ICCM23 workshop on 'Modernising Routes to Compliance with Composite Regulations: A Journey towards Virtual Testing and Digital Twinning'

Modernising Routes to Compliance with Composite Regulations: A Journey towards Virtual Testing and Digital Twinning

Ole Thybo Thomsen, Janice Dulieu-Barton & Stephen Hallett, Bristol Composites Institute, University of Bristol, UK

Enrique Garcia, National Composites Centre, Bristol, UK

Richard Butler & Andrew Rhead, University of Bath, UK

Overview

- Successful ‘industrial needs’ sessions on modernising composites regulations at previous ICCM in Xi’an in 2017, and the in Melbourne 2019
- Follow up from the previous workshops and University of Southampton position paper (2017) and NPL study (2019)
- Aim to define a cross sector view on the need for modernisation of routes to demonstrate compliance with composites regulations.
- Promote discussion on viable routes forward to reducing the burden of meeting regulations, including reducing cost and time to market whilst also enabling improved performance.

Programme Part 1

15:00-15:05: ‘Welcome & background and aims of workshop / introduction to speakers’: Janice Barton

15:05-15:15: ‘CerTest: scientific foundations for a novel framework for performance validation of composite aerostructures relying less on physical testing and adopting digital twinning’, Ole Thomsen, Bristol Composites Institute, University of Bristol, UK

15:15-15:45: ‘‘CerTest: enhanced performance and productivity through integration of multi-scale modelling, high-fidelity experimentation and Bayesian learning’, Richard Butler & Andy Rhead, University of Bath, UK

15:45-16:00: ‘Developing composite (and other advanced manufactured) product certification – a regulator perspective’, Simon Waite, EASA, DE

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Programme Part 2

16:30-16:50: ‘Session 1 Questions & Panel discussion’ / chaired by *Janice Barton*

16:50-17:05: ‘Overview of current processes and future developments in composites certification – a wind turbine industry perspective”, *Chris Harrison, DNV Denmark*, DK

17:05-17:20: ‘VVUQ framework to assess credibility of simulation of composite structures’, *Ludovic Barriere, IRT Saint Exupéry*, F

17:20-17:35: ‘Regulatory barriers across to efficient validation and certification of composites across sectors and applications’, *Enrique Garcia, National Composites Centre*, UK

17:35-17:50: ‘An Airbus perspective on challenges in certification for future airframes’, *Linden Harris, Airbus*, UK

17:50-18:05: ‘Offshore wind turbine blade certification – challenges and opportunities’, *Stephen Randall Vestas Wind Systems*, UK

18:05-18:20: ‘Barriers and opportunities in certification of composites for infrastructure applications’, *Lee Canning, Jacobs*, UK

18:20-18:40: ‘Session 2 Questions & Panel discussion’ / chaired by *Janice Barton*

CerTest: Scientific foundations for a novel framework for performance validation of composite aerostructures relying less on physical testing and adopting digital twinning

Ole Thybo Thomsen

Bristol Composites Institute, University of Bristol, Bristol, UK

Outline

- Background and motivation – what is the problem?
- CerTest
- Overview of research challenges and methodology
- Steps towards demonstration of new methodology

The prize?

Outline

- ...tivation – what is the problem?
- Step...

REDUCED DEVELOPMENT TIME / TIME TO MARKET!

REMOVING/REDUCING BARRIERS TO INNOVATION POSED BY CURRENT PROCESSES

The prize?

Background and motivation – is there a problem?

