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Design and development of Transport Aircraft Systems – Past, present and future – Challenges and Opportunities

Lecture of the Royal Aeronautical Society Hamburg Branch
Hamburg, 30 October 2008

(Note: Some charts of propriety nature removed for printed version)

Contents

1. Evolution of Design and Development of Systems for Transport Aircraft and Challenges
2. The Development Process, Validation and Verification
3. Methods and Tools
4. The World of Suppliers
5. The Future
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Top Objectives and Main Drivers, Today & Future

- **Top Systems Goals (Business Drivers)**
  - Safe aircraft
  - Mature, meet customer expectations
  - Meet environmental requirements (Agenda 2020: CO2 -50%, NOx -80%)
  - 100% Mission Available Systems, A/C operation under all conditions
  - Low cost of Ownership (fuel, maintenance, training, ……)

- **Industrial Processes**
  - Work on complete process: development to delivery

- More efficient integration of **Suppliers** and their capabilities

- World class **Technologies** and **Capabilities,** drive **Innovation**

- Master **Collaborative Engineering**

- Market and industrial challenges: Lead time reduction, cost reduction, ……

- More stringent **Environmental requirements**. Deliver "Green" products

- Manage **global crisis** (since September 2008)

Systems Necessary to fly and operate the aircraft

Flight controls

Landing Gear

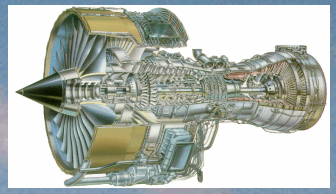
Cockpit

Ice and Rain Protection

Cabin pressure and Air Cond

Power & Energy

- Propulsion System
- APU
- Fuel system
- Electrical Power
- Hydraulic Power



Cabin Systems

Systems, necessary for c convenience and safety o and passengers, payload,

Revolutionary changes in Systems (examples)

Towards to the „**More Electrical Aircraft**

- Flight controls: Full Hydraulic → Hydraulic + Electrical
- Braking: Next step → Electrically powered braking systems

Landing Gear Systems more complex

More complex **fuel systems** with multiple reservoirs for minimization of wing structural loads and C.G. control

Revolutionary and innovative advancements **cabin climate** control for passenger comfort and health

Systems Complexity and increasing Automation

-**More complex architecture:** Increasing number of **functions** and **automation**

- More **data exchange** between systems and hierarchical levels of Command and Control in modern systems architectures

- Rapid increase in **data exchange with external environment** for Air Traffic Management and Airline Operations Management

- Increasing trend to **onboard systems and performance monitoring**
  → Systems Health Monitoring → Aircraft Health Monitoring → **More data**

- Rapid trend to **More Software Intensive Systems (SIS)**

- Systems organisation wide-spread over **different sites** and countries
  Increased trend to **off-shore subcontracting** (industrial globalisation)

Maturity is what our customers perceive
(in addition to basic performance & safety)

Non-Maturity leads to rework, operational impact
Objective for Engineering: Maturity at First Flight, early validation

Top Maturity Objectives for Design and Development.

- Meet validated Operational and dispatch reliability
  Objectives at First Flight to ensure robust maturity at EIS in ustomer operation
- No unplanned modifications after Entry into Service
- Ease and cost of maintenance

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Requirements Based Engineering is totally embedded in the V&V Process

USER NEEDS

VALIDATED END PRODUCT

TOP LEVEL REQUIREMENTS

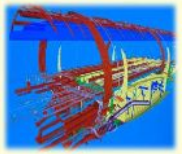
DESIGN ACTIVITY

Implementation Verification : Check Product/ Design against Requirements

Validation of Requirement : Check Requirements are correct, complete against upper level requirements

