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Construction Of Novel CERTification methOds
and means of compliance for disruptive technologies

EASA Certification Roadmap on H2 — International Workshop

CONCERTO – CRL & TRL for disruptive technologies and products: application to H2 aircraft

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CONCERTO in a nutshell

Construction **O**f **N**ovel **CERT**ification meth**O**ds and means of compliance for disruptive technologies

COORDINATED BY DASSAULT AVIATION

With participation of

Key objectives of this participation:

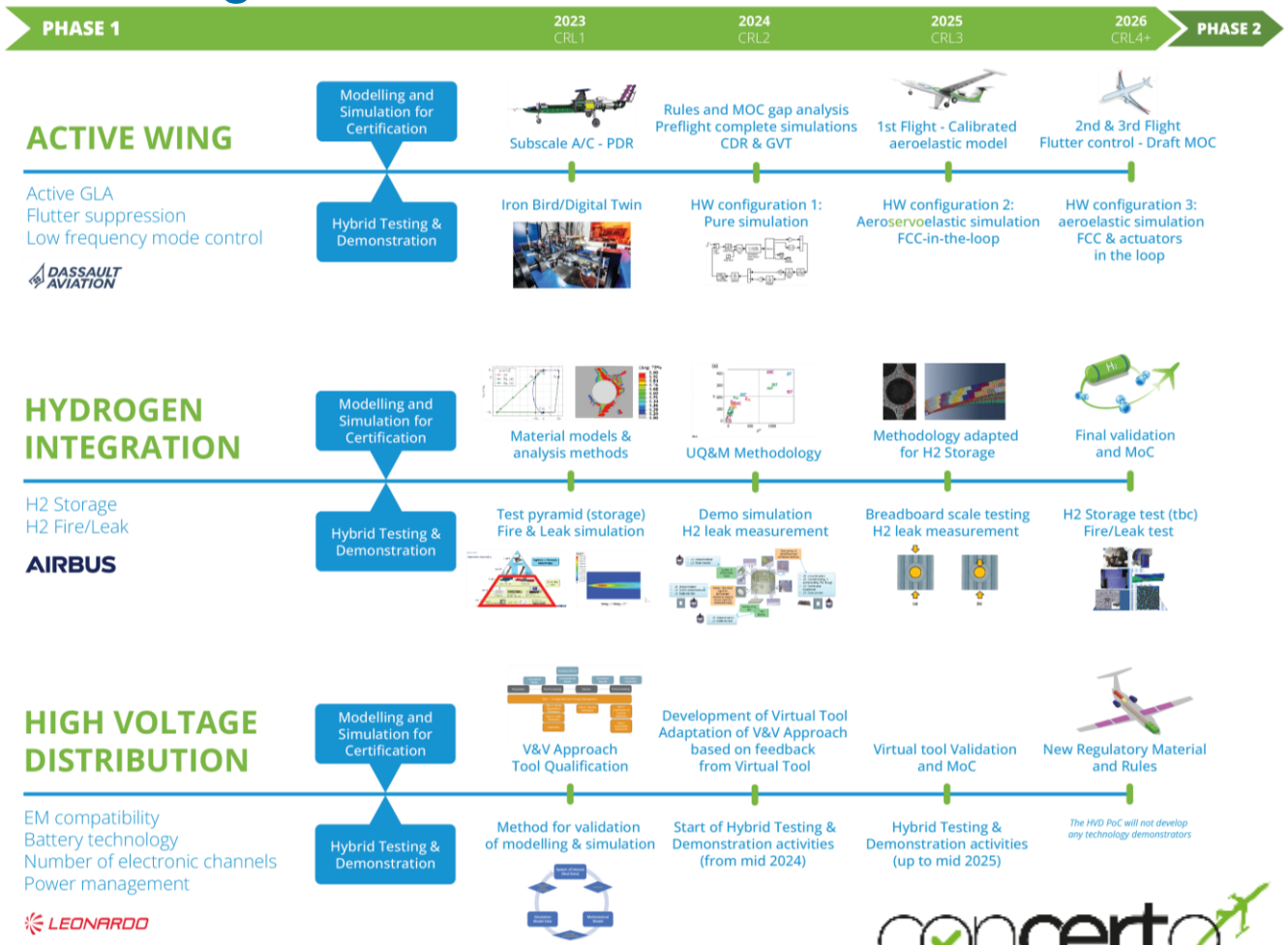
- **Involve EASA in the early stages of R&I**
- **Learn together with EASA to reduce time for certification of disruptive technologies**