- Mostly tests on coupon and generic element levels of testing pyramid – for certification purposes
- Few test on component/structural detail and full structure levels – but full scale tests are required for certification (very costly and time consuming)
- Full scale & component/structure tests – wind blade (LM Wind Power) & wing (Airbus)

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Complience with safety regulations – currently using ‘building block’ / ‘testing pyramid’

1. **Coupon:** a small test specimen for evaluation of basic laminate properties or properties of generic structural features
2. **Element:** A generic part of a more complex structural member
3. **Detail/Component:** a non-generic structural element of a more complex structural member
4. **Component/Full structure:** major three-dimensional structure - complete structural representation of a section of the full structure (or the full structure)

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Complience with safety regulations – currently using ‘building block’ / ‘testing pyramid’

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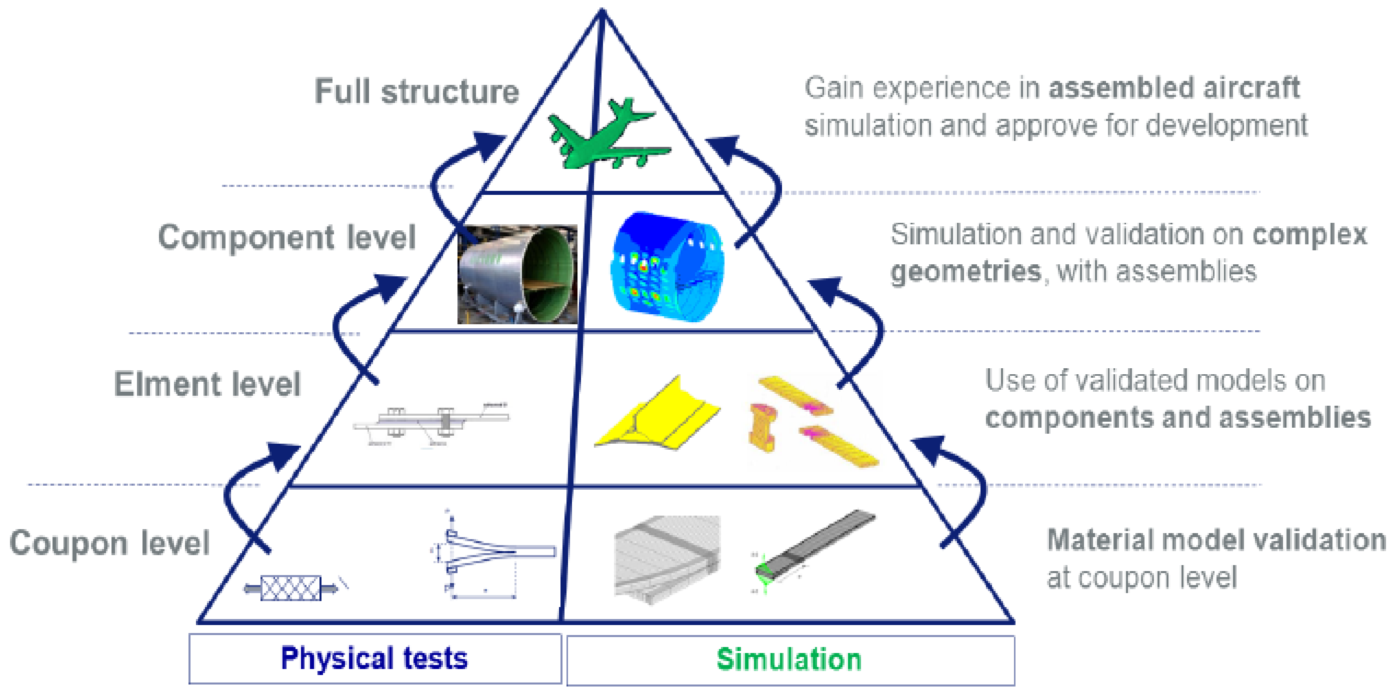

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Complience with safety regulations – currently using ‘… ’ / ‘testing pyramid’

Comprehensive and systematic methodology to prove/demonstrate airworthiness and proof of structural integrity - backbone of the certification processes for composite aerostructures, wind turbine blades, …

