Generic OIRD and ECSS

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Agenda

- Introduction
- The problem
- The generic OIRD
- PUS-C tailoring
- Conclusions and future outlook

Introduction

- **Operability requirements** are an early input to the spacecraft development
  - Functional requirements for the space segment, including the payload, necessary for the conduction of all mission operations
  - Prepared by the customer/operator (ESA for ESA missions)

- For (most) ESA missions→ **OIRD**: Operations Interface Requirements Document
  - **Mission-specific**
  - Standalone doc or integrated in System Requirements Document (**SRD**)
  - Tightly coupled with CCSDS and ECSS standards

The problem

- Mission OIRDs are created by **copy & paste** from similar previous missions
  - OIRDs are slowly diverging
    - Similar requirements…
    - …but different wording
    - …and sometimes small differences
    - Three main branches, one for each mission family
  - Lessons learned not always propagated to all mission families

→ Even if operability requirements for ESA missions are very similar, it is sometimes perceived by prime contractors as each missions is requesting something different to the other missions

The problem

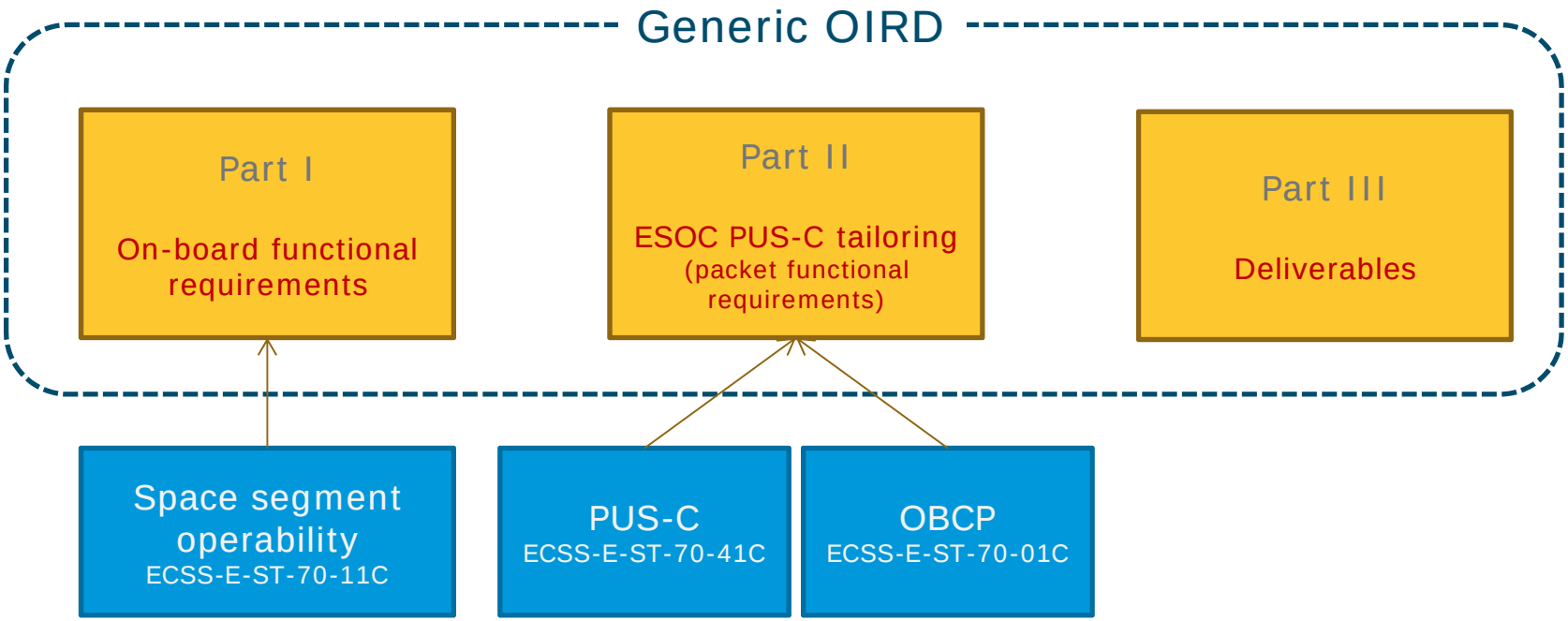
- Evolution of ECSS standards not well reflected in mission OIRDs. Relevant standards are:
  - Space segment operability standard
    - ECSS-E-ST-70-11C, published in 2008
  - Spacecraft on-board control procedures standard
    - ECSS-E-ST-70-01C, published in 2010
  - Telemetry and telecommand packet utilization standard, in its newest version
    - ECSS-E-ST-70-41C (PUS-C), published in 2016

