

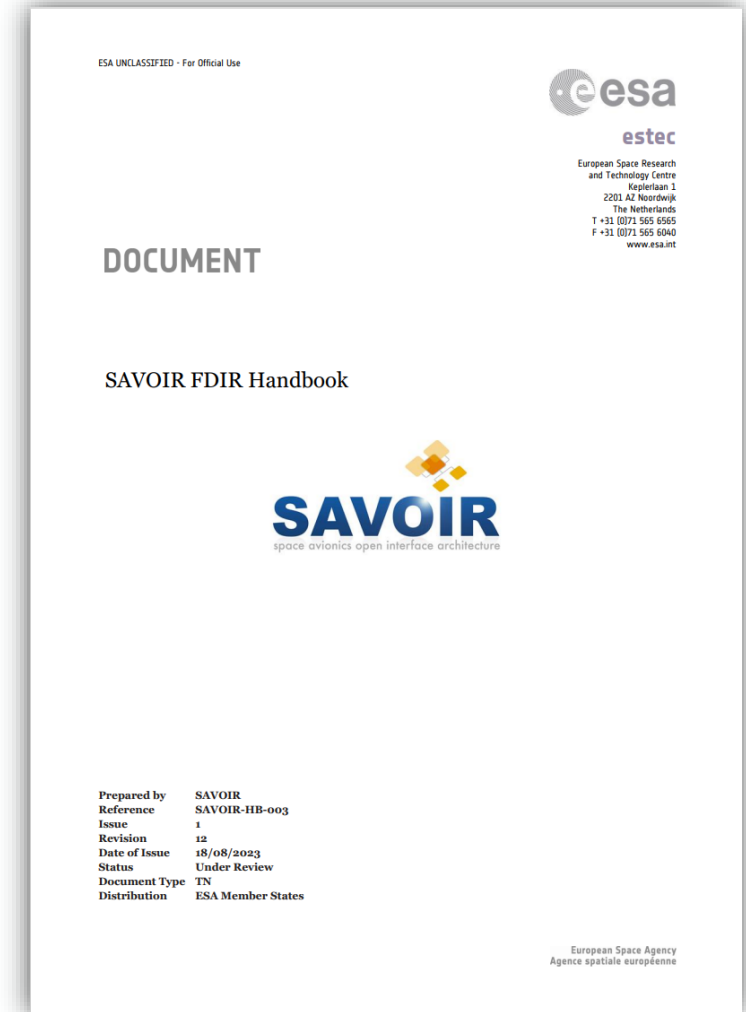
# SAVOIR FDIR Handbook update - ADCSS 2023

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Contributors: Benedicte Girouart, Silvana Radu, Paulo Rosa

13/11/2023

1. Scope
2. Major points raised
3. Changes with respect to last version
4. Composition and support
5. Updated planning and timeline
6. Major topics tackled
7. Major changes from previous version
  1. CPOs
  2. LLs
  3. RAMS
8. Minor points raised
9. Open topics
  1. AI-based FDIR ongoing research
  2. NewSpace
10. Way forward



- ✓ Identify missions or technologies for which common FDIR design and processes recommended in the first issue of the handbook are **not applicable or require tailoring**
- ✓ Identify minor aspects within the handbook that are needed for update in order to be **aligned with other existing handbooks or technical notes**
- ✓ **Revise** overall handbook and **alignment with ECSS**
- ✓ Gather **lessons learned** from satellite manufacturers and mission operators on FDIR, either internally and from the industry, and integrate those lessons learned in the handbook

**Ensure the handbook can be used for a large range of types of missions, including with regards to new niches such as Close Proximity Operations, CubeSats, high autonomy, use of AI/ML, etc.**

