

# Airbus view on Avionics Functional Verification

Implement the new  
ECSS-E-ST-10-03C Rev.1, Standard  
ECSS-E-HB-10-03A, Handbook

DEFENCE AND SPACE

M. Scheuble, Functional Verification Process and Product Owner  
25.10.2022

# Overview

- Background and motivation to develop
  - ECSS Testing Standard Rev. 1
  - ECSS Testing Handbook
- Functional Avionics Validation in Airbus
  - FV & its relation to ECSS Testing Standard & Handbook
- Synthesis & Conclusion

# Agenda

---

This presentation could be generated thanks to the work & support of my Airbus colleagues

- A. Konrad Astrobus Product
- P. Riant, former AOCS PPO
- J. Bourdon, AOCS PPO
- B. Kraft, AS400 AOCS
- F. Verges, AIT
- A. Michels, AIT
- P. Parmentier, CCS
- The Airbus transnational FV team

## Background and motivation to develop

- ECSS Testing Standard Rev. 1
- ECSS Testing Handbook

# Motivation for the ECSS Testing Standard Definition & Update

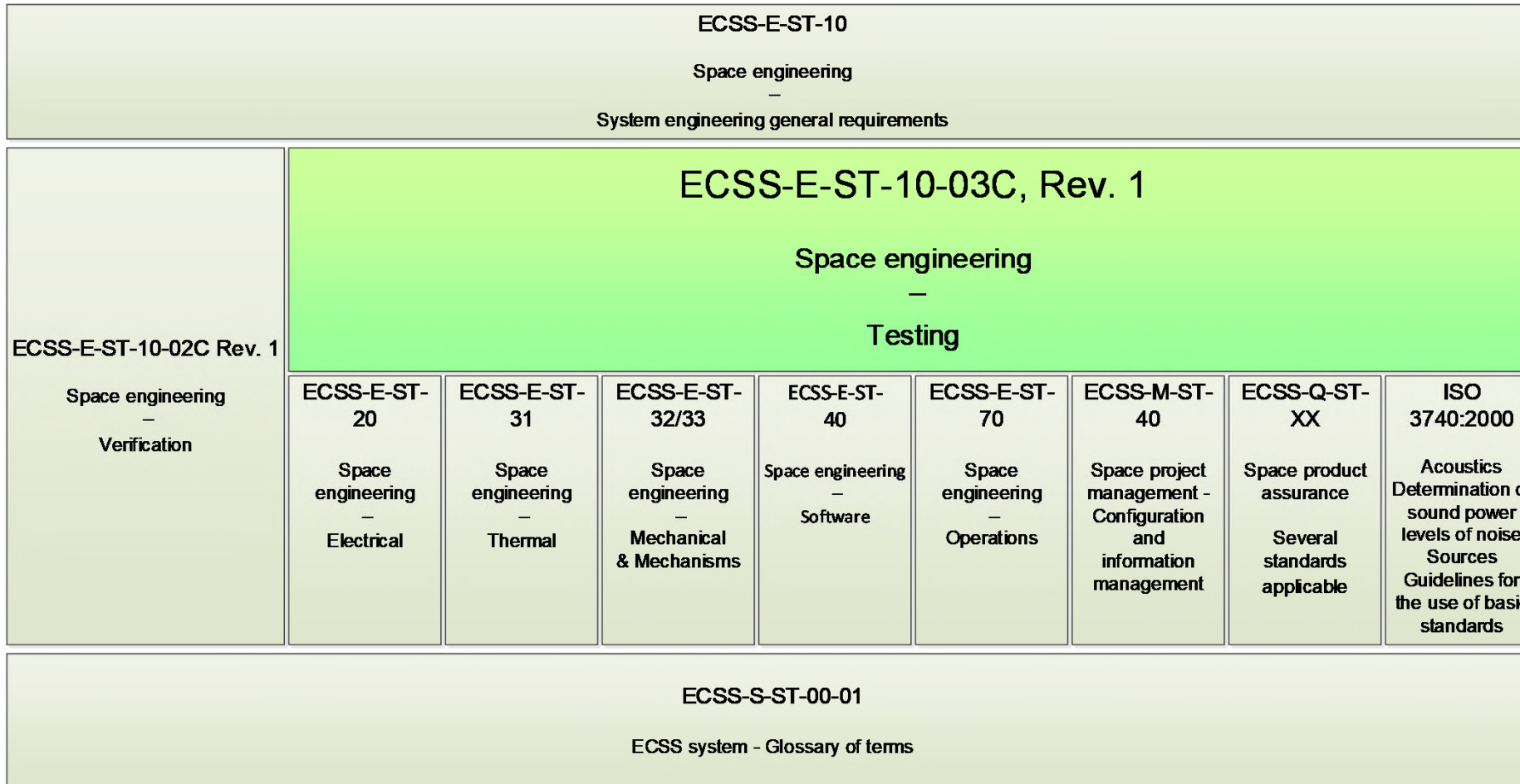
The ECSS Testing Standard aims at a consistent application of on ground testing requirements to allow proper qualification and acceptance of space products (*STD Introduction*)

