CENTER FOR Hydrogen SAFETY 2020 EUROPE CONFERENCE

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FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

# Statistics, lessons learnt and recommendations from the analysis of HIAD 2.0 database


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# Introduction

## European Hydrogen Safety Panel (EHSP)

### Background

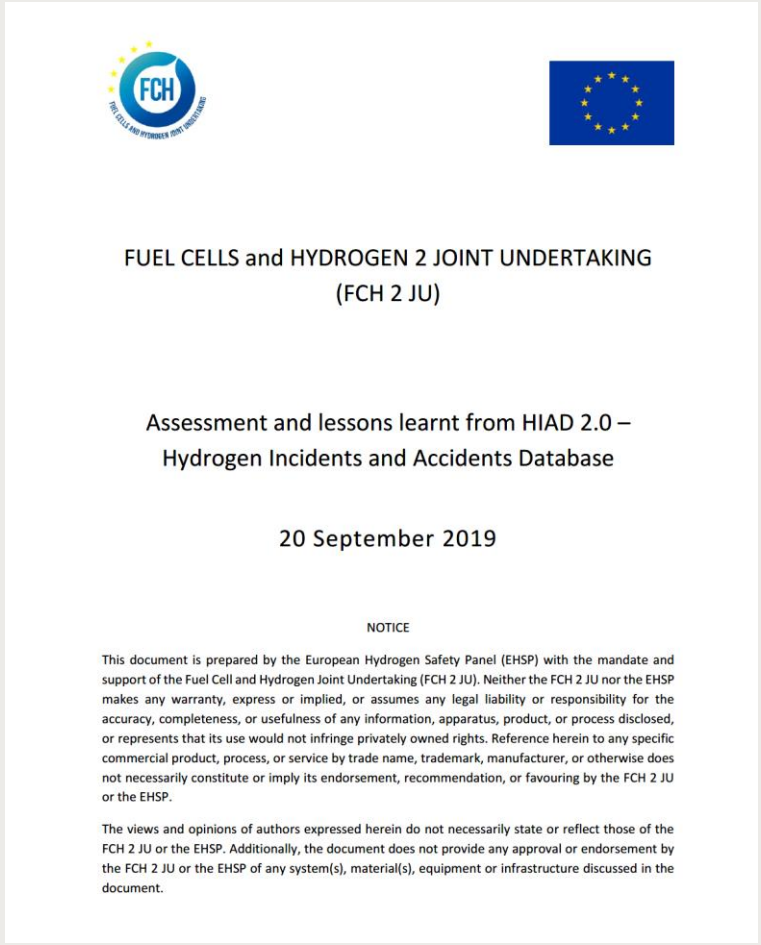
- Initially developed within the frame of HySafe, an EC co-funded Network of Excellence in the 6th Frame Work Programme by the Joint Research Centre of the European Commission (EC-JRC) as HIAD.
- Updated by JRC as HIAD 2.0 in 2016 with the support of FCH 2 JU.
- Since its launch in 2017, the EHSP has worked closely with JRC to upload additional/new events to HIAD 2.0.
- Subsequently, the EHSP and JRC have continuously worked together to enlarge HIAD 2.0 and improve the overall quality of the published events whenever possible.

# Introduction

European Hydrogen Safety Panel (EHSP)

## Assessment and lessons learnt from HIAD 2.0

- The EHSP under Task Force TF3 has been analysing the incidents in HIAD 2.0 since 2018.
- The first report was published in September 2019 for the events available in HIAD 2.0 in 2018.
- About 250 events were analysed.



FUEL CELLS and HYDROGEN 2 JOINT UNDERTAKING
(FCH 2 JU)

Assessment and lessons learnt from HIAD 2.0 –
Hydrogen Incidents and Accidents Database

20 September 2019

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*https://www.fch.europa.eu/sites/default/files/Assessment%20and%20lessons%20learnt%20from%20HIAD%202.0%20-%20Final%20publishable%20version%20%28version%201.3%29.pdf*

# Enlargement and enhancement of HAID 2.0

## European Hydrogen Safety Panel (EHSP)

### HIAD 2.0 front page

Sources of HIAD 2.0:

- public, from scientific literatures, news.
- Other public not hydrogen-specific databases such as French ARIA, European (SEVESO) eMARS, US CSB, NTSB ,OHSA national nuclear authorities, etc.

