

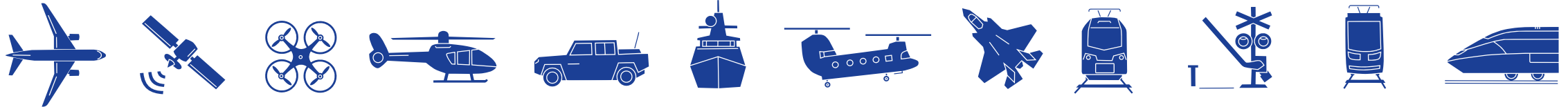


CONSULTING AND ENGINEERING

## Certification aspects of electric propulsion and aircraft electrification

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[www.adse.eu](http://www.adse.eu)

# Challenges of Aircraft Electrification

- Battery developments got the interest of aircraft manufacturers
- Challenges
  - Technical:
    - Capacity and weight
    - Thermal Management
    - Battery Management Complexity (incl. safety critical **software**)
    - Integration / Installation
    - Risk of thermal runaway and fire
  - Operational: Reserves, certified over life cycle
  - Regulations: maturing and harmonization of regulations and Means of Compliance
    - -> **Regulatory Authorities need data**
    - -> **expect quick changes**



# Developers dilemma: two main routes

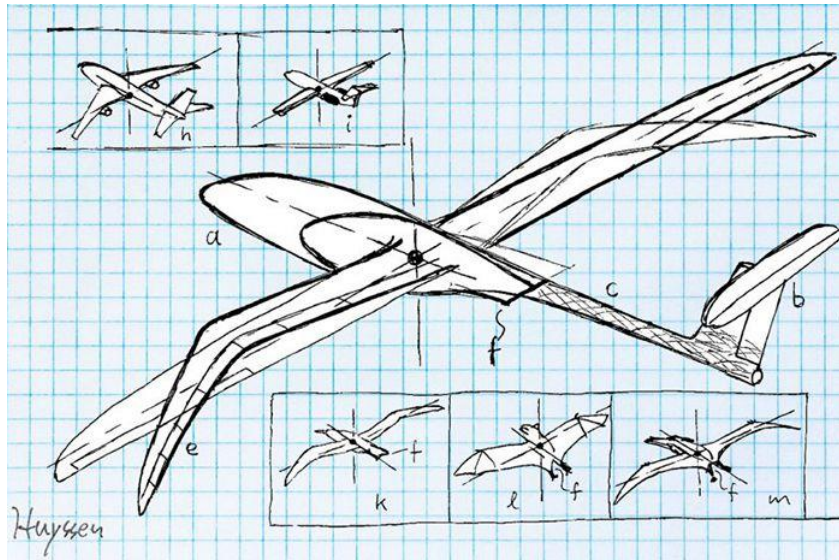
## Clean-sheet

- New configurations
- Optimize design
- Direct to market

## Propulsion Retrofit

- Accelerate development
- Reduce cost

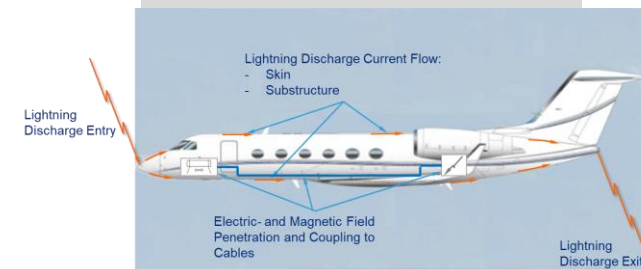
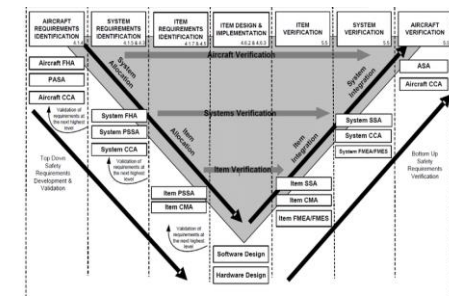
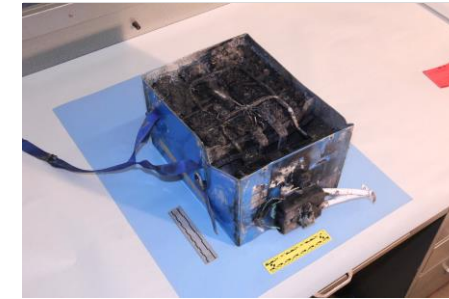
OEM is responsible for Type Certification



- Objectives: Development of
  - Means of Compliance
  - Standards
  - Test procedures
  
- EUROCAE
  - WG-112 eVTOL
  - WG-113 Hybrid/Electric Propulsion Systems
  - WG-116 High Voltage
  - ...
  
