Applying the Microspace Philosophy at the Norwegian Space Agency

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Norwegian Space Centre

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Overview

- Systems Engineering
- Microspace Philosophy and «Big Space»
- Microspace Project Structure and Phases
- Application to AIS satellite system

Space? Systems Engineering?

Why are we in space?

- A global perspective- the ultimate high ground
- A clear view of the heavens- unobscured by the atmosphere
- A free-fall environment- enables advanced material development
- Abundant resources- solar energy and extraterrestrial materials
- The Final Frontier

What is Systems Engineering?

- Holistic approach- **Technical Process** and **Management Process**
- Elicit and analyze user needs
- Determine requirements
- Mission design
- Design synthesis
- System validation
- Lifecycle and stakeholder considerations

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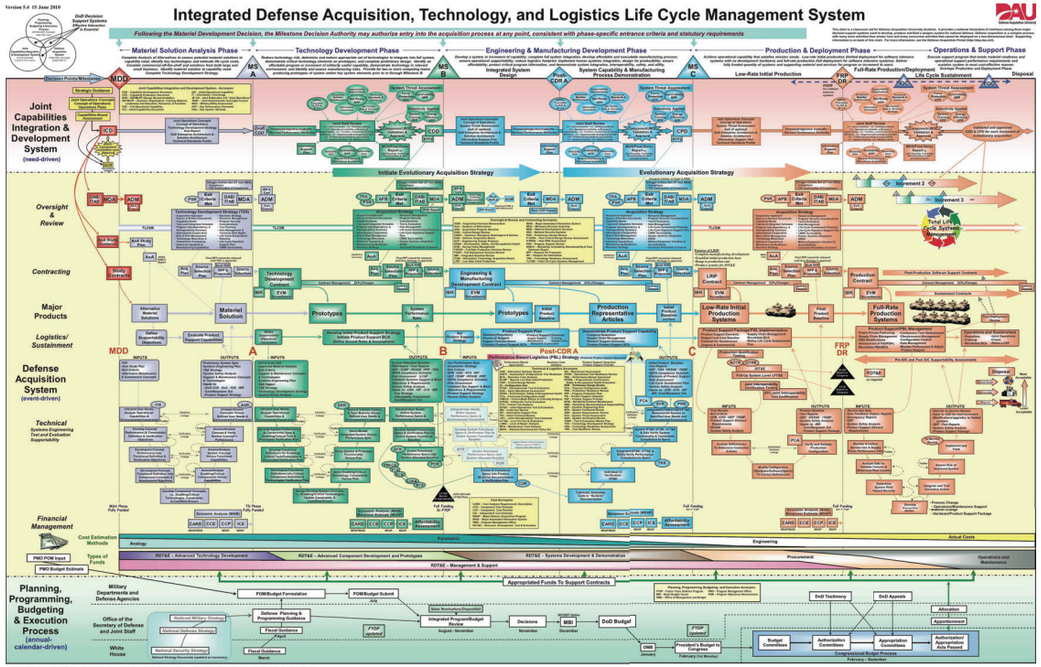
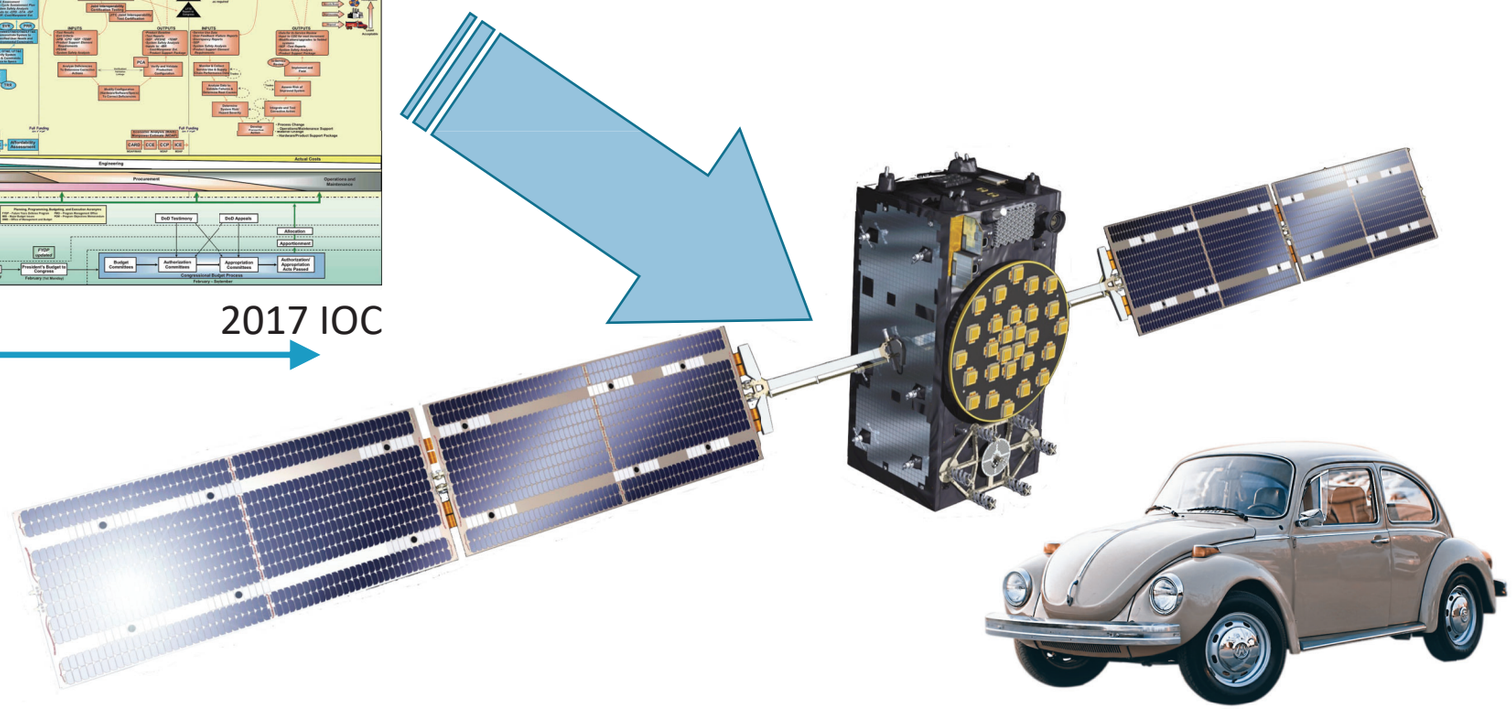
“Big Space” Systems Engineering



