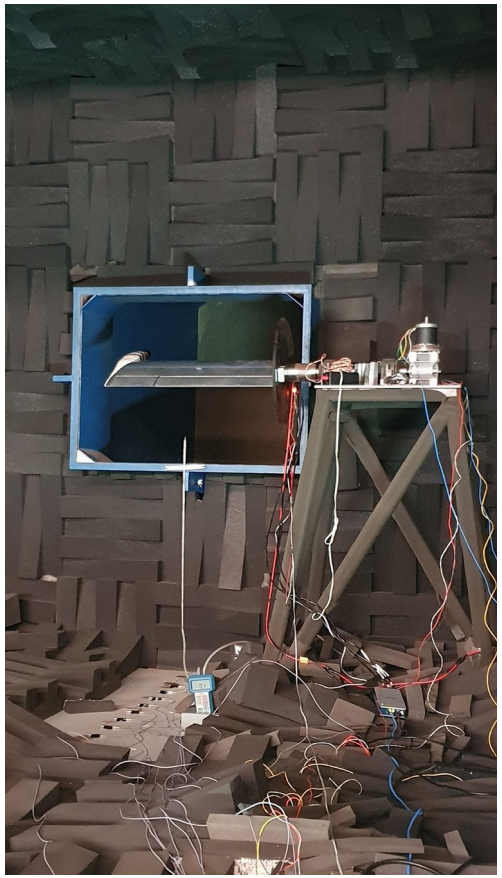




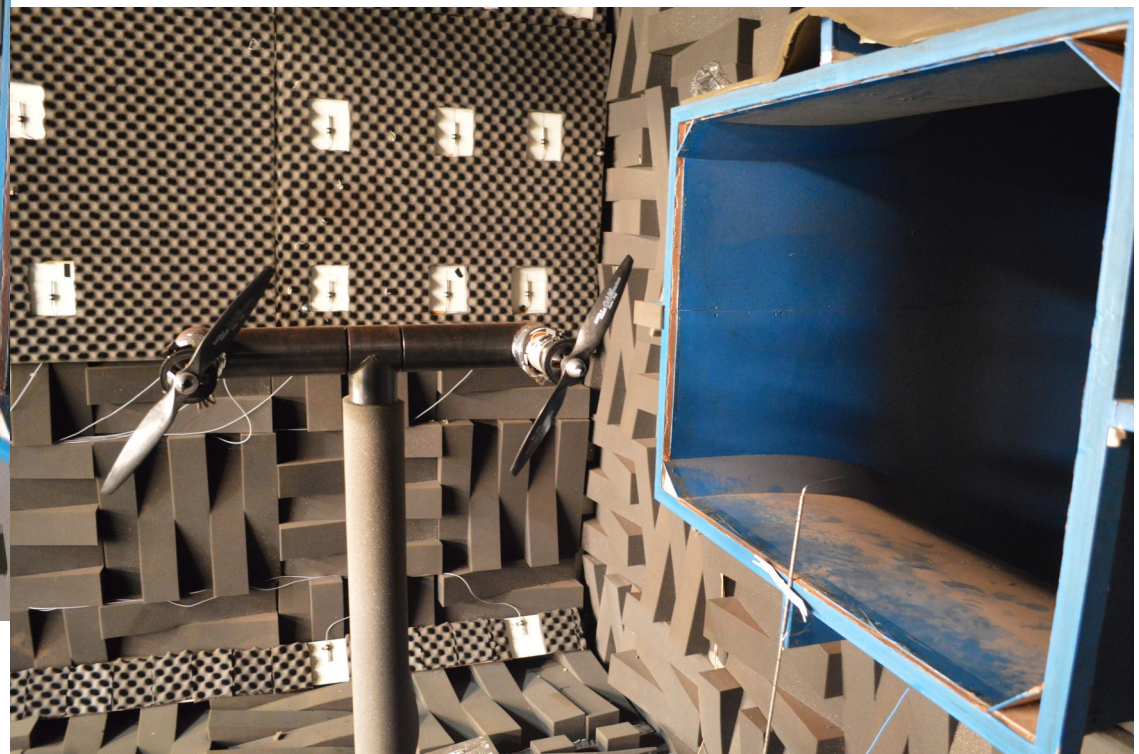


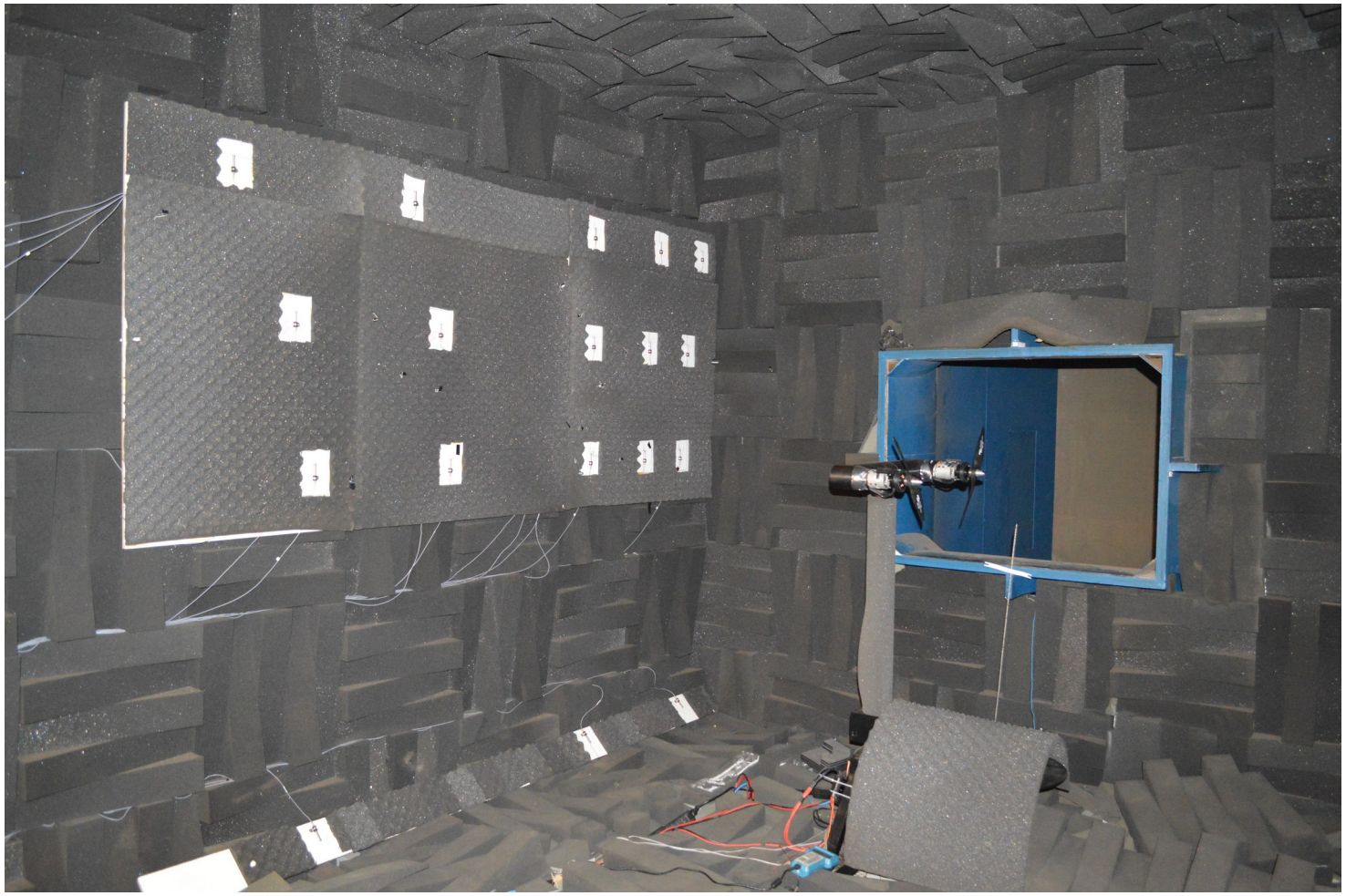


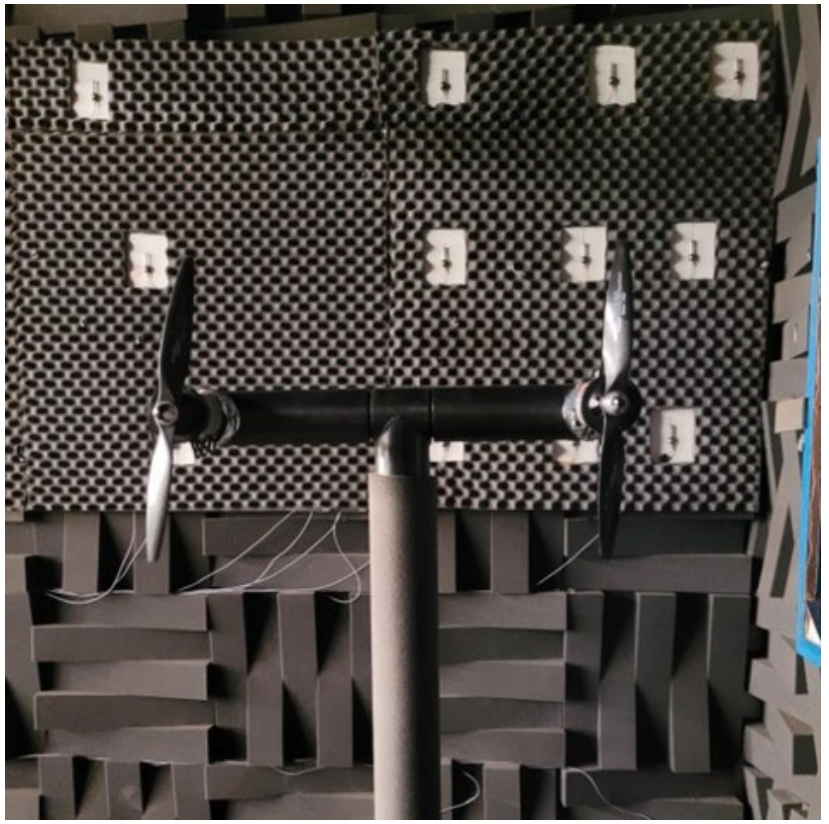
The proposal for measuring noise for the distributed propulsion platform includes positioning the grazing microphones on a smooth surface without acoustic treatment. 10 microphones were positioned at a distance of 1.36 m from the center line of the tunnel with a horizontal distance of 0.15 m between the microphones, the first of which was aligned with the propeller actuation disc. This configuration did not present any problems regarding noise measurement due to the incidence of airflow turbulence.

