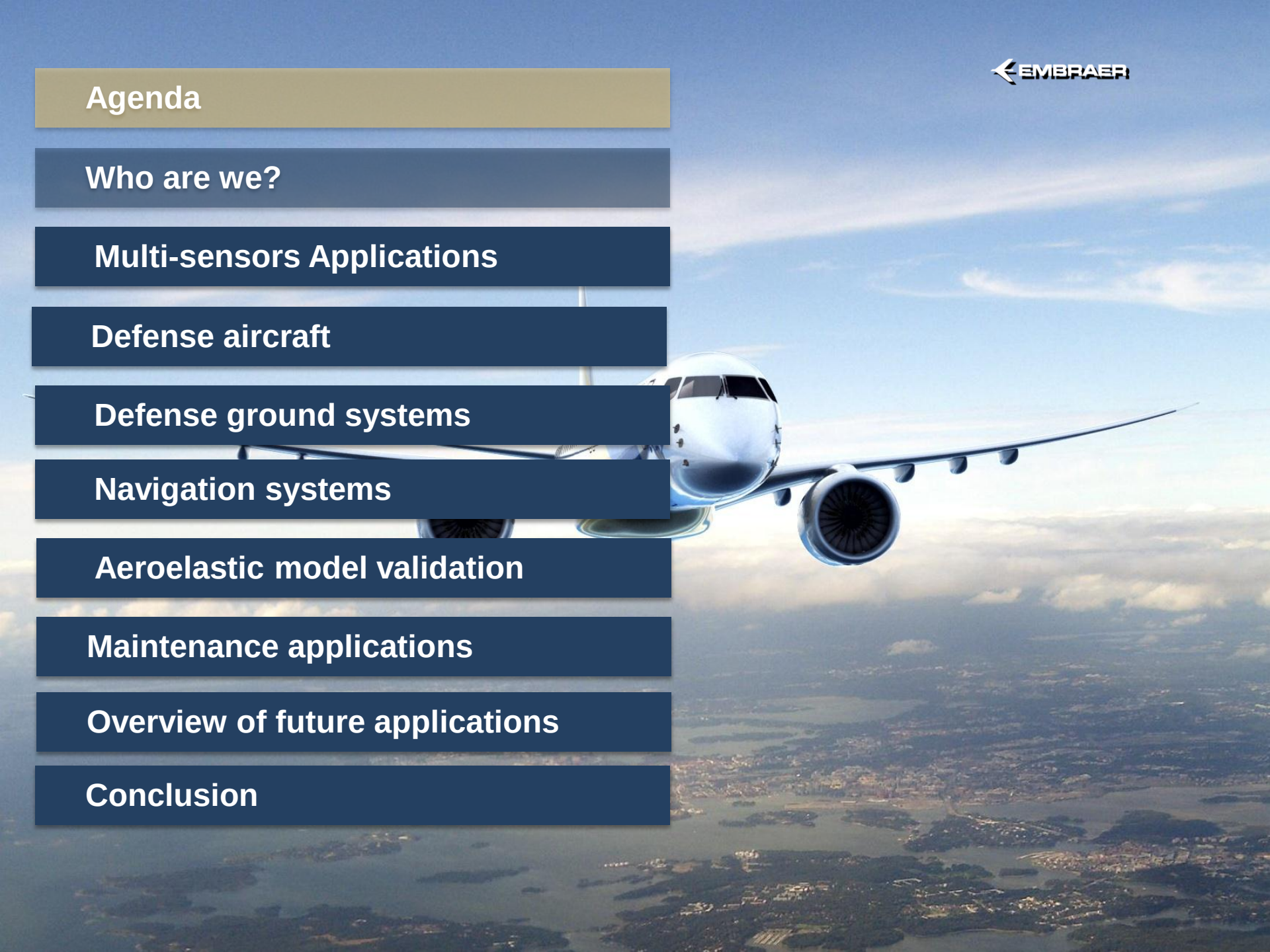
The Ninth IEEE Sensor Array and Multichannel Signal Processing Workshop

Multi-sensor applications in aircraft technology
Embraer experience

Helio Librantz – July 2016



Agenda

- Who are we?
- Multi-sensors Applications
- Defense aircraft
- Defense ground systems
- Navigation systems
- Aeroelastic model validation
- Maintenance applications
- Overview of future applications
- Conclusion

