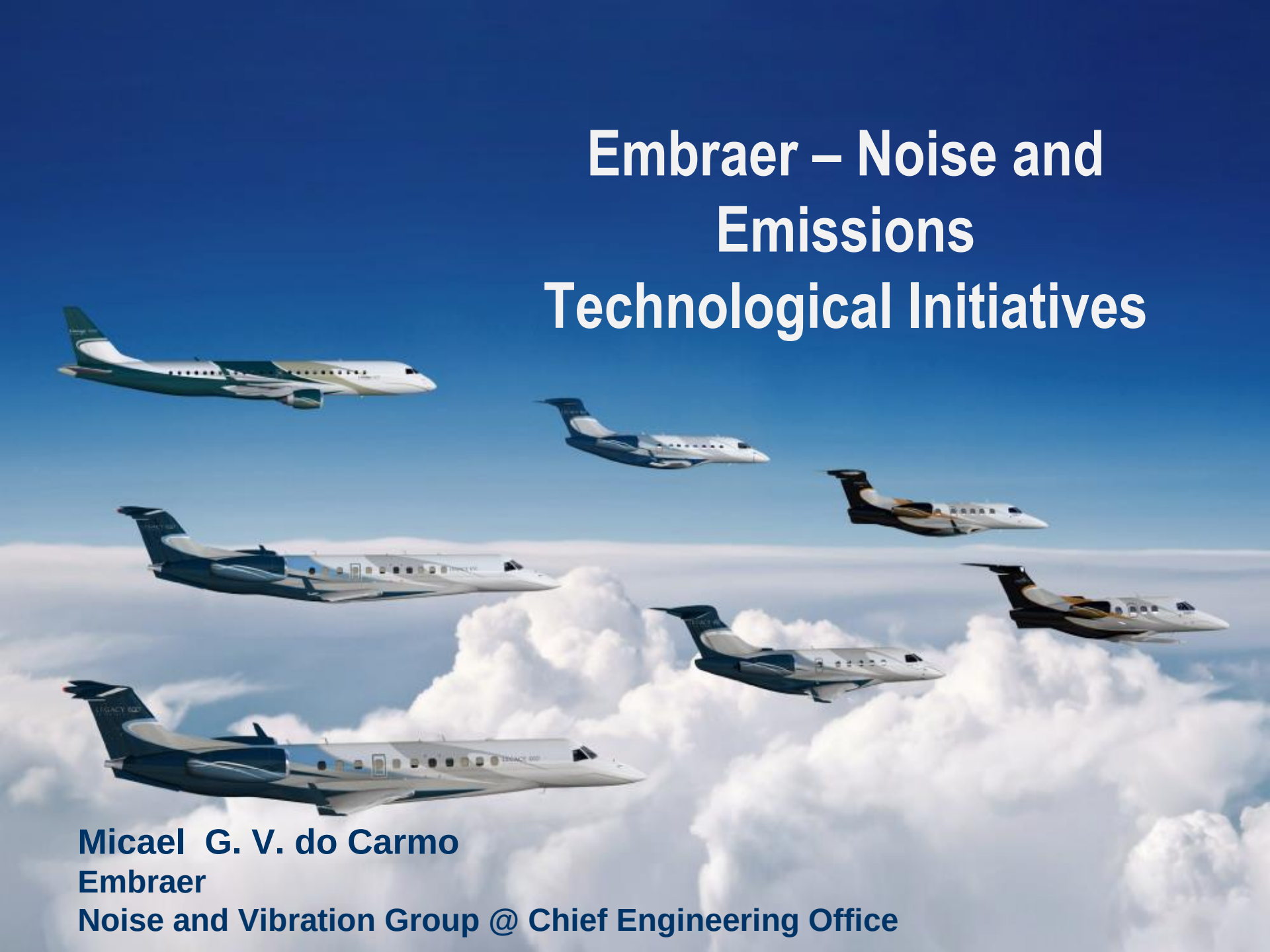
Embraer – Noise and Emissions Technological Initiatives



Micael G. V. do Carmo
Embraer
Noise and Vibration Group @ Chief Engineering Office

EMISSIONS INITIATIVES

ESTAS INFORMAÇÕES SÃO PROPRIEDADE DA EMBRAER E NÃO PODEM SER UTILIZADAS OU REPRODUZIDAS SEM AUTORIZAÇÃO ESCRITA DA EMPRESA.

4 - Pillar strategy

Flightpath to Reduce Aviation Emissions

- Technology
- Operational Practices
- Infrastructure Improvements
- Positive Economic Measures

→

- ✓ "Drop in" Biojet Fuels
- ✓ Airframe, Engine and Systems Aircraft Improvements

Source: ATAG

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Embraer EMB 202 Ipanema

The most employed agricultural aircraft in Brazil and the world's first ethanol-certified flying airplane (2004).

- Lower emissions
- 38% reduction in direct operating cost
- 80% aircraft sold and 40% fleet are ethanol powered
- Total fleet is 1200 aircraft;

BUSINESS JETS FUEL GREEN: A STEP TOWARD SUSTAINABILITY

THURSDAY, JANUARY 17, 2019
VAN NUYS AIRPORT (VNY)

OUTSTANDING INDUSTRY ENGAGEMENT

SAJF Coalition:	GAMA, NATA, NBAA, IBAC, EBAA
Fuel Suppliers:	AVFUEL, World Fuel Services
Fuel Producers:	World Energy, Gevo
FBOs:	Signature Flight Support, ABBA Aviation company; JET AVIATION, A GENERAL DYNAMICS COMPANY; Castle & Cook, Clay Lacy Aviation
OEMs:	BOMBARDIER, Gulfstream, A GENERAL DYNAMICS COMPANY, EMBRAER

HEFA Technology

Embraer E-170 Prototype Aircraft

Ground & Flight Tests – 2011

In partnership with GE Aviation

ITAKA
EU FP7 Project

Commercial flights Oslo Amsterdam
with HEFA Technology March 31st, 2016

1st Demo Flight of SIP Technology

June 19th, 2012

Azul
EMBRAER

This information ... ission.

NOISE INITIATIVES

ESTAS INFORMAÇÕES SÃO PROPRIEDADE DA EMBRAER E NÃO PODEM SER UTILIZADAS OU REPRODUZIDAS SEM AUTORIZAÇÃO ESCRITA DA EMPRESA.

ICAO/CAEP – BALANCED APPROACH

ICAO/CAEP - Balanced Approach to Aircraft Noise Management

ICAO's Balanced Approach consists of identifying the noise problem at an airport and then analyzing the various measures available to reduce the noise, using four principal elements, namely:

1- reduction of noise at source;

Monitored and evaluated through Certification Noise Levels and New Technology Insertion;

2- land-use planning and management;

Local Government policies and actions with inspection and control;

3- noise abatement operational procedures; and

Best Takeoff and Approach Procedure for each Airport and for each Aircraft, relatively low cost improvement;

4- operating restrictions.

Actions that limits or reduces aircraft access to airports. Intended to be used as a last resort.

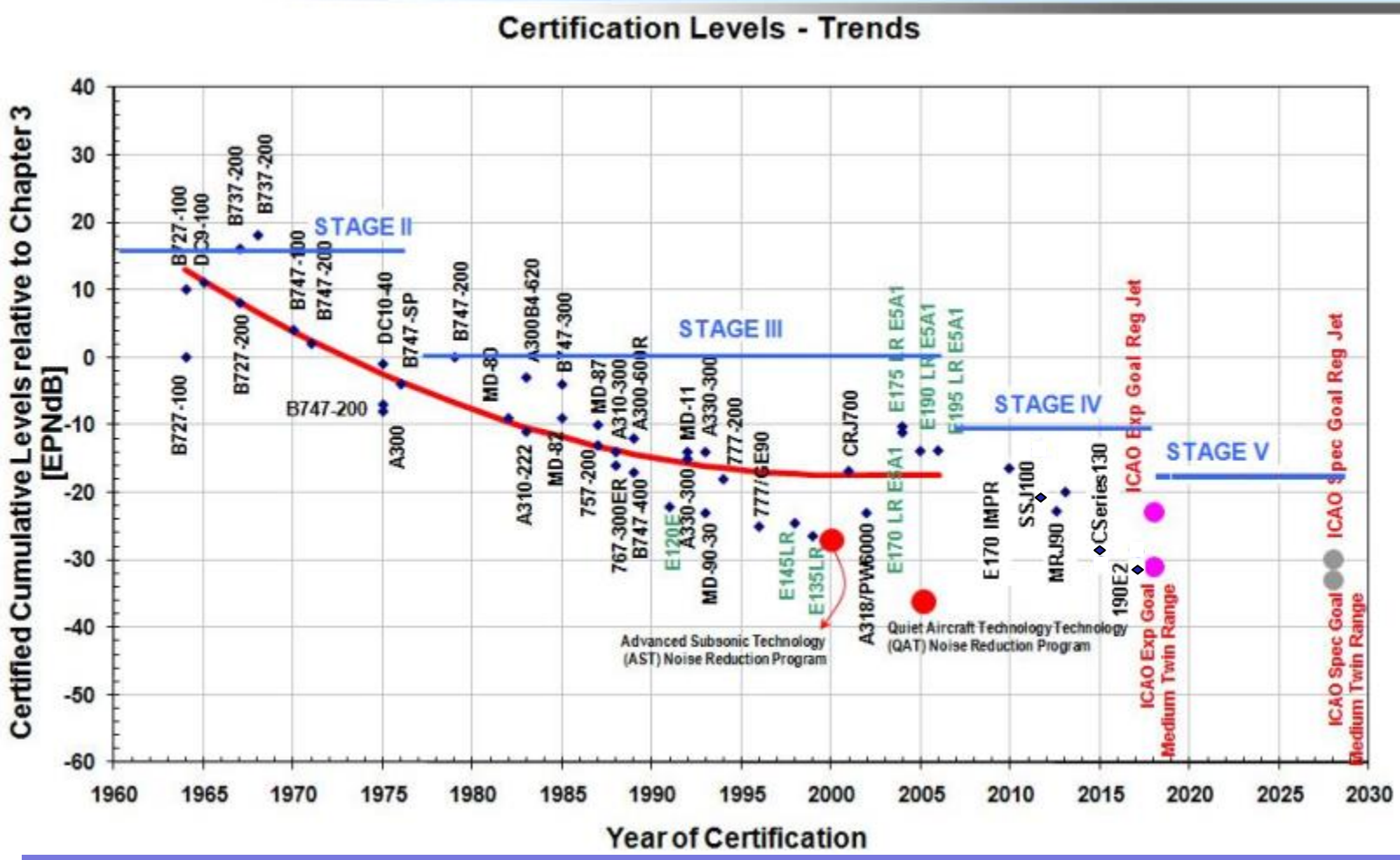
ESTAS INFORMAÇÕES SÃO PROPRIEDADE DA EMBRAER E NÃO PODEM SER UTILIZADAS OU REPRODUZIDAS SEM AUTORIZAÇÃO ESCRITA DA EMPRESA.

