Will the metaverse transcend the status quo?:

Challenges to overcome for relying on multiphysics smarter testing and simulation in aerospace

AIRBUS: PIONEERING SUSTAINABLE AEROSPACE FOR A SAFE AND UNITED WORLD

Prof. Linden Harris - Airbus, Technical expert

26-29 June 2023

ICAF Delft

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Agenda

- ***Recap;*** ICAF 2017 - The challenges in airbus to replace Full Scale Fatigue Testing by Predictive Virtual Testing.
- Post ICAF 2017 - SMARTER Testing
- Post ICAF 2017 - CAF
- ***Summary;*** LH2 - Introduction
- Multiphysics challenges for ATA based certification
- SAFE life systems?
- Multiphysics CAF Aleatoric and Epistemic uncertainty
- Conclusion

Recap; ICAF 2017

The challenges in Airbus to replace Full Scale Aircraft Fatigue Testing by Predictive Virtual Testing

Advanced Numerical Analysis and modelling and simulation.

Name Linden HARRIS ; Expert for Testing, Airbus SAS
Jun 2017

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Content;

- Objective of PVT
- Creation and validation needs
- Gaps - F+DT
- DoE large data
- Digital transformation
- Psychological change from Pyramid to Ladder
- Need for increased confidence

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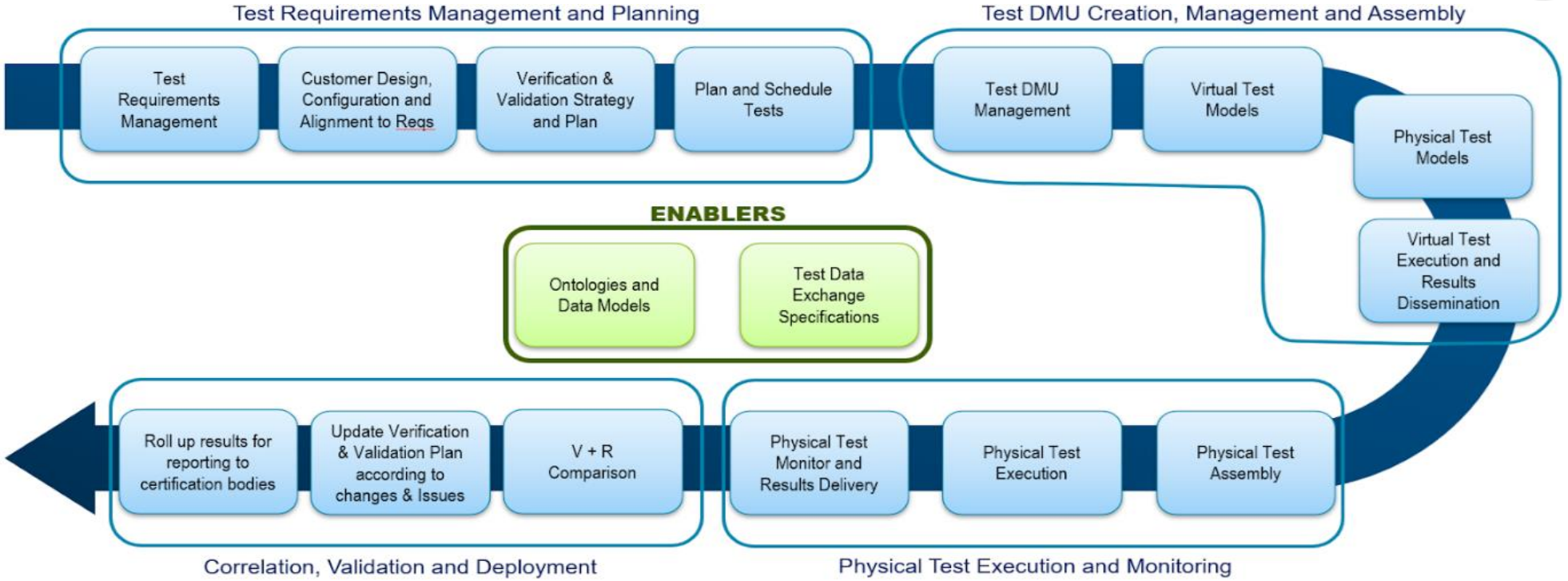
Post ICAF 2017 - SMARTER Testing ATI

Smarter Testing - Data Driven Platform



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Post ICAF 2017 - SMARTER Testing ATI

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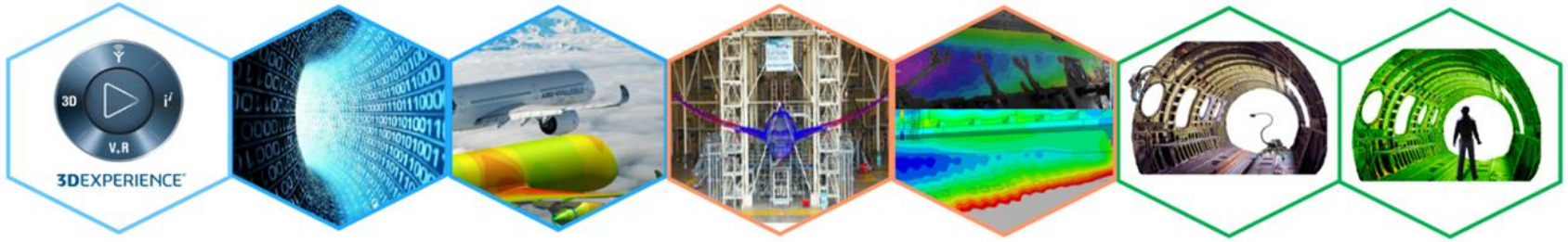
Hybrid Testing



Smarter Testing	
Data Driven Platform - DDP	**Physical Testing Solutions - PTS**
✈ Collaborative environment based on 3DEXPERIENCE	✈ Advanced measurement technologies
✈ Single point of access to virtual and physical test data	✈ Advanced quantitative data correlation
✈ Digital continuity across all test activities	✈ Advanced data analytics
	✈ Test optimization

Post ICAF 2017 - SMARTER Testing ATI

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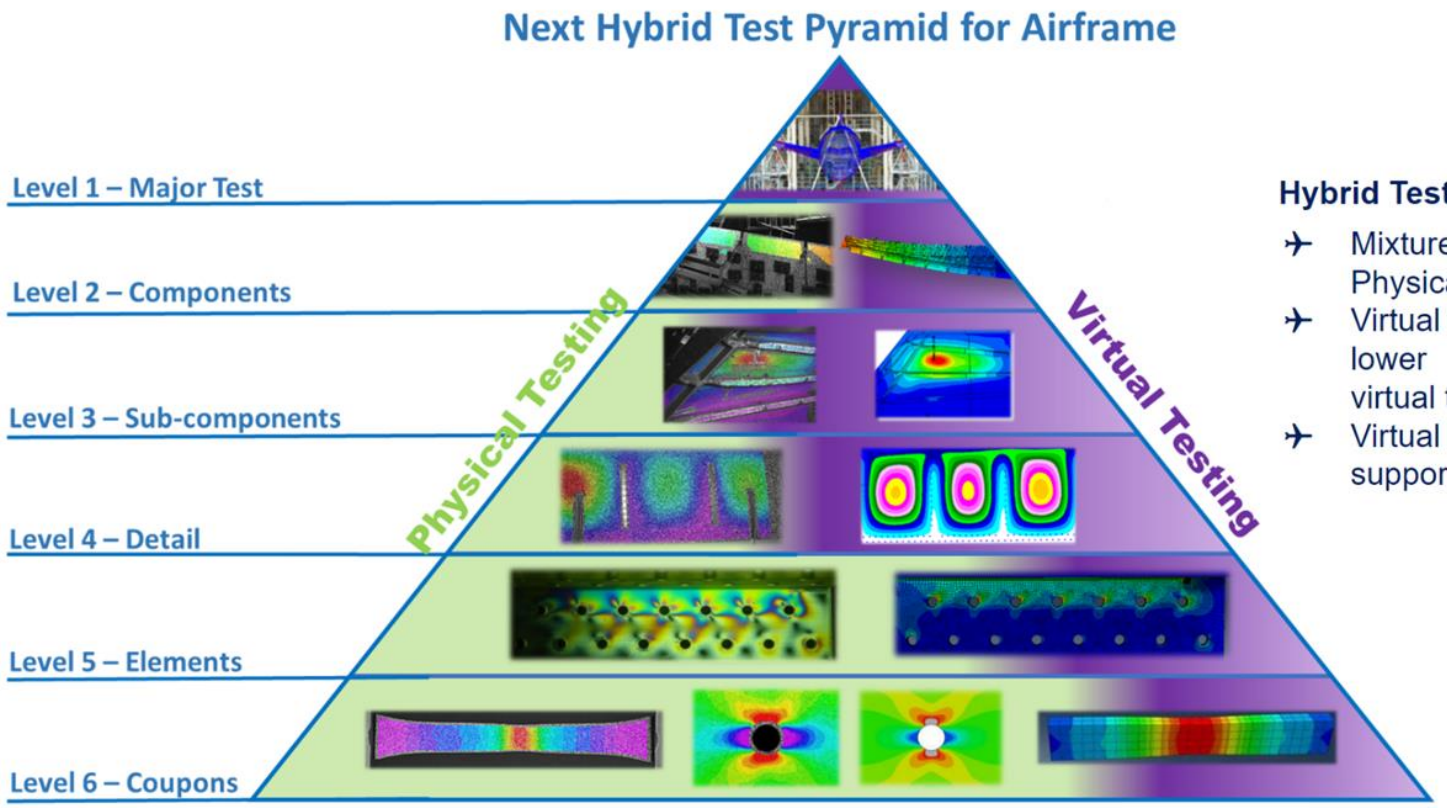
Structures Testing - To-Be Test Pyramid



