Design, Implementation, and Tests of KOMPSAT-2 S/W simulator

Sanguk Lee*, Sungki Cho, and Jae Hoon Kim

* Communications Satellite Development Center, ETRI, Taejon, Korea

(Tel : +82-42-860-5653; E-mail: slee@etri.re.kr)

Abstract: In this paper, we will present brief design feature, implementations, and tests for verification of KOMPSAT-2 simulator, which is a subsystem of KOMPSAT-2 MCE. SIM is implemented on PC server to minimize costs and troubles on embedding onboard flight software into SIM, OOA/OOD methodology is employed to maximized S/W reusability, and XML is used for S/C characteristics, TC, TM and Simulation data instead of commercial DB. Consequently, we can reduce costs for the system, efforts embedding flight software, and maximize software reusability. SIM subsystem test was performed successfully.

Keywords: Simulator, Design, Implementation, Test.

1. INTRODUCTION

KOrean Multi-Purpose SATellite-1(KOMPSAT-1) had been launched in December 1999 and has been being operated normally by Mission Control Element(MCE), which was developed by Electronics and Telecommunications Research Institute(ETRI). Now, we are in system test phase of development of MCE for KOMPSAT-2, which is equipped Multi-spectral Camera (1m panchromatic and 4m multi-band) KOMPSAT-2 MCE is consisted of four subsystems such as TTC(Tracking, Telemetry, and Command Subsystem), SOS(Satellite Operation Subsystem)[1], MAPS(Mission Analysis and Planning Subsystem)[2], and SIM(Satellite Simulator Subsystem)[3].

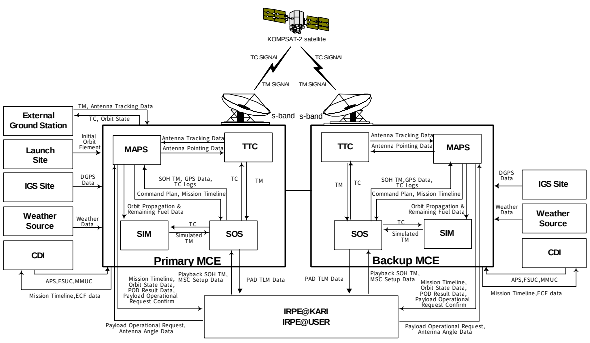

Fig. 1 Schematics of the KOMPSAT-2 MCE

SIM is a comprehensive application software system that simulates the dynamic behavior of KOMPSAT-2 by the use of mathematical models. SIM is utilized for command verification, operator training, satellite control procedure validation, and anomaly analysis. SIM models each of satellite subsystems as accurate as possible with the constraint of real-time operation condition, and display status of satellite including orbit and attitude in alphanumeric and graphic form.

SIM operates in real-time to receive telecommands, to distribute them to corresponding subsystems, and to send the results to SOS in telemetry format. SIM supports user friendly GUI for input/output of the operator.

SIM is capable of operating in on-line as well as stand-alone mode. SIM also operates in variable speed operation modes in order to be used for anomaly analysis etc.

In addition, the SIM supports simulation for the spacecraft status by providing the database containing various events and initialization data. SIM is composed of a PC, its peripherals and simulation software.

SIM is one of the KOMPSAT-2 MCE subsystems and Figure 2 shows the functional architecture of SIM.

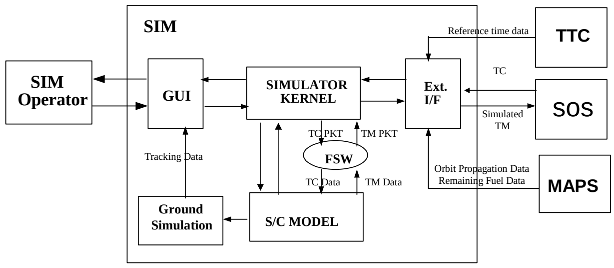

Fig. 2. SIM Functional Architecture

2. SIM DESIGN

Design of SIM is carried out using OOA (Object-Oriented Analysis) / OOD (Object-Oriented Design) methodology and is described as the use case model, domain model, user interface design, logical view, implementation view, process view, and deployment view[4][5]. The UML notation is common language to specify, construct, visualize, and document for designing object-oriented software system by using Rational Rose™. The standard OOA/OOD procedure has been applied to design KOMPSAT-2 SIM to maximize reusability, extensibility, and reliability.

2.1 Use Case Model

SIM is a software system of simulating the dynamic behavior of KOMPSAT-2 by use of mathematical models.

