STUDENTS' SPACE ASSOCIATION
THE FACULTY OF POWER AND AERONAUTICAL ENGINEERING
WARSAW UNIVERSITY OF TECHNOLOGY

PRELIMINARY DESIGN REVIEW

PROJECT OVERVIEW

Phase B of PW-Sat2 student satellite project

June 2015

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Changes

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Attention Phase B documentation may be outdated in many points. Please be aware of that and do not depend on Phase B or Phase A documents only. More recent documentation is available on project website.

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Abbreviated terms

ADCS – Attitude Determination and Control System

CAM - Cameras

COMM – Communication System

EPS – Electrical Power System

DT – Deployment Team

MA – Mission Analysis

OBC – On-board Computer

SunS – Sun Sensor

SKA – Students' Space Association (Studenckie Koło Astronautyczne)

TBD – To Be Defined

TCS – Thermal Control System

1 INTRODUCTION

This documentation is a summary of work performed during the Phase B of PW-Sat2 student satellite project. It is divided into the following parts:

Table 1-1 PW-Sat2 project documentation structure

	Phase 0**	**Phase A***	**Phase B****
Organization	PW-Sat2-0-00-MDR-Overview	PW-Sat2-A-00.00-PRR-Overview	PW-Sat2-B-00.00-PDR-Overview
Mission Analysis		PW-Sat2-A-00.01-PRR-MA	PW-Sat2-B-00.01-PDR-MA
Subsystems		PW-Sat2-A-01.00-PRR-ADCS	PW-Sat2-B-01.00-PDR-ADCS
		PW-Sat2-A-02.00-PRR-COMM	PW-Sat2-B-02.00-PDR-COMM
		PW-Sat2-A-03.00-PRR-EPS	PW-Sat2-B-03.00-PDR-EPS
		PW-Sat2-A-04.00-PRR-OBC	
		PW-Sat2-A-05.00-PRR-DT	PW-Sat2-B-05.00-PDR-DT
		PW-Sat2-A-06.00-PRR-SunS	PW-Sat2-B-06.00-PDR-SunS
		PW-Sat2-A-07.00-PRR-CAM	PW-Sat2-B-07.00-PDR-CAM
Thermal Control		PW-Sat2-A-09.00-PRR-TCS	PW-Sat2-B-09.00-PDR-TCS

* - Polish and English version ** - English version only

Both Phase A and Phase B documentation of PW-Sat2 project is available for everyone on project's website pw-sat.pl/en/documentation. If you have any remarks or you've found some error, please feel free to contact us via form on pw-sat.pl/en/contact-us/ or just write an e-mail to pwsat2@gmail.com.

Attention Phase B documentation may be outdated in many places. Please be aware of that and do not depend on Phase B or Phase A documents only. More recent documentation is available on project website.

2 PROJECT ORGANIZATION

The PW-Sat2 project had been launched in January 2013, about one year after the successful launch of the first Polish students satellite PW-Sat1. Detailed description of the project early phases can be found in the previous papers: Phase 0 Document and Phase A Project Overview.

This paper describes the changes and updates regarding the last documentation pack. During the phase B there were created a new team, established cooperation in the field of satellite components and parts manufacturing.

2.1 ORGANIZATION STRUCTURE

The organization structure had not been significantly changed since the phase A. The main project structure is presented in the diagram below (Figure 2-1).

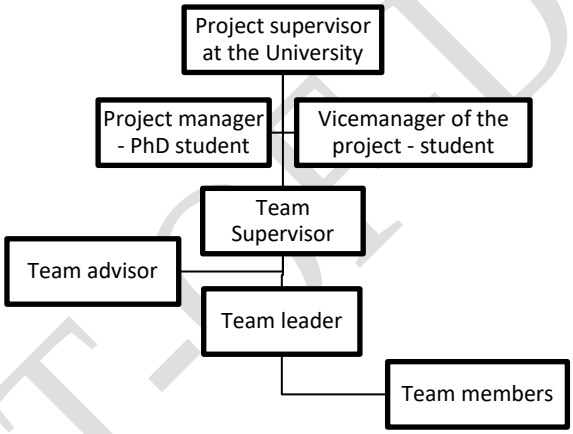

Figure 2-1 Scheme of the organization structure of the PW-Sat2 project

The main difference is that the project manager became a PhD student, which gives the project a certain stability factor. Every team has its team leader, a student who organizes the team meetings and reports to the project managers. Most of the teams also cooperate with the team supervisor and team advisor. The team supervisor is a person who works at the university, science center or company, and supports the team with his or her knowledge in the field related to the team's focus. It is important to have a person who can evaluate our work and judge it in a professional way. It is hard to find any one person who possesses detailed knowledge about all of the subjects connected with the satellite project; mechanics, electronics, software, thermal analysis etc. Taking this into account there were chosen three supervisors for the EPS, OBC and COMM teams, divided into software, hardware and radio communication profiles. It should be noted that the team advisor is a person who already finished his studies,