- The ECSS testing standard
  - Provides specific aspects of systems engineering process (ECSS-E-ST-10)
  - collects the requirements on Space product testing covering
    - overall test programm
    - on Space Segment Equipment Level (e.g the OBC, the STR, the instrument or a part of P/L)
    - on Space Segment Element Level (e.g the S/C)
    - for pre-launch testing
- The ECSS testing standard
  - imply new requirements – those are fully covered by the related ECSS testing standard
- The ECSS testing standard does not
  - define requirements for testing of multiple FMs part of aa S/C mass production

## Motivation

STD: Standard

# The context of the ECSS-E-ST-10-03C Testing Standard

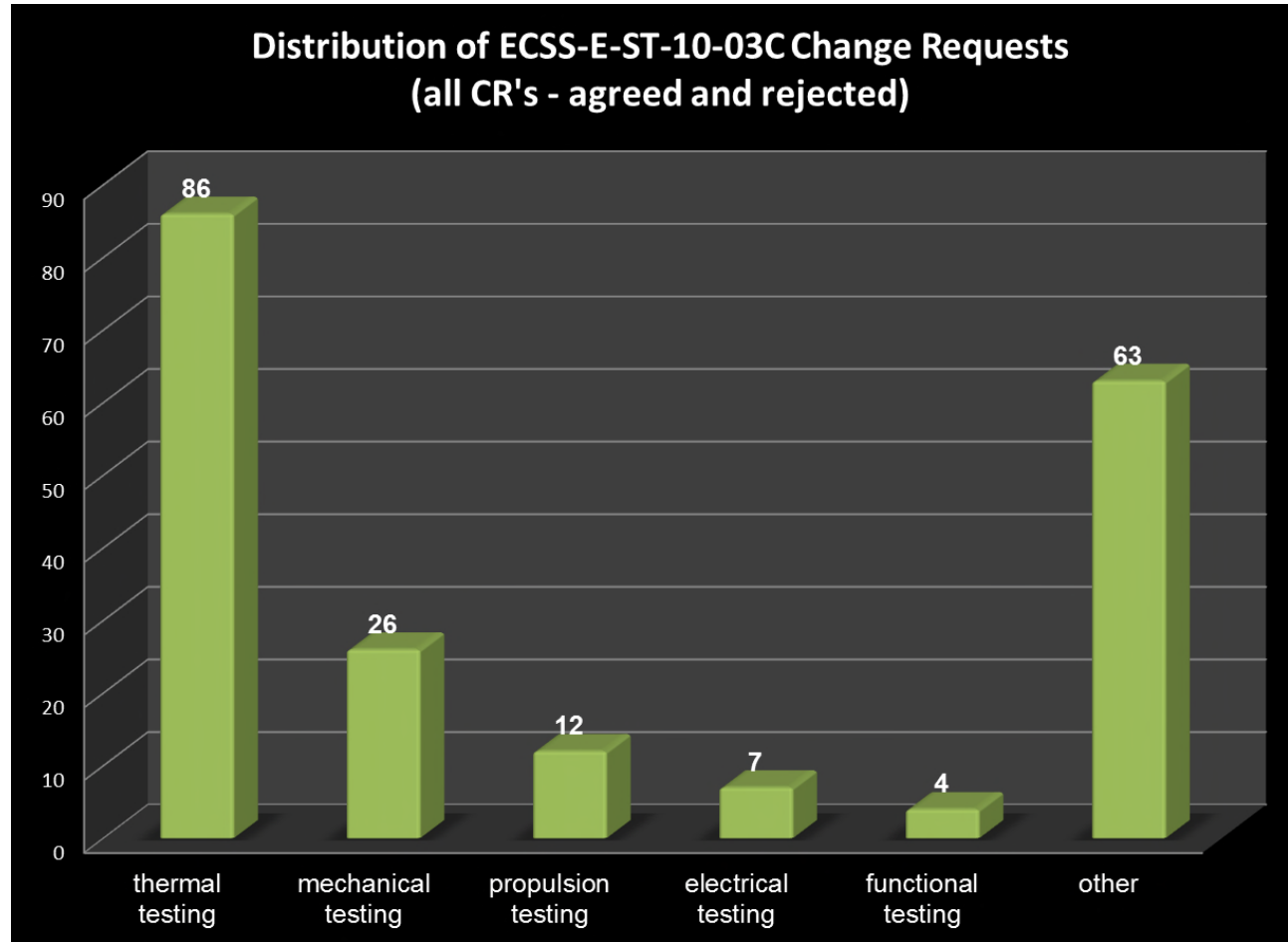


## Context Standard

- Testing standard is at the core of the ECSS standards
- Testing is an important part of the Space project
  - impacting cost
  - demonstrate function
  - demonstrate performance