1999 initial contract — 18 years — 2017 IOC

Galileo
Global Navigation Satellite System
30x 700 kg satellites in 3 orbital planes
2 Ground Control Centers



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Microspace Philosophy

The Microspace Philosophy has the goal to reduce the overall development, satellite, launch, and operations costs of useful satellite systems

- Streamline large procurement processes to an “appropriate” level
- Replace expensive space grade parts with industrial grade parts (COTS)
- Heavy on-board redundancy is replaced by multi-platform redundancy
- Extensive component and sub-component test campaigns are replaced by integrated system test
- Accepting the technical limitations, lifetime and risk associated with this design philosophy

A 700 kg mission and acquisition program doesn’t scale to a 7 kg satellite!

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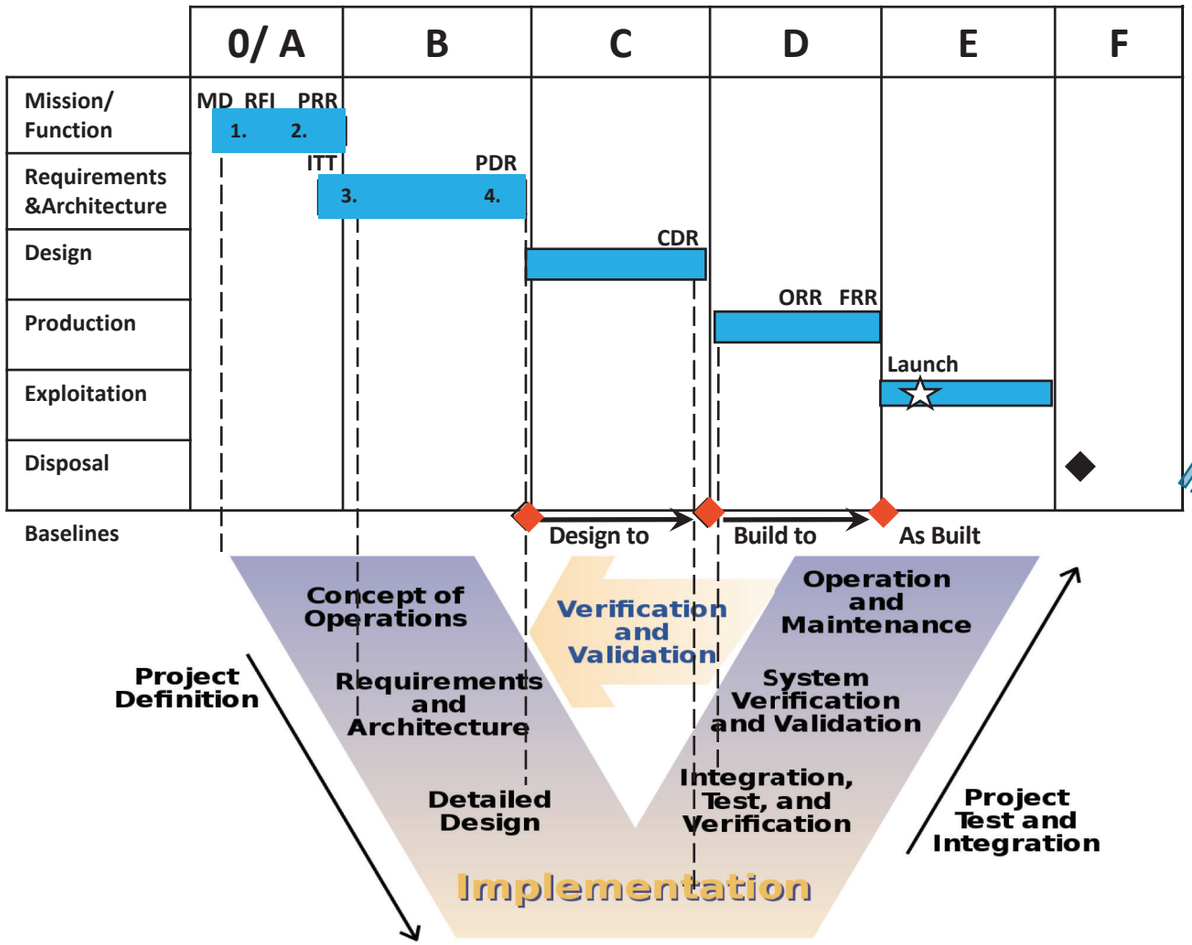
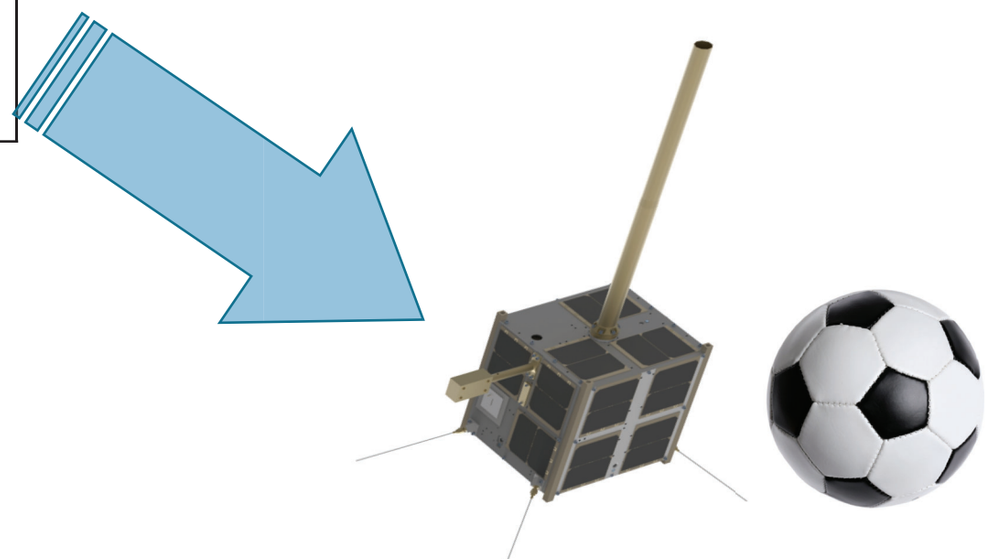
Microspace Systems Engineering