# Overview of the analysis methodology

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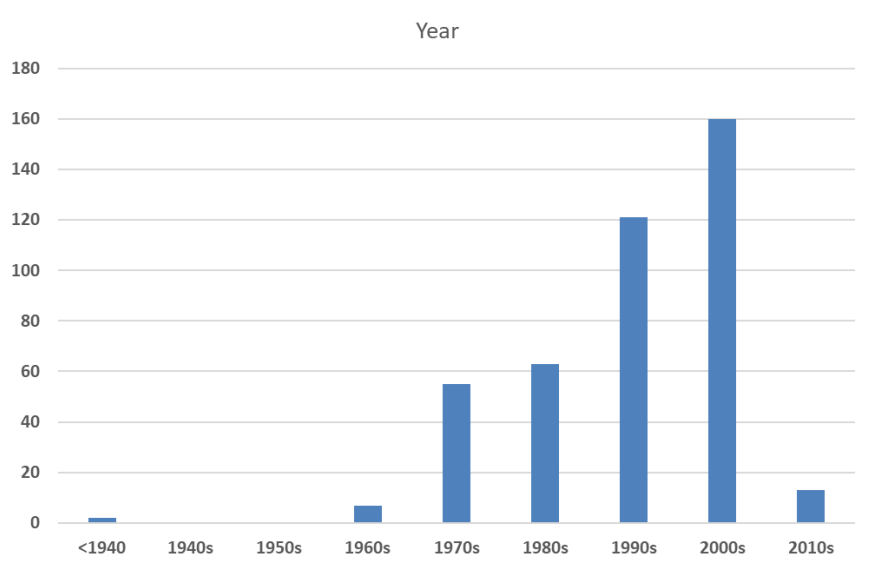
## Categories

- **Severity** (based on European scale of industrial accidents)
  - Quantities of hydrogen involved (releases acc. to Seveso threshold, explosions acc. to TNT equivalent)
  - Human consequences (fatalities, injured with hospitalisation, slightly injured)
  - Economical consequences (property damage)
- **Nature** of event (explosion, fire, unignited release, near miss)
- **Cause** (system design error, material/manufacturing error, installation error, job factors, Individual/human factors, organization and management factors
- **Recommendations** (based on EHSP safety principles)

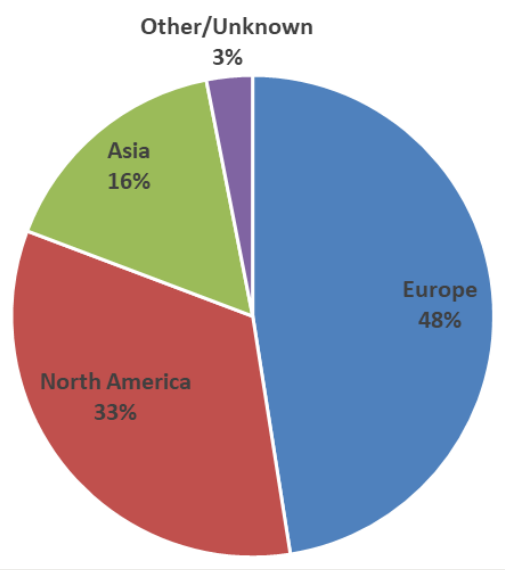
# Statistics analysis of the enlarged HIAD 2.0

European Hydrogen Safety Panel (EHSP)

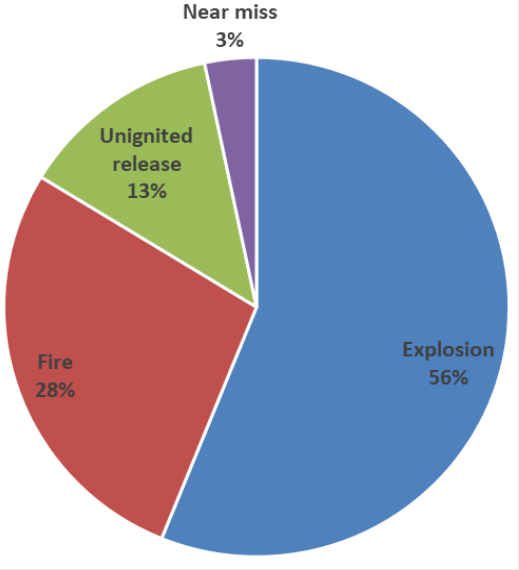
## Years




## Location




## Nature of the events




The analysis conducted in this report is based on the 485 incidents which were in the database in July 2020. During the individual analysis, the experts were asked to identify whether an event is worth including in the statistics. 426 of these incidents were considered to be statistically relevant with meaningful information.