but doesn't necessarily have much experience as a supervisor. The advisor is a person with which the team members can contact directly in any case.

2.2 TEAMS AND MEMBERS

Currently, there are 11 teams and about 40 active members in the project. Some part of the members is participating in more than one team at the same time. Since the beginning of the project there has been a strong group of team leaders maintaining continuous work and gathering new members around idea of team work.

2.3 CURRENT STATUS

Since the current status is strongly connected with the previous work it is necessary to describe the mission details presented in phase A report.

PHASE 0

In the phase 0 the following payload had been defined, according to the highest priority:

1. Deorbitation system – square-shaped sail, nitinol as a deploying material.
2. Sun Sensor (SunS),
3. Solar Arrays Deployment System (SADS),
4. Cameras: CAM1 (Main camera, Earth's photographs) and CAM2 (backup camera, registration of the sail deployment).

Basic systems

5. On-Board Computer (OBC) – quasi redundant,
6. Electrical Power System (EPS) – redundant,
7. Thermal Control System (TCS) – passive,
8. Communication System (COMM) – omnidirectional basic, additional directional,
9. Attitude Determination and Control System – (ADCS) – active, magnetic.

PHASE A

During phase A the subsystems have been confirmed, with the following alterations to the initial designs:

1. Deorbitation system – we gave up on the attempt to use nitinol as the deploying material, due to the following reasons: too low reliability and lack of proper knowledge in nitinol behaviour in dynamically changing temperature. Ultimately it has been decided to use flat springs instead. The prototypes are promising and demonstrate high reliability of the system. A detailed description one may found in the Deployment Team PRR documentation, which may be found on our website.
2. Sun sensor – the main assumptions which were defined in phase 0 have not been significantly changed. The simplicity of the device as well as the fact that it is a previously defined design results in less

modifications needed during the continued development. The first prototype tests were made during phase A. A detailed description can be found in the SunS phase A documentation which is available on the project website.

3. Solar Arrays Deployment System – during phase A the system has been developed and refined from the initial design. The calculations of the springs have been made, and the deploying mechanism has been designed. The detailed description can be found in the DT phase A documentation which is available on the project website.
4. Cameras:
    a. CAM1 – after a detailed mission analysis it was decided to forfeit the camera planned for Earth pictures. Main reason of this decision is the fact that the camera has a low scientific value, therefore it cannot be defined as a relevant scientific payload. With regard to the pictures resolution, its transmission requires S-Band antennas, which cause a higher system complexity of the communication system, as well as a significant growth of the project costs.
    b. CAM2 – during the defining of the project success levels it was determined that the CAM2 camera is an integral element of the deorbit system. The camera will verify the correctness of the sail deployment. This camera is physically smaller than the proposed CAM1, and it was designed to capture pictures in low resolution, which will cause 5 times less system charge (the resolution is 3 times smaller than that of CAM1, and the number of bits per each pixel is also 3 times smaller) and will allow to send the pictures by use of the omnidirectional antennas of the UHF/VHF system. A detailed description can be found in the COMM phase A documentation is available on the project website.

Basic systems [summary included]

5. On-board Computer (OBC) - quasi redundant,
6. Electrical Power System (EPS) - redundant,
7. Thermal Control System (TCS) - passive,
8. Communication System (COMM) - omnidirectional,

    After the communication system requirements analysis, no need was found to use the communication system in S band. The use of camera CAM1 was closely related with the planning of a high data transfer communication system. Withdrawal from the idea of using CAM1 caused the resignation of the S-Band system.