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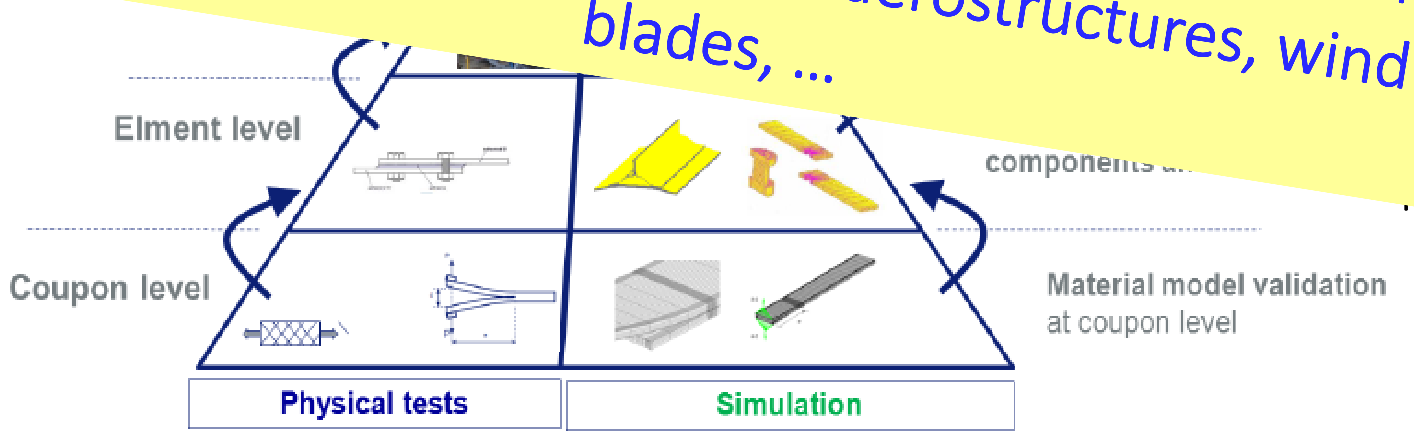

EVIDENCE – limitations to Building Block approach

- Failure models largely based on inputs derived from coupon tests comprising simple, mainly uniaxial, loading modes and unidirectional materials
- Large number of coupon tests to define 'allowables' - relatively few tests mid-tier and top-tiers of pyramid (larger length scales)
- Underlying assumption: Material properties from tests at the coupon level can be used to define design allowables at greater length scales
- Coupon properties do not represent the 'in-situ' properties well
- Transfer/upscaling of 'allowables' from coupon level to higher levels leads to large knock-down factors, lack of understanding of MoS and reliability on structure/system level
- Excessively costly (especially top-tier) and time consuming

Can we do things more efficiently (safer, cheaper, reduced time)?

- Reduce bottom tier of pyramid?
- Coupon tests still required – but at reduced levels/numbers (how many?)
- Reduce/eliminate top tier of pyramid?
- Modelling & testing integrated – validation: Mid-tiers of pyramid structural scale
- Models used to inform tests – tests used validate/inform models – *Data Fusion* & *Design of Experiments*
- High-fidelity tests – calibration/validation of model predictions
- Models benchmarked/challenged and validated via SUFFICIENTLY COMPLEX TESTS (geometry and load complexity) on structural length scales

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Can we do things more efficiently (safer, cheaper, reduced time)?

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- Mod of *Experiments*
- High-fidelity tests – calibration/validation of
- Models benchmarked/challenged and validated via **SUFFICIENTLY** co metry and load complexity) on **structural** length scales

If successful …
generic methodology/framework would be transferable to other emerging materials/ manufacturing technologies (AM, 3D printing, …)

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- Programme Grant: *'Certification for design – Reshaping the Testing Pyramid' (CerTest)*
- Grant award: £6.9M over 5 years (2019-2024)