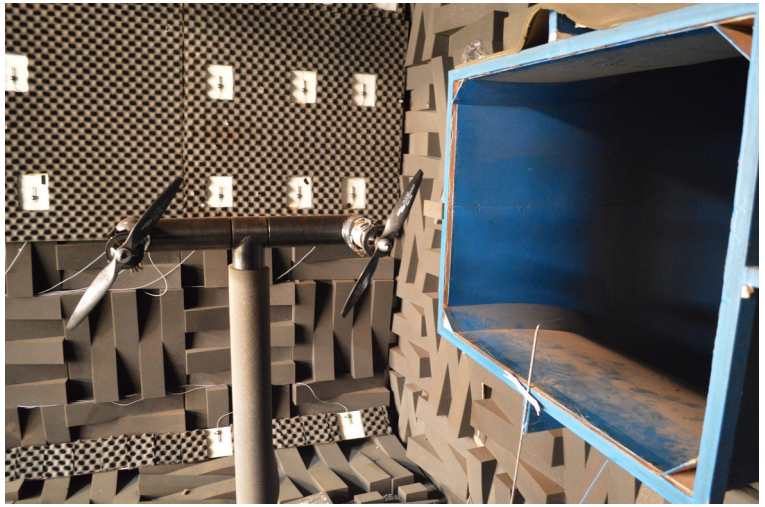






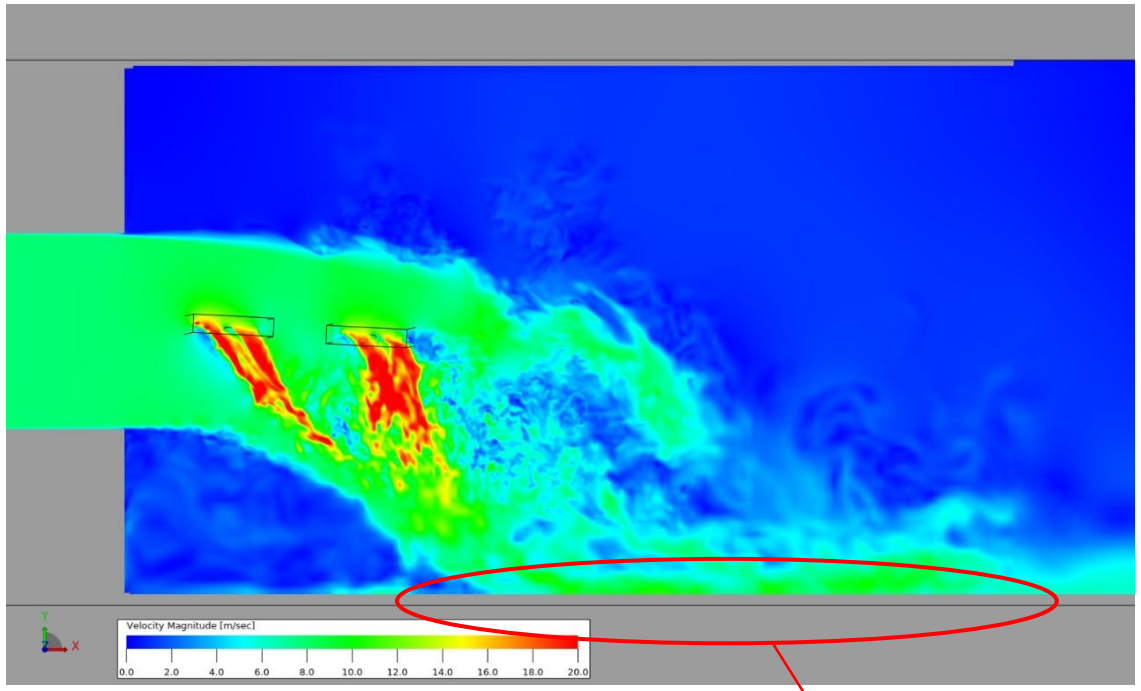






Rig de ensaios de rotores

Aerodinâmico: caracterização do escoamento Análise da interferência do slipstream:



Case 1 - WT 90, Propellers are rotated 90º to benefit from the larger dimension of the WT outlet. AoA 3 deg, V=7,7m/s, Velocity m/sec.