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


EMBRAER
Executive Jets

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

JOINT VENTURES & AFFILIATES

DIVERSITY IS WEALTH

MORE THAN **19,000** EMPLOYEES FROM OVER **20** COUNTRIES

MORE THAN **2,300** EMPLOYEES IN JOINT VENTURES AND AFFILIATES

Section Two | Multi-Sensors Applications

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

Section Two | Defense Aircraft

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

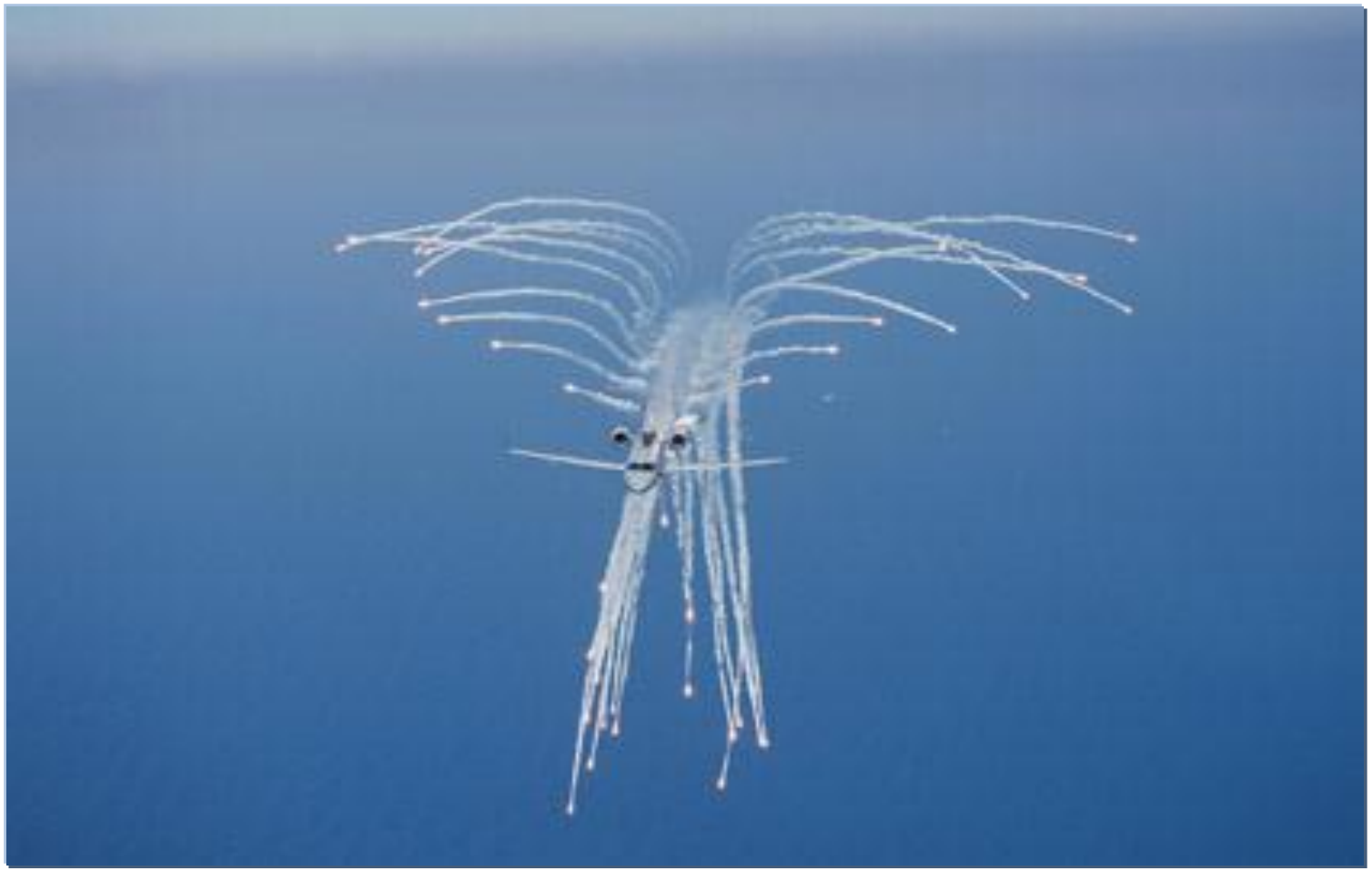
EMB145 Multi Intel – FAB R99

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

