Mission Analysis and Planning System for Korea Multipurpose Satellite-I

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The Mission Analysis and Planning System (MAPS) has been developed for a low earth orbiting remote sensing satellite, Korea Multipurpose Satellite-I (KOMPSAT-I), to monitor and control the orbit and the attitude as well as to generate mission timelines and command plans. The MAPS has been designed using a top-down approach and modular programming method to ensure flexibility in modification and expansion of the system. Furthermore, a graphical user interface has been adopted to ensure user friendliness. Design, implementation, and testing of the KOMPSAT MAPS is discussed in this paper.

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I. INTRODUCTION

The Korea Multipurpose Satellite I (KOMPSAT-I) is a satellite scheduled for launch in November of 1999. The main mission of KOMPSAT-I is to perform cartography of the Korean peninsula during the design life of three years. Other missions include taking large-scale multi-spectral images of the ocean, measuring the ion layer, and detecting high energy particles. The KOMPSAT-I is designed to operate at an altitude of 685.13 km, an eccentricity of 0.001, an inclination of 98.13 degrees (sun synchronous), and a local time of ascending node of 10:50 am. The KOMPSAT-I is 1.33 m in diameter, 2.13 m long, and its total weight is 510 kg. For monitoring and control of this satellite, a satellite ground facility is being built in Taejon, Korea.

Satellite ground control facilities control, track, and maintain a satellite in orbit. It also supports the overall mission, from commanding to collecting telemetry data. For the first time in Korea, a satellite ground control system is being developed. The KOMPSAT ground control station (KGS) is comprised of Image Reception and Processing Element (IRPE) and Mission Control Element (MCE). IRPE is responsible for collecting and processing the image data from KOMPSAT-I. On the other hand, MCE monitors and analyzes the satellite, plans the mission, and controls the satellite [1]. Figure 1 shows the overall configuration of the KOMPSAT MCE.

MCE is made of four systems; the Tracking, Telemetry, and Command (TTC) System, the Satellite Operations System (SOS), the Satellite Simulator System (SIM), and the Mission Analysis and Planning System (MAPS). TTC receives telemetry from the satellite, transmits telecommand and tracks the satellite. SOS processes the telemetry, generates and sends telecommand to the TTC or the SIM. SIM validates telecommand, simulates the KOMPSAT-I, analyzes anomalies and trains the MCE operators. MAPS analyzes the orbit and attitude of the

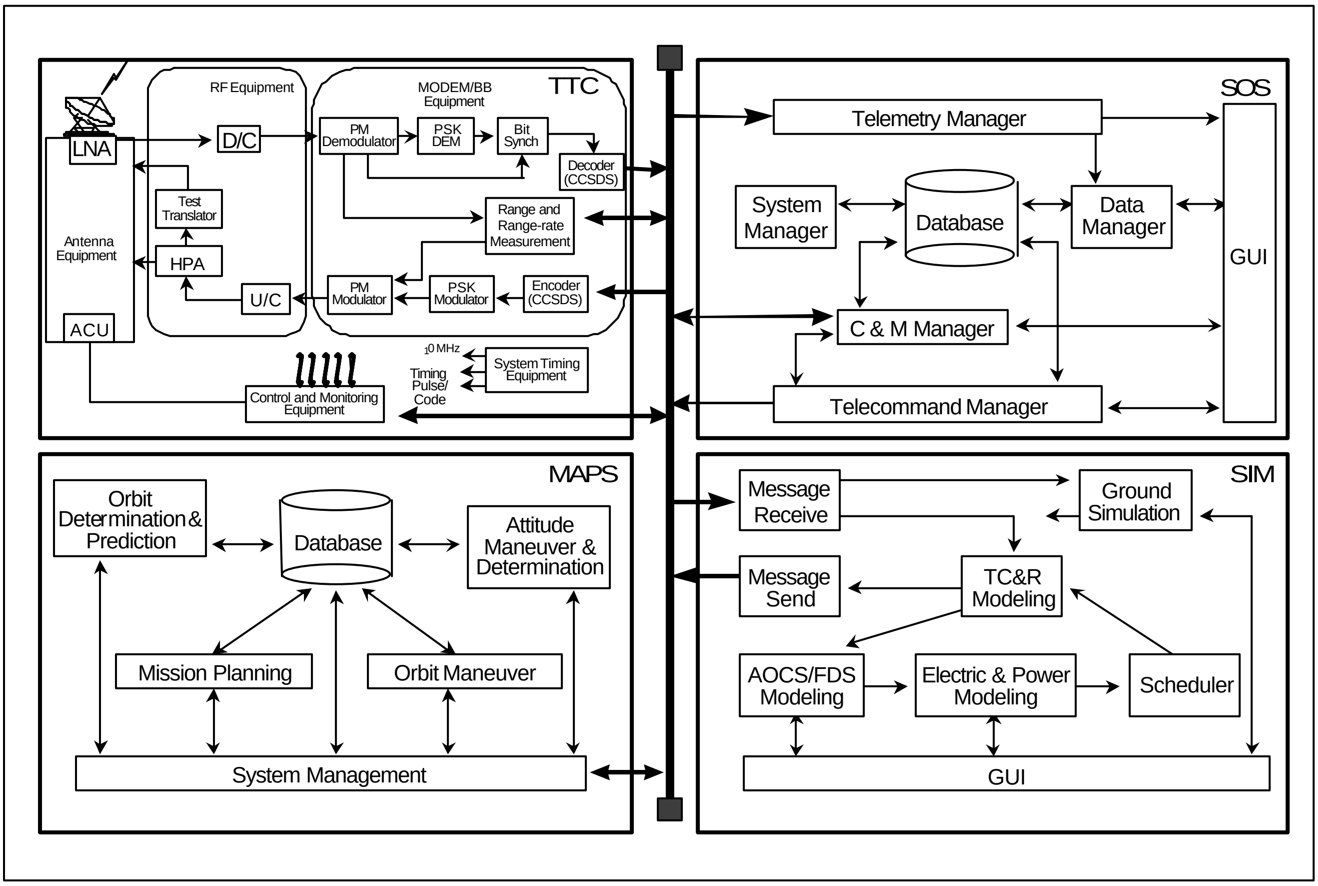

Fig. 1. MCE configuration.

