

Generic Operations Interface Requirements Document (GOIRD)

13th ESA Workshop on Avionics, Data, Control and Software Systems

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Agenda



- **Introduction**
- Generic OIRD overview
- Functional requirements
- PUS-C requirements
- Conclusions





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 **ESA**
- 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

- A dedicated Operations Interface Requirements Document (**OIRD**) per mission
- New mission OIRDs are derived from previous OIRDs
 - Lessons learnt not always propagated to other missions and mission families
- OIRDs are perceived as significantly different from one mission to another...
 - ...but difference not necessarily justified or not as big as perceived
 - A similar problem is perceived by operators for what concerns on-board SW implementations
- The operability requirements drives the mission data management services on-board and the Mission Control System on-ground
 - The variability of requirements and implementations hamper product orientation
- OIRDs evolved independently of standards (PUS-C, OBCP, etc.)
 - Partial overlap between OIRD and PUS requirements

- **Generic OIRD (GOIRD) foundations**
 - SAVOIR entrusted ESOC in June 2016 the task to establish a Generic OIRD
 - It shall form the baseline spec for future missions
 - It shall allow the definition of compatible OBSW libraries

- **The goal**
 - Create a **common** OIRD for **all** new missions
 - Maximize commonality among missions
 - Minimize differences and group them by **mission families**
 - Mission OIRDs to be created starting from the generic OIRD
 - Changes limited to mission specific deltas
 - Plus sizing of PUS-C services (e.g. MTL capacity, etc.)
 - Generic OIRD to be evolved with lessons learnt and feedback from new missions

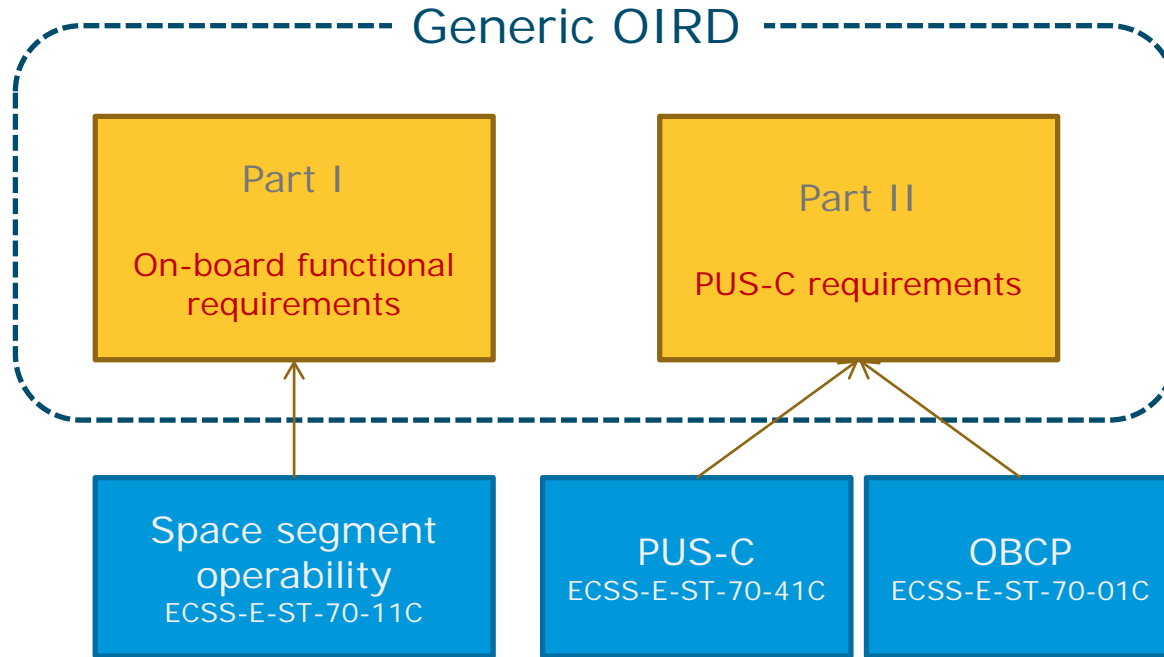
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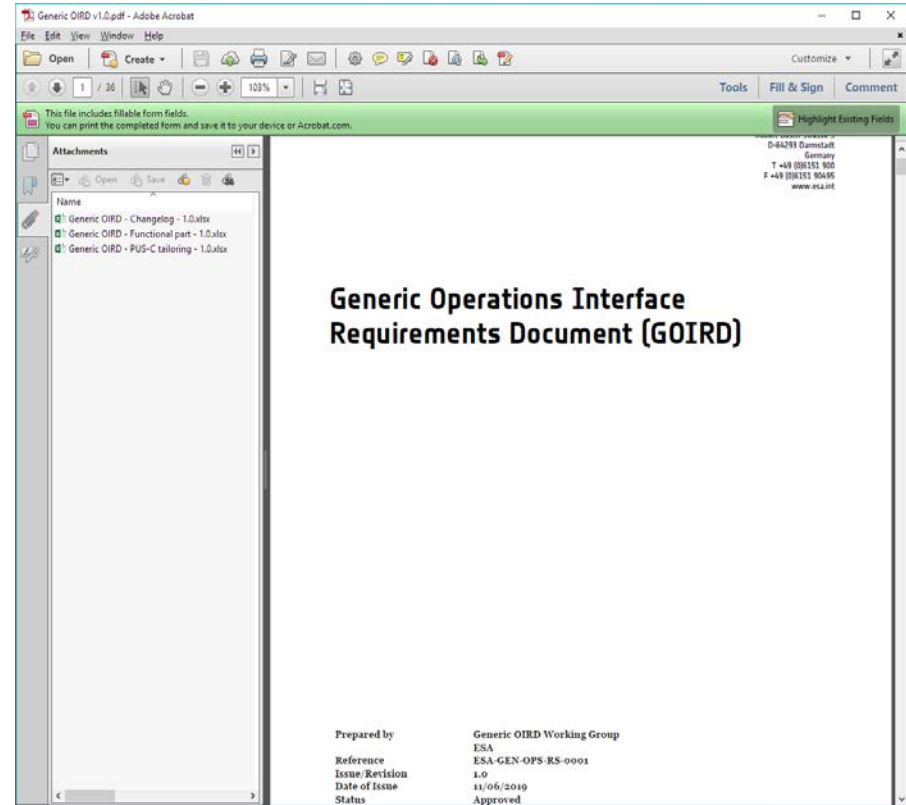
Generic OIRD - Structure