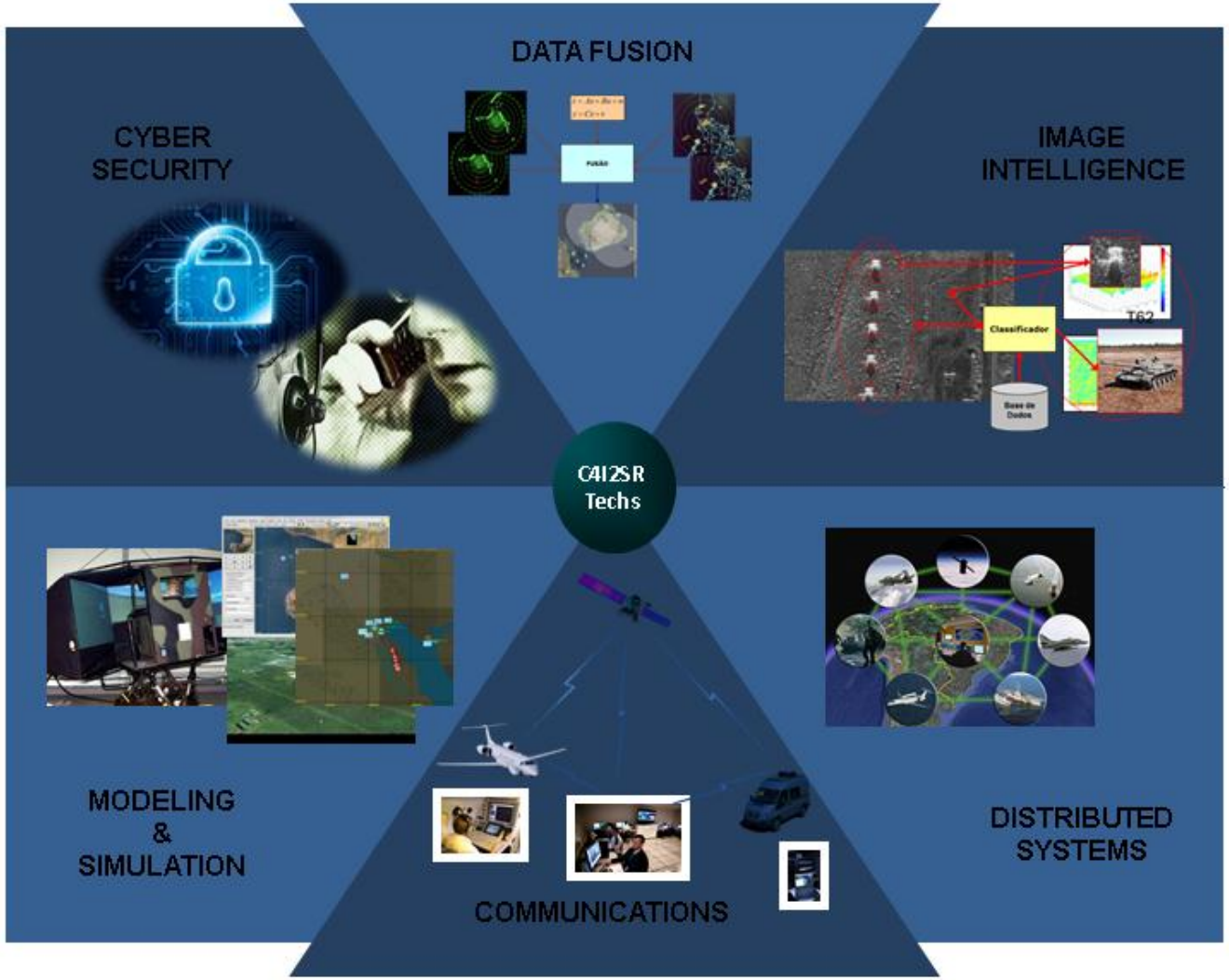
Defense ground systems

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



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

Transportable Radar far from Cameras

Radar and Cameras integrated at tower

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

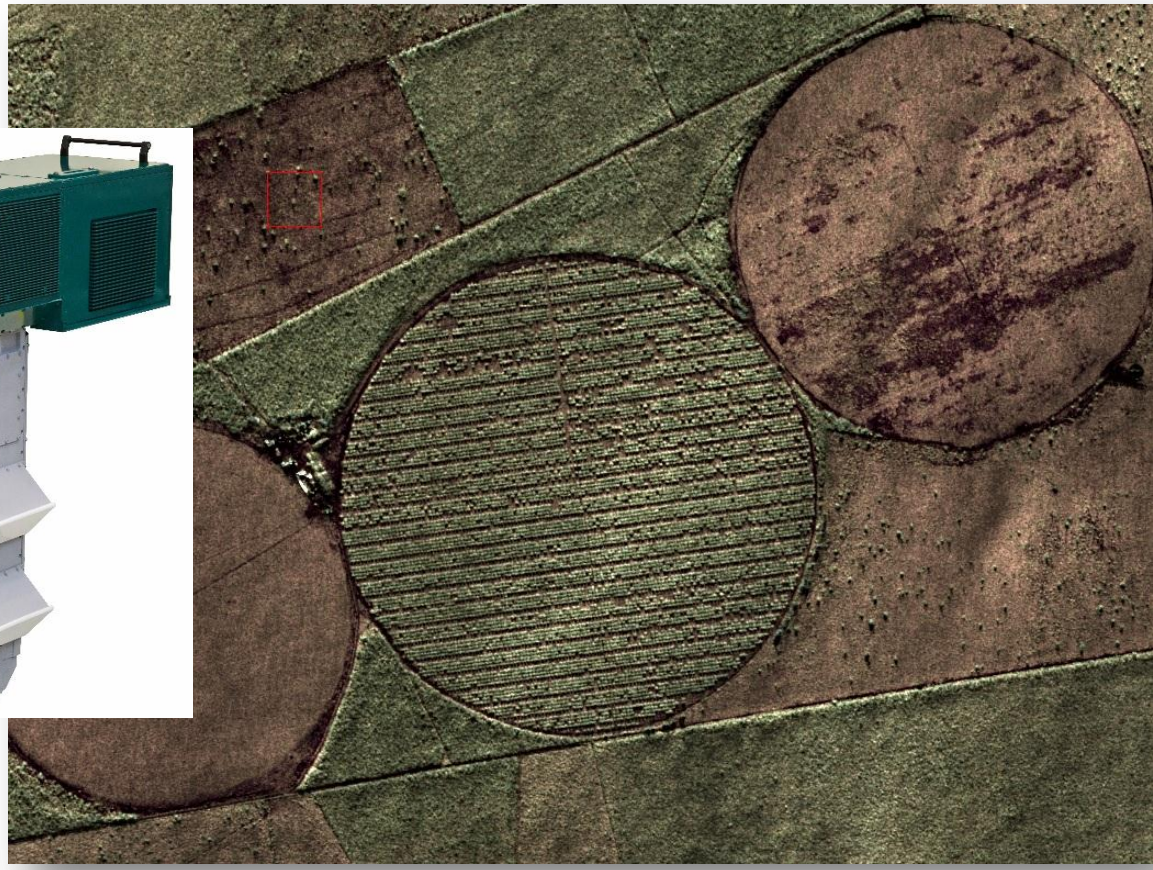
Airborne Radar: BradarSAR

- 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

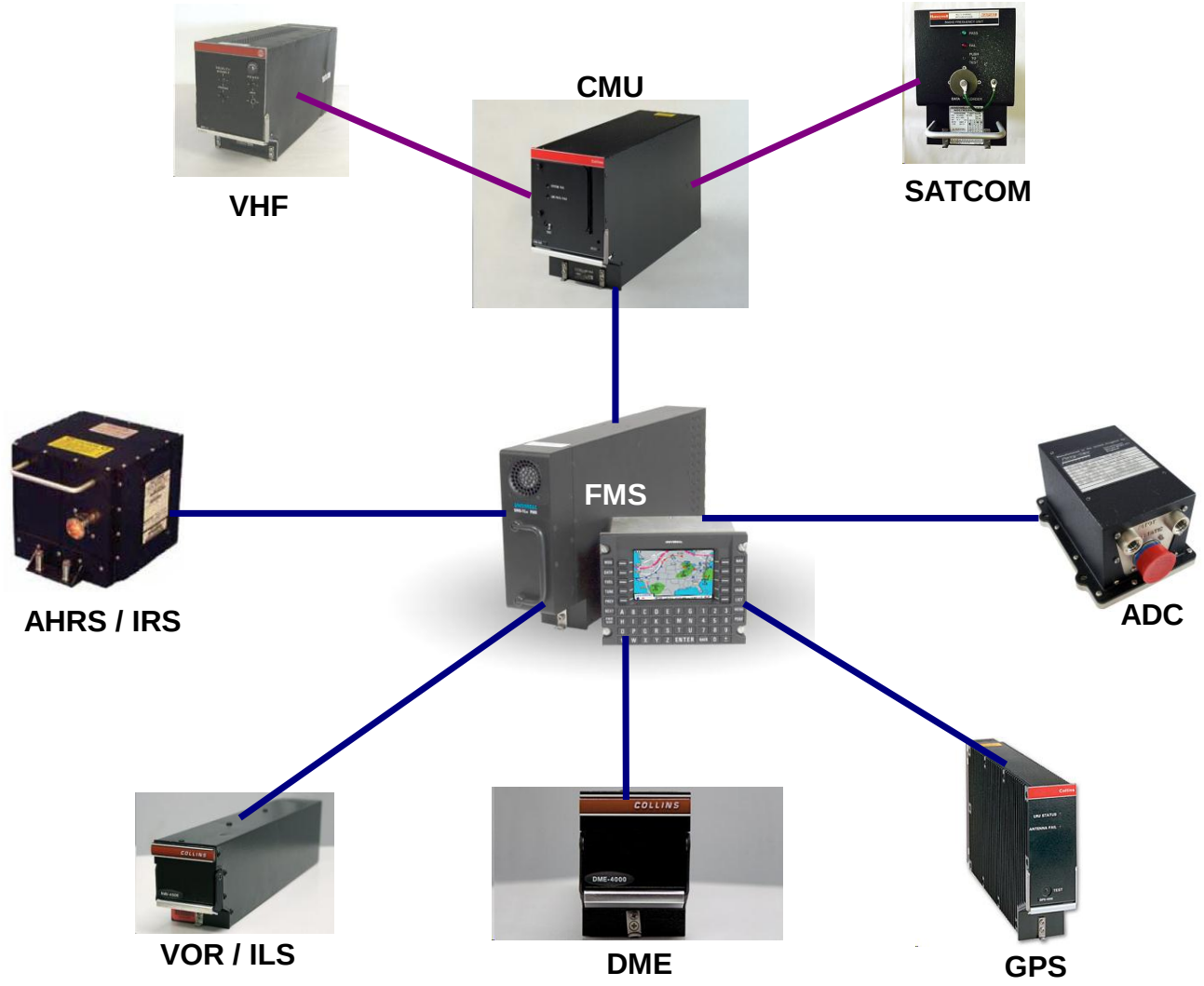


X/P band BradarSAR radar image with 1 m resolution

Section Four | Navigation systems

Navigation Systems

FMS (Flight Management System)