Efeito nos microfones

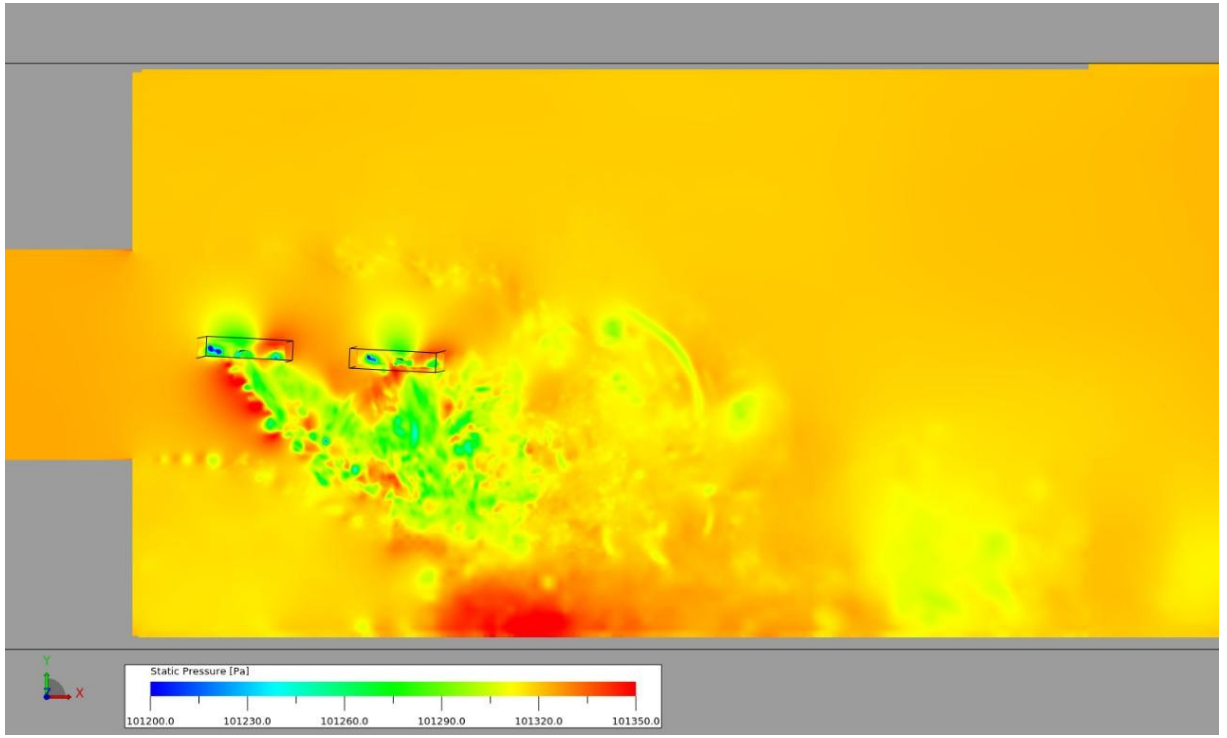


Figura 10 - Case 1 - WT 90, Propellers are rotated 90º to benefit from the larger dimension of the WT outlet. AoA 3 deg, V=7,7m/s, static pressure(Pa)