Generic OIRD - Format



- GOIRD delivered as a **PDF document**
- 3 Excel files attached → core of the GOIRD
 - **Functional requirements**
 - **PUS-C requirements**
 - Plus changelog
 - All changes to PUS-C & functional requirements since Draft A tracked



Generic OIRD - Content



- Generic OIRD **document**
 - Motivation and scope
 - Scope limited to robotic missions with an **avionics-like subsystem in mind**
 - Description of spreadsheet structure and requirements format
 - Including relationship with ECSS standards
 - Mission OIRD generation instructions



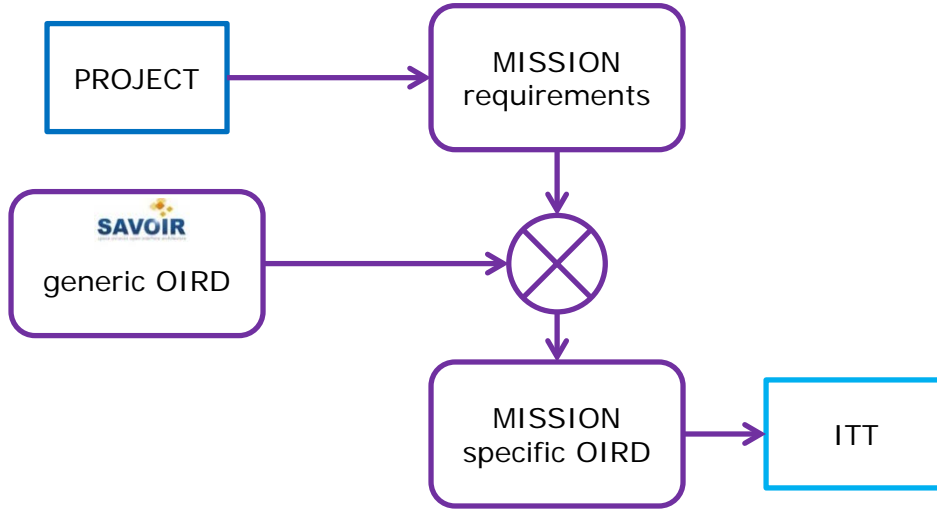
Mission OIRD generation



- GOIRD is **NOT** a replacement of mission OIRDs
 - Missions are still expected to generate their own mission OIRD
 - GOIRD is only a reference document for the mission

- Mission OIRDs shall be produced starting from GOIRD
 - No copy & paste from previous mission OIRDs
 - Instead take all GOIRD requirements and implement mission-specific changes
 - Clear tracing in mission OIRD of changes/additions with respect to GOIRD
 - Changes shall be truly mission specific:
 - Very few deltas with respect to the GOIRD expected in the mission OIRD
 - Definition of mission constants and sizing of PUS-C services
 - De-scope of PUS-C services and functional requirements not applicable to the mission

Mission OIRD generation



Generic OIRD - Status



- Generic OIRD 1.0 formally released in **July 2019**

- **Used already by multiple projects to build their mission OIRDs**
 - Copernicus high-priority candidate missions OIRD
 - ERO / Mars Sample Return OIRD
 - HERA OIRD

- Generic OIRD will evolve over time
 - Feedback from new projects preparing their mission OIRD (e.g. new features)
 - Lessons learnt from flying missions



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Functional requirements - Content



- **High-level operability requirements**
 - No assumptions on the underlying system architecture
 - PUS agnostic requirements
 - Which capabilities are required is left to the PUS-C tailoring
 - Linked to ECSS Space Segment Operability Standard
 - Traceability maintained w.r.t. Operability Standard
 - But GOIRD functional requirements are self-consistent

Functional requirements - Content



- Functional requirements groups:
 - General
 - Modes
 - Operations/mission phases
 - Spacecraft control
 - Telecommands
 - Authentication
 - Only applicable to Earth Observation missions.
 - Telemetry
 - Timing
 - In-flight testing
 - General autonomy
 - Failure detection isolation and recovery
 - Safe mode
 - Subsystems: Attitude Control And Navigation, On-board Processors and Software, Data Storage and File System, Power, Thermal, TT&C, Payloads and Mechanisms.

Functional requirements - Format



- Functional requirements maintained in **DOORS**
 - Requirements can be provided as DOORS modules on-demand

- First module contain all the requirements
 - ID
 - Requirements and notes
 - Relationship to ECSS-E-ST-70-11C (unchanged, new or modified) and clause
 - Justification for modified requirements wrt ECSS
 - Mission-family specific flag to report requirements specific to interplanetary, astronomy or Earth Observation