# Overview on the changes of the Testing Standard

- Total number of CR's – 198
- Majority in of CR's on
  - Thermal testing
  - “others”
  - Mechanical testing
- Interestingly little on functional testing



## CR's of Standard

Update of standard motivated by

- CR's on the standard
- Standard an Handbook consistency
  - Updates triggered by WG discussions while implementing the handbook

# Motivation for the ECSS Testing Handbook

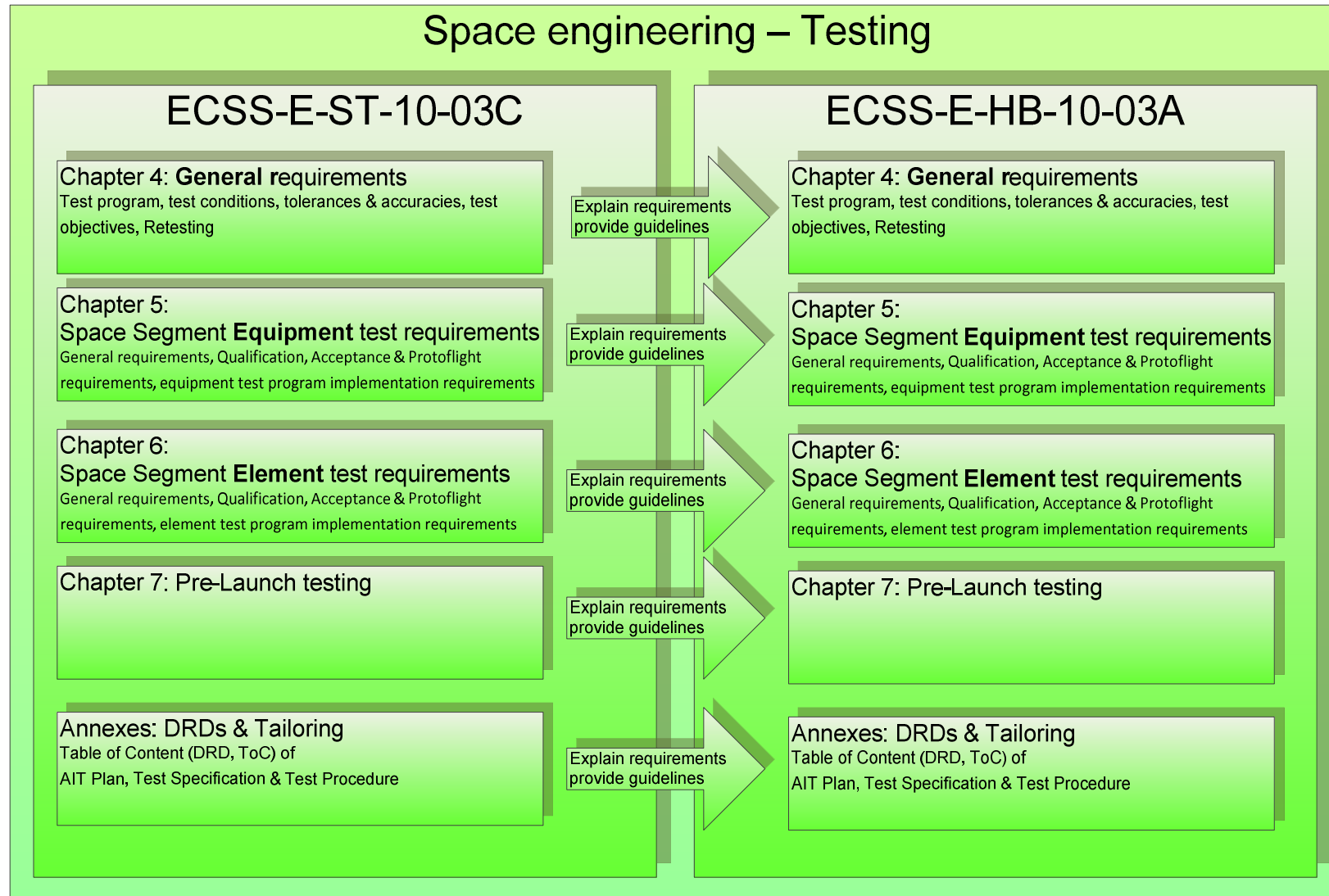
The ECSS Testing Handbook shall be a guideline to establish an appropriate test program *(WG objective 2017)*

