Command Auto-Loader System for KOMPSAT-1

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Abstract: There is a world-wide trend to implement autonomous TM/TC system in satellite operations. KARI developed CALS(Command AutoLoader System) for KOMPSAT-1 operation automation in 2004. This paper provides system requirement, system design, system test and operational procedure. Through test with simulator and KOMPSAT-1, CALS was verified to meet all functional and operational requirement like scheduling, real-time telemetry check, CRC generation, command grouping. CALS is expected to be used in KOMPSAT-1 normal mission operation in end of 2004
Keywords: CALS, AUTOMATION, OPERATION, KOMPSAT-1.

1. Introduction

KOMPSAT-1, which was launched on 21 December 1999, has completed its planned mission life of 3 years and been continuing its normal mission operation until now(30 September 2004).

The TM/TC system for operating the KOMPSAT-1 is based on HP workstations using Unix O/S. As this system has been using since the launch of KOMPSAT-1, the necessity of developing new TM/TC system to replace the current system was raised. The current TM/TC system has potential problems like the deterioration with aging and maintenance difficulty from the dependent middleware.

Recently, KARI developed autonomous TM/TC system named CALS, based on PCs using Windows O/S as going with the recent trend[1][2]. CALS is designed to accomplish functions such as the automatic transmission of telecommands by scheduling, real-time telemetry check, CRC generation, command grouping, and so on.

In this paper, we present the functional system requirement, system design, operational procedure, and test result of CALS.

2. Functional Requirement

The function requirements demanding for developing CALS are as followings:

- Command object file format resolution
- Scheduled command regeneration(including grouping)
- Scheduled command presentation
- Scheduled command transmission
- Transmitted command verification(ground ACK check, command counter check, dump check)
- CRC generation
- Command transmission fail recovery
- Command progress(transmission and receipt)
- Log and presentation
- Telemetry receipt
- Telemetry storage
- Telemetry information fetch
- Telemetry information check
- Telemetry information check log
- Telemetry information log and presentation
- Fault management/tolerance
- Direct command transmission(direct input)

3. System Design

The functional module is composed of command manager, connection manger, fault manager, antenna manager, telemetry manager, command direct input submodule as shown in Fig 1.

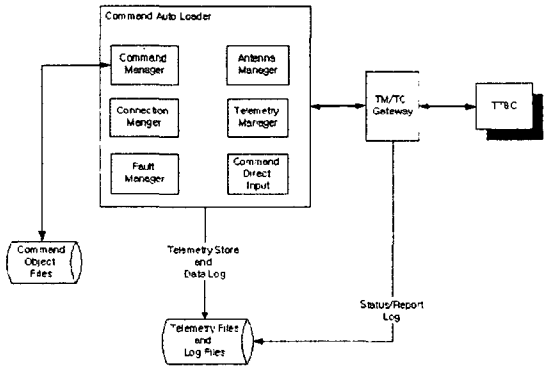

Fig 1. Software architecture of CALS.

Fig 2 shows the use case diagram which presents the functionality and activity of system from the point of view of an operator.

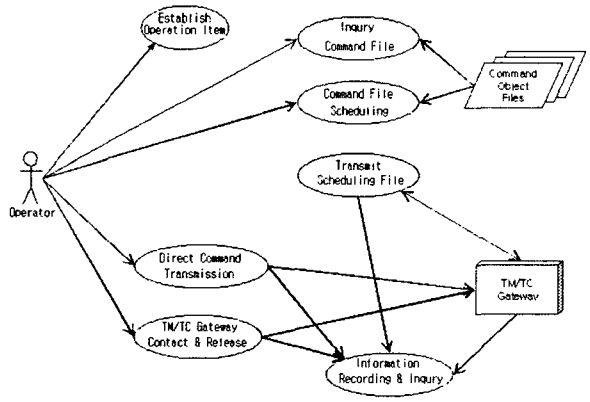

Fig 2. Use case diagram of CALS.

4. Operational Procedure

In CALS operation, the role of an operator is just to select the command object file which will be uploaded to the satellite and to register them in schedule manager of CALS. Once the schedule is set, CALS performs all procedures required in accordance with the operational procedure shown as Fig 3.