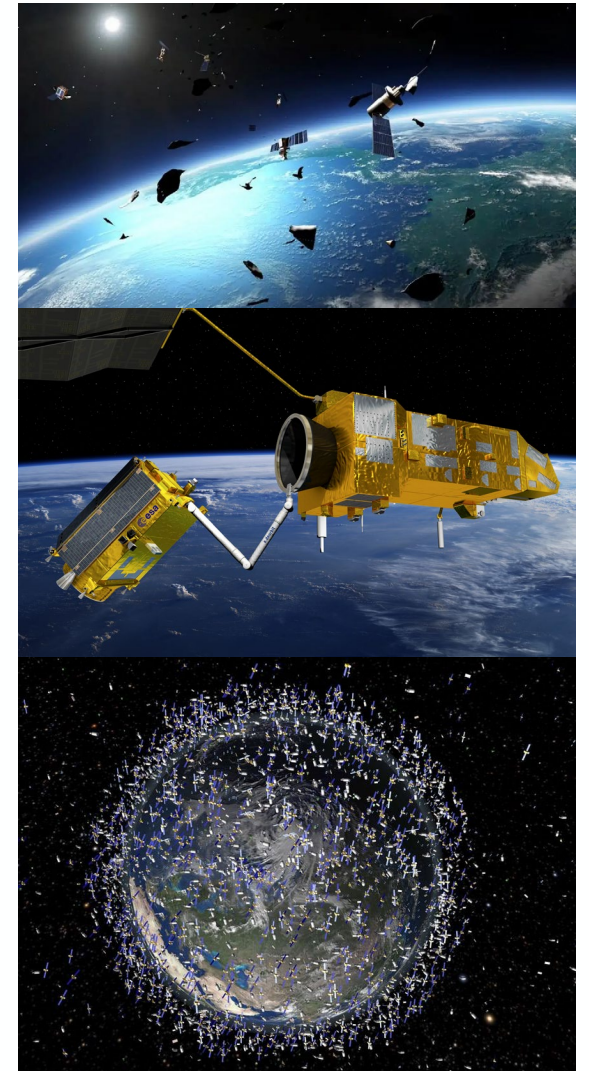
- ✓ At the SAVOIR Advisory Group meeting #61, the SAG has decided to continue the FDIR working group for the elaboration of the **second issue** of the SAVOIR FDIR.

# Major points raised

1. Alignment with ESA mission classification
2. CubeSats/Small Sats performing complex missions
3. Close Proximity Operations (e.g. in-orbit servicing, ADR, etc.)
4. Use of RAMS analysis for FDIR definition
5. Use of MBSE in FDIR definition
6. Use of AI and ML for FDIR
7. Identify constellations gaps
8. Identify ground segment gaps
9. Establish timeline of FDIR concept definition
10. Disposal
11. FDIR tools recommendation
12. Verification approach for FDIR
13. NewSpace

*postponed to next iteration due to lack of available information*

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## Additions

- Lessons Learned
- Recommended tools
- Use of RAMS for the FDIR process development
- Specific use cases (Close Proximity Operations, CubeSats)
- ESA Mission Classification

## Changes

- Based on the SAVOIR FDIR working group discussion and RIDs
- Based on the additional lessons learned received internally and from industry

# Composition and support

Expertise provided from ESA side:

Avionics	Software	Product Assurance	RAMS
FDIR	System	Close Proximity Operations	GNC
Constellations	Clean Space	Operations	MBSE
CDHS	AI/ML	CubeSats	Power



Co-chairs:

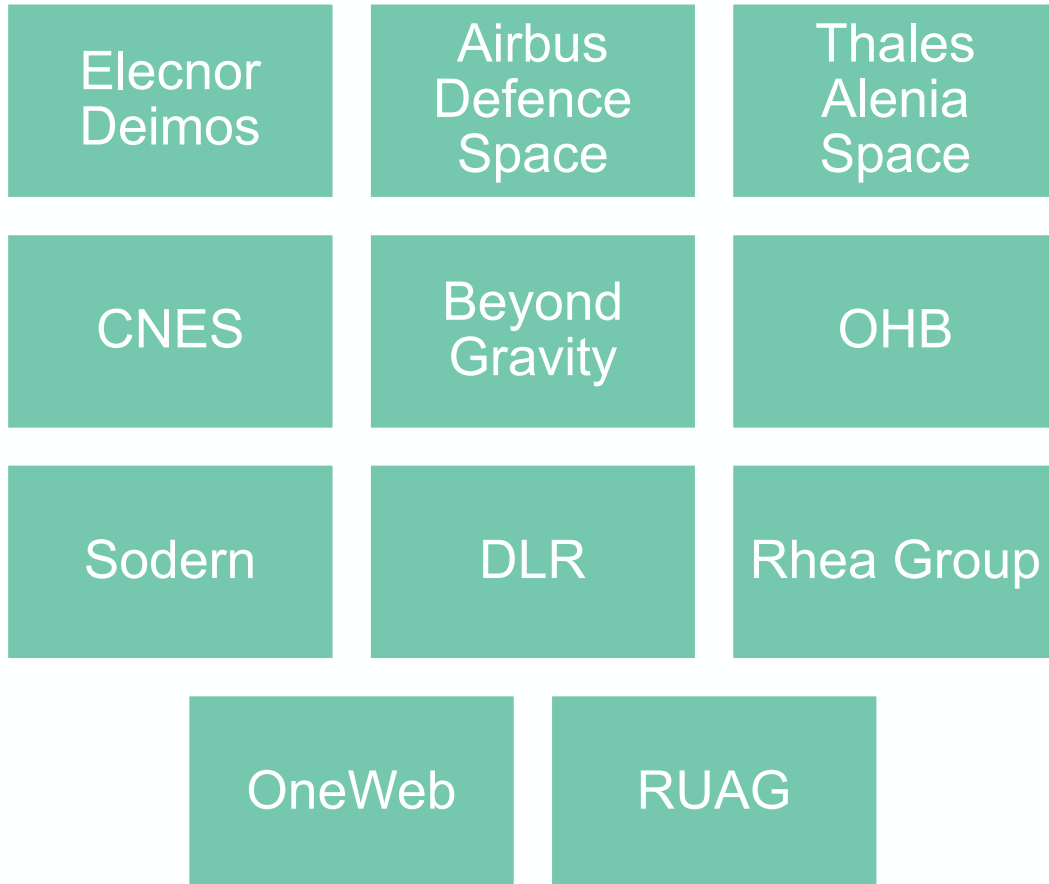
- Silvana Radu
- Benedicte Girouart

Support:

- Tatiana Fontana

# Composition and support

From industry side:



Support to ESA Co-chairs from the industry:

- Paulo Rosa (Deimos)

# Composition and support

To be continued by Deimos for the duration of the activity.

Deimos main tasks:

- Organise splinters
- Support convergence towards a consensus



- Maintain the shared repository
- Gather the lessons learned from industry
- Keep minutes of meetings
- Prepare status reports