EXTERNAL SCENARIO ANALYSIS

- **Aircraft on development**
  - Lower External noise levels (30dB Cum Margim Stage IV);
  - Stricter Airport noise limits;
- **New Engines (higher BPR and larger diameter)**
  - Lower jet noise;
  - Installation effects of jet-pylon-flaps;
  - Lower relative area for engine acoustic treatment;
  - Fan noise source will be the most important;
- **Low Airframe Noise Solutions**
  - Increase of patents and inventions during last years
  - Higher importance of airframe noise (flaps, slats, landing gear)
  - Larger landing gear due to larger engines;
- **World Noise Projects Goals**
  - 32dB CUM Stage IV in 2015 (Ref: Single Aisle Configuration, TRL 4 a 6) – NASA ERA;
  - 42dB CUM Stage IV in 2020 (Ref: Large Twin Aisle Configuration, TRL 4 a 6) – NASA ERA;
  - 20dB CUM Reduction in 2020 – ACARE - X-Noise;
  - 3-5dB Airframe Noise Reduction (Ref. 2000 Technologies - EJets) – X-Noise – Valiant;

ESTAS INFORMAÇÕES SÃO PROPRIEDADE DA EMBRAER E NÃO PODEM SER UTILIZADAS OU REPRODUZIDAS SEM AUTORIZAÇÃO ESCRITA DA EMPRESA.

CERTIFICATION NOISE LEVELS EVOLUTION



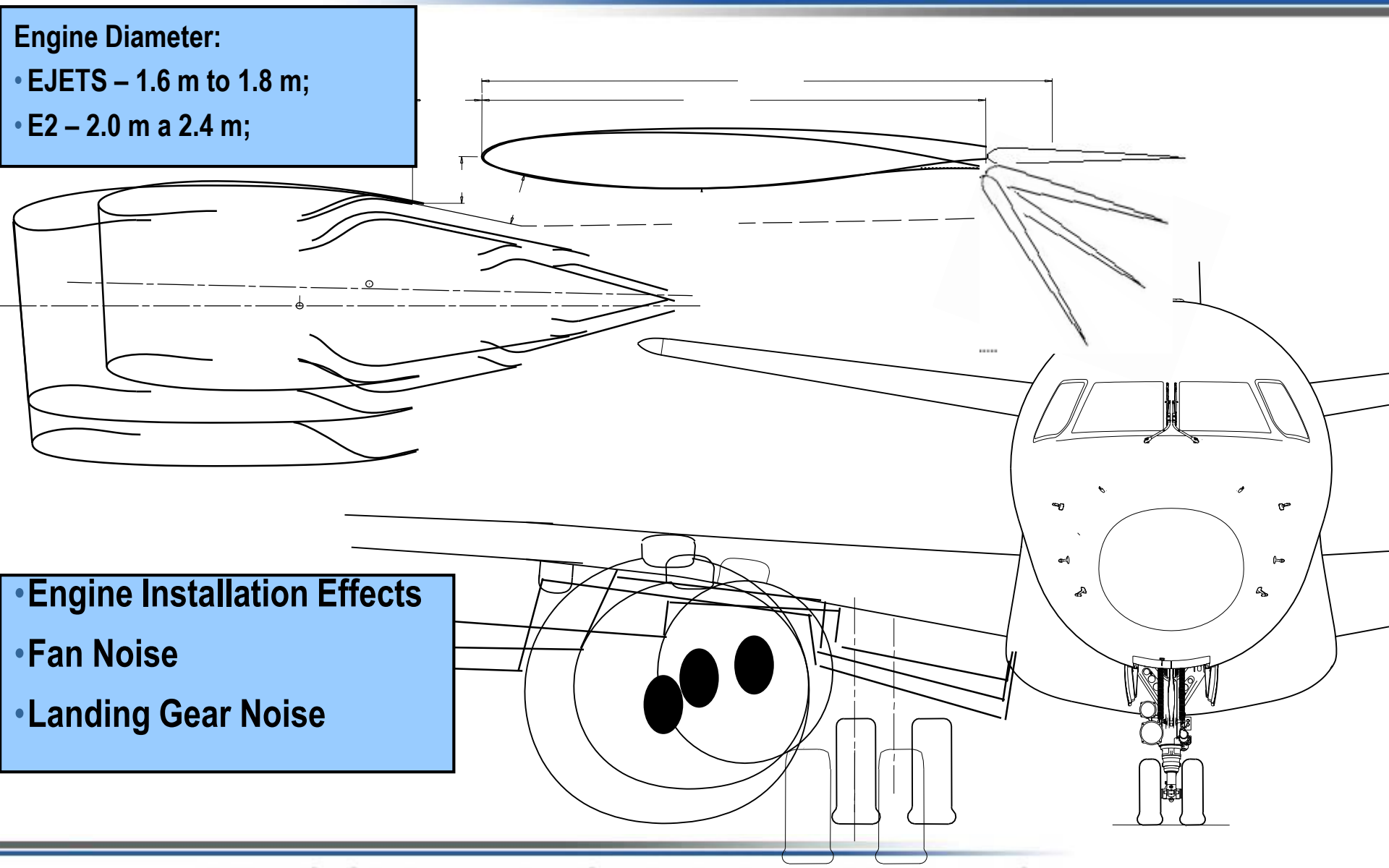
New Technologies have been produced significant noise reductions at noise source.

ESTAS INFORMAÇÕES SÃO PROPRIEDADE DA EMBRAER E NÃO PODEM SER UTILIZADAS OU REPRODUZIDAS SEM AUTORIZAÇÃO ESCRITA DA EMPRESA.

NEW ENGINES - TRENDS

Engine Diameter:

- **EJETS – 1.6 m to 1.8 m;**
- **E2 – 2.0 m a 2.4 m;**

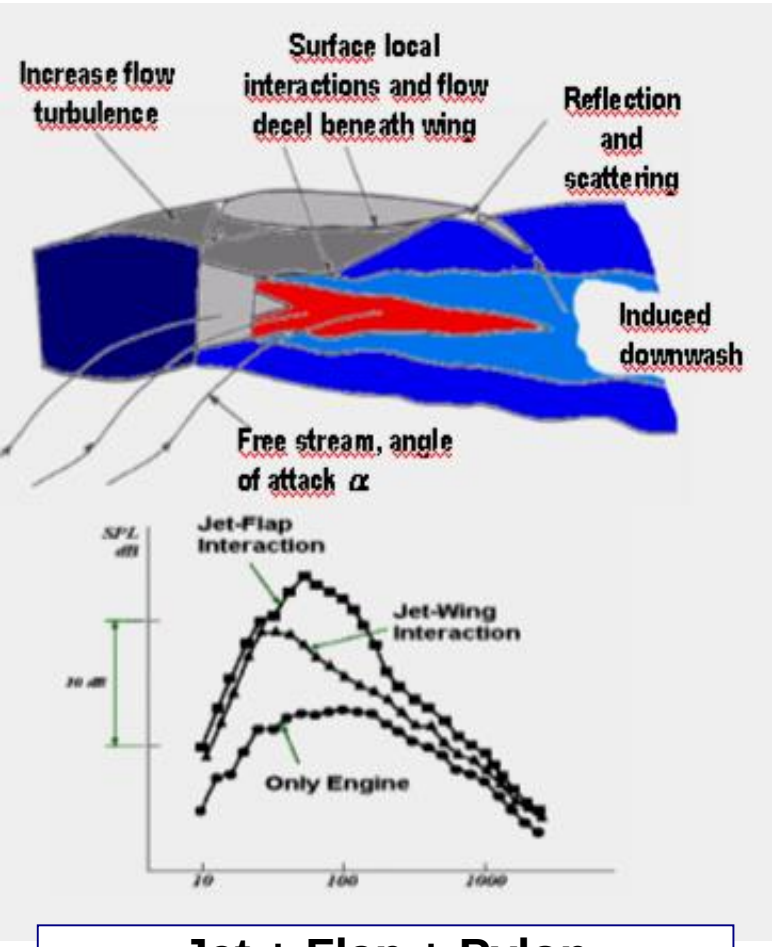


- **Engine Installation Effects**
- **Fan Noise**
- **Landing Gear Noise**

ESTAS INFORMAÇÕES SÃO PROPRIEDADE DA EMBRAER E NÃO PODEM SER UTILIZADAS OU REPRODUZIDAS SEM AUTORIZAÇÃO ESCRITA DA EMPRESA.

