Hydrogen Fire & Explosion Research Steering Group

Rémi DELETAIN - Senior Expert - CS-25 Powerplant & Fuel System

With help of
EASA H2 Core Team and Enzo CANARI

EXTERNAL (EXT)
Regulator Industry (RI)
V6

Hydrogen Fire & Explosion Research Steering Group meetings , Bremen, 15-18 Apr 2024

- Background
  - Around 2021, activities coming to the Agency in various areas and format
    - IPC, TC application, research,…
  - Jul 2022 - EASA-FAA discussion on AC 20-135 genesis : Any parallel for an H2 fire testing standard?
  - Fire and Cabin Safety Research Group (F&CSRG) and associated forums (IASFPF & IAMFSF) plus conference (Triennial International Fire & Cabin Safety Research Conference): ideal context to reach the fire protection specialists community

COB: Certification Oversight Board

Background

- Aug 2022 FAA-EASA eMail exchange to work out a slot within the Cabin and Fire safety Falls conference
- Oct 2022 - 10th Triennial International Fire and Cabin Safety Research Conference
  - Some topics on H2 (Boeing, Universal Hydrogen,…)
  - Meeting planned but not optimally advertised
  - Regulators only meeting : interest showed by ANAC, TCCA, JCAB, DGA, FAA (various product branches): exchange on on-going activities, list of fire topics of interest, …
  - Regulators / Industry : very few participants : Boeing, Airbus, Elements but interest is there.
  - Agreed to renew the exercize with the IASFPF / IAMFSF meetings (June 2023 at EASA, October 2023 at the FAA Tech Center) and other meetings (SAE, MPS Cargo,…)

HF&ERSG

- Jun 2023, EASA Headquarters (Cologne, Germany)
  - 2 meetings (Regulator only, Regulator/Industry)
    - Concurrent to IASFPF and IAMFSF meetings
    - Hydrogen as aviation fuel - Workshop 2023 - Aircraft Certification - Fire and Explosion challenges
    - Good participation
    - Wide scope of questions/answers
    - Invitees : known H2 actors … but not only

HF&ERSG

- Jun 2023, EASA Headquarters (Cologne, Germany)
  - Regulators Only meeting
    - JCAB, FAA, CAAI, CAA NL, DLR, CAA NZ, CAA UK, ANAC, TCCA CAA Singapore
    - FAA-TC discussion on activities:
      - Study on HRR with small concentration of H2
      - Report on fuel cell with leak
      - H2 fire testing: some test done
      - What about Post Crash fire, In-flight fire, H2 fire duration,…

HF&ERSG

- Jun 2023, EASA Headquarters (Cologne, Germany)
  - Regulators Only meeting
    - Debate on government vs industry path
    - Preferred regulator map for fire testing
    - Need to start now on selected topics/issues, then gradually expand
    - Promote use of IASFPF & IAMFSF
    - Agreed to repeat the activity in the Falls 2023 meeting

- Jun 2023, EASA Headquarters (Cologne, Germany)
  - Regulator/Industry meeting
    - Quite an interest : Circa 50 persons in presence, Webex oscillating between 130 – 150 connections
    - Quite a string of questions:
      - Some far away from aircraft certification and fire & explosion problematics
      - Other very pointing
    - Need to define list of issues and put some priority
    - Any showstopper topic? Example of an aircraft ground explosion that destroys airport facilities and terminals…

- Jun 2023, EASA Headquarters (Cologne, Germany)
  - Regulator/Industry meeting
    - Airbus presentation generated some exchange between FAA and AI on data collected due to lack of correlation: further exchange to come.
    - Agreed to repeat the activity in the Falls 2023 meeting

- October 2023, FAA Tech Center (AC, USA)
  - Regulators Only meeting
    - The regulators should cooperate to establish a road map for rulemaking and research on H2 fire and explosion challenges
    - It is essential to start now with focus on selected topics with limited scope, then gradually expand
    - Preferred way forward: use of International Aircraft Systems Fire Protection Forum (IASFPF) & International Aircraft Materials Fire Test Forum (IAMFTF)
    - H2 workshops (AA only first, followed by a second one open to the industry) will be held in conjunction with the Materials and Systems Forum with the objective to make progress with the issues that have already been identified as well as with new issues that may be identified in the future.