AISSat System
Ship AIS message collection
4x 6-16 kg satellites in 4 orbital planes
1 Ground Control Center



2008 initial contract — 2 years — 2010 IOC

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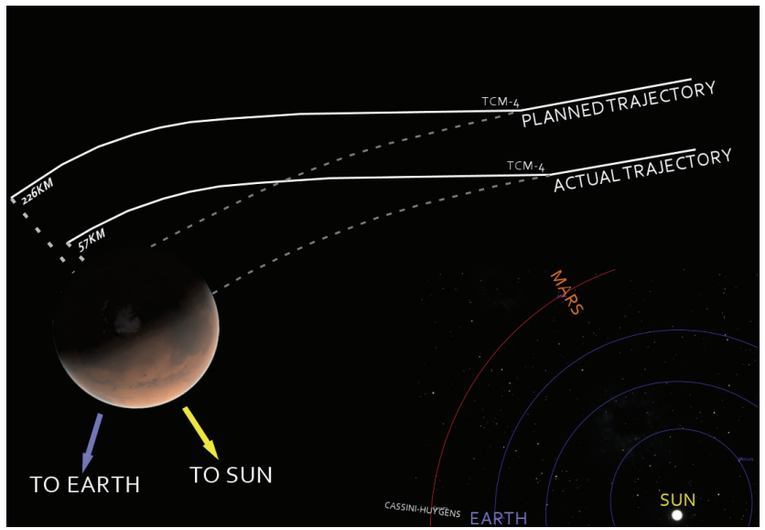
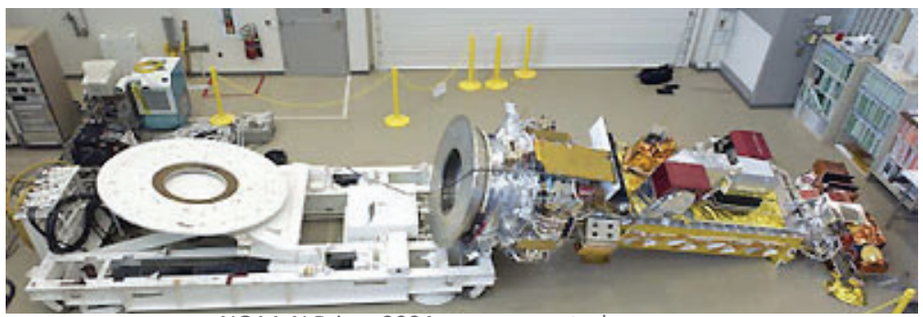
Streamline large procurement processes to an “appropriate” level

