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SYNTHETIC APERTURE RADARS DATA FORMATTING BASED ON SPACE PACKET PROTOCOL

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For Earth remote sensing systems based on synthetic aperture radars it is important to ensure the reliability of information transfer from the platform carrier to the receiving point on Earth. In this paper an effective packetization algorithm according to Space Packet Protocol and Committee for Space Data Systems recommendations is presented. This algorithm implemented in MatLab software and all formed packets contribute to SPP requirements.

Currently, Earth remote sensing systems (RSS) based on synthetic aperture radars (SAR) are increasingly used. Such systems allow obtaining detailed area radar images with quality close to optical systems. The main advantage of remote sensing based on SAR is robustness to weather conditions and time of day. For these systems, it is important to ensure the reliability of information transfer from the SAR carrier to the receiving point on Earth.

To ensure the reliability of spacecraft SAR data reflected signal transmission and the necessary metadata to the receiver of such information, packet transmission is used. Based on the recommendations of the Consultative Committee for Space Data Systems (CCSDS [2]), the spacecraft SAR data package is based on SPP (Space Packet Protocol [1]). The packet generated according to the SPP, has to combine the data samples block where there are written radar image data and metadata. This packet is transmitted from a source to one or more terrestrial users. The content of the package data field entirely depends on application process and the specific characteristics of the spacecraft. The data sequence can be of variable or fixed length.

The source packet header must contain the application process identifier required to address the packet to the appropriate recipient and information about the packet length, packet sequence, and other characteristics. An optional secondary header should be provided for standardizing the transmission of time stamps and supporting data. The source package must consist of a 48-bit base header and a variable-length package data field. The minimum packet length is 7 bytes and the maximum length is 65,549 bytes.

In accordance with the requirements of SPP and CCSDS, an algorithm has been developed to form the spacecraft SAR package, which includes:

– packet primary header contains such fields as packet version number, packet type, secondary header flag, application process identifier, packet category, sequence flag, packet sequence count, and packet length. This fields are located in the first 6 octets.

– packet secondary header takes up 55 octets from 6 to 61 and includes the following fields: coarse and fine time, sync marker, data take ID, ECC number, test mode, Rx channel ID, instrument configuration ID, sub-commutated ancillary data word index, sub-commutated ancillary data word, space packet count, PRI count, error flag, BAQ mode, BAQ block length, range decimation, Rx gain, Tx ramp rate, Tx pulse start frequency, Tx pulse length, rank, pulse repetition interval (PRI), sampling window start time (SWST), sampling window length (SWL), SAS SSB message, polarisation, temp comp, elevation and azimuth beam addresses.

- data field includes calibration mode, Tx pulse number, signal type, swap, swath number and number of quads. This field is located in 62–67 octets. SAR data are written from 68 to 65549 octets.

A more detailed package structure description is presented in Table 1.

Raw data of RSA ERS-1[3] were used as initial data. In forming a packet process, the in-phase and quadrature samples of the reflected signal are ordered according to the SPP Protocol as follows: the in-phase part of a right sample, the in-phase part of a left sample, the quadrature part of a right sample, the quadrature part of a left sample.

The combining of the data of the reflected signal counts and metadata is performed in a cycle, the repetitions number is determined by the number of radiogram rows. The algorithm stage was modeled for one set of measurements, so the cycle was repeated 65 times. In order to unify and process more than one set of measurements, the software provides the necessary conditions for changing the coordinates of the position and speed of the platform.

Table 1. – SPP structure

Octet №	Bit 0	Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7
0	Packet version number			Packet type	Secondary header flag	Application process identifier □		
1	Application process identifier				Packet category			
2,3	Sequence flag		Packet sequence count					
4,5	Packet length							
6-9	Coarse time							
10-11	Fine time							
12-15	Sync marker							
16-19	Data take ID							
20	ECC number							
21	n/a	Test mode			Rx channel ID			
22-25	Instrument configuration ID							
26	Sub-commutated ancillary data word index							
27-28	Sub-commutated ancillary data word							
29-32	Space packet count							
33-26	PRI count							
37	Error flag	n/a		BAQ mode				
38	BAQ block length							
39	n/a							
40	Range decimation							
41	RX gain							
42-43	TX ramp rate							
44-45	Tx start frequency							
46-48	Tx pulse length							
49	n/a			Rank				
50-52	PRI							
53-55	SWST							
56-58	SWL							
If SSBFLAG = 0, then:								
59	SSBFLAG=0	Polarisation			Temp comp		n/a	
60	Elevation beam address				n/a		< --------------	
61	------------------------Azimuth beam address ------------------------ >							
If SSBFLAG = 0, then								
59	SSBFLAG=1	Polarisation			Temp comp		n/a	
60	SAS test	Cal type			n/a		< -------------	
61	------------------------Calibration beam address ------------------------ >							
62	Cal mode		n/a	Tx pulse number				
63	Signal type				n/a			Swap
64	Swath number							
65-66	Number of quads							
67	n/a							
68-65549	SAR data							

Further, the coordinate and velocity values are represented as a 32-bit array, followed by division into 2 arrays, each of which will further be an element of the metadata matrix. The formation of headers and metadata according to the structure of the package is showed in Listing 1.

