“One step beyond in the design of on-board Test Software architectures based on Data Distribution Service (DDS)”

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PASSARO
CAPABILITIES FOR INNOVATIVE STRUCTURAL AND FUNCTIONAL TESTING OF AEROSTRUCTURES

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Agenda

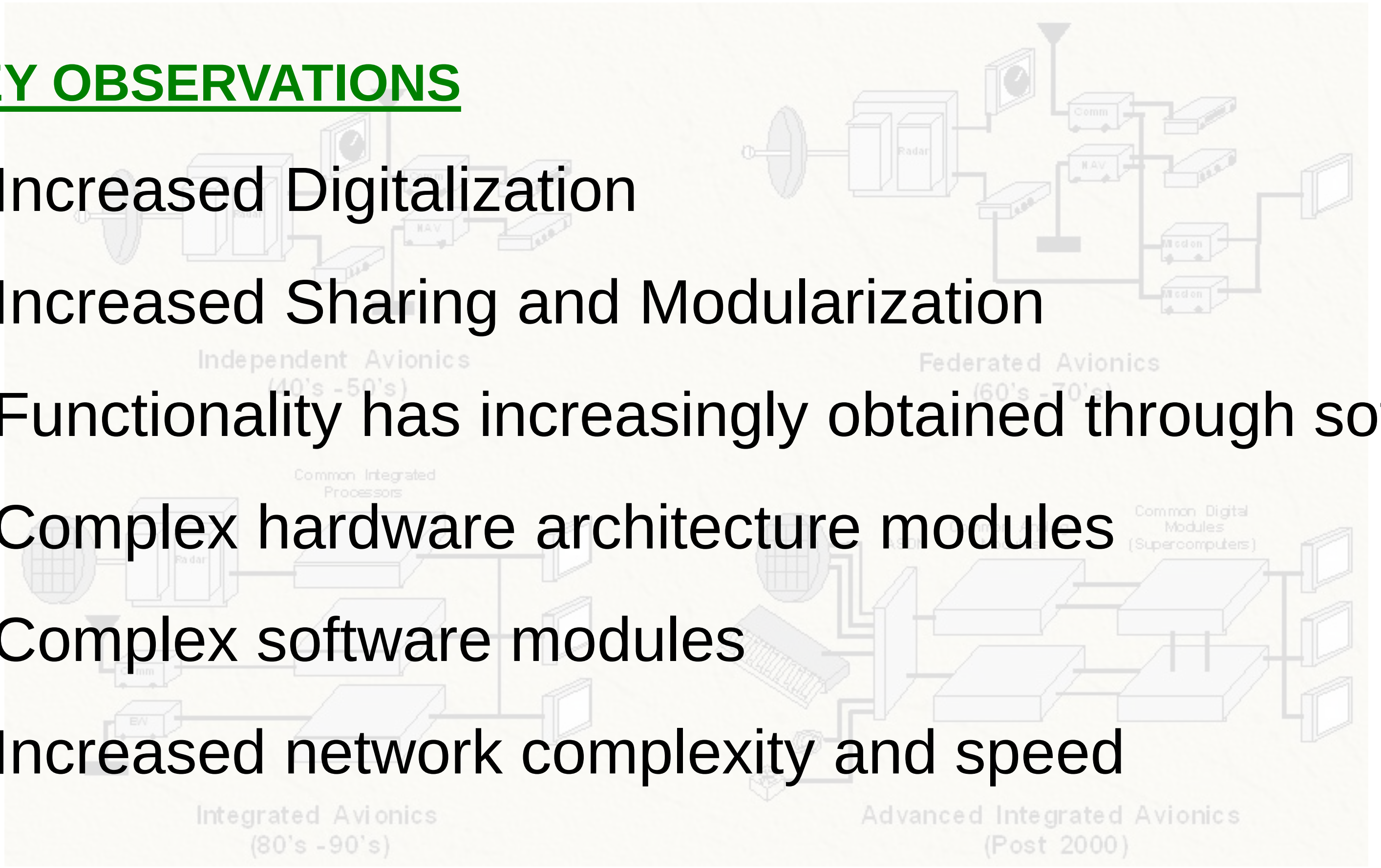
1. Challenges
2. Base Pillars for the solution
3. Project Objective
4. Prototype Implementation
5. Demonstration
6. Project Results

