

Phase A/B system study for Norwegian IOD initiative: Procedure and Schedule

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- New initiative to be started within the frame of the ESA General Support Technology Programme (GSTP) “Fly” element for a Norwegian Small Satellite In-Orbit Demonstration (IOD) mission
- GSTP “Fly” element covers all dedicated small sat IOD missions (e.g. CubeSats, micro/mini-sats) and Technology Flight Opportunities (i.e. hosted payloads on third party carrier platforms)
- Initially, the Phase A/B (mission/system definition phase) of the project has been funded
- Open competitive Invitation To Tender for the Phase A planned to be issued on EMITS (emits.esa.int)
- ITT open to bids from Norwegian consortia with an experienced external platform provider
- ITT process will result in the selection of a Norwegian consortium to carry out the Phase A study: contract negotiation will be carried out and a 250 kEuro contract will be placed
- Upon successful completion of the Phase A (closure of PRR), a Contract Change Notice for 250 kEuro for the Phase B work will be placed
- Upon successful completion of the Phase B (closure of the PDR), a separate contract for the implementation phase may be issued to the Norwegian consortium via direct negotiation, depending on the available budget and interest of NO delegation

Norwegian IOD mission overview



- Mission objective:
 - demonstrate a number Norwegian payloads on a 30-50 kg small satellite platform in LEO
 - build up Norwegian competencies in small satellite project management & system engineering
- Primary technology payload (intended, depending on maturity):
 - hydrogen peroxide monopropellant propulsion system
 - developed by NAMMO under a separate ESA GSTP activity “Propulsion System for Orbit Control of Microsatellites”
 - demonstrate the performance required for de-orbiting and orbit control/station keeping applications (restartable with total delta-V of up to approx. 100 m/s)
- Secondary payloads:
 - to be pre-selected based on an ESA/NSC Announcement of Opportunity early in Phase A
 - proposals from Norwegian industry/research institutes and academia
 - tech demo & science/application payloads
 - selection criteria: end utility/merit, technical feasibility, accommodation within on-board resource constraints, technical maturity and programmatic aspects
 - final selection will be made jointly by ESA and NSC at end of Phase A



Invitation To Tender for Phase A study



- Schedule:
 - ITT planned to be issued in November/December 2017
 - 6 week bidding period to submit proposals
 - Proposal evaluation in January/February 2018
 - Contract negotiations and KO in February/March 2018
 - Preliminary Requirements Review at KO + 12 months
- Scope:
 - support ESA/NSC in the pre-selection of Norwegian secondary payloads suitable for IOD
 - study the accommodation of selected payloads in the small satellite platform for two different platform configurations (with/without propulsion)
 - define the mission/system requirements
 - define a baseline mission/system design, with engineering trade-offs/analyses/budgets
 - confirm the technical feasibility and payload complement
 - provide preliminary estimate of cost/schedule of the follow-on implementation phase, including any co-funding & in-kind contributions