- The ECSS testing handbook explains
  - “typical” approaches, guidelines, methods and techniques for testing S/Cs
  - Provide experiences, examples but also & limitations
- The ECSS testing handbook provides
  - clarifications of requirements of the ECSS Testing Standard
  - Describes baseline testing and possible alternative approaches
- The ECSS testing handbook does not
  - imply new requirements – those are fully covered by the related ECSS testing standard

## Motivation

WG: Workgroup

# Context ECSS Testing Standard & Handbook



# Context Handbook

Chapters:  
 Standard ← → Handbook

Handbook Annex  
 • Many more details



# Key topics discussed at handbook development

## Test prediction, accuracy, uncertainty & errors

- “Warhorse” topic which was discussed in nearly each WG meeting – definition now oriented on ISO standards

## Thermal

- Large sections on thermal testing benefitting from decades of experience of WG members

## Mechanical

- Several discussions on the subject, basis from standard was already quite elaborated

## Propulsion

- Difficult and intense discussions to reach common agreements

## Electrical

- Fewer discussions than on mechanical but
  - Section 6.5.1.2.3 Electrical functional test of standard initially confused functional test with electrical integration and EMC tests
  - Handbook tried to provide clarifications

## Functional, Polarity & Mission Testing

- Several intense and very constructive discussions on WG level
  - New test terminology explained including mapping
  - Full Functional Tests (previously called IST/ISST)
  - Polarity Tests (E2E Tests and stepwise testing)
  - Mission Tests (previously called SFTs)
  - Clarification on test benches including mapping to ECSS-E-TM-10-21A (System Modelling & Simulation)

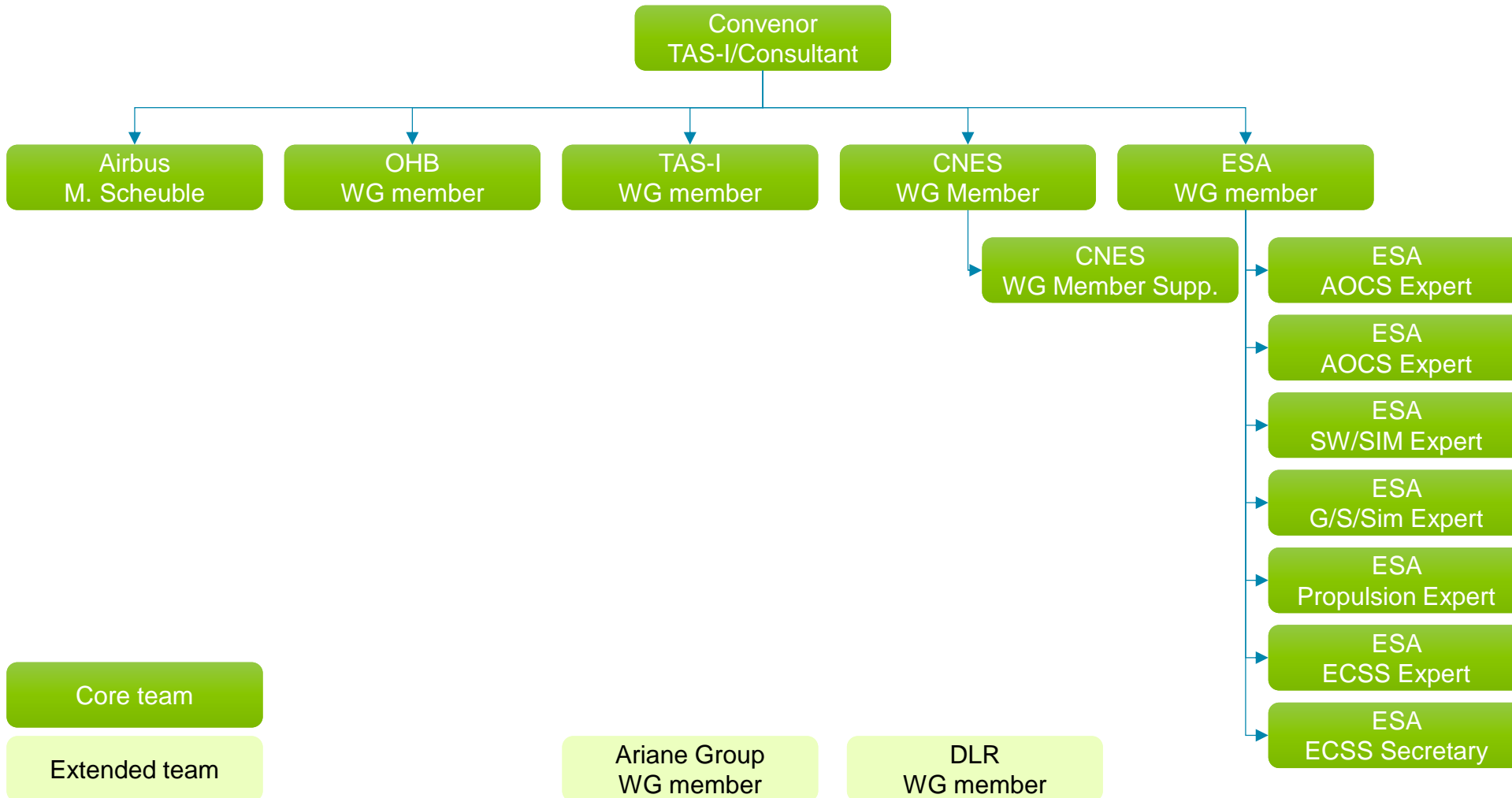
# Handbook Overview

Summary of selected key topics

It was a journey for:

- battling to use the right wording
- sharing expertise & experience
- enjoying a grand WG team and interesting individuals

# ECSS Testing Workgroup team (end 2018 – to 2022)



## The WG Team

Strong team with broad experience from all AIT fields

- Thermal
- Mechanical
- Propulsion
- Electrical
- Functional

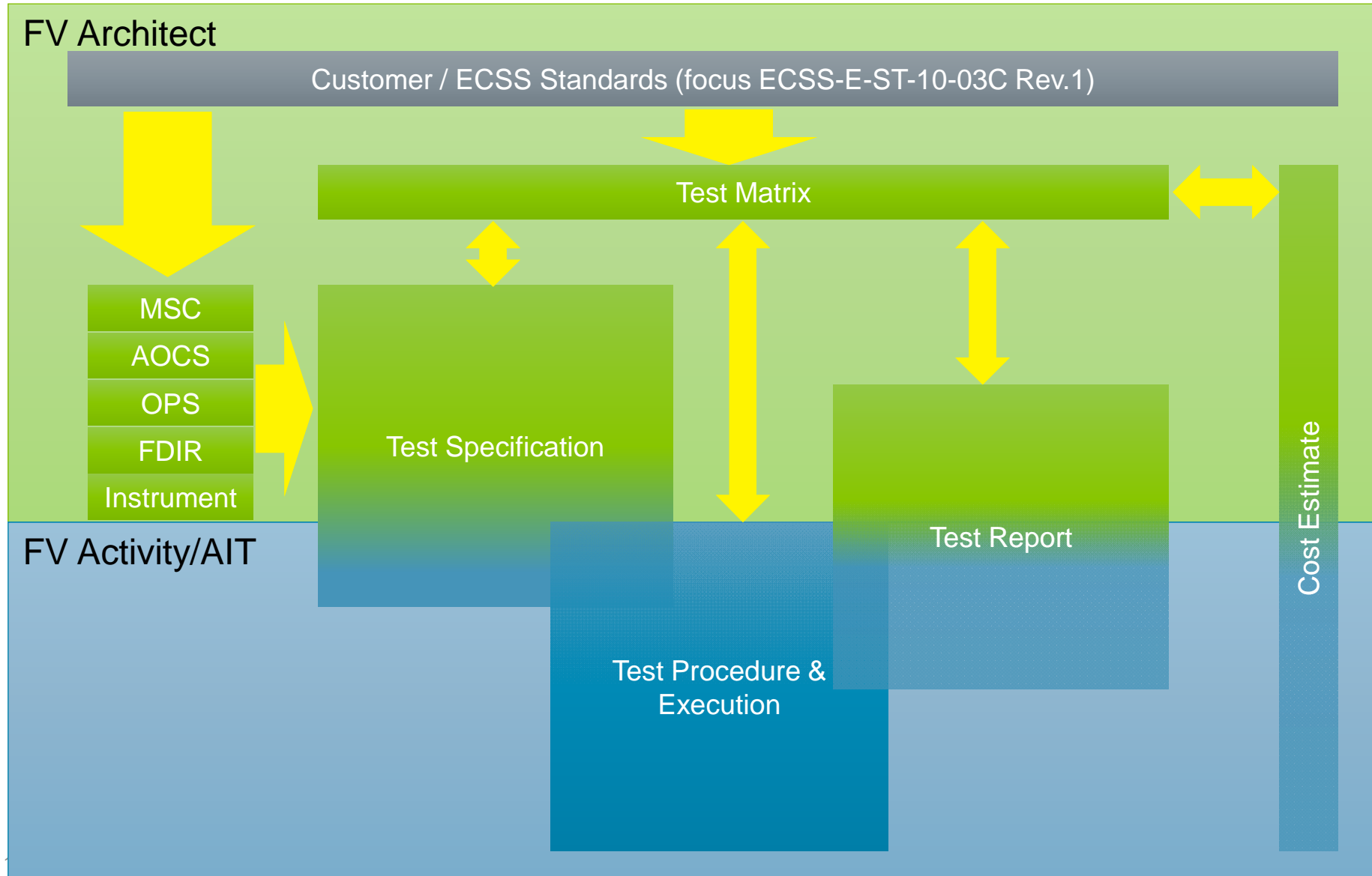
Regular meetings

- Approx. 3 times a year several days
- Full hit by Covid-19
- Switch to many remote meetings
- Unfortunately no final WG meeting to celebrate release of Standard Rev. 1 and Handbook