Clean Sky 2

- **Evolution of Aircraft Systems Architecture**

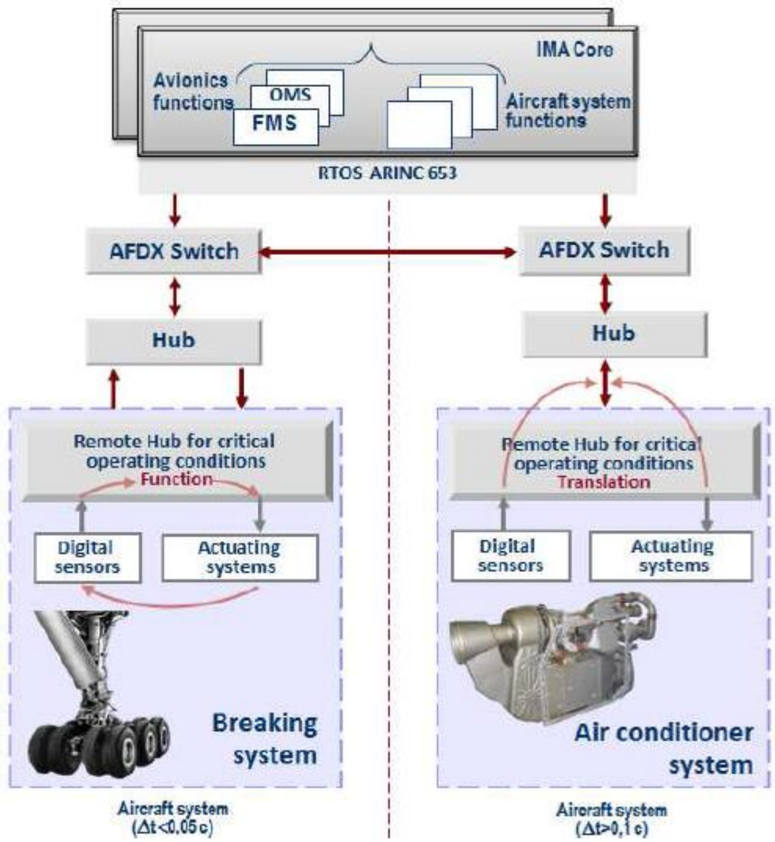
KEY OBSERVATIONS

- Increased Digitalization
- Increased Sharing and Modularization
- Functionality has increasingly obtained through software
- Complex hardware architecture modules
- Complex software modules
- Increased network complexity and speed