KOMPSAT-I and plans the mission schedule.

The MAPS has the capability to provide the satellite operation schedules by analyzing and predicting the orbit of the KOMPSAT-I. The MAPS includes the functions of orbit determination, orbit prediction, and orbit maneuver. The MAPS may also plan satellite attitude maneuvers for the image data collection of specific areas. The MAPS can generate conflict-free monthly, weekly, and daily satellite operation schedules and mission timelines. Then the operation schedules and command plans are transmitted to SOS, for command generation and uploading to the KOMPSAT-I. The design of KOMPSAT MAPS has been presented in [2], and the KOREASAT advanced real-time satellite simulator has been discussed in detail [3]. This MAPS design utilized Wertz's Space Mission Analysis and Design [4] and Department of Defense's Software Development and Documentation [5].

In the next section, a brief functional description of MAPS is given. In Section III, the MAPS configuration and external interfaces are described. Section IV describes each block of the MAPS in detail. In Section V, testing and verification of the MAPS is discussed. Finally the conclusions are given in the last section.

II. A BRIEF FUNCTIONAL DESCRIPTIONS OF MAPS

MAPS software analyzes satellite orbit and attitude and generates mission timeline and command plans. The MAPS includes the functions of orbit determination and prediction as well as orbit maneuver using satellite tracking data. The MAPS also prepares the satellite attitude maneuver plan for the image data collection of specific areas. The MAPS generates conflict-free monthly, weekly and daily satellite operation schedules and mission timelines. The MAPS consists of five blocks as shown in Fig. 2: System Management Block (SMB), Mission Planning Block (MPB), Orbit Determination and Prediction Block (ODPB), Orbit Maneuver Block (OMB), and Attitude Maneuver and Determination Block (AMDB).

The SMB performs the start-up procedure of MAPS, security check of the operator, and the shut-down procedure of MAPS. SMB is responsible for receiving processed telemetry data and tracking data from SOS and saving them into a database. SMB creates the database by combining data files from other blocks.

The MPB has mission planning and scheduling capabilities. The planning can be considered as the long term development

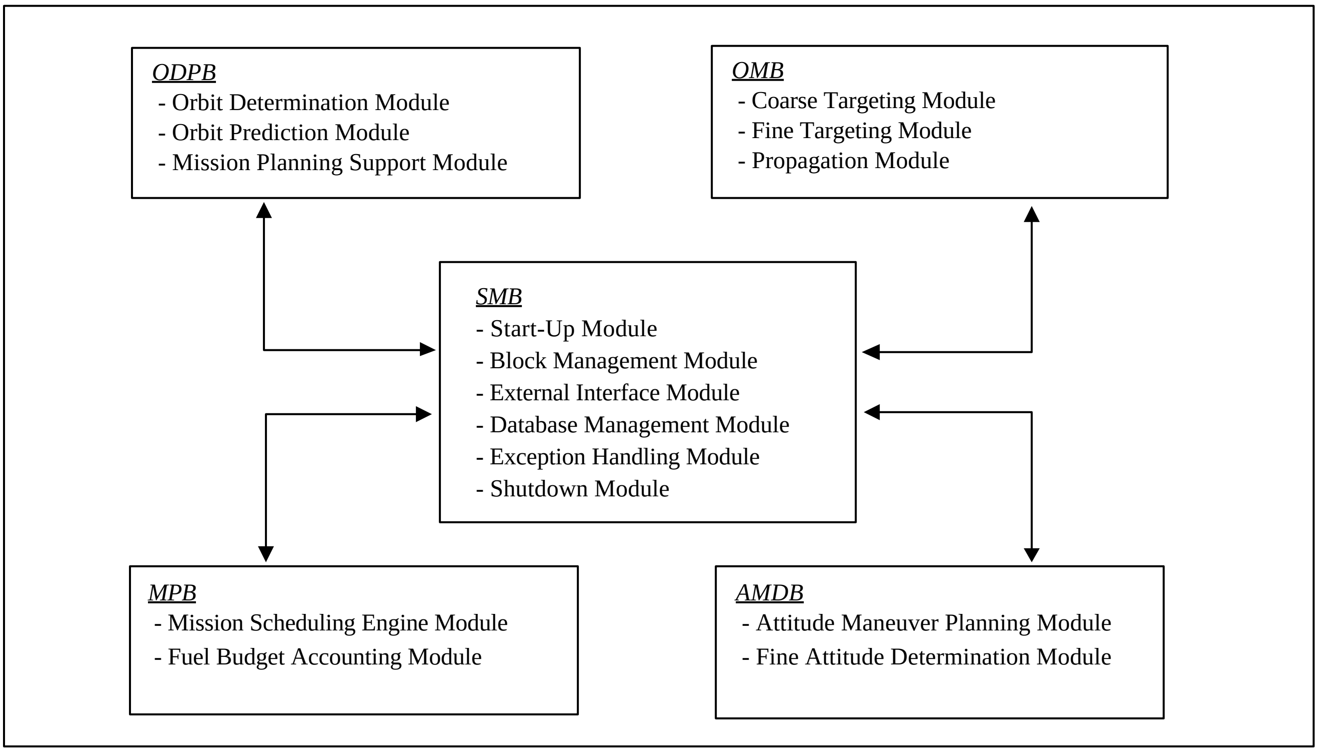

Fig. 2. Functional block diagram of the MAPS.

to the high level mission objectives in which the scheduling function can draw their general guidance. The scheduling is associated with the interpretation of near term specific activities from the plan that will be accomplished by the KOMPSAT-I. Thus MPB coordinates the execution of specific activities and payloads to efficiently collect and/or transmit data of KOMPSAT-I. This block also provides the fuel budget accounting function for the mission analysis support and spacecraft lifetime prediction.

The two major functions of ODPB are orbit determination and orbit prediction. The orbit determination and prediction is the ability to determine and predict the orbit of a satellite around the Earth. The KOMPSAT-I has two methods of determining the orbit. The first method uses the Global Positioning System (GPS), and this GPS navigation solution is transmitted to the ground. Then in ODPB the received data are processed via least square method to precisely determine the position of KOMPSAT-I. The second method uses the tracking data from the ground station. We use this second method as a backup and to verify that the GPS method gives a reasonable solution. In orbit prediction, after the position and velocity of the satellite is determined, these data are propagated to predict the future position and velocity of the satellite. Knowledge of the future KOMPSAT-I orbital position is essential information in deciding when and where an activity can be supported by the KOMPSAT-I.

