

Command and Data Handling

Dream vs Reality

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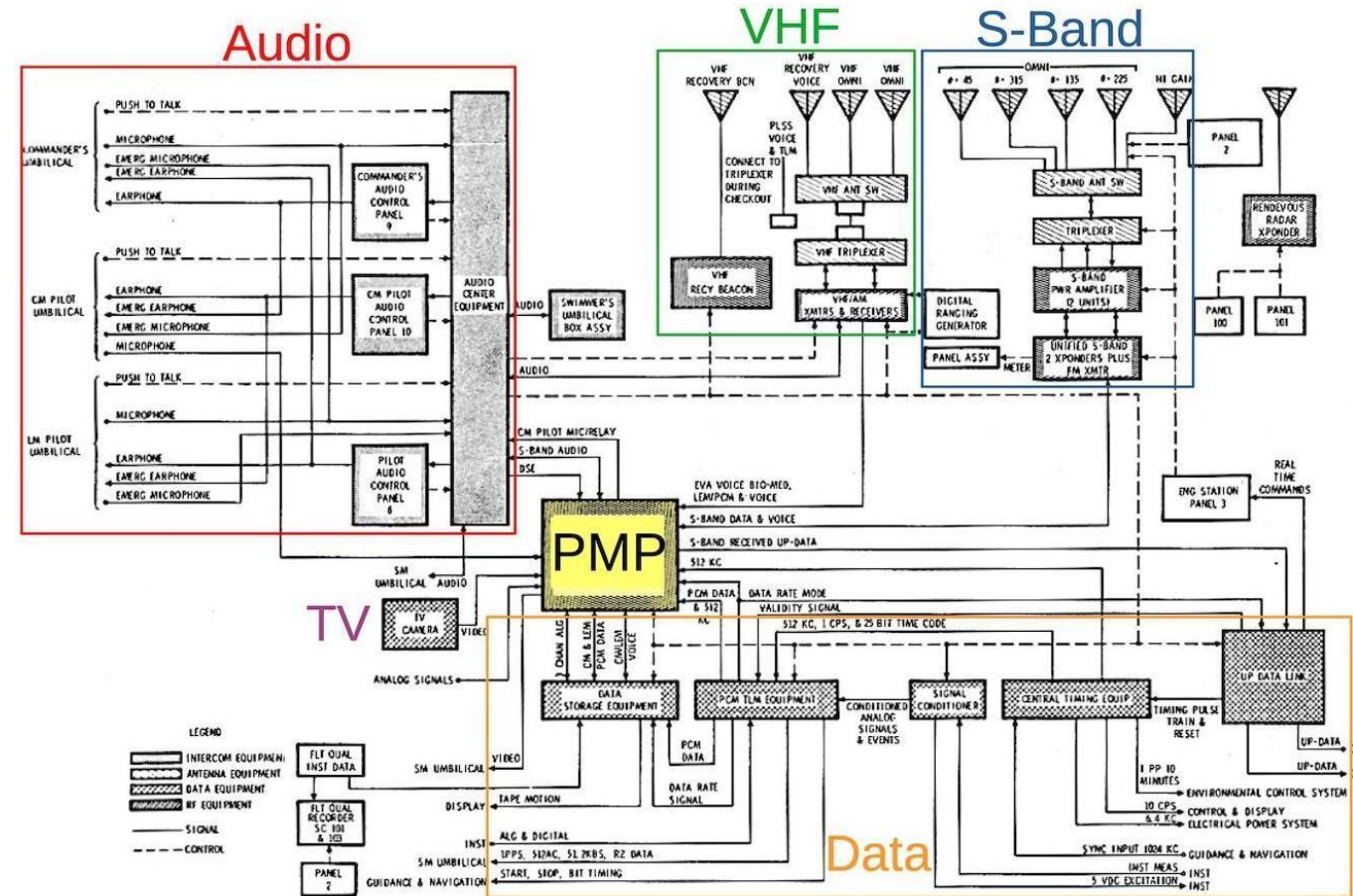
SDSE Fall 2024

Plan

- Introduction
- Requirements & Complexity
- Compromises & Budgets
- Data Buses & Architecture
- Units & Flat Sat
- Questions

Introduction

- Focus on System Engineer for Avionics
 - Avionic $\approx$ CDH, DHS, ODH, OBC and also sensors, data bus
 - Usually power (PCDU) not included
- Insight
 - Avionic subsystem selection
 - Implication at system level
 - Testing