Hybrid Test Pyramid

- Mixture of Virtual Testing and Physical Testing at most levels
- Virtual / Physical correlation at lower levels used to support virtual testing at higher levels
- Virtual testing used directly to support certification

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Post ICAF 2017 - Credibility Assurance Framework Industrial working group

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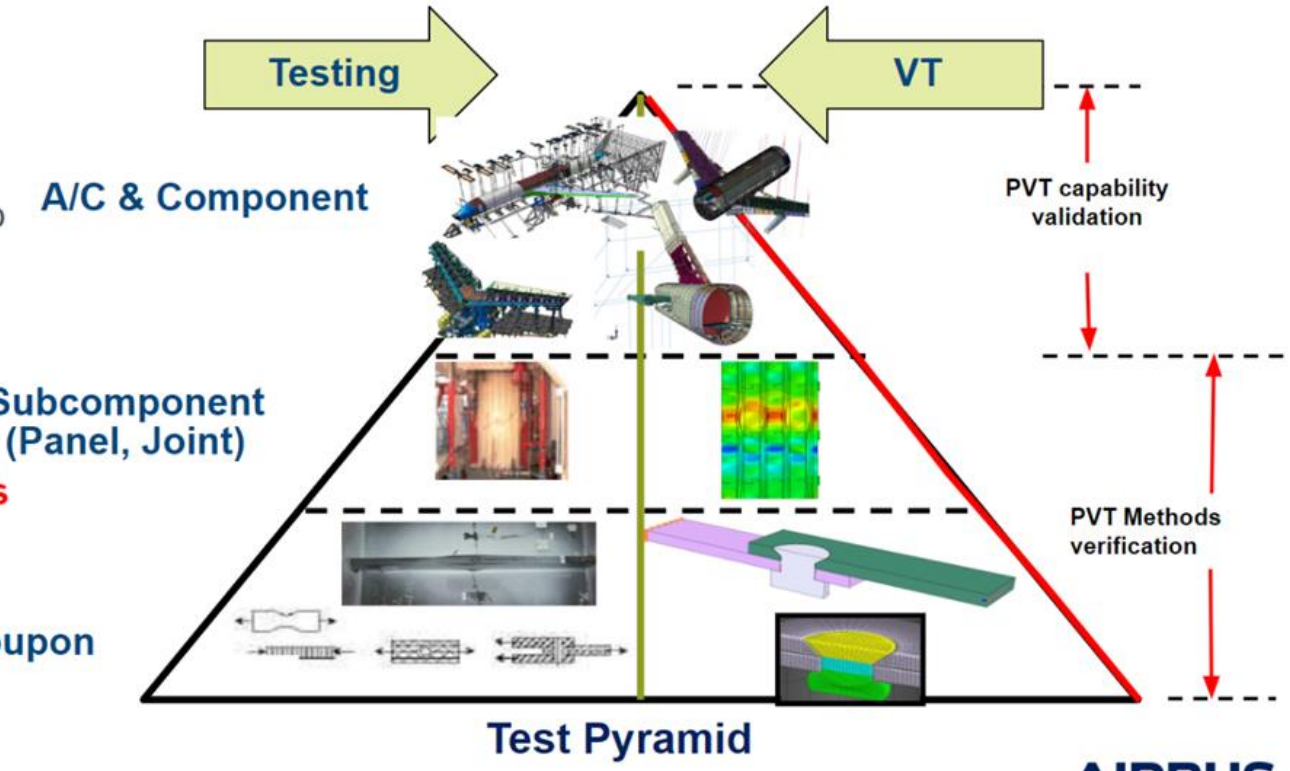
Refresher; How to build confidence?

- Definition;
  - **Confidence** is a state of being certain either that a hypothesis or prediction is correct or that a chosen course of action is the best or most effective. *(Wikipedia)*
  - **Confidence** is the quality of being certain of your abilities or of having trust in people, plans, or the future. *(Cambridge dictionary)*
- Or by the understanding of Uncertainty;
  - High complexity – validation
    - The process of evaluating **PVT capability** to determine whether it meets the specified requirements.
  - Low low – verification
    - The process of evaluating the **PVT methods** development (not the PVT capability) to determine how they meet the specified requirements.



Post ICAF 2017 - Credibility Assurance Framework Industrial working group

"Industry Standard to Promote and Support Airframe Structures Modelling & Simulation for Certification"

Airframe Structures M&S Credibility Assurance Framework (CAF)