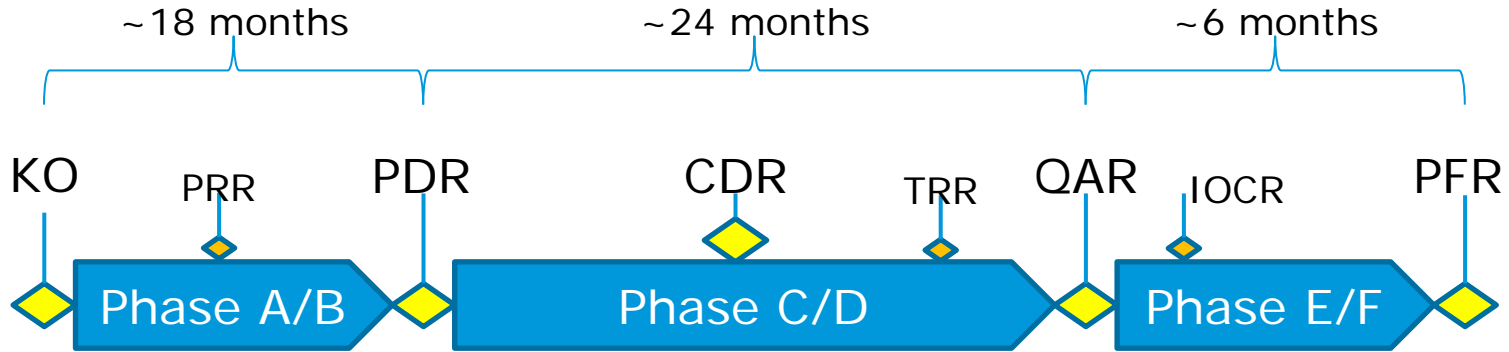
Invitation To Tender for Phase A study



- Typical proposal evaluation criteria for ESA ITTs:
 1. Background and experience (related to the particular field concerned) of the company (ies) and staff (including adequacy of proposed facilities)
 2. Understanding of requirements and discussion of problem areas
 3. Quality and suitability of proposed programme of work; adequacy of engineering approach
 4. Adequacy of management, costing and planning for the execution of the work
 5. Compliance with administrative tender conditions and acceptance of contract conditions
- Weighting factors are applied to the criteria (specified in the ITT package)
- Consortia shall include an experienced platform provider able to provide System Engineering support to the Norwegian Prime in task execution



Project Phasing & Milestones



Mission/system definition

- Mission reqts
- Mission design/analysis
- System reqts
- Prelim. design
- Devt plan
- Analysis (mechanical, thermal, AOCS, power, link)

Implementation

- Detailed design
- Interface defn
- Launch procure
- Freq. allocation
- E(Q)M devt & test
- (P)FM production & test
- COTS FM procure
- System AIV
- Ground seg. setup

IOD mission

- Launch prep
- Integration w/ deployer
- (Launch campaign)
- Ops rehearsal
- LEOP
- Nominal ops
- Flight data analysis



Phase A Main Tasks



- Mission:
 - mission requirements spec
 - mission operations concept and mission design (options with/without propulsion)
 - mission analysis (ground station visibility, eclipse periods, orbital lifetime, manoeuvres)
 - space debris mitigation compliance
 - space & launch environment specification
- System:
 - system requirements spec
 - system design trade-offs (options with/without propulsion)
 - system functional breakdown & architecture (space and ground segments)
 - s/c configuration & pointing/operating modes
 - subsystem trade-offs, make-or-buy list, equipment selection (incl. qualification status)
 - accommodation of payloads & equipment
 - system budgets (mass, power, data, link, propellant, and pointing)
 - launch opportunity trade-offs



Phase A Main Tasks



- Programmatics:
 - risk & criticality assessment (TRL, critical items, long lead items)
 - preliminary cost & schedule estimates per phase to completion



- Consolidation of Phase A work
- Preliminary design:
 - detailed payload accommodation
 - new or heavily modified platform equipment
 - ground segment & new ground segment elements
- Engineering analysis/budgets:
 - s/c mechanical, thermal, power, comms link, pointing errors
- Interface definition:
 - Satellite-launcher (deployment system)
 - Payload-platform (mechanical/thermal, electrical, data)
 - Space-ground (RF freq, modulation & coding, TM/TC protocols)
- Programmatics:
 - system development, AIV and PA plans for Phase C/D
 - detailed cost and schedule breakdown to completion

Project Reviews



- Review procedure (typically 2 months)
 - Delivery of data package by contractor
 - Review of data package by ESA panel and generation of Review Item Discrepancies (RIDs)
 - RID screening by panel chair
 - Submission of RIDs to contractor
 - Response to RIDs by contractor
 - Co-location meeting at ESTEC to disposition RIDs
 - Board meeting to assess achievement of review objectives
 - Contractor completion of RID close-out actions
- Review panel
 - Chairperson: ESA Technical Officer
 - Members: system engineer, PA/QA, space debris, subsystem engineers
- Review board
 - Co-chaired by senior manager from TEC and other Directorate
 - Members: panel chair, contractor PM