REQUIREMENTS

PRODUCT UNDER INTEGRATION



DESIGN& DEV ACTIVITY

DESIGNED SOLUTION = PRODUCT

Validation & Verification

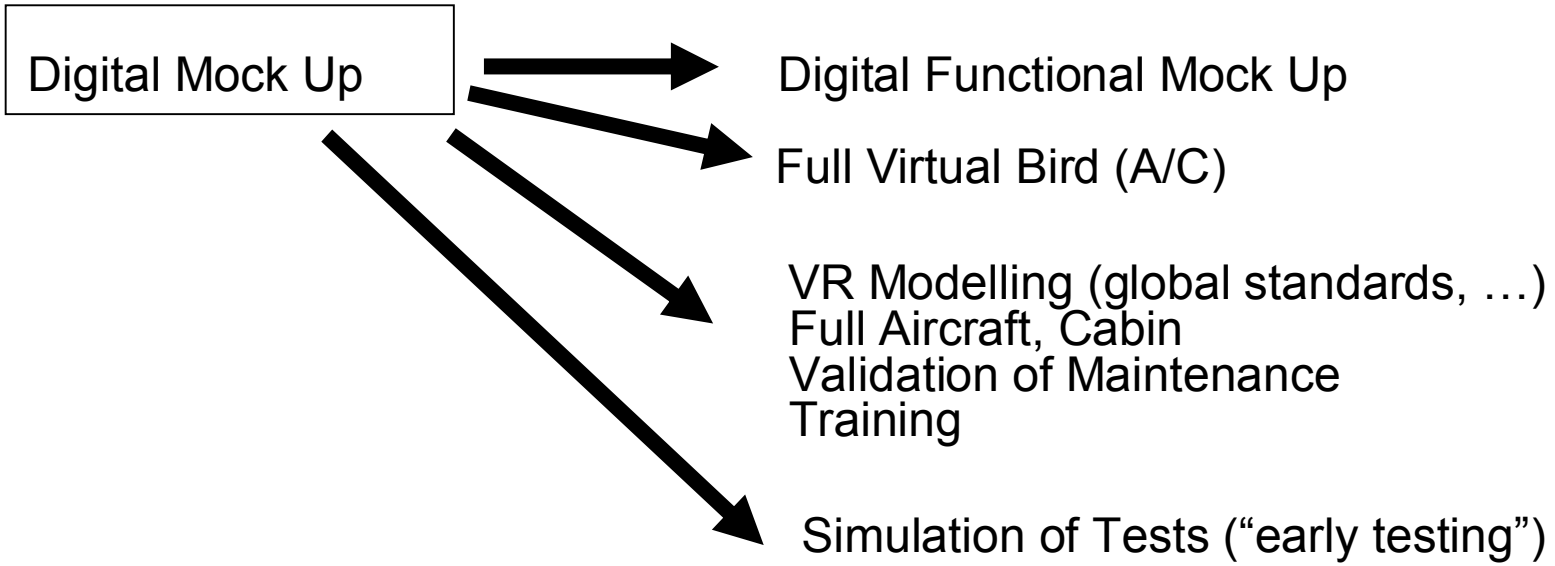
Validation and Verification by simulation and test

- Early simulation
- Iron Bird: Full build up of systems and installation features representing complete aircraft → **Aircraft 0**
- Integration test facilities for all major component assemblies:
  - Landing Gear
  - Fuel System
  - Secondary flight control system
  - Payload and freight system
  - Full „Cabin Bird“ **(Cabin 0)**
  - Airconditioning system complete
  - Complete aircraft (Iron Bird) → **Aircraft 0**
  - Flying Test Bed for propulsion system validation prior to 1 flight

The Digital World of Systems Engineering

Model based Systems Engineering

- Digital modelling of systems and equipment for systems layout
- Application for space optimimisation for systems installation
- Definition and validation of systems installation for production release