# Statistics analysis of the enlarged HIAD 2.0

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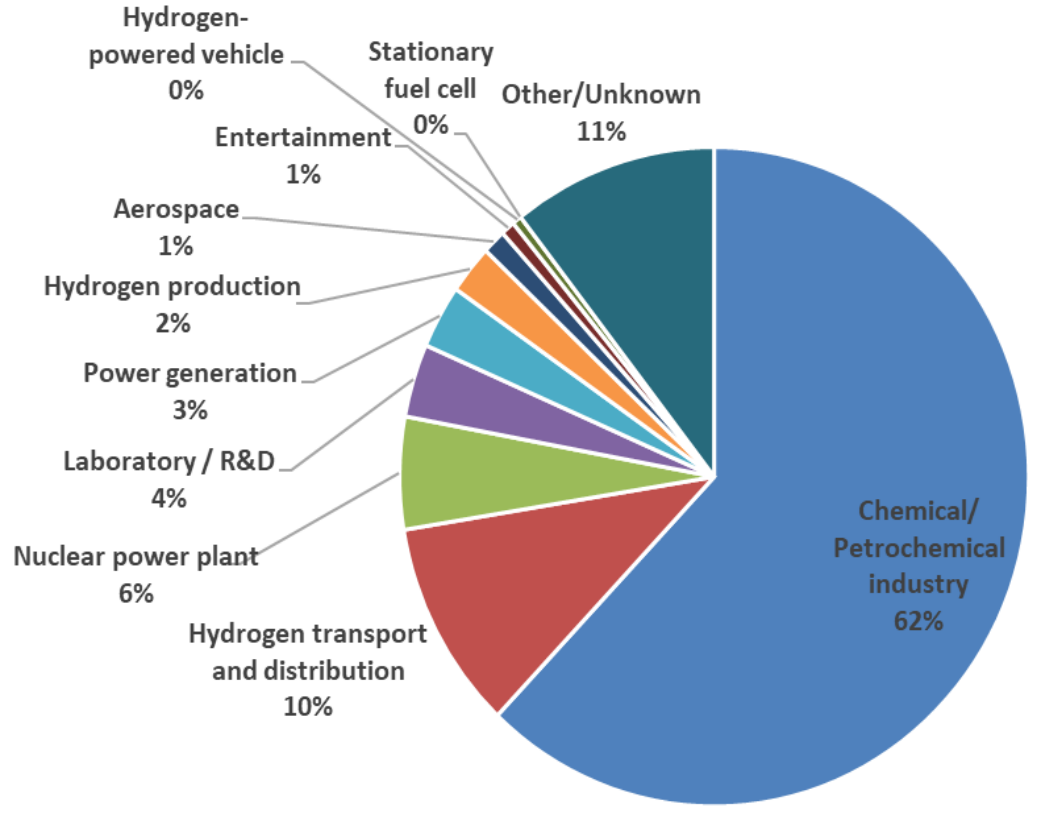
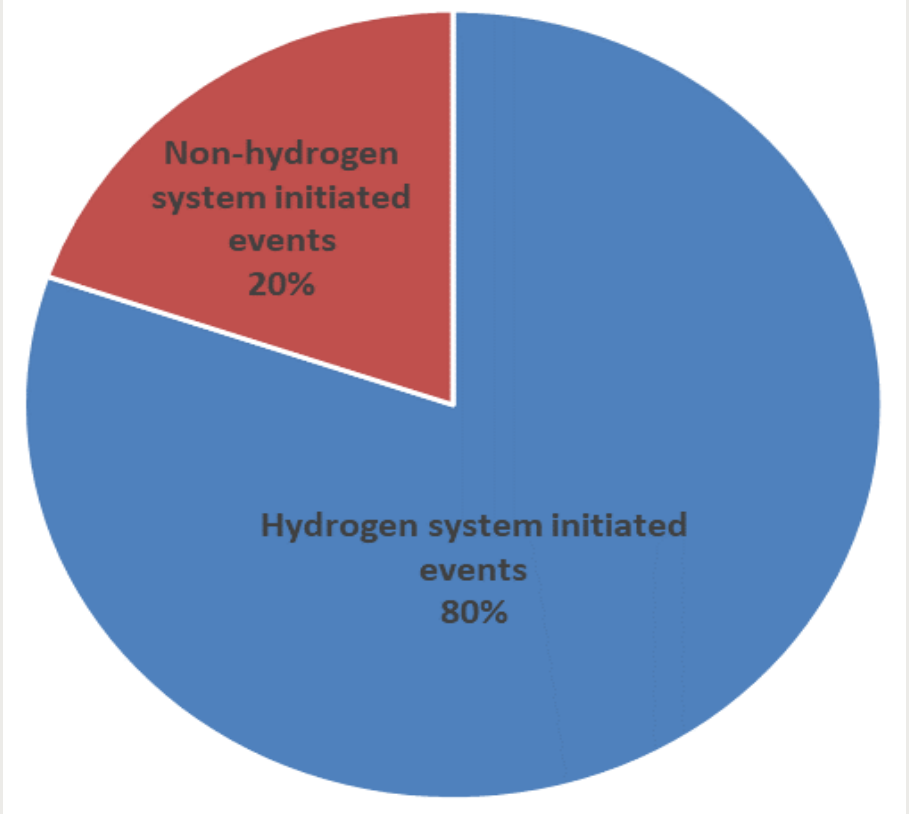
## Industrial sectors