CERTIFICATION FOR DESIGN: RESHAPING THE TESTING PYRAMID

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CERTIFICATION FOR DESIGN: RESHAPING THE TESTING PYRAMID

Close interaction with EASA

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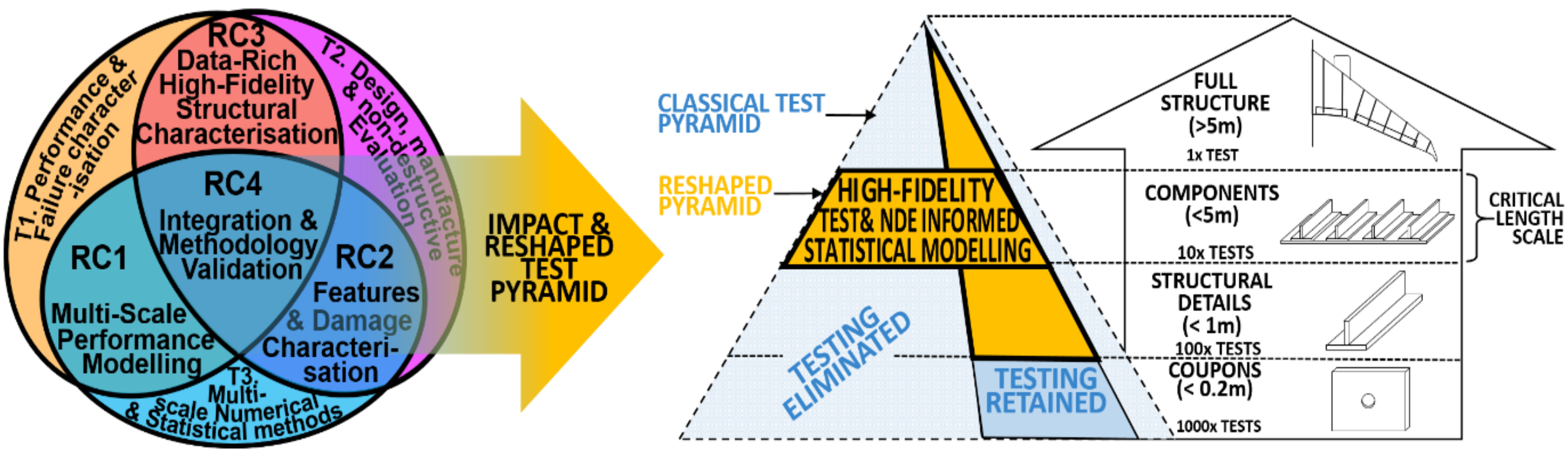
Aim – Development and validation of scientific/engineering tools that will enable VIRTUAL composite structure performance validation - relying on less physical testing and accounting for uncertainty and variability on all levels

Key enabler – integration of multi-scale modelling and high-fidelity data-rich testing on structural scale via Bayesian learning and ‘Design of Experiments’



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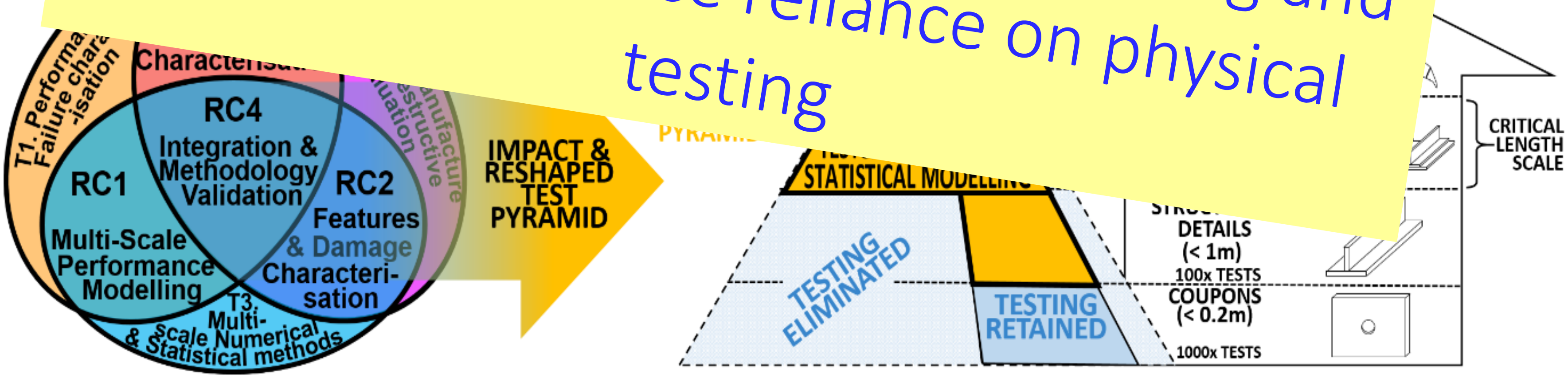
Key enab… delling and high-fidelity data-rich testing on structur… ents'