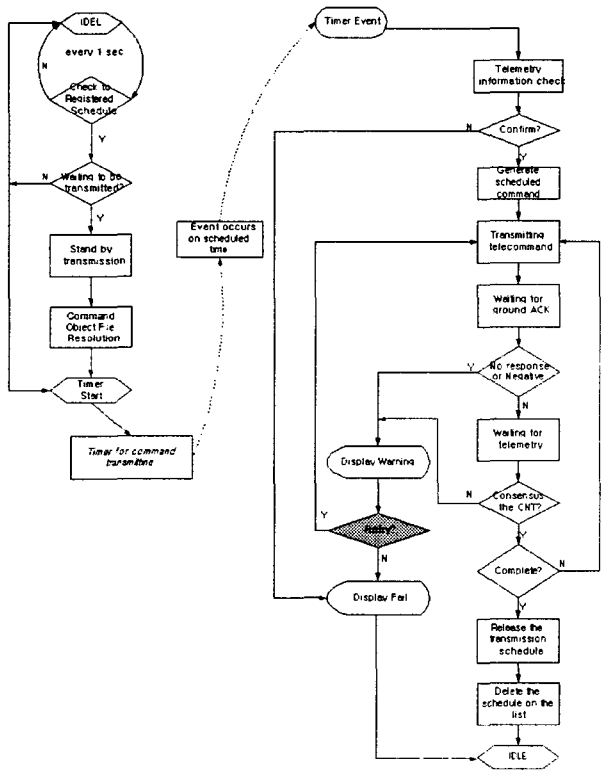

Fig 3. Operational Procedure of CALS.

1) Command object file resolution

The command object file is an aggregate composed of hexadecimal data. If the schedule is registered, CALS loads the command object file registered and interprets its contents which are presented in binary type. After that it shows the comprehensible command file like the right part of Fig 4. Fig 4 shows the main window of CALS.

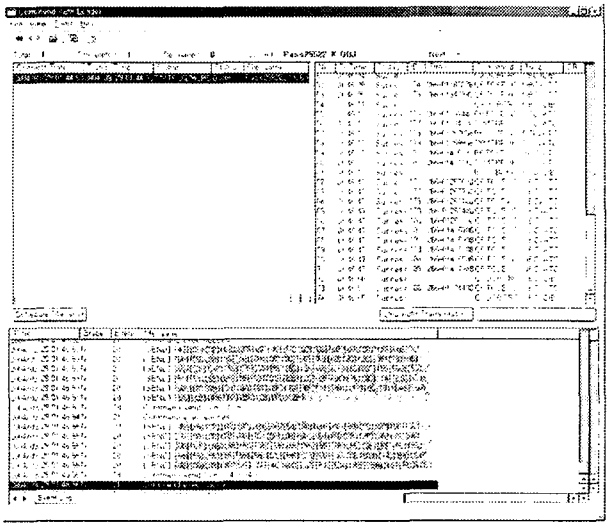

Fig 4. Main window of CALS.

2) Telemetry information check

When command transmission is ready according to registered schedule, CALS extracts following information needed as pre-requisite for transmitting commands from received telemetry before transmitting commands.

- Receiver lock status of satellite
- Command frame acceptance counter of OBC, RDU and ECU
- CIB(Command Input Buffer) transfer complete toggle information of OBC, RDU and ECU

CALS is in "standby" status during maximum 32 seconds to extract above information. If the information extraction is failed during 32 seconds due to telemetry receipt failure or the unsuccessful command link, CALS will enter "IDLE" status after sending the transmission failure message.

3) Scheduled command generation(including grouping)

Selected commands from the scheduled command objected file are reformatted in accordance to KARI ground internal transmission format by attaching headers and trailers. In this procedure, the grouping function is provided to raise the transmission efficiency.

4) Transmitted command verification

The verification of transmitted commands is optional function for an operator. When an operator registers a

schedule, the operator can select verification level from "ground ack only", "ground ack + command counter ack", and "ground ack + command counter ack + dump check". Under the normal operation, the use of command verification function is mandatory to check previous command status before transmitting next command.