## Hydrogen systems/Non-hydrogen systems

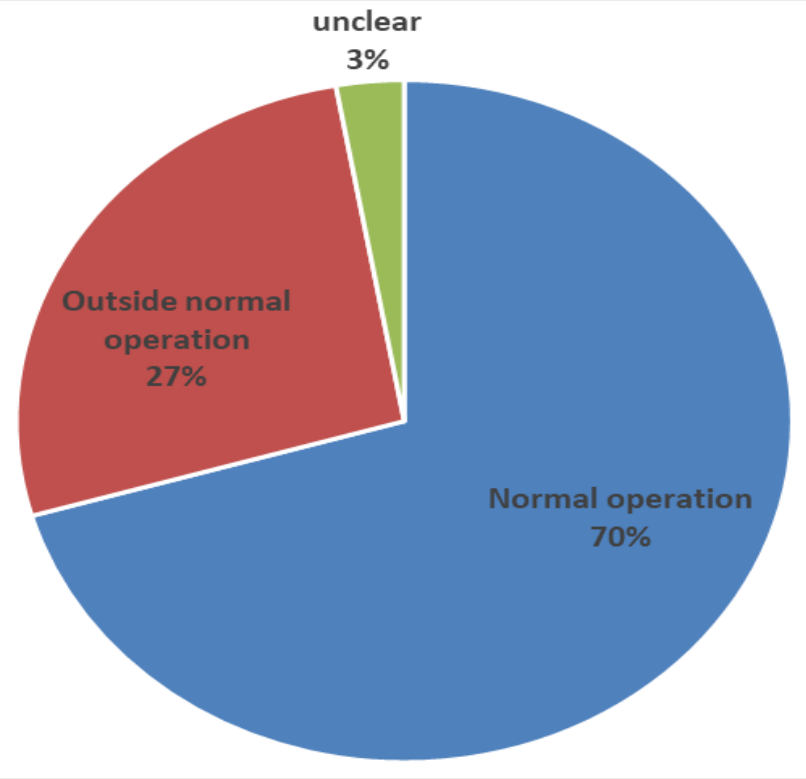


# Statistics analysis of the enlarged HIAD 2.0

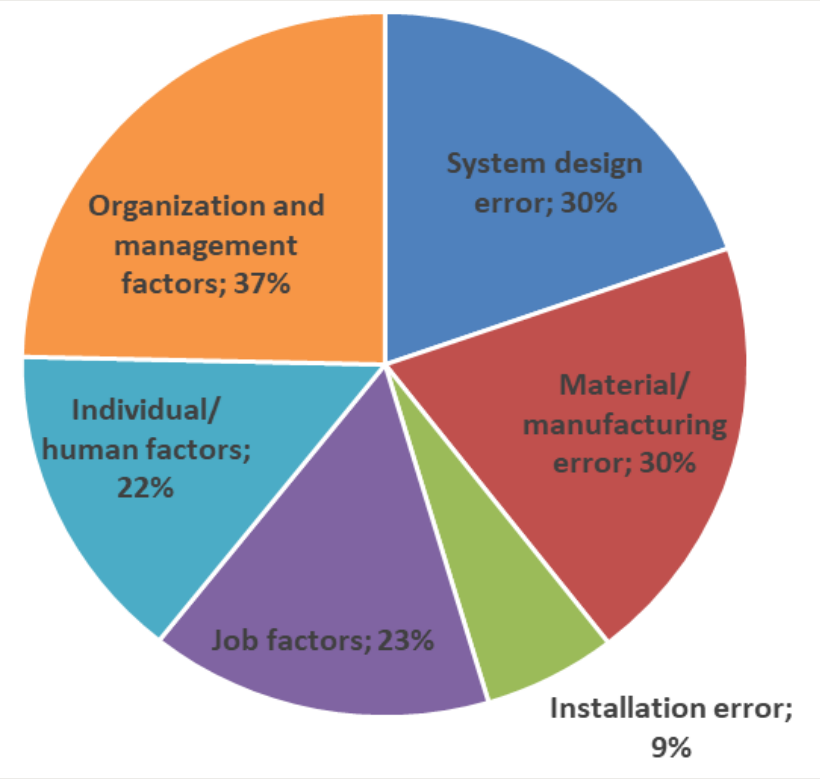
European Hydrogen Safety Panel (EHSP)

**Normal operation**

**Outside normal operation:** during maintenance or special services or immediately after