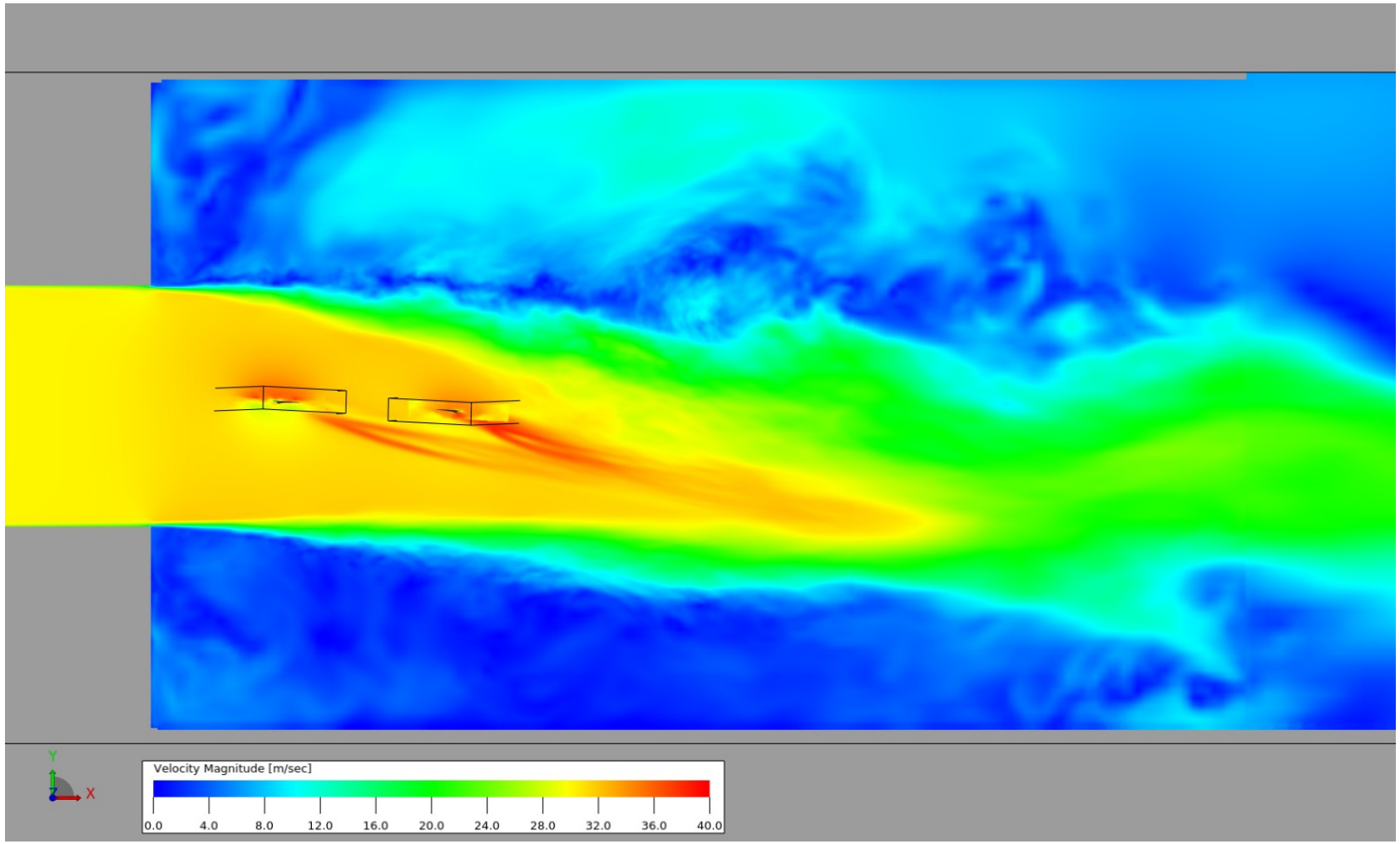