SIM can be used as a virtual satellite harness for MCE system with low cost. SIM is utilized for command verification, operator training, satellite control procedure validation, and anomaly analysis. SIM models each of satellite subsystems as accurate as possible. Also, SIM displays status of satellite including orbit and attitude in alphanumeric and graphic format. Figure 3 shows the Use Case Diagram of SIM.

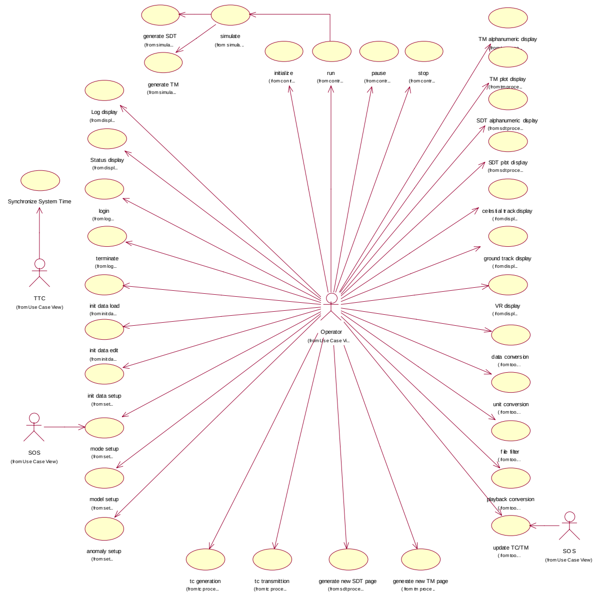

Fig. 3. Use Case Diagram of SIM

2.2 Domain Model

Domain Model describes how the Use Case is realized in Use Case Model. Domain Modeling can be expressed by Class Diagram, which describes how these classes interact with each other as shown in Figure 4.

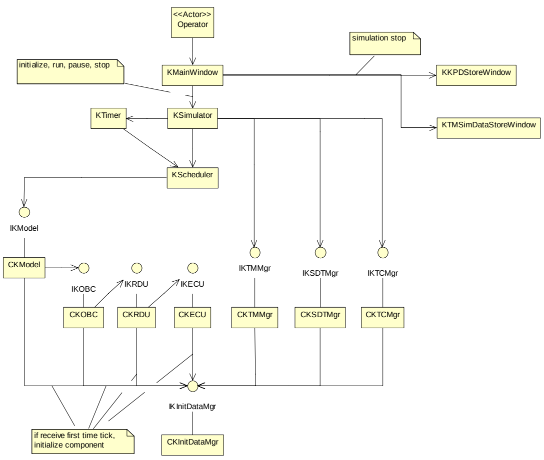

Figure 4. Class Diagram of Simulation Control

2.3 Logical View

Logical view of SIM decomposes into conceptual packages or logical components and describes connections between them. Figure 5 shows Logical View of SIM subsystem which is consisted of Kernel, UI, OBC(OnBoard Computer), RDU(Remote Drive Unit), ECU(Electric Control Unit), Models, TCProcess, SDTProcess, SecurityMgr, TMMgr, InitDataMgr, TCMgr, SDTMgr, EXTINTFACE, Tread, and Socket packages.

For the KOMPSAT-2 SIM, the onboard flight software is embedded into SIM as an independent process that has thread for interface with scheduler, and 1553B bus is emulated by COM(Common Object Model).

For example, we go through into more detailed design with CES(Conical Earth Sensor) as a sensor model. CES model belong to Sensor subpackage of Models Package, which is one of SIM subsystem packages. Figures 5 and 7 show top-down hierarchy from SIM top-level package down into the CES Class.

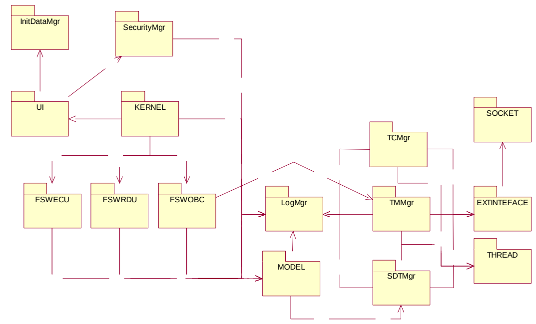

Fig. 5. Logical View of SIM Subsystem

As shown in figure 6, sensor package is inherited from generalized S/C H/W subsystem model for maximizing extensibility and reusability. Sensor Package consists of CES, TAC(Tachometer), POT(Potentiometer), FSS(Fine Sun Sensor), TAM(Three Axis Magnetometer), CSS(Coarse Sun Sensor), Gyro, and STA(Star Tracker Assembly) and they are inherited from sensor class. Each of sensor class has parameter class that defines characteristics of each sensor and provides extensibility.