32 BENEFICIARIES

11 COUNTRIES

>20 MIL EUROS GRANT AMOUNT

48 MONTHS DURATION



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Certification Readiness Level CRL Scale

Level	Description
CRL 1	Safety regulator familiarization with techno and Concept of Operations (ConOps)
CRL 2	Confirmation of the proposed ConOps assumptions and Safety Objectives by all stakeholders
CRL 3	Identification of key regulations that would be mainly affected along with an identification of those that would need to be amended/developed in priority (Note: so called Gap Analysis)
CRL 4	Identification of the main principles for technical standards and roadmap for overall necessary rulemaking and/or recommended Industry Standard Activities associated to the novelties/specificities of the design
CRL 5	Identification of the roadmap / action plan for a comprehensive aviation framework readiness
CRL 6	Confirmation of necessary technical (TRL) knowledge and availability of first draft of rulemaking material
CRL 7	When applicable: mature draft generic elements of a certification basis, in the form of published Generic Special Conditions (SC), Interpretative Material or Means of Compliance <-> TRL6
CRL 8	Product (integrating the technology) certified. DOA granted
CRL 9	Actual system (Design, Operation, Maintenance) proven in operational environment

EASA involved at each step

Certifiability and Technologies related

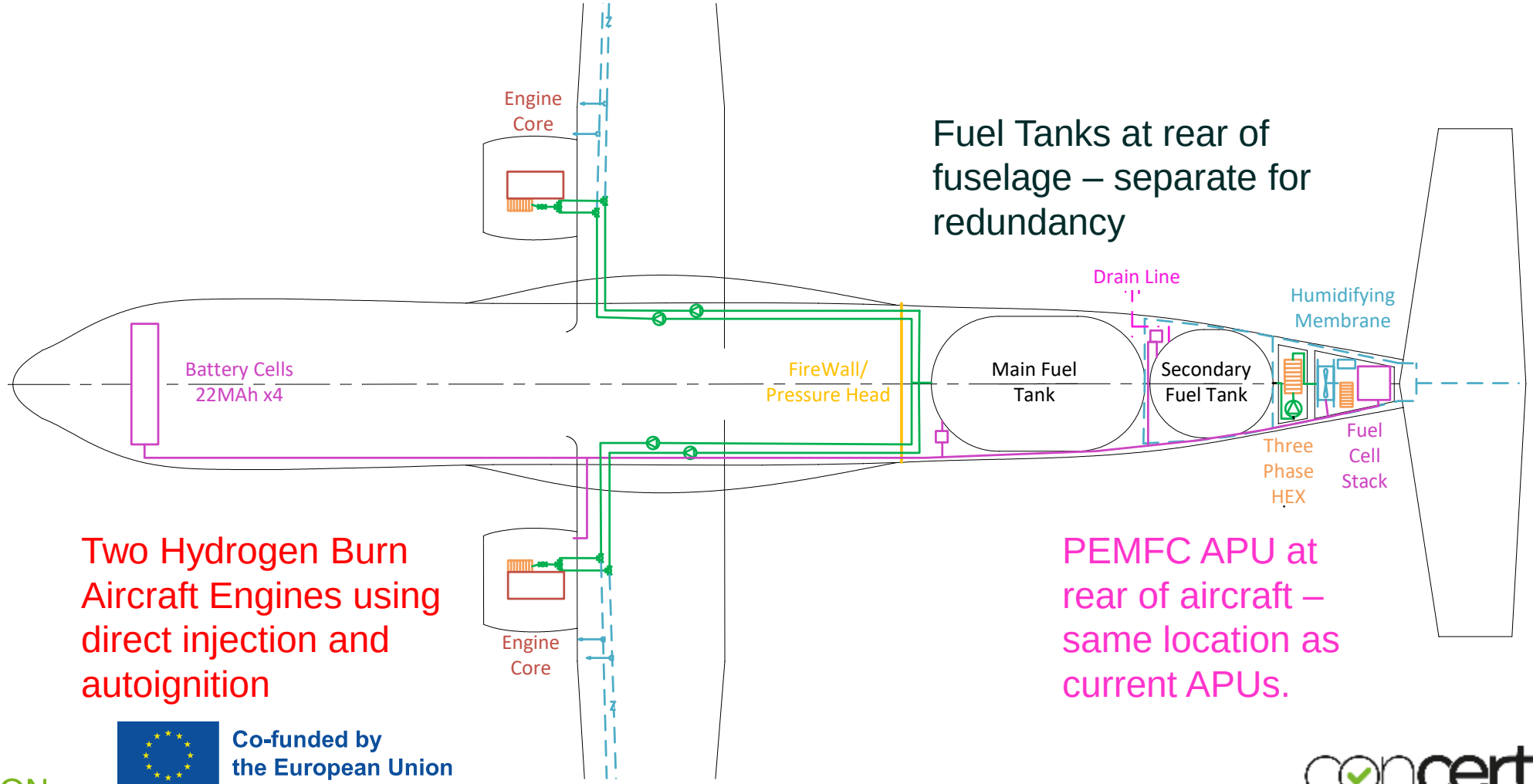
Certification and Products related

To be noted:

- Recommanded by EASA as part of Pre-Application Services
- To be included in next revision BNAE RG AERO 00 050

PoC H2 CRL1

- Definition of Generic Concept & ConOps for H2 aircraft



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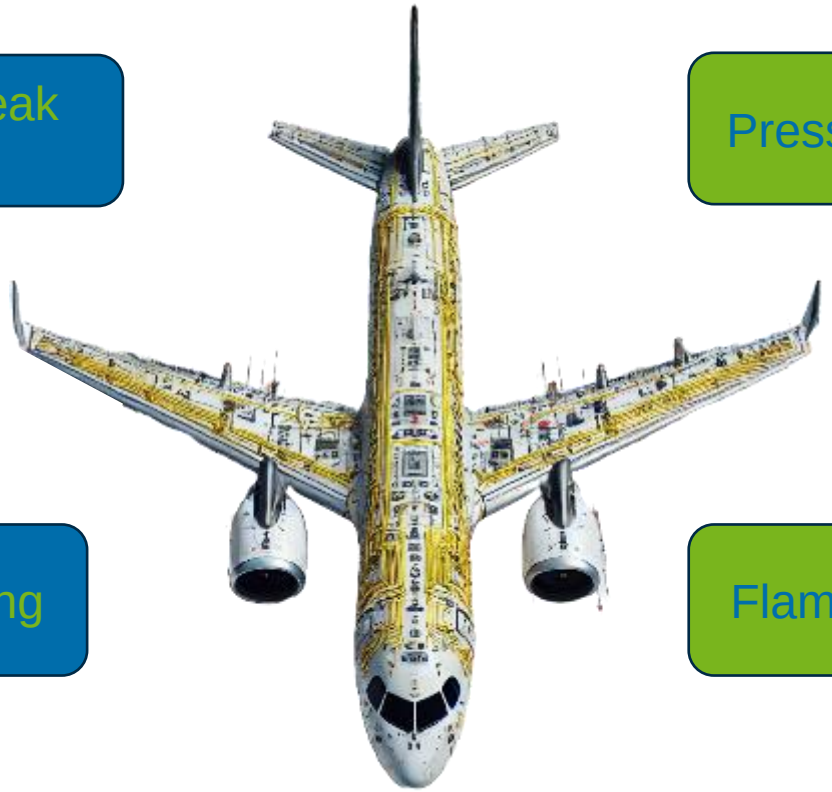
PoC H2 CRL1

- Definition of Generic Concept & ConOps for H2 aircraft
  - Proactive safety through sensing and monitoring systems