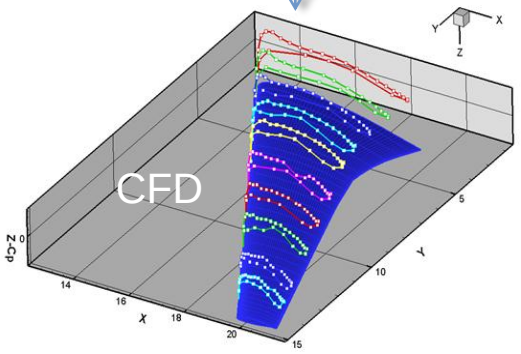
Section Five | Aeroelastic model validation

Aeroelastic model validation

Aerodynamics and Loads

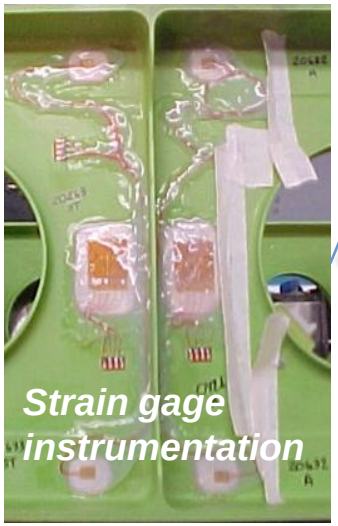
PREDICTED

*Aerodynamic Models: Tunnel + **CFD*

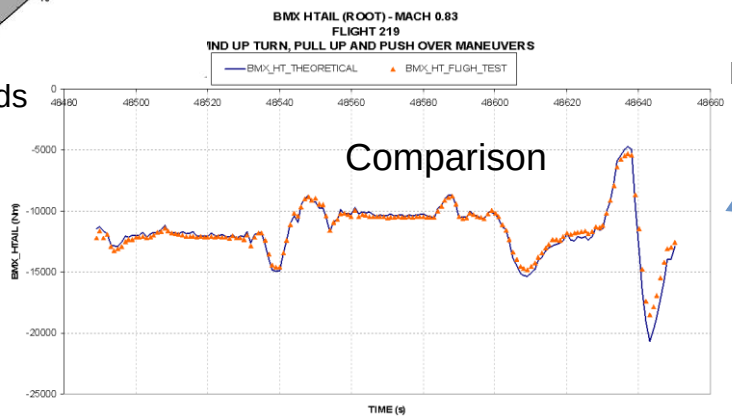


Theoretical design loads

FLIGHT TEST (EXPERIMENTAL LOADS):



Measured in-flight loads



***Computational Fluid Dynamics*

Aeroelastic model validation

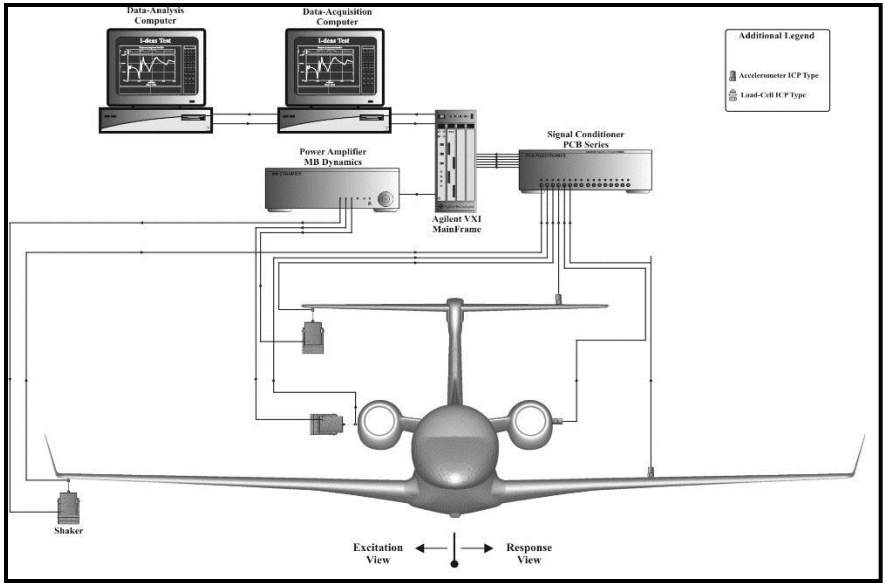
Ground Vibration Test (GVT)