Microspace failures, smaller yet frequent

Genisis 2004, mis-mounted accelerometer



Mars Climate Orbiter 1998-1999, thruster units control



NOAA-N Prime 2004, process control

However there is a failure rate of 45% for academia and 77% for industry microspace missions

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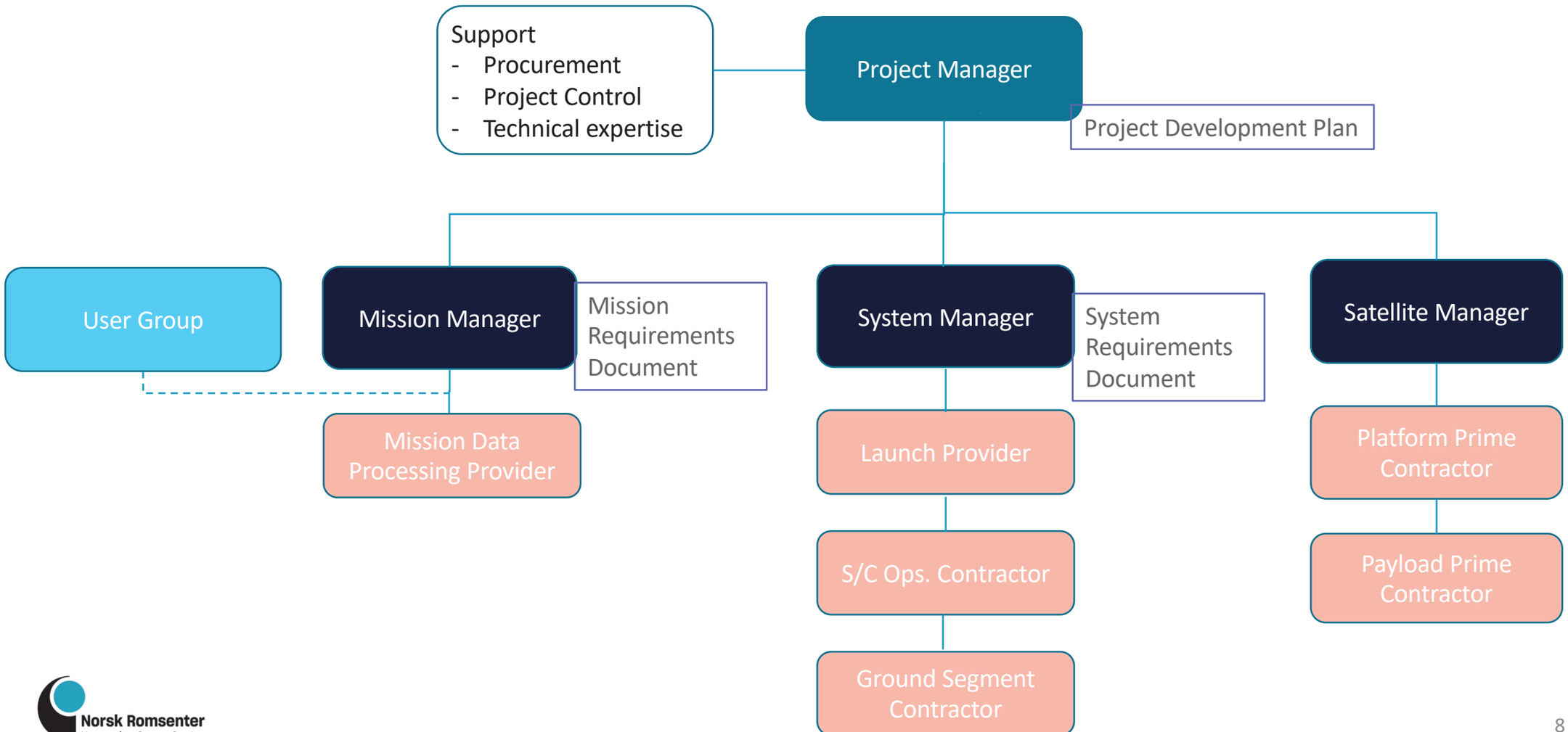
Project Development structure



