EE-584
Spacecraft Design & Systems Engineering

Space Operations

EPFL

EPFL

Spacecraft Operations

learn to fly a spacecraft

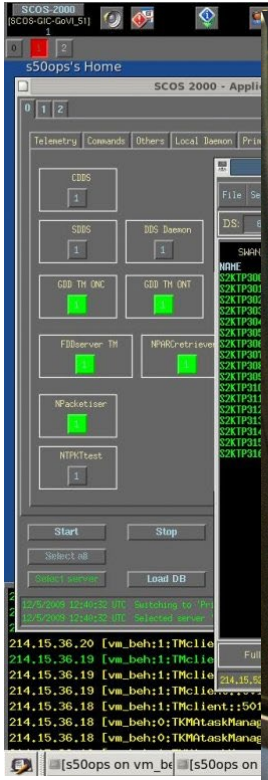
About the presenter

- MSc Aerospace Engineering, Delft University of Technology (2006)
- ISS-Columbus Module operations preparation (ESA-ESTEC)

- Planetary Mission Operations (ESA-ESOC)
  - Mars Express (and Venus Express / Rosetta)
  - Exomars 2016 - Trace Gas Orbiter and Schiaparelli Lander
  - Meteosat Second Generation
- Sentinel-3 Operations Service Manager (Eumetsat)

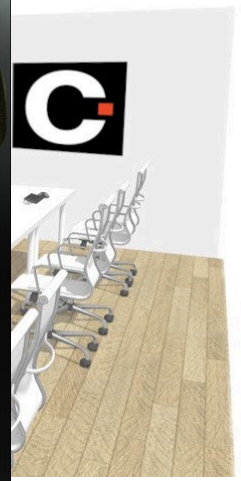
- Space Situational Awareness (Northstar Earth & Space)

- ADR and IOS Product and Mission Operations (ClearSpace)



Expectation

Reality



Mission or space operations

Activities related to the planning, preparations, execution and evaluation of the combined space segment and ground segment Operations

As soon (and simple) as possible

Driving design of system functions and performance requirements

Ship analogy

Captain - Decide where to go and what to do

Navigators - How to get there, knowing where are we now

Planners - Convert activity timeline into a viable schedule

Sailors - Execute the day to day schedule, respond to all situations

Engineers - know the ship, including payloads, its performance and behaviour

Sailors, planners, navigators and captain work in harmony with ship's engineers while it is designed, integrated and tested, to be able to sail safely and reliably

The people involved

Flight Operations Team – Execute Timeline

Ground Support Team – Keepin it connected

Flight Dynamics Team – Move and Point

Mission Support Team – Offline and backoffice

Industrial Support Team – “Switch OFF and ON”

Mission Operations Team

Getting ready

Design:

- Establish Concept of Operations
- Flow-down to ground and space functions
- Create operability requirements and system level

Develop: Timelines, Rules, Procedures, Databases

Reviews: Are we on right track, fitting system design, on time and (will we be) ready?

Verify: Support to testing - procedures and databases Satellite and Ground tests?

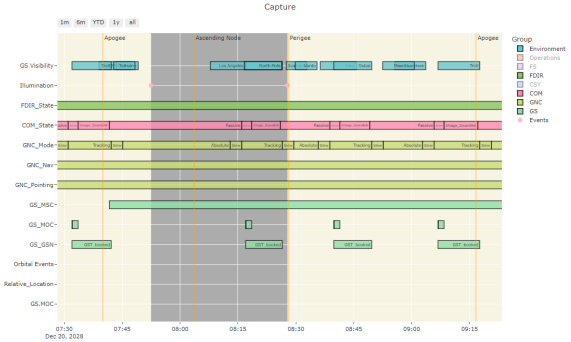
Validate: Integrate all products, validate through architecture in facilities by operations team

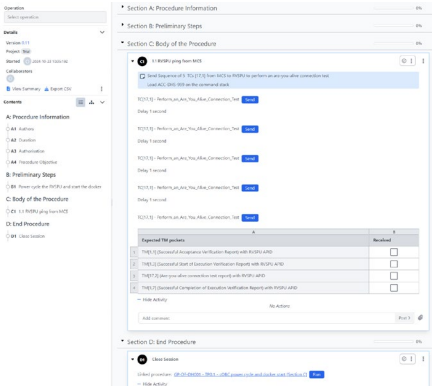
Train: Nominal and anomalous scenarios cosplay before launch, internalising the process.