- October 2023, FAA Tech Center (AC, USA)
  - Regulators Only meeting
    - The task to work on an issue and possibly resolve it should be assigned on a case-by-case basis to:
      - A task group in the Materials/Systems Forum
      - A competent Industry group (e.g. SAE A-22 for Powerplant systems flammability)
    - At the same time, the H2 workshops should serve to identify the need to launch research projects to generate data to support strategic decisions related to specific issues.
    - It was agreed that EASA (Canari, Deletain) and the FAA (Gardlin, Hill) will draft the Terms of Reference of the Committee and share the document with the other AAs representatives for review and comment.

- October 2023, FAA Tech Center (AC, USA)
  - Regulator/Industry meeting
    - EASA H2 Challenges – General and fire/explosion problematics
    - H2 Pool fire discussion:
      - Presentation on past activity on H2 Pool fire : there is some data (size, gradient)
        - Tank will release different amount of H2 under the same impact conditions
        - Effect of wind on pools
    - H2 leak detection/suppression vs different A/C zones.
      - How much can be acceptable

- October 2023, FAA Tech Center (AC, USA)
  - Regulator/Industry meeting
    - Learn from hydrogen-based engine manufacturers what their fire protection measures are; what they've seen in experimental efforts to certify hydrogen powered aircraft
    - Look at other standards on hydrogen already out there in the chemical industry, NFPA, Automotive, etc. and apply it considering the constraints of the aviation industry
    - Cryogenic hydrogen leak may freeze systems surrounding it (Non-fire hazard of hydrogen)
    - Look into non-fire hazards related to hydrogen transport
    - Hydrogen embrittlement/material compatibility (specifically for fuel tank)

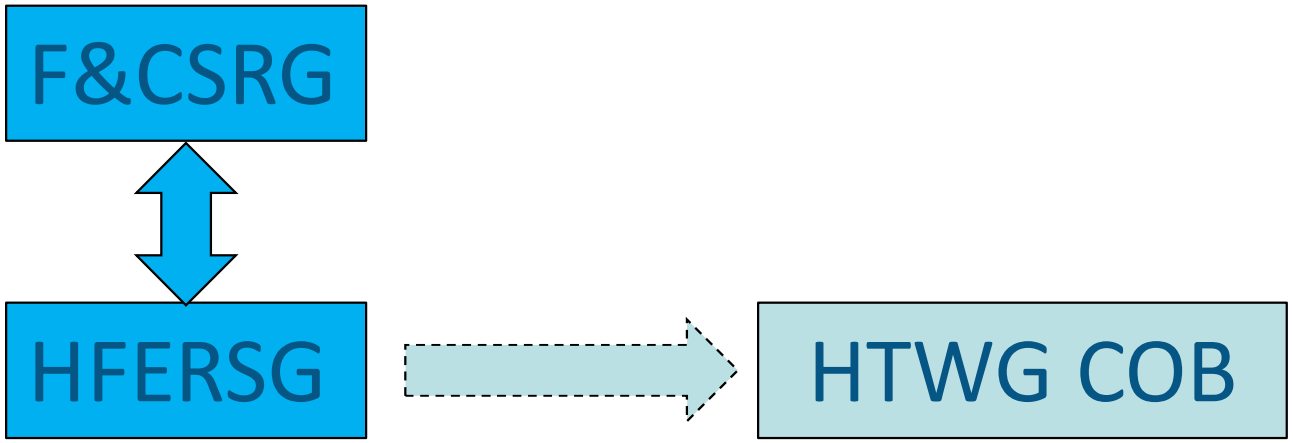
- October 2023, FAA Tech Center (AC, USA)
  - Regulator/Industry meeting
    - Vibration effect on seals – allow hydrogen leakage since smaller molecule
    - Leverage what is already in place for hydrogen powered buses, but most ground transport is able to be ventilated…
    - Boil off condition of cryogenic hydrogen tank – continuous venting
  - Discussion on the EASA-FAA COB WG setting-up : Hydrogen Technologies Working Group (HTWG)