The OMB is responsible for orbit maintenance of KOMPSAT-I. It consists of the orbit propagation, coarse orbit targeting, and fine orbit targeting modules. The orbit propagator, which is a simpler version than the ODPB propagator, is used to determine the orbit maneuver time. In the coarse orbit targeting module, given initial and target orbital elements, appropriate direction and magnitude of the delta velocity vector is calculated. In the fine orbit targeting module direction and magnitude of the delta velocity vector is calculated as in the coarse orbit targeting module, but the orbit is integrated while the maneuver is taking place to assure a more accurate orbit maneuver.

The AMDB has two major functions, attitude maneuver planning and fine attitude determination. The main reason for attitude maneuver planning is to maintain the satellite hardware, sensor, antennas, and payloads in the proper alignment to support the desired mission. Autonomous attitude control is performed using earth sensors, sun sensors, and onboard gyroscopes in KOMPSAT-I. Precise attitude determination is done using the satellite telemetry on the ground to verify the onboard attitude determination and for better image processing.

III. MAPS CONFIGURATION AND EXTERNAL INTERFACES

The MAPS hardware platform consists of a workstation and a printer. KOMPSAT MAPS is developed on an HP workstation. However, because of its modular design, it may be easily changed to other platforms with minor modifications. Table 1 shows the specifications of MAPS hardware and system software in detail. MAPS uses a LAN-based communications network to interconnect all platforms and external interface elements. Commercially available programs and products have been used to support some of the functions of MAPS. Moreover, a graphical user interface (GUI) is used in MAPS to support user-friendly human-machine interface.

Table 1. MAPS H/W and system S/W specifications.

Configurations	Items	Components	Specifications
Hardware Configuration	Workstation (HP-9000/J210)	Main Memory	128 Mbytes
		Hard Disk	2Gbyte
		Tape Driver	2Gbyte DAT
		CD-ROM Driver	4X Speed
		Ethernet Controller	LAN1: HP 100VG I/F LAN0: Built-in Ethernet
	Printer	(HP laser jet)	
System Software Configuration	Operating System	HP-UX	10.2
	Programming Language	HP-FORTRAN	HP-UX f77 B.10.20.01
		HP-C	HP C/ANSI C A.10.30
		HP-C++	HP C++ S700 A10.09
	Graphic User Interface	Motif / Xlib	Motif 1.2 / X11R5
	Network		Ethernet/TCP/IP

The MAPS has external interfaces with SOS, TTC, weather source, IRPE, external ground station, and launch site as shown in Fig. 3. The interfaces shall be established using telephone, fax, and LAN with TCP/IP protocol. From SOS, the GPS navigation solution and telemetry state of health data shall be provided to MAPS in the form of electronic files. From MAPS, ground track data, mission timeline, and command plan shall be provided to SOS in the electronic file format. TTC sends the system timing data, when requested by NTP client daemon in MAPS, and KOMPSAT-I antenna tracking data, via Ethernet to MAPS. Conversely the MAPS sends the antenna pointing data to TTC. The weather data shall be obtained from the Korea Meteorology Administration's web-site. The MAPS transmits the antenna control data and timeline to IRPE. The MAPS shall receive the schedule request and antenna tracking data from IRPE over the LAN using TCP/IP protocol. The MAPS may also receive antenna tracking data from an external ground station. The launch site shall provide the orbital elements to MAPS.

IV. MAPS DESIGN AND INTEGRATION

1. System Management Block

As the name System Management Block (SMB) suggests, this block manages all the processes and data of the MAPS. It is responsible for starting and shutting down of the MAPS. Moreover, SMB provides the external communication capability and manages the processors and the database of all the blocks in MAPS via the graphical user interface. The SMB and GUI of MAPS are written in C programming language. The SMB consists of six modules; the start-up module, the block management module, the database management module, the external interface module, exception handling module, and the shutdown module.

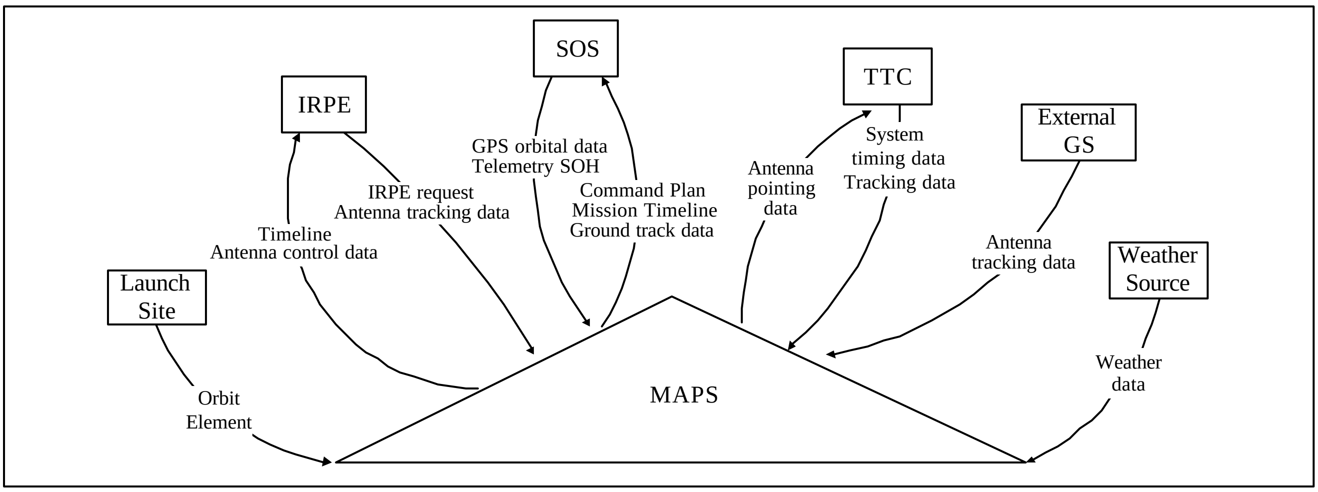

Fig. 3. MAPS external interfaces.