9. Attitude Determination and Control System (ADCS) – active, magnetic.

PHASE B

During phase B the subsystems have been confirmed, with the following alterations to the initial designs:

1. Deorbitation system – we continue to use flat springs instead of nitinol. Most of the time we spend to check a various types of solutions for this system. A detailed description can be found in the DT phase B documentation, which is included with this document.
2. Sun sensor – most of the assumptions for this device had not been changed from the last phase. During the phase B there were proposed a few various geometrical configuration of the Sun Sensor. The decision of using a reference sun sensor on the satellite had been made. A detailed description can be found in the SunS phase B documentation which is included with this document.
3. Solar Arrays Deployment System – during phase A the system has been developed and refined from the initial design. No additional system solutions had been introduced during the phase B. The detailed description can be found in the DT phase B documentation which is included with this document.
4. Cameras:
    a. CAM1 – during the phase B we had decide to give up using of Camera 1. However one of the project partners showed its interest in using the space on the satellite to implement its our optical device. Creotech Instuments will test their star tracker camera on board PW-Sat2 satellite. The detailed description of the cooperation and technical aspects can be found in the phase B cameras documentation.
    b. CAM2 – the purpose of using camera 2 stayed the same from the phase A. The cooperation with Creotech Instruments results also on the development of the second camera device. The partner will deliver the camera for observation of the sail deployment moment. During the phase B the mounting concept had been also evaluated. A detailed description can be found in the CAM phase B documentation which is included with this document.

Basic systems [summary included]

1. On-board Computer (OBC) - quasi redundant,
2. Electrical Power System (EPS) - redundant,
3. Thermal Control System (TCS) - passive,
4. Communication System (COMM) - omnidirectional,
5. Attitude Determination and Control System (ADCS) - active, magnetic.

2.4 TEAMS SUPERVISORS

The establishments regarding the project supervising from the last phase report had not changed significantly. Most of the teams have supervisor from the university and additional support from the space companies and institutions. The detailed description can be found in the Table 5-1 in the Appendix.

At the beginning of the project we assumed that every team will have a supervisor and advisor. Time showed that not every team needs such person. Furthermore, some of the supervisors assigned to one team also support another. Due to newly established cooperation with Polish space sector's companies and other institutions there is no need to have a supervisor at the University.

Since the last report we have established the cooperation with university professors and company specialists who offered their support in reviewing the phase B technical documentation as well as continuous consultations.

3 PUBLIC AWARENESS AND PROMOTION

Last year may be considered as a successful in terms of promotion and enlargement of support for PW-Sat2 project. One of the major achievements is a creation of new visualizations and press kits. There have been two large recruitment campaigns carried out that allowed us to redistribute and advance the work in project and in the PR team as well. Moreover, the cooperation with few Polish companies became close and there are many promotional ideas being scheduled and designed at the moment.