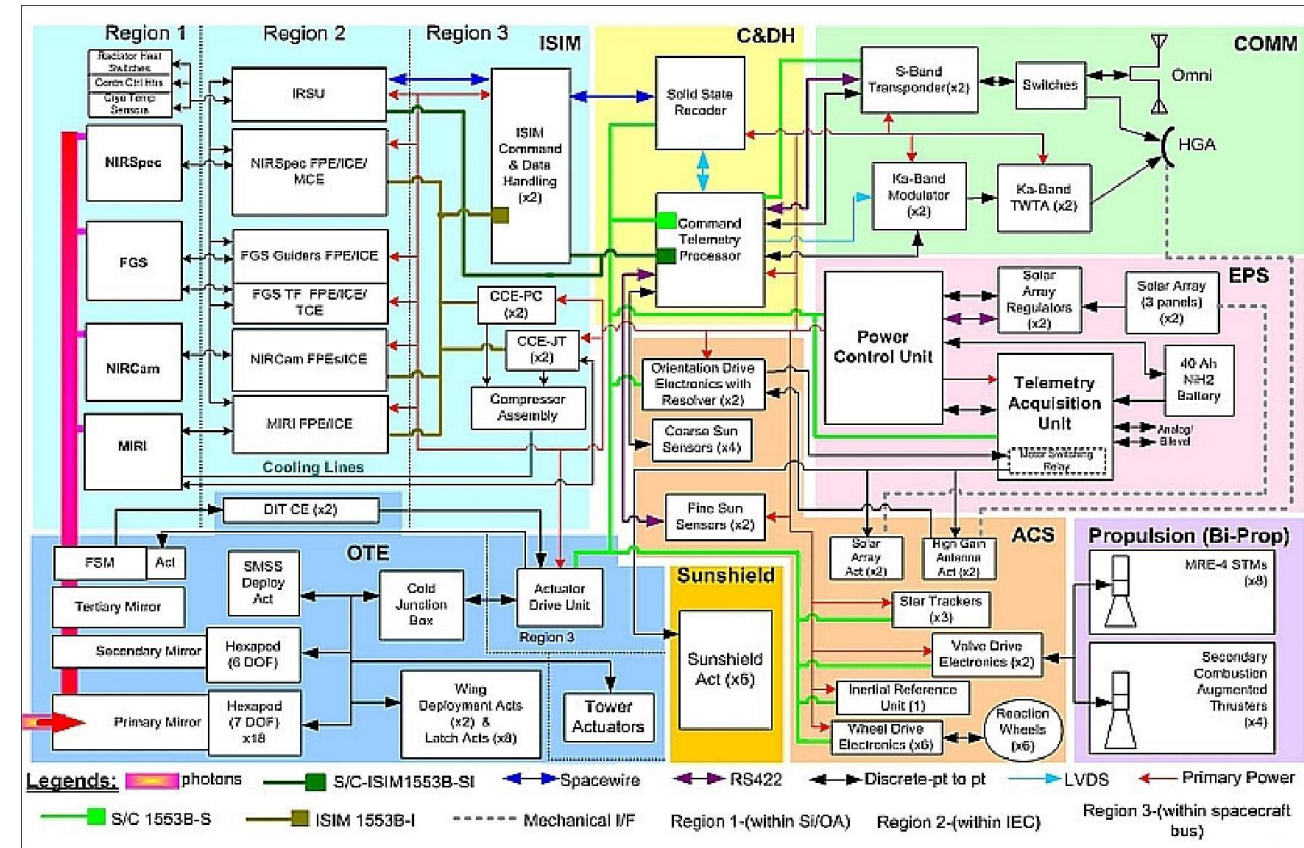
Apollo Command Module, communications system[1]

The double-edge sword of requirements

- Requirements are KEY
- Flow DOWN not UP
- Traceability and Testing are essential
- Avionics is highly interconnected
 - Payload/mission
 - Environment
 - Power
 - SW
 - Money/Time
- The nightmare of PC/NC (Partially Compliant/Not Compliant)
- Take away : Always have requirements up to date

The clash of time/money vs reality

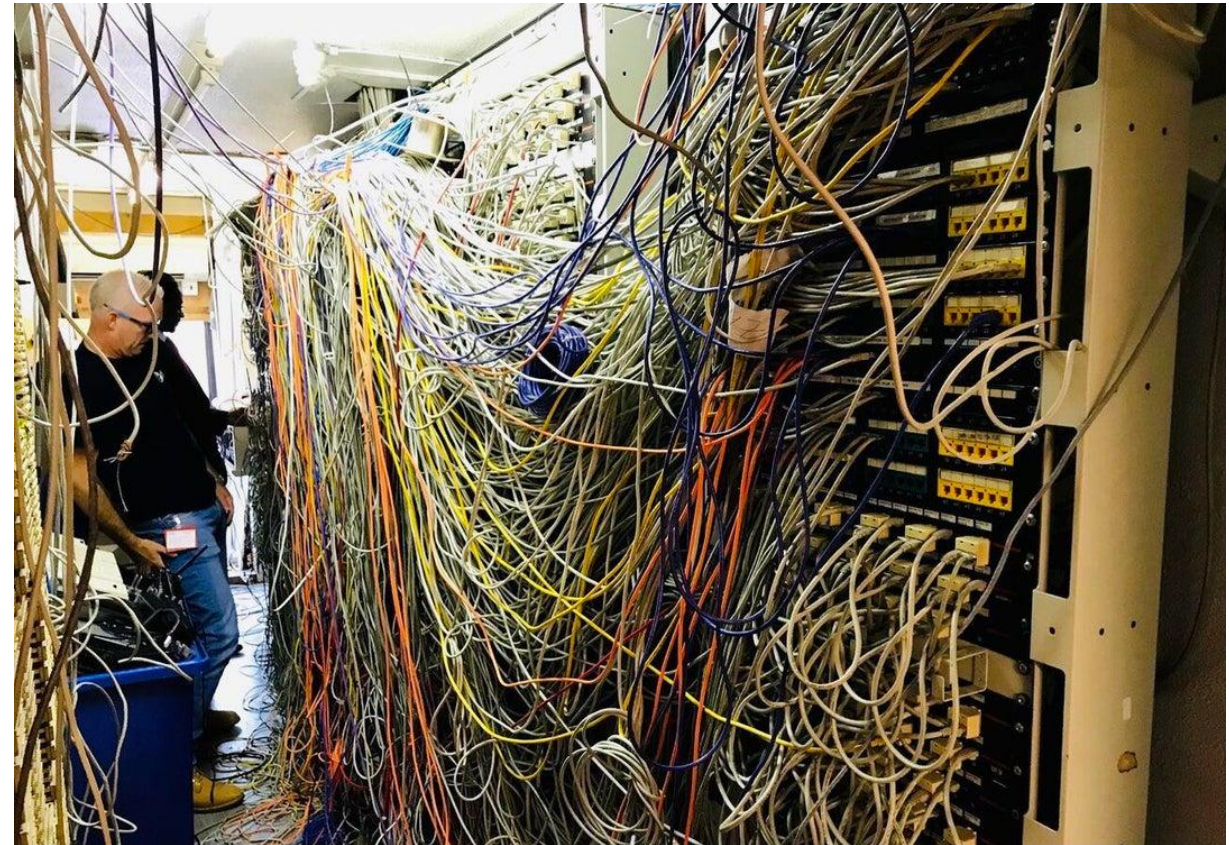
- With infinite money & time, easy to have the perfect architecture & OBC
- Compromises needed
 - See Requirements
 - Your solution is usually a product (not custom)
- Take away: Trade-offs Matrices



