Multi-sensor applications in aircraft technology
Embraer experience

Helio Librantz – July 2016
Section One | Who are we?
WE HAVE DEVELOPED OUR BUSINESS IN THE AREAS OF:

COMMERCIAL AVIATION

EXECUTIVE AVIATION

EMBRAER DEFENSE AND SECURITY
Commercial Aircraft

EMB 110 Bandeirante

EMB120 Brasilia

ERJ 170 /190
Defense Aircraft

EMB 312 Tucano

ALX and SIVAM EMB145 AEW&C / RS

AMX

KC 390
Timeline

1946
Brazil launches a national strategic aerospace initiative via the Aeronautics Technical Center (CTA) and the Technological Institute of Aeronautics (ITA).

1969
Federal Government creates Embraer to develop aeronautical engineering and manufacture aircraft in Brazil.

1994
Embraer is privatized, fusing technological and industry expertise with an entrepreneurial approach.

2015
Embraer is one of the world’s leading manufacturers of commercial and executive jets, with substantial and growing operations in defense and security.
WHERE WE OPERATE

USA
Nashville
Fort Lauderdale
Melbourne
Mesa
Windsor Locks
Jacksonville

BRAZIL
São José dos Campos
Gavião Peixoto
Botucatu
Taubaté
Brasília
Belo Horizonte
São Paulo
Rio de Janeiro
Sorocaba
Campinas

NETHERLANDS
Amsterdam

IRELAND
Dublin

PORTUGAL
Évora
Alverca - OGMA

UNITED KINGDOM
Farnborough

FRANCE
Villepinte
Le Bourget

UAE
Dubai

CHINA
Beijing
Harbin – HEAI

SINGAPORE
Singapore

IRELAND
Dublin

NETHERLANDS
Amsterdam

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UAE
Dubai

CHINA
Beijing
Harbin – HEAI

SINGAPORE
Singapore

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DIVERSITY IS WEALTH

MORE THAN 19,000 EMPLOYEES FROM OVER 20 COUNTRIES

MORE THAN 2,300 EMPLOYEES IN JOINT VENTURES AND AFFILIATES
Multi-sensors Applications in Aircraft Tecnologies

- Embraer has a long history of sensor arrays and multichannel signal processing applications to its products with very positive results.
- There is a wide range of technologies which employ multi-sensors as the basis of the product concept
- Some examples are:
  - Defense products
  - Navigation systems
  - Tools for Aeroelastic Certification of Aircraft
  - Maintenance Optimization Means
Defense aircraft

Integration of multi-sensor systems in defense aircraft for armed forces of several countries:

- AEW (Airborne Early Warning)
- Surveillance aircraft
- Maritime patrol
- SIGINT (Signal Intelligence)
- Ground attack aircraft

Multi-sensor system applications include

- AESA (Airborne Electronic Scanning Array) Radar
- IFF (Identify Foe or Friend) Interrogator
- RWR, ESM (Electronic Support Measures), SIGINT
- MAWS (Missile Approach Warning Systems)
- Commint (Communication Intelligence)
- Interferometric SAR (Synthetic Aperture Radar)
- ECM (Electronic Counter Measures) and more

Including data fusion from different sensors in many cases
Defense aircraft

ISR Family  FAB - Brazilian Air Force
Defense aircraft

EMB145AEW&C – IAF Indian Air Force

EMB145 Multi Intel – FAB R99
Defense aircraft

EMB145MP and EMB145AEW&C – “FAM” Mexico Air Force
Defense aircraft

EMB145AEW&C – HAF Helenic Air Force
Defense aircraft

KC-390 Military Transport
Section Two | Defense ground systems
Defense ground systems

C4I2SR Systems

- C4I2SR: Command, Control, Communications, Computers, Intelligence, Information, Surveillance and Reconnaissance

- C4I2SR System increases the situation awareness and support commander decision.

- NATO definition: “Integrated System of doctrine, procedures, structured organizational structures, personnel, equipment, facilities, communications, intelligence, and identification designed to support commander’s exercise of command and control across the range of military operations.”
Defense ground systems

C4I2SR Systems

- Data Fusion
- Image Intelligence
- Cyber Security
- Modeling & Simulation
- Communications
- Distributed Systems
Defense ground systems

Ground Surveillance: Radar and Cameras

- Radar for early warning, target detection and classification
- Day and Night Cameras for target description
- Radar detects crawling and walking man and vehicles
- Radar points the cameras to target
- Cameras describe target with high resolution and powerful zoom
- Radar and camera can be locally and remotely operated
- Integrated with a powerful visualization unit
Defense ground systems

Air-Traffic Control: Saber M200

- Multi-Mission AESA Radar
- 20 feet ISO Container format
- Multi-Tasking and Parallel Radar Architecture
- 258 independent radars
- More than 4000 T/R modules.

It operates simultaneously as:
- Long Range Primary Radar
- Long Range Secondary Radar
- Precision Approach Radar
- Meteorological Radar
- Defense Radar
- Fire-control radar
Defense ground systems

Airborne Radar: BradarSAR

- X band Radar;
- P band Radar;
- Visual Camera;
- Infrared Camera;
- X/P band InSAR and D-InSAR.