Fig. 4. MAPS login window.

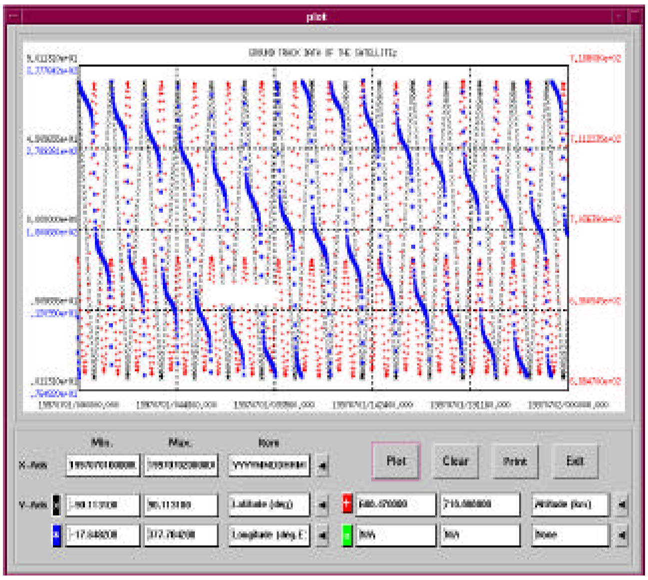

Fig. 6. MAPS plot window.

The start-up module provides a login method, checks the authority of the user, starts the MAPS software, and initializes the graphical user interface. Figure 4 shows the MAPS login window, and Fig. 5 shows the main icon window and the event message window. All the MAPS blocks and some of the modules are displayed by the graphical icons and can be selected simply by clicking of the mouse button. The event message window displays the messages which are sent from the MAPS blocks and modules.

The block management module provides the graphical menu to start each block. The database management module provides such functions as management of common data, backup and restore of data, plot of the output data, and generation of reports. The external interface module receives and sends data from/to the external data sources (SOS, SIM, TTC, IRPE and External Ground Station). The exception handling module processes abnormal events that has occurred in the MAPS. The shut-down module performs safe exit of the MAPS. Finally, the report is generated according to the demand of the operator, and a graph of the output data is provided by a plot-window as shown in Fig. 6.

2. Mission Planning Block

The Mission Planning Block (MPB) is made up of two modules: the scheduling engine module to generate the mission timeline and command plan and the fuel budget accounting module to estimate the fuel remaining onboard the satellite. The scheduling engine module is written in C while the fuel budget accounting module is written in Fortran.

The scheduling module generates an integrated and conflict-free timeline. This module uses Generic Resource, Event, and Activity Scheduler (GREAS) for the benefit of saving development time and reducing risks [6]. Figure 7 shows the graphical user interface window for mission scheduling.

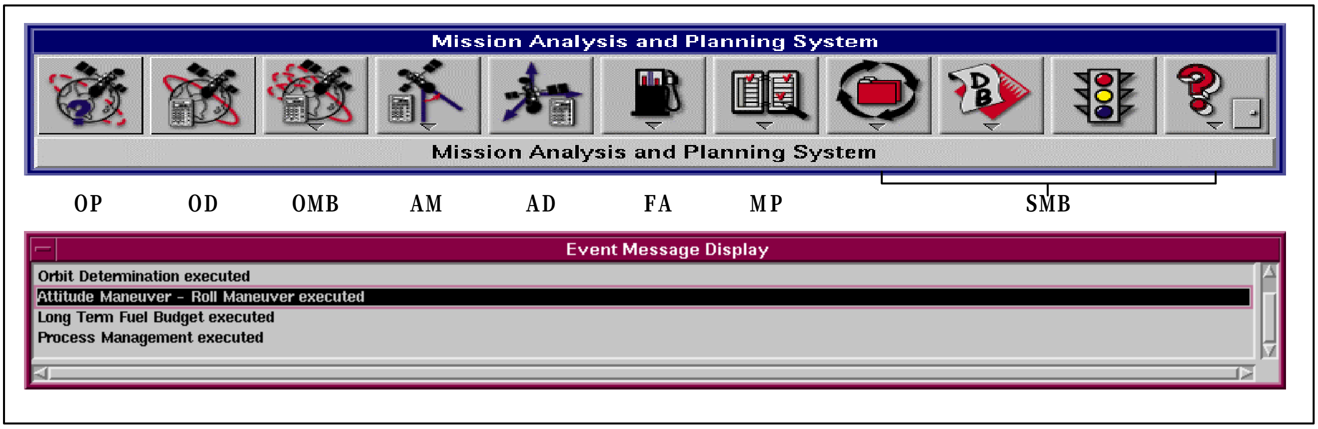

Fig. 5. Main icon window and event message window of MAPS.

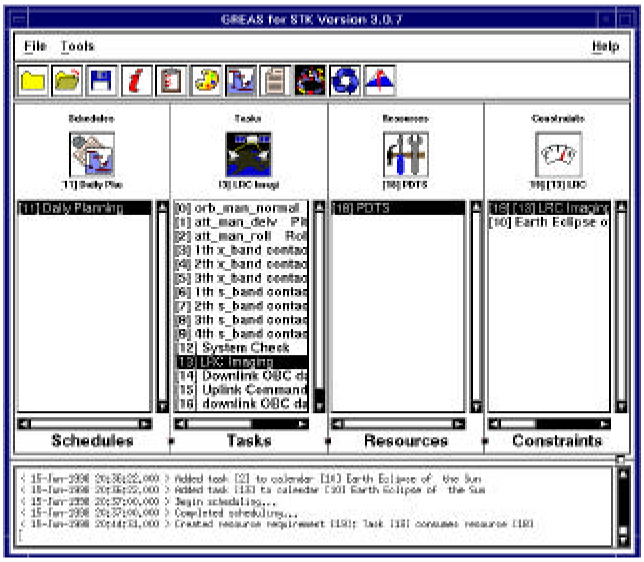

Fig. 7. Mission scheduling window.