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

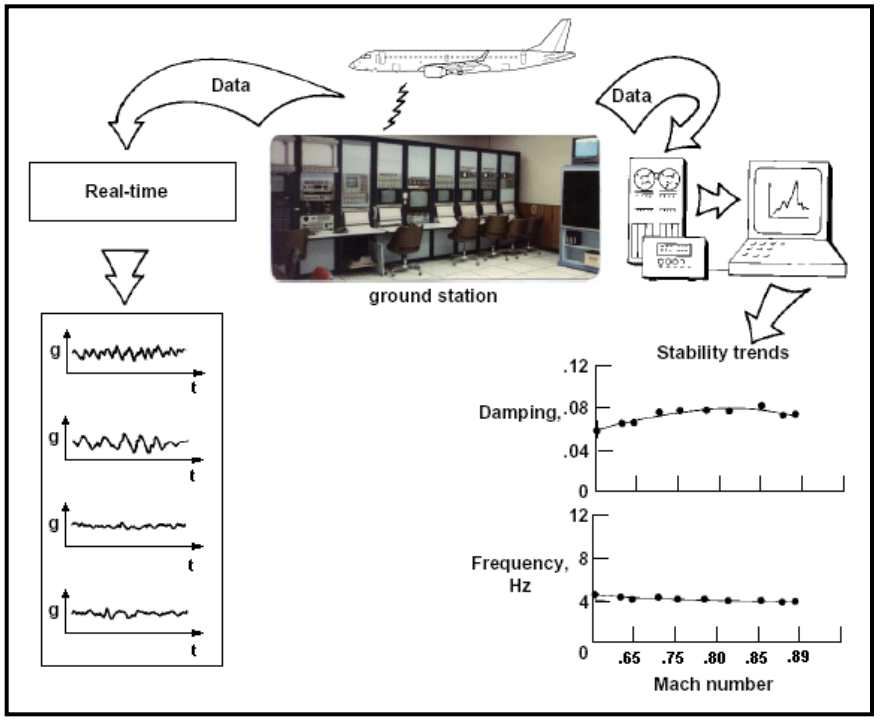


Aeroelastic Validation

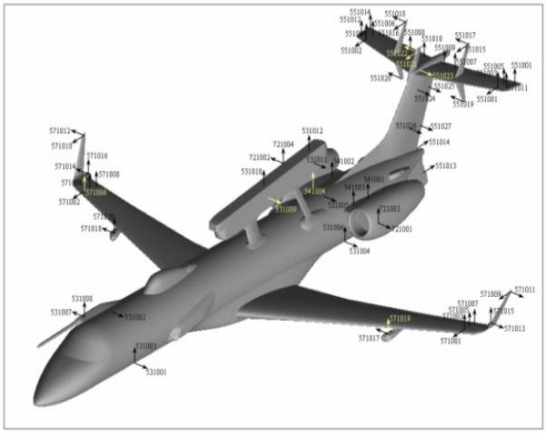
Flutter Flight Test (FFT)

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



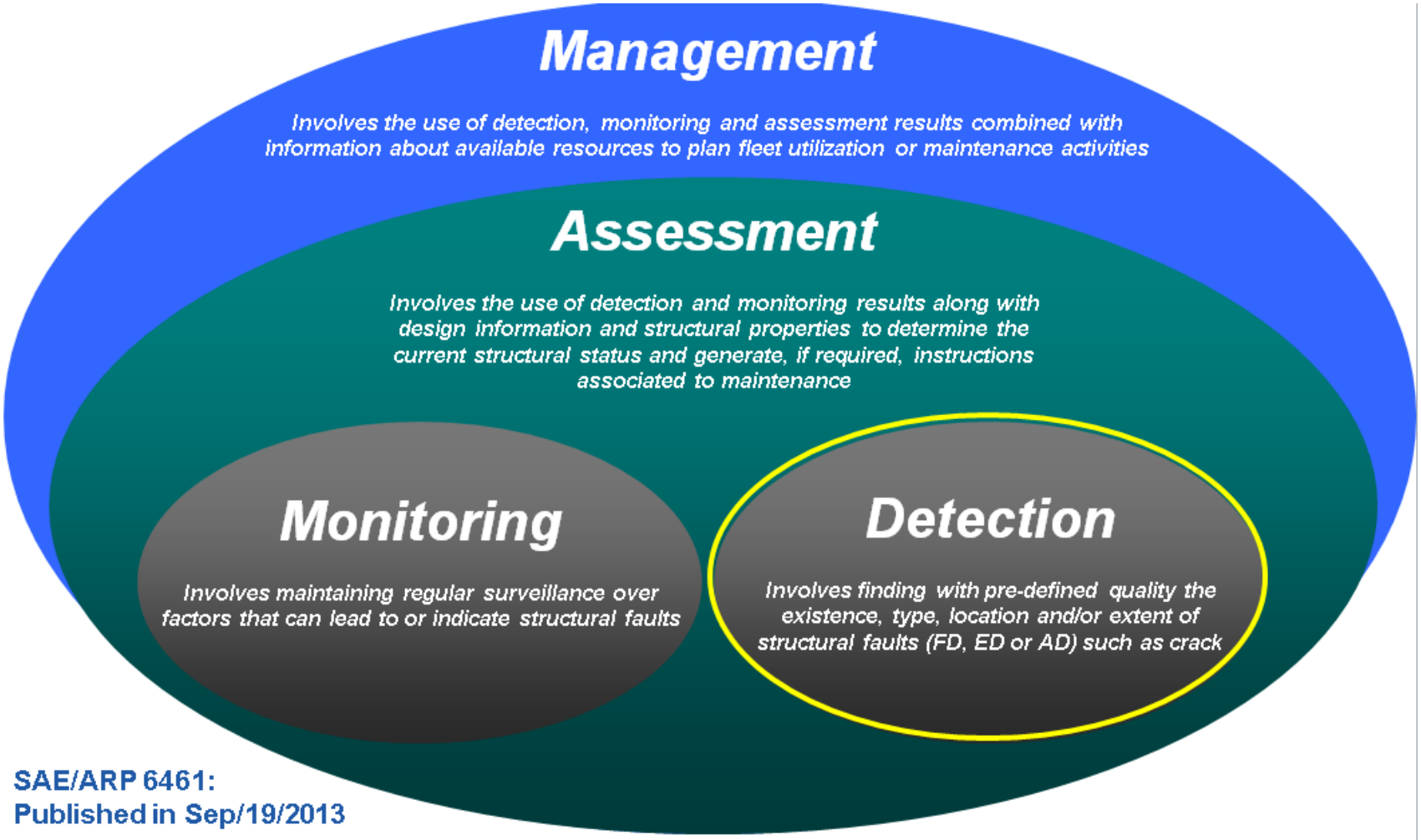
- Excitation System Applies Known Input;
- Instrumentation System Measures Airframe Response;
- Data System Generates Transfer Functions;
- Modal Frequency and Damping Estimated;
- Flutter Velocity Predicted by Extrapolation.