JWST, schematic block diagram [2]

The painful compromises 1/2

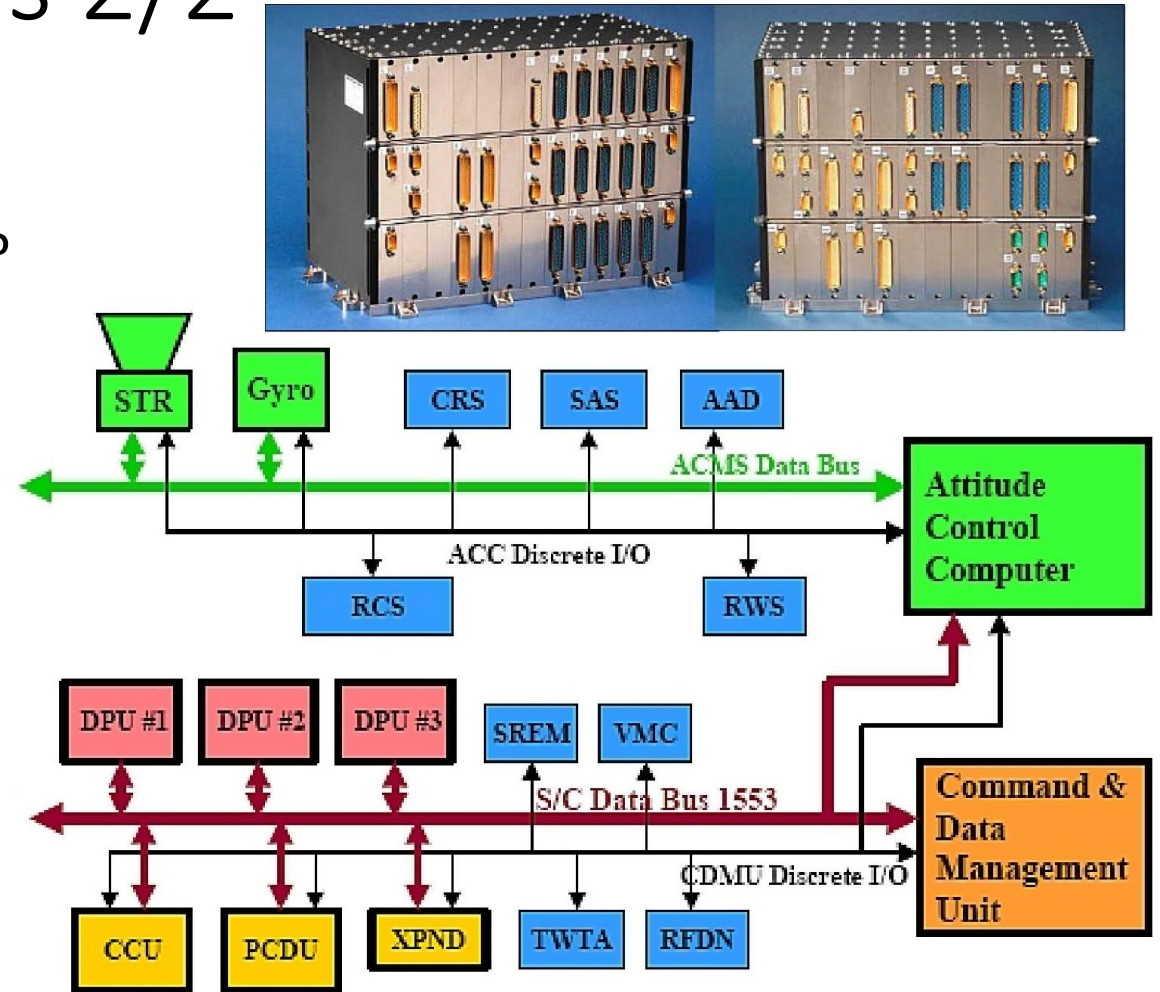
- Number of IOs
 - What sensors do you have? (types)
Restrictions ? Already selected ?
- Type of architecture (more later)
- Radiation tolerance
 - What limit? What mission ?
Shielding (mass!) ?



The feeling when dealing with IOs, random server room [3]

The painful compromises 2/2

- Processing capability
 - What SW? What needed in Orbit (AOCS) ?
Update of OBC ?
- Power & Voltage
 - Enough power ? What is the EOL consumption/voltage ?
- FDIR, Memory, Scrubbing, etc.
- Take away : Clear Requirements & Budgets



