# QB50

## CubeSat Preliminary Design Review Results

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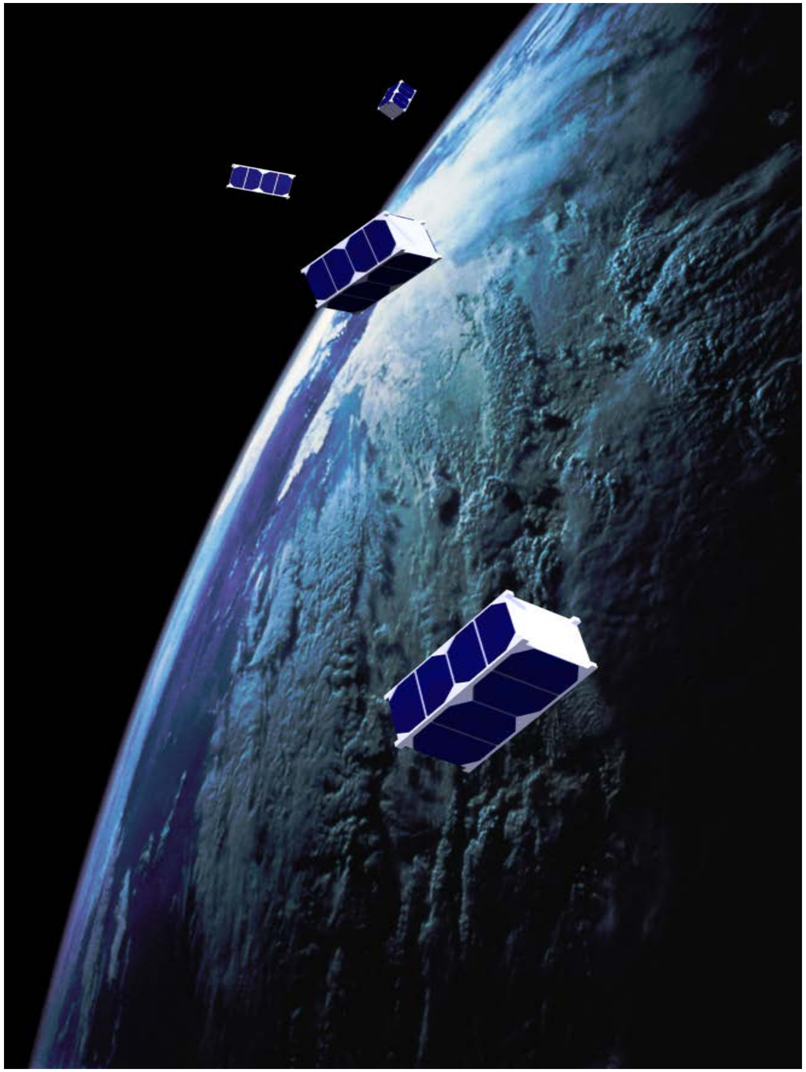
Lessons



**6th QB50 Workshop**
6 June 2013
von Karman Institute
Rhode-Saint-Genèse, Belgium

# PDR Procedures

PDR Procedure – is available on the QB50 website by 1 Feb 2013

- Each CubeSat team – responsible for their own PDR
- Independent reviewer – at least 1 external
- Summary of PDR sent to VKI – template provided
  - QB50 PDR Summary Report
  - Compliancy Table (an Excel file)

- VKI, ISIS and MSSL (5 reviewers) are now internally checking the submissions
- VKI contacts CubeSat teams re: non-compliancy report
- PDR evaluation informed to CubeSat teams – answers expected

**See Fiona Singarayar's presentation given at 5$^{th}$ QB50 WS,**

**available at www.QB50.eu**

# PDR Summary Report

## QB50 PDR Summary Report Template

| | | | | |
|---|---|---|---|---|
| 1 | CubeSat name / number | BEO5 QARMAN | | |
| 2 | Lead institute | von Karman Institute (VKI) | | |
| 3 | Contact person(s) | Cem Asma | asma@vki.ac.be | +32 2 888 9970 |
| | | Isil Sakraker | sakraker@vki.ac.be | +32 2 359 9423 |
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| | | Lamberto Dell'Elce | Lamberto.DellElce@ulg.ac.be | +32 4 366 9449 |
| | | Gaetan Kerschen | g.kerschen@ulg.ac.be | +32 4 366 4852 |
| 4 | Other institute(s) | University of Liege – for ADCS integration<br>Astrium SAS – for ablative TPS material and characterization<br>Centre Spatial de Liege – for Integration and Testing | | |
| 5 | CubeSat unit | 3U | | |
| 6 | Science payload | N/A | | |
| 7 | Other payload | Differential Drag Control<br>Thermal protection system (TPS)<br>Aerodynamic Stability and De-orbiting System (AeroSDS)<br>Aerothermodynamic Measurements | | |
| 8 | Ground station | Located at VKI (to be built) | | |
| 9 | Independent Reviewer | Gregory Pinaud (Gregory.Pinaud@astrium.eads.net)<br>Jasper Bouwmeester (Jasper.Bouwmeester@tudelft.nl) | | |