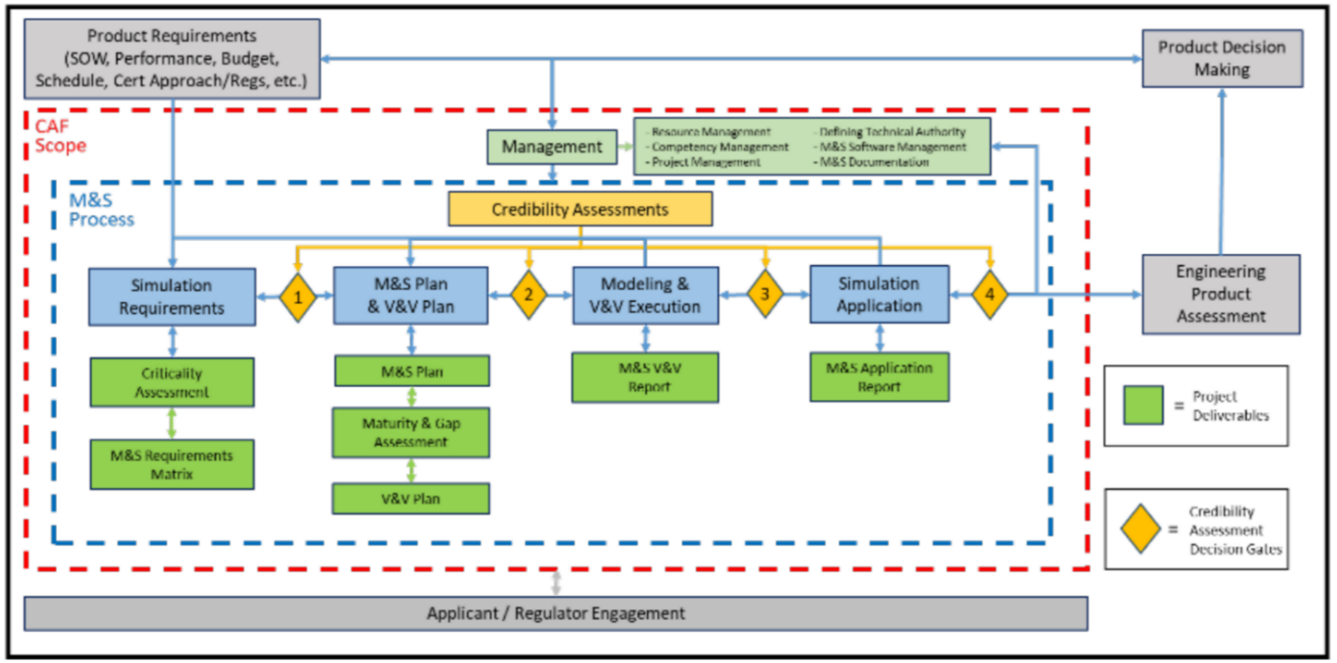
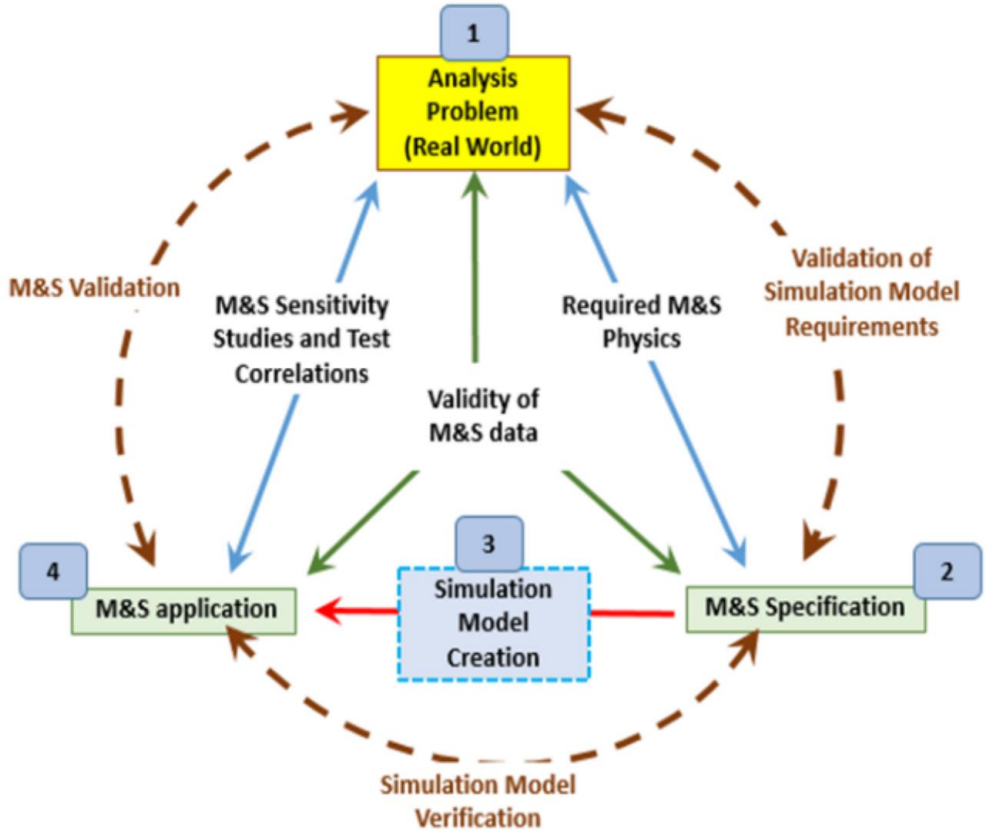


Figure TBD: M&S Credibility Assurance Framework



M&S Working and V&V Framework

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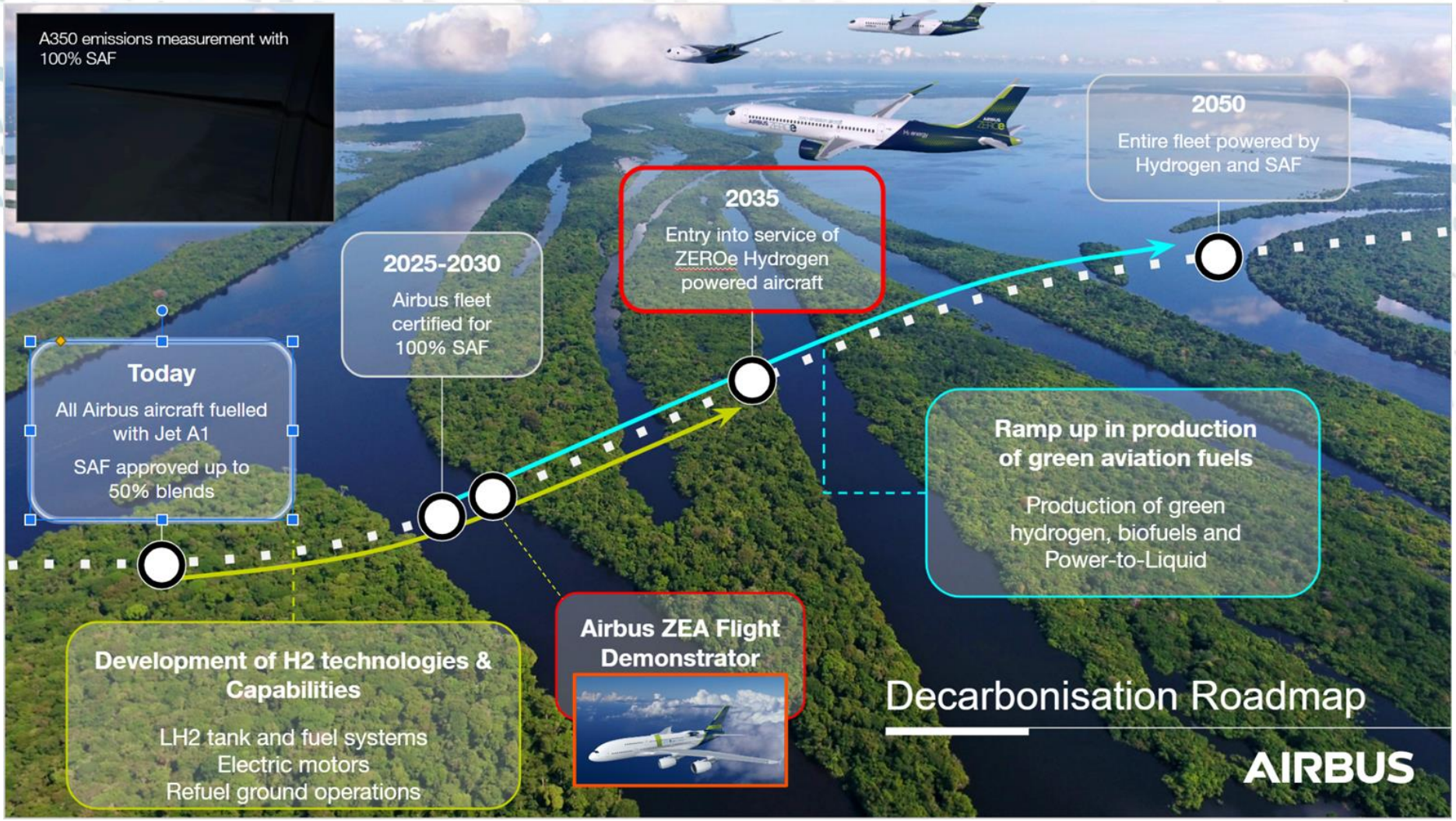
Summary; LH2 - Introduction



(Aerospace testing symposium 2022, Farnborough)

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Summary; LH2 - Introduction

(Aerospace testing symposium 2022, Farnborough)

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Summary; LH2 - Introduction

(Aerospace testing symposium 2022, Farnborough)