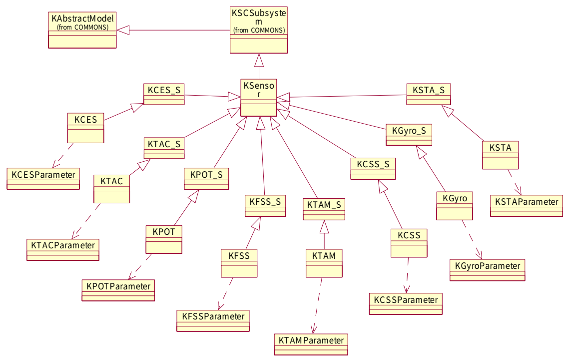

Figure 6. Logical View of Sensor Package

Figure 7 shows detailed design of CES class and Figure 8 shows sequence diagram of calculateCount method of CES class in flow chart format.

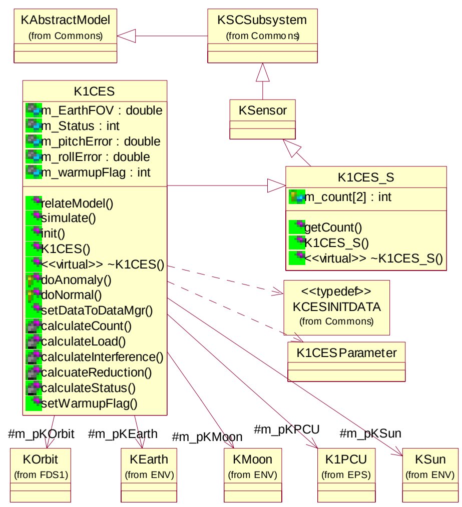

Fig. 7. CES and related Classes

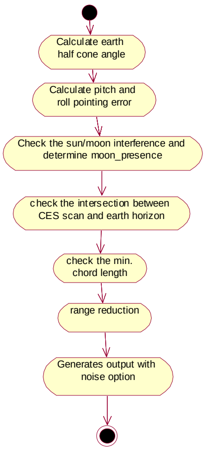

Fig. 8. Activity Diagram of calculateCount Method

2.4 Implementation View Design

The Architecture of SIM from Implementation view of the system is described here. Implementation view describes the actual software module, their relations, and contents along with consideration of the requirements as shown in Figure 9.

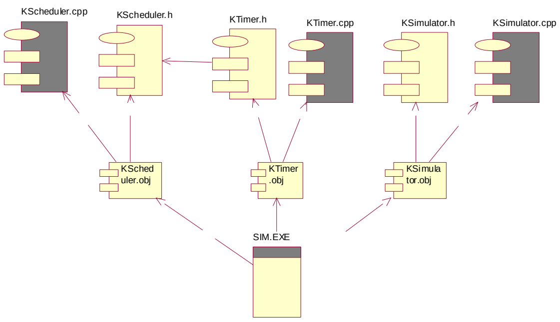

Fig. 9. Implementation View of Control Package

2.5 Process View Design

SIM has the only one EXE file and number of DLL(Dynamic Link Library)s, which are running like independent processes as shown in Figure 10. Hereafter, EXE and DLLs are named after process. Process view describes execution structure of the SIM system along with consideration of the requirements related to performance, reliability, expandability, system management, and synchronization.

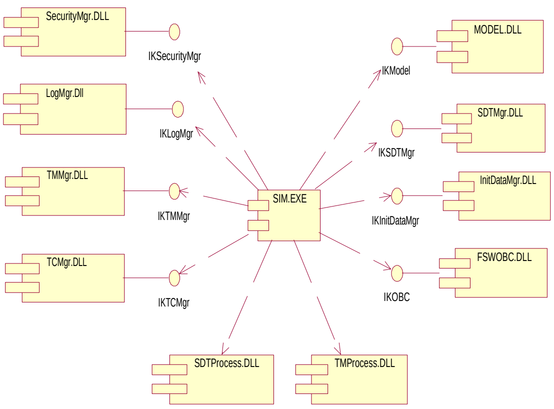

Fig. 10. Process View of SIM

2.6 Deployment View Design

In deployment view, SIM architecture is described in the physical point of view. Figure 11 shows nodes, links between nodes, and their platform.