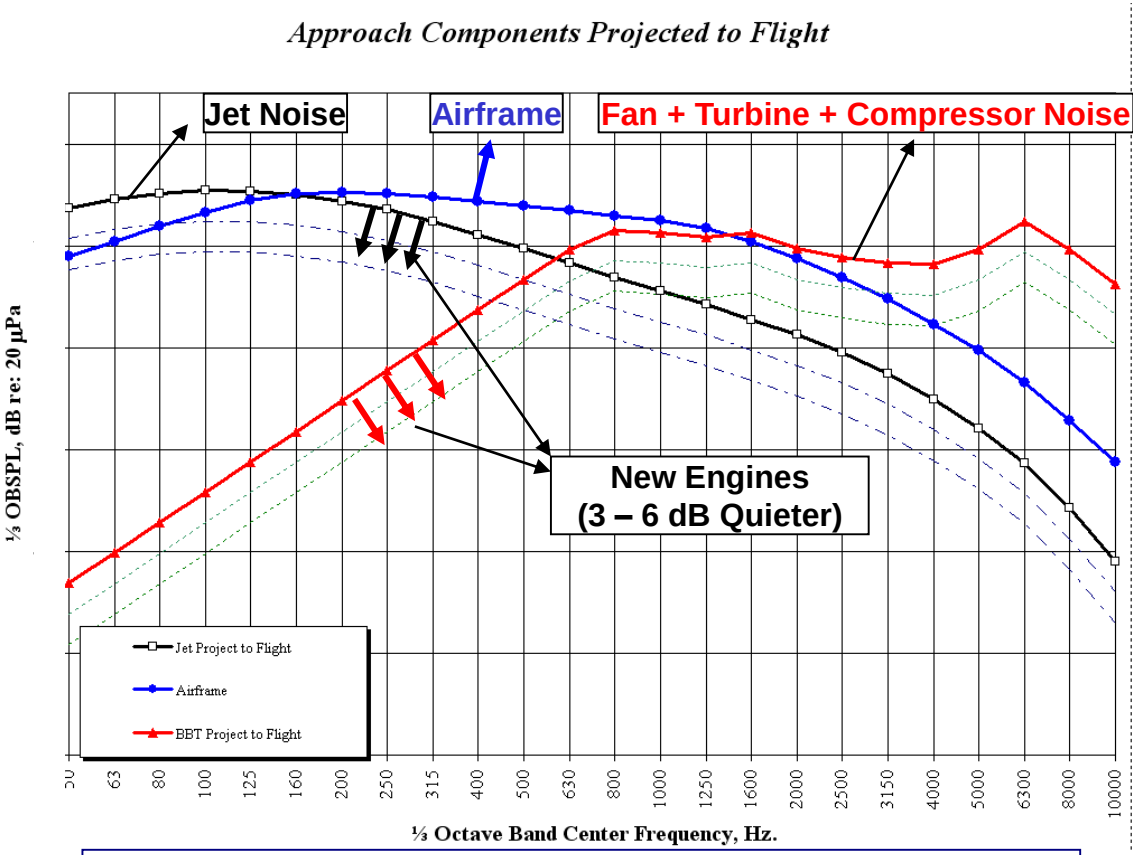
AIRCRAFT NOISE TRENDS

- Engine Installation



Jet + Flap + Pylon

Airframe Noise



Airframe noise will be the dominant noise source in approach conditions

ESTAS INFORMAÇÕES SÃO PROPRIEDADE DA EMBRAER E NÃO PODEM SER UTILIZADAS OU REPRODUZIDAS SEM AUTORIZAÇÃO ESCRITA DA EMPRESA.

“Brick by Brick” – Embraer Noise Road Map

2019

2015

2012

2008

2003

SILENCE

Excelence in Low Noise Development and Certification

Propulsion Noise Models and Engine Installation Solutions

Low Noise High Lift Design and Portfolio

Flight Projection Techniques

Integrated Analysis & Proof of Concepts

Brazilian Silent Aircraft 2 & 3

Propulsion Noise Studies

High Lift Noise Studies

Model Improvements and Solutions

Brazilian Silent Aircraft

Aeroacoustic Flight Tests

Aeroacoustic WT Tests

Basic CAA Development

Aeroacoustic Simulations and Testing

External Noise 1 & 2

Development of Noise Tests

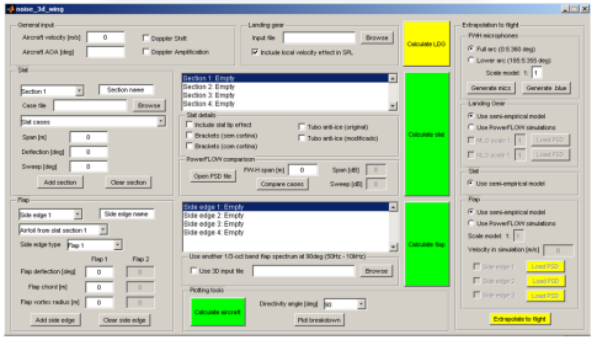
Test Data Processing Tools

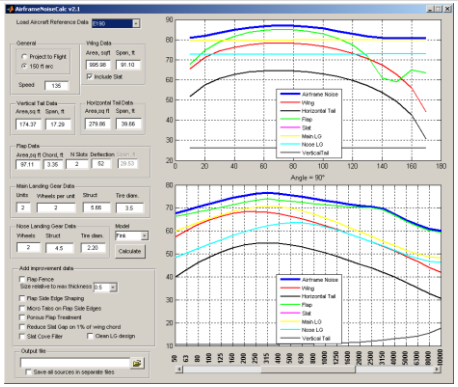
Basic Noise Prediction Tools

Engineering Basis and Certification

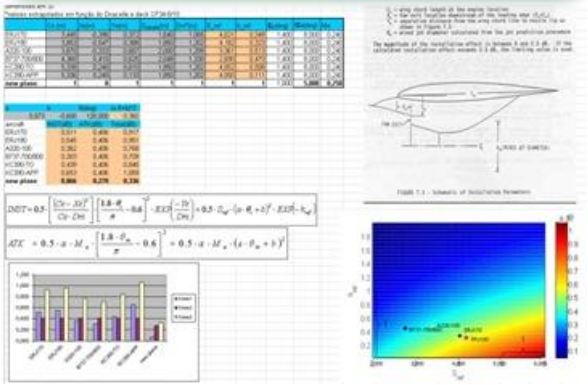
Low Cost Design Tools

Airframe Noise

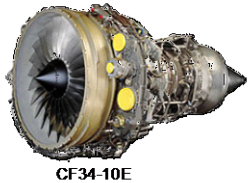




Engine Installation Effects



In-flight Engine Noise



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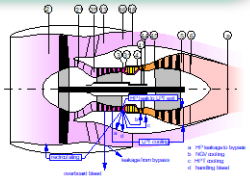
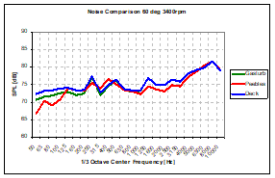
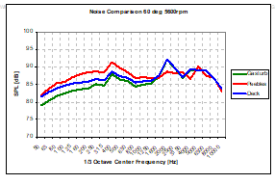
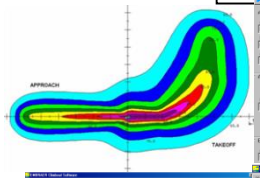


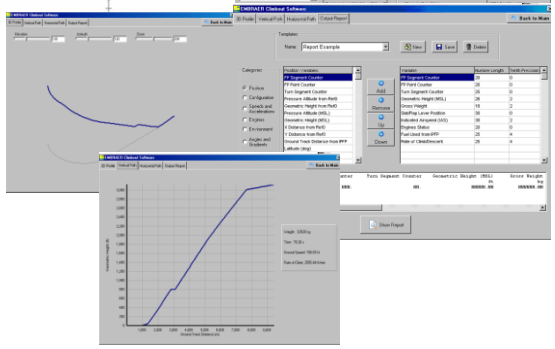
GasTurb Simulation





Operational Noise





ESTAS INFORMAÇÕES SÃO PROPRIEDADE DA EMBRAER E NÃO PODEM SER UTILIZADAS OU REPRODUZIDAS SEM AUTORIZAÇÃO ESCRITA DA EMPRESA.

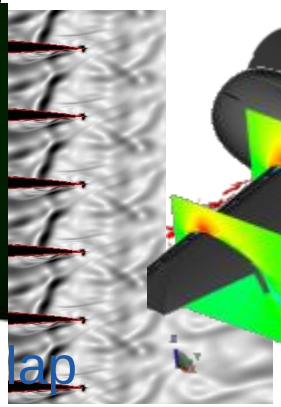
Real Geometry Cases Studies
Intermediate Cases – Simplified Real Geometries