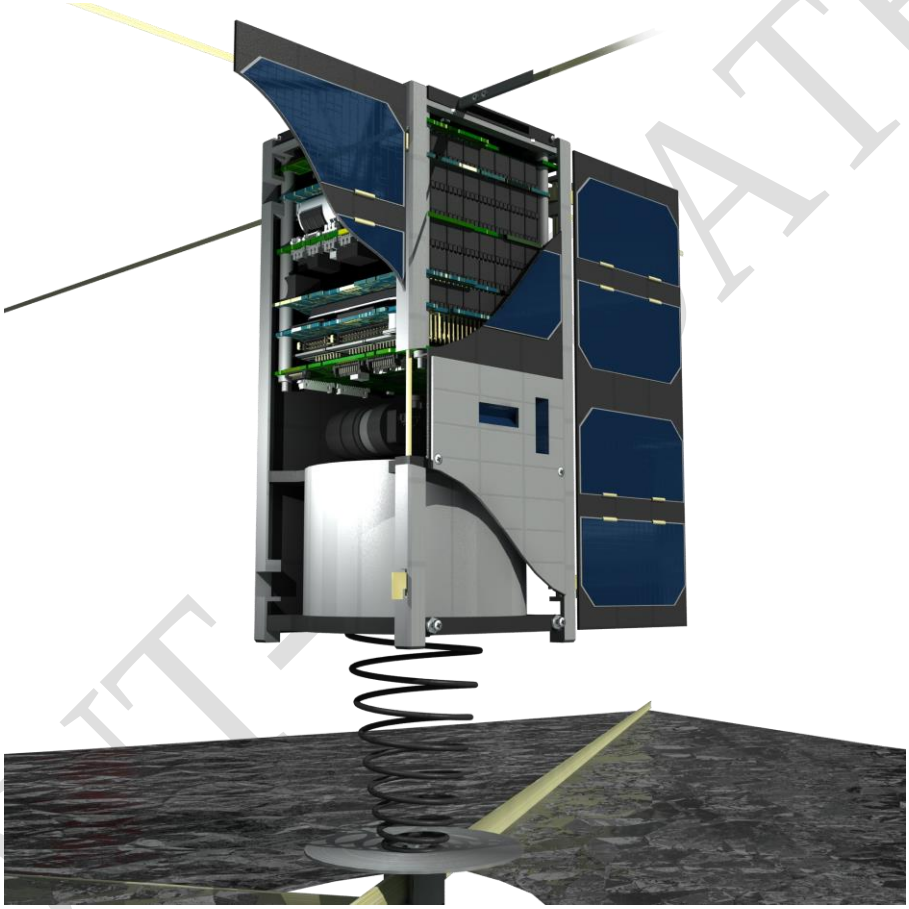

Figure 3-1 PW-Sat2 render made by Marcin Świetlik

Also, the website and Facebook profile popularity has increased significantly. More than 30% of last year's visits has its source out of Poland. It is clear that there should be a bilingual communication performed both on the website and social media channels.

One of the major plans for the next year is to make the promotion process more professional and coordinated. There is a need to increase the number of publicly active members and recognition of project's idea and Students'

Space Association position. Finally, one of the main goals for the next year is to find a sponsorship for the launch campaign. More on this topic may be found in the Mission Analysis part of this document.

4 COOPERATION WITH POLISH SPACE SECTOR

The phase B period from April to December 2014 was very successful in terms of establishing cooperation. Not saying only about the collaboration with Polish space sector that this chapter is dedicated to but also the cooperation with other universities' professors and students not only from Poland.

As it was mentioned in section 2.4 some of the companies took the role of team supervisors. The PW-Sat2 team offers three optional ways to support the project:

1. Substantive support – knowledge and experience exchange,
2. Providers support – providing the services and goods free of charge or with special discount,
3. Financial support – purely financial operations.

Among the options of support presented above the most popular is substantive support and the second is providers support.

Significant number of companies learned about the project during the special events and expositions for professionals, such as ESA Day at Copernicus Science Centre, Poland Luxembourg Business and Financial Forum, International Defense Industry Exhibition and many other events.

However, even when the companies showed their interest and wish for cooperation, such cooperation not always have been successfully established. The team tried to investigate the main reasons of failure in cooperation. Generally the reason was in communication problems. Most of the companies are not located in Warsaw, therefore it is hard to keep in touch or organize the meeting. Nevertheless, we hardly believe that this can be fixed in next phase.

The list of companies with their field of possible cooperation is presented in Table 4-1.

Table 4-1 List of companies of Polish space sector that show their interest in cooperation with PW-Sat2.

No	Company	Team	Kind of support	Status
1	Antmicro	OBC	software	Suspended
2	GMV	MA, ADCS	simulations	In progress
3	Sener	DT, TCS	experience sharing	In progress
4	LTT	SunS	rent a lamp for simulations	Suspended
5	Hertz Systems	COMM	experience sharing	Not run
6	Śląskie Centrum Naukowo - Technologiczne Przemysłu Lotniczego	DT	components manufacturing, carbon fiber	Not run
7	Radiotechnika Marketing	EPS	components providing	Not run
8	Dremel	DT	components providing	Not run
9	SSBV	SunS	components providing	Suspended
10	Creotech Instruments	OBC, CAM	components providing, services, experience	In progress
11	Rapid Crafting	DT, SunS	components providing, 3D printed elements	In progress
12	Omax	SunS	service for solar cells cutting	Finished
13	SoftwareMill	COMM, OBC	Software for Ground Station, software for OBC	In progress

The negotiations with one of the company brings us to closer cooperation. Creotech Instruments proposed to be a strategic partner of the project. While the preparing the agreement the main time frames and details of cooperation were agreed.

Creotech Instruments offered to deliver the On-Board Computer OBC and Cameras CAM1 and CAM2. Furthermore, the team members may have an access to laboratories and workshops for the project needs. The company also offered the possibility to undergo the internship for PW-Sat2 students.