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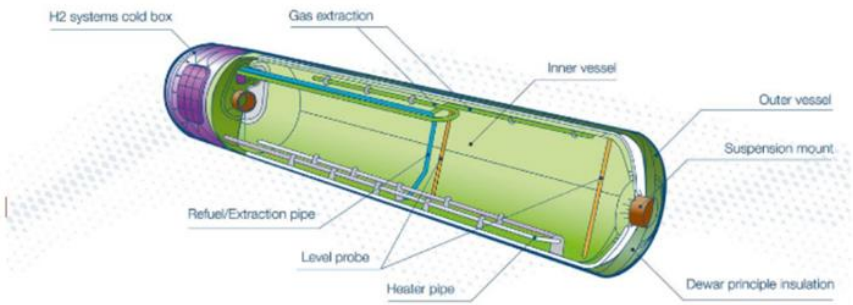
Summary; LH2 - Introduction

Hydrogen Storage

[Airbus Amber]

Liquid H_2 tank



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Multiphysics challenges for ATA based certification

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Structure V&V

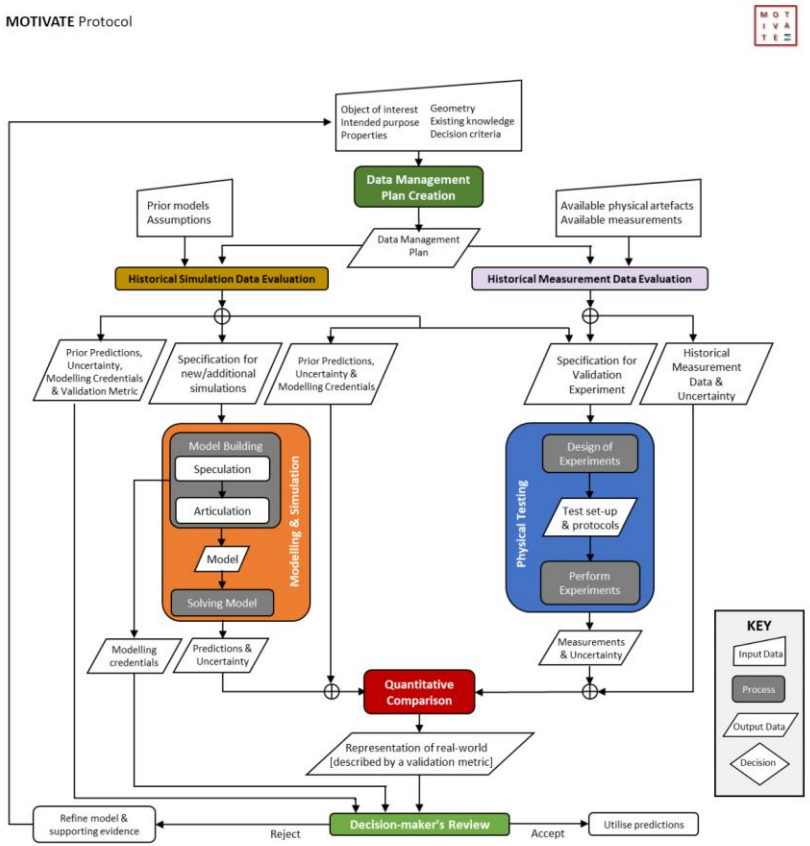
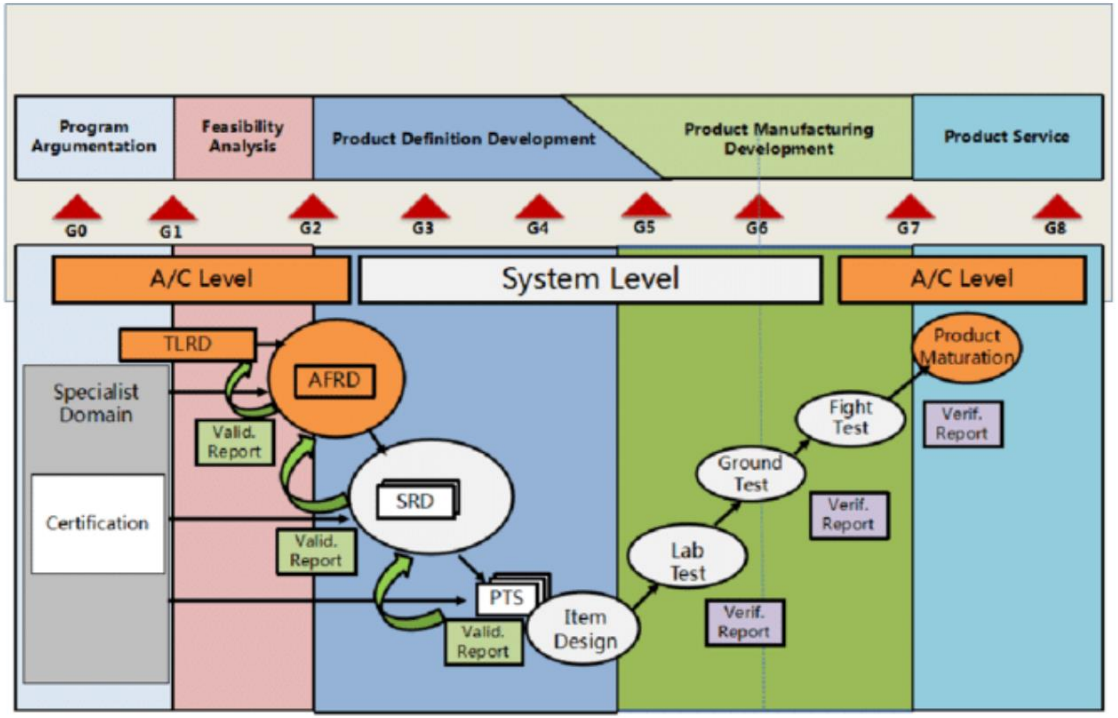


Fig. 1: A revised version of the MOTIVATE validation flowchart, updated relative to Hack et al.[2] following user feedback. The coloured boxes represent sub-charts broken out in tabular form over the next sections.

Systems V&V



The civil aircraft requirement based development process.

Is it a Structure or a system; Depends on the regulations……

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Multiphysics challenges for ATA based certification