HF&ERSG

- Apr 2024 meetings (Regulator only, Regulator / Industry)
  - Topics For Discussion
    - ToR For Hydrogen Fire & Explosion Research Steering Group (HFERSG)
    - Work Plan/Task Groups
    - List of Topics and Prioritization

HF&ERSG

- ToR : drafted for Hydrogen Fire & Explosion Research Steering Group (HFERSG) activity
  - Subset of Fire and Cabin Safety Research Group, F&CSRG
  - Contributor to Hydrogen Technologies Working Group (HTWG) COB



ToR : Objective

Objective: The overarching objective of the Hydrogen Fire & Explosion Research Steering Group is for both EASA, FAA as well as other national authorities' systems – with support of industry - is to develop a roadmap to identify the fire and explosion problematics related to transport category airplanes design certification in case of use of hydrogen as fuel, and to address them through the definition of a research plan.

The Steering Group will determine knowledge gaps in hydrogen fire and explosion threat /consequences understanding and characterization, considering the introduction of both liquid and gaseous hydrogen use in propulsion systems, including both aircraft and engine considerations for:

1. Hydrogen fuel cells powering electric engines used for aircraft propulsion.
2. Hydrogen as a combustible fuel in aircraft engines used for propulsion.

The Steering Group will work with industry to determine if those gaps can be filled with present knowledge or if additional research is needed. If additional research is needed, the Steering Group will utilize the International Aircraft System Fire Protection Forum and International Aircraft Materials Fire Test Forum as a means for public discussion. Task group within the forums may be formed for additional discussion. Specific development tasks may also be assigned to other Industry Working Groups and Institutions.

The Steering Group will develop a plan for additional research needed and harmonize among aviation authorities.

ToR : WorkPlan

Workplan: In order to achieve the objective, the Steering Group will need to:

1. Review and list all 14 CFR/CS 25 / 14 CFR/CS-E / CS-APU airworthiness fire and explosion requirements that would be affected directly and/or indirectly by the introduction of hydrogen was a fuel.
2. List and prioritize safety risks associated with using hydrogen for propulsion/powerplant
3. Discuss above with industry in the International Aircraft System Fire Protection Forum and International Aircraft Materials Fire Test Forum meetings.
4. Determine gaps in the present 14 CFR/CS 25 / 14 CFR/CS-E fire and explosion requirements with the introduction of Hydrogen as a fuel.
5. Identify areas where H2 threat and or consequences would need further understanding and characterization.
6. Develop a draft research plan to fill any gaps found above. Among others users, the research plan will be shared with the HTWG COB for any use of recommendations

ToR : Scope & Limitations

Scope and limitations: The scope of the Steering Group tasking is to define a roadmap in an overall context of regulations and guidance associated with the fire and explosion requirements of 14 CFR/CS 25 aircraft and corresponding / 14 CFR/CS-E engines / CS-APU category. This team will not address: operational, aerodrome, environmental issues or other product categories. While the Steering Group will not specifically address risks posed by ground-based transportation, storage, and handling of hydrogen, the Steering Group could identify areas (e.g. list) of necessary investigation to be addressed in a subsequent phase of the Steering Group activities, or, in case of more urgent needs, by other Groups/Coordination bodies. This may include the identification of similar concerns for other product category (e.g. CS-23/14 CFR 23 and corresponding / 14 CFR/CS-E engines category airworthiness fire and explosion requirements. This may take the format of recommendations.

ToR : Governance

Governance: Each member of the Steering Group will report directly to his/her own management. The Steering Group will be managed by FAA and EASA co-chairs. Steering Group members shall coordinate all formal results or recommendations with their respective management chains.

ToR : Timeline

Timeline: The Steering Group will work to develop a draft research plan by September 30th 2024. The Steering Group will work through the F&CSRG until such time as all gaps in the regulations fire and explosion requirements in 14 CFR/CS 25 , 14 CFR/CS-E engines and CS-APU, regarding the use of hydrogen as a fuel and the 14 CFR/CS 25 , 14 CFR/CS-E engines and CS-APU fire and explosion certification guidance can be harmonized between the FAA and EASA as well as other national authorities.

ToR : Deliverables

Deliverables: The Steering Group will produce a draft research plan outlining research needed in order to modify the fire and explosion requirements in 14 CFR/CS 25, 14 CFR/CS-E engines and CS-APU and relevant guidance material for the certification of transport airplanes / engine using hydrogen as a fuel.