Project Deliverables –Phase A/B Documentation



Document Name	Phase A Preliminary Requirements Review	Phase B Preliminary Design Review
Mission Requirements Document (MRD)	Issue	Maintain
Mission Analysis Report (MAR)	Issue	Maintain
System Requirements Document (SRD)	Issue	Maintain
System Design Report (SDR)	Issue	Maintain
Environmental Design Specification	Issue	Maintain
Space Debris Mitigation Document	Issue	Maintain
Space-to-ground Interface Control Document		Issue
Declared Lists for Parts, Materials and Processes		Issue
Satellite Mechanical Analysis Report		Issue
Satellite Thermal Analysis Report		Issue
Satellite AOCS Analysis Report		Issue
COTS User Manuals		Issue
System Development Plan (SDP)		Issue
Payload-Platform Interface Control Document (ICD)		Issue
Product Assurance Plan (PAP)		Issue



Document Name	Preliminary Design Review	Critical Design Review	Qualification & Acceptance Review	Post-Flight Review
Mission Requirements Document (MRD)	Issue	Control	Control	
Mission Analysis Report (MAR)	Issue	Maint.	Maint.	
System Requirements Document (SRD)	Issue	Control	Control	
System Design Report (SDR)	Issue	Control	Control	
Environmental Design Specification	Issue	Control	Control	
Space Debris Mitigation Document	Issue	Maint.	Maint.	
Space-to-ground Interface Control Document (SGICD)	Issue	Control	Control	
Declared Lists for Parts, Materials and Processes (DLs)	Issue	Control	Control	
Satellite Mechanical Analysis Report	Issue	Maint.	Maint.	
Satellite Thermal Analysis Report	Issue	Maint.	Maint.	
Satellite AOCs Analysis Report	Issue	Maint.	Maint.	
COTS User Manuals	Issue	Maint.	Maint.	
System Development Plan (SDP)	Issue	Maint.	Maint.	
Payload-Platform Interface Control Document (ICD)	Issue	Control	Control	
Product Assurance Plan (PAP)	Issue	Maint.	Maint.	
Engineering Model Test Procedures		Issue (before tests)		
Engineering Model Test Reports		Issue		
Satellite AIV Plan		Issue	Maint.	
System Verification Control Matrix (VCM)		Issue	Maint.	
Non-Compliance Reports (NCRs)		Issue (as needed)	Issue (as needed)	
Request For Waivers (RFWs)		Issue (as needed)	Issue (as needed)	
Safety Data Package		Issue	Maint.	
Satellite Integration Logbook			Issue	
Satellite Proto-Flight Model Test Procedures			Issue (before test)	
Satellite Proto-Flight Model Test Reports			Issue	
Ground Segment Acceptance Test Procedure			Issue	
Ground Segment Acceptance Test Report			Issue	
System End-to-End Test Procedure			Issue	
System End-to-End Test Report			Issue	
Mission Operations Plan			Issue	
Mission Operations Status Reports				Issue
Post-flight Analysis Report				Issue

A

B

- Models (Phase B)
 - 3D Computer Aided Design (CAD) model of the satellite configuration
 - Finite Element Model (FEM) of the satellite structural design
 - Thermal Mathematical Model (TMM) of the satellite thermal design
- Hardware (Phase C/D)
 - Engineering Models (EMs) of the newly developed platform and payload items (electrically representative of flight configuration)
 - Satellite ProtoFlight Model (PFM) for launch
 - Mechanical and electrical Ground Support Equipment associated with the EMs & PFM manufactured/procured under the contract
 - Mission Control Centre equipment procured under the contract
 - Satellite flight spare items procured under the contract

