# Contents

# List of acronyms

| | |
|---|---|
| SSH | Secure Shell |
| JSON | Java Sytnax Object Notation |
| IP | Internet Protocol |
| SR | SatRevolution |
| PUT | Poznan University of Technology |
| RGS | CBSR Ground Station |
| CGS | Control Ground Station |
| SS | Space Segment |
| SP | Session Plan |
| RS | Retransmission Schedule |
| SI | Status Info |
| OBC | On-board Computer |
| CBTM | C-band Transmitter Module |
| TT | Telemetry, Tracking and Control |
| CBSR | C-Band Satellite Radio |

# 1. Mission Level Protocol

## 1.1. Main goals and assumptions

Mission level protocol describes the highest layer of cooperation of CBSR Ground Station[1] (RGS), Control Ground Station[2] (CGS) and the Satellite/Space Segment (SS) during the entire mission. In this context:

- RGS is responsible for receiving, demodulation and decoding of data packets sent over CBSR downlink as well as controlling CBSR system, which includes building session plans (SP) and retransmission schedules (RS); SPs and RSs are forwarded to the CGS using a terrestrial link
- CGS has the role of transmitting SPs and RSs as packets over TT&C uplink to the SS
- SS receives commands (SPs and RSs), sends status infos (SI) and data packets in the downlink.

Both, files containing SP and files containing RS, may be sent to the SS at any time, including periods of CBSR inactivity[3]. Therefore, they must be buffered before transmission in CGS and on reception in OBC. When the CBTM is activated by the OBC for the specific session, it reads the available information (SP and RS files) and performs the scheduled operations.

The information regarding the start and end time of the session should be copied from every SP to a spreadsheet (XLS format) and transmitted to the CGS together with SPs and RSs. This information will be used by the OBC scheduler to activate/disactivate the CBTM.

[1] Currently located in Poznań
[2] Currently located in Wrocław/Kyiv
[3] Due to the possible separation of RGS and CSG their visibility windows may not overlap.

# 2. Session Level Protocol

## 2.1. Main goals and assumptions

During the mission there are multiple visibility windows (i.e. transmission opportunities) where the CBSR sessions may happen. Before any visibility window starts, the OBC must activate the CBTM on SS by powering it and setting ENABLE signal. When activated the module reads the buffered files containing SP and RS for the current session. Using the information the module starts its scheduler which interprets and runs specific actions, based on time stamps defined in the SP.

SPs are read via UART interface from the OBC's storage directory, while RSs are read via ETH interface from the YYY directory. The SP/RS for the current session is deleted by the CBTM after copying to its internal buffer. RS are processed according to their order delivery, which is the same as sending order.

After planned time (session duration) CBTM stops activity and shuts down itself. The module closes all running processes and, when ready, informs the OBC which turns off the module.

RS files are analyzed in the same order as they were sent to OBC. This order is hidden in name of these files.