It operates for:
- Cartography 1:5.000 – 1:50.000
- Deforestation monitoring
- Illegal settlement monitoring
- Erosion monitoring
- Land Slide monitoring
- *MTI: detection, classification and description

*Moving Target Indicator

X/P band BradarSAR radar image with 1 m resolution
Navigation Systems

FMS (Flight Management System)

The primary function of the FMS is to supply high-accuracy lateral and vertical navigation from any point in the world, to any other point in the world.

To accomplish this function, the FMS navigation computer must interface with a variety of short and long-range sensors, although the sensors themselves are not part of the FMS.

- AHRS / IRS
- VHF
- SATCOM
- CMU
- FMS (Flight Management System)
- ADC
- VOR / ILS
- DME
- GPS
- VHF SATCOM

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Aeroelastic model validation

Aerodynamics and Loads

PREDICTED

Wind tunnel

Aerodynamic Models: Tunnel + **CFD

CFD

Theoretical design loads

FLIGHT TEST (EXPERIMENTAL LOADS):

Calibration

Strain gage instrumentation

Flight Test

Measured in-flight loads

Comparison

**Computational Fluid Dynamics
Aeroelastic model validation

Ground Vibration Test (GVT)

Scope:
- Identification of natural frequencies, damping and mode shapes of the aircraft structure and control surfaces
- Identification of rotational frequencies of the control surfaces
- Identification of flutter vanes structural modes
- Verification of the flight control system influence on the aircraft structural modes

Structural Modes Identification
- MIMO Concept
- ~250 accelerometers
- Up to 6 shakers
Aeroelastic Validation

Flutter Flight Test (FFT)

Scope:
• Verification in flight of the aeroelastic stability of the aircraft
• Comparison of frequency and damping evolution with aeroelastic model
• Verification of dynamic pressure and compressibility effects
• Verification of automatic pilot, FBW, and yaw damper effects on the aircraft stability

- Excitation System Applies Known Input;
- Instrumentation System Measures Airframe Response;
- Data System Generates Transfer Functions;
- Modal Frequency and Damping Estimated;
- Flutter Velocity Predicted by Extrapolation.
Section Six | Maintenance applications
Maintenance applications

SHM (Structural Health Monitoring)

**Management**
Involves the use of detection, monitoring and assessment results combined with information about available resources to plan fleet utilization or maintenance activities.

**Assessment**
Involves the use of detection and monitoring results along with design information and structural properties to determine the current structural status and generate, if required, instructions associated to maintenance.

**Monitoring**
Involves maintaining regular surveillance over factors that can lead to or indicate structural faults

**Detection**
Involves finding with pre-defined quality the existence, type, location and/or extent of structural faults (FD, ED or AD) such as crack.

SAE/ARP 6461: Published in Sep/19/2013
Maintenance applications

SHM – Damage Detection Systems
Maintenance applications

SHM Damage Detection Technologies considered by Embraer

- Acoustic Emission (AE)
- Electro-Mechanical Impedance (EMI)
- Fiber Bragg Gratings (FBG)
- Comparative Vacuum Monitoring (CVM)
- Lamb Waves (LW)
- Meandering Winding Magnetometer (MWM)
Maintenance applications

SHM - Applications
Maintenance applications

PHM – Proof of Concept

Partners:

Hydraulic Pump

Brake Control Valve

APU

Azul Linhas Aéreas Brasileiras

Virgin Blue

Copa Airlines
Maintenance applications

PHM (Prognostics and Health Monitoring) Concept

1. On board sensors and recorder
2. Data transmission infrastructure
3. Central PHM databases
4. Automatic Data processing
5. Web Interfaces

Visibility of on-board systems condition over aircraft operational life

Equipment health indexes

Schedule maintenance, Order parts, Prepare staff

Perform Maintenance avoiding service interruption

Processed data
Raw data

Internet
Maintenance applications

PHM – New technologies for IVHM (Integrated Vehicle Health Monitoring)

- MEMS/Digital Sensors;
- Wireless Sensors/Energy Harvesting
- Integrated Wireless Data transfer and Power Generation
- Multifunctional materials (Structures and Sensing)
- High-temperature sensors/electronics
- RFID
- Noncontact sensing
- Fiber optics
- Embedded Sensors
- Deposited Sensors
- Self-Aware and Self-Calibrating Sensors
- Self-reacting and Self-Repairing Components
Overview of future applications

IVHM

- Integrated Vehicle Health Management (IVHM) is the transformation of system data on a complex vehicle or system into information to support operational decisions and optimize maintenance (Cranfield/Boeing IVHM Centre).
Overview of future applications

IVHM – Major role in the evolution to Smart Integration in aviation

Digital Aircraft
Air/Ground and Ground/Air data flow

Sensors, recording, diagnosing & connectivity

In flight – limited
On ground – broad band

Operations
Maintenance
Parts and Logistics

Value added to several Customer processes

Value returned to Customer Supply Chain

Data Management
Processing Tools

Heavy processing & info handling performed on Embraer provided infrastructure

Integrated Fleet Management Center

Customer awareness of fleet health and most recommended actions

Embraer Engineering

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Thank you!