- Ground ACK check

CALS waits for ground ACK signal from FEP or TM/TC Gateway after transmitting commands. If there is no response or Negative ACK is received within 5 seconds, CALS retransmits same commands once again. If same situation is occurred, CALS sends "Transmission Failure" message and next activity is canceled after this.

- Command acceptance counter check

CALS stores current values of the command accept counter of OBC, RDU, and ECU respectively into buffers before transmitting commands. It compares the incremented value of command acceptance counter with the number of transmitted commands and retransmit same command if values are not equal each other. If same situation is occurred, CALS sends "Transmission Failure" message and next activity is canceled after this.

- Dump check

CALS verifies RTCS(Relative-Timed Command Sequence) dump and memory dump. CALS stores the transmitted RTCS commands and memory load commands respectively into dedicated buffers to compare with dumped ones by ground commands. If values are not equal each other, CALS sends "Transmission Failure" message and next activity is canceled after this.

5) CRC generation

CALS provides the function of CRC generation and transmission. Because CIB transmission commands such as stored commands and memory load commands are calculated with CRC, CRC values are also transmitted with the corresponding commands.

6) Completion

After all scheduled commands were uploaded successfully, CALS closes the "standby" status and removes completed schedule in the schedule catalogue for next schedules accomplishments.

7) Other functions

- Direct command transmission

The interface is provided for real-time transmitting single commands when the operator desires.

- Log and presentation

Every event is presented in event log window and stored in log file.

- Telemetry store

Received telemetry is stored in the designated directory.

5. Test result

Test for functionalities and stability of CALS was performed by using a simulator before the real operation of KOMPSAT-1. Sufficient tests was essential because an error commands can result in severe danger for the satellite. For this, the test was performed more than 100 times.

Via the test, the amendment of software related bugs and improvement of functions were accomplished.

After the functionalities and stability of CALS were sufficiently verified with simulator tests, the real test with KOMPSAT-1 was performed. In the incipient stage, general functionalities and stability of CALS had been tested by using commands which affect little to the satellite such as "NOOP command".

After that, the actual test of normal mission operation was performed using KOMPSAT-1 for 2 months. Scheduled commands were transmitted total 104 times for two different down link modes, 81 and 23 times for high rate downlink mode and real time mode respectively, to perform various tests as shown in Table 1. The result of commands transmission of Table 1 tells us that the actual test of normal mission operation was performed successfully.

Table 1. The result of commands transmission test using CALS with KOMPSAT-1.

Down Link mode	Number of Tests	Success	Fail	Success Rate
Real Time Mode	23	23	0	100 %
Playback Mode	81	81	0	100 %

Table 2 shows that comparative results of commands transmission time tests for the current TM/TC system and CALS. In current TM/TC system, the transmission time is time required to finish both command transmission and telemetry check by an operator. In case of the CALS, the transmission time is time required to finish for transmitting scheduled commands automatically.

This transmission time test was performed using a simulator and the twenty cases were extracted from the real command set for KOMPSAT-1 operation. For reference, the average number of commands for the normal KOMPSAT-1 operation is around 80. The value of Table 2 is the average of test result using the twenty cases. The test result shows that the command transmission time of CALS is just about 70% of one of the current system.

Table 2. The result of transmission time test with simulator

	Current System	CALS
Average Transmission Time	≈ 5min 10sec	≈ 3min 30sec

6. Conclusion

In this paper, we presented the CALS developed for operating KOMPSAT-1. Minor bugs and software defects were amended via thorough tests using a simulator since the initial development phase. Also, the functional and performance requirements of CALS were fully verified.

Moreover CALS shows the successful operation capability in real normal operation with KOMPSAT-1.

CALS can save the operator's working time by the function of automatic commands transmission with scheduling. Its command transmission time is just about 70% of the current system, therefore the effective mission operation is possible.

With CALS development, KARI could get the experience and technical know-how of the satellite operation system. These successful results will be fully utilized in next system development and related work.

CALS is expected to be used as main TM/TC system for mission operation of KOMPSAT-1 in the end of 2004.

7. Reference

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