

## Playback Data Analysis Utility for a LEO Satellite

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**Abstract**— All telemetry data generated on a low earth orbit satellite are stored in a mass memory and downlinked to the ground together with the real time data during the contact time. The playback telemetry data are stored in the ground station as a playback raw data file, which includes all types of telemetry frames. The file should be analyzed if there is any error in telemetry format and frame sequences. And also, it needs to separate the file by each frame type, and combine or split the playback files by the size or by the time for the convenience of the post processing. The playback data analysis utility is developed to perform the above requirements. It can be used for analyzing the playback data file generated by the ground test equipment during the ground test phase, as well as the real playback data file received from the satellite. This paper shortly introduces the telemetry data storage and downlink operation in a low earth orbit satellite developed in Korea, and presents the playback data analysis utility program.

*Keywords-telemetry; downlink; playback.*

### I. INTRODUCTION

All telemetry frames generated on the satellite are stored in a mass memory of the On-Board Computer (OBC) [1]. The mass memory data structure is showed in Figure 1, and it is divided into blocks that are called pages. Each memory module has 2048 pages and a page consists of 128 Kbytes. Normally, one memory module is used and the other is ready for the backup. If required, both memory modules can be used at the same time [2]. The page structure is showed in Figure 2. A number of 585 Virtual Channel Data Unit (VCDU) frames are stored on each page. The telemetry frame format is derived from Consultative Committee for Space Data Systems (CCSDS) VCDU format [3].

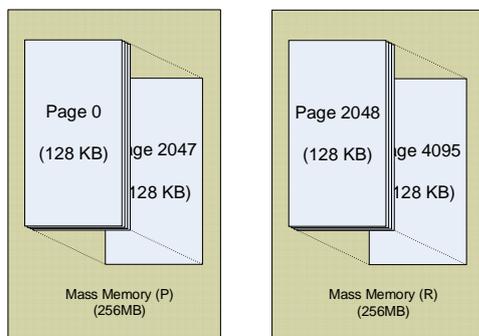


Figure 1. Mass memory structure for telemetry storage

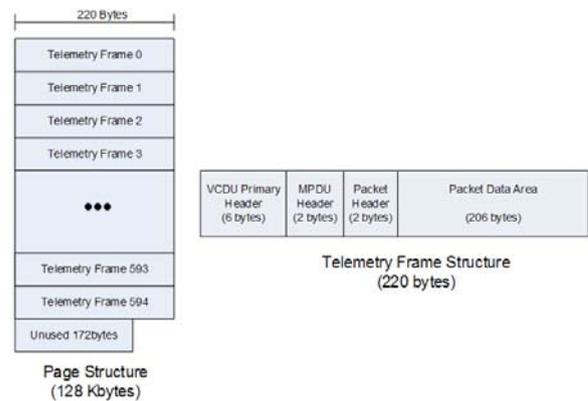


Figure 2. Page and frame structure

There are many telemetry types including several kinds of State of Health (SOH) frames, specified dump area frames, Precision Orbit Determination (POD) related frames, Precision Attitude Determination (PAD) related frames, and so on. Each telemetry frame has its own VCDU ID and sequence counter, and stored in the mass memory in chronological order without overwriting older data which has not yet been downlinked. The newly generated telemetry frames are stored on the memory location pointed out by the current write pointer.

There are two downlink rates: low downlink rate (4096bps) and high downlink rate (1.5626Mbps). Only real time telemetry frames can be downlinked to the ground in the low downlink rate. In the high downlink rate, there are two downlink modes: real-time mode and playback mode. Only real-time telemetry frames are downlinked in the real-time mode and real-time and playback telemetry frames stored in the mass memory are downlinked in the playback mode. 2 real-time frames in low downlink rate and 2 to 4 real-time frames in the high downlink rate can be downlinked to the ground every second. A total of 762 telemetry frames including 2 to 4 real time frames can be downlinked to the ground every second in the high downlink rate.