- SAE
  - E-40 Electrified Propulsion
  
- ASTM
  - F39 Aircraft Systems
  - F44 General Aviation Aircraft

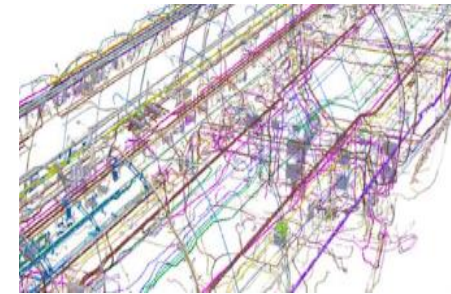
# Challenges - Design

- Physics is physics and cannot be negotiated with
- Lack of industry experience with novel technologies makes trial and error unavoidable
- Flight and propulsion control complexity is increased
- Significant amount of automation and critical **software** needs to be developed and certified
- Novel components and materials need to be developed and qualified to become reliable;
- High Voltage / High Power electronics in harsh environment (Temperature, Pressure, Moist)
- Detailed system safety assessment to be done (ARP4754B, ARP4761A) , CS-25 safety levels also for CS-23
- High levels of integration and complexity, more potential for common failure modes



# Integration - Integration

- Space allocation and zonal installation safety, battle for scarce resources
- Weight and volume allocated to packaging and harnessing of energy carriers
- Thermal management integration is required for safe and energy-efficient operation
- Interface management early on
- Unintended interfaces and interactions are discovered during design and need to be mitigated
- Implicit requirements need to be (re)discovered
- Costly and undesirable redesign iterations due to lessons learned and changing requirements
- Models and digital twins are only as good as their assumptions – testing is needed
- Multiple disruptive technologies complicate integration and certification



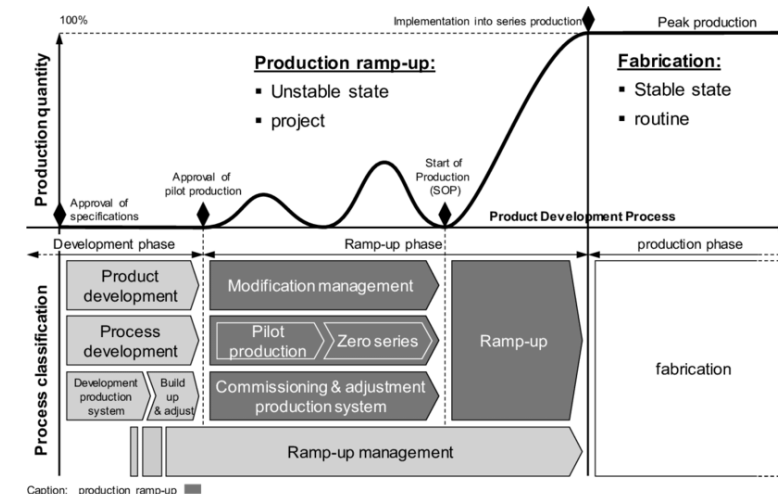
## Challenges – Industry – Authority cooperation

- Industry and authorities need both to discover this novel territory
- Authorities are criticized for slow regulation development, however...
- Industry is doing the innovations, so authorities can only follow, not lead
- Authorities are not a consultant or “the expert”, industry needs to do its homework
- Authorities and industry have a common goal and need to work together to develop Special Conditions and Means of Compliance
- Body of knowledge of legacy regulations and “know why” is slowly getting lost
- Foundational safety levels that the public expects, shall be maintained
- Certification challenges are actually engineering challenges



# Challenges – Program and Organizations

- Battery-electric aircraft development at start-up organizations create also non-technical challenges – to build up the organization, to maturity
  - Needs:
    - Acquire skilled resources, embed them, and then keep them
    - Building a supply chain; influx from automotive industry knowledge and technology is useful but requires adaptation to aerospace practices
    - Growing fast without introducing volatility and loss of organizational coherence
  - Constraints
    - Shortage of experienced resources in the current labor market
    - Experienced people are not a team “out of the box”: DOA and TC applications come in too soon, at insufficient maturity levels
    - Project and target market dynamics lead to changing requirements and costly redesigns
    - Standardization is key for viable business cases but industry is fragmented, designs are diverse, IP is protected
    - Investor appetite is slipping, to be maintained with promises of future success?



Caption: production ramp-up ■



## ADSE “Make it Work” Experience

- Building for 28 years on the Fokker Aircraft OEM integration legacy, maintained through work for all major OEMs, suppliers and customers
- ADSE provides ongoing support to various electric/hybrid developments
- Provides a unique understanding of the industry
  - Certification Support, including planning and compliance demonstration
  - Technology Appraisal and Feasibility Studies
  - Conceptual Aircraft Design
  - ADSE DOA 21J.481 with broad scope
  - Start-up and Newcomer Management Consulting
  - DOA/POA/ETSO establishment support and training
  - Engineering and integration (Interim) Management