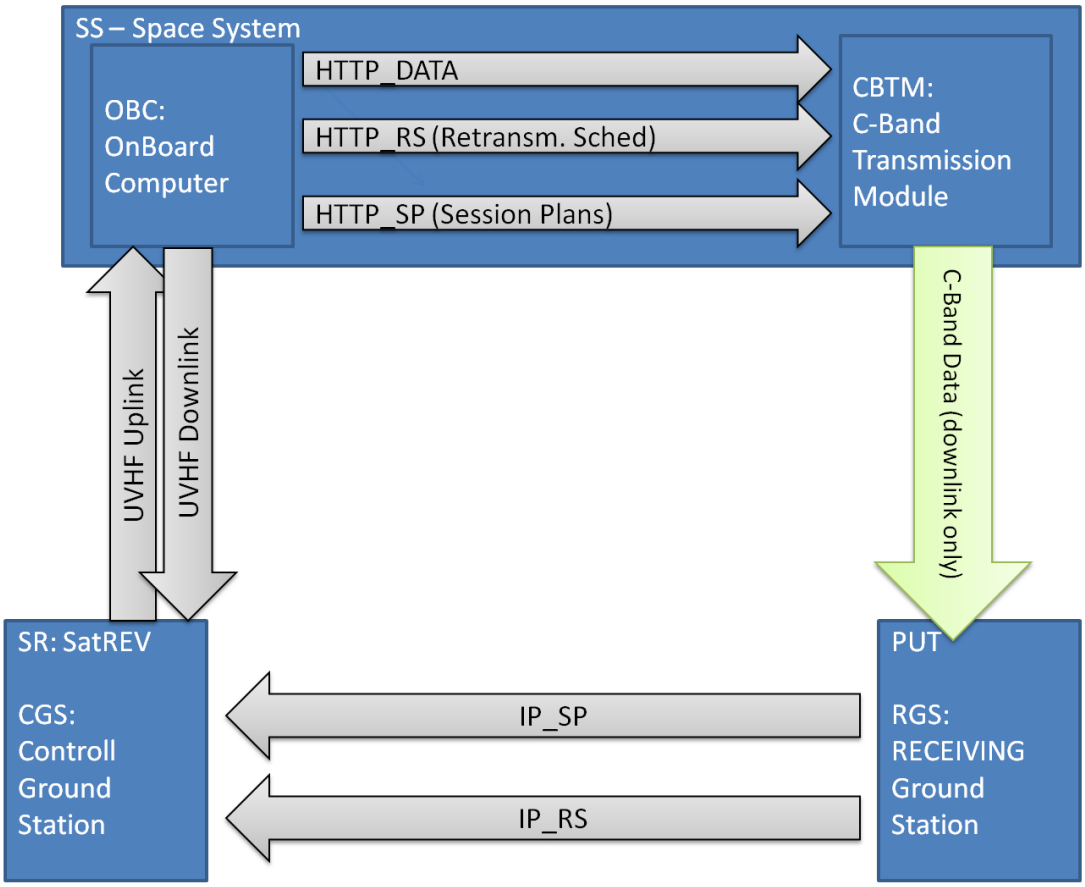
# 3. Link Level Protocol

## 3.1. Main goals and assumptions

This subsystem is dedicated for serving transmission of files from SS (Satellite Segment) to RGS (Receiving Ground Station). It is responsible for gathering data for transmission, dividing them into parts for radio transmission, recover primary files, retransmission if it is needed and control overall process.

Data files for transmission are divided into proper segments, after transferring whole file, successfully transferred file is deleted. To ensure correct transmission, confirmation and retransmissions of data segments are implemented. Data files are prepared by OBC and served to CBTM by UP_API interface.

The general idea and elements of the system are presented in the figure below.




Arrows represent interfaces between modules of the system. Only C-Band Data is unidirectional. The rest of them are bidirectional, but direction of arrows represent direction of information flow.

## 3.2. Interfaces of the system

1. C-Band Data – this interface is unidirectional. It allows to transmit data from CBTM to RGS.
2. UVHF_Uplink and UVHF_downlink interfaces are dedicated for telemetry and control information.
3. HTTP_DATA – this interface is dedicated to gathering data to transmission, it is implemented between OBC and CBTM with UP_API protocol described in another document.
4. HTTP_RS – this interface is dedicated to receive by CBTM from OBC information about confirmation or retransmissions. This interface is implemented by UP_API protocol.
5. IP_RS – this interface is implemented by XXX, it is dedicated to deliver to CGS RS files generated by RGS.

   Interfaces related with planning and mission control are omitted in this chapters.

## 3.3. Interfaces between vendors

There are three points of contact with PUT and SR/KPI modules. On these interfaces common functionalities should be implemented. These interfaces are dedicated for:

- HTTP_Data
- HTTP_RS
- IP_RS

The rest of interfaces is implemented by one vendor.

## 3.4. Elements of this system

This system works in spread space, one module is on satellite, second one is on earth. The module on the satellite consists of two modules – module from PUT and module from SR/KPI. Module on the earth also consists of two modules – analogically, one from SR/KPI (CBS), one from PUT (RGS). Moreover, modules on the earth can be separated geographically, to connect them logically, IP/Ethernet connection will be used. In this chapter, due to placement of communication protocol, description will focus on the satellite module from PUT and the earth module from PUT.

## 3.5. General rules of system

File data for transmission are gathered and managed by CBTM. For transmission they are divided into proper segments, numbered and sent via C-Band Downlink. There exist mechanism of confirmation properly transmitted parts. Not correct parts are retransmitted. Information about retransmission and state of each segment (or group of segments) are generated by RGS, transmitted to CGS and further to OBC via UVHF link, and from OBC downloaded to CBTM by HTTP_RS interface. After confirmation of full transmission of data file, it can be safely deleted on SS.

## 3.6. Actions on Satellite Module

3.6.1. Files are stored on CBTM from OBC by UP_API protocol They are stored in dedicated folder and wait for further processing. This folder will be noted in further description as directory_00. Size of this directory is not unlimited, files after successful transmission will be deleted by functionality implemented by module PUT.