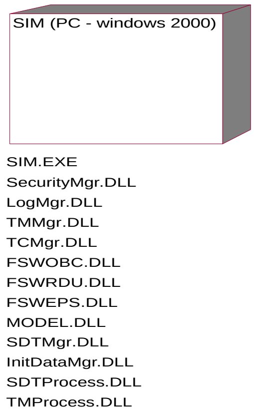

Fig. 11 Deployment View of SIM

3. SIM IMPLEMENTATION

3.1 SIM H/W Implementation Environment

The hardware configuration and equipment specifications for KOMPSAT-2 SIM are shown in Figure 12 and Table 1, respectively. Different from KOMPSAT-1 SIM, which was developed on HP workstation, KOMPSAT-2 SIM is developed on a PC server, which communicates with the other MCE subsystems, i.e. SOS, TTC, and MAPS, using TCP/IP protocol via MCE LAN.

A PC server as platform including in Window 2000 as an operating system will be used as H/W platform and software environment of KOMPSAT-2 SIM. The PC server also contains VR graphic display of the KOMPSAT-2 attitude and orbit motion.

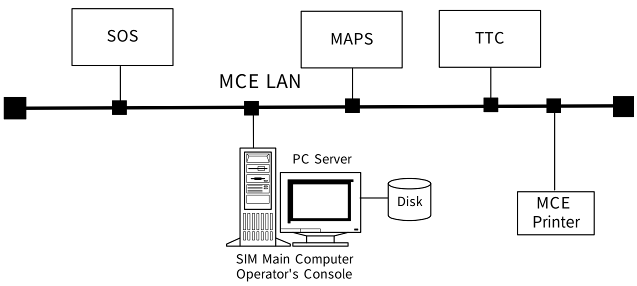

Fig. 12 H/W Configuration and KOMPSAT-2 SIM

Table 1 SIM H/W Elements

Usage	Element	Specification
Simulator Operation	Simulator Main computer	- Main Memory (above 1GB) - Hard disk (above 20G *2) - Above 1.0GHz Intel CPU
	Display device	- Color graphic monitor (21”)
	Interface	- Ethernet LAN transceiver

3.2 SIM S/W Implementation Environment

The SIM S/W environment is shown in Table 2. The SIM VR is implemented using Open GL.

Table 2 SIM S/W Environment

Usage	Element	Specification
	Operating System	- MS Windows 2000
	Programming Language	- C++ : GUI, Models - C : FSW embedded
	Data Management	- XML & Text files
	Library	- Open GL : VR Display

3.3 SIM Implementation

KOMPSAT-2 SIM was implemented as one process that drove several DLLs as shown in figure 10. Those DLLs are implementation of elements packages for SIM in implementation and process views. Figure 13 is the main window configuration of the implemented KOMPSAT-2 SIM GUI.

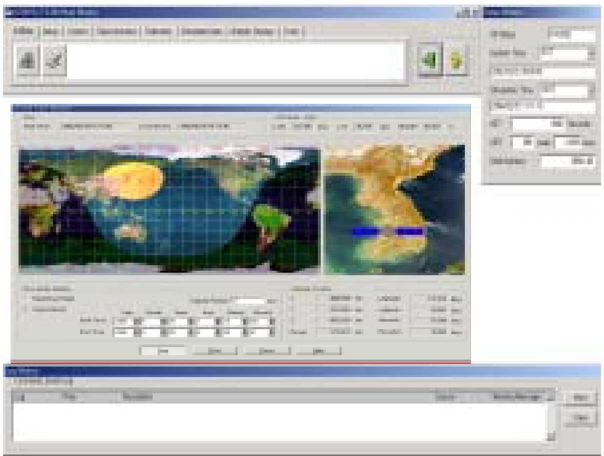

Fig. 13 Main Window Configuration of KOMPSAT-2 SIM

4. KOMPSAT-2 SIM TEST

4.1 Test Philosophy

The philosophy used in the development of the subsystem test procedure is based on testing the subsystem softwares on a test-by-test basis. Although all of the subsystems in MCE are interrelated, the major focus in each subsystem test is tested as a single isolated system. During the testing, numerous operations are performed following the test steps in the test procedure. In general, test setup should be checked first and then the test execution follows in the test procedure for the specific test item. There are many checking points in the test procedure to verify a specific function and/or number

The KOMPSAT-2 MCE SIM subsystem inherits from the previous project, the KOMPSAT-1 MCE SIM, in some part. And the KOMPSAT-1 MCE SIM has been successfully operated up to now. The some test items and some part of test procedures are inherited from the KOMPSAT-1 MCE SIM subsystem test procedures.

4.2 Test Prerequisites

Prior to the performance of subsystem testing, the following criteria must be satisfied:

1) The SIM software shall be under configuration control.
2) The SIM Test Plan and Test Procedures shall be signed off and released.
3) The equipment and data required for testing shall be in place and connected.