[1] Challenges. Test enviroment

- **Evolution of Aircraft Systems Architecture**



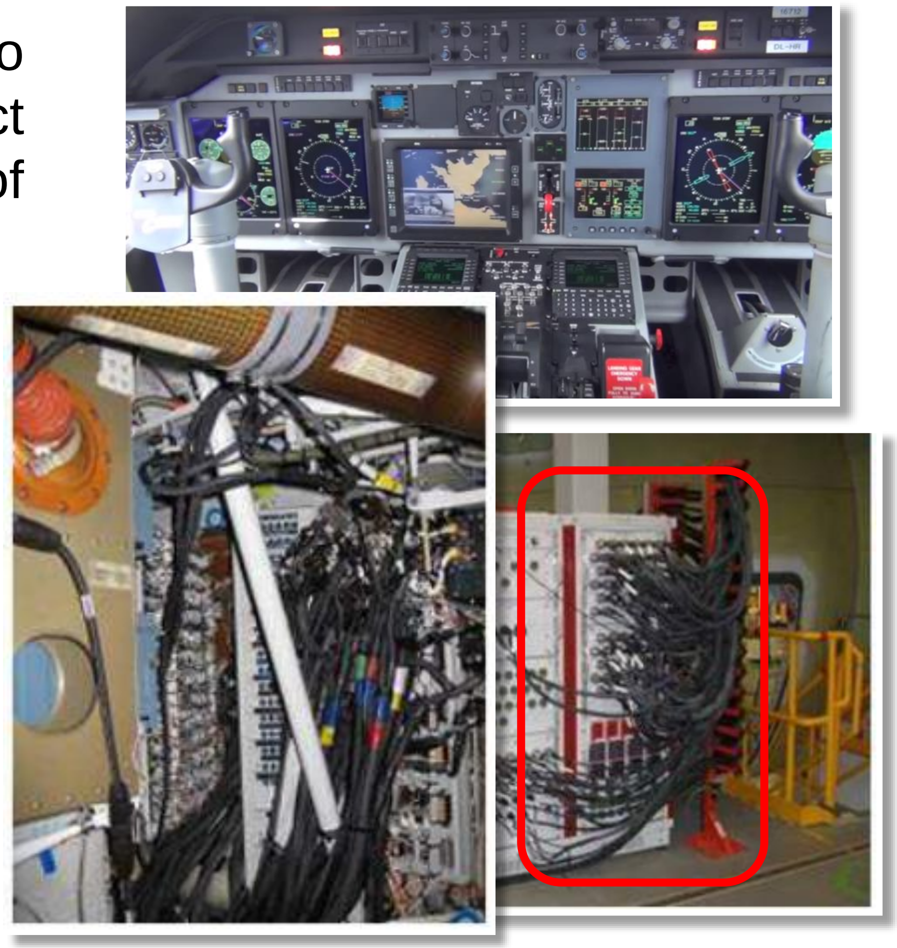
Functional System Tests Impact:

- All systems on aircraft connected trough a common network.
- Huge amount of digital data available to increase the capabilities and safety of the aircraft.
- More robust and complex systems.
- Systems/equipment from different suppliers, with non common test capabilities solutions.
- The ground tests phases during the final assembly process are more complex.

1. Challenges. Test enviroment

- **Ground System Tests phase impact**

- Functional tests are necessary to check and confirm the correct integration and operation of systems.
- The aircraft flight conditions must be simulated by stimulation, many of them through intrusive methods.
- High recurrent costs (RC) are incurred due to intrusive means installation, de-installation and maintenance (also NRC).



[1] Challenges. Testability capabilities

- **Current Systems Testability capabilities**
  - **On-board BITE (Built-In Test Equipment)**
    - Equipment performance monitoring and fault detection (maintenance tasks).
    - It's not possible to simulate aircraft conditions.
  - **Test Software loaded for ground tests phases**
    - Loadable software replacing operational one.
    - Intrusive method. Once the ground tests phase is finalized, the Operational Software must be re-loaded and tested again.
    - SW architectures and communication protocols not standarized (i.e. MK3 MICBAC).
  - **On-board Test Software**
    - Only a few systems/equipment are implemented with this feature.
    - SW architectures and communication protocols not standarized.

[1] Challenges. Testability capabilities

- **Summary**
  - In the ground tests phases carried out in a FAL, the ideal situation is to use the real aircraft HW & SW to ensure that the whole system, once integrated, works as expected.
  - Experience from the latest developments has shown the advantages of using the plane's own components and facilities, avoiding accessibility problems and test complexity, increasing the safety and the final quality, reducing related recurring and non-recurring costs, as well as the lead time at the FAL
  - Therefore, the systems must be developed with testability capabilities provided by a standard Test SW and communication protocol, allowing the Ground Test System to control the aircraft's HW and SW resources.

[2] Base Pillars (I): DDS

- Standard testability software architecture.

→ Standard communications protocol.

→ Specific network for testing and maintenance purposes.

DDS

- Mature standard with clear specifications.
- Real-time. Performant. Pub/Sub.
- Quality of Service (QoS).
- Multiple vendors (Long term support).

[2] Base Pillars (II): IMA

- Leverage the Distributed Integrated Modular Avionics (DIMA) architecture to define a standard software solution based on ARINC-653 for embedding testing capabilities in the aircraft on-board computers.
- Reusable software components (ARINC-653 partitions).
- Standard solution for integrating test-software into old and new LRUs.