returning to routine operation




**Causes** (multiple entries per incident possible)



# Statistics analysis of the enlarged HIAD 2.0

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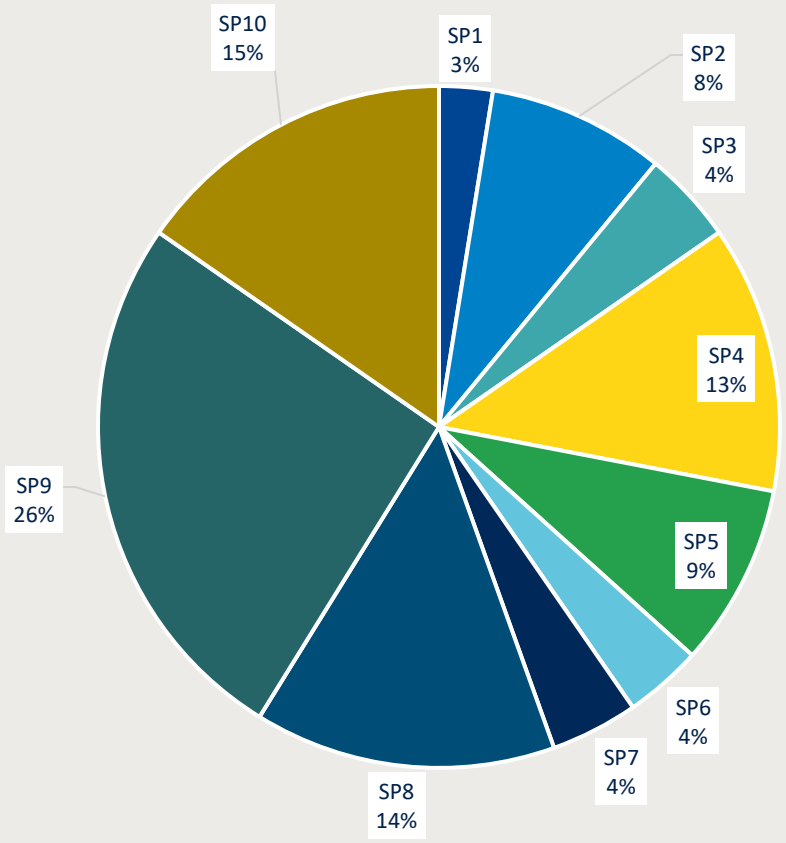
## Statistics showing the number of cases reported with different safety principles (SP)