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Phase 0

Produce a broad spectrum of ideas

- Define User Group, mission needs, goals & objectives
- Study range of mission concepts that contribute to goals and objectives
- Develop **1. Draft Mission Requirements Document**, operations concept, and potential technology needs
- Show that at least one mission concept can work with feasibility study

Exit- Mission Definition (**MD**): select a baseline Concept of Operations . Mission Requirements Review (**MRR**) defines preliminary mission requirements captured in the **Mission Requirements Document** (**MRD**)

Phase A

Determine the feasibility of proposed system

- Perform trade studies to compare mission concept options
- Draft **2. Project Development Plan**
- Draft requirements to the subsystem level
- Define preliminary ICDs
- Define mass, link, performance, data, power, thermal budgets, EMC

Exit- Preliminary Requirements Review (**PRR**): Review preliminary system requirements to establish finalized requirements for procurement. And finalized **MRD**

Phase B

Define the project in enough detail to establish an initial baseline capable of meeting mission needs

- Define and evaluate system architecture and preliminary design details to meet mission requirements
- Intention to Tender (**ITT**): Release project to procurement bids
- Evaluate and select contract bids

Exit- Preliminary Design Review (**PDR**): Review requirements, design and operations to establish the “design-to” baseline. Freeze interfaces with final **ICD**s

Phase C

Critical design of the system (and its associated subsystems, including operations systems) to meet requirements

- Demonstrate that the detailed system design meets requirements
- Establish the ”build-to” baseline
- Begin fabrication of test and flight article components

Exit- **Critical Design Review** (**CDR**) Review design drawings and test plans, decision to build flight design

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Phase D

Build, integrate, and test the subsystems while developing confidence that it will meet systems requirements

- Perform assembly, integration, and test
- Verify system meets requirements
- Perform an Operational Readiness Review (**ORR**):

Exit- Complete Flight Readiness Review (**FRR**): Review system preparedness for launch and establishes the “as-built” baseline

Phase E

Implement the Mission Operations Plan developed in earlier phases

- Launch the certified system
- Perform Early Operations and Checkout to define In-orbit performance to establish the operational “as-deployed” baseline
- Conduct mission operations

Phase F

Disposal of the system in a responsible manner. Orbital debris!

Documents

1. Draft Mission Requirements Document

Mission Manager

Short description of system, high level and general spacecraft requirements, mission phases

2. Project Development Plan

Project Manager

Establish the development logic and management plan for the project, define constraints and risk analysis, work description, validation logic, funding, schedule, model policy

3. Mission Requirements Document

Mission Manager

Elaborate on draft document, launch, lifetime, ground segment and payload level requirements defined

4. Systems Requirements/ Customer Specification

System Manager

Document communicating to the contractor the specifications derived from mission requirements that are to be designed to

AISSat Phase 0

- Define User Group, mission needs, goals and objectives
  - Coastal authority has responsibility for monitoring ship traffic in Norwegian waters
- Study range of mission concepts that contribute to goals and objectives
  - Coastal antennas have limited range, AIS messages can be collected from space
- Define operations concept, and technology needs
  - Keep it simple, fly only an AIS receiver, we won't see every ship on the globe but we will see the ships in the arctic