EMBRAER

Silent Aircraft Initiative – FASE II

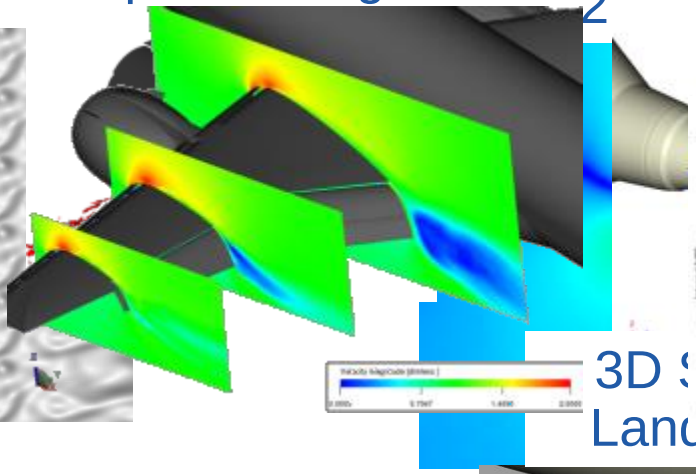
Complete Landing Gear

Slat + Gear Fan Cascade



Flap Side Edge

Wind Tunnel x Flight 2



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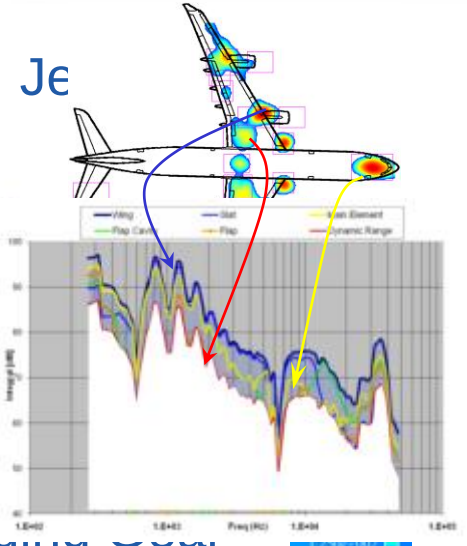
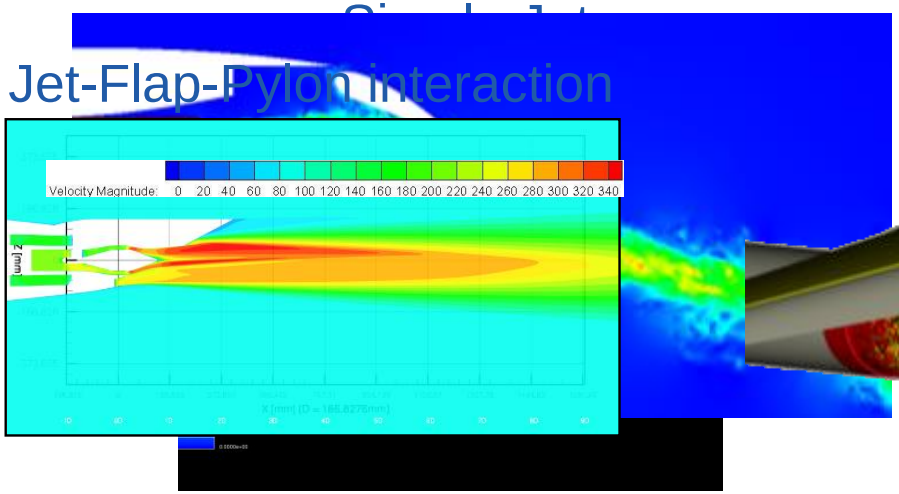


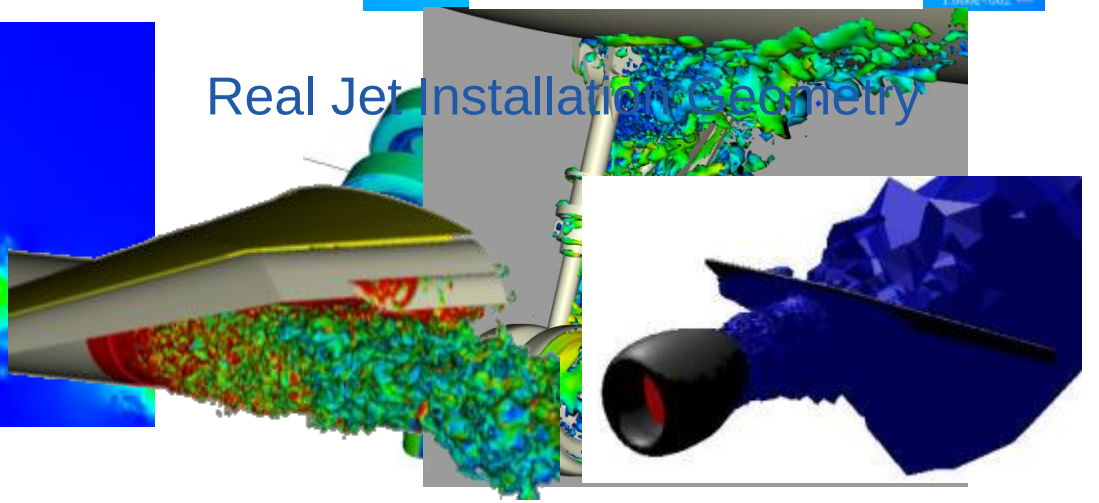
3D S

Landing Gear

Jet-Flap-Pylon interaction



Real Jet Installation Geometry



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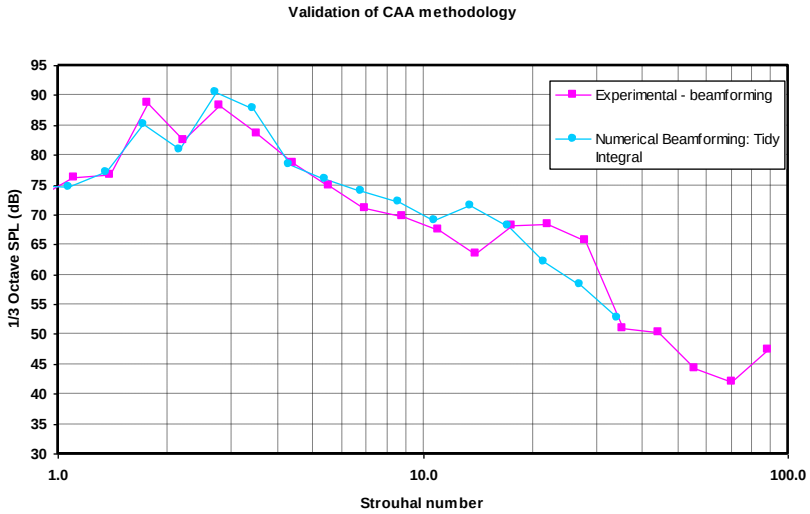
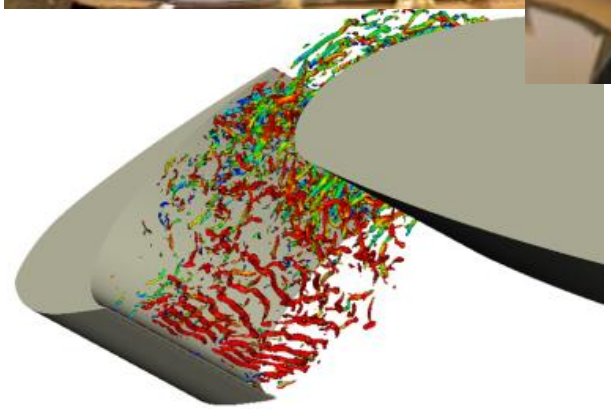
AIRFRAME NOISE METHODOLOGIES

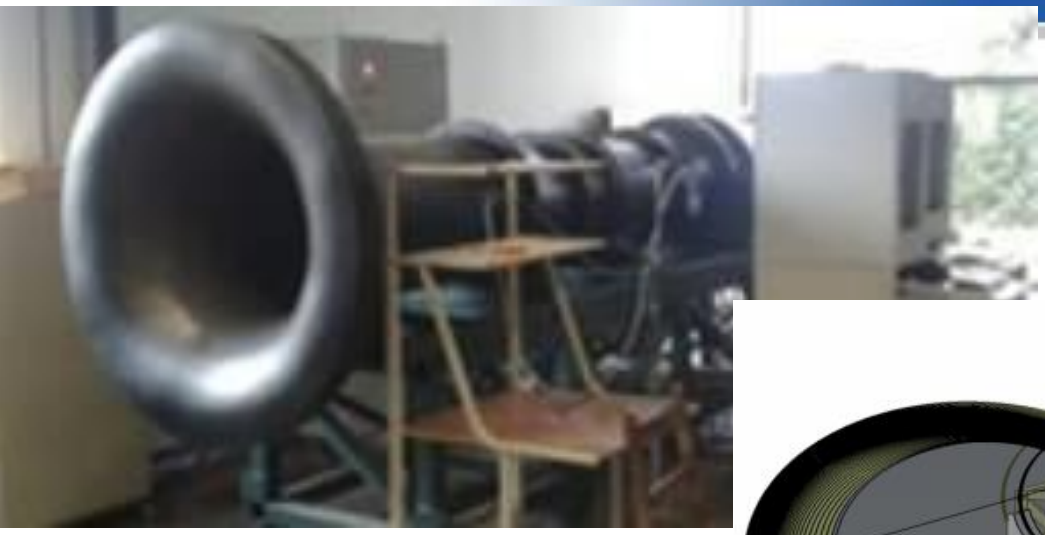


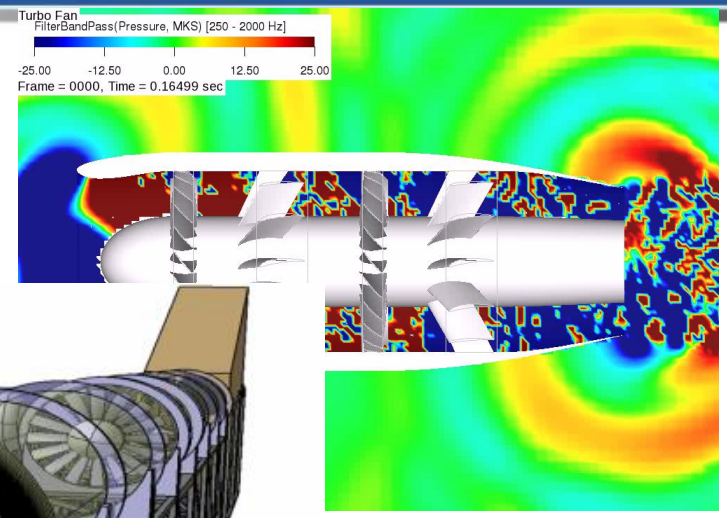


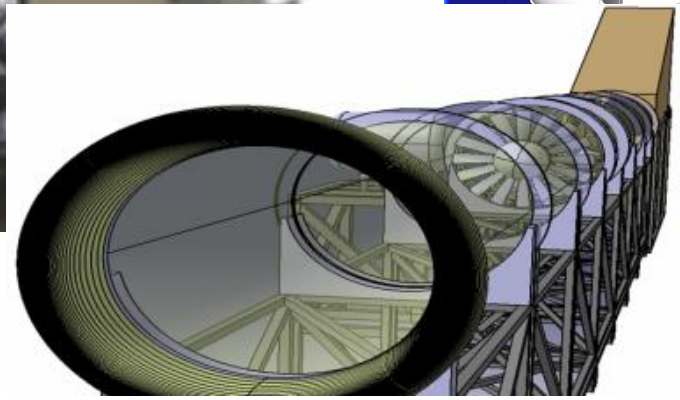
‘Quiet’ Slat Cuts Noise In Boeing-Embraer E170 EcoDemonstrator