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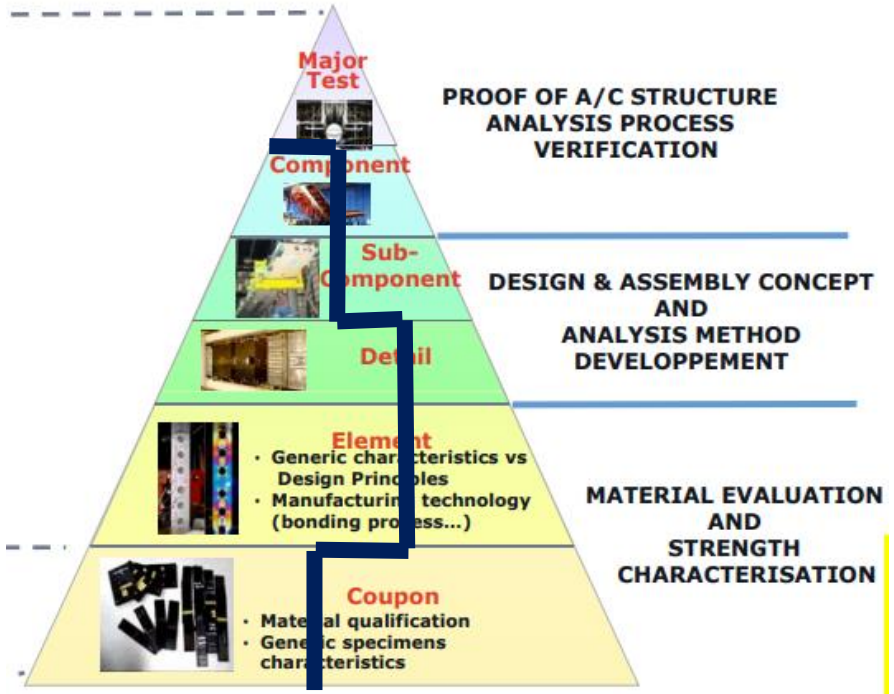
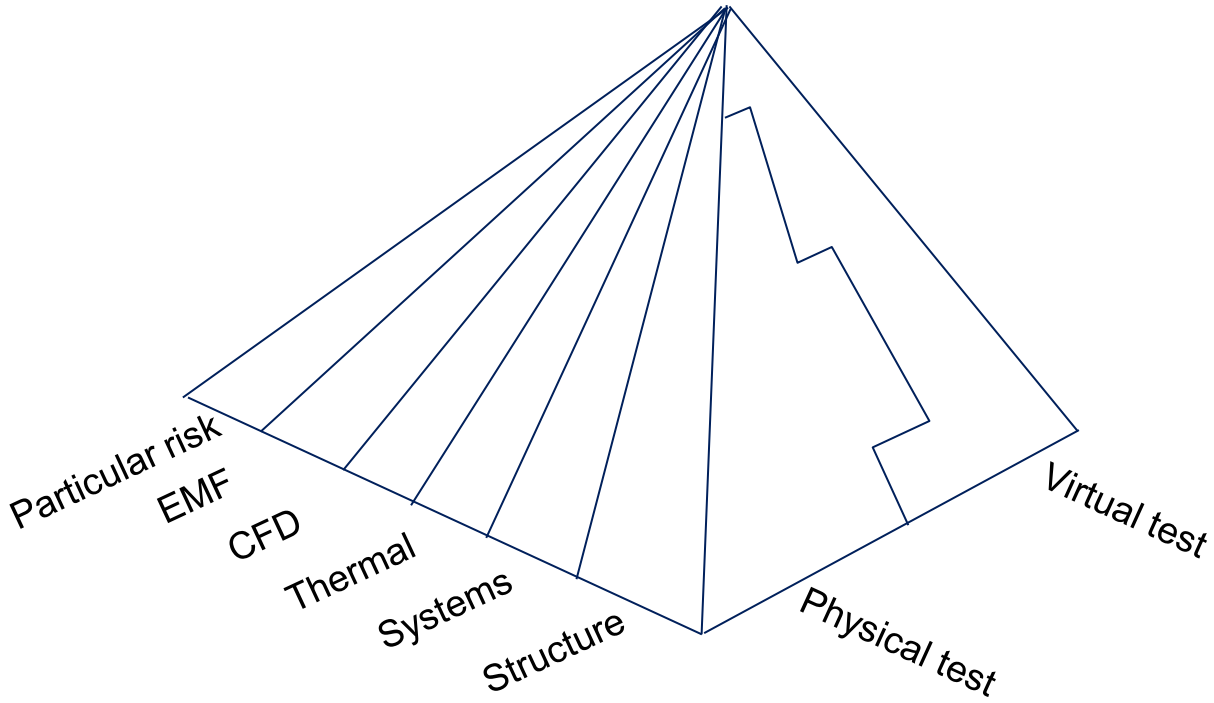
Structure test pyramid triangle

“True” pyramid……





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Multiphysics challenges for ATA based certification

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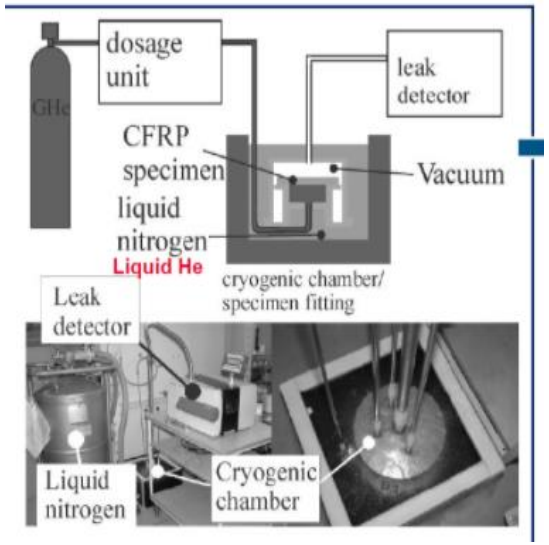
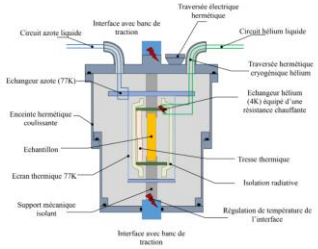
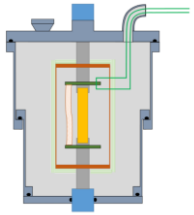
Physical & chemical

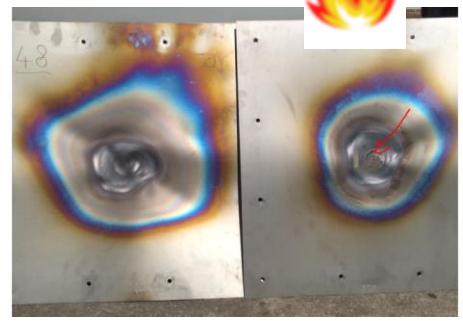


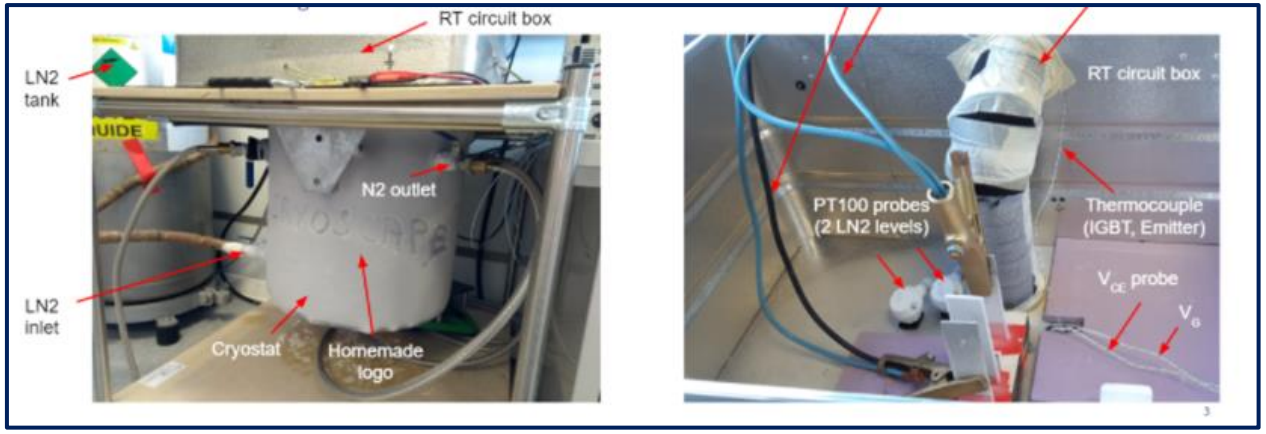
mechanical tests

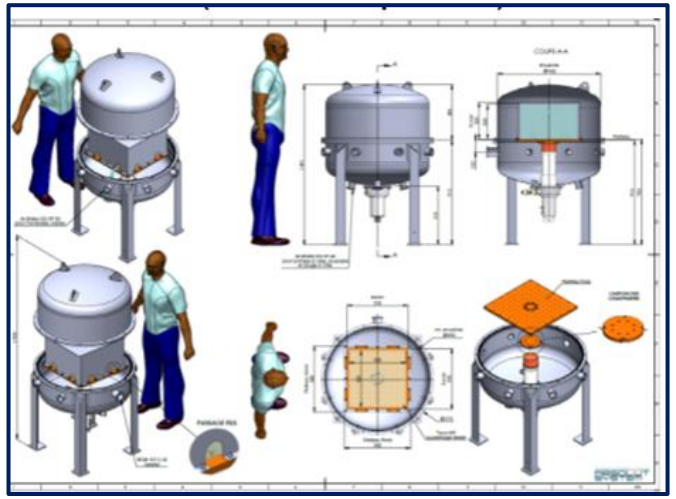




Fire safety







Airbus Structures Test capability development

(Aerospace testing symposium 2022, Farnborough)

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Safe Life systems?