- Second module contains list of Operability Standard requirements tailored out

Functional requirements - Format



Functional Requirements: current 0.0 in /Generic_ORD (Formal module) - DOORS

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ID	Functional Requirements	ID	Functional Requirement	Notes	ECSS-70-11C clause	Trace to 70-11C (U, M, N)	Justification	Specific? (OA, OE, OP, FBO)
410	1 INFO	INFO	Enunciation of functional requirement.	Any notes or clarifications on the subject requirement.	Clause on the Operability Standard ECSS-70-11C that the specific Requirement is traced to.	Trace to Operability standard. One of: U: Unchanged M: Modified N: New	Justification for change with respect to Operability Standard. Only for requirements marked as 'N'.	Specificity of the requirement. One of: OA: Applicable only to Astronomy missions. OE: Applicable only to Earth Observation missions. OP: Applicable only to Planetary missions. FBO: Applicable only to missions with File-Based Operations.
411	2 GENERAL	GEN						
412	2.1	GEN-001	The space segment shall provide visibility of its internal status, configuration and performance to the ground segment in conformance with the level of detail and the time delays specified for all routine and specified contingency operations, including subsequent diagnostic activities.	Specific contingency operations are derived during the failure analysis performed during the mission development process (e.g the failure modes, effects and critically analysis FMECA)	4.2a	U		
413	2.2	GEN-002	The control functions (telecommands) provided at each level of the system hierarchy shall be capable of achieving the mission objectives under all specified circumstances.	This can include the use of redundant equipment to meet the overall system reliability requirement.	4.3a	U		
414	2.3	GEN-003	The space segment design shall be such that its operation is not constrained by, nor adversely constrains, the availability or capacity of the space/Earth communications links.	This means the operation of the comm link is decoupled from platform/instrument operations	4.4b	M	Revised, added Note for clarification.	
415	2.4	GEN-005	The spacecraft shall provide the capability to determine at any point in the mission and with the	If ground processing of spacecraft telemetry is required, the algorithms to perform such calculations	4.6h	M	Modified with concrete cases where this is needed.	

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PUS-C requirements



- **PUS-C** is a major step forward compared to PUS-A
 - Solid PUS foundational model
 - Clear and extensive system requirements
 - Behavior of each service type and related TCs is (almost) unambiguous
 - Clear interface definition separated from system requirements
 - New service types and sub services (file management, S3 func. Reporting, etc.)

- **Why do not use the PUS-C standard as is?**
 - 20 services with 33 subservices defined but no mapping to a specific architecture
 - Which services to implement and where?
 - **316** TCs and TM reports (if all subservices implemented) but only **88** are **mandatory**
 - Tailoring required to define functionality required by the mission
 - 382 "shall be declared when specifying" statements
 - Large number of capabilities and options
 - Without tailoring, 2 PUS-C implementations will result in very different interfaces
 - Some important functionalities for ESOC missions are not covered
 - Critical Event Log/System Log, file transfer, backup MTL...
 - Feedback and lessons learnt from 50+ years of operations
 - A few important requirements from mission OIRDs not captured in PUS-C

PUS-C requirements - Format



- PUS-C implemented in **DOORS**
 - Against the original PUS-C standard in DOORS format
 - Additional columns
 - Applicability flag (unchanged/modified/deleted/new)
 - Justification for each change
 - Multiple export possibilities
 - Full tailored standard or deltas only
 - In Excel, PDF, DOORS module...



PUS-C requirements - Format



ECSS Source Id	ECSS Object Type	Object Text	ECSS Notes	Applicability	Modified or New requirement	Justification
80 6.3.3.6e	Requirement	For each instruction to report a housekeeping parameter report structure that it rejects, the housekeeping repo A				
81 6.3.3.6f	Requirement	The housekeeping reporting subservice shall process any valid instruction that is contained within a request to r A For each valid instruction to report a housekeeping parameter report structure, the housekeeping reporting subservice shall generate a single housekeeping parameter report structure report that contains exactly one housekeeping parameter report structure notification that includes: 1.the housekeeping parameter report structure identifier; 2.if the housekeeping reporting subservice provides the capability for managing the periodic generation of housekeeping parameter reports, the periodic generation action status; 3.the collection interval; 4.the ordered list of simply commutated parameters; 5.the ordered list of super commutated parameter sets.	NOTEFor item 2 capability for managing the periodic generation of housekeeping parameter reports, refer to clause 6.3.3.4.	A		
82 6.3.3.6g	Requirement	Generate a one shot report for housekeeping parameter report structures		A		
83 6.3.3.7a	Requirement	The housekeeping reporting subservice capability to generate a one sh	NOTEThe corresponding requests are of message type "TC[3,27] generate a one shot report for housekeeping parameter report structures". The responses, one for each instruction, are data reports of message type "TM[3,25] housekeeping parameter report".	M	The housekeeping reporting subservice capability to generate a one shot report for data, housekeeping parameter report structures shall be provided.	This capability is considered mandatory for ESA missions. One-shot reporting is practical for static configuration
84						
85 6.3.3.7b	Requirement	Each request to generate a one shot report for housekeeping parameter report structures shall contain one or m A Each instruction to generate a one shot report for a housekeeping parameter report structure shall contain: 1.the housekeeping parameter report structure identifier of the report to generate.		A		
86 6.3.3.7c	Requirement	The housekeeping reporting subservice shall reject any instruction to generate a one shot report for a housekeeping parameter report structure if: 1.that instruction refers to a housekeeping parameter report structure that is unknown.		A		
87 6.3.3.7d	Requirement	For each instruction to generate a one shot report for a housekeeping parameter report structure that it rejects, A		A		
88 6.3.3.7e	Requirement	The housekeeping reporting subservice shall process any valid instruction that is contained within a request to g A				
89 6.3.3.7f	Requirement					