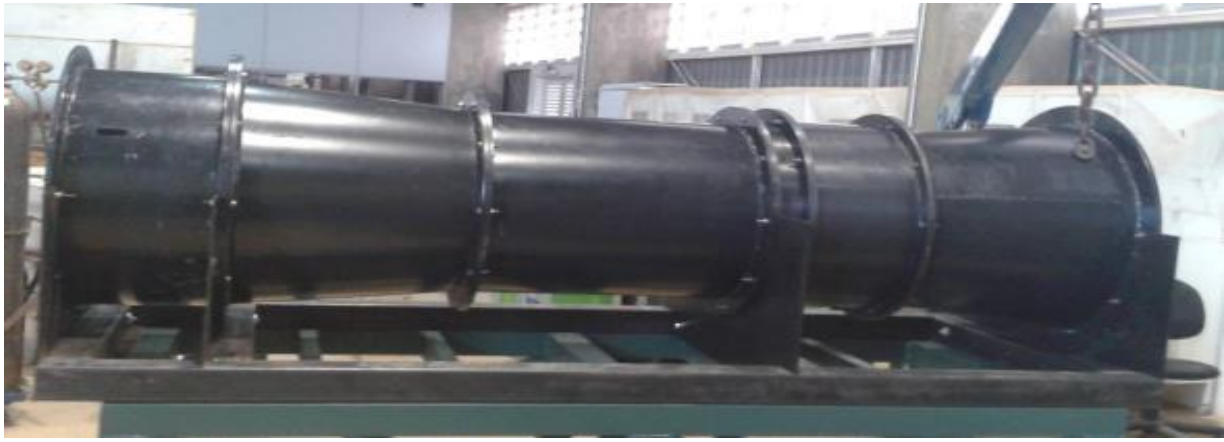
Guy Norris | *Aviation Week & Space Technology* *Jan 24, 2017*

FAN NOISE METHODOLOGIES





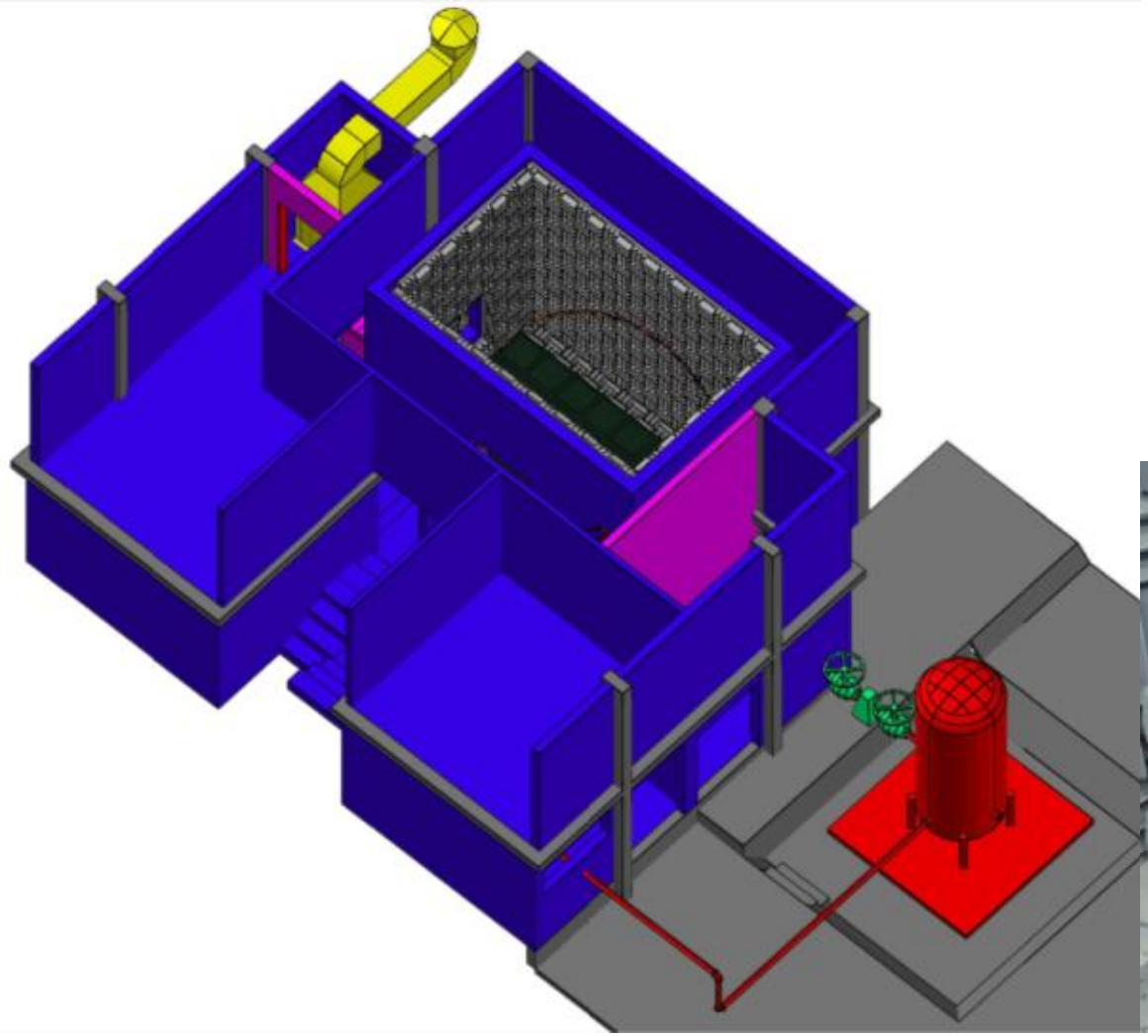




- Fan Rig development, construction and testing, for fan noise R&D

ESTAS INFORMAÇÕES SÃO PROPRIEDADE DA EMBRAER E NÃO PODEM SER UTILIZADAS OU REPRODUZIDAS SEM AUTORIZAÇÃO ESCRITA DA EMPRESA.

JET NOISE METHODOLOGIES



- Single cold jets
- Mach 0.4 - 0.9
- Dj 25 - 50 mm
- No flight stream
- Different nozzle configurations

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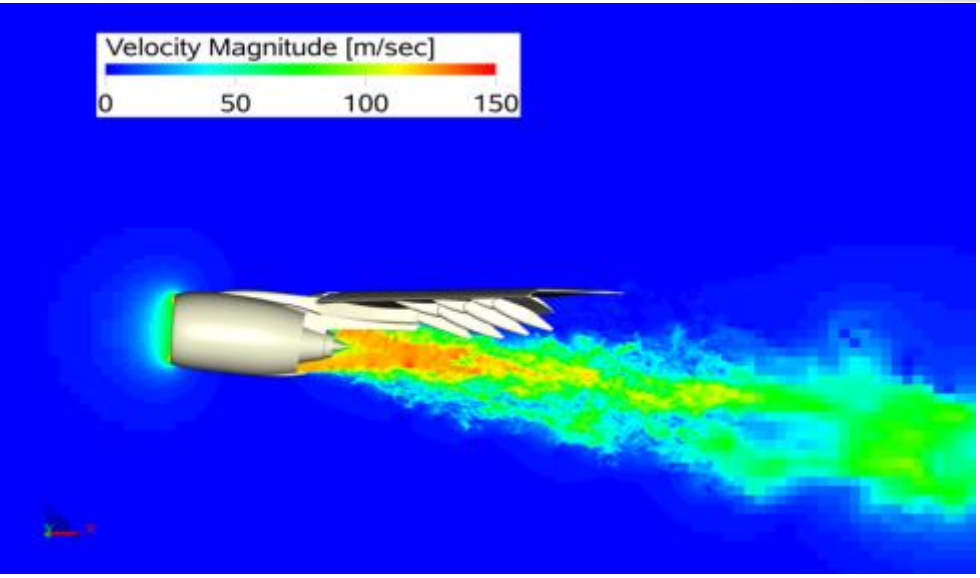
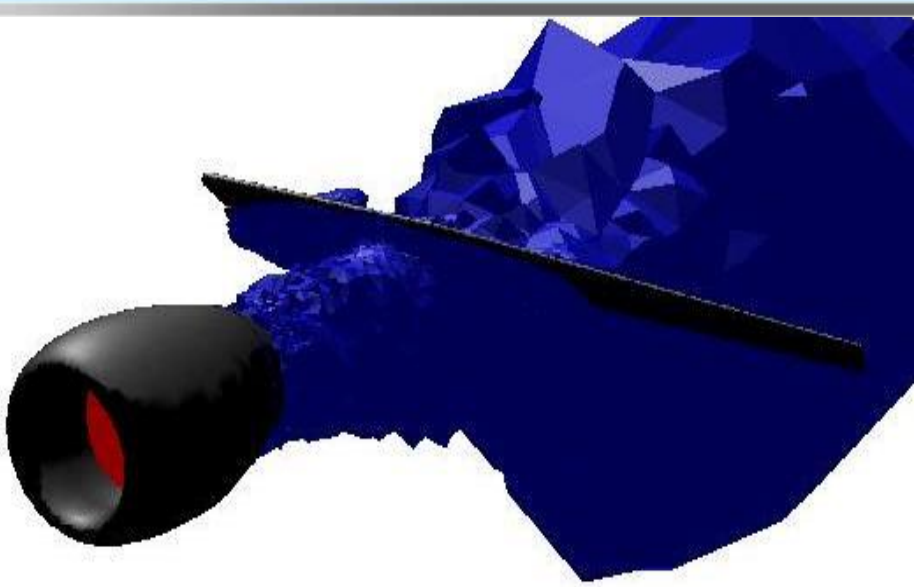
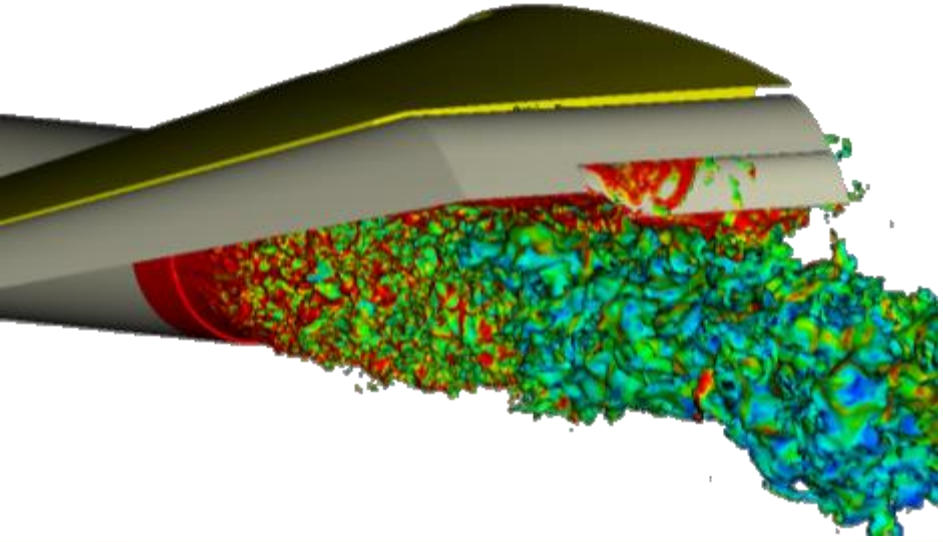
JET NOISE INSTALLATION