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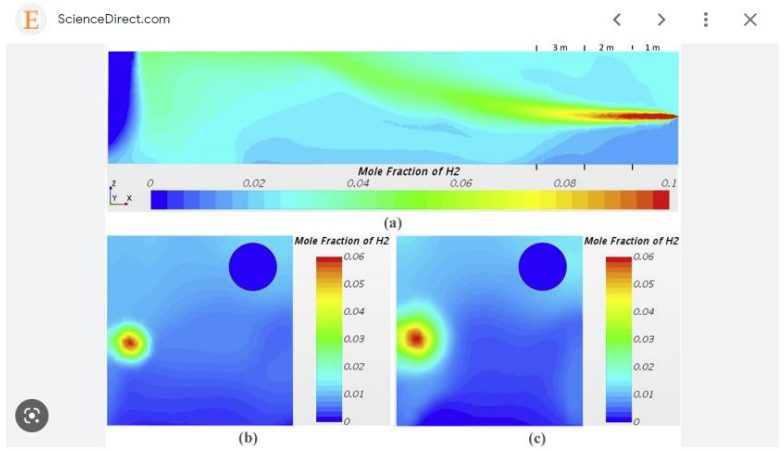
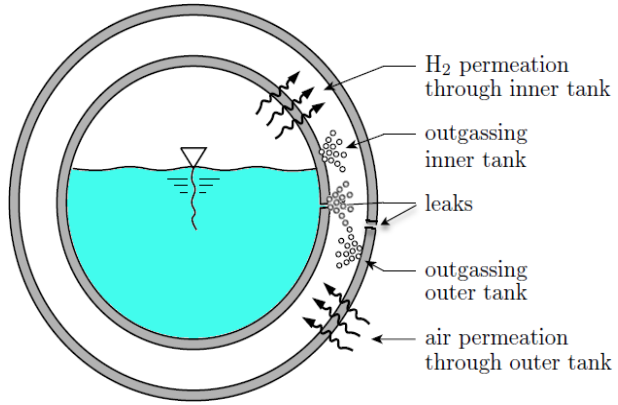
(NASA Artemis open source data).



(Science Direc)t

Permeation & Leakage



(Semantic Scholar)

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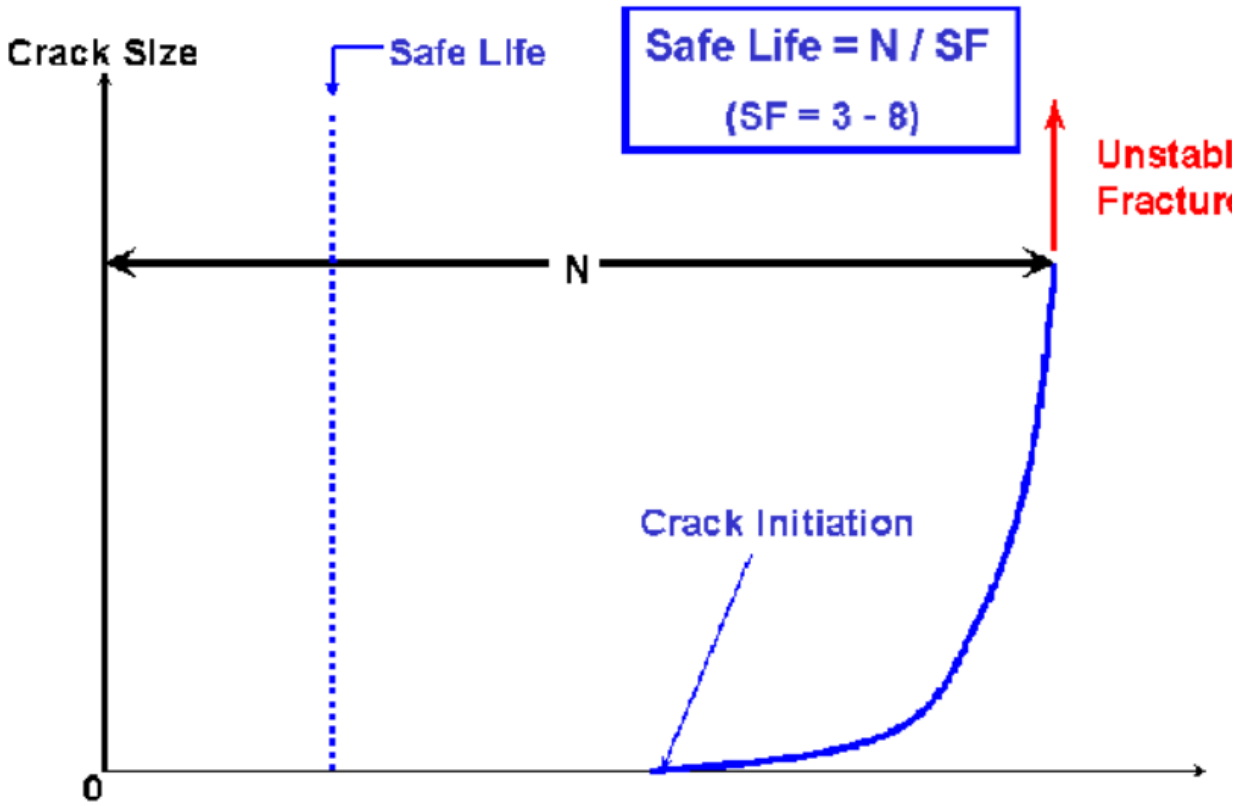
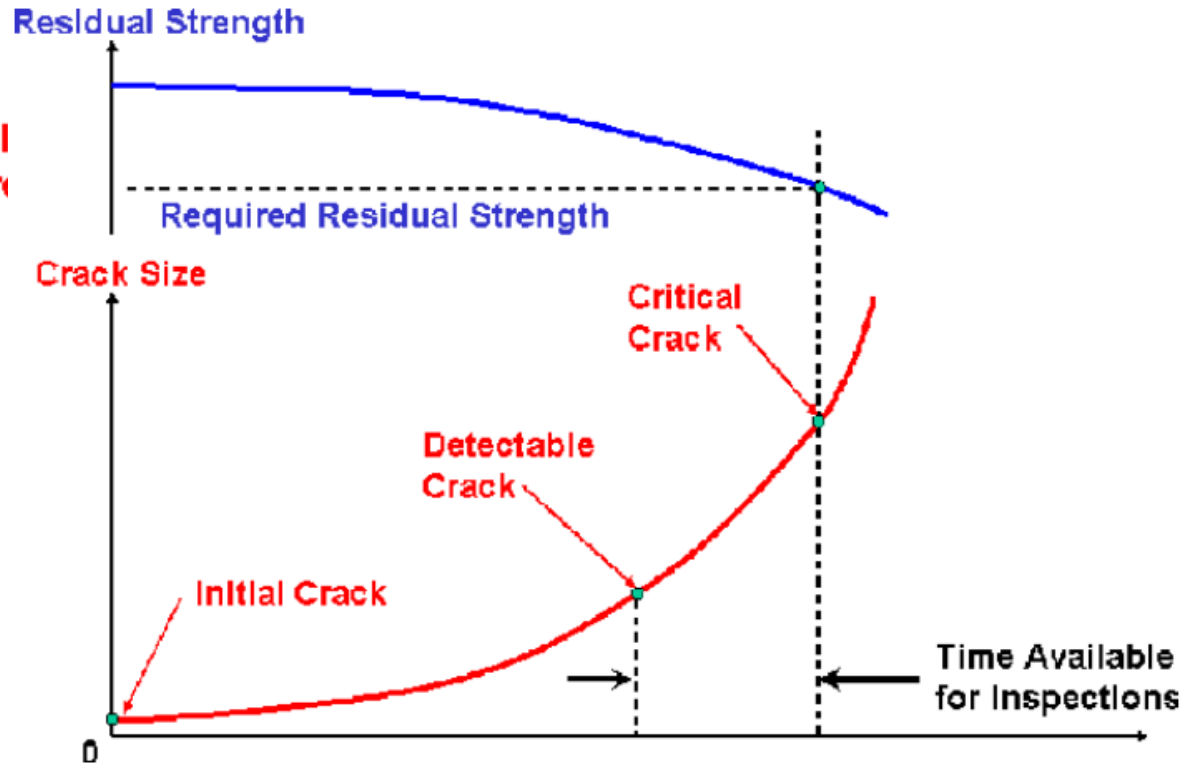
Safe Life systems?