Hydrogen Leak Sensing

Structural Health Monitoring

Acoustic Sensing



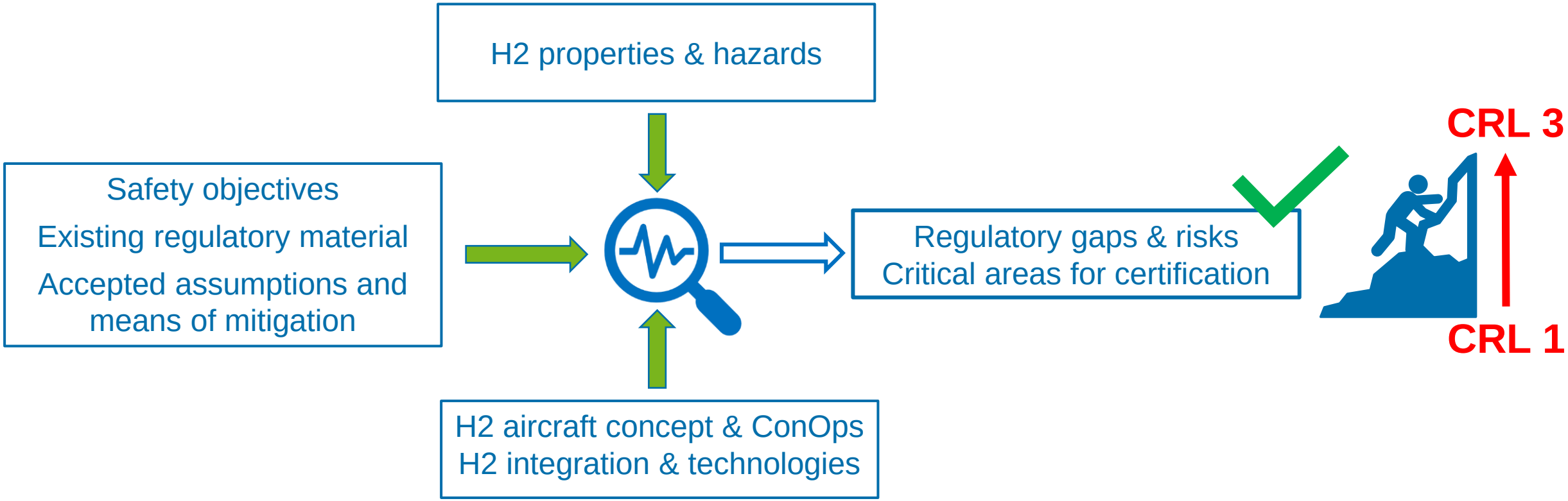
Pressure Sensing

Temperature Sensing

Flame Monitoring

PoC H2 CRL2 & CRL3

- Regulatory gap analysis: methodology [1]

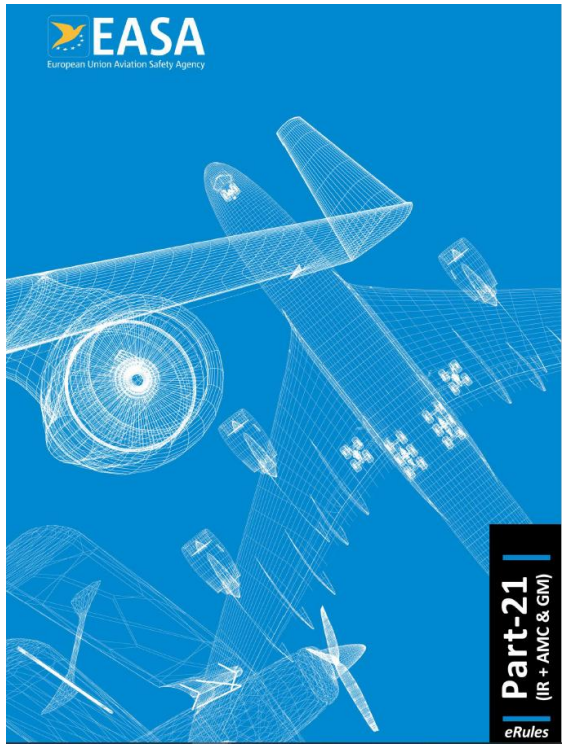


[1] Jézégou Joël, André Robert, Gourinat Yves, Hydrogen Aircraft Certification: Determination of Regulatory Gaps. 2024 , International conference proceedings , International Conference on More Electric Aircraft (MEA2024)