4.3 Test Organization

Test organization for SIM subsystem test is shown in Fig. 14.

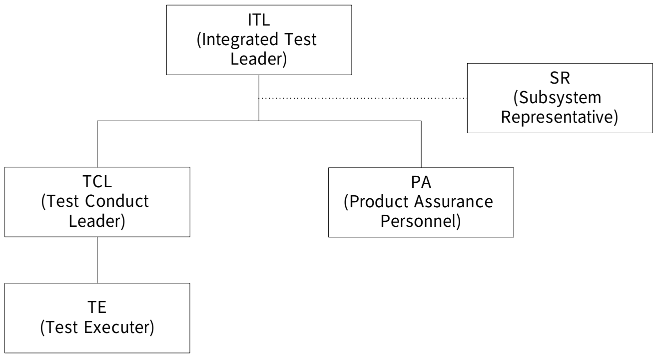

Fig. 14 Test Organization for SIM Subsystem Test

4.4 Test Discrepancy Handling

When the test activity cannot proceed as specified in the test procedure, test discrepancy is issued. Test discrepancies are divided into four categories such as simple error, minor discrepancy, major discrepancy, and critical discrepancy. It is TCL's decision along with SR's and PA's suggestion to assign the corresponding discrepancy into one of those discrepancy categories.

4.5 Test Results

<u>Test Report</u>

The Acceptance Test of the KOMPSAT-2 MCE SIM was performed during 2 days in May 15 ~ 16, 2003. Before starting the official SIM test, test procedure was completed and signed off on May 14, 2003 and Test Readiness Review (TRR) meeting was held on May 14, respectively. Since the final version of K2 FSW is not released, eight test items in 25 test items are waived. The waived test items will be tested in the Upgrade Test. Normally, the test was started in the morning and completed before 5 PM. Daily test result review meeting was held after test.

The first test was carried out in 2 days for the 17 test items in the SIM test procedure. Totals of 15 test items were successfully passed and 2 test items were failed. All of the related TRSs, SCOs, and TDRs were issued and the software codes were changed. There were corrections of the test procedure.

Retest was performed after the completion of the software code change for the two failed items and one SCO item. All of the retests were successfully passed by the 16th of May, 2003.

Summary of the test (2003-05-15 ~ 2003-05-16)

Totals of 17 SIM test items were tested. Retest was performed for the failed test items after simple modification of the source code, when applicable. Table 3 shows the summary of the test.

Table 3 Summary of the test

Test Date	Test Items	Success	Fail	TRS
2003-05-15	11	10	1	1
2003-05-16	6	5	1	1
After 1st test	**17**	**15**	**2**	**2**
2003-05-16 (Retest)	2	2	0	0
After Retest	**17**	**17**	**0**	**2**

Test Anomalies

This section itemizes the failed item during the test and summarizes the departures and causes of the failures, and the resolution for the pass. Total of 2 failures out of 17 SIM test items were occurred during the test. The followings show the contents, causes, and resolution of the failed items.

A. Telemetry Process and Trend Analysis(TSIM-011)

- Departure (TRS-001)
  The single item plot of the playback TM was not displayed
- Cause of the Departure
  Data range scaling error.
- Resolution
  Software change was required by SCO-001.
- Comments
  Software change was completed.
  The retest was successfully completed.

B. Simulation Data Analysis and Display (TSIM-013)

- Departure (TRS-002)
  SDT data "AAELRANGZECI" values are fixed at zero (TP page 71, step 65).
- Cause of the Departure
  Data filtering error.
- Resolution
  Software change was required by SCO-002.
- Comments
  Software change was completed.
  The retest was successfully completed.

5. CONCLUSIONS

The brief design feature, implementations, and tests for verification of KOMPSAT-2 simulator, which is a subsystem of KOMPSAT-2 MCE. SIM is implemented on PC server to minimize costs and troubles on embedding onboard flight software into SIM. OOA/OOD methodology is employed to maximized S/W reusability and expendability. XML was used for S/C characteristics, TC, TM and Simulation data instead of commercial DB.

The subsystem test was performed to verify the SIM according to test procedure, which was prepared to meet SIM requirements items and it was passed. Each of test items was mapped to the SIM specifications via verification matrix. Consequently, we can reduce costs for the system, efforts embedding flight software, and maximize software reusability.

KOMPSAT-2 MCE system will be delivered to KARI for variable test such as acceptance test, RF compatibility test, end-to-end test, and so on.

ACKNOWLEDGMENTS

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