➡ **DIMA ARCHITECTURE**

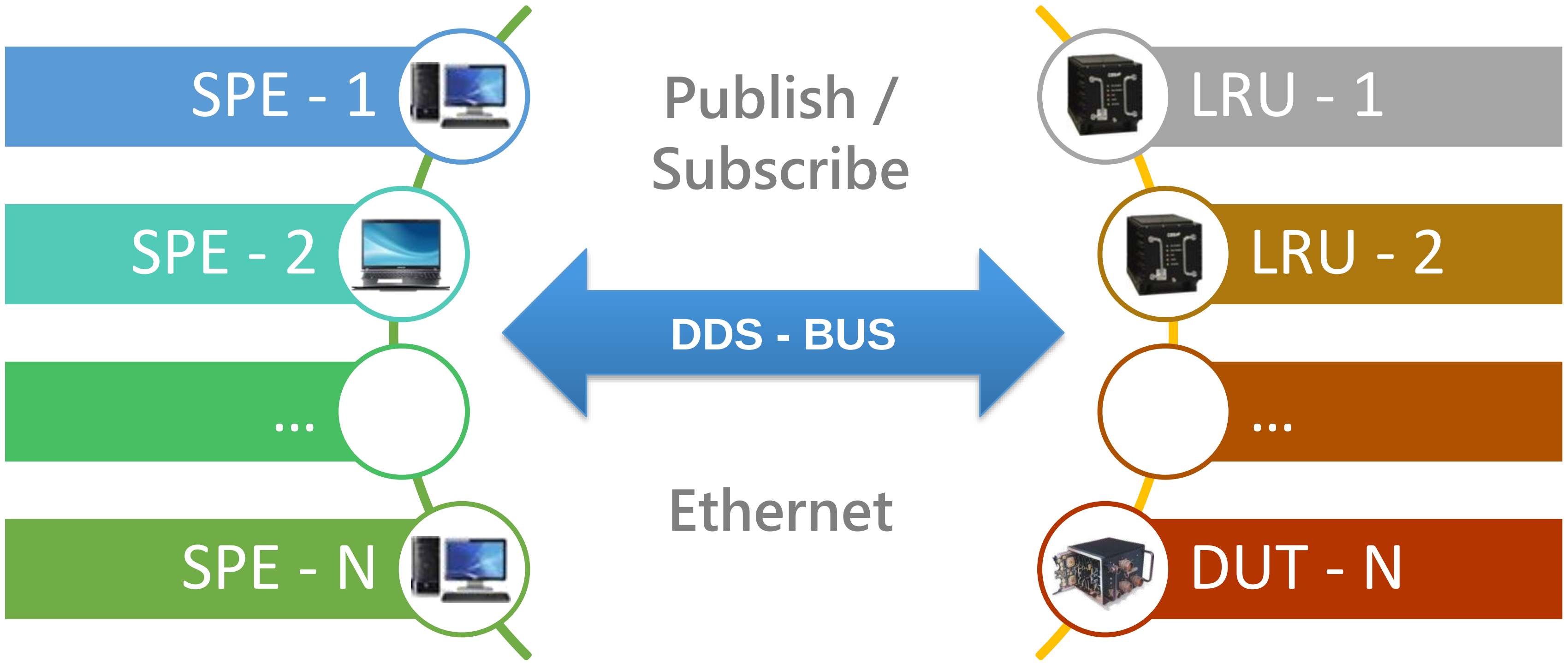
(ARINC-653 SW LAYER)

[2] Base Pillars (III): ETH PORT

- Take advantage of available ethernet ports provided in many IMA Computers for testing purposes.
  - Doesn't interfere with avionics buses (***side-channel***).
- Ethernet:
  - High BW. Allows for more complex testing.
  - Common and mature HW. Lower cost of operation.
  - Already available Ethernet networks for testing purpose.