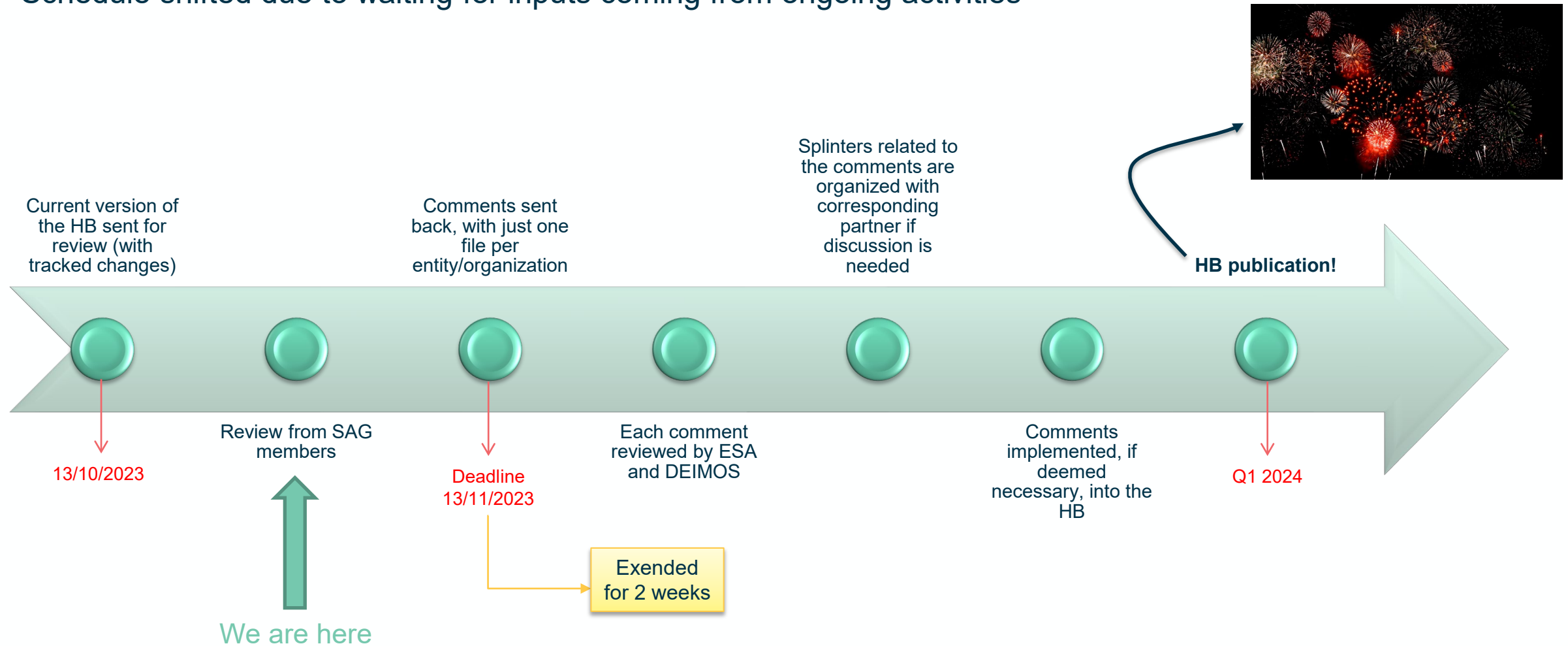
... and the most important => perform the update of the FDIR Handbook.





# Updated planning and timeline

- Schedule shifted due to waiting for inputs coming from ongoing activities



CPOs use cases added:

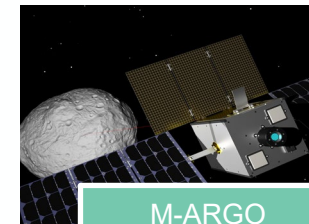
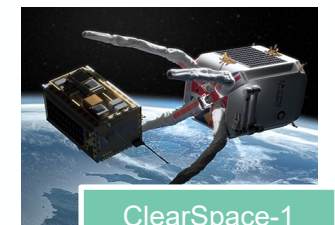
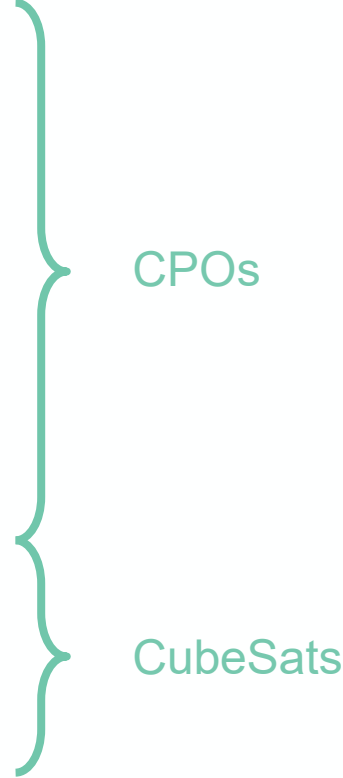
- ✓ Cooperative rendezvous without capture and formation flying
- ✓ Cooperative rendezvous with capture
- ✓ Non-cooperative rendezvous without capture
- ✓ Non-cooperative rendezvous with capture



# Major changes from previous version: LLs

Missions and lessons learned and designs considered when updating:

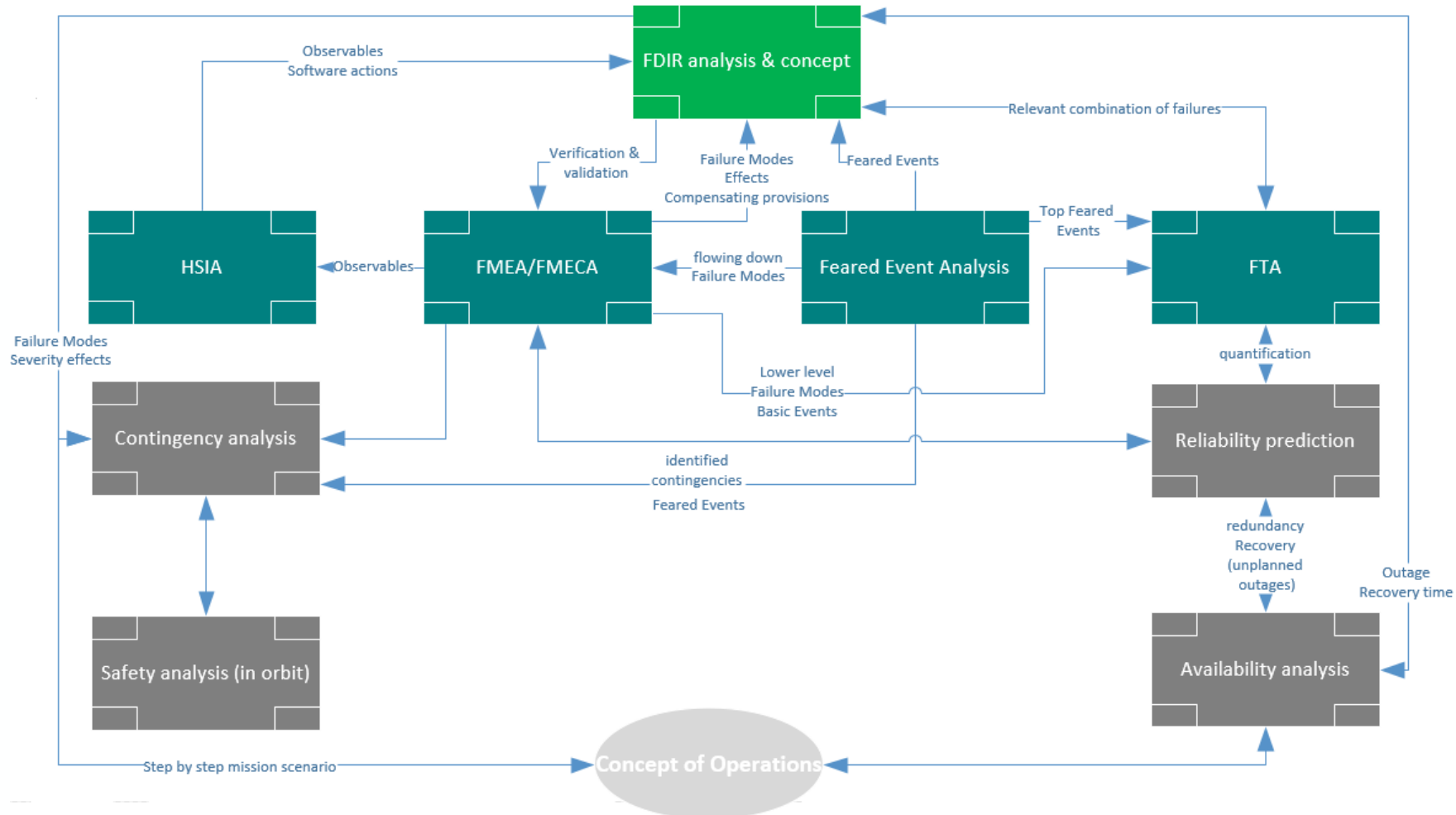
- Proba-3
- Mars Sample Return – Earth Return Orbiter (MSR-ERO)
- PRISMA
- ClearSpace-1
- Sunrise (ELSA-M)
- RISE (IOS)
- e.inspector
- M-ARGO
- LUMIO
- VMMO



Included in the CPOs and Example Mission section in the FDIR use cases annex (F)

# Major changes from previous version: RAMS

Direct contribution to FDIR  
 Indirect contribution to FDIR



## Purpose:

- To better showcase the interaction between FDIR and RAMS (it is often noticed that this aspect is a constant lack in projects)
- To provide an easier read of the interactions between analysis.