Decisive move towards virtual testing and validation – reduce reliance on physical testing



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RC1
Multi-scale Performance Modelling

RC2
Features and Damage Characterisation

RC3
Data-rich High Fidelity Structural Characterisation

RC4
Integration and Methodology Validation

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- RC1 – lead: Richard Butler (Bath)

  Focus: Multi-scale statistical modelling framework incorporating Bayesian statistics – load response & damage (HPC & surrogate models/GPEs)

- RC2 – lead: Stephen Hallett (Bristol)

  Focus: NDE toolset for damage & intrinsic meso-scale features, as-designed & deviations from design - knowledge base of structurally important features and in-service damage

- RC3 – lead: Janice Barton (Bristol)
  - Focus: Data-rich experimental techniques - evolving stress/strain due to features, defects and damage - high-fidelity data-rich testing - complex loading

- RC4 – lead: Ole Thomsen (Bristol)
  - Focus: Integration of data-rich experimental procedures and statistical and multi-scale models - Bayesian Learning and DoE techniques

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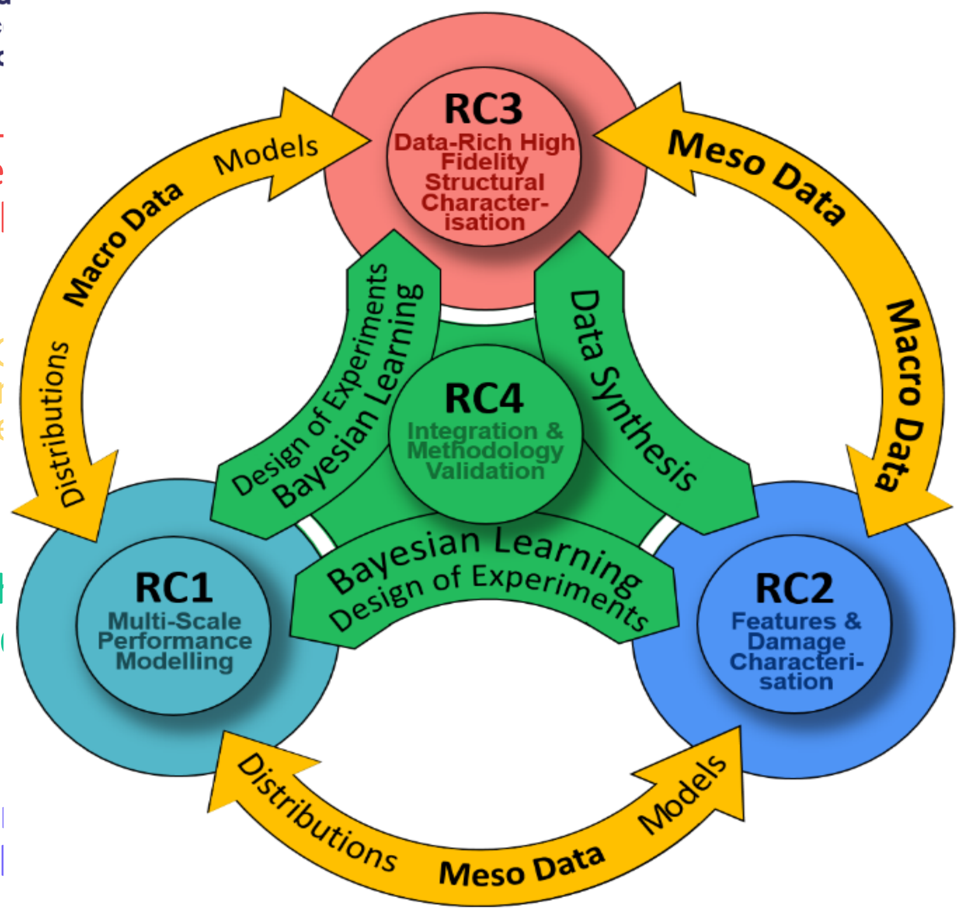