PoC H2 CRL2 & CRL3

- Regulatory gap analysis: perimeter

Initial Airworthiness



CS & AMC under analysis
CS-25 Amdt. 27
CS-E Amdt. 7 (Turbine engine only)
CS-34, CS-CO2 (ICAO Annex 16)
CS-23 Amdt. 6

EASA Certif. Panels
3 – Structure & Material
5 – Electrical systems incl. EWIS and fuel cell
7 – Powerplant installation and fuel system
11 – Cabin Safety
19 - Propulsion

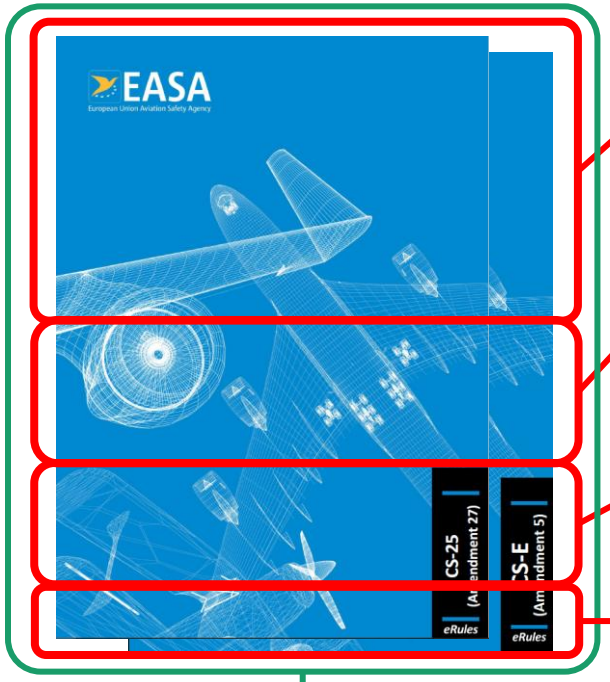
+ some sections of panels 1, 6, 12, 14

PoC H2 CRL4

- On-going activities towards CRL4
  - Development of principles for future rulemaking and standardization to address gaps and critical areas for certification
  - Development of AMCs for H2 flame and H2 leak characterization, including testing campaigns
  - Material models and test pyramid for LH2 storage

Key outcomes

Results from CS-25 / CS-E regulatory gap analyis



No gap identified
(P3&P5: 90% - P11: 68% - P19: 86%)

Adjustement to existing requirement needed
(typ.: safety intent is valid, but precision in the wording needed)

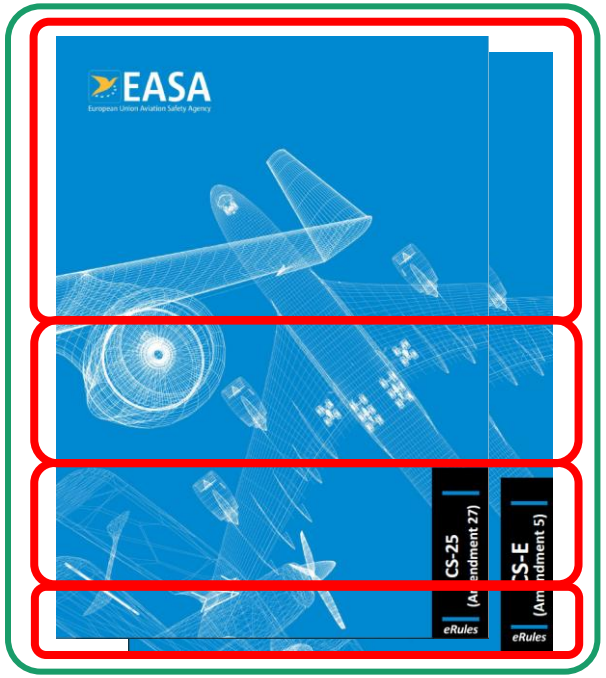
Significant revision needed, from definition of aircraft level safety objectives to definition of new requirements adapted to H2
➔ Critical Areas for Certification