G. Pinaud
28/03/2013

J. Bouwmeester
28-03-2013

QARMAN PDR Summary Issue 1

- Title page
- Independent reviewer name, contact info and signature
- Overall design
- Own payload
- Sections for mass, power, data budgets
- **Reviewer's comments**

# PDR Compliancy Table

| Requirement Number | Requirement Text | Compliancy | Verification Method | Action / Intent | Date |
|---|---|---|---|---|---|
| **CubeSat System Requirements** | | | | | |
| **Structural Subsystem** | | | | | |
| QB50-SYS-1.1.1 | CubeSats dimensions shall be as shown in Table 1 | Compliant | Numerical model and Measurement of FM | Integration test into Test-POD | FRR |
| QB50-SYS-1.1.2 | In launch configuration the CubeSat shall fit entirely within the extended volume dimensions shown in Figure 1 for a 2U CubeSat or Figure 2 for a 3U CubeSat, including any protrusions. | Compliant | Numerical model and measurement of the FM | Integration test into Test-POD | FRR |
| QB50-SYS-1.1.3 | CubeSat mass shall be no greater than that shown in Table 2 . | Partially Compliant | Numerical model and scaling of FM | Measurement of FM. CubeSat merged with Ulg (current mass: 3.1kg incl. margin) | FRR |
| QB50-SYS-1.1.4 | The CubeSat centre of gravity shall be located within a sphere of 20 mm diameter, centred on the CubeSat geometric centre. | Compliant | Numerical model and scaling/measurement of FM | Measurement of FM | FRR |
| QB50-SYS-1.1.5 | Total Mass Loss (TML) shall be < 1.0% and Collected Volatile Condensable Material (CVCM) shall be < 0.1% [RD2]. | Compliant | Vacuum test of EM/FM and sub systems | Verify TML of the ablative TPS | Before CDR and FRR |
| QB50-SYS-1.1.6 | The CubeSat rails and standoffs, which contact the deployer rails, pusher plate, door, and/or adjacent CubeSat standoffs, shall be constructed of a material that cannot cold-weld to any adjacent materials. | Compliant | Use of standard CubeSat rail material | Check contact area between CS and Test-POD with EM/FM | CDR |
| **Attitude Determination and Control Subsystem (ADCS)** | | | | | |
| QB50-SYS-1.2.1 | The CubeSat shall be able to recover from tip-off rates of up to 10 degrees/second within 2 days (TBC before CDR). | Compliant | Simulation of detumbling | Perform simulation of 6DOF detumbling simulation | CDR |
| QB50-SYS-1.2.2 (*) | The CubeSats carrying the science sensors shall have an attitude control with pointing accuracy of ±10° and pointing knowledge of ±2° from its initial launch altitude at 350 km down to at least 200 km (TBC before CDR). | | N/A - no sciene unit | | |

- Compliant, partially compliant and non-complaint
- Verification method, action plan and date are important
- Relying on the internal reviewer’s check

# PDR Philosophy

## Create Awareness

***For the CubeSat teams:***

- What is expected from us?
- What are the challenges?
- Planning and risks
- What do the others do/think?

## Create Awareness

***For the QB50 Consortium:***

- Which CubeSat teams are on board?
- How realistic are the requirements?
- What are the new developments?
- Where are the risks at?
- Can the CubeSat teams make it?

## Augment Responsibility

- We are all on the same boat and we need to help each other
- It is indeed an ambitious and challenging mission
- What is the final product?

**Network of CubeSats, science, technology, international synergy, educational impact**

# PDR Results



Out of **79 potential CubeSat teams**

2 never submitted a proposal or PDR (Argentina, New Zealand)

5 withdrawn because of lack of funding (Austria, 2 Belgium, Czech, UK)

---------------------------------------------

**72 remaining**

2 Belgium IODs within QB50 but at higher orbits

**7 non active teams**

**65 active members**, although some delayed

**Thank you and Congratulations !!!**

# IODs and Science CSs

**These numbers are indicative and they will be frozen by end-June**

(info obtained from proposals, 4th QB50 WS minutes and PDR)

51 2-unit CubeSats

14 3-unit CubeSats

Preferred science sets:

| | |
|---|---|
| 23 Set I | INMS |
| 17 Set II | FIPEX |
| 11 Set III | mnLP |

# IODs and Science CSs

All 3U CubeSats are IOD CubeSats, irrespective of whether they fly one of the standard science sensor sets or not.