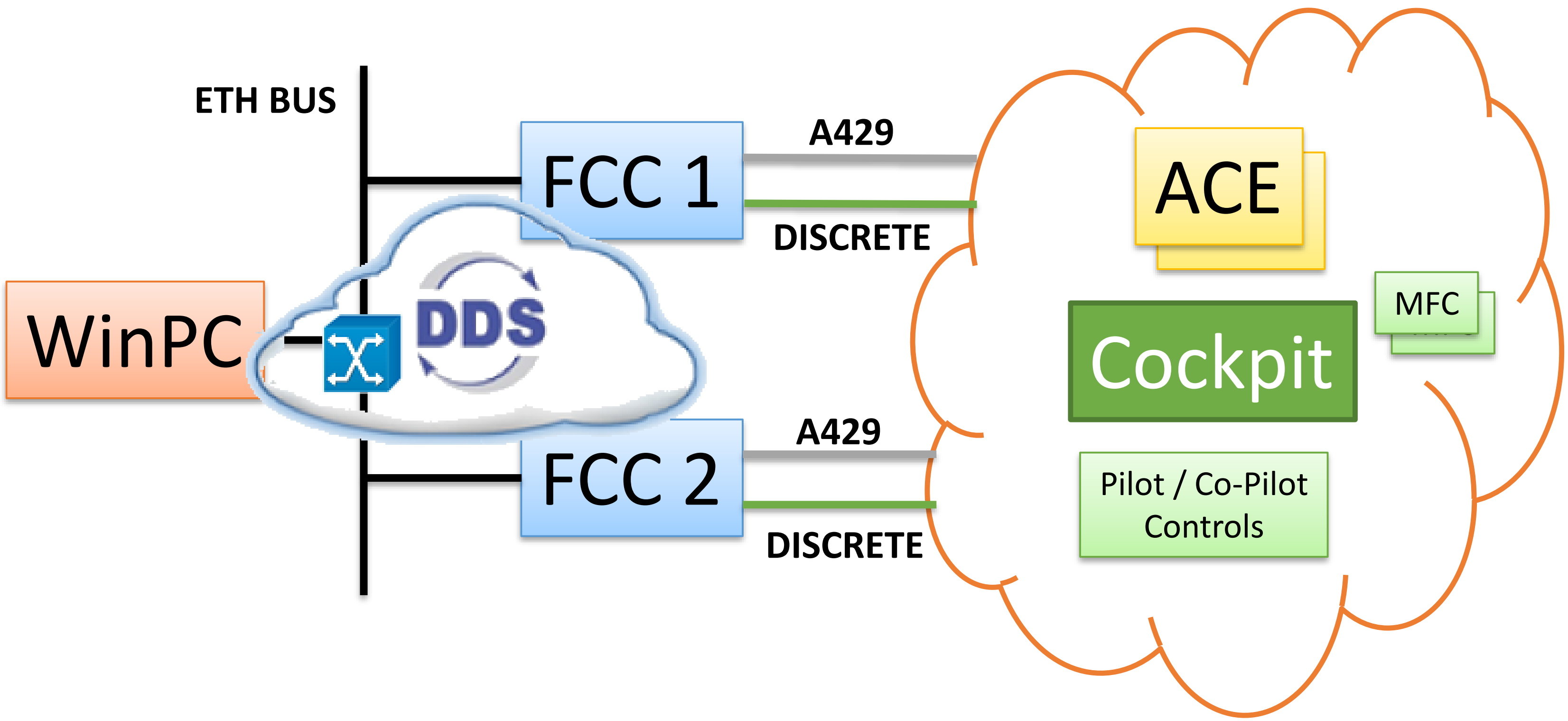
EXTENDED USE OF ETH PORTS

STANDARD AVIONICS GROUND TEST NETWORK



INTEGRATION INTO CS2 ITD AIRCRAFT FRAME

FLIGHT CONTROL COMPUTER (FCC)