Operational Products

In Flight Operations Plan

- Governance
- Rules
- Processes
- Timelines
- Procedures





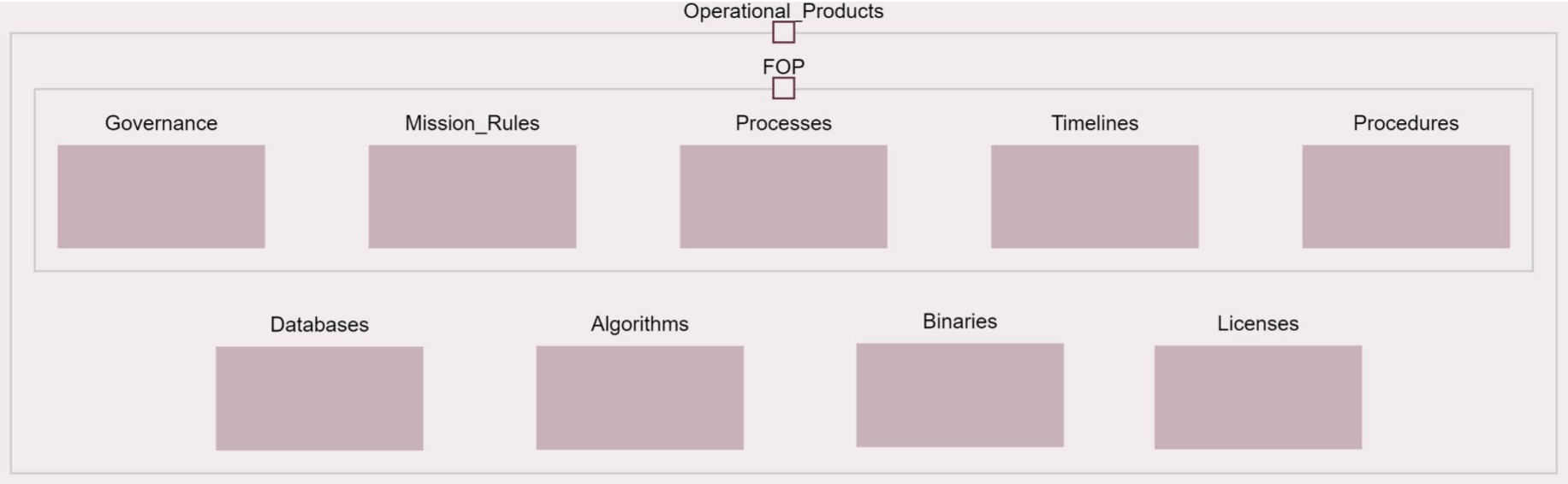
Databases (Dictonaries)

- Software Database
- Flight Dynamics
- Mission Database

Binaries and Algorithms (Software)

Licences (operate, launch, emit, receive)

Operational Products

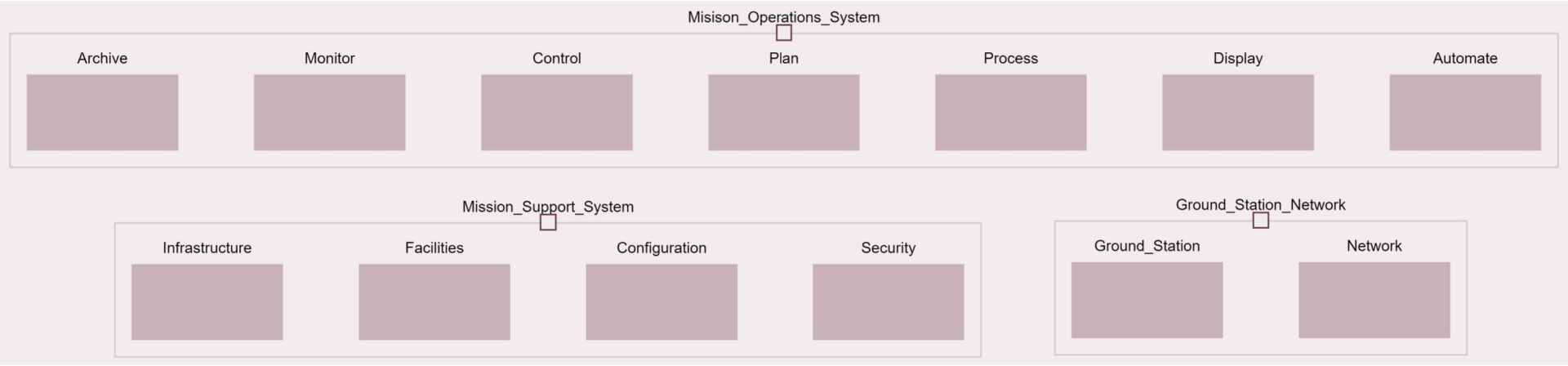


Ground Tools

Ground Segment

- Online Systems:
  - Monitor, Control, Plan, Archive, Process, Display, Automate
- Offline Systems:
  - Infrastructure (HW/SW), Facilities, Configuration, Security
- Ground Station Network:
  - Track, Receive, Transmit, Distribute