Other than customizing GREAS for the KOMPSAT-I, MPB has the enhanced capability to order the schedule by time and the capability to generate the appropriate command plan automatically. The orbital constraints data and orbit/attitude maneuver plan data generated by ODPB, AMDB, and OMB are converted and merged to the Object Scheduling Language (OSL) format file, which is a standard input format of GREAS. The mission planner can generate the spacecraft command plans based on the generated timeline using the command plan window as shown in Fig. 8. This command plan is transferred to SOS for command generation.

The fuel accounting module estimates the propellant remaining onboard the spacecraft for mission planning. The fuel budgeting is done using two methods. One is prediction and another is the Pressure-Volume-Temperature (PVT) method. The fuel usage prediction is performed before the actual mission considering various nominally expected orbit and attitude maneuvers during the planned mission life. The output can be used as a fuel budget analysis data. The specific impulse (Isp) calibration results are provided by the propulsion system manufacturer. The PVT function receives processed telemetry data containing tank pressure and tank temperature. Using these parameters the PVT function calculates the volume of the pressurant gas in the tank and, then, the mass of the fuel. In order to compensate for the low accuracy of this function, predetermined reference data is used. This data contains the fuel mass versus pressure information. Figure 9 shows the graphical user interface window for fuel accounting.

3. Orbit Determination and Prediction Block

The Orbit Determination and Prediction Block (ODPB) consists of the orbit prediction module, the orbit determination module, and the mission planning and support module. All the modules of ODPB are written in Fortran.

The orbit prediction module uses the direct numerical integration of the satellite equations of motion in rectangular coordinate system by the Cowell method [7]. The equation of motion that includes all of these effects is as follows:

$$\ddot{\vec{r}} = -\frac{\mu_e}{|\vec{r}|^3}\vec{r} + \ddot{\vec{r}}_{geo} + \ddot{\vec{r}}_{sm} + \ddot{\vec{r}}_{srp} + \ddot{\vec{r}}_{drag}$$

where μ_e is earth gravitational constant and $\vec{r}$ is spacecraft position vector. $\ddot{\vec{r}}_{geo}$, $\ddot{\vec{r}}_{sm}$, $\ddot{\vec{r}}_{srp}$, and $\ddot{\vec{r}}_{drag}$ are the acceleration

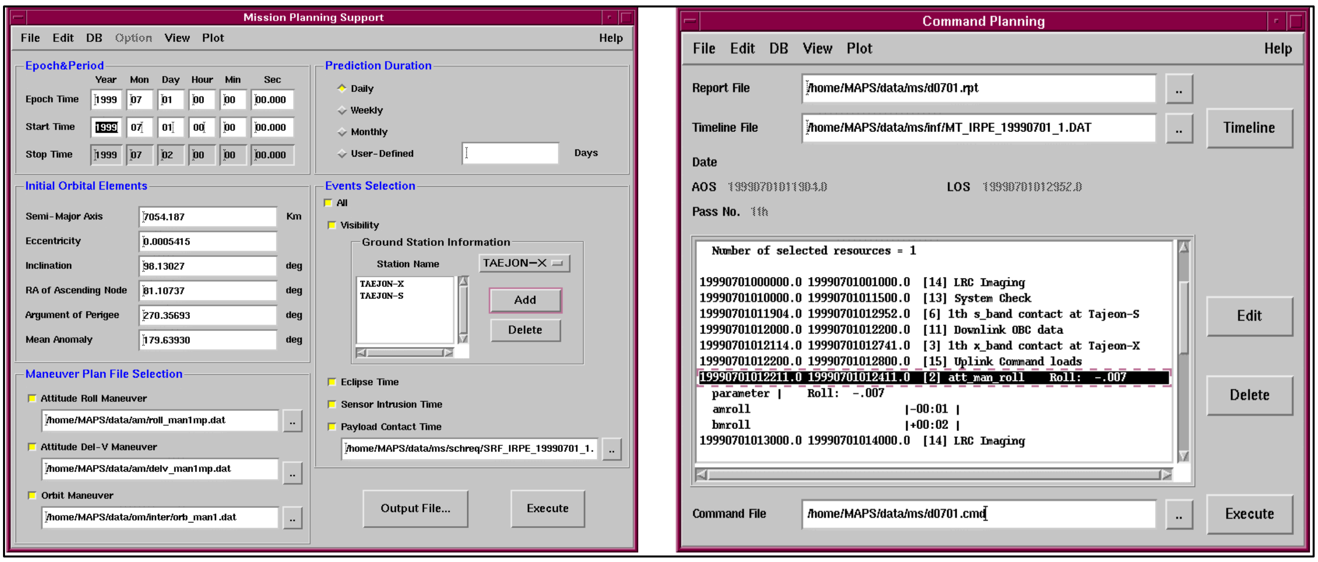

Fig. 8. Mission planning support and command plan windows.

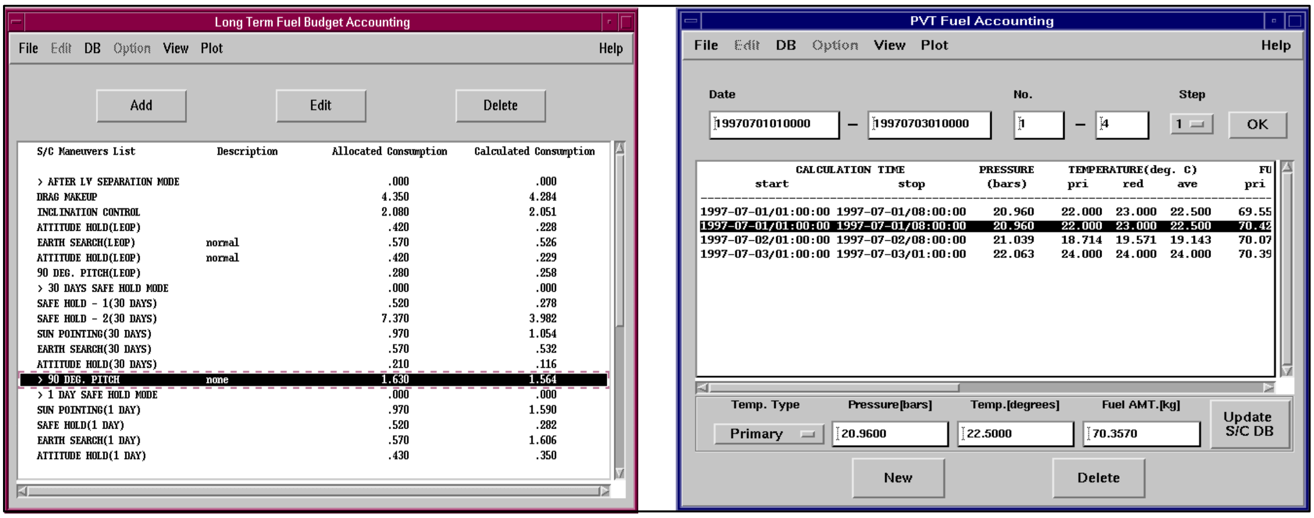

Fig. 9. Fuel accounting windows.