Analysis pending (typ.: relevant data missing, dependancy on new requirements to be defined)

Extensive need for AMC, Interpretative Material and Standards adapted to H2

Key outcomes

Results from CS-25 / CS-E regulatory gap analyis



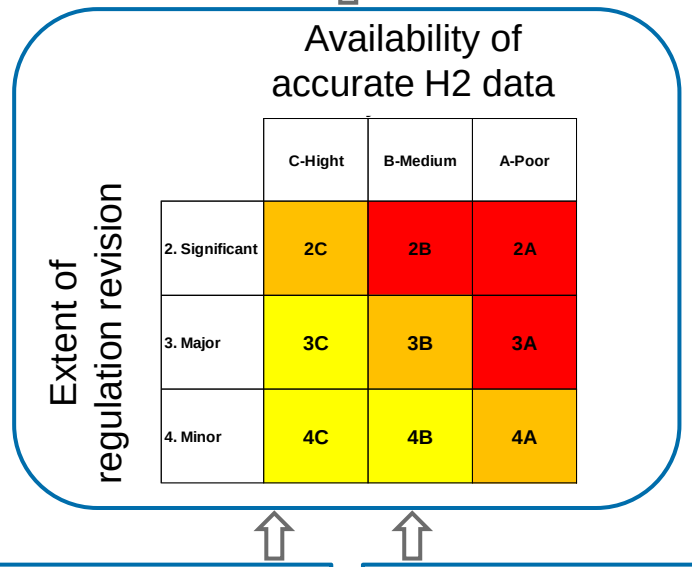
Recommanded way to proceed for Book 1: adapting and complementing current Books 1

- Need to avoid ‘conflict’ with current practices prescribed in current CS-25/CS-E that remain valid for products other than H2 ones, or design elements not affected by H2 in an HPA
- Complementing with § dedicated to H2, or AMC20
  - *e.g.* LH2 storage system & Fossil fuel storage system
  - *e.g.* LH2 fuel system & Fossil fuel system
- Design options are numerous => a case-by-case PBR approach?

Key outcomes

Critical areas for certification that are determined

Identification of Critical areas for certification



Outcomes of gap analysis

Knowledge about H2, and hazards

Fire and explosion prevention & protection	
Crashworthiness and occupant survivability	
H2 fuel system (aircraft, engine)	
LH2 storage system (incl. Interaction of systems and structures and safety devices)	
Impact of H2 on environmental protection	
Effect of H2 environment on structural durability	
Fuel cell (as a power source)	
Effect of contaminants on H2 flow	
Effect of cryogenic conditions (internal icing)	
Lightning protection + EWIS	

Knowledge on H2-related phenomenology
Knowledge on mature H2 systems and components

Key outcomes

Extended knowledge data about hydrogen in aeronautical environment is needed

Overall characterization of H2 fire/explosion in aeronautical environment including: - definition of standardized H2 flame and standardized tests - definition of fire proofness and resistance - post-crash H2 fire behaviour - ignition energy / ignition conditions (*e.g.* static electricity)
Definition of H2 environmental conditions (H2, cryogenic conditions, inerting gas, water vapor)
Effects on materials of exposure to H2 and H2 environnement (e.g. mechanical properties, degradation modes, sealing, permeation, ageing effects, etc.)
Physics of H2 leaks and built-up of flammable atmosphere
Influence of contaminants on H2 fuel / fuel flow
Environmental impacts of H2 emissions (combustion, leak, venting) and water vapor
Interactions EWIS ⇔ H2 systems (installation rules)
…

Essential inputs for:

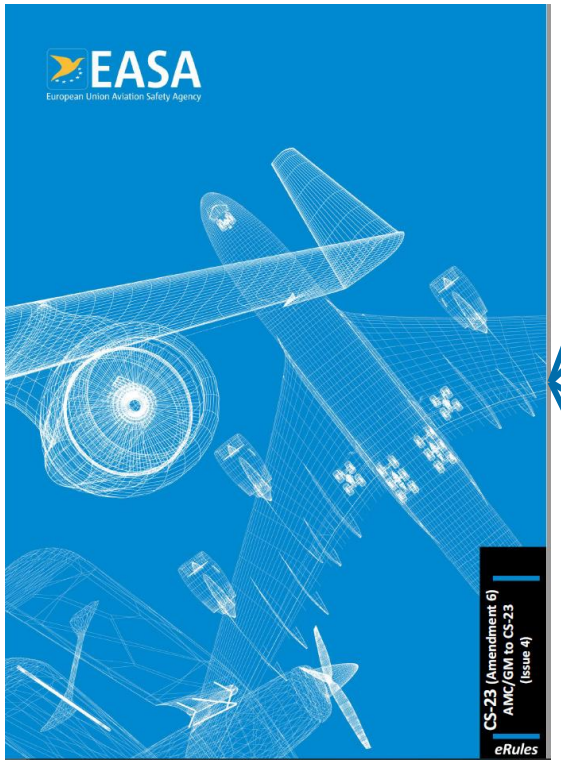
① Better understanding and characterizing threats, failure modes, degradation, etc, and refining gap analysis.

② Development of standards

③ Rulemaking (incl. AMCs)

Key outcomes

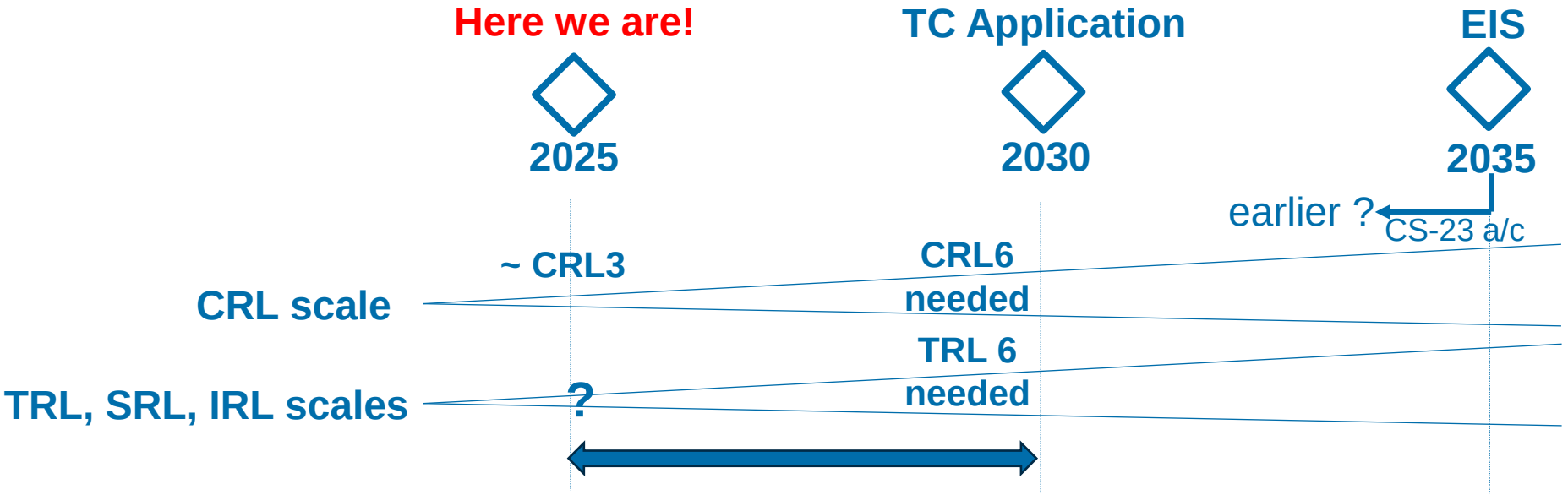
CS-23, as a PBR regulation, is adapted to H2… but:



- Revision needed to address H2 hazards not (fully) covered
- The CS-23 upper MTOW limit could be a showstopper
- Extensive need for Acceptable Means of Compliance, Accepted Means of Compliance in the form of standards
- Complement needed to include propulsive fuel cell and its aircraft integration (incl. thermal management system) [CS-23 and SC-EHPS]

