

# PW-SAT2

## PRELIMINARY REQUIREMENTS REVIEW

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### *Cameras*

Phase A of PW-Sat2 project

1.1 EN

pw-sat.pl



**2014-05-21**

#### **Abstract**

The following paper is a part of Phase A Summary of student satellite project PW-Sat2. The document presents the assumptions and requirements of the camera observing the deorbitalational sail and contains an overview of proposed cameras.

The document is published as a part of:

PW-Sat2 – Preliminary Requirements Review



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## REVISIONS

Version	Date	Changes	Responsible
		Polish version of the document	Mateusz Sobiecki
1.0 EN	2014-05-21	English version of the document	Mateusz Sobiecki
1.0.1 EN	2014-07-02	Small editorial changes	Dominik Roszkowski
1.1 EN	2017-03-21	Disclaimer added – out of date doc	Dominik Roszkowski

**Attention** Phase A documentation may be outdated in many points. Please do not depend on Phase B or Phase A documents only. Current documentation is available on the project website [pw-sat.pl](http://pw-sat.pl)

This document is also available in Polish.

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# 1 INTRODUCTION

## 1.1 GOAL

CAM2 camera is a part of the experimental payload of PW-Sat2 satellite and is designed to observe the process of opening the deorbital sail. Recorded video and images after sending to ground station will allow the visual evaluation of the sail mechanism operation, which can be used to further development of this technology.

The camera will be mounted on the inner surface of the folding wall with solar cells. Due to small distance between the camera and sail surface there may be necessary to use a camera with a wide field of view or the use of additional optical system.

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## 2 REQUIREMENTS



### 2.1 REQUIREMENTS FOR CAMERA SELECTION

After a review of commercially available camera modules and cameras used on other CubeSat satellites, it was decided to restrict the choice to CMOS camera modules, similar to these used in mobile phones or notebooks. The selected type is able to meet the following requirements:

- Low weight – up to 40 g (weight of camera module is about 5-10 g; due to the required large field of view camera can be equipped with an optical system (being developed), whose weight is up to 10g; possible to obtain a total weight of less than 20g);
- Small dimensions – up to 20 x 20 x 20 mm (dimensions of the camera modules are in the range 8 x 8 x 5 mm; the estimated dimensions of the dedicated optical system 8 x 8 x 8 mm);
- Ability to work in space (vacuum tests are necessary);
- Temperature range – initially was estimated a wider temperature range in which cameras without supply can be stored – -40°C do +90°C (the operating temperature range given by the manufacturers is from -20/30°C to +70°C; required clarifying the assumptions by performing thermal analysis, in particular due to the placement of camera on the inner side of the folding wall with solar cells);
- Power supply – less than 5V (typical for all camera modules with CMOS sensor is 3.3V);
- Power – less than 1W (typical for all camera modules with CMOS sensor is about 0.5W);
- Resolution – about 0.3 Mpix (determined by the capabilities of data transfer to ground station and by the minimum acceptable resolution);
- Field of view – about 100°-130° (necessary to design the optical system giving the field of view increased from typical 70° in order to allow the observability of more sail area; a large image distortion is acceptable);
- Automatic white balance;
- Build-in image compression (for easy processing of the collected data and enabling to send images or video during a single communication session);
- I<sup>2</sup>C interface for camera control and an 8-bit parallel interface for on-board data transfer;

### 2.2 REQUIREMENTS OF OTHER SUBSYSTEMS AND LEVELS OF SUCCESS



The following requirements for the camera operation have been identified:

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- CAM2 camera requires proper activation of opening the solar panels (SADS);
- The supply system should provide sufficient power required for operating the camera;
- Operational memory must provide the ability to store at least 20 compressed images of size 200kB each and 10 compressed videos of size 1MB each (based on analyses of the compression of images and videos);

CAM2 levels of success:	
1	<ul style="list-style-type: none"> <li>▪ the camera run before opening the sail;</li> <li>▪ recording a video while opening the sail and taking a few photos of the subsequent behaviour of the sail in space;</li> <li>▪ send data back to Earth;</li> </ul>
2	<ul style="list-style-type: none"> <li>▪ in case of problems with transmitting large amount of data, limitation to transmit an image/images;</li> </ul>
3	<ul style="list-style-type: none"> <li>▪ in case of problems with transmitting an image, limitation to on-board computer comparison of images acquired before and after a hypothetical opening the sail;</li> <li>▪ data stored in telemetry transmitted to the ground station.</li> </ul>



Table 2-1 CAM2 levels of success


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### 3 CAMERAS OVERVIEW

Several cameras have been selected so far, meeting all the requirements:



Camera	Description	Prize	Picture
Sparkfun	available in shop Nettigo optical size 1/6" resolution: 640x480 up to 30 fps dimensions: 6x6x4.5mm interface I2C image format: YUV422, RGB565 weight: 1g field of view: 45°	41 zł	
Micron	available in shop Kamami optical size 1/6" resolution: 1600x1200 up to 30 fps power consumption: up to 245mW image format: BT601, RGB565/555/444, YCbCr422 field of view: 45°	47 zł	
Leopard Imaging LI-OV5640-MIPI-AF	availability: Mouser Electronics from Czech Republic with service and technical support in Poland optical size 1/4" resolution 5Mpix fps: from 15 to 120 field of view: 65° image format: RAW RGB, RGB565/555/444, YUV422/420, YCbCr422, build-in compression current consumption: up to 140mA dimensions: 7.4x7.4mm	64€	

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<p>Leopard Imaging LI-5M05CM-AF</p>	<p>availability: Mouser Electronics from Czech Republic with service and technical support in Poland optical size 1/4" resolution 5Mpix fps: from 15 to 120 field of view: 66° image format: RAW RGB, RGB565/555/444, YUV422/420, YCbCr422, I2C build-in compression current consumption: 550mW dimensions: 8.5x8.5x5.5mm</p>	<p>72€</p>	
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#### 4 SELECTION OF CAMERAS FOR TESTS AND FURTHER WORK

So far we have been bought two Sparkfun cameras because of their low prize. They are being integrated with dedicated electronics; strength tests in the vacuum chamber are planned. There are plans to buy a camera from Leopard Imaging.

Also work on the designing the optical system increasing the field of view has started.

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## 5 ESTIMATED COSTS

Camera modules	up to 1,5 tys. zł (possible to purchase up to 5 pieces);
Electronics	up to 1 tys. zł;
Lens making	up to 0,5 tys. zł;
Shipping costs	up to 0,5 tys. zł
<b>Total</b>	<b>about 3,5 tys. zł</b>

**Table 5-1 Estimated camera system costs**

In the case of first cameras passing the tests, possible is not exceeding the amount of 2500 zł.