Project Deliverables –Other

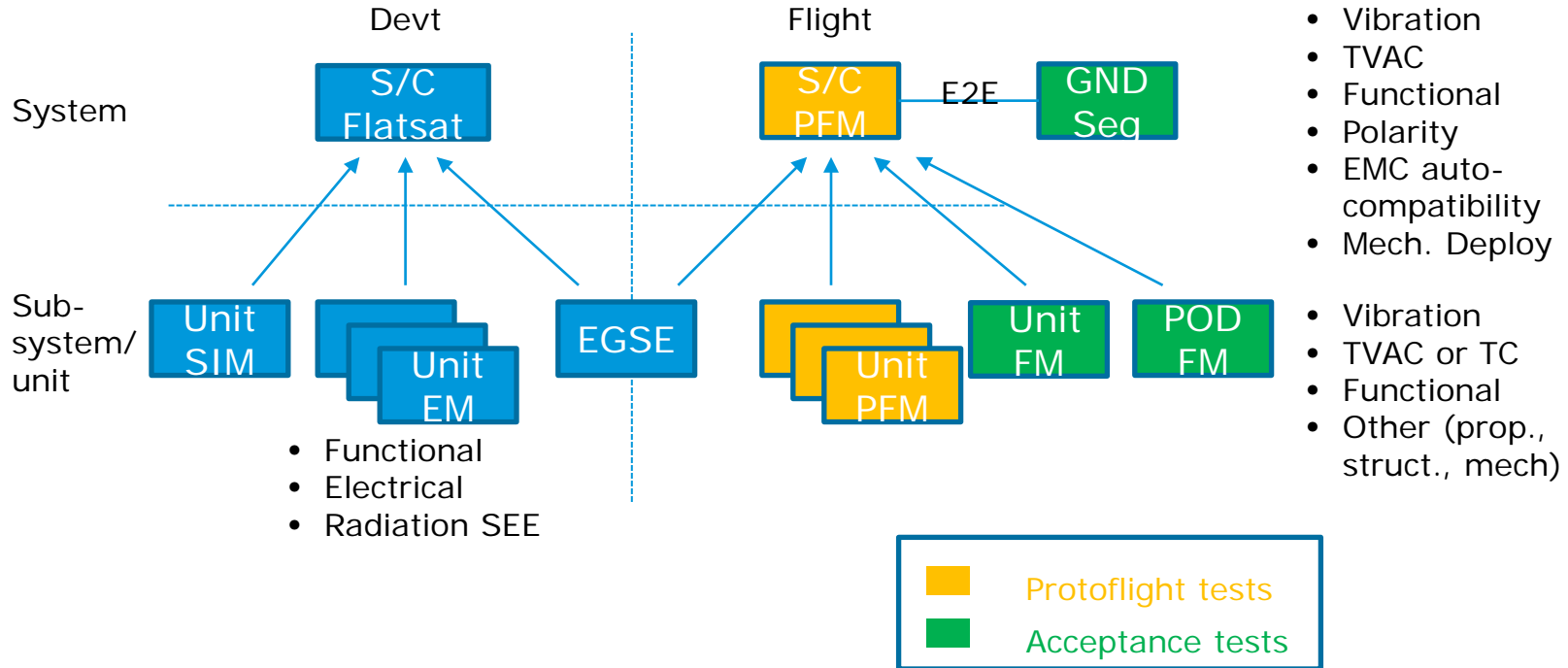


- Software (Phase C/D)
 - On-board flight software installed on the PFM
 - Mission control software developed/procured under the contract
- Database (Phase E/F)
 - Satellite database
 - Payload database