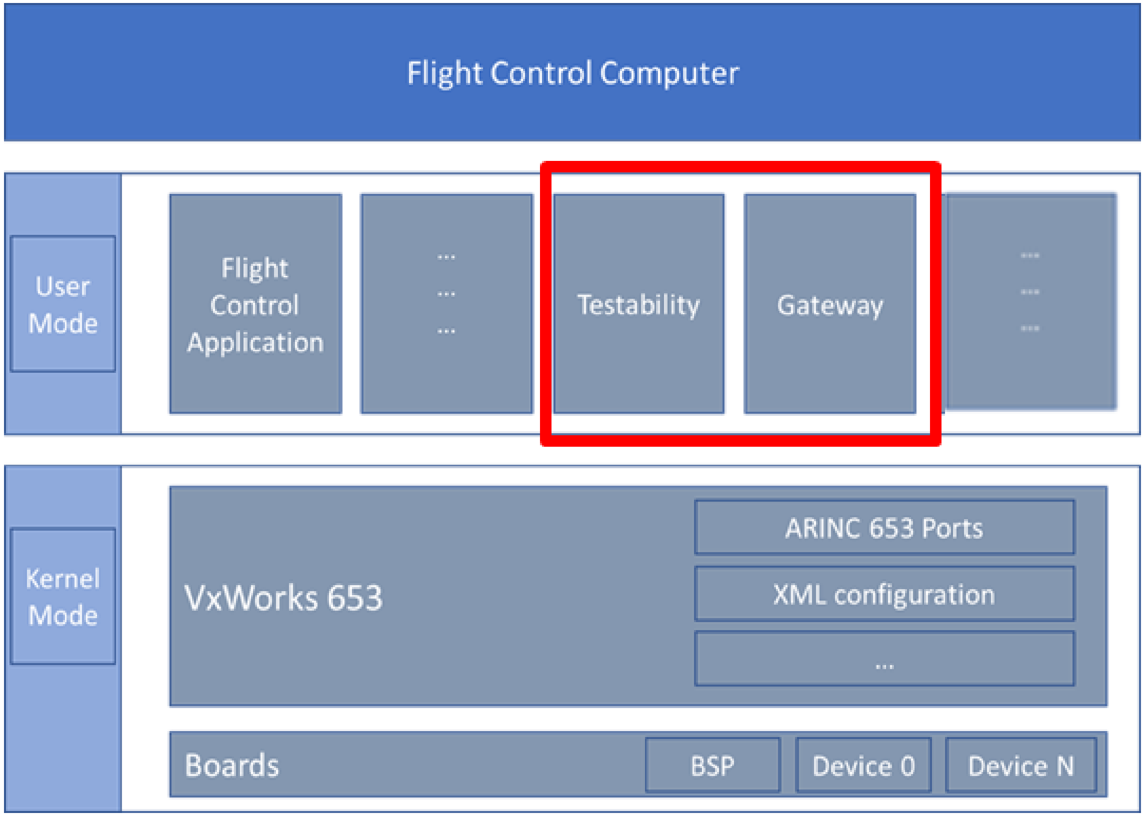


[4] FCC – SW Challenges

- Peculiarities of the VxWorks653 2.2 (Circa 2004).
- The networking stack (BSP and ETH driver) were developed during the course of the project by a third-party (Mercury).
- DDS integration in VxWorks653 (exotic platform) with a custom UDP stack.
- Develop a standardized testability architecture for future use in different aircraft programs and equipment.

[4] FCC – SW Architecture

- Integrated Modular Avionics (IMA) – ARINC-653



[4] FCC – Comms (I)

- FCC internal communications:

  TESTABILITY PARTITION

- Developed by Airbus D&S.
- Manage real inputs/outputs (disable/enable) to be able to mock with the external test signals.
- Activation conditions:
  - Discrete/analog signal enabled.
  - DDS – Auth.
  - DDS – ICD signal value enabled.