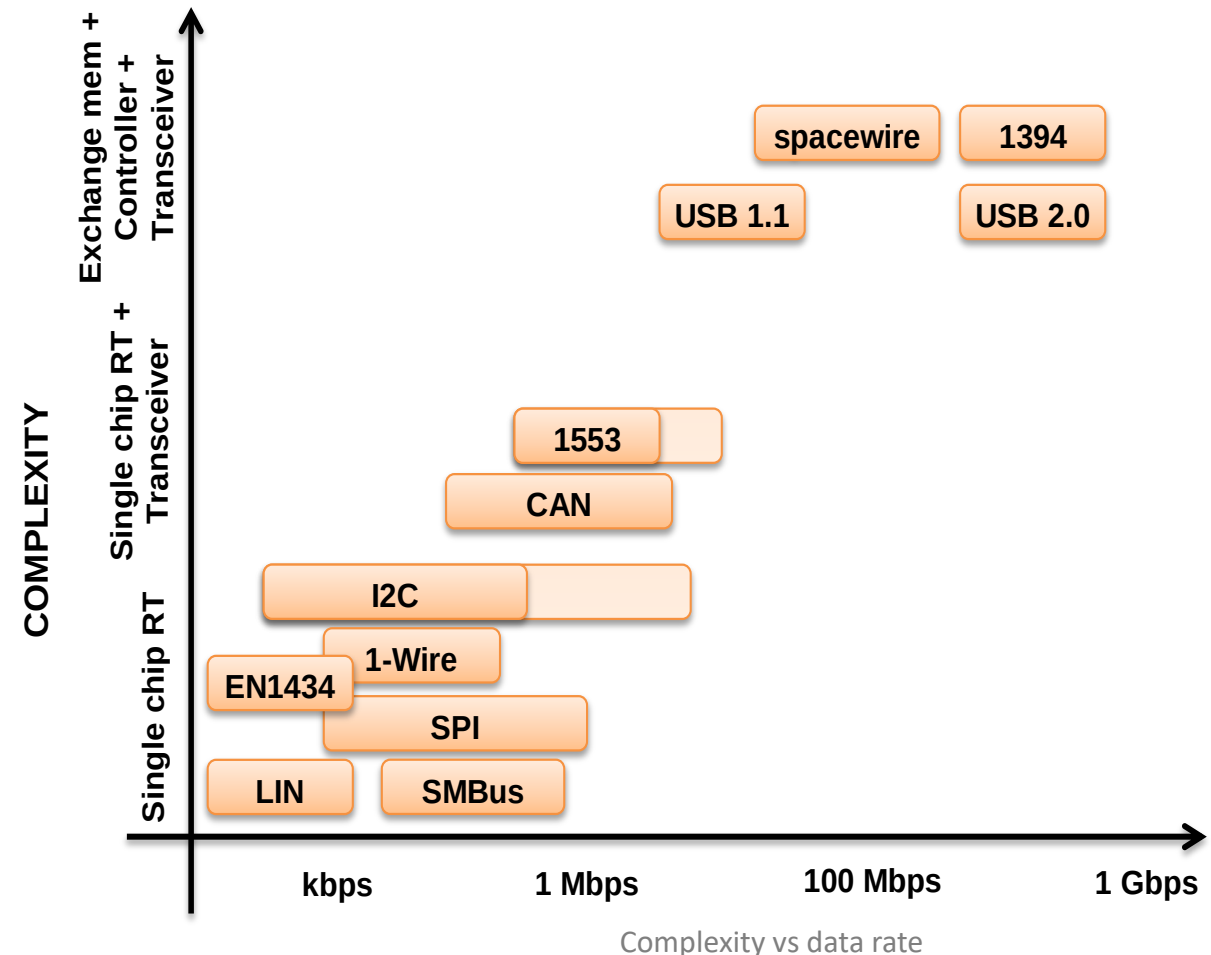
Top : Photo of the CDMU (left) and the ACC (right)
Bottom : Avionics of HSO (Herschel Space Observatory) [4]

The mighty budgets

- What budgets ?
 - Number of I/O on OBC/Avionics
 - Data budget for payload
 - Processing power budget
 - Electrical power budget
 - Electrical voltage lines budget
 - Acquisition lines budgets (ASM, BSM, ...)
 - ...
- Take away: Approximation & Margin are the way to go!

Data buses nightmares 1/2

- What about them
 - RS-422, RS-485, etc.
 - Ethernet
- And their compatibility ?
 - Sensor with RS-422 can talk to a RS-485 ?
- Take away: Constraint by other subsystems



Data buses nightmares 2/2

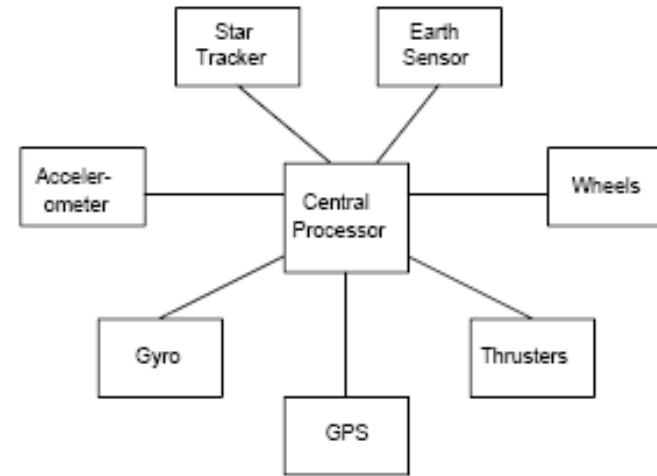
- Which OSI Model layer does it cover ?
- Data buses ≠? Protocol
- Take away : proper Interface Control Document (ICD)

7	Application Layer	Human-computer interaction layer, where applications can access the network services
6	Presentation Layer	Ensures that data is in a usable format and is where data encryption occurs
5	Session Layer	Maintains connections and is responsible for controlling ports and sessions
4	Transport Layer	Transmits data using transmission protocols including TCP and UDP
3	Network Layer	Decides which physical path the data will take
2	Data Link Layer	Defines the format of data on the network
1	Physical Layer	Transmits raw bit stream over the physical medium

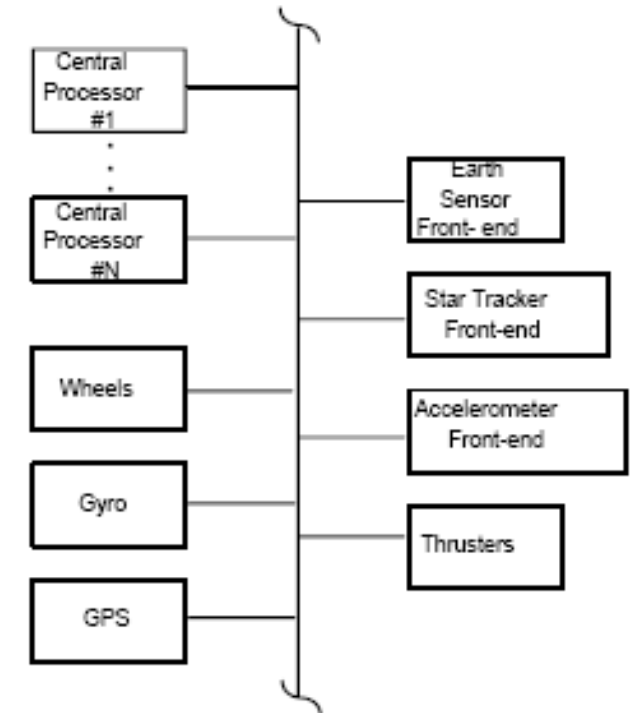
OSI Layer [5]