Ground Tools



Read the procedure

Follow instructions

Respect reporting lines

Log your work

Stop if unclear

Methodical approach to anomalies

Trends impacting operations

File Based Operations:

- More logical control over all data types ensuring integrity
- Closer to a regular file and operating system

Automated Ground Segments

- Fewer manual functions, releasing brainpower and reducing team sizes
- Tools providing corrective maintenance

Autonomous Satellites

- Different Interface to ground: “tell me when you need help” instead of “is it done it yet?”
- Operator as a babysitter instead of puppet master, enabling fleet management.

OnBoard Processing, Inter-Satellite Links and Optical Direct-to-Earth

- Only downlink the interesting date, allowing quicker follow up tasking or downstream distribution.
- Orders of magnitude throughput and overhead enhancement

The space sustainability factor

Adhere to standards (But which one...)

Be a good neighbour

Leave no trace

Free your place

Enable traffic management

Prepare to be Removed/Refueled/Repaired

Design for demise

SPACE SUSTAINABILITY RATING

ISO 24113:2023

Space systems — Space debris mitigation requirements

2021

IADC Space Debris Mitigation Guidelines

Publication of Guidelines for Safe Close-Proximity Operations

Fighting space junk: More than 100 partners sign Europe's 'Zero Debris Charter'

CONFERS

FOSTERING THE SATELLITE SERVICING INDUSTRY

Platform for Shaping the Future of Mobility

Space Industry Debris Statement

WORLD ECONOMIC FORUM

Standard interfaces for Design for Removal

ASTRA CARTA

What can possibly (will definitely) go wrong

False Instructions: “Where was that +X band antenna pointing”

Wrong Databases: Closed/Open is 0/1, but which valve did we open

Badly Timed Safe Modes: “Hey! Was that our planet?”

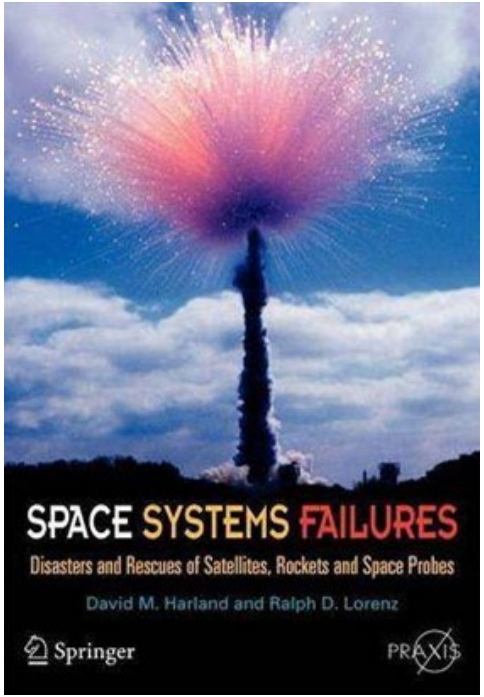
(AIT) Checklist: “This cable was meant to go to Mars”

Notable Saves:

Stuck-in-the-middle Antenna Switch: “Let’s fry it”

(Ab)using systems for other purposes: Star trackers as imagers

Prop system leak: Slow dancing using the Reaction Control Thrusters



Assignment

Compile a timeline and associated procedure for 1 of these three options

Topic 1 : Lunar orbit insertion of your GNSS asset

Topic 2 : Space weather event reception and alert distribution procedure

Topic 3 : Debris capture timeline

Objective A : Write a definition of done for this phase

Objective B : Create a logical procedure with steps and context

- Order, duration, dependencies and handover criteria
- cover the constraints on: Time, Exclusion, Power, Data, Staffing, Ground visibility, System redundancy (also ground systems)

backup

Operations nomenclature

Concept of Operations - High level mission description covering phases and users

Timeline - the visual breakdown of (part of) the concept of operations

Procedure - Logical breakdown of instructions to implement mission operations

Space-to-Ground ICD - Interface control document covering data interfaces from and to space

Database - Telecommand and telemetry protocol and constraint dictionary controlling (space) segments

Mission Operations Centre – aka MOC/MCC - the place from where system is controlled

Mission Operations Team - combination of ops/ground/flight/industry teams

Operational Concept - How the system is used to achieve mission goals

Operability - The tailoring of the system to the operational functional needs