[4] FCC – Comms (II)

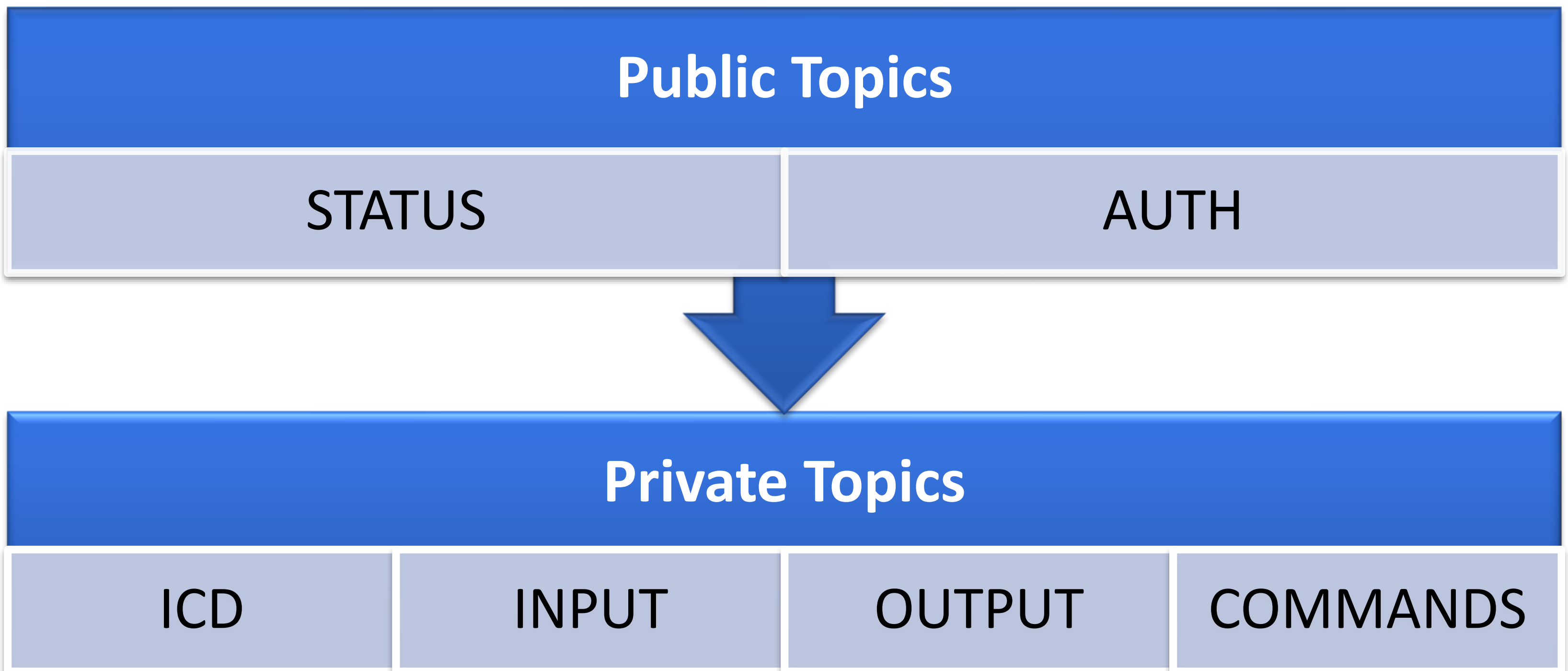
- FCC external communications:

  GATEWAY PARTITION

- Developed by AERTEC/PASSARO.
- Based on RTI DDS Connext Micro 2.4.10
  - VxWorks653 support.
  - Run in resource constrained systems.
  - [BONUS] Certifiable DO-178C DAL A.
- Custom networking stack → RTI CERT was necessary
  - Only **DPSE** mode: Predefined Topics; Unicast; etc.

[4] DDS Architecture – Topics

- DDS Topics are divided in two levels of access (AUTH)



[4] Topics Data – IDL

Common DDS Architecture

ICD

(Excel File)

- ARINC-429
- Discrete
- …

Common IDL

+

Specific IDL

IDL

* ICD (Interface Control Document)

[4] IDL – Workflow (I)

1) ICD (Excel file) → IDL file
   → DB Scheme (SPE)
2) IDL file → [CLI] rtiddsgen → Source code (Types)
3) Integrate DDS files into GATEWAY partition
4) Compilation for VxWorks653 (makefiles)
5) Deployment into FCC-1 & FCC-2

[4] IDL – Workflow (II)

AUTOMATED WORKFLOW FROM ICD FILE !!!