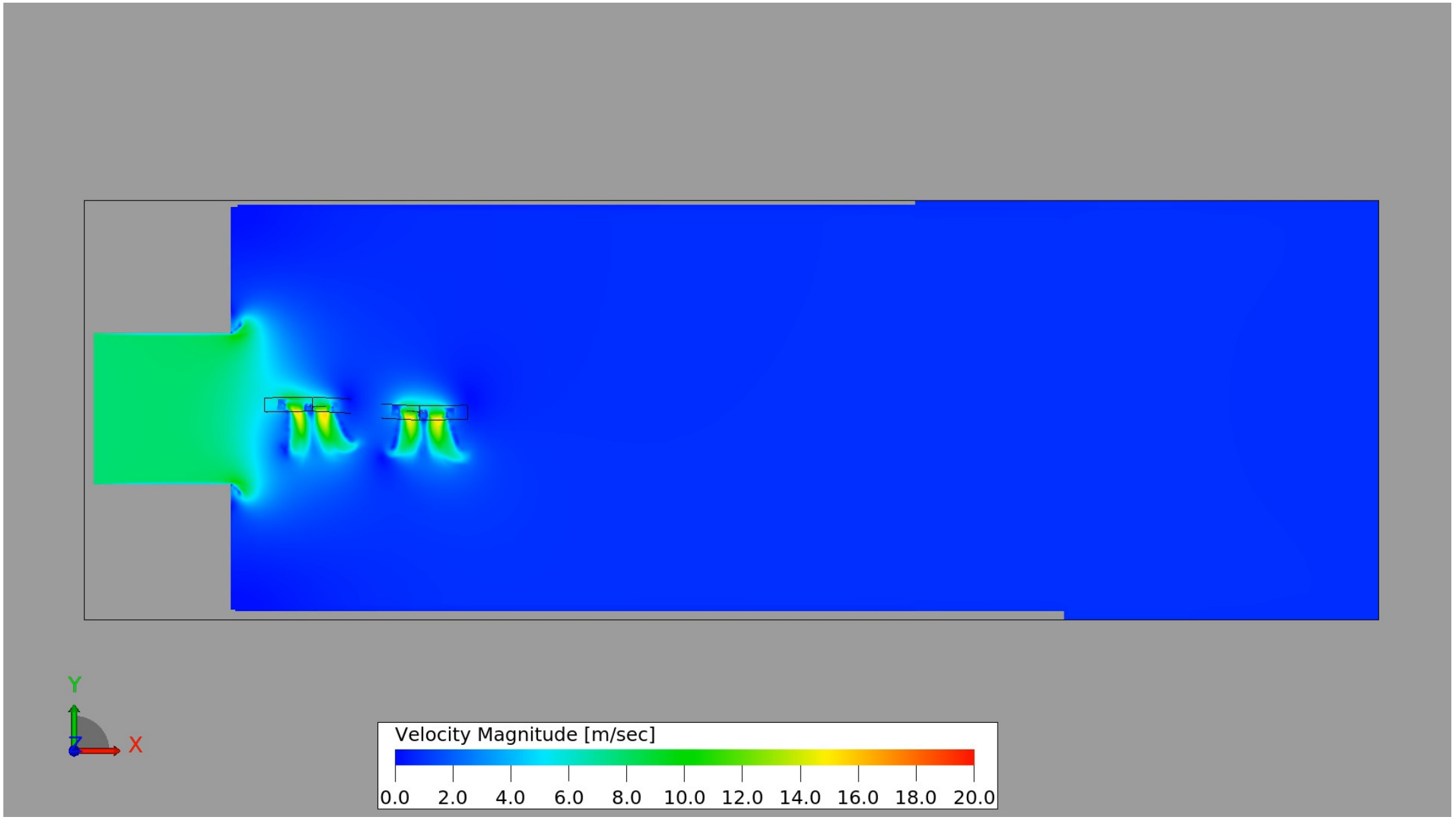