The perfect Avionic Architecture

- *Depend on your subsystems*
- What protocol / data buses can you use ?
- Architecture linked to your needs and constraints
- Take away : Trade-offs

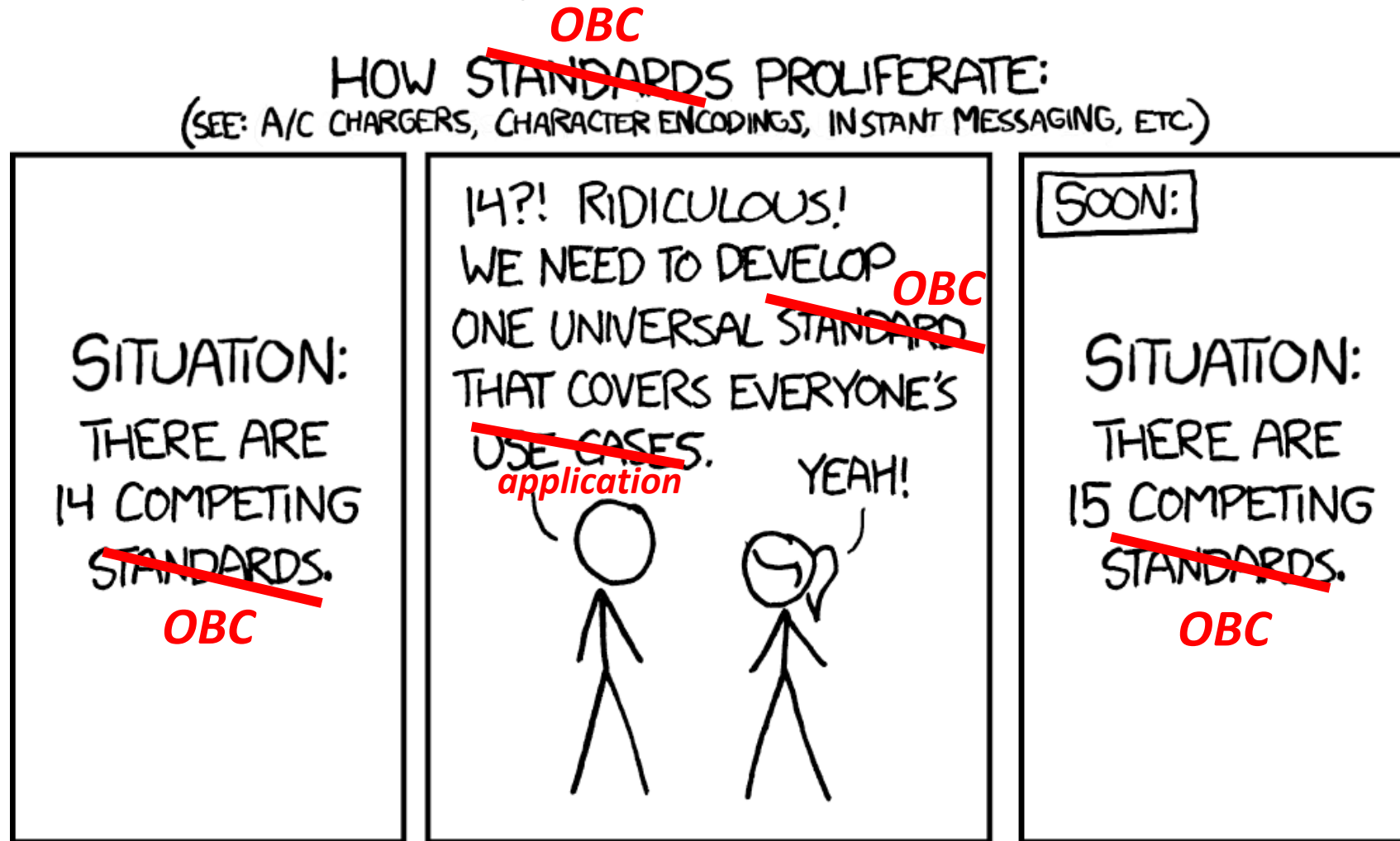


Star architecture



Bus architecture

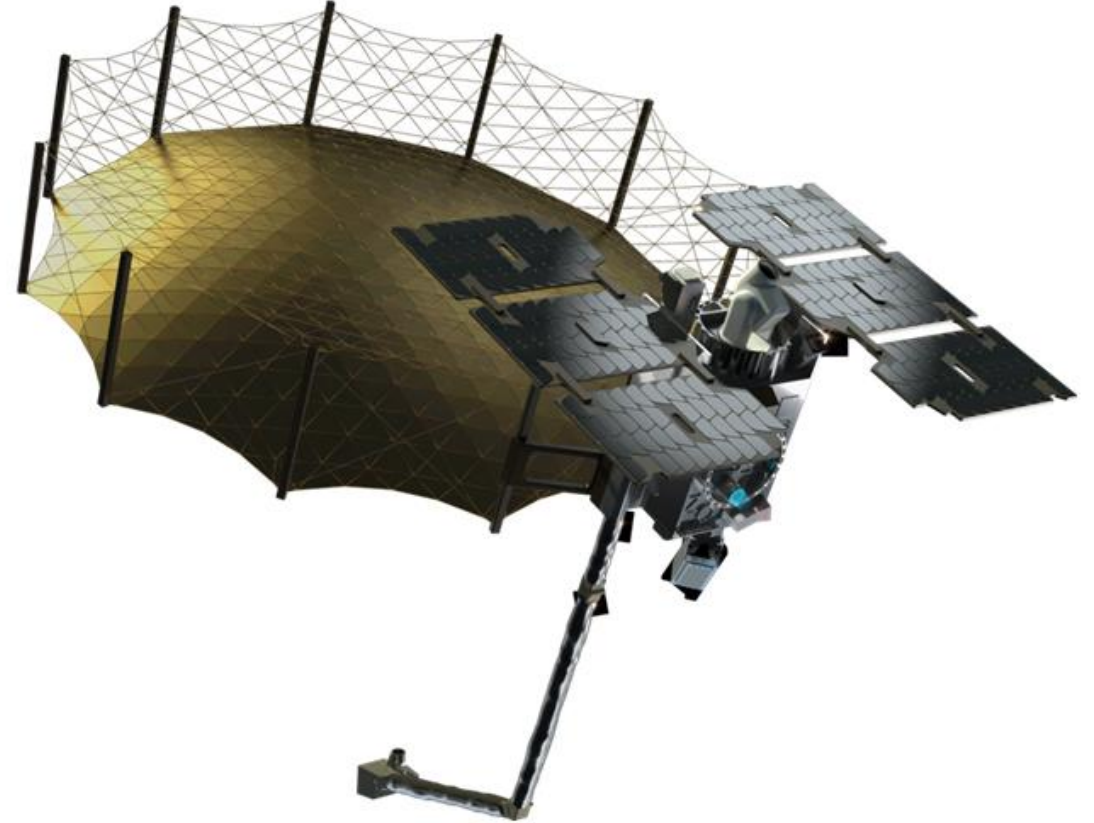