All 2U CubeSats without standard science sensors are IOD CubeSats.

There is one 2U CubeSats with standard science sensors which is proposed as IOD CubeSats. The category of this CubeSats could be questioned.

- *SamSat-QB50* from the Samara State Aerospace University in Russia, which will expand from a 2U-CS to a 3U-CS.

# Internal Review Status

An internal QB50 committee of members (from VKI, MSSL and ISIS) have been **checking the PDR results**.

- Summary report and the compliancy table
- Reviewer's signature and comments
- New developments
- Two reviewers per CubeSat team, at least one of them from VKI

We have been sending the **Review Item Discrepancy (RID)** reports to the CubeSat teams.

- Information sent is:

  Reference Requirement, RID Title, Discrepancy, Initiator Solution

- Information requested is:

  Contractor Answer, Action item

# Internal Review Status

| Reference Requirement | RID Title | Discrepancy | Initiator Solution |
|---|---|---|---|
| QB50-SYS-1.2.2 | Attitude knowledge requirement | The required attitude knowledge is +/2 degrees, not +/-5 degrees. This is required for the mNLP. | Please design the ADCS to meet the +/-2 degree pointing requirement. |
| Page 5 of PDR Summary report | mNLP mass | The mNLP mass as specified in the ICD is to be less than 600 grams. Not 180 grams as estimated in the mass budget. | Please take this into account when updating the mass budget of RioSat. |
| Page 5 of PDR Summary report | power margin | It is unclear how the power margin is calculated. | Please indicate or clarify how these were calculated.  It was imagined that the margin would be calculated using the following formula: (power generated - power consumed) / power generated * 100% |
| General | Verification Method | "Demonstration" is stated as the verification for certain requirements.  Does this mean demonstration on orbit? And if its demonstration on the ground - then what is the difference between demonstration and test? | Please be a bit more clear in the verification method. Specify the type of test / anlaysis that is to be carried out. |

# Remarks and Conclusions

**Mass requirement (2 kg for 2U, 3 kg for 3U)**

- This requirement is from Shtil launcher payload mass capability
- Can be increased depending on the new launcher
- Not a killer, we will try to remain flexible
- Miniaturization is an objective for the CS teams
- Ballistic coefficient variation is an advantage

**Margins, efficiencies and duty cycles**

- A lot of assumptions, are they realistic?
- Margins of new developments at PDR should be ~20%
- Power efficiency of 80% is a very popular number, reality check?
- 5% duty cycle on GPS, reality check?
- Be pessimistic and safe now

# Remarks and Conclusions

**New or in-house developed subsystems**

- COTS with flight heritage and/or high TRL is less of an issue
- Higher risk on these items, higher margins at PDR
- What is the plan for development, integration, risk mitigation?
- What is the TRL now, what will it be at the end, and how?
- http://en.wikipedia.org/wiki/Technology_readiness_level

**Technology Readiness Levels in the European Space Agency (ESA)**[4]

| Technology Readiness Level | Description |
|---|---|
| TRL 1. | Basic principles observed and reported |
| TRL 2. | Technology concept and/or application formulated |
| TRL 3. | Analytical & experimental critical function and/or characteristic proof-of-concept |
| TRL 4. | Component and/or breadboard validation in laboratory environment |
| TRL 5. | Component and/or breadboard validation in relevant environment |
| TRL 6. | System/subsystem model or prototype demonstration in a relevant environment (ground or space) |
| TRL 7. | System prototype demonstration in a space environment |
| TRL 8. | Actual system completed and "Flight qualified" through test and demonstration (ground or space) |
| TRL 9. | Actual system "Flight proven" through successful mission operations |

# Remarks and Conclusions

**YOUR Review Procedure**

- Number of independent reviewers (and their fields of expertise)
- Face-to-face meeting with reviewers?
- Did the reviewer question and challenge?
- Consider peer review as well

**Lessons Learned:**

- Requirements being revised
- Procedure being revised, CDR is indeed critical
- More reviewers, more review time
- Planning and risk mitigation
- QB50 CubeSat teams are reliable and responsible
- THANK YOU