Key outcomes & Recommandations

Fast-pace maturation and work ahead for EIS2035



Safety objectives ⇔ Technologies&Integration ⇔ Scientific knowledge ⇔ Regulations → Act collectively to be ready and to fill gaps

Key outcomes & Recommandations

Fast-pace maturation and work ahead for EIS2035

Safety objectives ⇔ Technologies&Integration ⇔ Scientific knowledge ⇔ Regulations

- Maturation of competencies (as per Part 21) ➔ DOAs will have to be granted
- Involvement of ressources (EASA, SDOs, industry, research) for accepted standards & AMC development, and rulemaking

EASA & CONCERTO « H2 Synergies Workshop » initiative

- Among Clean Aviation H2-related projects
- Mapping Gaps & critical areas for certification / Learning needs with Contributors to gap analysis / Contributors to gap fillers

Extension of this initiative?

Acknowledgements

The project is supported by the Clean Aviation Joint Undertaking and its members.

Clean Aviation is the EU's leading research and innovation program for transforming aviation towards a sustainable and climate neutral future.
As a European public-private partnership, Clean Aviation pushes aeronautical science beyond the limits of imagination by creating new technologies that will significantly reduce aviation's impact on the planet, enabling future generations to enjoy the social and economic benefits of air travel far into the future.
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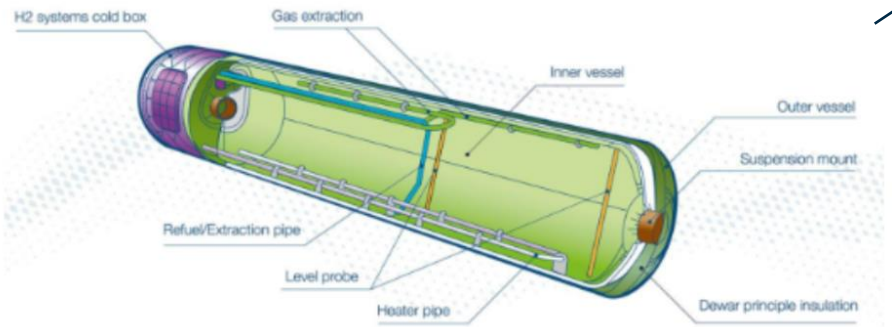
Critical areas for certification

- LH2 storage system



Interaction of systems and structures (pressure control, temperature control)

Safety relief systems

Failure and degradation modes incl. leaks

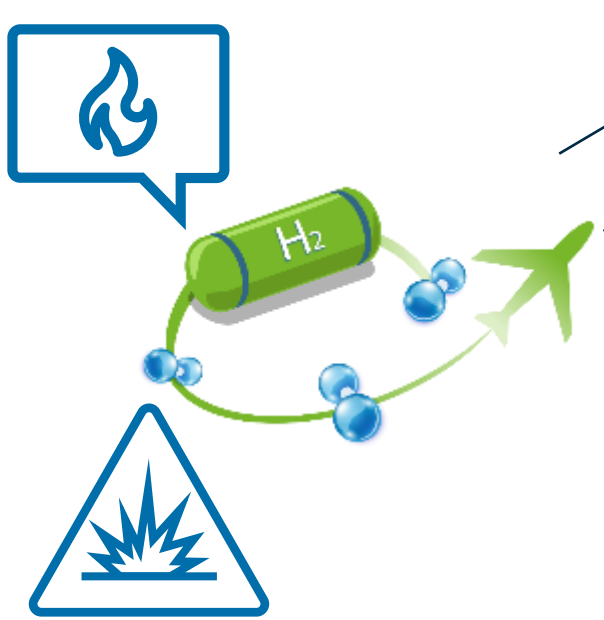
Ageing effects of exposure to H2 environment

Fatigue and damage tolerance

Detectability of damages, including reliance on new detection techniques for certification

Critical areas for certification

- Fire & Explosion prevention and protection



Switch to H2 fire behavior (instead of kerosene)

Fire mitigation means, e.g. inerting, extinguishing

Explosion to be better considered

Prevention & Protection strategies

Aircraft fire / explosion zoning

Leak detection, ventilation

Differenciation needed as other flammable substances than H2 still existing