| Number | Safety Principle<br>*https://www.fch.europa.eu/sites/default/files/Safety_Planning_for_Hydrogen_and_Fuel_Cell_Projects_Release1p31_20190705.pdf* |
|---|---|
| 1 | Limit hydrogen inventories, especially indoors, to what is strictly necessary. |
| 2 | Avoid or limit formation of flammable mixture, by applying appropriate ventilation systems, for instance. |
| 3 | Carry out ATEX zoning analysis. |
| 4 | Combine hydrogen leak or fire detection and countermeasures. |
| 5 | Avoid ignition sources using proper materials or installations in the different ATEX zones, remove electrical systems or provide electrical grounding, etc. |
| 6 | Avoid congestion, reduce turbulence promoting flow obstacles (volumetric blockage ratio) in respective ATEX zones. |
| 7 | Avoid confinement. Place storage in the free, or use large openings which are also supporting natural ventilation. |
| 8 | Provide efficient passive barriers in case of active barriers deactivation by whatever reason. |
| 9 | Train and educate staff in hydrogen safety. |
| 10 | Report near misses, incidents and accidents to suitable databases and include lessons learned in your safety plan. |

Propose to add a new safety principle SP11 to avoid poor design of hydrogen system and material selection.

# Lessons learnt

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## Examples for lessons learnt (1/2)

- Cascading effects of minor events could result in extremely serious consequences.
- Quite often incidents are caused by multiple factors.
- Typical examples of design related lessons learnt
  - Lack of precaution during the design stage to limit hydrogen inventory
  - Lack of protection of vessels against thermal attacks
- Typical weak points
  - Gauge glass for liquid tank level monitoring
  - Flange connections
  - Welded joints

# Lessons learnt

European Hydrogen Safety Panel (EHSP)

## Examples for lessons learnt (2/2)

- Job factor
  - Lack of maintenance or inspection, special attention for safety devices during maintenance
  - Reoperation after repair
  - Individual/human factors, lack of clear instructions
  - Re-use of tanks or pipes previously containing flammable liquid or gas
- Lessons learnt for the first responders
  - Quick action to limit inventories
  - Firewater drainage is a longstanding problem at many disaster sites
  - Domino events such as fires common after many gas explosions, raising the severity

# Recommendations

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## Recommendations for different operational modes

- An adequate training of personnel is key (SP9). Periodic training of personnel, new personnel and senior one is crucial for keeping the skills and getting used to following the procedures.
- Both passive and active safety measures should be given a crucial role. At least 19% of the incidents considered involved lack of sufficient and adequate safety devices or passive measures (SP7, SP8). Leak detection (SP4) and ATEX zoning (SP3, SP5) should be applied to reduce the opportunities for incidents.
- It is necessary to keep the equipment and systems up to date and clean with appropriate surveillance and maintenance. Updating maintenance procedures to consider changes is crucial.

# Recommendations

European Hydrogen Safety Panel (EHSP)

## Recommendations for hydrogen energy applications – system design

- Perform Process Hazard Analysis for the new/updated installations (SP1-10);
- Use materials which are compatible with hydrogen services. It should be noted that in certain incidents, this resulted in the need to change standards/codes for pressure vessel (SP11); and
- Install high fidelity leak detection and other extra mitigation barriers (SP4, SP8).

# Concluding remarks

European Hydrogen Safety Panel (EHSP)

- HIAD 2.0 is being continuously enlarged and enhanced by EHSP and JRC
- Currently 577 events have been validated and released online.
- Since June 2020, EHSP has analysed 485 incidents which were in the database in July 2020 with the following outcome which are included in an updated report to be published by FCH 2 JU:
  - Statistics
  - Lessons learnt
  - Recommendations
- Analysis will be conducted for new events added/consolidated in 2021.