Accept Microspace Philosophy limitations

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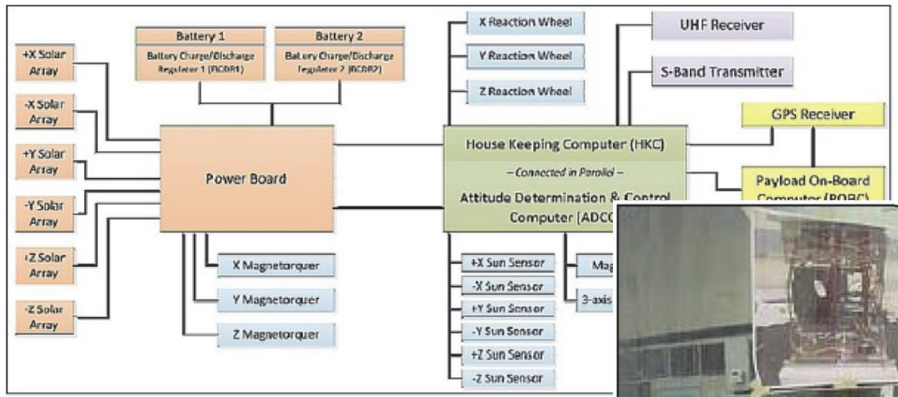
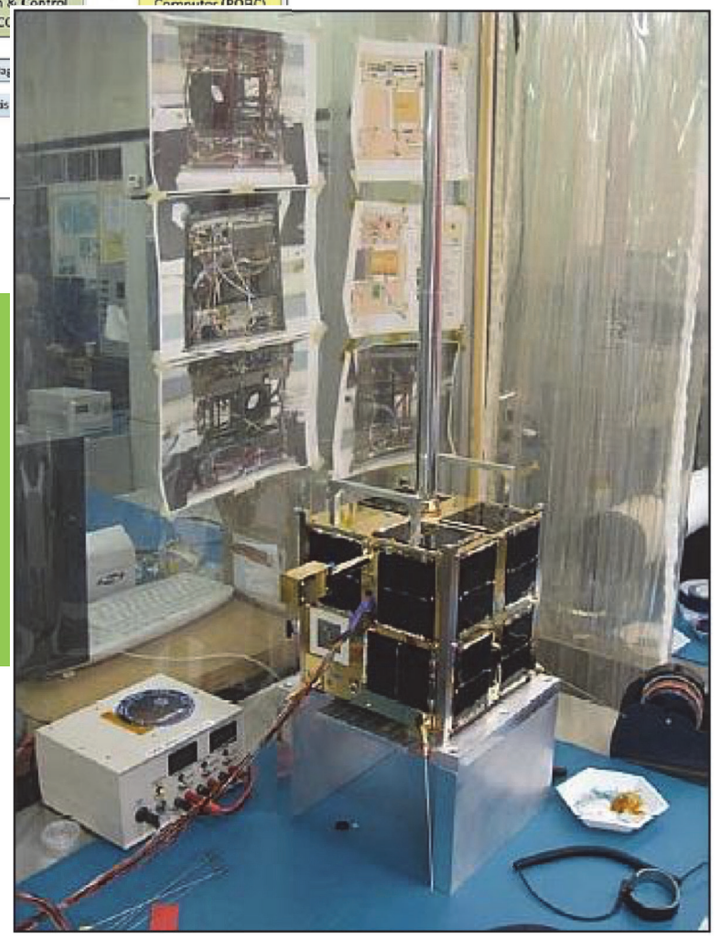
Phase A/B

- Develop Mission Architecture
  - Leverage existing bus
- Author MRD
- Define sub-system req’s
- ITT / award contract (6 months)





Replace expensive space grade parts with industrial grade parts (COTS)

Extensive component and sub-component test campaigns are replaced by integrated system test