Taking into account the fact that one of the subsystems which will be developed by the company is the one of the most critical satellite subsystem, fixed time frames must be given to avoid the delays for the whole project. The time frames are presented in Table 4-2.

Table 4-2 Time frames for components delivery for Creotech Instruments.

OBC	
December 2014	first prototype
April 2015	final version of the prototype
August 2015	flight model
Cameras CAM1 and CAM2	
January 2015	first prototype
May	final version of the prototype
August 2015	flight model

So far the deadlines were met. Nevertheless the contingency plan is required. For the OBC subsystem the optional solution is to buy the board from ISIS company, if the main partner will not fit one of the deadlines. In case of cameras, the requirements are not critical, since this is only tertiary payload. The CAM2 element is needed for sail deployment moment recording and can be treated as one of the sail sub elements. The CAM1 is an optional payload which was under the question to use and was set aside in phase A due to its complexity and time consumption regarding to main satellite purpose.

The companies interested in cooperation with the project can be divided into three groups:

1. Already existing international company active in space field, which open their department in Poland,
2. Polish companies active in non-space field, which would like to start some activities related with space,
3. Polish companies active in non-space field, providing their services for the project.

For the companies from the first kind (Sener, GMV) take benefit of cooperation in future human resources. The companies from the third kind (LTT, Omar) take benefit of cooperation in promotion their brand or support the education community. The last but the most important for the project are the companies from the second type (Antmicro, Creotech Instruments). Those companies take benefit from cooperation in the chance of test their solutions on the satellite.

Every cooperation must bring benefits to both sides. Therefore we do not neglect the benefits provided from our side. For the most of the companies this kind of cooperation is very valuable. During the next phase we are planning to strengthen our cooperation with the current partners and find new partners in order to solve the problem of launching the satellite.

5 APPENDIX A: TEAM'S SUPERVISORS

Table 5-1 List of teams' supervisors (2015)

Team	Description	Team Leader	PW Supervisor	CBK Supervisor	CAMK Supervisor	Other
ADCS	Attitude Determination and Control System	Paweł Jaworski (MEiL)	dr inż. M. Zasuwa (Zakład Automatyki i Osprzętu Lotniczego, MEiL)	mgr inż. Grzegorz Juchnikowski (Laboratorium Konstrukcji Elektronicznych)		Arthur Overlack (ISIS)
CAM	Cameras	Mateusz Sobiecki (MECH)				Creotech Instruments
COMM&GS	Communication & Ground Station	Patryk Oleniuk (EiTI) Kamil Sażyński (EiTI)	dr inż. Krzysztof Kurek (Instytut Radioelektroniki, EiTI)	dr inż. Marcin Stolarski (Laboratorium Satelitarnych Aplikacji Układów FPGA)	GS – mgr. inż. Grzegorz Woźniak (CAMK)	mgr inż. Tomasz Rybarski
CONF	Configuration	Paweł Brunne (MEiL)				
DT	Deployment Structures	Ewelina Ryszawa (MEiL)	dr inż. Zbigniew Kusznierewicz (Instytut Mikromechaniki i Fotoniki, Mechatronika)			Sener
			prof. dr hab. inż. Włodzimierz Kurnik (Zakład Mechaniki, SiMR PW)			Creotech

EPS	Electrical Power System	Piotr Kuligowski (EiTI)	dr inż. Mariusz Suchenek (Instytut Systemów Elektronicznych, EiTI) dr inż. Stanisław M. Pietruszko (Instytut Mikroelektroniki i Optoelektroniki, EiTI)			Ant Micro
MA	Mission Analysis	Artur Łukasik (MEiL)			mgr. inż. Elżbieta Zocłońska (CAMK)	GMV
OBC	On-Board Computer	Piotr Kuligowski (EiTI)	dr inż. Mariusz Suchenek (Instytut Systemów Elektronicznych, EiTI)			Creotech Instruments, Ant Micro
PR	Public Relations/ promotion team	Dominik Roszkowski (MEiL)				
SunS	Sun Sensor	Mateusz Sobiecki (MECH)	dr inż. Stanisław M. Pietruszko (Instytut Mikroelektroniki i Optoelektroniki, EiTI)	dr inż. Mirosław Rataj (Laboratorium Fotoniki i Mikromechaniki)		
TCS	Thermal Control System	Alan Budzyński (MEiL)				mgr inż. Michał Szwajewski (Sener)