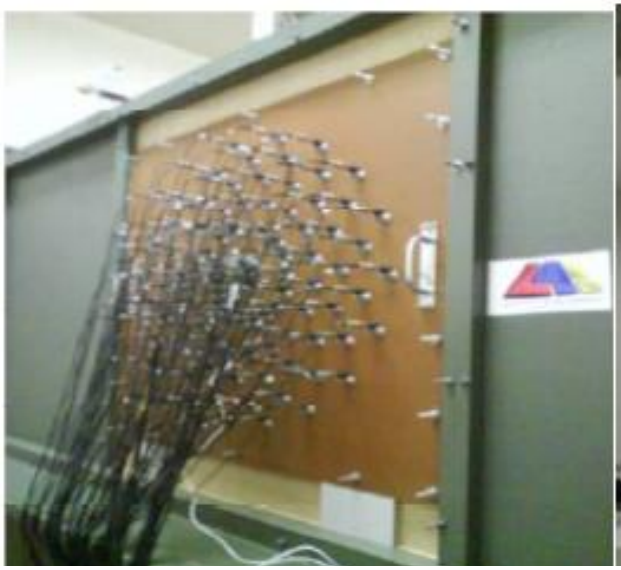






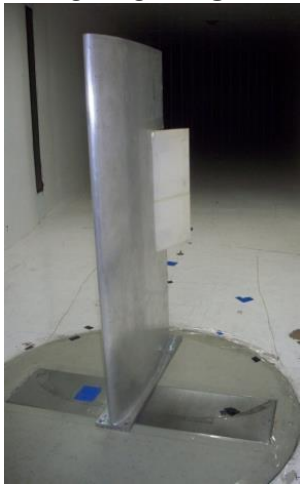
ESTAS INFORMAÇÕES SÃO PROPRIEDADE DA EMBRAER E NÃO PODEM SER UTILIZADAS OU REPRODUZIDAS SEM AUTORIZAÇÃO ESCRITA DA EMPRESA.

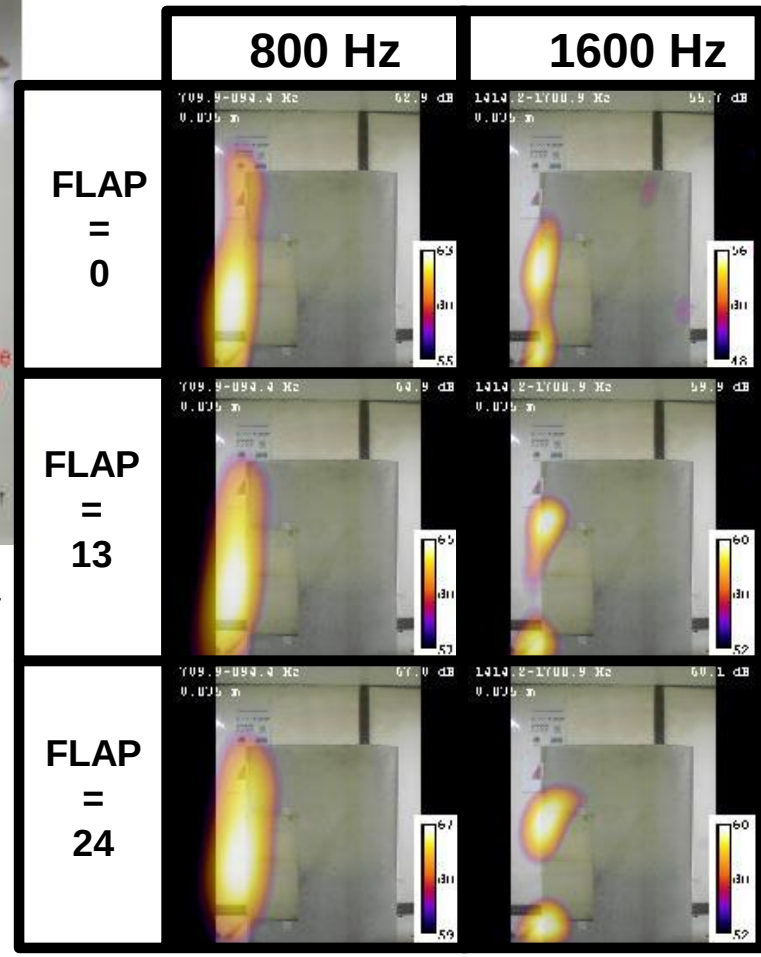
AEROACOUSTIC WIND TUNNEL TESTS



External and Internal View of the Wind Tunnel Antenna

Microphone Clamp





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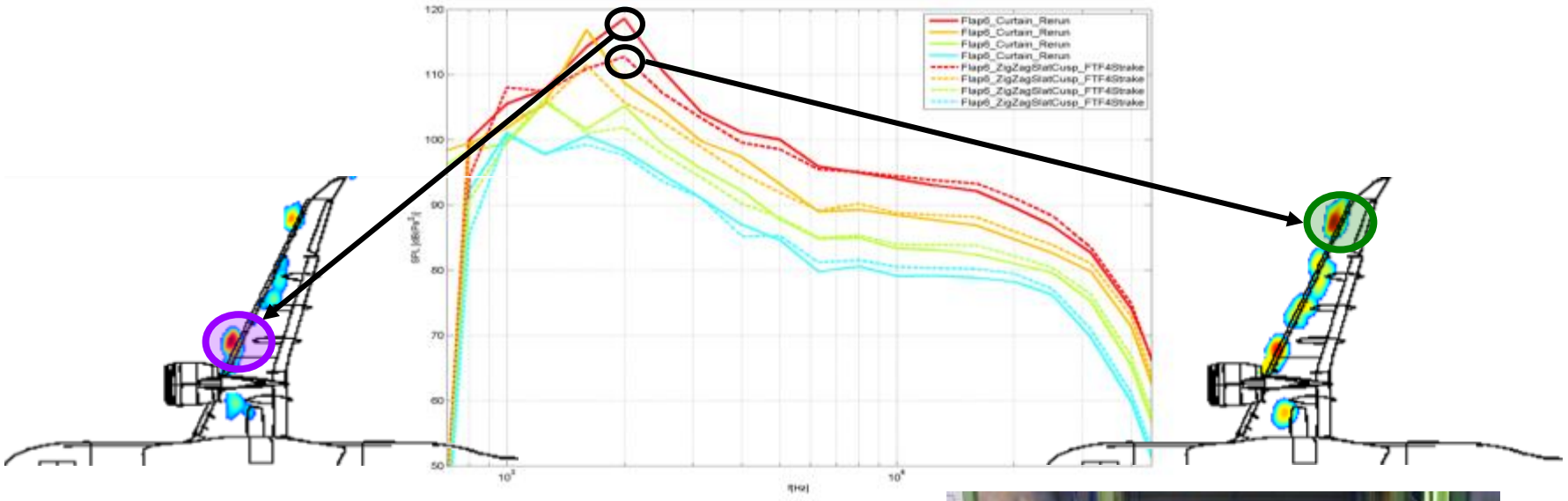
AEROACOUSTIC WIND TUNNEL TESTS



• Characterization and Development of Airframe Noise Improvements through Aeroacoustic Wind Tunnel and Flight Tests.