# Functional Avionics Validation in Airbus

## FV & its relation to ECSS Testing Standard & Handbook

# Functional Validation & relation to ECSS-E-ST-10-03C Rev.1



## FV & ECSS

### ECSS Testing Standard

- Basis for defining FV & AIT
- Defines “What to do”

### ECSS Testing Handbook

- “What to do and Why”
- Indicates “How to do”

# The Functional Test Types in ECSS-E-ST-10-03C Rev. 1

## Functional Test Types

### Lessons Learned on Test Types @ Airbus

**FFT-Q = FFT-D**  
 • Test of Design = Func. Qual.

**FFT-W = FFT-A**  
 • Test of Workm. = Func. Accept.

**CFQ = FFT-AOCS Design Test**  
 • CFQs are AOCS Mode tests  
 • Core are SW Algorithm test  
 • Can be done on repr. SatSim

**NO „Functional“ Performance**  
 • Func is there or not  
 • A Function has no „Performance“  
 • Don't mix with Performance Test

Previous Terminology (ECSS-E-ST-10-03A)	New Terminology (ECSS-E-ST-10-03C)	Test Types @ Airbus
<p>ELI Electrical Integration Test</p>	<p>ELI Electrical Functional <b>(Integration)</b> Test</p> <p>ECSS-E-ST-10-03C Section 6.5.1.2.3</p>	<p>ELI Electrical (Functional) <b>Integration</b> Test</p>
<p>IST/ISST Integration or Integrated (Sub-) System Test</p>	<p>FFT-D/W Full Functional Tests (Design/Workmanship)</p> <p>ECSS-E-ST-10-03C Section 6.5.1.2.1</p>	<p>FFT-Q/W Full Functional Tests (Qual.Workmanship)</p>
<p>AOCS IST or AOCS CLT Closed Loop Test</p>	<p><b>AOCS FFT-D</b> <b>AOCS Closed Loop Full Functional Test - Design</b></p> <p>Not explicitly covered in ECSS-E-ST-10-03C but important to be explicitly mentioned</p>	<p><b>AOCS CFQ</b> <b>AOCS Closed Loop Functional Qualification</b></p>
<p>AFT Abbreviated Functional Test</p>	<p>RFT Reduced Functional Test</p> <p>ECSS-E-ST-10-03C Section 6.5.1.2.1</p>	<p>RFT Reduced Functional Test</p>
<p>SFT System Functional Test</p>	<p>MT Mission Test</p> <p>ECSS-E-ST-10-03C Section 6.5.1.4</p>	<p>MT Mission Test</p>
<p>Polarity</p>	<p>Polarity Test</p> <p>ECSS-E-ST-10-03C Section 6.5.1.5</p>	<p>Polarity Test (EPT/E2EPT)</p>

# Functional Tests – Main Purposes & relations

## FFT-D - Open loop Full Functional Test – Design (or Qualification)

- Comprehensive tests which objective is to demonstrate design qualification at functional level

FFT-D

## FFT-W – (Open loop) Full Functional Test - Workmanship

- A set of test blocks to demonstrate absence of manufacturing and integration error, to assure freedom from workmanship defects and flawed materials in conformance with acceptance needs on PFM/FM

FFT-W

## RFT – Reduced Functional Test

- Sub-set of the Full Functional Test to verify the integrity of the major functions of the item under test, with a sufficiently high degree of confidence, in a relatively short time

