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DOCUMENT

IOD CubeSat Document Requirements Definition

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Reference TEC-SY/127/2013/DRD/RW
Issue 1
Revision 3
Date of Issue 24/11/2016
Status Approved/Applicable
Document Type DRD
Distribution TEB

European Space Agency
Agence spatiale européenne

APPROVAL

Title IOD CubeSat DRD	
Issue 1	**Revision** 3
Author TEB	**Date** 24/11/2016
Approved by	**Date**
TEB	26/03/2013

CHANGE LOG

Reason for change	Issue	Revision	Date
Clarified DRD for thermal analysis report (model uncertainties and margins) and Environment Design Specification (natural electromagnetic environment).	1	3	24/11/2016

CHANGE RECORD

Issue 1	**Revision** 3		
Reason for change	**Date**	**Pages**	**Paragraph(s)**

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1 INTRODUCTION

The purpose of this document is to provide the requirements for the content of all documentation specified in the Deliverable Items List ([AD1] to SOW) for the CubeSat Technology Pre-development project.

2 DOCUMENT REQUIREMENTS DESCRIPTIONS

Title	Purpose	Content
Mission Requirements Document (MRD)	To specify the mission requirements and constraints, and high level payload user requirements	The MRD shall include as a minimum: • mission objectives • mission constraints (launcher, orbit, target launch date, duration, comms coverage) • science observation requirements • payload requirements, incl. operational & data • mission phases and operational modes requirements • autonomy requirements • ground segment requirements • mission data acquisition, storage and dissemination requirements
Mission Analysis Report (MAR)	To describe all of the analysis performed in support of the mission planning prior to launch	The document includes: *Mission design:* • mission profile including mission duration, phases, satellite operational modes • Orbit and pointing profiles during the phases/modes • Available ground segment resources, including ground stations • degree of ground segment automation and satellite on-board autonomy • mission operations concept *Mission analysis:* • launch/operational orbit trade-offs and selection • orbit/trajectory predictions throughout the mission • payload operations planning and analysis (e.g. imaging revisit analysis) • ground track and ground station visibility analysis • solar eclipse analysis • contingency analysis with respect to mission recovery in cases of failures during critical periods
System Requirements Document (SRD)	To specify the system requirements relating to the spacecraft, payload and ground segment	The SRD shall include as a minimum: • system functional, performance and interface requirements • requirements for environment, cleanliness and ground handling, AIV, EMC, interfaces, modes and on-board autonomy/FDIR • ground segment requirements for ground stations, flight dynamics and simulation support, ground systems automation • programmatics requirements (project cost and schedule)

System Design Report (SDR)	To provide a summary technical description of the overall baseline mission, spacecraft system and ground segment, including external interfaces and system budgets.	Technical description, to include: • introduction, • mission phases, performances and operations overview • launch, LEOP and on-orbit configurations • satellite operational modes • spacecraft design concepts & trade-offs, including electrical, thermal and mechanical architecture • data processing hierarchy / software architecture • baseline spacecraft description • system budgets (mass, power, link, data) • For each subsystem, including Primary Payload, and for GSE: ➢ functional block diagram / schematic ➢ description of key design features, performances and interfaces • external interfaces (Launcher, GSE, Ground Segment) • ground segment architecture
Environmental Design Specification (EDS)	To define the launch and space environments that the satellite is expected to be encountered by the spacecraft throughout the mission, and to form an Environment requirements specification for application to the system and subsystem design.	The document shall specify the launch environment considering compatibility with all specified launch vehicles. The specification shall consist of (at both qualification and acceptance levels) the following environments: • quasi-static loads • sine and random vibration • shock • acoustic • pressure • temperature and humidity under fairing on launch pad The document shall specify the following space environments (based upon analysis results): • energetic particle fluxes and fluences (protons, electrons, cosmic-rays) • natural electromagnetic radiation (see ECSS-E-ST-10-04C section 6 and Appendix F.5) The document shall also specify the following effects of these environments on the spacecraft: • total ionizing radiation dose • single event effects • materials outgassing due to vacuum
Space Debris Mitigation Document	To define how the project plans to fulfil the ESA space debris mitigation requirements, and report on analysis results demonstrating compliance	As per ESA/ADMIN/IPOL(2008)2 - Space Debris Mitigation for Agency Projects.