due to earth geopotential, lunisolar perturbation, solar radiation pressure and atmospheric drag, respectively. We have used the Jacchia 71 atmospheric drag model and the solar radiation pressure is modeled using the following formula,

$$A_R = -\nu C_R \frac{A_S}{m_S} P_S \hat{r}_S \ ,$$

where ν is the eclipse factor, C_R is a factor depending on the reflective characteristics of the satellite, A_S is the cross sectional area of the satellite, m_S is the mass of the satellite, P_S is the solar radiation pressure in the vicinity of the Earth, and $\hat{r}_S$ is the geocentric true of date unit vector pointing to the Sun. The average values for the cross-sectional area are used.

The initial condition of the above differential equation is given by the epoch position and velocity vectors. The Earth geopotential model is complete through degree and order 70. And JGM2 model is used [8]. The numerical integration algorithm used in this module is a predictor-corrector type [8]. The orbit prediction module generates antenna pointing data, ground track data, and ephemeris generation data for the other block of the MAPS. The orbit determination process consists of editing and smoothing of the tracking data followed by a batch least square curve fit using iterative differential corrections to optimize the estimated trajectory. As a part of the optimization process, the corrected orbital elements must be integrated in order to re-compute the residual data. The results of orbit determination module are the estimation of the spacecraft state vector for a specific epoch which are based on the observation data obtained by the GPS receiver or the ground station antenna. The batch weighted least square estimation formula which has been used in the ODPB is given as follows

$$\overline{dx}^{(n+1)} = \left[H^T W H + P_A^{-1}\right]^{-1} \left[H^T W y + P_A^{-1} \left[\overline{x}_A - \hat{\overline{x}}^{(n)}\right] \right]$$

where, $\overline{x}_A$ is the n^{th} approximation to the true solution $\hat{\overline{x}}$, y is the vector of residuals from the n^{th} approximation, $\overline{dx}^{(n+1)}$ is the vector of corrections to the parameters; i.e., $\overline{x}^{(n+1)} = \overline{x}^{(n)} + \overline{dx}^{(n+1)}$, and H is the matrix of partial derivatives of the observations with respect to the estimated parameters. The iteration formula given by the above equation solves the nonlinear equations formed by minimizing the sum of weighted residuals. Figure 10 shows the graphical user interface window for orbit prediction and orbit determination.

The mission planning support module provides event data and orbit-related data for the KOMPSAT-I mission planning block. The spacecraft events such as eclipse, sensor intrusion, nodal crossing time, apsidal crossing time, polar crossing time, contact time of the ground antenna, and payload contact time of the target area are calculated in this module.

4. Orbit Maneuver Block

The primary function of Orbit Maneuver Block (OMB) is to translate orbit maneuver objectives into maneuver control parameters. The OMB consists of the coarse targeting module, the fine targeting module, and the propagation module. These modules analyze and plan the necessary orbit maneuvers. All the modules are written in Fortran except for the interface between the OMB and the GUI which is written in C++. The structure diagram for OMB is shown in Fig. 11.

The coarse targeting maneuver module performs orbit coarse targeting maneuver predictions for the KOMPSAT-I in order to obtain the initial estimates of the maneuver requirements ne-

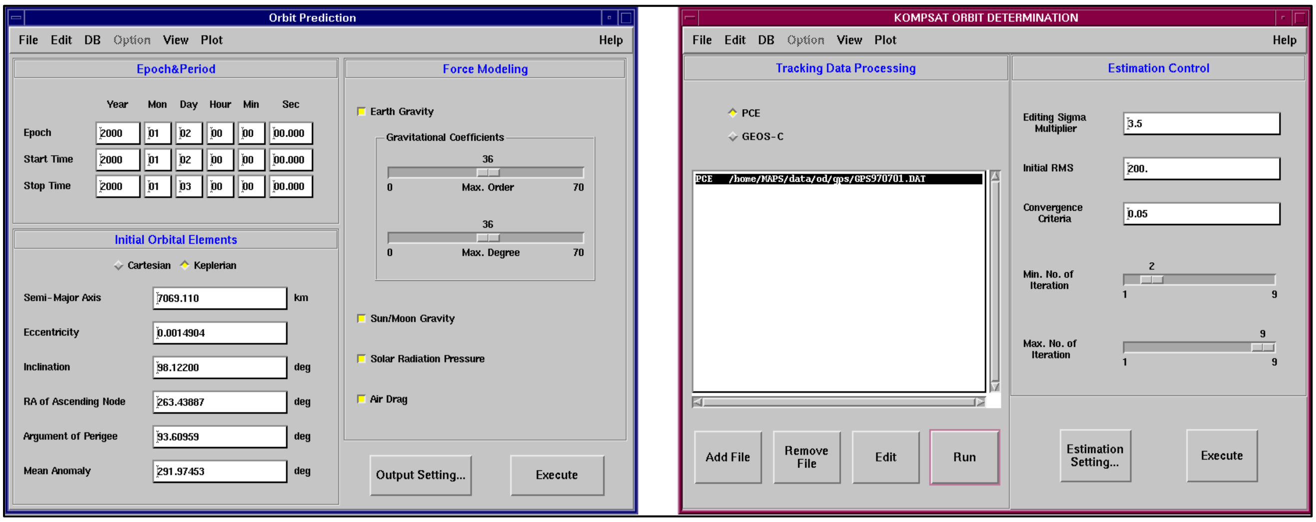

Fig. 10. Orbit prediction and determination windows.

cessary to satisfy specific maneuver objectives. This module computes orbit maneuver control parameters using impulsive two-body approximations [9]. This is mainly used to perform preliminary orbit maneuver analysis. The coarse targeting module is called to compute estimates of the maneuver velocity, burn time, fuel usage, and attitude direction based on impulsive two-body approximations.