The safe-life concept for ensuring a sufficient service life.



The damage-tolerance concept for ensuring a sufficient service life.

(Research Gate)

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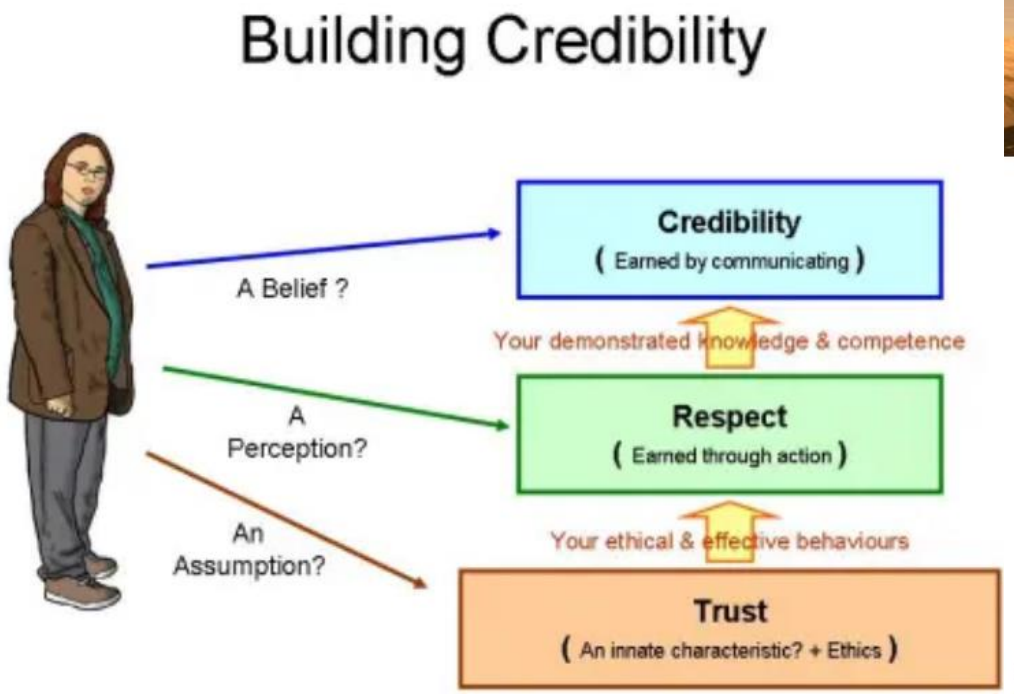
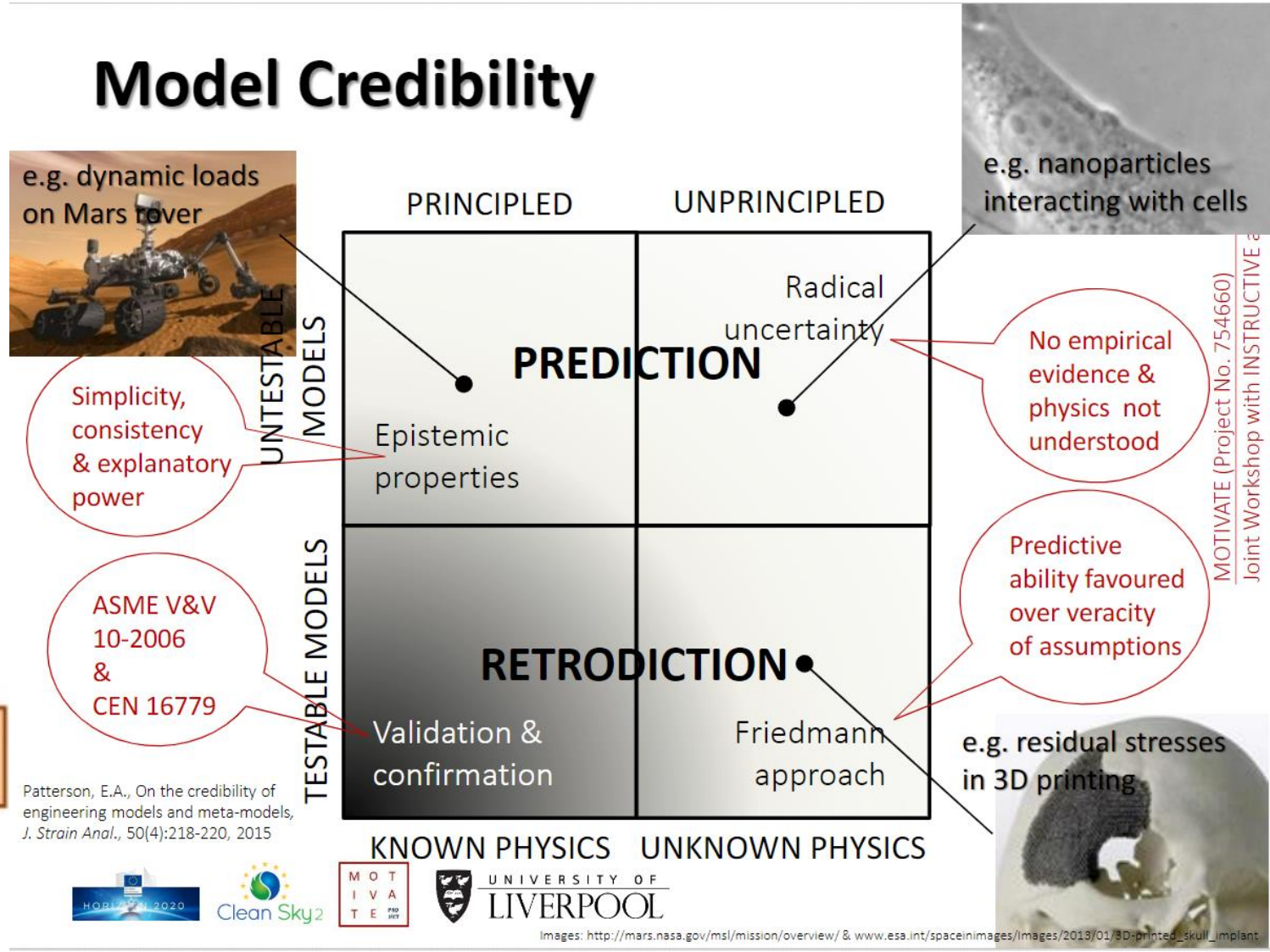
Multiphysics CAF Aleatoric and Epistemic uncertainty



(WWW Stakeholder management)



(Patterson, 2018)

(Aerospace testing symposium 2022, Farnborough)

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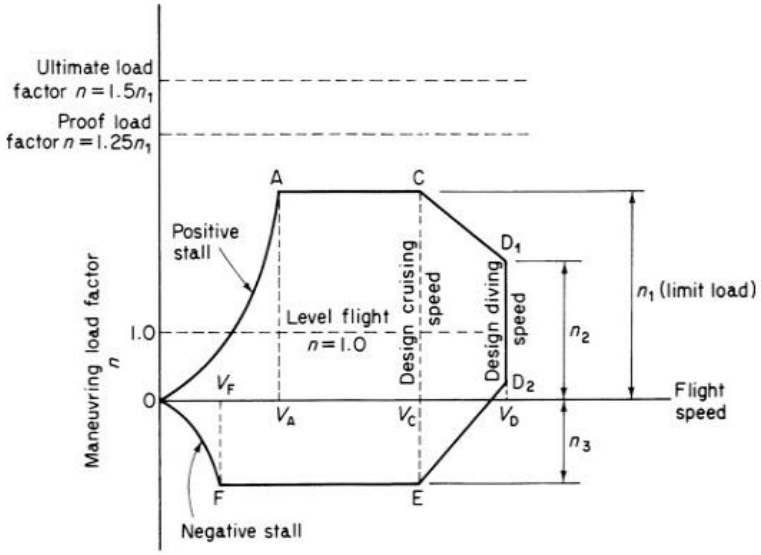
Multiphysics CAF Aleatoric and Epistemic uncertainty