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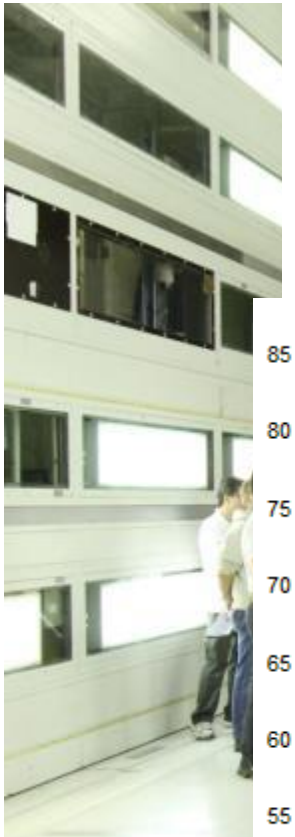
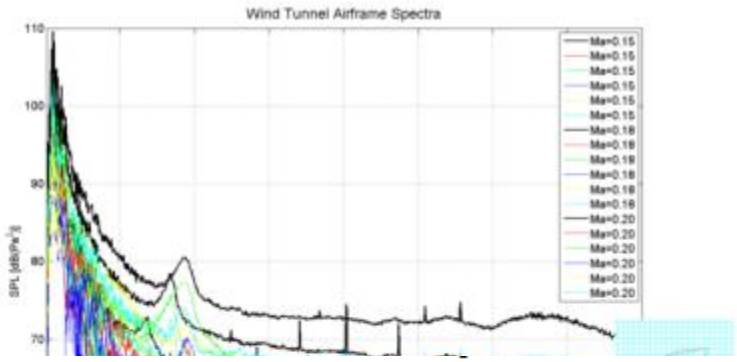
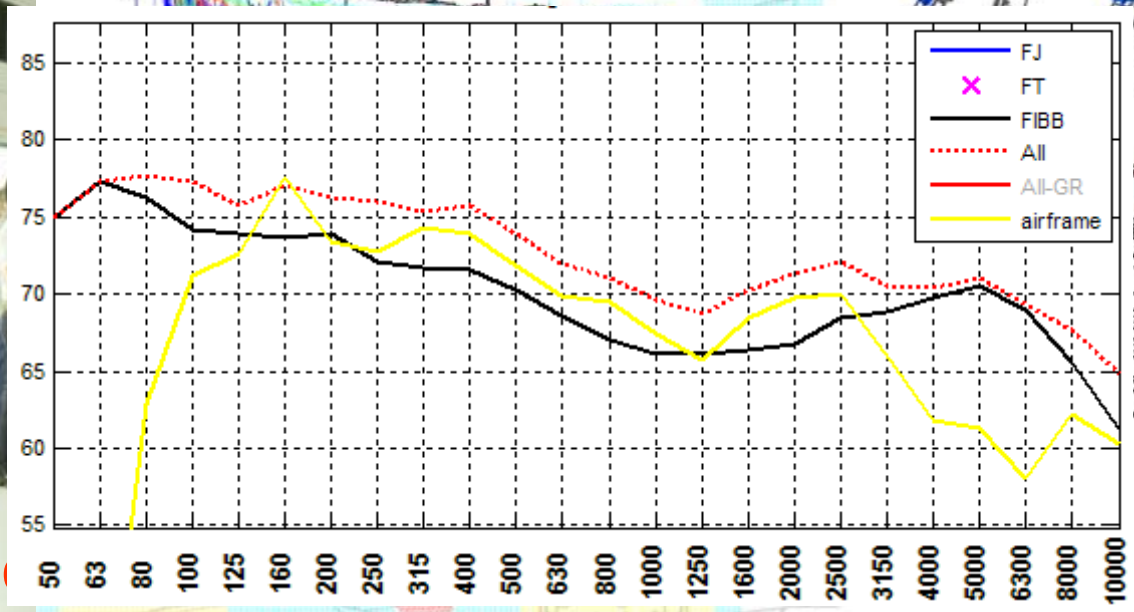
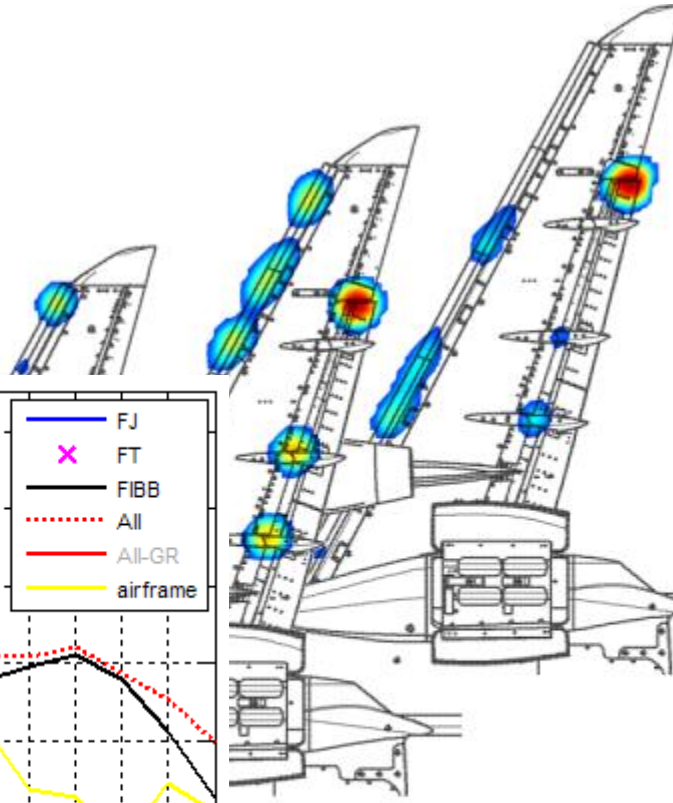
AEROACOUSTIC WIND TUNNEL TESTS





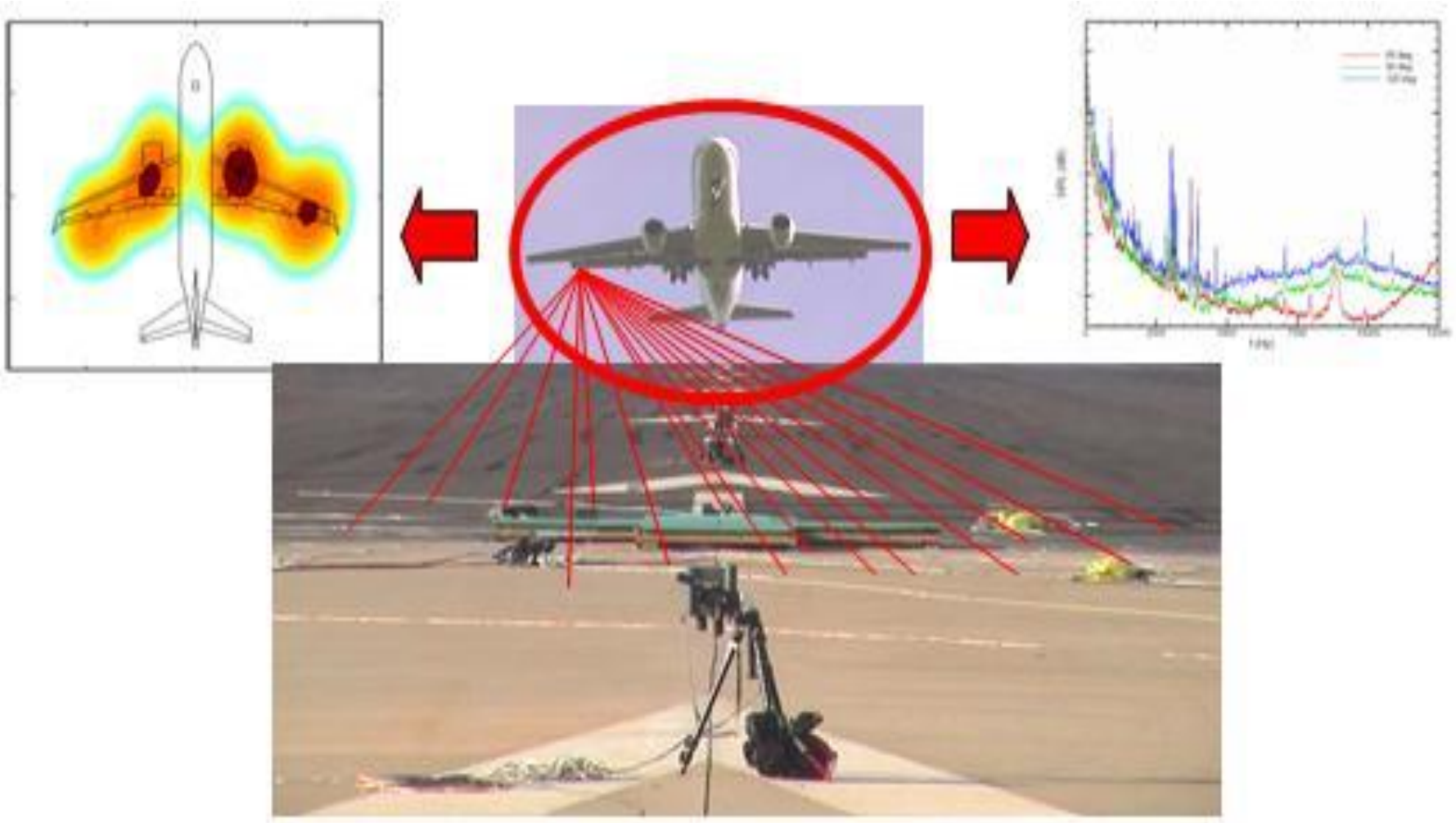




60 degre
array

ESTAS INFORMAÇÕES SÃO PROPRIEDADE DA EMBRAER E NÃO PODEM SER UTILIZADAS OU REPRODUZIDAS SEM AUTORIZAÇÃO ESCRITA DA EMPRESA.