The generic OIRD

- **Goal**
  - Create a **common** set of operability requirements for **all** new missions
    - Maximize commonality among missions
    - Minimize differences and group them by **mission families**
    - Maximize the **alignment with ECSS**
  - Mission OIRDs to be created starting from the generic OIRD
    - Changes limited to mission specific deltas

→ **Ideally**: >85% generic, <10% family specific, <5% mission specific

Generic OIRD structure

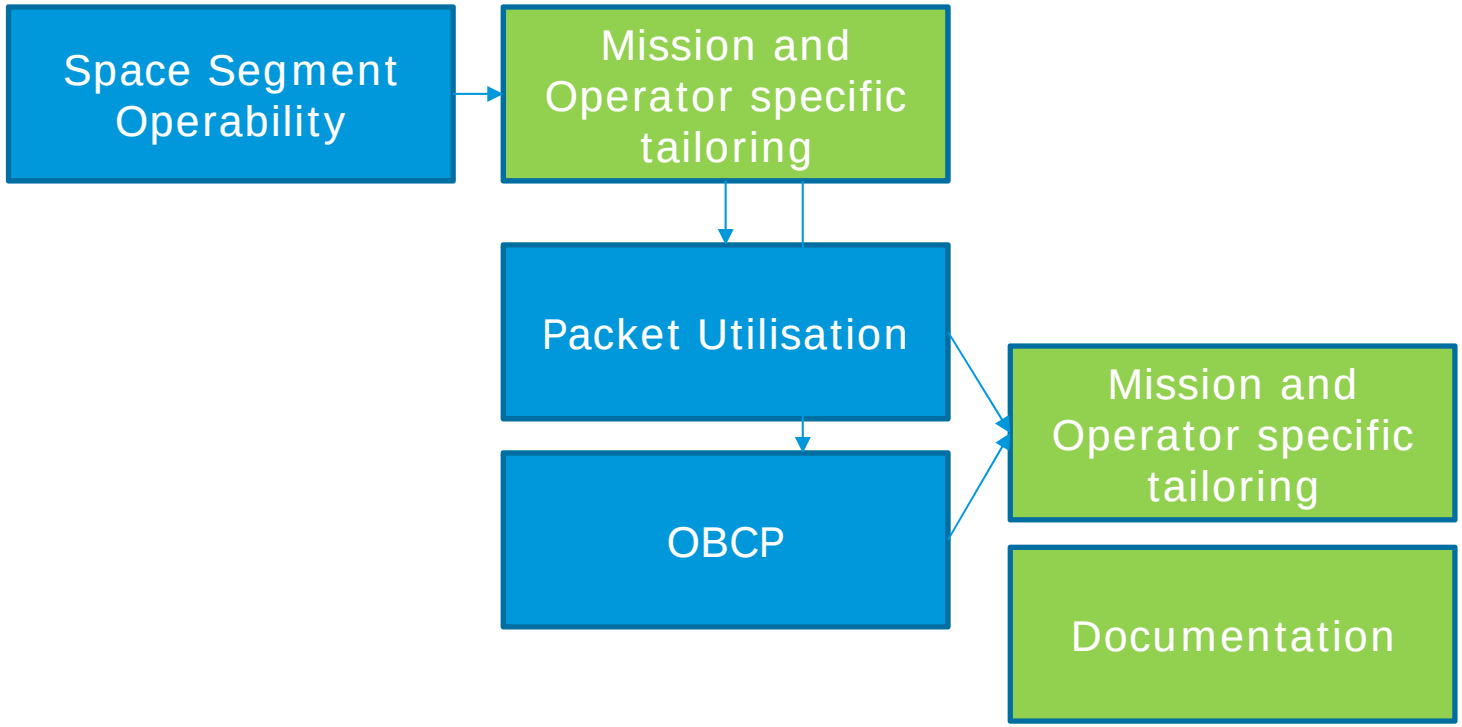


The generic OIRD

- The birth of the **generic OIRD**
  - Space Avionics Open Interface Architecture Initiative (**SAVOIR**)
    - Representatives of European space agencies and industry
    - Clear need of harmonizing satellite operability requirements identified