Playback operation is started by ground commands. Several types of the playback commands are used. Upon receipt of the playback command, telemetry frames are downlinked from the last playback pointer or specified start address designated by the command until the current write pointer or specified end address designated by command is reached. The downlink mode is automatically switched to the

real-time mode when the playback is completed. The playback telemetry data are stored in the ground station as a playback raw data file, which includes all types of telemetry frames. The file should be analyzed if there is any error in telemetry format and frame sequences. And the summary information (start/end time, the total number of frame, the number of each frame, and so on) of the telemetries included in the file need to be exposed. And also, it needs to separate the playback file into the individual frames, and combine or split the playback files by the size or by the time for the convenience of the post processing. The playback data analysis utility program is developed to perform the above requirements. It can be used for analyzing the playback data file generated by the ground test equipment during the ground test phase, as well as the real playback data file received from the satellite. Section II describes the utility program overview. Section III describes the utility program details. And conclusion closes the article.

## II. UTILITY PROGRAM OVERVIEW

The major functions of the playback data analysis utility program are as follows:

- Extracts each telemetry frame from the raw data file and check if there is any error in the telemetry frame format and individual frame sequences.
- Reports the file information including start/end time, the total number of frame, the number of each frame, and the error information
- Lists the total frame sequence and the individual frame sequences
- Stores the individual raw data frames in binary or text format
- Combines two playback files and splits a playback file into two playback files

The feature of the program is that it is possible to use easily on the other satellite programs by adjusting the several identification data fields dedicated to each satellite. And it can be used for analyzing the playback data file generated by the ground test equipment during the ground test phase, as well as the real playback data file received from the satellite. There are three types of telemetry data frame lengths in playback file stored in the ground station or the ground test equipment. The data structure of each frame length is described in Table 1. All types of frames can be used as the program input.

TABLE I. DATA STRUCTURE OF EACH FRAME SIZE

| Frame Length (byte) | Structure                                       |
|---------------------|---|
| 224                 | Sync Pattern(4)+VCDU(220)                       |
| 256                 | Sync Pattern(4)+VCDU(220)+Reed-Solomon Code(32) |
| 288                 | Frame Header(64)+VCDU(220)+R-S Code(32)         |

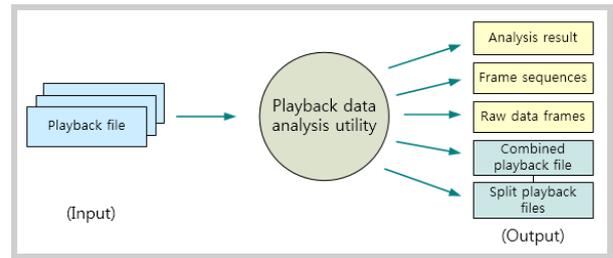


Figure 3. Input / output of the program

Figure 3 shows the input/output of the program. The outputs are the analysis result of the playback data file, frame sequences, individual raw data frames in binary or text format, combined playback file, and split playback files.

## III. PROGRAM DETAILS

### A. Playback data analysis

When the playback file to be analyzed is selected, the file type and frame size are checked in advance, and then each frame is checked if the header format coincides with the CCSDS telemetry frame format and each VCDU sequence counter is incremented orderly in accordance with each frame type. After extracting and checking all frames included in the file, it displays the check result including the start/end On-Board Time (OBT), the total number of frame, the number of each frame and error information. Total frame sequence and individual frame sequence can be stored as separated files. And individual raw data in binary or text format can be also stored as separated files. The storage of the frame sequences and raw data can be controlled by the user selection wholly or individually. Figure 4 shows the major control process of the playback data file analysis program. And Figure 5 shows the Graphical User Interface (GUI) of the program and an example of the analysis result of a selected playback file. Figure 6 shows an example of the frame sequences and raw data outputs derived from a playback data file.