Thus, data packaging modeling occurs in a cycle, the number of repetitions corresponds to the radar image rows number. The output product is implemented in MatLab is 65 packages of combined metadata and SAR RSS data.

Listing 1 – headers and metadata formation in accordance with the SPP structure

```
packetvers =[0 0 0];                 %packet version number
typ=[0];                  %packet type
sehead=[1];                          %secondary header flag
identapl=de2bi(65,7)                 %application process ID
categ= de2bi(12,4, 'left-msb')       %Packet category
sequencfl= [1 1];
countseqflag= de2bi(count,14);
lengthpack= de2bi(5616*8+(62*8),16);%packet length
time= Data_time;                     %fine time
sync=[0 0 1 1 0 1 0 1 0 0 1 0 1 1 1 0 1 1 1 1 1 0 0 0 0 1 0 1 0 0 1 1];Sync marker 352EF853 in HEX
datatakeID= de2bi(11527,32);                  %Data take iD
eccnumbr= de2bi(1,8);                %ECC number
testmode=[0 0 0];                    %Test mode
rxchannelID=de2bi(RXCHIDcode,4);     %Rx channel ID
instrumconfigID= de2bi(3,32);                 %Instrument configuration ID
subcommutwrdind= de2bi(count,8);     % Sub-commutated ancillary data word index
subcommutwrd= ADWIDX(j,:);           %Sub-commutated ancillary data word
countpack= de2bi(t,32);              %Space packet count
pricount= de2bi(tre,32);             %PRI count
errorflag=[0];                       %Error flag
baqmod= de2bi(12,5);                 %BAQ mode
baqblock= de2bi(128,8);              %BAQ block length
```

Using the *histogram* function, which displays the values in the vector or matrix as horizontal bars, a graph is constructed (Fig. 1) implemented in MatLab models for the formation of packages showing the value of the dimension field of the secondary and primary headlines.

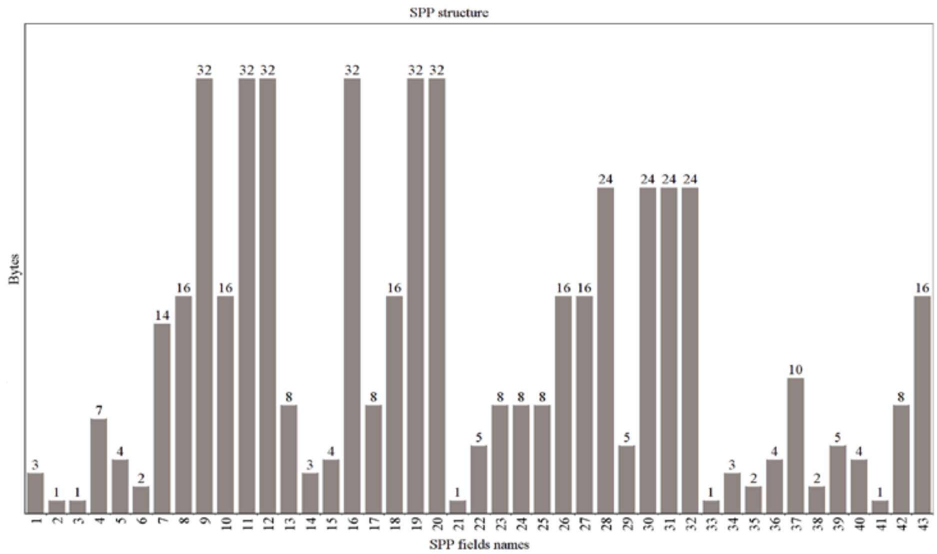

Fig.1. Metadata ordination according to SPP: 1 – Packet version number; 2 – Packet type; 3 – Secondary header flag; 4 – Application process identifier; 5 – Packet category; 6 – Sequence flag; 7 – Packet sequence count; 8 – Packet length; 9 – Coarse time; 10 – Fine time; 11 – Sync marker; 12 – Data take ID; 13 – ECC number; 14 – Test mode; 15 – Rx channel ID; 16 – Instrument configuration ID; 17 – Sub-commutated ancillary data word index; 18 – Sub-commutated ancillary data word; 19 – Space packet count; 20 – PRI count; 21 – Error flag; 22 – BAQ mode; 23 – BAQ block length; 24 – Range decimation; 25 – Rx gain; 26 – Tx ramp rate; 27 – Tx pulse start frequency; 28 – Tx pulse length; 29 – Rank; 30 –PRI; 31 – SWST; 32 – SWL; 33 – SAS SSB message; 34 – Polarisation; 35 – Temp comp; 36 – Elevation beam address; 37 – Azimuth beam addresses; 38 – Calibration mode; 39 – Tx pulse number, 40 – Signal type; 41 – Swap; 42 – Swath number; 43 – Number of quards

As can be seen from Fig.1, the names fields, and the duration of the reading values of the secondary and primary heads correspond to the SPP. It confirms that the packets were formed correctly according to SPP requirements.

REFERENCES

1. Sentinel-I SAR Space Packet Protocol Data Unit, S1-IF-ASD-PL-0007. – 2014. – Issue 12. – 85 p.
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