  - Task force established at ESOC with representatives of all mission families
    - Astronomy, Interplanetary and Earth Observation
    - Bottom-up approach, proposal built upon **consensus**

Generic OIRD structure



Mission OIRD generation

- Future mission-OIRDs shall start from the generic OIRD
  - No copy & paste from previous mission

- Format is **open** to satisfy mission/project needs:
  - **Standalone** mission OIRD
    - Full export of generic OIRD requirements
    - Any mission delta requirement must be **highlighted**
  - **Delta** mission OIRD
    - Document containing only delta requirements wrt generic OIRD
  - OIRD integrated as a section of the **SRD**

- Feedback mechanism to be established in the feature
  - Update generic OIRD with lessons learned from flying missions

Tailoring motivation

- Why tailoring an ECSS standard?
  - Tailoring is enabled by the standard itself!
  - Large number of capabilities and options!
  - Important functionalities for ESA missions not covered
  - Feedback and lessons learned from 50+ years of operations
    - A few important requirements from mission OIRDs not captured

→ **Reducing variability → reducing cost**

- For the S/C operator: same interfaces allow large reuse of mission data systems
- For the S/C manufacturer: reuse PUS-C libraries and platforms, minimize validation

Tailoring scope

- Tailoring done with an **avionics like subsystem** in mind
  - System architecture similar to modern spacecraft implicitly assumed

- Sub-tailoring across **on-board users** is left mission specific
  - Payloads and other packetized units may rely on a smaller subset
  - Generic tailoring not trivial due to large differences between units