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European Space Agency

PUS-C requirements – Classification



- **Services, subtypes and capabilities selection**

- Agreed in a common set of services and subservices for all future ESA missions
 - Same set of TC and TM packet types and subtypes
 - Fix set of capabilities
- Interface to satellite is fairly independent of the mission → A **single** tailoring for all ESA missions
- About 60% of the total GOIRD requirements for PUS-C

PUS-C requirements - Classification



- **Additional observables**

- 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
- About 2% of the total GOIRD requirements for PUS-C

PUS-C requirements - Classification



■ New capabilities

- Features required by ESA missions not covered by PUS-C standard
 - Critical event log / System log
 - Parameter extraction from HK
 - Backup MTL
 - **File based operations**
- Covered as **new sections**
 - High level requirements only → no PUS-C style text, TC and TM interface not defined
 - Implementation details left intentionally open
- To be raised as change requests to the standard to be considered in future versions
- About 19% of the total GOIRD requirements for PUS-C

PUS-C requirements - Classification



- **Avionics architecture definition**
 - PUS-C does not make any assumption about the avionics architecture
 - But architecture definition has a huge impact on operability
 - A few services required to be implemented in a centralized way
 - E.g. Service 11 (Mission Timeline)
 - A few services mandated to be implemented in all packetized units
 - Services 1, 3, 5, 6 (if applicable) and 17
 - Less than 1% of the total GOIRD requirements for PUS-C

PUS-C requirements - Classification



- **Clarifications and refinements**
 - Lessons learnt from previous missions and mission OIRDs
 - About 12% of the total GOIRD requirements for PUS-C

- **Changes to the standard**
 - Changes to PUS-C behavior limited to the **absolute minimum**
 - No modification of defined TCs and TMs interfaces
 - Clear justification (typos or omissions, strong operational needs)
 - Less than 1% of the total GOIRD requirements for PUS-C
 - To be raised as change requests to the standard to be considered in future versions



PUS-C requirements - Problems



- **PUS-C implementation is not straightforward**
 - Key low level aspects have not been standardize in PUS-C
 - Example: number of bytes to encode certain packet fields
 - Very important for **inter-operability of PUS-C units!**
 - Interface and detailed implementation of new features proposed in GOIRD is open
- **Coordination across PUS-C library implementers desired!**

OBCP requirements



- No tailoring of the ECSS OBCP standard in the GOIRD
 - The current version of the standard satisfies most ESA needs
 - Few extra requirements added directly in the PUS-C requirements for service 18 (OBCP)



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Conclusions



- Generic OIRD
 - New approach at ESA for operability requirements
 - Common set of functional and PUS-C requirements for future ESA missions
 - **Goal is to reduce variability and cost**
 - Definition of compatible OBSW libraries
 - Further harmonisation of ground segment

- Long term vision
 - Collaboration among PUS-C libraries developers?
 - Interoperable PUS-C implementations and generic TM/TC ICD?
 - Further harmonization of other elements: procedures, databases...



A blue-tinted photograph of a control room. In the foreground, a man with glasses and a headset is seated at a console, looking towards the right. Behind him, another operator is visible. The room is filled with various pieces of electronic equipment, including large monitors and control panels. On the wall, there are several framed displays, including a clock, a small portrait, and a large circular emblem on the right side. The overall atmosphere is professional and technical.

THANK YOU!

QUESTIONS?