The fine targeting maneuver module provides fine maneuver predictions of the targeting elements. This module is used to compute orbit maneuver control parameters for achieving target in-plane and out-of-plane orbital elements. The orbit source is initialized with the required parameters. Then the main driver calls the targeting subdriver. The targeting subdriver reads the spacecraft data file, and initial estimates of thruster performance are computed. Also, the maneuver ignition time is computed. The coarse targeting module is called to compute estimates of the maneuver velocity, burn time, and attitude direction based on impulsive two-body approximations. Control is returned to the targeting driver, which then calls the fine targeting module. Then the orbit targeting convergence routine is called. If the maneuver objectives were not achieved, adjustments are made to the maneuver targeting variables, the orbit coarse targeting module is called again, and the process is repeated. If the requested goals are met, control returns to the targeting subdriver. When the maneuver objectives have been achieved, the coarse targeting summary and the fine targeting summary are printed. Figure 12 shows the graphical user interface windows for orbit maneuver.

The propagation module (PRM) is used to propagate premaneuver orbital elements and to create the EPHEM file for use by the targeting subdriver. This propagator is not as accurately modeled as the propagator in the ODPB block, but it includes the thruster model which is not done in ODPB. The OMB

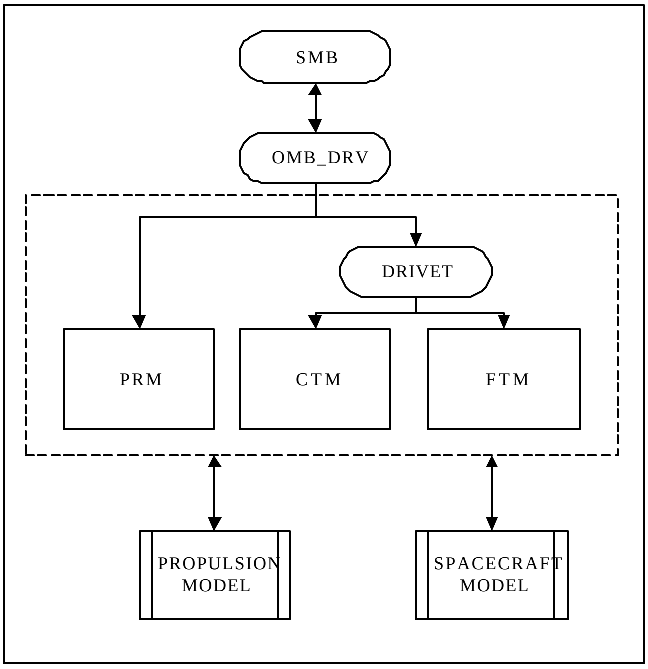

Fig. 11. Structure diagram for OMB.

driver reads and loads the driver control inputs and data inputs. The PRM driver performs all initialization for the orbit integrator, translates the requested propagation span into times relative to epoch, writes the header record on the EPHEM file, performs necessary orbital element conversions, and verifies the validity of the propagation. Then finally, it calls the orbit integrator. The orbit integrator performs the requested propagation, prints propagation records, prints orbital elements, and notes the sun/moon interferences. The control is returned to the propagation subdriver, and it prints orbital summary page, and closes the EPHEM file.

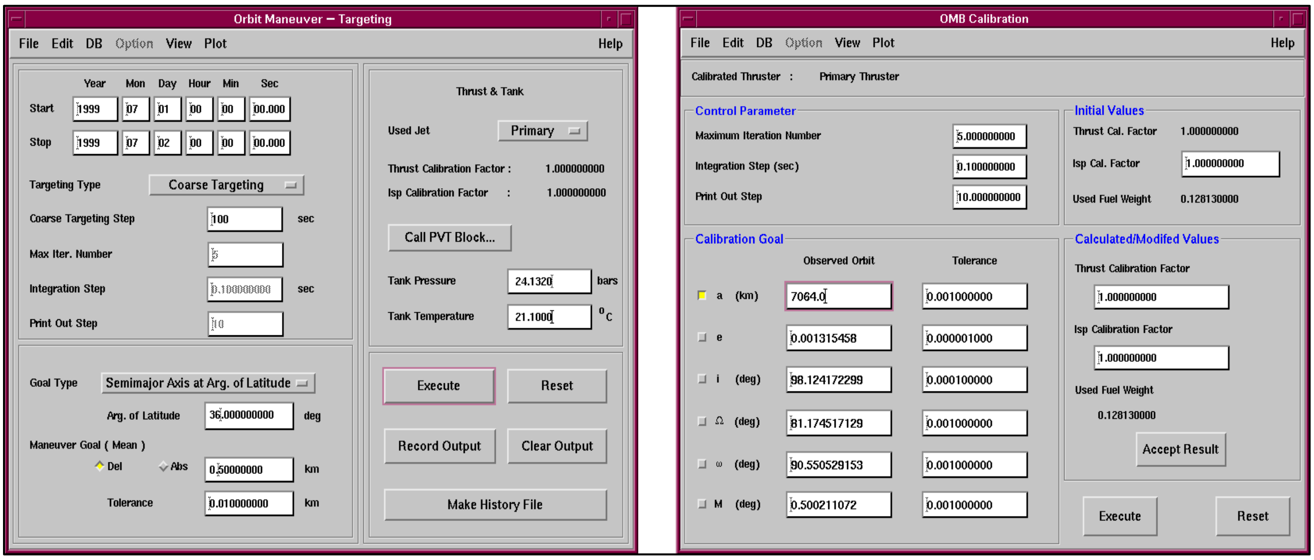

Fig. 12. Orbit maneuver windows.

5. Attitude Maneuver and Determination Block

The attitude maneuver and determination block is made up of the attitude maneuver planning module and the attitude determination module. The attitude maneuver planning module provides the attitude maneuver parameters in normal mode. The attitude determination module provides fine attitude determination using the Kalman filtering technique. All the modules of Attitude Maneuver and Determination Block (AMDB) are written in Fortran.