Product Assurance Plan (PAP)	Ensure that the organization, requirements, methods, tools, resources and responsibilities for the product assurance and safety disciplines are well defined before development and implemented at each project level.	The PA plan shall describe the resources, tasks, responsibilities, methods and procedures adopted by the Contractor for the implementation of the ESA PA&S requirements and for the achievement of the PA objectives. The PA plan shall include the following major elements: • Scope, Applicability, • PA management: Objectives, Policies, Implementation Approach, Responsibilities, Organization, Reporting, • Applicable and reference documents. • Tasks and activities to be performed for compliance with ESA PA/QA requirements • Cleanliness plan
Space-to-ground Interface Control Document (SGICD)	To define the interfaces between the spacecraft and the ground segment, including all ground stations.	The main interfaces to be addressed are at the level of command and control, Mission data and telecommunications aspects for which format, content and RF transmission need to be described. Spacecraft to Ground Segment I/F definition, including: • system overview • spacecraft and orbit, range definition • data formats and rates, coding scheme and modulation • encryption, authentication • reference profile assumptions • telecommunications: o frequencies o link budgets, indicating worst case link margins expressed in dB for meeting the bit error rate requirements expressed in the SRD. • data formats • TM/TC formats • ground station front-end interfaces • ranging interfaces • database interface • spacecraft to Ground Segment verification.

Satellite Mechanical Analysis Report	To describe the s/c mass properties, structural analysis set-up, assumptions, and analysis results in relation to the relevant requirements	*Mass Properties Analysis* The document shall contain (based on analysis of the satellite 3D CAD model): • Overview of the stowed and deployed satellite configurations • Satellite total mass • Satellite Centre of Gravity position (& uncertainties) in spacecraft coordinate system –stowed and deployed configurations • Satellite Moments of inertia –stowed and deployed configurations *Structural Analysis* The document shall contain: • Input loads description • Analysis cases • FEM description and underlying assumptions & approximations • Materials properties • Model cross-checks • Analysis tool description & outputs • FEA results, including Margins of Safety on structural elements • Conclusion with respect to requirements compliancy & areas of further work *Mechanisms Analysis* The document shall contain (for each mechanism): • Design overview and description of operation in flight for all mechanisms, including hold-down, release, deployment and actuation functions • Identification of worst case operational and environmental conditions • For new developments: o Pre-load & tolerance budget analysis o Actuation torque or force analysis o Performance analysis o Analysis of lubrication selection & sizing for the application & lifetime • Prediction of the number of on-ground and in-orbit cycles • Power demand of electrically actuated mechanisms

Satellite Thermal Analysis Report	To describe the thermal analysis set-up, assumptions, and analysis results in relation to the relevant requirements	The document shall contain: • Input parameters and assumptions • Analysis cases (hot, cold, transient etc) • TMM description and underlying assumptions & approximations • Materials properties • Thermal Reference Point definitions • Model checks • Analysis tool description & outputs • Analysis results, including temperatures of satellite equipment respecting modelling uncertainties • Temperature margin and model uncertainty approach • Sensitivity analysis • Conclusion with respect to requirements compliancy & areas of further work
Satellite AOCS Analysis Report	To describe the AOCS analysis set-up, assumptions, and analysis results in relation to the relevant requirements	The document shall contain: • S/C design configuration relevant to AOCS • Input parameters and assumptions (sensor/actuator noise, controller bandwidth) • Analysis cases (pointing modes, orbits/trajectories, stowed/deployed configurations) • AOCS performance model description and assumptions • AOCS performance analysis results, including pointing error budget • Conclusion with respect to requirements compliancy & areas of further work
COTS User Manuals	To describe the Commercial Off The Shelf products to be used in the satellite design baseline.	The document shall provide user manuals provided by suppliers of all the COTS products to be used in the satellite, including: • Option sheets and clear selection of options used in the satellite • Electronic circuit diagrams (if available) • Interface definitions (if available) • User instructions (if available) • Acceptance tests performed by the supplier prior to delivery (if available) If a user manual is not available for a particular COTS product, then as a minimum a product data sheet shall be provided.