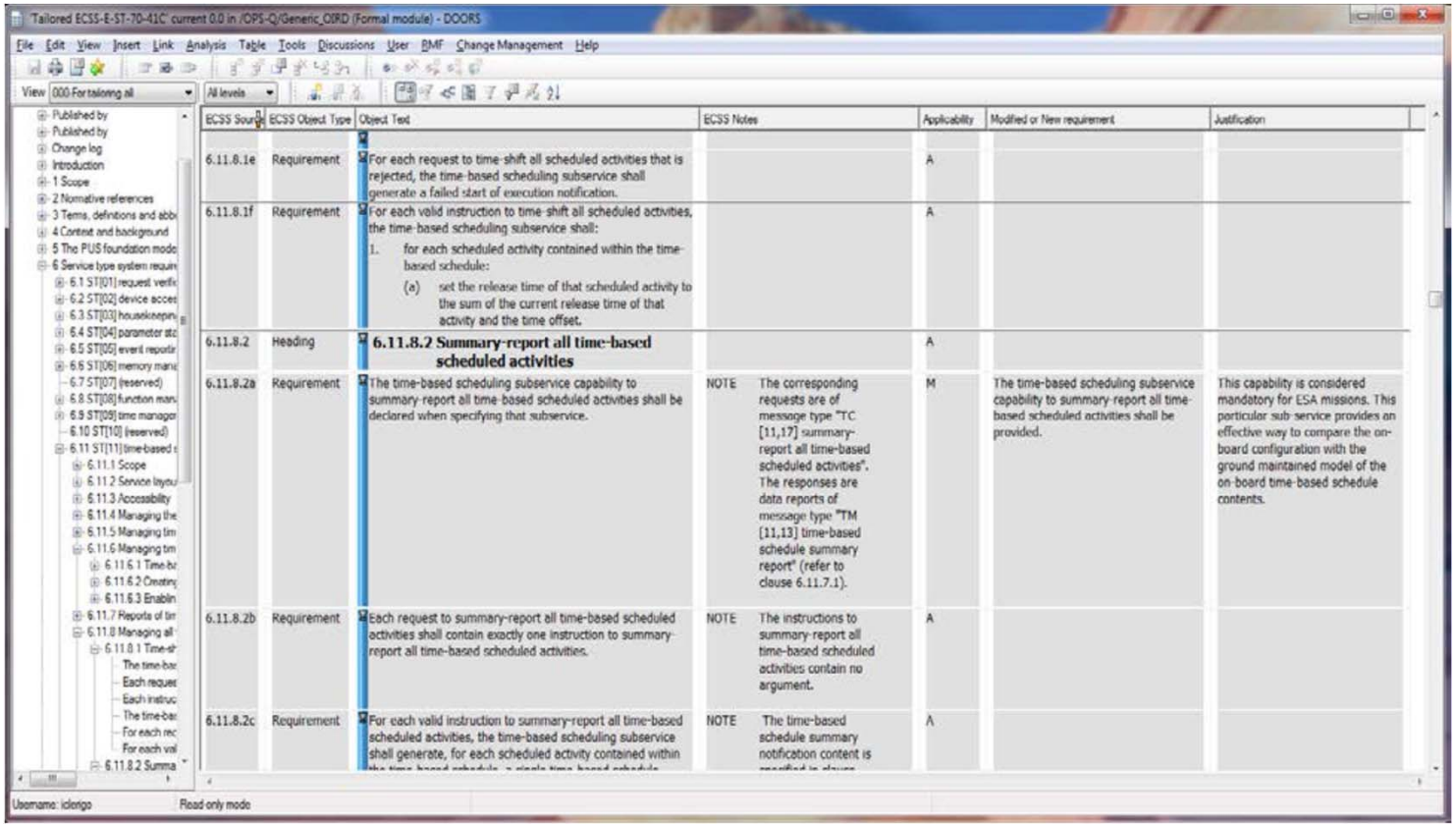
- Generic OIRD does not cover low level details
  - For example, number of bytes to encode ids, event id ranges, etc.
  - This could be useful, but should be addressed at implementation level
    - Technical cooperation among PUS-C library developers desired

Tailoring format done by ESOC

- Tailoring in Rational Dynamic Object-Oriented Requirements System (**DOORS**)
  - Starting from the original standard
  - ESA tailoring and the original requirements combined but not mixed
    - Added flag to track new or modified requirements
    - Possible to export full tailored standard or only deltas

- Justification field included for every change and addition
  - For future maintainability

Tailoring format



ECSS Sour	ECSS Object Type	Object Text	ECSS Notes		Applicability	Modified or New requirement	Justification
6.11.8.1e	Requirement	For each request to time-shift all scheduled activities that is rejected, the time-based scheduling subservice shall generate a failed start of execution notification.			A		
6.11.8.1f	Requirement	For each valid instruction to time-shift all scheduled activities, the time-based scheduling subservice shall: 1. for each scheduled activity contained within the time-based schedule: (a) set the release time of that scheduled activity to the sum of the current release time of that activity and the time offset.			A		
6.11.8.2	Heading	**6.11.8.2 Summary-report all time-based scheduled activities**			A		
6.11.8.2a	Requirement	The time-based scheduling subservice capability to summary-report all time-based scheduled activities shall be declared when specifying that subservice.	NOTE	The corresponding requests are of message type "TC [11,17] summary-report all time-based scheduled activities". The responses are data reports of message type "TM [11,13] time-based schedule summary report" (refer to clause 6.11.7.1).	M	The time-based scheduling subservice capability to summary-report all time-based scheduled activities shall be provided.	This capability is considered mandatory for ESA missions. This particular sub-service provides an effective way to compare the on-board configuration with the ground maintained model of the on-board time-based schedule contents.
6.11.8.2b	Requirement	Each request to summary-report all time-based scheduled activities shall contain exactly one instruction to summary-report all time-based scheduled activities.	NOTE	The instructions to summary-report all time-based scheduled activities contain no argument.	A		
6.11.8.2c	Requirement	For each valid instruction to summary-report all time-based scheduled activities, the time-based scheduling subservice shall generate, for each scheduled activity contained within	NOTE	The time-based schedule summary notification content is	A		