# Major changes from previous version: RAMS

Analysis 1	Analysis 2	Output Analysis 1 to Input Analysis 2
FMEA/FMECA	FDIR	FM, effects equipment/subsystem/system, compensating provisions (serving to recovery), observables (serving to detection/identification)
FDIR	FMEA/FMECA	Verification and validation of implemented functions
FMEA/FMECA	HSIA	FM, observables
HSIA	FDIR	Observables, SW actions, effects of failure upon SW/HW
Availability analysis	FDIR	Planned and unplanned outages
FDIR	Availability analysis	Time to perform a recovery action
Availability analysis	CONOPS	Overall system availability and unavailability
CONOPS	Availability analysis	Concept of operations, planned outages
Contingency analysis	CONOPS	Contributes to FOM
FTA	FDIR	Relevant combinations of failures to be accounted for within the FDIR design
FEA	FDIR	Top feared events for which FDIR shall be design in order to react accordingly
Reliability prediction	FDIR	Indirect contribution through redundancy scheme

## Purpose:

- Table added to clarify inputs and outputs coming from each analysis.

Minor points raised, among which several can be mentioned as being more interesting:

- ✓ Constellation-Level FDIR Considerations
- ✓ Minor RAMS aspects revision
- ✓ Alignment with ECSS
- ✓ Bringing updated version of the handbook in line with the generic OIRD evolution
- ✓ Alignment of handbook with decisions and updates ongoing within the PUS C WG
- ✓ Alignment of handbook with ongoing discussions within the SAVOIR Power WG

100% of minor points raised were solved in the current update of the SAVOIR FDIR Handbook.



Some topics are still to be added to the handbook, but at the moment the standards and/or document that support their update are still to be reviewed and published .

- ✓ Standardized XML formats → Requires approval for a standardized format before inclusion
- ✓ Accordance with latest ECSS standard → Awaiting the next ECSS review, expected in the first quarter of the coming year
- ✓ MBSE inputs → To be injected once made available by the MBSE HUB activity
- ✓ ESA Mission Classification → Under revision
- ✓ Accordance with Standards → Pending the availability of the latest version of GOIRD/ECSS-E-ST-70-11C

To be left open for next version



**Detect-AI study:** exploring the feasibility of innovative Failure Detection, Isolation, and Recovery (FDIR) concepts for predictive failure analysis.

Example

- Thorough examination of existing literature on AI-based FDIR, excluding in-orbit applications as no literature is present as of today, to discern theoretical advancements.
- Comparative analysis of drawbacks, advantages, and applicable scenarios for diverse FDIR algorithms.
- Investigation into the potential benefits of MBSE-based FDIR, and the possibility of merging it with AI algorithms to optimize system performance.

→ Feasibility study expected to be concluded by year-end.  
→ Continuation of activity anticipated for 2024

In collaboration with 



**NewSpace** denotes emerging companies deviating from traditional space industry norms. These entities often harness Commercial Off-The-Shelf (**COTS**) technologies, introducing a challenge in terms of reliability while minimizing the costs.

Despite the potential inherent in NewSpace ventures, a crucial impediment surfaced due to the **lack of a universally accepted definition and formal standards**.

- The study's progression is on hold as we await more inputs and a clearer definition.
- It is likely it will be resumed for the next update

# Way forward

- Gather all comments from ESA and SAG representatives
- Consolidate comments and discuss them in splinters
- Implement the comments in the HB
- And finally...

...publish second issue of the HB!



→ Continue with the remaining topics once information is available

# Thank you, Questions?