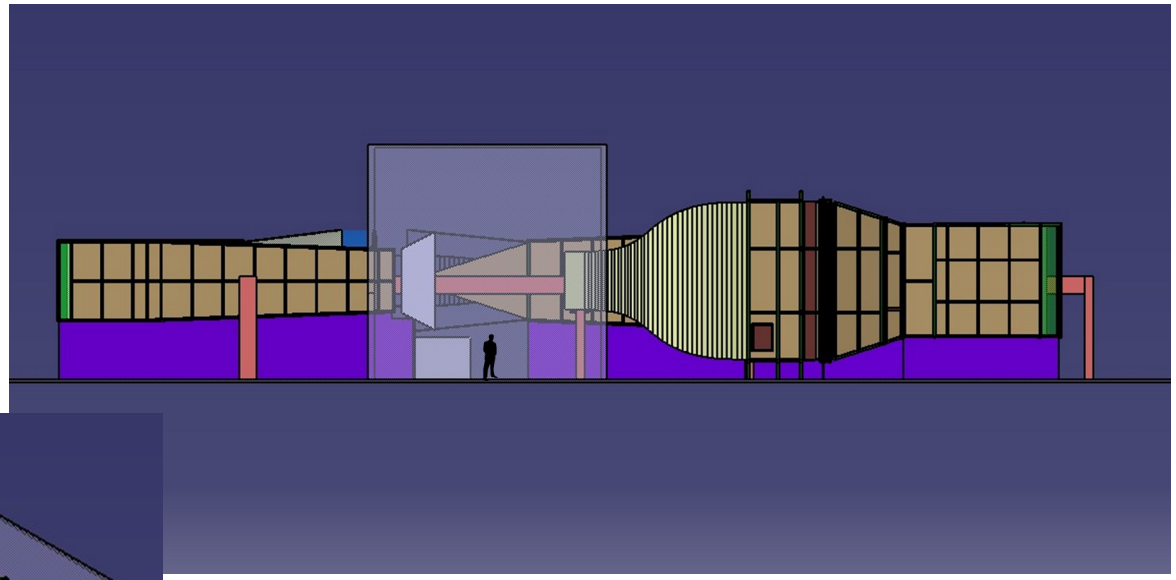
Figura 18 - WT 90, Propellers are rotated 90º to benefit from the larger dimension of the WT outlet. AoA 3 deg, V=30m/s, velocity m/sec.