PUS-C tailoring content

- About ~400 requirements, grouped in 6 categories
  - Services, subtypes and capabilities selection
  - Avionics architecture definition
  - Additional observables
  - New services
  - New capabilities for standard services
  - Lessons learned from past missions

PUS-C tailoring content

- **Services, subtypes and capabilities selection**
  - ~50% of the total requirements
  - Identify capabilities and optional subtypes required by ESA missions
    - Easy to summarize in a table, but harder to formalize

[6.4.7.1.a] The parameter statistics reporting subservice capability to add or update parameter statistics definitions shall be declared when specifying that subservice

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The parameter statistics reporting subservice capability to add or update parameter statistics definitions shall be provided.

PUS-C tailoring content

TC or TM	Subtype ID	Description	Tailoring
TC	1	report the parameter statistics	Full, **with** reset flag
TM	2	parameter statistics report	Full, maximum, minimum and mean (but not standard deviation)
TC	3	reset the parameter statistics	Full
TC	4	enable the periodic parameter statistics reporting	No
TC	5	disable the periodic parameter statistics reporting	No
TC	6	add or update parameter statistics definitions	Full, **without** sampling interval
TC	7	delete parameter statistics definitions	Full
TC	8	report the parameter statistics definitions	Full
TM	9	parameter statistics definition report	Full, **without** reporting & sampling interval

Service 4 - Subtypes and capabilities selection

PUS-C tailoring content

- **Avionics architecture definition**
  - Few requirements only
  - Single centralized implementation is preferred for several services
    - Example: service 11 (mission timeline) or service 22 (position scheduler)

[6.22.2.1.1.a] Each position-based scheduling service shall contain at least one position-based scheduling subservice

→

There shall be a single on-board instance of the position-based scheduling service

PUS-C tailoring content

- **Additional observables**
  - ~5% of the total requirements
  - PUS-C heavily relies on (on-demand) reports
    - Few mandatory parameters to be provided in HK
  - Additional observables added to most services
    - Based on observables typically available on modern spacecraft

[6.4.8.1 new] The following observables shall be defined for the parameter statistics reporting subservice:

1. The number of parameter statistics definitions currently defined on-board.

PUS-C tailoring content

- **New services and new subtypes/capabilities**
  - ~20% of the total requirements
  - High-level requirements, left details for implementation
  - Few basic functionalities available to most ESA missions missing in PUS-C
    - System log (or Critical Event Log)
    - Parameter extraction
    - Backup mission timeline (interplanetary missions only)
  - File-based operations
    - Uplink and downlink file transfer (CDFP protocol selected)
    - Files for science storage (equivalent to service 15 but for files)

PUS-C tailoring content

- **Lessons learned from past missions**
  - ~20% of the total requirements
  - Based on operational experience not covered by PUS-C requirement
  - Very diverse set of requirements
    - Extracted from mapping current OIRDs to PUS-C and identifying gaps

[6.11.4.5.l new] Telecommands with the same execution time shall be inserted in the schedule and executed in the order they were uplinked

Current status

- First full version of generic OIRD almost **completed**
  - Functional requirements → Done
  - PUS-C tailoring → Most services in DOORS now, pending open points
  - Deliverables → Pending
- Few PUS-C **open points** under discussion
  - Handling of large packets and service 13 limitations
  - Lack of bandwidth control mechanism
  - Command verification and failure reporting (service 1)
- Next steps
  - Complete the tailoring and generic OIRD
  - ESA internal consolidation, then expose it to Industry in the context of SAVOIR
  - Apply generic OIRD to future ESA missions

NEXT STEPS

Outlook and planning

- ESOC has provided their initial analysis and tailoring of operability and PUS-C standards
- 1st iteration has taken place on PUS-C aspects
  - Further refinement to better separate (operations) requirements from potential on-board implementation
- Operability requirements currently under consolidation between ground and space segment, to ensure common understanding
- Alignment of activities with ECSS
  - Taking into account the further evolution of the relevant standards
- Presentation to SAVOIR Advisory Group (SAG) planned in 01/19 for further discussion