BEAMFORMING FLIGHT TESTS

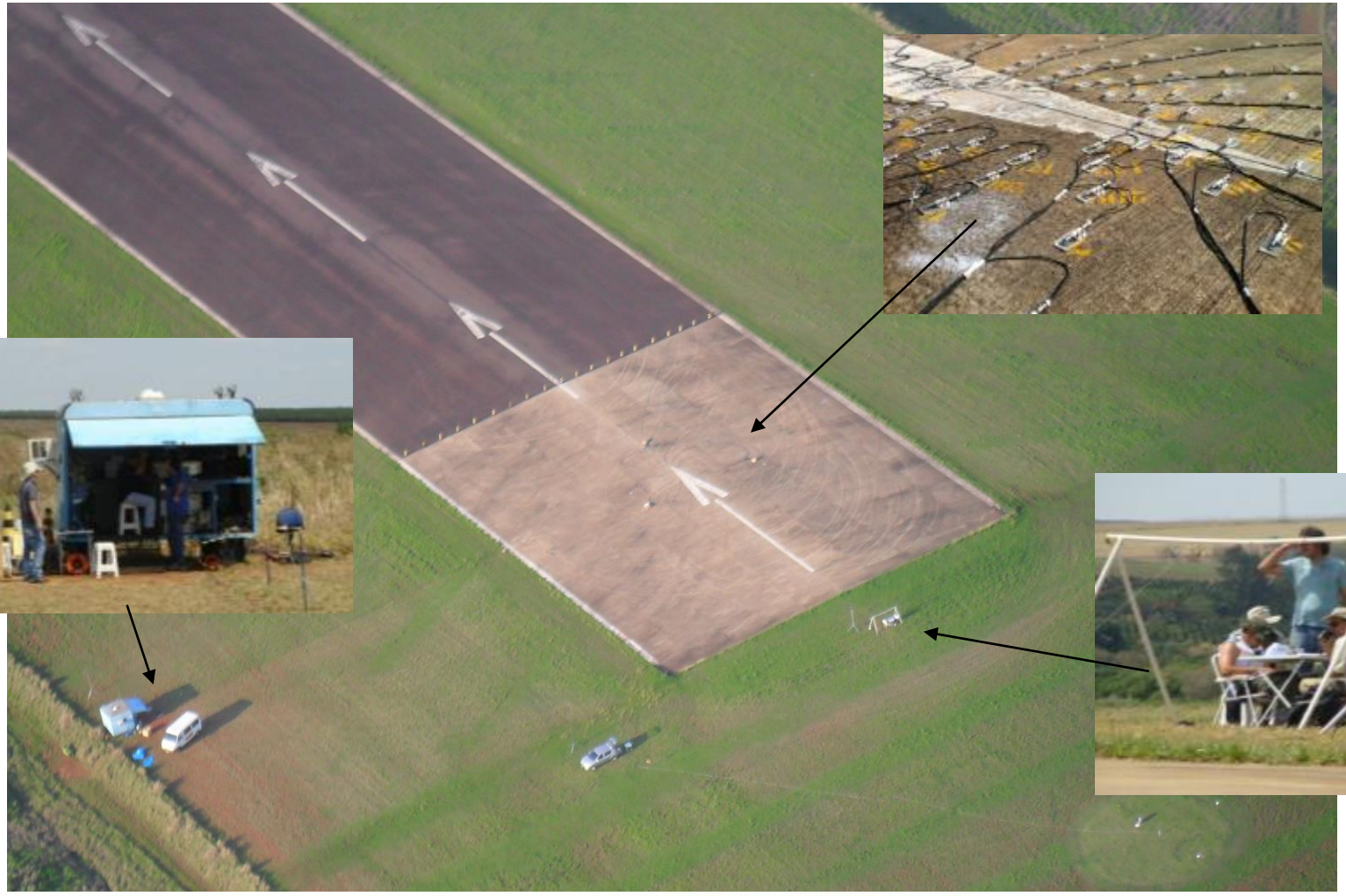


Noise Source Identification Flight Tests

ESTAS INFORMAÇÕES SÃO PROPRIEDADE DA EMBRAER E NÃO PODEM SER UTILIZADAS OU REPRODUZIDAS SEM AUTORIZAÇÃO ESCRITA DA EMPRESA.

BEAMFORMING FLIGHT TESTS

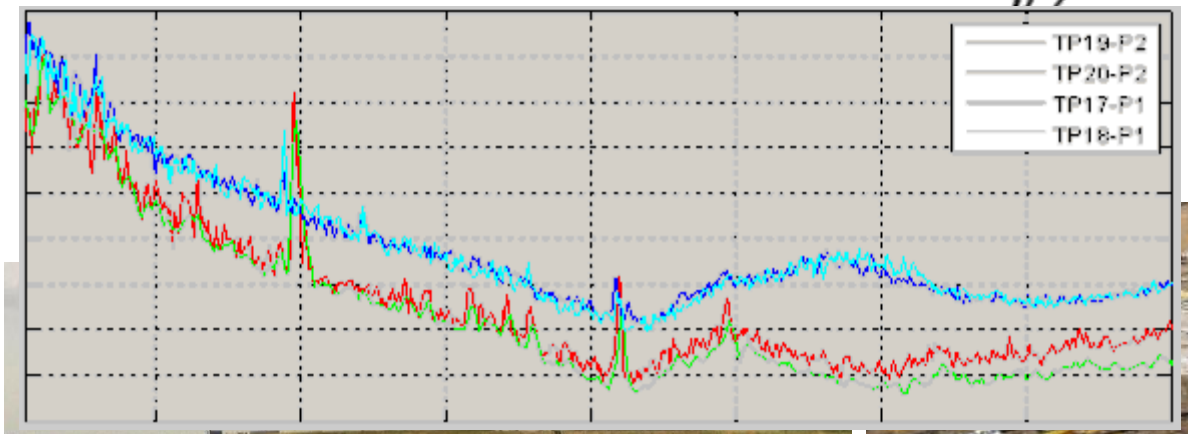
FLIGHT TESTS AT EMBRAER – GPX TEST SITE

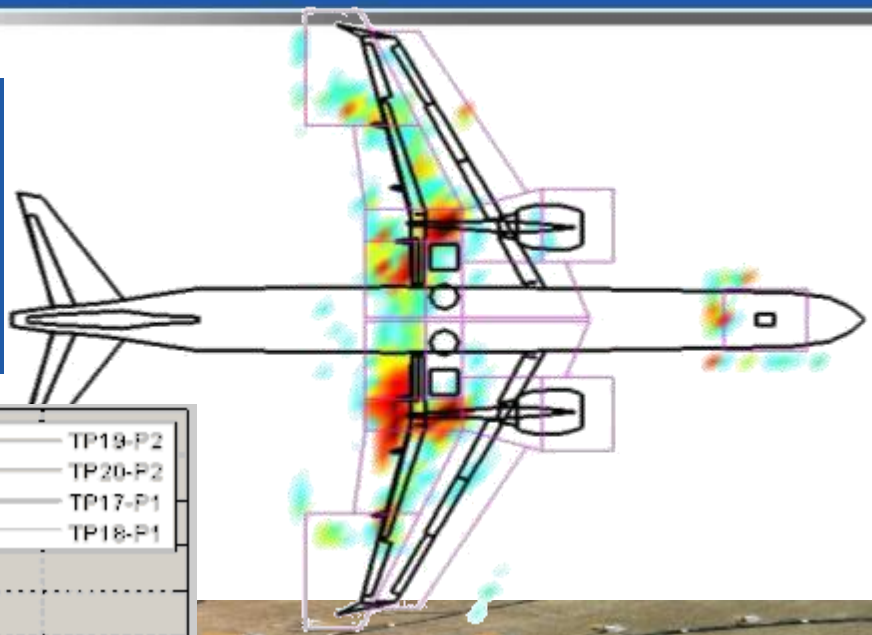


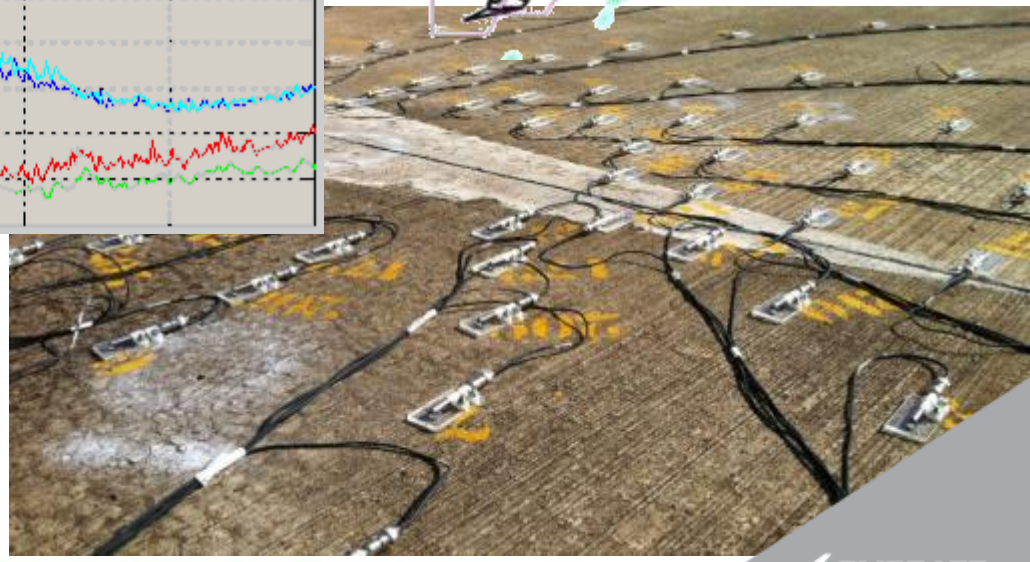
ESTAS INFORMAÇÕES SÃO PROPRIEDADE DA EMBRAER E NÃO PODEM SER UTILIZADAS OU REPRODUZIDAS SEM AUTORIZAÇÃO ESCRITA DA EMPRESA.

BEAMFORMING FLIGHT TESTS

- On flight Beamforming testing methodology for source identification and quantification implemented and fully tested







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Thank you!