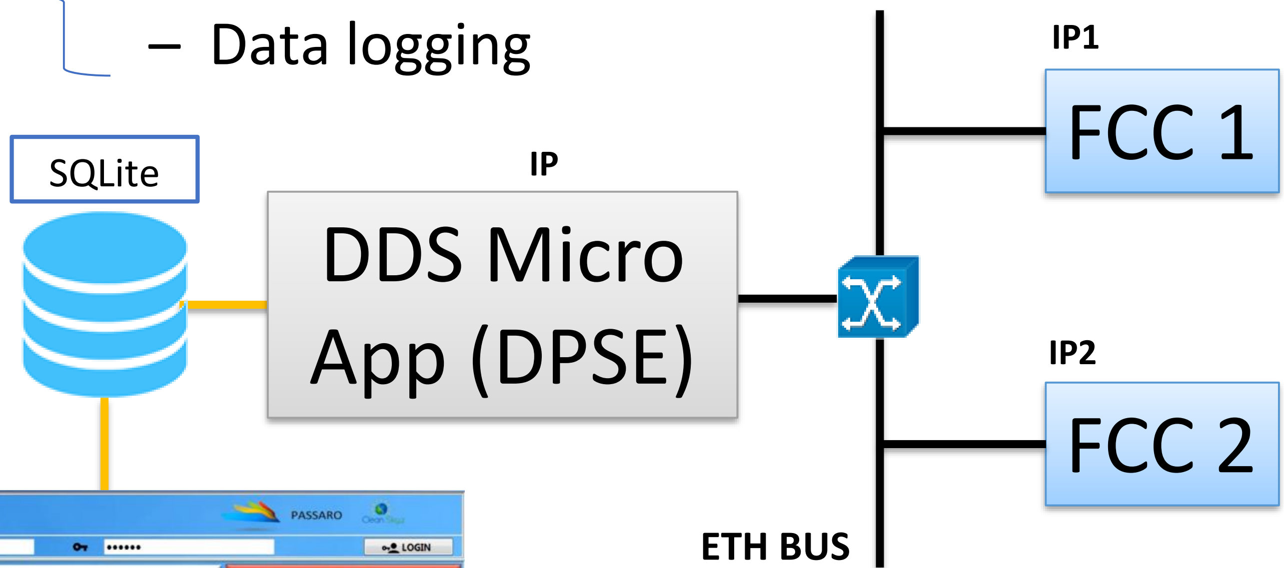
- Run complex suite of tests using ICD signals for the required extended functional testing in manufacturing / assembly.
- Test-cases defined by system designers

[4] SPE – Architecture (I)

- Multiple and simultaneous connected test stations.
- Windows based
  - Airbus D&S internal custom SW & network.
- Able to run suite of test-cases.
  - Current HMI for only for demo purposes.
- Store test results in a Database.
  - Auto-generated DB scheme form ICD.
  - Currently only support for SQLite.

[4] SPE – Architecture (II)

- Database
  - Interface point
  - Data logging



HMI only for demo purposes.

Future: Only a Test-Runner is required

[5] DEMO (I)

- **Demonstration on a relevant environment (*TRL6)**
  - CleanSky2 ITD Frame aircraft avionics testbench
    - Real cockpit
    - Real Flight Control Computers (FCCs)
    - Real Flight Control and Actuators

** Technology Readiness Level*

[6] Project Results

- To provide a standard unified aircraft systems testing architecture and communication protocol.
- To easy and reduce the time for the preparation and execution of ground systems tests.
- Real-Time communications with Quality of Service (QoS) configurable performance.
- Integrated into ARINC-653 compliant aircraft computers with and Ethernet port.
- Allows for a use of a non-intrusive testing architecture.

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JOINT UNDERTAKING

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Q & A

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Thanks rti for your support!
Thanks to all the attendees!

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