The dream of the perfect OBC



XKCD 927 [6]

The Bug-Free Units

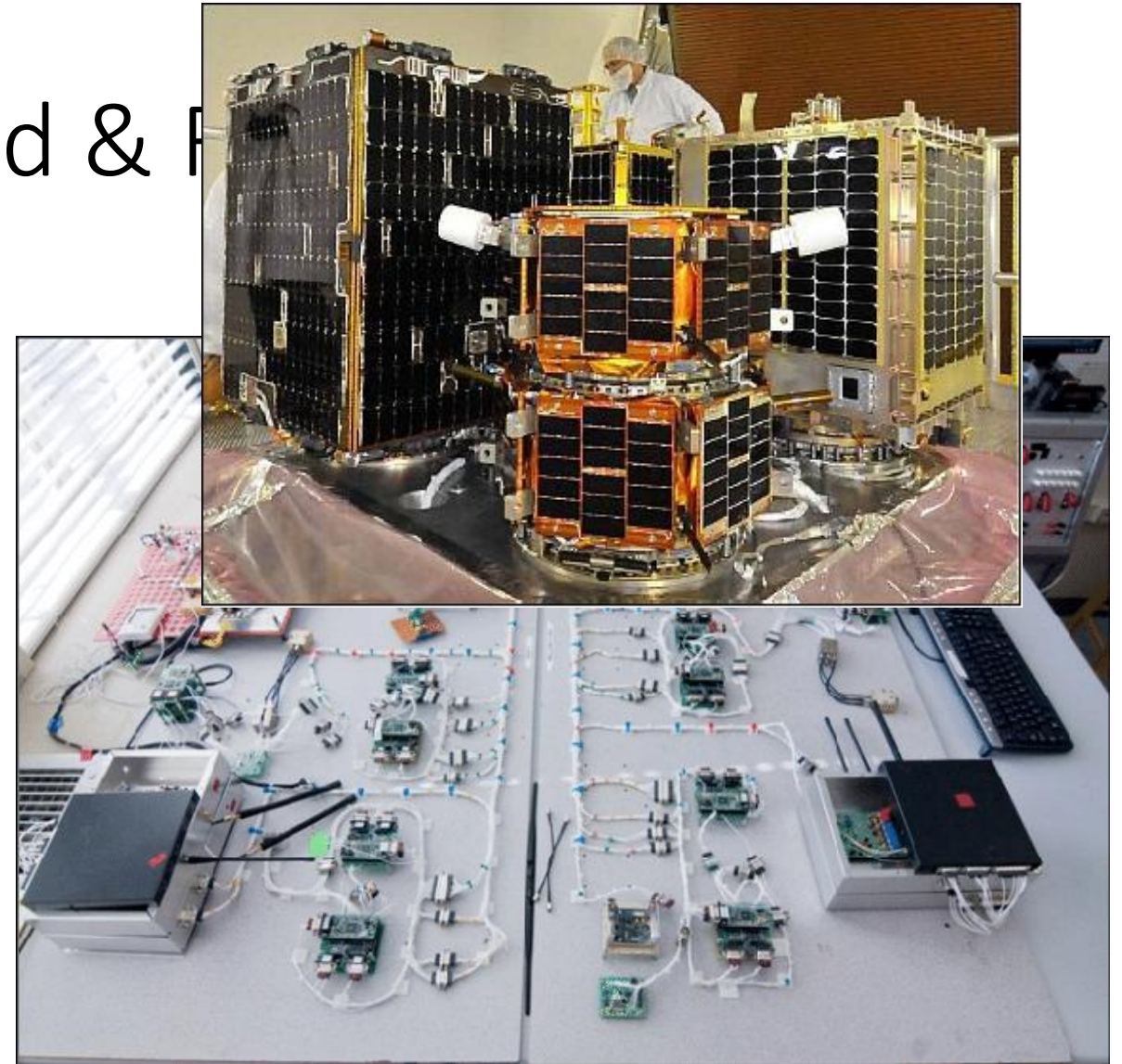
- Why order EM (or proto)
- Acceptance test
 - Ground
 - Voltage & Power
 - Interface
 - Functionality
- Take away : test everything with HW



Capella's Acadia SAR satellite [7]