Phase C/D

- Finalize Design, CDR
- Production, COTS bus
- Tests performed at high levels

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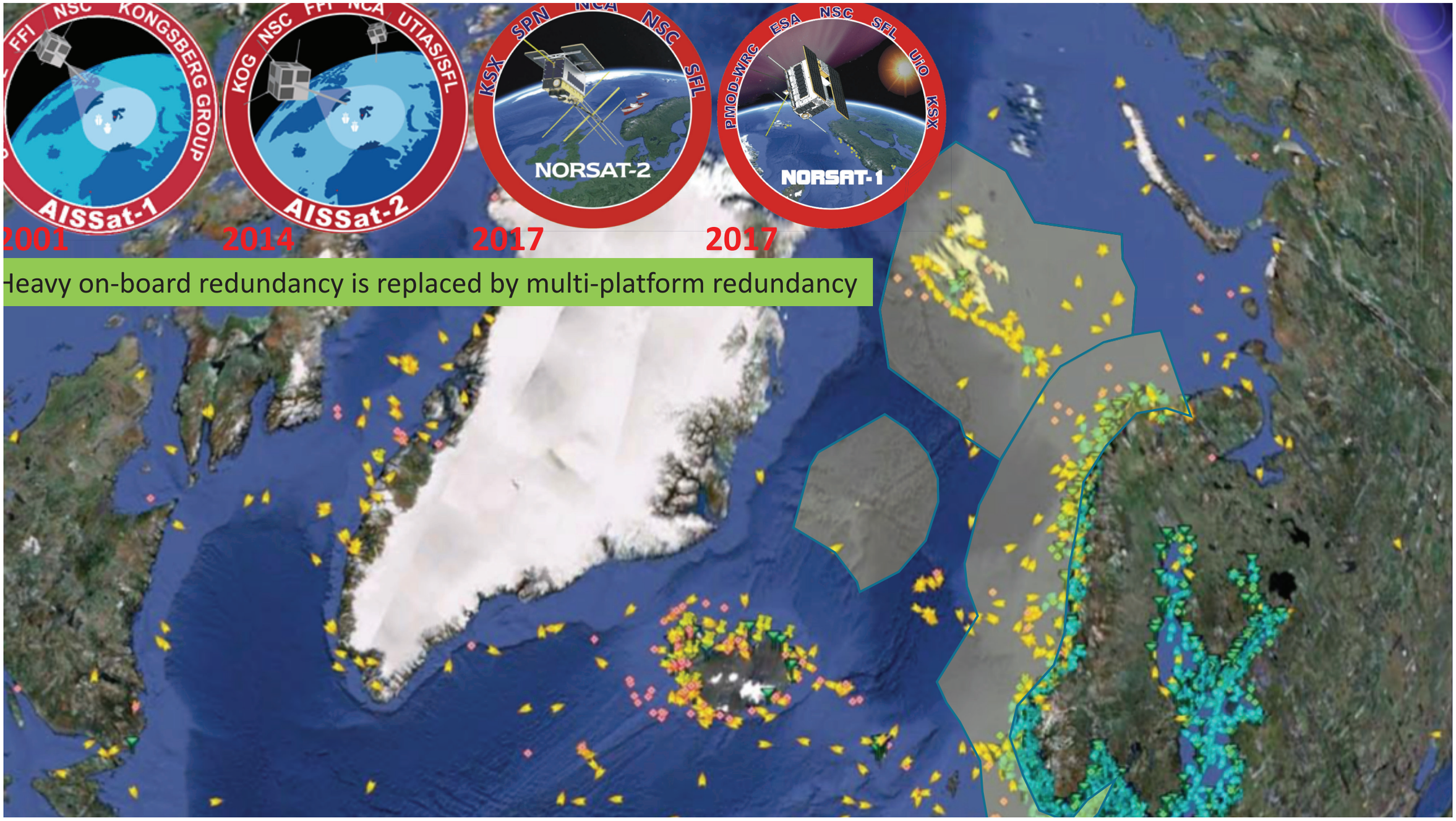
FFI
NSC
KONGSBERG GROUP
AISSat-1
2001
KOG
NSC
FFI
NCA
UTIAS/SFL
AISSat-2
2014
KSX
SPN
NCA
NSC
SFL
NORSAT-2
2017
PMOD-WRC
ESA
NSC
SFL
UIO
KSX
NORSAT-1
2017
Heavy on-board redundancy is replaced by multi-platform redundancy


Thank you!
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