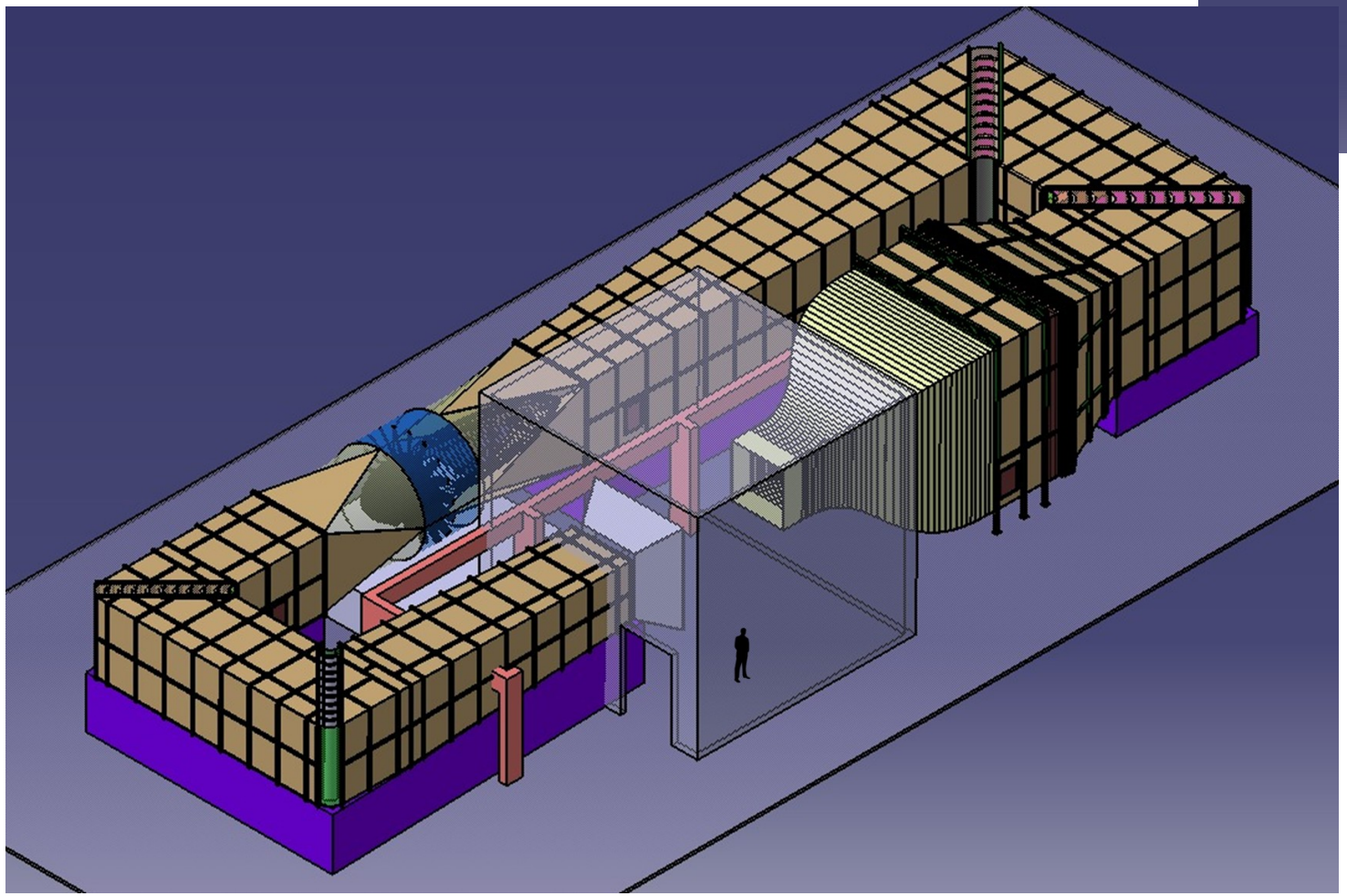

Y
X
Velocity Magnitude [m/sec]
0.0 2.0 4.0 6.0 8.0 10.0 12.0 14.0 16.0 18.0 20.0

Wind Tunnel for aeroacustics testing

2023

Type 100%
EMBRAER/EESC-USP/FIPAI





Thank You!
谢谢

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