RFT

# Functional Tests

## Lessons Learned

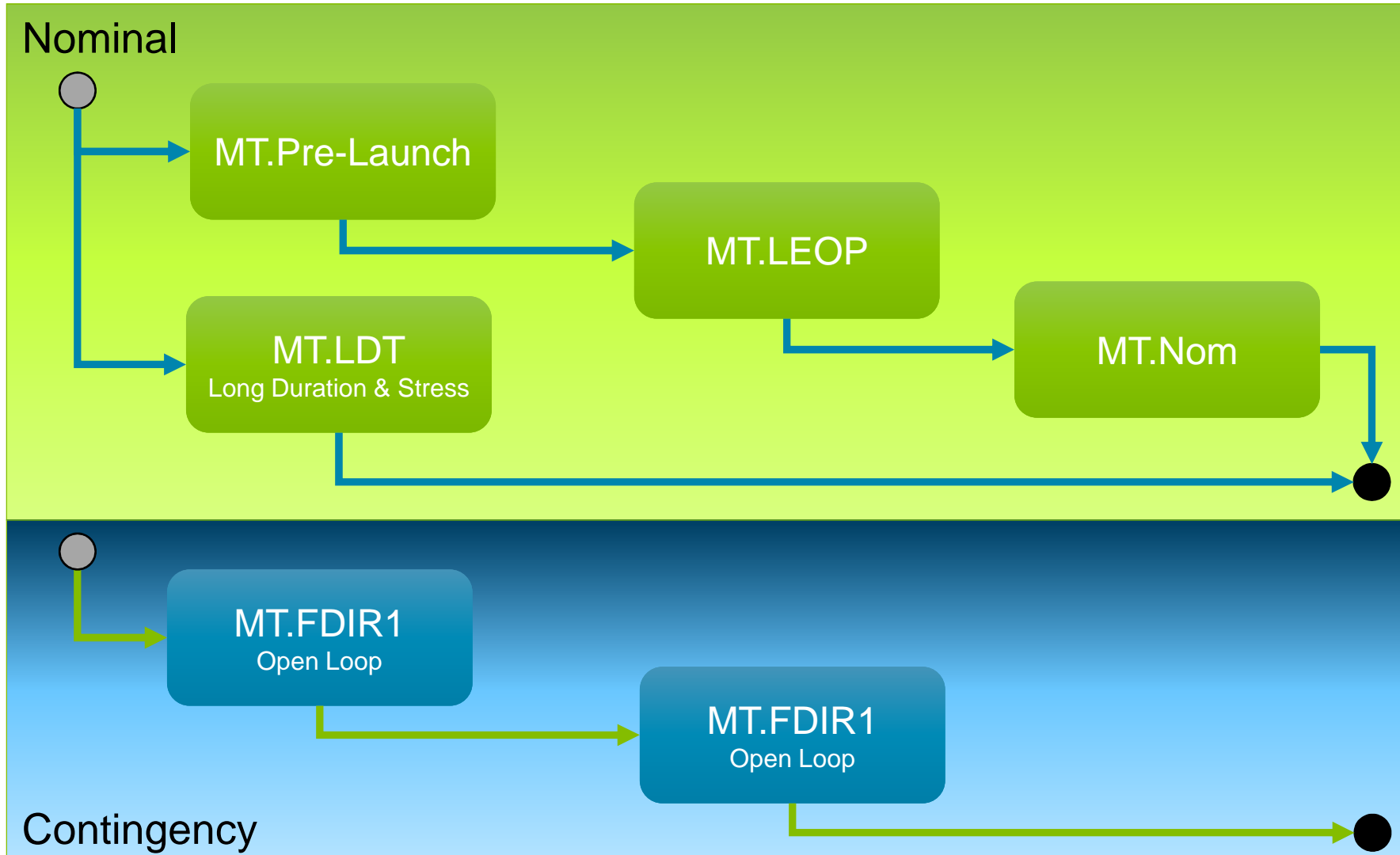
### Engineer your test campaign

- Define a complete Test Matrix
- Get all functions covered
- Correlate the requirements

### Design your FTs

- From FFT-Q to FFT-W
- From FFT-W to RFT

# Mission Tests



## Mission Tests

### Lessons Learned

#### Check the mission context

- Analyse your mission phases

#### Golden rules

- Stress your S/C
- Perform the mission „as-you-fly“
  - Nominal
  - Selected key contingencies
- Prevent IUT manipulation
  - e.g. SW patches to allow AOCSS Closed Loop on HW

# Polarity Testing

## Objective

- Verify the correct sign or polarity of the functional chain
- from sensors to actuators,
- through a number of interfaces
- including transformation matrices.