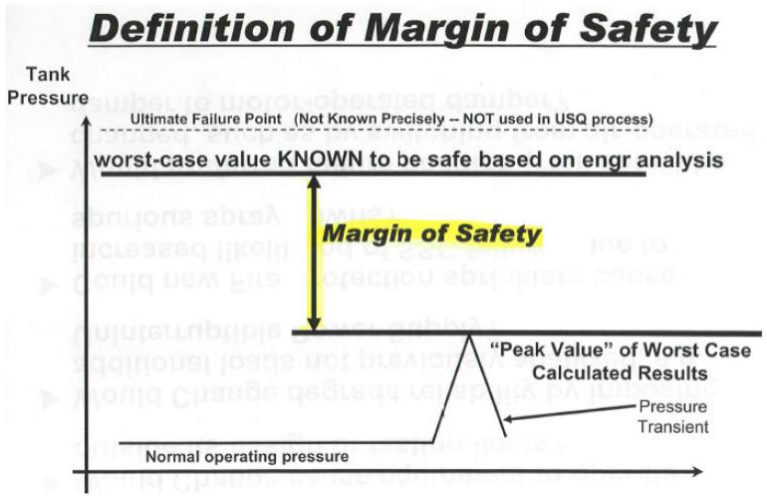
Flying Test Bed confidence

Crew safety

Airframe safety



System safety



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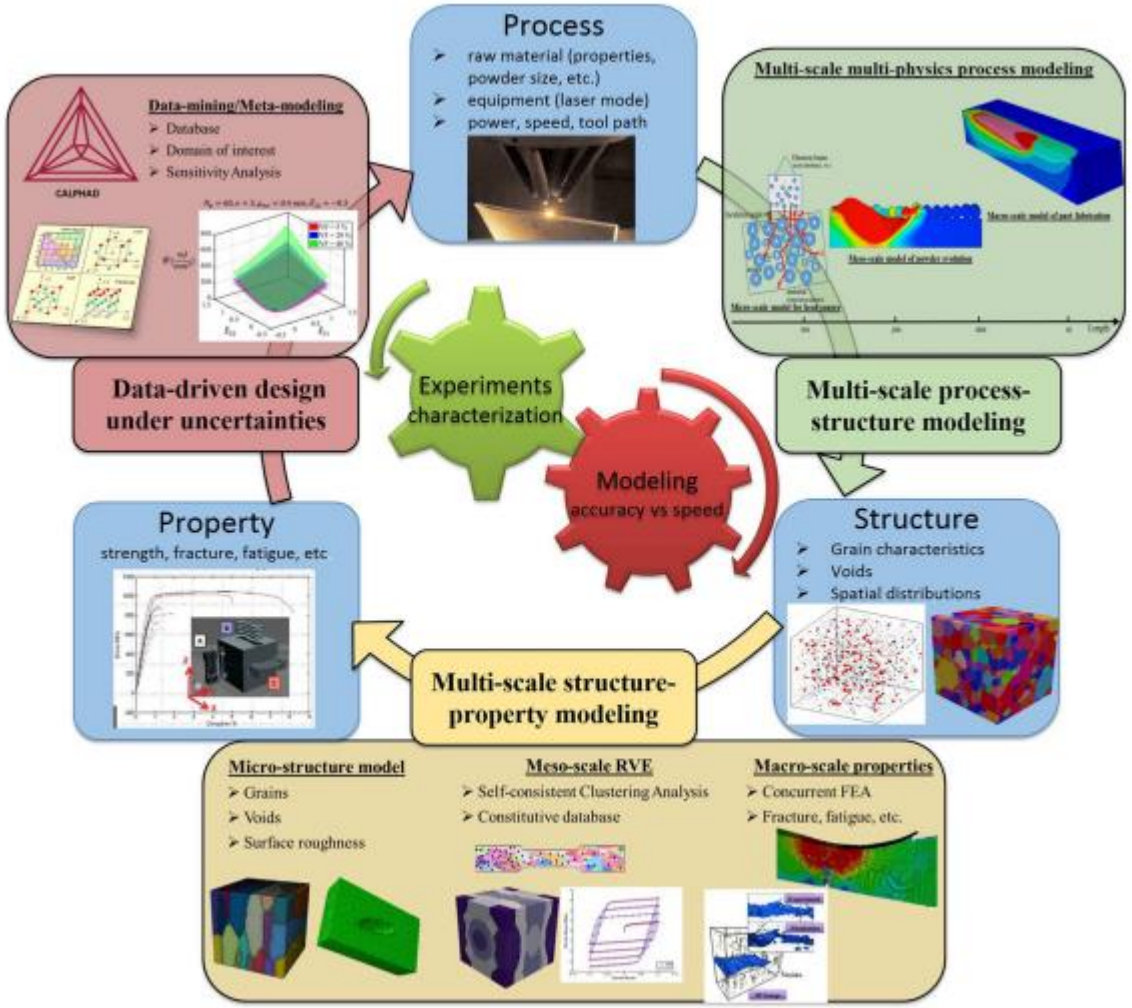
Conclusion

TRL6 requirements



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Thank you

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Will the metaverse transcend the status quo?: Challenges to overcome for relying on multiphysics smarter testing and simulation in aerospace

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Abstract. Smarter testing and simulation of aerospace structures can allow development lead-time and costs to be decreased when compared to the current methods, which rely almost solely on physical testing. By combining outputs from computer simulations with physical approaches, an optimised process of hybrid testing, based on the concept of a digital twin, can be applied throughout the lifecycle of a product from development to certification.
But now our challenge is to integrate cryogenic LH2 fuel storage and distribution systems into our airframes which will require our thinking to transcend into a multiphysics world, with a high level of credibility.

Introduction

The development and certification of aerospace structures requires significant investment from industry in time, labour, and money and can have a major impact on competitiveness.

Physical testing of aerospace materials from coupons to components through to full-scale aircraft allows the behaviour under flight conditions to be observed and quantified, permitting the development of new components and aircraft (i.e., the status quo). The use of simulation and augmented reality (metaverse) technologies, combined with this physical testing, allows a "digital thread" to combine information from the full product lifecycle. These changes have the potential to decrease development lead-time and costs, and therefore make the design and certification process more efficient and competitive.

The reliance on a digital thread and associated simulation tools is increasing almost exponentially in industry, mainly in order to decrease the development lead time but also to improve product robustness or maturity. For the aerospace industry the need to maintain product safety is paramount and the certification process is mandatory to ensure this is achieved. But there is also a business and market need to develop and manufacture aircraft faster so we can replace the aged inefficient fleet powered by fossil fuels with more modern clean and environmentally efficient airliners [1].

The challenges of integrating a LH2 fuel storage and distribution system into our airframes will cause us to examine how our different physics interact, how they are linked together, and more importantly how the uncertainties propagate between them and are validated. It is likely to challenge the "ATA" based certification meaning in place today in particular how traditional systems certification can be thought of as safe life.

Model validation

In order to use simulation in the place of, or in combination with, physical testing, confidence in the computer simulations must be assured. This assurance can be provided using quantitative validation, where the prediction outputs of models are compared to "real-world" measurement data and an assessment can be made of how well the predictions represent the measurements [2,3].

However as most of this validation relies on traditional measurement techniques, these will need to be repurposed for multiphysics validation in order to be able to measure the individual parameters identified by the multiphysic simulation. Our challenge is to be able to derive a credible validation which fully describes the new environment of our Airframe.

References

[1] L. Harris *The challenges in airbus to replace Full Scale Aircraft Fatigue Testing by Predictive Virtual Testing* 35th ICAF Conference (2017) p. 1226-1231.
[2] *Standard for verification and validation in computational solid mechanics*, ASME V&V 10-2019. New York, NY: American Society of Mechanical Engineers, 2020.
[3] *Validation of computational solid mechanics models*, CWA 16799:2014. Brussels: Comité Européen de Normalisation, 2014.