The ultimate Test Stand & P

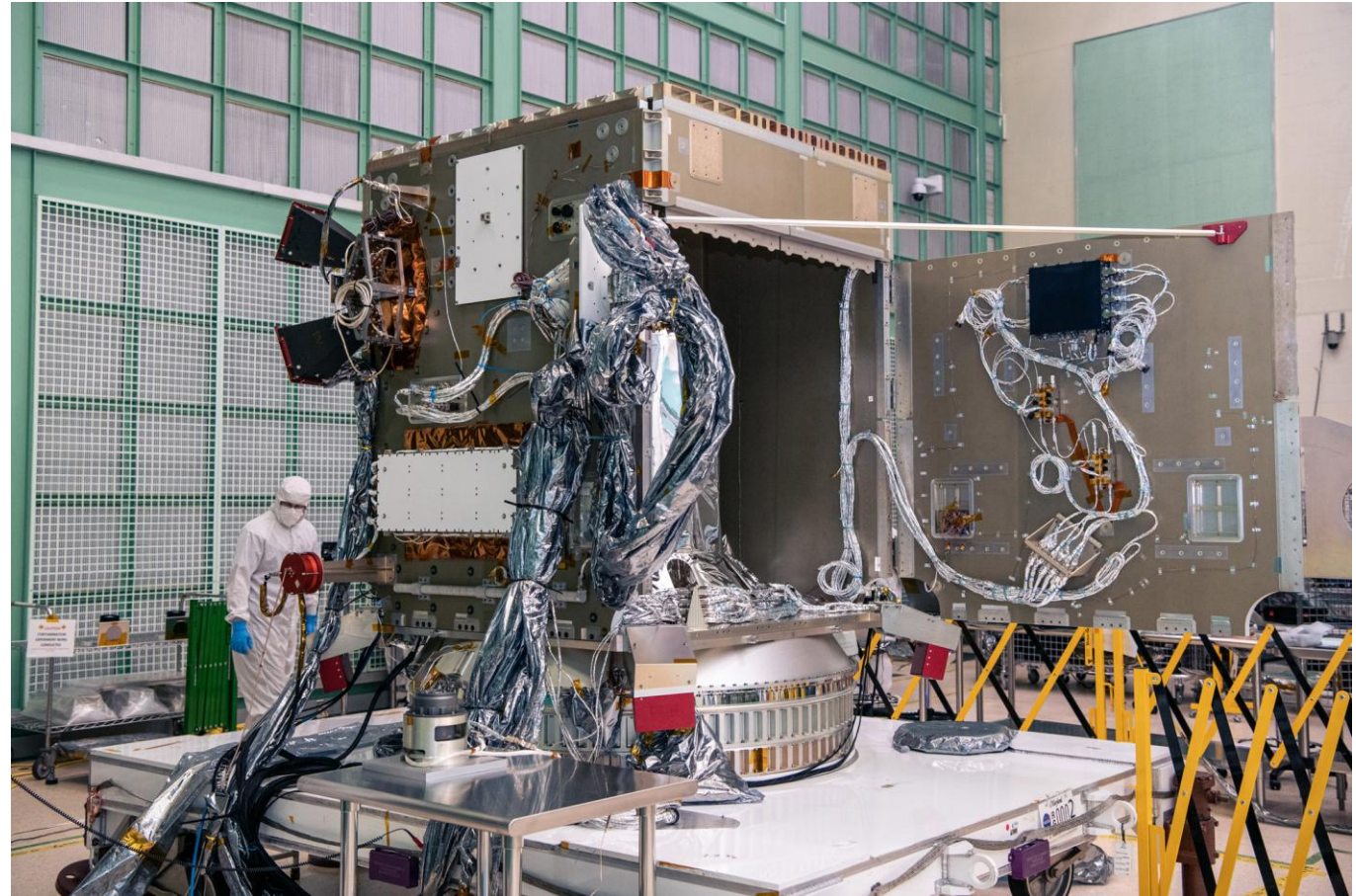
- What to test is in your Requirements
- To test & verify
 - Interface
 - Power drop
 - EE cross-compatibility
 - SW
 - Etc
- Ideally connected to simulator
 - Mission phase testing
- Take away : As Early As Possible



FASTRAC Flatsat Electrical Testbed [8]

