



# System Engineering Approach in Galileo

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#### **GALILEO** Presentation

- The Services
- The Architecture
- Historical Background

#### **Requirement Engineering in GALILEO**

- Requirement Documents Tree
- Boundary Evolutions

#### **The Design Definition and Justification File**

- Key Role in Requirement Derivation
- Functional Tree and Functional Chains
- Data-Dictionary
- Use Cases Database

#### Conclusion

#### **GALILEO SERVICES**



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#### GALILEO will provide the following main Services: Open Service (OS): Positioning and Timing

- 4m horizontal, 8m vertical (95%)
- 30ns (95%)
- □ Safety of Life (SoL) Service:
  - Provides safety information to professional users
  - Dimensioning parameters: low non detection probability, time to alarm (6s), high availability (99,5%)
- □ Public Regulated Service (PRS)
- Other Services: Search and Rescue (SAR), Commercial Service (CS), External Region Integrity Service (ERIS).





## GALILEO ARCHITECTURE SUMMARY



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#### **GALILEO DEPLOYMENT**









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#### **GSRD Top-Down Derivation Metrics**

**GSRD-327 5.2.3.4 Position Accuracy (Single-Carrier Satellite-Only Receiver, E5a)** The Galileo Global Component shall ensure that a user equipped with a Standard Open-Service Receiver, which provides the functions specified in Req. GSRD-3102 and meets the performance requirements specified in Req. GSRD-3156,

- receiving the Open Service signals on the E5a carrier (as specified in AD-18),

- under the Normal Open Service Environment for Rural Pedestrian Users (as specified in Req.

GSRD-266 and subsidiary requirements),

will be able to determine its position with a horizontal accuracy of 24 metres and a vertical accuracy of 35 metres with 95% confidence at least once every second, without any other aids.  $\rightarrow$  59 Regs



#### GSRD-1854 8.5.10 Other Scenarios

Operational Scenarios shall be defined to cover other plausible failure cases defined by FMEA (Failure Modes and Effects Analysis) (see AD-1).

**Ranging Code Time Reference** 

 $\rightarrow$  0 Req

#### GSRD-208 5.1.2 Open Services

The Galileo Open Services shall provide Navigation & Timing using Open Service signals in accordance with AD-18, to which access shall be open to the public.

→ 278 Reqs

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#### All Ranging Codes in each satellite shall be generated from the time reference source. $\rightarrow$ 1 Reg

GSRD-697 6.2.2.2.7



#### **GSRD Top-Down Derivation Metrics**

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#### **Bottom-Up ReqsTraceability Metrics**

Page 12 0 31--INF Not a Tree but... A mesh network of Reqs SPACE SEGMENT REQS 85 56 50 з 0 1--1 2--3 4--5 31--INF 6--10 11--20 21--30 Nb of Links to SRD THALES BUNVC

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- The links between requirements and/or design objects is a key indicator of complexity
  - In GALILEO: GSRD contains 340 System Requirements Derived to around 3000 Segment Requirements, BUT... Inter-Requirements Traceability of around 11500 links!!
- Links deserves being treated as objects







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#### **BUT... TRD not accepted by the Customer**

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#### **NO TRD Consequence, an Example**

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Justifies



## **FUNCTIONAL DERIVATION**

Is Allocated

by

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#### **DESIGN OBJECTS:**

Functional Chain Clusters (SFC) Functions, Message/Signals « Activity » Diagrams « Use Cases » States and Modes **Physical Entities** 



GSRD

#### **FUNCTIONAL MODEL**

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The functions defined in the SDL Tau are described in the DDF Segment Functions DOORS module and traced to the segment requirements and the data-dictionary.



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#### System Functional Chains: "Activity" Diagram

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**Data Dictionary** 

## The Data Dictionary contains all the Signals exchanged by the functions

- It has several layers down to "Simple" data
- Example: Almanacs parameters simple data

Signals Data Base	Generated By	<b>Dedicated To</b>	ICD Flag	Size	Scale Factor(text)	Unit	TopSignal
almAf1: Satellite Clock Correction Linear -Truncated-	OSPF	User	GMSSCICD, GCSGMSICD, GMSSSICD, GCSSSICD, SISICD, GMSERISICD	13	2~38	s/s	SPF_ReportToSc, NAV_SbandUplkData, DISS_MsgSubFr, SPF_ReportToGalsee, SIS_DegradedNavigationData MM_TopLevelSpaceCraftRepc SIS_NavigationSignals, SPF_ReportToEris
almEcc: Eccentricity	OSPF	User	GMSSCICD, GCSGMSICD, GMSSSICD, GCSSSICD, SISICD, GMSERISICD	11	2~16	N/A	SPF_ReportToSc, NAV_SbandUplkData, DISS_MsgSubFr, SPF_ReportToGalsee, SIS_DegradedNavigationData MM_TopLevelSpaceCraftRepc SIS_NavigationSignals, SPF_ReportToEris







#### Example: Data Dictionary → ICD Check





"Use Case" Objects have been a key communication tool between System Engineering Activities (Operations, RAMS, System Integration Verification/Validation SIV, ...)



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- The Performance Budget File (PBF) "DOORS" part has been limited to the minimum so called PBF clusters. Their objective is:
  - To ensure the completeness of the performance requirement derivation
  - To capture all assumptions needed to demonstrate the performance.



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#### **Performance « Assumptions » Capture**



#### **Example: Accuracy Performance Clusters**



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#### **Example: Availability Performance Clusters**







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Politics plays an important role in the design of a complex system like Galileo

Design Simplification phases do no exist

Alternative Data Model based on Design Definition and Justification File (no TRD)

Limited number of "Design Objects" (or Clusters) in order to control the complexity and keep the design readable





## **APPENDIX**