Section Six | Maintenance applications

Maintenance applications

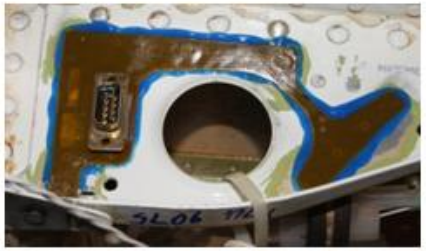
SHM (Structural Health Monitoring)

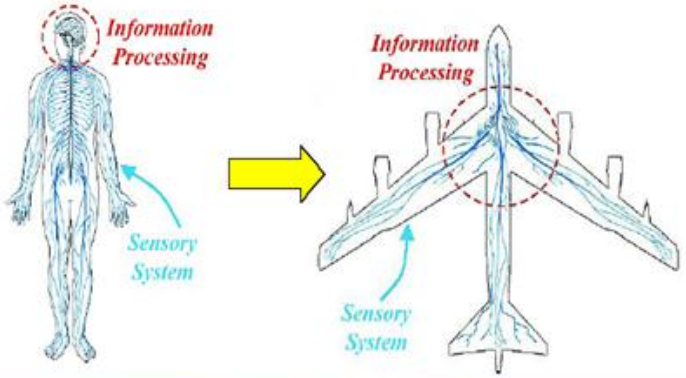


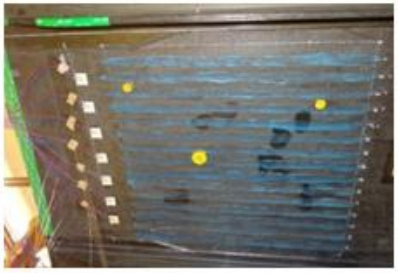
SAE/ARP 6461:
Published in Sep/19/2013

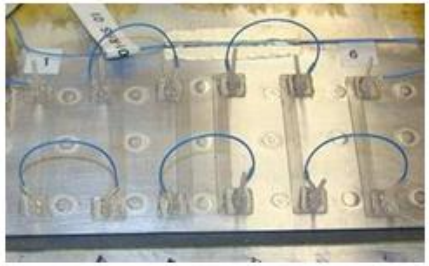
Maintenance applications

SHM – Damage Detection Systems





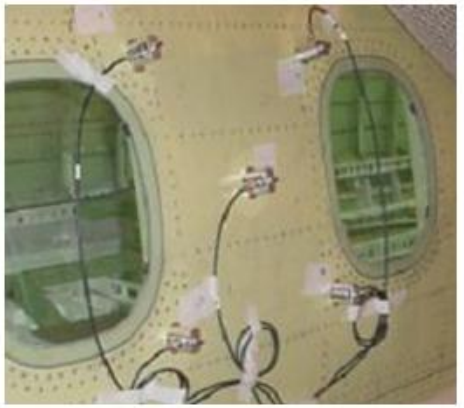


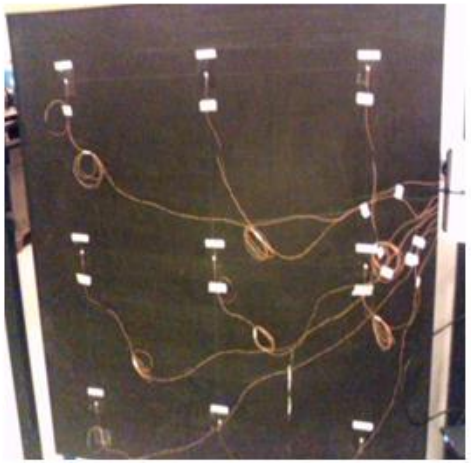


Maintenance applications

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







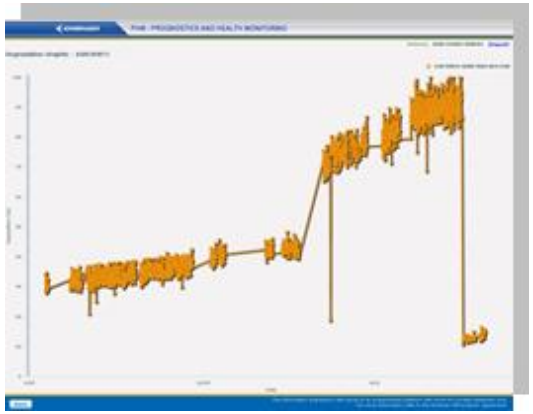


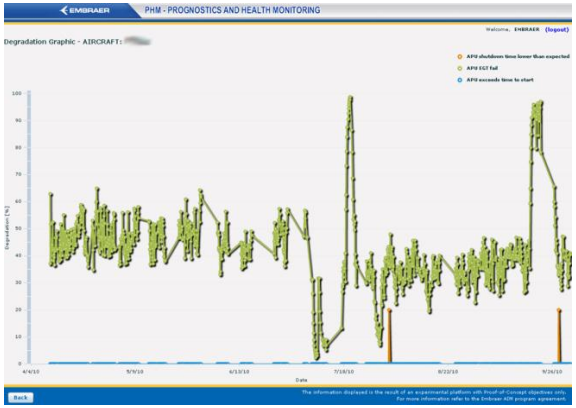


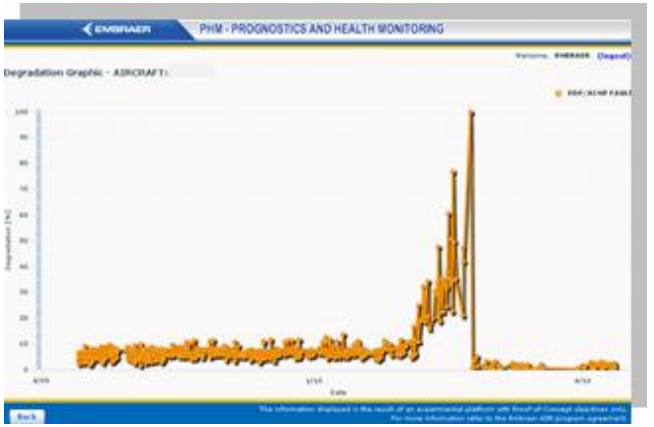


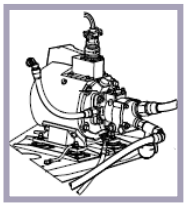
Maintenance applications

PHM – Proof of Concept

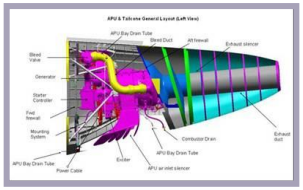




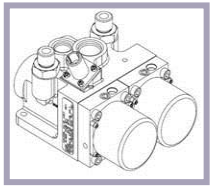




Hydraulic Pump



APU



Brake Control Valve

Partners:

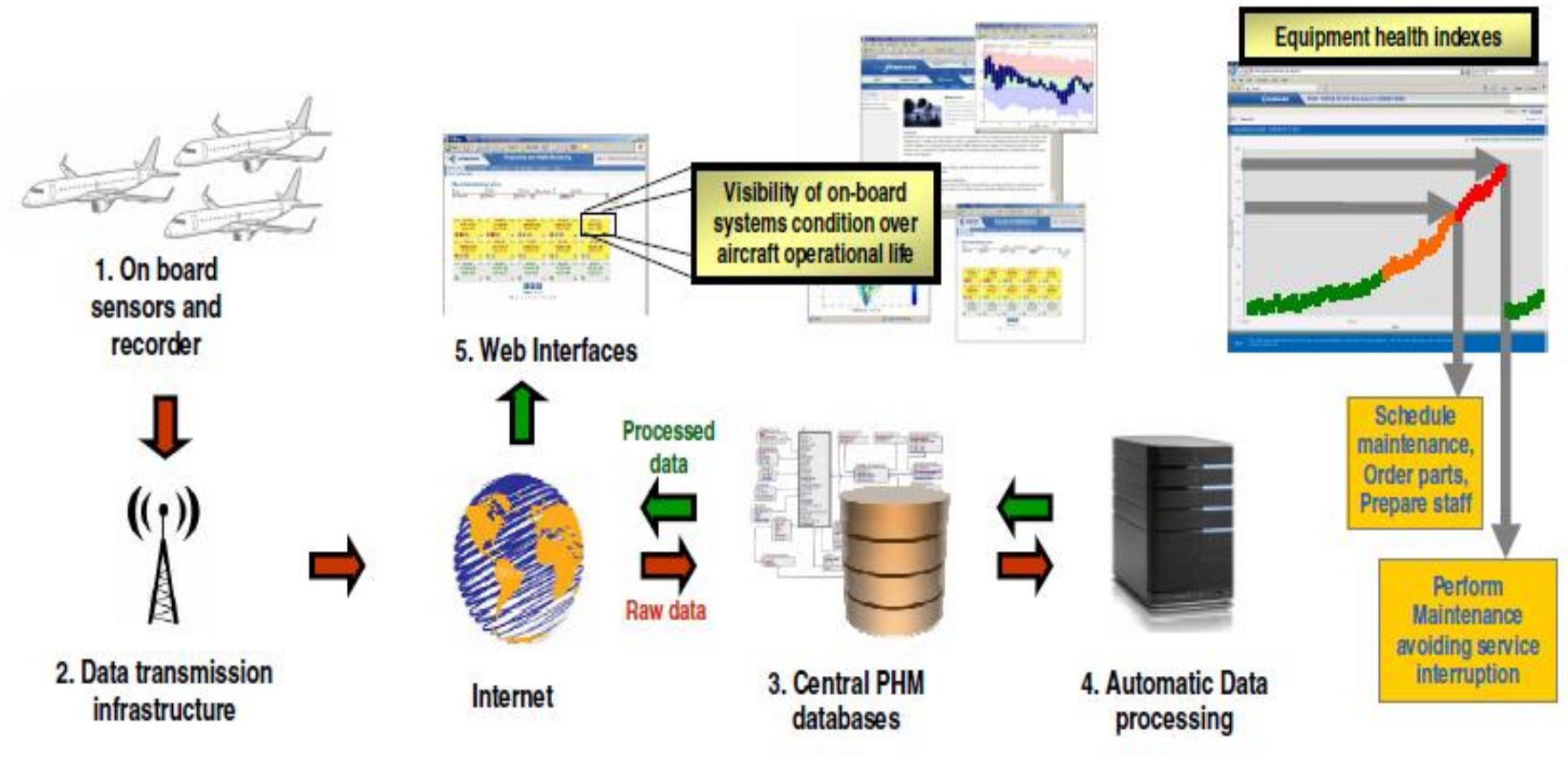
Azul Linhas Aéreas Brasileiras

Virgin blue

Copa Airlines

Maintenance applications

PHM (Prognostics and Health Monitoring) Concept



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

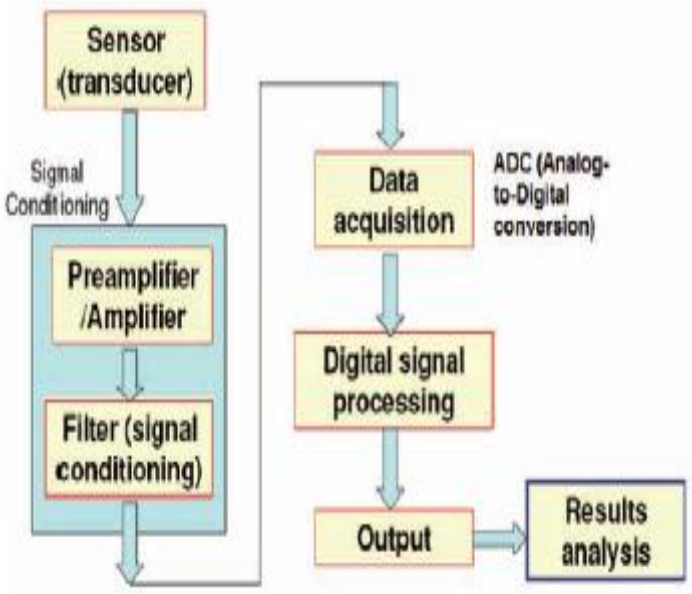


