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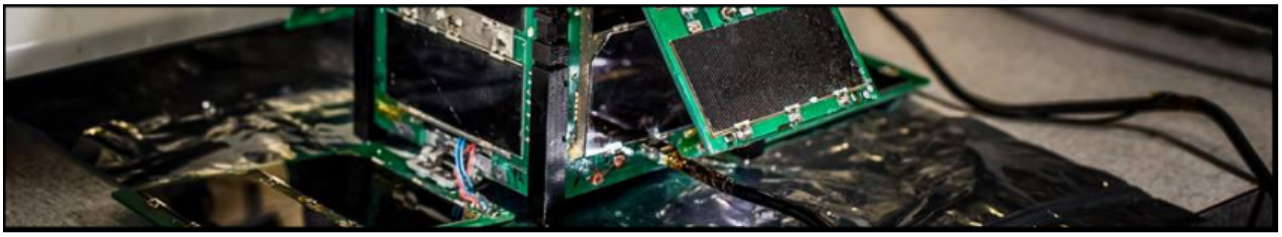

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Part I

introduction

0.1 Purpose

The purpose of this document is to write the specification and software requirement for the on board computer of Arogat-1 cubesat. It provide answer to developer to know what should the system do and not do.

0.2 Acronyms

ADCS	Attitude Determination and Control System
CCSDC	Consultative Committee for Space Data Systems
CFDP	CCSDS File Delivery Protocol
COM	Communication
EPS	Electrical Power Supply
OBC	On Board Computer
TCP	Transmission Control Protocol

0.3 Reference

[1] CFDP CCSDS report: https://public.ccsds.org/Pubs/727x0b4.pdf

[2] TCP summary: https://www.ietf.org/rfc/rfc1594.txt

[3] IP over CCSDS CCSDS report: https://public.ccsds.org/Pubs/702x1b1c1.pdf

[4] Encapsulation Service CCSDS report: https://public.ccsds.org/Pubs/133x1b2c2.pdf

[5] TM CCSDS report: https://public.ccsds.org/Pubs/130x1g2.pdf

[6] TC CCSDS report: https://public.ccsds.org/Pubs/230x1g2e1.pdf

[7] Specification of AX.25 Protocol: https://www.tapr.org/pdf/AX25.2.2.pdf

[8] Specification from: Preliminary Requirements Review ARAGOSAT-1 (AR-050118-001)

[9] Interfaces-Commands compared with Documentation of AAU-Cubesat On Board Computer Software: http://www.space.aau.dk/cubesat/dokumenter/software.pdf

[10] Specification can be compared with QB50 System Requirements and Recommendations, Issue 6: https://www.qb50.eu/index.php/tech-docs/category/QB50_system_requirements_issue_606e0.pdf?download=58:qb50-docs

Nomenclature:

ADCS	Attitude Determination and Control System
CCSDC	Consultative Committee for Space Data Systems
CFDP	CCSDS File Delivery Protocol
COM	Communication
EPS	Electrical Power Supply
OBC	On Board Computer
TCP	Transmission Control Protocol

Part II

Modules

0.4 OBC

The OBC (On-Board Computer) is the brain of the cubesat. His role is to coordinate all of the other modules and the ground, and also take care of the potential errors and threats for the cubesat. It will periodically (The time interval will depend on the type of data and must be determined individually) send commands to the different critical modules to order them to send critical data (like battery charge for the EPS or spatial orientation for the ADCS). It is absolutely vital for the success of the mission. OBC module shall respect the following requirement:

OBC 1.1 OBC shall collect all Housekeeping data periodically for the entire duration of the mission. Those Data are: Time, the mode, position in space, battery bus voltage, entry voltage of every module, exit voltage from solar panels, engine temperature, engine actual thrust.

The period will be determined in the testing process depending on our memory and how many Data can we collect until a downlink.

OBC 1.2 This Data shall be stored in memory until a successful downlink send them to ground.

OBC 1.3 OBC shall be protected against infinite loop or other kind of Freeze

For that we will use Watchdog that are timer that send periodically a ping to the OBC. If the OBC do not respond in time it will be restart. For this we will use real time to be sure that the OBC respect the deadline from the Watchdog except in case of infinite loop or another freeze.

OBC 1.4 OBC shall not override hardware inhibits like deployment switch, remove before flight. [8]

OBC 1.5 The CubeSat shall allow re-programming of the on-board software during processing on ground and during in-orbit operation. [8]

OBC 1.6 The CubeSat shall allow changing the software configuration in-orbit, through the use of modifiable parameters (software parametrization). [8]

0.5 EPS

The EPS manages the electricity on board. It's stand alone, it works without the OBC, but the OBC can discuss with it throw different command command.
The OBC can read its stats (for example battery charge) and react accordingly. For that the OBC must send periodically a command through a bus (surely an I^2C bus or similar bus) and the EPS sends the data back.EPS module shall respect the following requirement:

EPS 2.1 The EPS shall be able to provide the voltage necessity of all subsystem in all modes.

EPS 2.2 The EPS shall be powered off until the deployment of the cubesat.

EPS 2.3 ARG1 electrical system design shall not permit the ground charging circuit to energise the satellite systems (load), including flight computer. [8]

0.6 ADCS

The ADCS is the module which controls the position of the satellite in space (attitude) and also analyses the environment to determine its position in space.
It is very important for our mission because of our payload, we must control the direction of our engine to control our trajectory.ADCS module shall respect the following requirement:

ADCS 4.1 Position Data shall be determined and translate between the OBC and the ADCS.