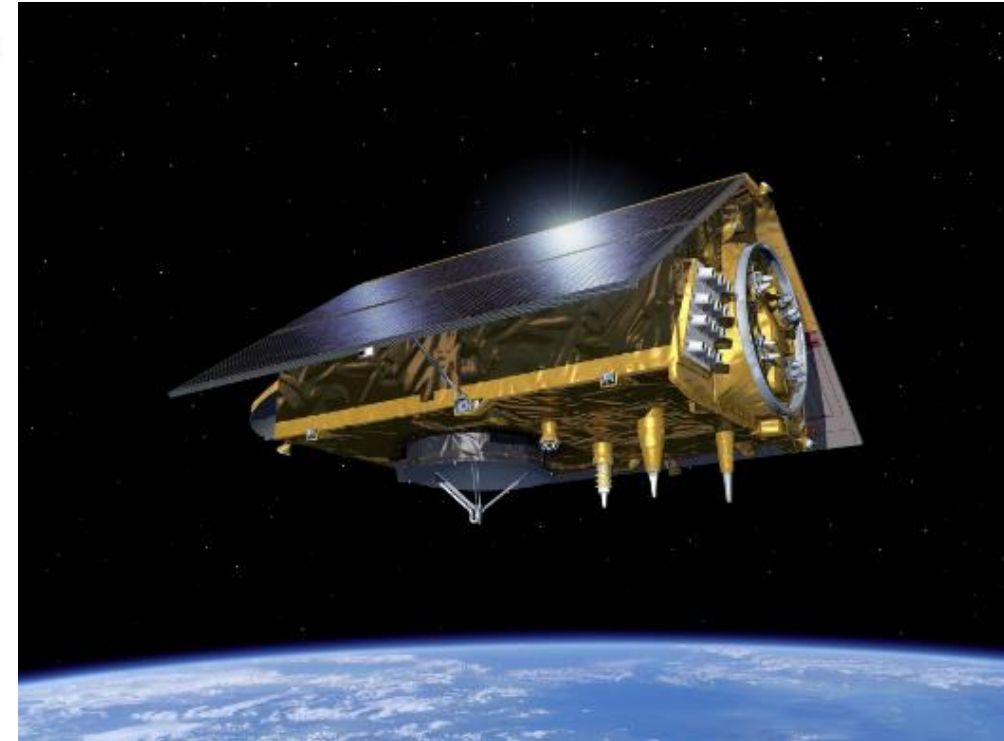
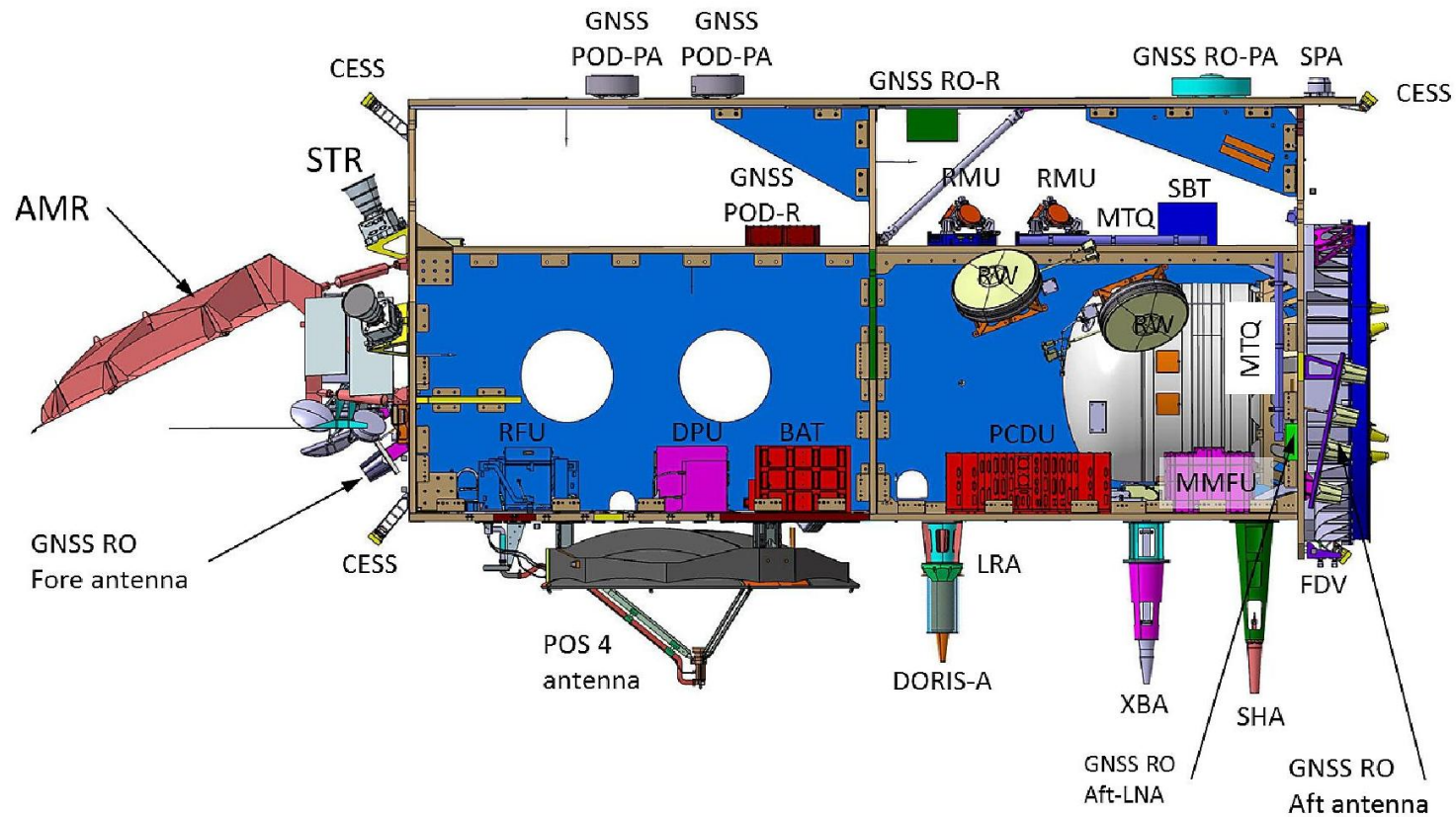
The ultimate Test Stand & Flat Sat 2/2

- Not a fix thing
 - Proto => EM => QM
 - FM for AIT
- Always useful after launch
 - SW update
 - Debug issue
 - Mission extension
- Take away : It is living thing



PACE (Plankton, Aerosol, Cloud, ocean Ecosystem) integration , NASA [9]

Questions ?



Sentinel 6 avionics & rendering [10]

References

- [1] <http://www.righ.to.com/2022/05/talking-with-moon-inside-apollos.html>
- [2] <https://www.eoportal.org/satellite-missions/jwst#spacecraft-bus-and-sunshield>
- [3] <https://twitter.com/nixcraft/status/1439155940087894020/photo/1>
- [4] <https://www.eoportal.org/satellite-missions/hso#svm-service-module>
- [5] <https://www.imperva.com/learn/application-security/osi-model/>
- [6] <https://xkcd.com/927/>
- [7] <https://www.eoportal.org/satellite-missions/capella-x-sar#mission-status>
- [8] The FASTRAC Mission: Operations Summary and Preliminary Experiment Results, 25th AIAA Smallsat Conference, August 2011
- [9] <https://www.eoportal.org/satellite-missions/pace-mission#pace-plankton-aerosolcloud-ocean-ecosystem-mission>
- [10] <https://www.eoportal.org/satellite-missions/copernicus-sentinel-6-michael-freilich#satellite-system-design-overview>