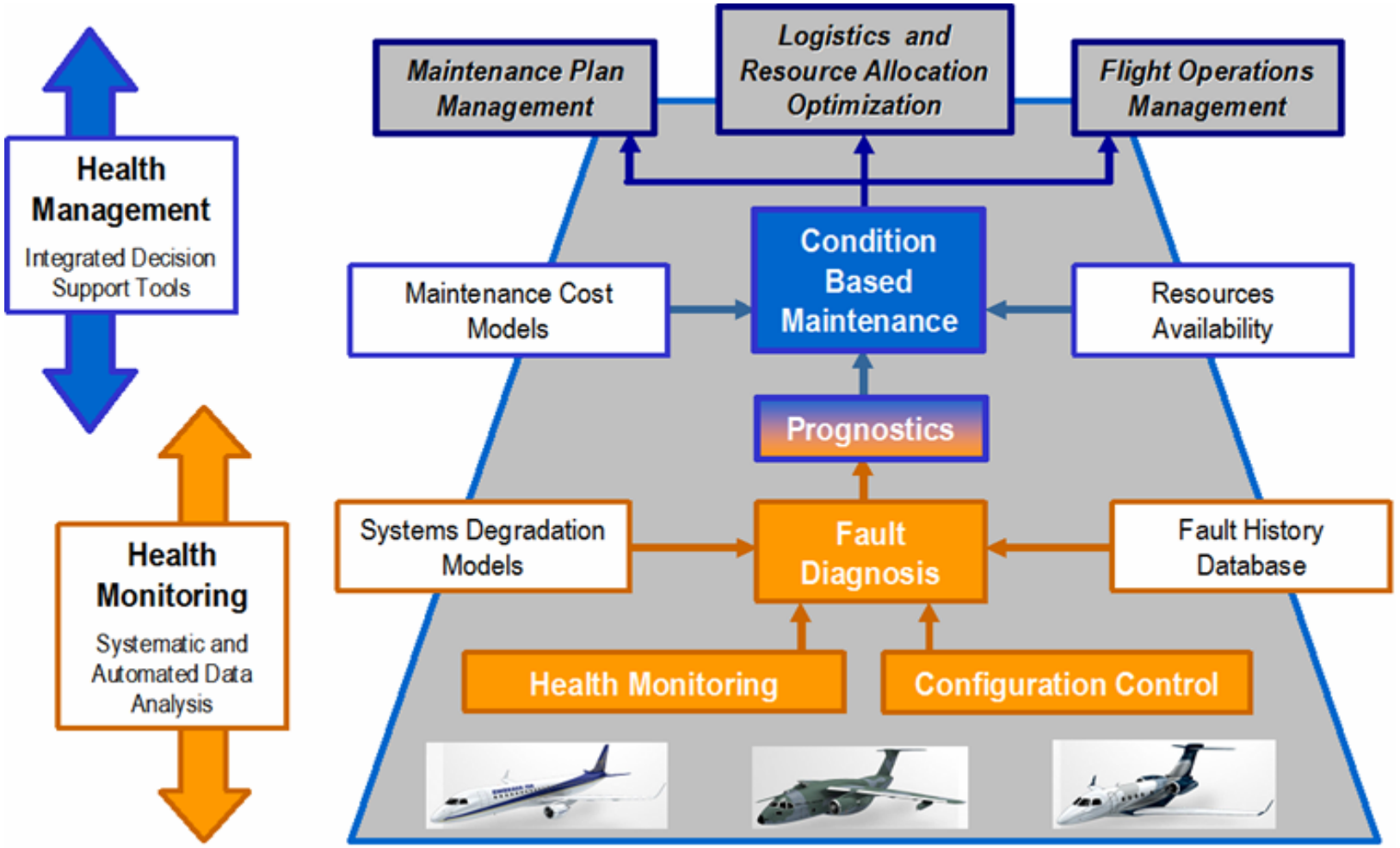
Figure 2.1 Measurement chain for an IVHM system.

Section Seven | Overview of future applications

Overview of future applications

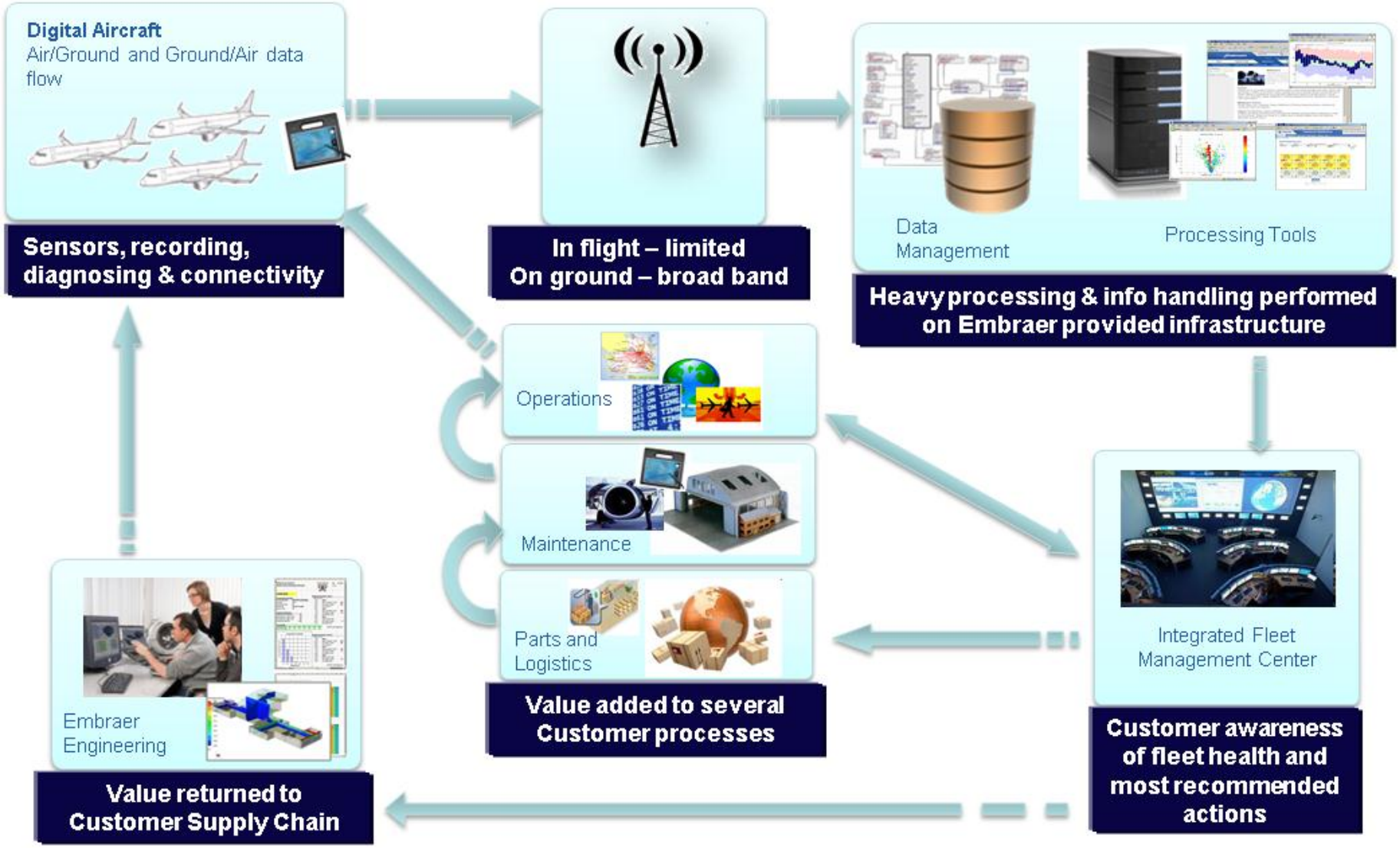
IVHM

- 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




Thank you!
FOR THE JOURNEY
EMBRAER