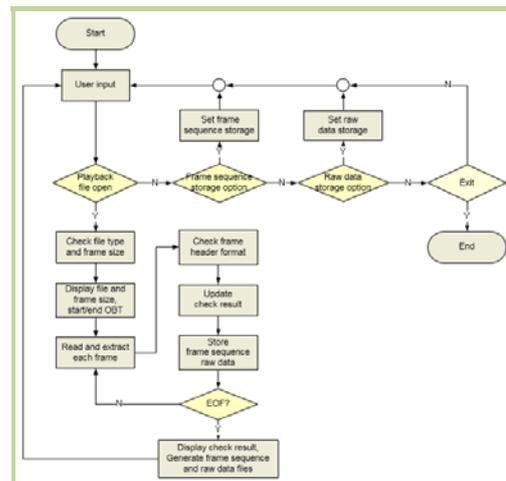


Figure 4 Major control process of the analysis program

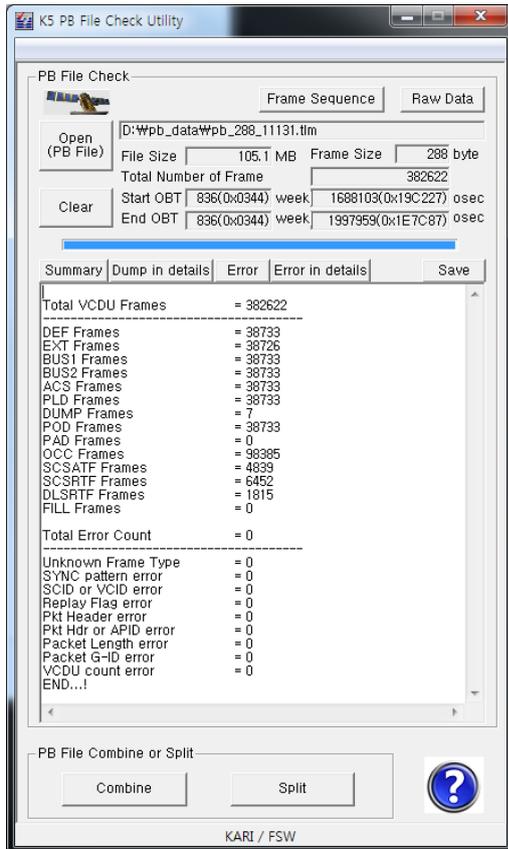


Figure 5. GUI of the playback file analyzer and an example

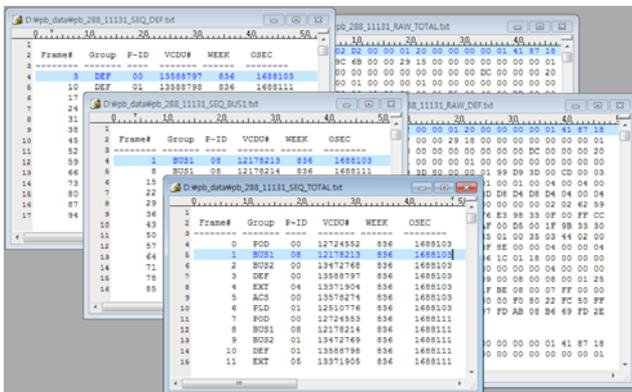


Figure 6 Example of the frame sequences and raw data outputs

**B. Playback Files Combine**

According to the file size or start/end time of the file, it can be required to combine two playback files. The playback file combine function is used to combine two separate files into a file. When two files for combining are selected, the format and frame size of two files are checked whether they consist of correct format and they are same frame size, and they are also checked the continuity or overlapping. If two files are not continuous in time sequence, the warning message is reported. If two files have overlapping frames,

the number of overlapping frames is calculated automatically and reported. According to the user selection, overlapping frames can be excluded when combined file is generated.

Figure 7 shows the GUI of the playback files combine program and a combining example with two playback files. The information of two playback files before combining and the combined playback file is summarized in Table 2. There are 19 overlapping frames in two playback files and they are excluded in combined file.