3.6.2. Files for transmission are chosen by time/date. i.e. the oldest file will be transmitted earlier.

3.6.3. File chosen for transmission will be moved to directory with name directory_01. In this directory there will be at least one candidate for transmission.

3.6.4. To directory directory_01, if it will be necessary, some modules can add file (log file, urgent communications, results of requests) for immediate transmission to earth station.

3.6.5. File during transmission is stored in directory directory_02

3.6.6. During transmission, for each file its metric and table of state is prepared.

3.6.7. Metric contains name of file, its ID, size, number of parts for transmission and optional data. It is stored in semi JSON format. It will be transmitted to earth station as first element of file.

3.6.8. Table of state contains information about each part of file. It has information about sending or not yet, received confirmation or not yet.

3.6.9. Metric and table of state are stored in directory_05, on different partition that this one for files with data.

3.6.10. Urgent file will be transmitted immediately, transmission of data file will be stopped until urgent file will be transmitted.

3.6.11. After transmission of file it will be moved to directory with name directory_03.

3.6.12. During transmission confirmation of successful transmission can be received from OBC.

3.6.13. During transmission commands or requests can be received from ground station. They control transmission process.

3.6.14. When module receives signal to stop transmission, it will save actual state of table to file (including counters) and stop transmission.

3.6.15. After start (or restart) first module will try to recover unfinished transmission – its state is in file. If there is no such a transmission, new file will be transmitted.

## 3.7. Actions on Module on Module on Earth

3.7.1. RGS receives parts of data file. It knows ID of actual file. It has a state of transmission stored in table of state. Correctly received parts of file are stored in datatable, its confirmation are prepared, missing elements are identified.

3.7.2. If there is possible to send immediate request, such a request of retransmission of part with given id is sent to SS in RS files.

3.7.3. If whole file is transmitted, it is stored in final directory and command with request of deleting this file is sent to satellite.

3.7.4. It is also possible to prepare set of RS files basing on segments of data files received from SDR Receivers, such a file is analyzed and set of commands is prepared for future use, when transmission in uplink will be possible.

3.7.5. When uplink transmission is restored, commands from offline can be send to refill missing parts and finalize transmission by deleting file on satellite.

## 3.8. Framing and elements of protocol

3.8.1. Each file will be divided into small amount of data for transmission.
3.8.2. Each part has its own ID.
3.8.3. Each part has its representation in two tables.
3.8.4. Tables on earth and satellite do not have to be the same.
3.8.5. After successful receiving part with given ID, Information about successful its transmission is generated on earth and stored in table. Analysis of state of this table allows to make a decision about retransmission of particular parts or finalization transmission of whole file (when all parts are successfully received on earth).
3.8.6. Tables of state on satellite shows which part of file was transmitted. Confirmation of particular parts are not necessary.
3.8.7. All transmission process can be realized without active UVHF_uplink.
3.8.8. GCS generates commands and they are sent to satellite immediately in RS files.
3.8.9. It is possible that GCS obtains data received by third party nodes. These data are analyzed and table of state is prepared. Basing on analysis of this table, missing elements are identified, their retransmission is planned (as a set of commands) and after successful gathering whole file, file is treated as transmitted and commands for its deleting on satellite is prepared to sending it while uplink is active.
3.8.10. Frame contains ID of file, ID of part of file, which is also used as Frame ID.
3.8.11. First frame with given file ID contains its metrics
3.8.12. Frame IDs are continuous, even for different file.
3.8.13. Frame ID counter can be reset by proper command from earth.
3.8.14. Frame ID size can be increased during transmission – this decision can be made by satellite module if it is necessary.

## 3.9. Commands and requests

3.9.1. Only GCS can decide that part or whole file has been successfully transmitted. When this is identified, command for deleting this file on SS is sent to CBTM.
3.9.2. When GCS identifies missing part, request of its transmission is to be prepared.
3.9.3. It is also assumed that whole file can be dedicated for retransmission – in such a situation it will be moved to directory_00.
3.9.4. Commands and requests can be send immediately when UVHF_UPlink is active
3.9.5. Set of commands will be prepared basing on data collected from file form third party receivers. In this case, particular set of commands will be sent to satellite, when uplink will be restored.

## 3.10. Additional comments and important remarks

3.10.1. Additional functionality is built in the system. It allows to sent custom command for operating system on CBTM (i.e. “ls /home/user/transmission/direcotory_00 >> /home/user/directory_02.txt”) and result of this command will be stored in a file, which will be transmitted immediately from CBTM to RGS.