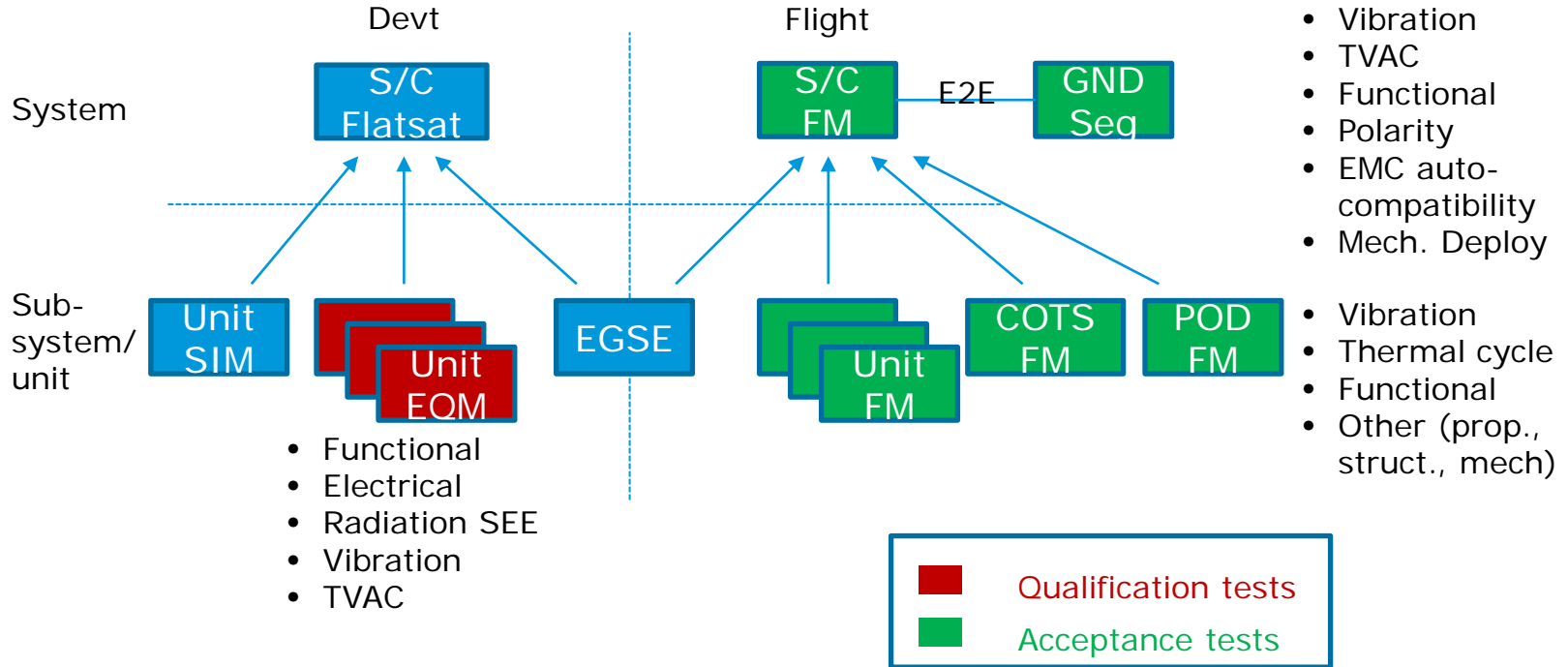
Phase C/D Model & Testing Philosophy (1)

Option 1: EM+PFM Approach



Phase C/D Model & Testing Philosophy (2)