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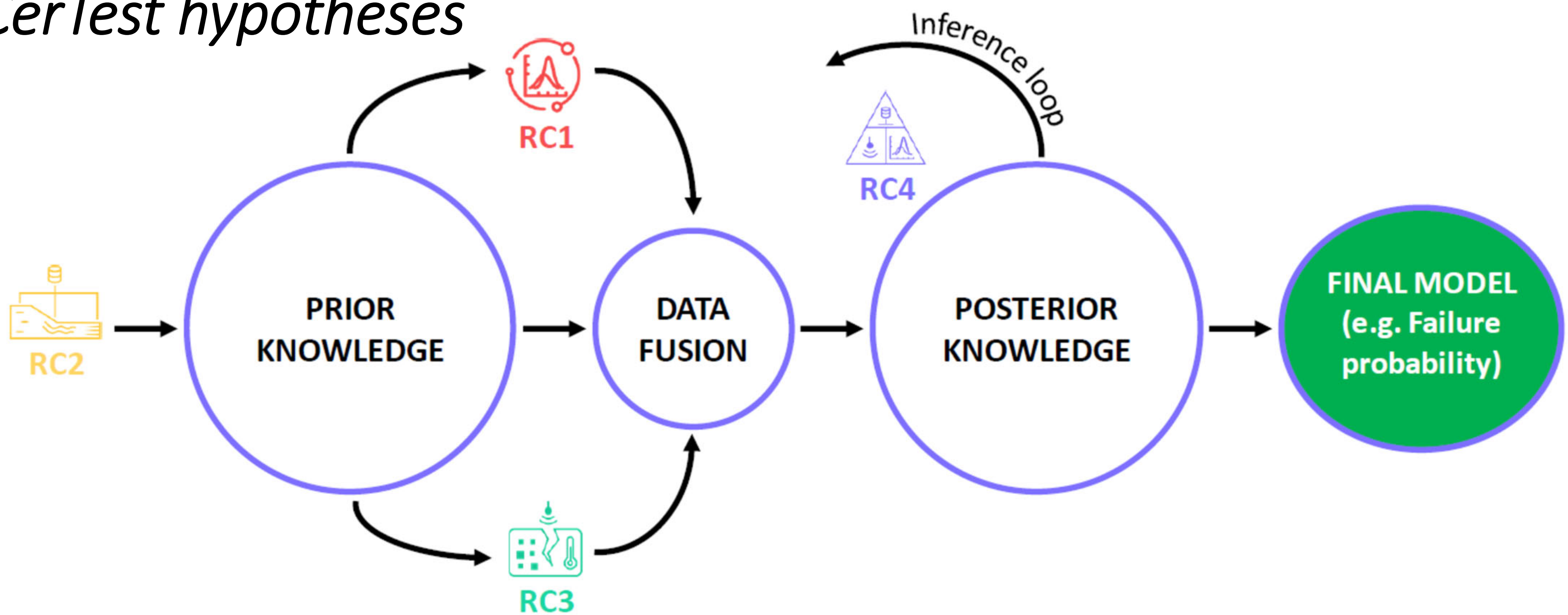

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Thank you for your attention. Questions?

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