System Development Plan	To define the planning for the detailed activities to be performed on new development items.	Plan shall include: • Qualification Status List of the equipment with respect to the mission/system requirements • model philosophy • hardware development plan (covering manufacturing and assembly plans) • software development plan (covering coding) • hardware/software co-engineering approach • engineering tools and facilities used to support developments (hardware and software)
Platform-Payload Interface Control Documents (ICDs)	To define the payload item interfaces with the platform.	The document shall define the payload interfaces in terms of: • mechanical interfaces • electrical interfaces • thermal interfaces • data interfaces
Declared Lists for parts, materials and processes (DLs)	To identify all types of electrical components, mechanical parts and materials needed for the current design for all system-level models.	See ECSS-Q-ST-60C Annex B, ECSS-Q-ST-70C Annexes A, B and C for example format.
Satellite AIV Plan	To define and control all assembly, integration, verification and transportation activities associated with the satellite proto-flight model	Spacecraft model assembly/integration plan • Integration sequence • Integration constraints • Use of MGSE/EGSE • Payload calibration Protoflight test programme definition in terms of: • Test philosophy • Test conditions • Hardware/software matrices • Functional and performance verification, including interface integrity verifications. • Protoflight test programme (involving functional testing at ambient, vibration and TV test limits, TV profile and EMC) • Test plan, criteria and methods
Safety Data Package	To demonstration the compliance with the launch safety requirements	Defined by the launch authority.

System Verification Control Matrix	To identify verification methods to track verification status with respect to requirements during the project lifecycle	For each system requirement: • Requirement identifier • Requirement description • Design configuration item • Verification method (review/ analysis/inspection/ demonstration/test • Verification status • Reference to supporting documentation (ie. inspection/analysis/test reports) Requirements to be verified in this matrix include: • Mission/system requirements • Space debris mitigation requirements • Environmental Design specification requirements • Applicable CubeSat design specification requirements • Launcher requirements • Safety requirements
Test Procedures	To establish the objectives, organization, set-up and constraints of verification tests. To establish the procedures/success criteria used in verification tests and the requirements to be verified.	As per ECSS-E-ST-10-03C Annex C
Test Reports	To describe the results of the verification tests at all levels against the specified requirements.	The document shall include for each test: • Test method • Test equipment and set-up description • As-ran test procedure • Pass/fail criteria • Test results including pre- and post-processed test data in the form of tables and graphs • Interpretation of the test results with respect to the criteria • Conclusion regarding test outcome and identification of any remedial measures in case of test failure
Satellite Integration Logbook	To record the actual events of the satellite integration process	The document shall contain: • Integration methods and equipment used • Ambient conditions during the integration • Cleanliness conditions, including clean room and clothing of the AIV personnel • Condition of the incoming hardware • Integration as-run procedure • Fasteners, adhesives and harness tie-downs used • Notable events during integration: o Anomalies o Discrepancies o Errors o Any corrective measures

Mission Operations Plan	To define the full plan of activities immediately preceding and during the mission operations phase, including the Mission Timeline. It shall cover all mission phases, from lift-off from the launch pad until and including the Spacecraft end of life disposal, covering nominal and contingency recovery operations.	The document shall include: • Pre-launch mission rehearsals planning • Mission timeline including all mission events and telecommand/telemetry flows • Mission planning activities & work flow (including flight dynamics and simulator activities) • Payload operations planning & work flow • Operations personnel, operator responsibilities & lines of authority • Operations work schedule & flow • Support services and emergency contact points in case of ground systems failure
Mission Operations Status Reports	To regularly report on the health status of the platform and payload in orbit and the progress with respect to the Mission Operations Plan	The document shall include: • Platform health status and major operations performed • Payload operation status • Communications link sessions and data uplinked/downlinked • Major/minor in-orbit anomalies and associated cause • Recovery actions with respect to the anomalies (if any)
Non-Conformance Reports (NCRs)	To record non-conformances of the system product with respect to requirements in terms of nature, root cause, and corrective actions.	As per ECSS-Q-ST-10-09C, Annex C.
Request For Deviations (RFDs)	Request departures from an approved configuration baseline	As per ECSS-M-ST-40C Annex I
Request For Waivers (RFWs)	Request waivers for established requirements.	As per ECSS-M-ST-40C Annex J
Post-flight Analysis Report	To summarise the main results of the mission based on the data acquired, and describe the lessons learned	The document shall include: • Overview of the actual mission as performed, including the payload operations and any interruption in the mission due to in-orbit anomalies/failures (if any) • Overview of the operations data post-processing • Post-processed results of the mission operational data (including any failure analysis if failures occurred) • Outcome and achievements of the in-orbit demonstration mission with respect to the mission objectives • Lessons learned from the mission operations for: o application of the demonstrated technology to future missions o future missions using CubeSat platforms