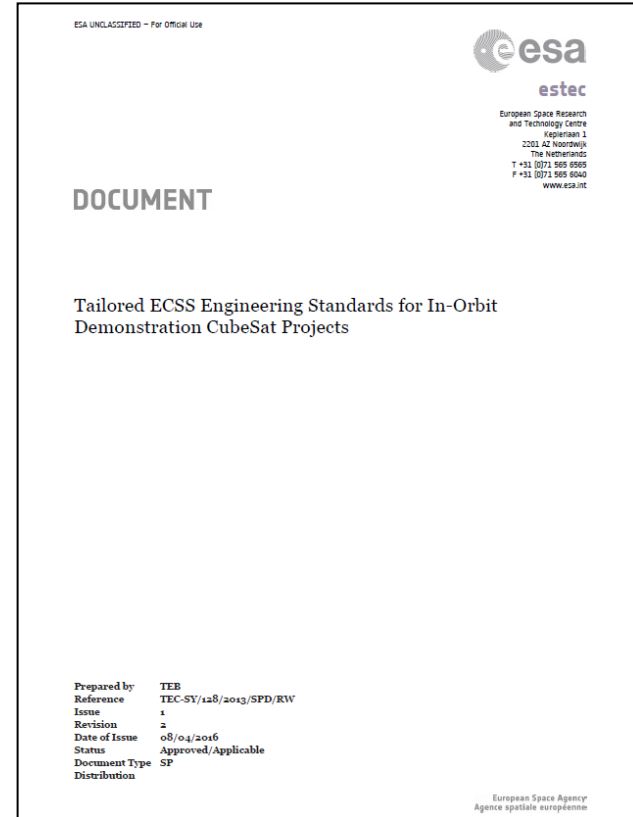
Option 2: EQM+FM Approach



Engineering and PA/QA Requirements



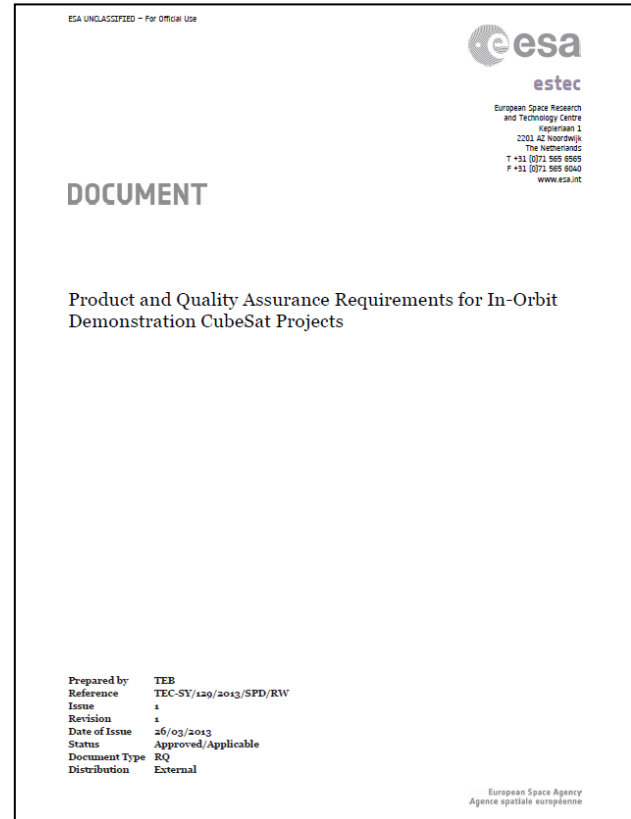
- Challenges:
 - Improving in-orbit reliability within the very tight project cost/schedule constraints
 - Accepting higher risk due to limited/no redundancy, extensive COTS components
 - Eliminating/preventing known failure root causes
- Risk management:
 - Identification of risks at the start of the project
 - Maintenance of the project risk register during the project and regular reporting to ESA
 - Review of risk register at project reviews
- Engineering standards:
 - Highly tailored version of the ECSS-E engineering standards
 - Emphasis on engineering best practices, functional verification, environmental testing



Engineering and PA/QA Requirements



- Product/Quality Assurance:
 - Light PA/QA requirements adapted from those proven for small ESA payloads
 - Emphasis on configuration control, traceability, inspection/handling/storage, cleanliness, verification control, non-conformance handling, workmanship, EEE component selection
 - Space debris mitigation requirements
- Specific risk mitigation:
 - Radiation (SEE) testing of COTS components/boards without flight heritage/test data



THANK YOU

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