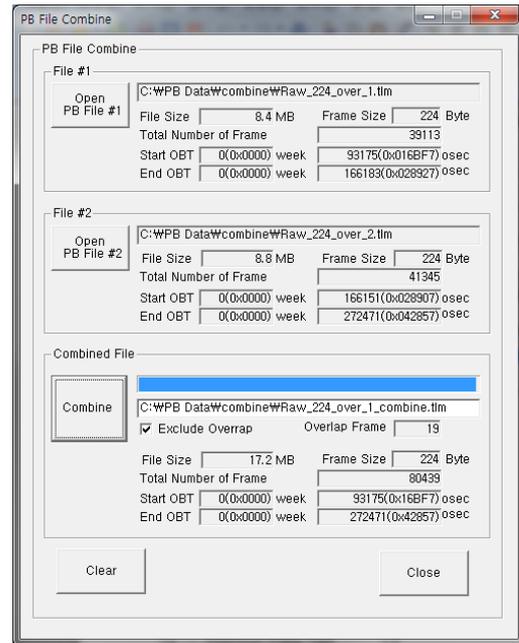


Figure 7. Playback files combine program and an example

TABLE II. PLAYBACK FILES COMBINE EXAMPLE

| Item       | File #1 | File #2 | Combined File |
|------------|---------|---------|---------------|
| File Size  | 8.4MB   | 8.8MB   | 17.2MB        |
| Frame #    | 39113   | 41345   | 80439         |
| Start Time | 93175   | 166151  | 93175         |
| End Time   | 166183  | 272471  | 272471        |

**C. Playback File Split**

According to the file size or start/end time of the file, it can be required to split a playback file. The playback file split function is used to split a file into two separate files. When a playback file for split is selected, basic information about the file such as file size, frame size, start/end time are displayed. And the information about two half sized files are displayed as default. The sizes of two files can be adjusted by Microsoft Foundation Class (MFC) slider control. And more exact file size can be set by writing the number of frame size of the first split file. The information of two files to be split is displayed continuously during adjusting the file size.

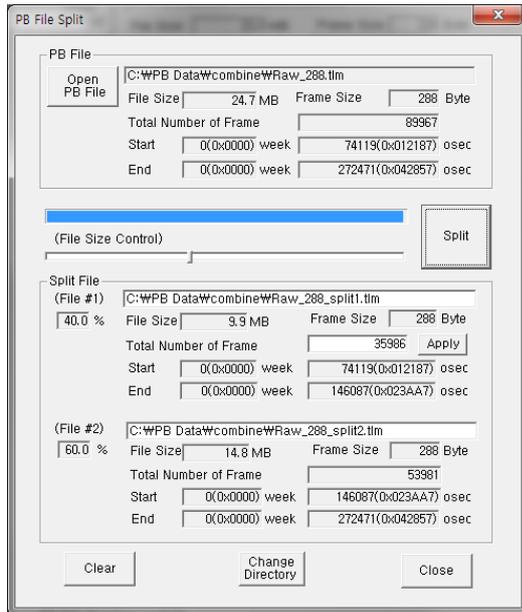


Figure 8. Playback file split program and an example

TABLE III. PLAYBACK FILE SPLIT EXAMPLE

| Item       | File   | Split File #1 | Split File #2 |
|------------|--------|---------------|---------------|
| File Size  | 24.7MB | 9.9MB         | 14.8MB        |
| Frame #    | 89967  | 35986         | 53981         |
| Start Time | 74119  | 74119         | 146087        |
| End Time   | 242471 | 146087        | 272471        |

Figure 8 shows the GUI of the playback file split program and a split example. The information of the original playback file and two split playback files after splitting is summarized in Table 3.

#### IV. CONCLUSION

In this paper, the telemetry data storage and downlink operation in a low earth orbit satellite developed in Korea is shortly introduced. And the playback data analysis utility program including playback files combine and split functions are presented. This utility program can be used for analyzing the playback data generated in satellite test phase, as well as the real playback data received from the satellite

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