## Baseline Approach

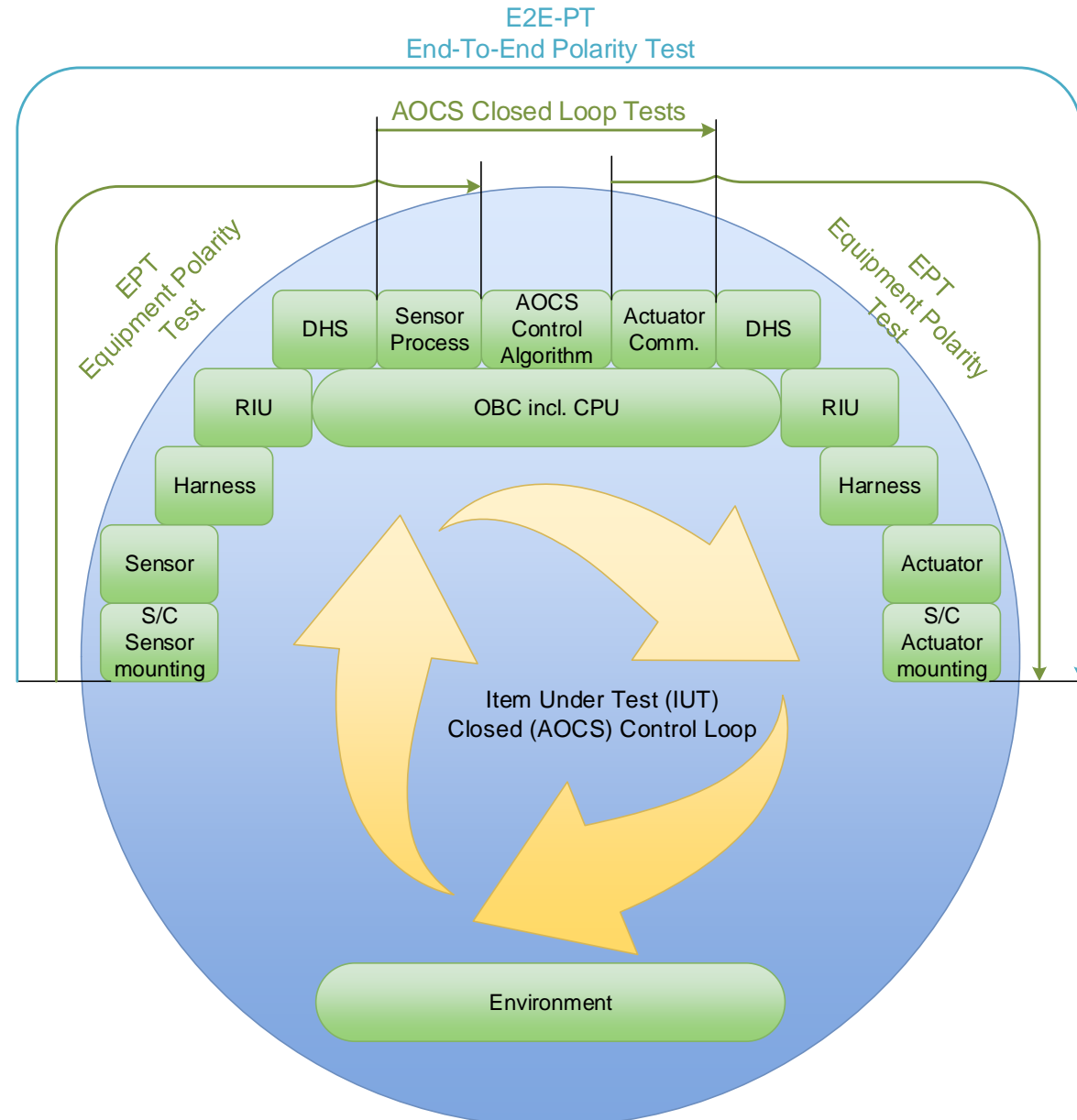
- E-2-E Polarity, ie. full chain at once

## Alternative Approach

- Equipment Polarity, stepwise

## Major Requirement Change

- *all “critical” modes* – new Rev.1
- *all “specific” modes* - old



# Polarity

## Lessons Learned

### Be aware on all signs in the chain

- HW signs/polarity
- Harness polarity
- SW including AOCS matrices
- Check mode relation with signs

### Polarity is key & Workmanship

### Golden rules

- Establish a clear polarity testing
- Follow your tests closely



# Synthesis and Conclusion

ECSS Testing WG provides consistent Standard and Guidelines

ECSS Testing Standard & Handbook is foundation of Airbus Functional Validation

## Testing is an important part of a Space Project

- because of its impact on cost
- the most effective way to demonstrate a product functionalities and performances.

## ECSS Testing Standard is

- setting the scope and boundaries for testing

## ECSS Testing Handbook is

- guideline to establish appropriate test program

## New Test Type terminology fully applied

- It is difficult to convince all at once & skip heritage but we are almost there

## Engineer the test campaign

- We transform more and more from
  - „What to do“ towards „How to do it“
  - „One-Off“ to product „re-use“

## Our trends motivated by Standard & Handbook

- Rely more and more on Test by Simulators
  - Test the SW algorithms instead debugging your test environment for AOCS Closed Loop
  - But be sure of a representative Simulator

# Conclusion

## Testing Standard & Handbook

- Interesting
- Relevant
- Containing decades of experience

## It can serve

- To engineer your test campaign
- Building the foundation to derive your test methods (the how to)

And the rest was:

A lot of



Good



A very nice WG



Some



And lots of



Thank  
you

# Thank you

Airbus Defence and Space GmbH / for ADCSS Workshop 2022, ESTEC Noordwijk, Airbus view on FV & ECSS Testing

This document and all information contained herein is the sole property of Airbus. No intellectual property rights are granted by the delivery of this document or the disclosure of its content. This document shall not be reproduced or disclosed to a third party without the expressed written consent of Airbus. This document and its content shall not be used for any purpose other than that for which it is supplied. Airbus, its logo and product names are registered trademarks.