estec

European Space Research
and Technology Centre
Keplerlaan 1
2201 AZ Noordwijk
The Netherlands
T +31 (0)71 565 6565
F +31 (0)71 565 6040
www.esa.int

DOCUMENT

System Margin Policy for ESA IOD CubeSat Projects

Prepared by	**Roger Walker**
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1 INTRODUCTION

1.1 Purpose

This document specifies the system margin policy applicable to ESA In-Orbit Demonstration (IOD) CubeSat projects during the design and development phases.

1.2 Project Classification

CubeSats are defined here as nano-satellites whose designs are compliant with the CubeSat Design Specification [AD1] and are multiples of a single CubeSat unit (10x10x10 cm, <1.33 kg) ranging from 2 units up to 6 units.

CubeSat projects for In-Orbit Demonstration (IOD) purposes in Low Earth Orbit are generally characterized by the following attributes:

- Complete stand-alone systems including platform, payload, ground segment & operations
- Higher risk acceptance profile
- Low level of complexity (relative to other ESA space projects)
- Low cost and short schedule (typically <1 MEuro and <2 years to flight readiness)
- Short operational lifetime (typically <1 year in low altitude LEO)
- Acceptance of single point failures
- Limited redundancy (where possible within the constraints)
- Limited fault tolerance (where possible within the constraints)
- Robust safe mode (thermal and power safe in any attitude)
- Extensive use of commercial off-the-shelf elements (modules that have previous flight heritage and are supplied by small industrial suppliers at a fixed price)
- Extensive testing focussed on system level (functionality and environmental qualification/acceptance)
- Simple project organisation with well integrated teams (single entity for system engineering, AIV and operations, very few suppliers or subcontractors)

Despite possessing the above characteristics, core ESA System Engineering practices and principles are still fully applicable. An important aspect, apart from requirements specification and verification, is the establishment and control of engineering margins through the preliminary and detailed design phases of the project in order to ensure a system product with a robust design able to meet the relevant project requirements as the design process evolves.

1.3 Applicable Documents

[AD1] CubeSat Design Specification, revision 12, California Polytechnic, 1 August 2009.

2 DESCRIPTION OF SYSTEM MARGIN POLICY

2.1 Performance Margins

The Contractor shall design the satellite and its subsystems with sufficient performance margins with respect to the relevant performance requirements.

2.2 Mass and Power Margins

In general for mass and power, the following margin philosophy shall be used:

System level margin:
20% at PDR

Design Maturity Margin for Equipment:
New developments or existing units requiring major modifications: 20%
Existing units requiring minor modifications: 10%
Existing units: 5%

The propellant calculation shall be based on the total dry mass at launch including all margins.

2% of propellant residuals shall be added to the propellant calculated.

2.3 Delta-V Margins

The following Delta-V margins (covering uncertainties in mission design and system performance) shall be applied to the Effective Delta-V manoeuvres:

- 5 % for accurately calculated manoeuvres (trajectory manoeuvres as well as detailed orbit maintenance manoeuvres)
- 100 % for general (not analytically derived) orbit maintenance manoeuvres, over the specified lifetime
- 100 % for the attitude control and angular momentum management manoeuvres

When manoeuvres budgets concern theoretical values, and do not take into account gravity losses (for instance: impulsive manoeuvres performed by chemical propulsion engines), such gravity losses shall be quantified and added to the specified Effective Delta-V.

In case of electric propulsion, a 5% Delta V margin shall be foreseen for navigation during the cruise phase, to compensate for trajectory inaccuracies.

2.4 Data processing margins

Any on-board memory (Random Access Memory RAM used for code and / or data) shall include a memory margin of at least 50 %.

Any on-board processor peak usage shall not exceed 50 % of its maximum processing capability.

2.5 Communications margins

Links (up-and down-link) budgets and associated margins, for all phases of the mission, shall be computed as defined in ECSS-E-ST-50-05C rev.1, including: nominal, adverse, favourable, mean – 3 sigma and worst RSS (Root Sum Square) cases.

Telecommand and telemetry data rates shall be satisfied with minimum margins as defined in ECSS-E-ST-50-05C rev.1, for all mission phases, under all cases specified in R-C-1.

2.6 Mechanical margins

Structural elements shall demonstrate positive margins of safety in accordance with ECSS-E-ST-32C Rev. 1.
Mechanisms shall demonstrate positive margins of safety for pre-load and actuation according to ECSS-E-ST-33-01C.

2.7 Thermal control margins

The different temperature ranges (calculated, predicted, design, acceptance, qualification) shall be in accordance with ECSS-E-ST-31C. A sensitivity analysis on the following parameters shall be carried out in order to assess the uncertainties of the design:

- Electrical dissipation
- Conductance of materials and Harness
- Multi-Layer Insulation (MLI) efficiency
- Contact Resistance
- Emissivities
- Interface Temperatures