ToR : Milestones

- ✓ Meeting and approval of TOR: April 15, 2024
- ✓ List of affected requirements May 31, 2024
- ✓ List of hazards May 31, 2024
- ✓ Determination of regulatory Gaps Jul. 31, 2024
- ✓ Determination of research Gaps Aug.31, 2024
- ✓ Draft research plan Sept 30, 2024

ToR : Membership

Membership: EASA and the FAA will designate members (4 maximum each) with expertise in transport aircraft fire safety certification / research, in the areas of propulsion, fuels and/or cabin safety. Other authorities, that are members of the Fire & Cabin Safety Research Group may also designate members (maximum 2 each). Additional experts from each organization may be invited to join specific Group meetings on an ad-hoc basis, subject to the agreement of the Steering Group members. A subject matter expert (SME) from other government agencies may be invited to participate, subject to the agreement of the Steering Group members..

ToR : Meetings

Meetings: The lead(s) will facilitate scheduling of the Steering Group meetings. The Steering Group will initially meet virtually in conjunction with meetings of the F&CSRG and face to face in conjunction with the International Aircraft System Fire Protection Forum and International Aircraft Materials Fire Test Forum meetings. Additional virtual and/or face to face meetings may be required and scheduled, subject to the agreement of the Steering Group members. An agenda shall be agreed and circulated by e-mail prior to each meeting, and notes taken of each meeting, that includes at the minimum the action items to be completed, with timeframes for completion and names of the member in charge, and decisions made at the meeting. The note taker for each meeting shall be decided at the beginning of the meeting.

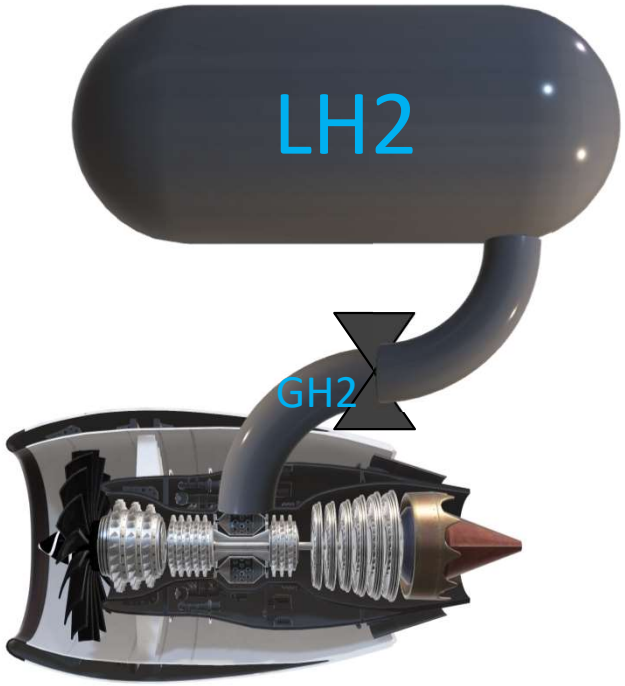
HF&ERSG

- ToR : Status
  - EASA/FAA in agreement
  - ToR shared with F&CSRG members and regulators participating to H2 IASFPF/IAMFSF meetings
  - No comment received neither from F&CSRG nor regulators participating to H2 IASFPF/IAMFSF meetings
  - JCAB/ANAC/TCCA agreed to participate

- Next steps (by 30th April 2024):
  - Release of the ToR
  - HF&ERSG Membership
  - Task Groups roster definition