Enhance collaborative engineering

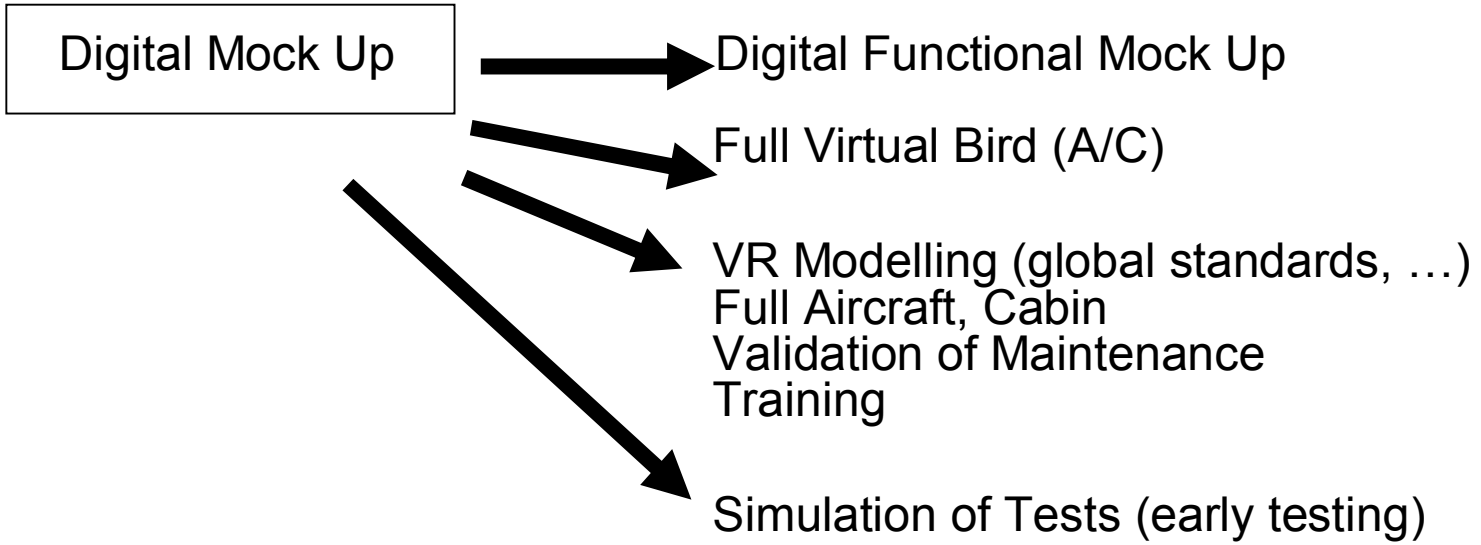
Systems Engineering Best Practices

Virtual Reality,Augmented Reality, Mixed Reality

- New techniques and tools for more efficient Systems Engineering
- All phases of development and industrial processes
- Reduced time for interdisciplinary systems installation definition
- Common model for systems life-cycle support and training
- Early and more efficient Human-Machine Interface evaluation
- Techniques, methods, tools and data-banks to be standardised

The Digital World of Systems Engineering

Digitalised Systems Definition and Installation data



Note: 1) Digital Tools provide wide scope of highly interactive capabilities.
Systems interactive, human-interactive
2) Essential to take account of human-machine/user interfaces and standardisation of all involved tools, data banks and working groups

Electromagnetic Compatibility and Hardness

HIRF (High Intensity Radiated Field)
External emitters

Lightning

Electrostatic

NEMP
(Nuclear Electro Magnetic Pulse)

Internal EMC(Electro Magnetic Compatibility)
Avionics, PED (Portable electronic Device)

The supplies world is changing

Working with systems suppliers
- Supplier world is changing
- High pressure to reduce cost and lead time
- More efficient ways of working together
- More efficient exploitation of resources and know how

INCREASING SUPPLIERS ACTIVITIES

INCREASING SUPPLIERS POWER

- More responsibility to suppliers
- Larger packages
- Strategic partnerships

SOURCING ACTIVITIES REQUIRE A PERMANENTLY UPDATED STRATEGIC APPROACH

INCREASING SHAREHOLDERS REQUIREMENTS

INCREASING CUSTOMERS PRESSURE

The Future ?

- Innovation
- Systems Architect, Aircraft Architect
- Competence
- Teamwork
- Global collaborative engineering

Make

The Future ?

Drive

Main Drivers today

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Main Drivers today +

- New aircraft configurations

- More pressure on economy of operation and industrial challenges
- Show environmental results. Alternative Fuels
- Step improvements inAir Traffic Management.
- More electrical aircraft → full electrical aircraft
- Supersonic ??

Concluding Remarks

- Focus on systems in their operational environment
- Mature systems at Entry into Service are a must
- Work interdisciplinary and collaborative
- Early definition and validation of systems architecture
- Early identification of risks (Risk and Failure Analysis)
- Develop and maintain competence of Architect and Integrator
- Explore new System Engineering capabilities in the new digital world of Virtual Engineering
  → Simulation and Model-based Systems Engineering
  → Failure simulation
  → Training and maintenance (→ keep operation going)
- Take account of Human Machine Interfaces and User oriented design early in the definition and development process. User validation.
- Integrate Lessons Learnt and Knowledge Management early in the development process

Ensure environmental friendliness → Green Aircraft