ADCS 4.2 ARG1 shall be able to recover from tumbling rates of up to 90 deg/s per axis by stabilising the satellite attitude before initiating nominal operations. [8]

0.7 COM

The COM is the module which allows the communication between the ground and the cubesat. The COM is the link between the ground and the cubesat, so all telecommands and data recovery will go through this module. All data will go through 10 protocoles layer (5 for the ground station and 5 for the cubesat). In terms of data rate, the maximum of our antenna is about 9600bits/s (ref ?).

COM 6.1 The transceiver shall be able to use a secured transmission protocol using Forward Error Correction. [8]

COM 6.2 The transceiver shall have a sensibility high enough to receive the GB signal. [8]

COM 6.3 The antenna shall be able to transmit without a significant power loss in the worst orientation related the ground station. [8]

COM 6.4 OBC shall try to deploy the antenna periodically until OBC receive the StopAntennaDeployment command from the ground.

Layer	Protocol	Sources
Application Layer	CFDP	[1]
Transport Layer	TCP	[2]
Network Layer	Encapsulation Service → IP over CCSDS	[4] / [3]
Data Link Layer	TC / TM (Depending on the direction)	[6] / [5]
Physical Layer	AX.25	[7]

Figure 1: Table of the different protocols layers between the ground and the COM

0.8 Engine

The Engine is the payload of our cubesat. His goal is to fight the atmospheric drag to allow the cubesat to have a better life span.

Engine 7.1 ARG1 Propulsion systems shall have a minimum of three inhibits to its activation.

Engine 7.2 ARG1 propulsion system shall remain inhibited until at least TBD minutes after separation.

0.9 Interfaces

In this part we will see different commands between each modules and the OBC to communicate. This command will surely circulate on I²C bus but it will depend on the commercial hardware that each team will choose.

Command	Direction	Response
GetStatusEPS	OBC→EPS	Request housekeeping Data from EPS (Voltage of the EPS, Voltage of the Solar Panel)
SystemReboot	OBC→EPS	Request a reboot to the EPS
ChangeModeEPS	OBC→EPS	Request the EPS to change the alimentation of modules to fit the new mode
AcknowledgeOBC_EPS	OBC→EPS	Tell the EPS that the OBC receive and understand the command sent
EPSstatus	EPS→OBC	Response of GetStatusEPS command with all the Data
ErrorShutDown	EPS→OBC	Tell the OBC that a subsystem has been shut down by hardware protection
BatterieLowLevel	EPS→OBC	Informs the OBC that the Batterie level are below the first threshold
BatterieCriticalLevel	EPS→OBC	Informs the OBC that Batterie are below the second threshold
BatterieQuickDischarge	EPS→OBC	Informs the OBC that Batterie is discharging at an alarming rate
AcknowledgeEPS_OBC	EPS→OBC	Tell the OBC that the EPS receive and understand the command sent

Figure 2: Interface between OBC and EPS

Values of the two thresholds shall be determined with the simulation.
For the command BatterieQuickDischarge we must be careful that EPS launch it not because of the current mode (For example a massive communication or the Engine at full thrust). Maybe only count unknown consumption.

Command	Direction	Response
GetStatusADCS	OBC→ADCS	Request housekeeping Data from EPS (Voltage, Position)
ChangeModeADCS	OBC→ADCS	Request the ADCS to change his behavior to fit the new mode
ChangeOrientation	OBC→ADCS	Request the ADCS to change the orientation of the spacecraft
TimeSynchronized	OBC→ADCS	Informs ACS that system time is valid
AcknowledgeOBC_ADCS	OBC→ADCS	Tell the ADCS that the OBC receive and understand the command sent
ADCSstatus	ADCS→OBC	Response of GetStatusADCS command with all the Data
AcknowledgeADCS_OBC	ADCS→OBC	Tell the OBC that the ADCS receive and understand the command sent

Figure 3: Interface between OBC and ADCS

Command	Direction	Response
GetStatusCOM	OBC→COM	Request housekeeping Data from COM (Voltage, Antenna Status)
ChangeModeCOM	OBC→COM	Request the COM to change his behavior to fit the new mode
SendData	OBC→COM	Instruct the COM to download a specific Data to ground
AcknowledgeOBC_COM	OBC→COM	Tell the COM that the OBC receive and understand the command sent
COMstatus	COM→OBC	Response of GetStatusCOM command with all the Data
GroundCommand	COM→OBC	Execute the command request by the ground
NewSoftware	COM→OBC	Reprogramming the software with the upgrade
StopAntennaDeployment	COM→OBC	Command from the ground that tell the OBC to stop trying to deploy the antenna
AcknowledgeCOM_OBC	COM→OBC	Tell the OBC that the COM receive and understand the command sent

Figure 4: Interface between OBC and COM

Command	Direction	Response
GetStatusEngine	OBC→Engine	Request housekeeping Data from the Engine (Voltage, Thrust, Heat)
GetScience	OBC→Engine	Request science Data from the Engine
ChangeModeEngine	OBC→Engine	Request the Engine to change his behavior to fit the new mode
SetThrust	OBC→Engine	Request the Engine to set his thrust to a other value
AcknowledgeOBC_Engine	OBC→Engine	Tell the Engine that the OBC receive and understand the command sent
EngineStatus	Engine→OBC	Response of GetStatusEngine command with all the Data
EngineScience	Engine→OBC	Response of GetScience command with all the Data
AlarmCaptor	Engine→OBC	Tell the OBC that one of the captors have an inadequate value (out of range) (Voltage,Heat)
AcknowledgeEngine_OBC	Engine→OBC	Tell the OBC that the Engine receive and understand the command sent

Figure 5: Interface between OBC and Engine

Part III

Modes

Part IV

Tests Specification

Part V

Other Specification