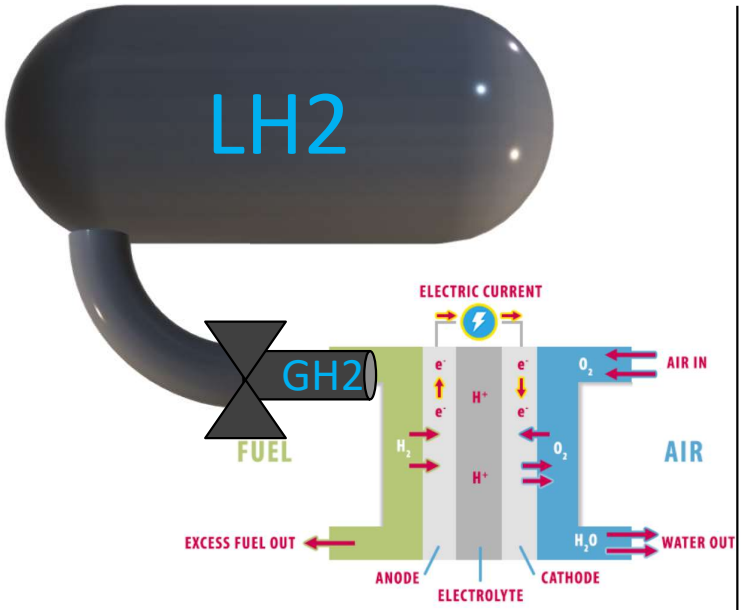
Work Plan

- CS-25 Amdt 28 as reference
- Make some high level assumptions of architecture



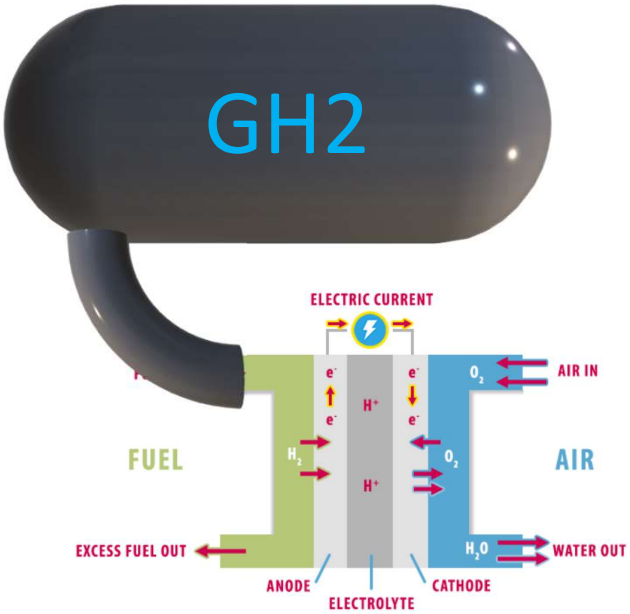
Option 1

H2 burn



Option 2

LH2 FC



Option 3

GH2 FC

Work Plan

1. List and prioritize safety risks associated with using hydrogen for propulsion/powerplant
2. Define research needs
3. Identify resources available to each AA
4. Allocate the resources based on needs and priority levels, considering existing constraints (budget allocation, workflow, etc.)

Proposal for Task Groups definition

Preliminary list of issues	Post Crash	In-flight
Cabin Safety	FAA (S. Rehn) 1) Characterization of a fire resulting from a crash landing 2) Impact on materials flammability 3) Stay-out zones 4) …	EASA (E. Canari) 1) H2 Accumulation in pressurized areas (cargo, cabin, hidden areas) 2) Impact on materials flammability 3) Need for leakage detection 4) Impact of H2 accumulation on fire-fighting / fire suppression 5) ….
Powerplant	FAA (?) 1) Powerplant fire 2) Fuel tank/systems crashworthiness 3) Fuel tank/systems explosion 4) …	EASA (R. Deletain) 1) Powerplant fire 2) Leakage detection 3) Fuel tank/systems explosion 4) Fire suppression 5) …
Other problematics	1) Evacuation Strategy 2) Refueling 3) Impact on MPS for cargo compartment / engine fire suppression 4) Freighter aircraft	

- Task groups
  1. Industry co-chairs
  2. Definition of task group member list
  3. Regular conf calls + presentation to the Fall 2024 H2 workshops
  4. Deliverables:
     1. Minutes of meetings
     2. Final report by **31st August** defining:
        1. list of threats
        2. threats for which adequate mitigations exist (based on already available research/experience)
        3. Gaps with respect to current requirements/means of compliance (ref. ARC report DOT/FAA-TC-19/16)
        4. recommendations for research needs

EASA
European Aviation Safety Agency

End slide

Your safety is our mission.

An agency of the European Union