The attitude maneuver planning module provides the means to determine the attitude maneuver parameters for attitude maneuver planning in science mode and orbit maneuver planning (i.e., delta velocity maneuver). For the KOMPSAT-I, most attitude maneuvers are the roll maneuvers that change the roll of the spacecraft for short periods to take pictures using the Electro Optical Camera. The yaw axis of the spacecraft body frame is defined to coincide with the Electro Optical Camera boresight direction. This module calculates the required maneuver angle, maneuver start time and end time to achieve the mission goal in normal mode (i.e., science and delta velocity mode) for the KOMPSAT-I from the target position and sub-satellite points so that payload points precisely at the desired target point. For the in-plane maneuver, only a pitch maneuver is required to align the thrust vector with the velocity vector. The required in-plane maneuver angle is found from the delta velocity direction in an Earth Centered Inertial coordinate system. For an out-of-plane maneuver, only a roll maneuver is required to align the thrust vector direction with the velocity vector. The ephemeris data such as spacecraft trajectory and subsatellite points are received from the ODPB block. Figure 13 shows the graphical user interface windows for attitude maneuvers.

The attitude determination module provides the fine attitude solution for the KOMPSAT-I using gyros, fine sun sensors, and conical earth sensor telemetry data. Although the attitude determination is done onboard the KOMP SAT-I, the MAPS provides this capability to verify the onboard process. The attitude computations are contained in two parts, kinematic integration and attitude estimation. The gyro provides a direct measurement of the attitude rate. However, the attitude estimation error increases with time due to the gyro drift and noise. A Kalman filter based sub-optimal filter is adopted to update these gyro drift biases and to compensate the attitude error for the OBC. For this module, a Kalman filter based optimal filter algorithm is used. A six-state optimal filter with major cycle (16 seconds) update interval is adapted for the update filter. The fine sun sensor assembly and conical earth sensor noise effects are considered as observation error sources. Attitude determination is performed with the attitude data of science or attitude hold mode after the post-launch attitude sensor calibration is completed. Figure 14 shows the graphical user interface window for attitude determination.

6. MAPS Internal Interface

The system management block is mainly responsible for the MAPS internal interfaces. It calls and initializes other blocks such as ODPB, OMB, AMDB, and MPB on the operator's demand. The common database for the spacecraft data, universal data, and station data is used in each block and it is managed by SMB. Each function block in MAPS has the internal interfaces with other functional blocks as shown in Fig. 15.

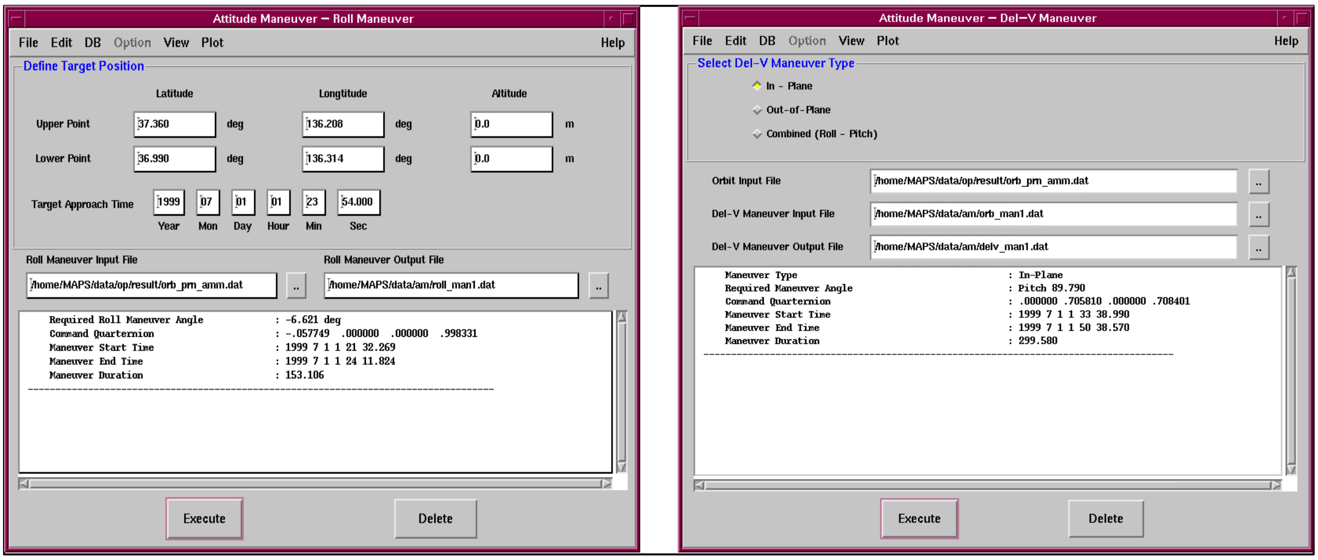

Fig. 13. Attitude maneuver windows.

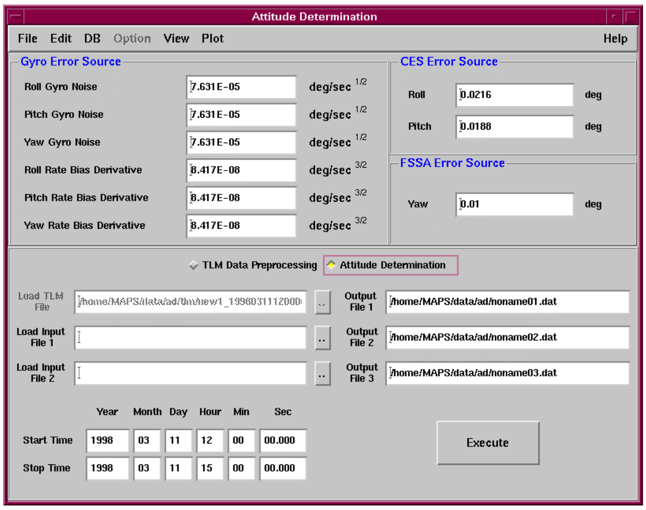

Fig. 14. Attitude determination window.

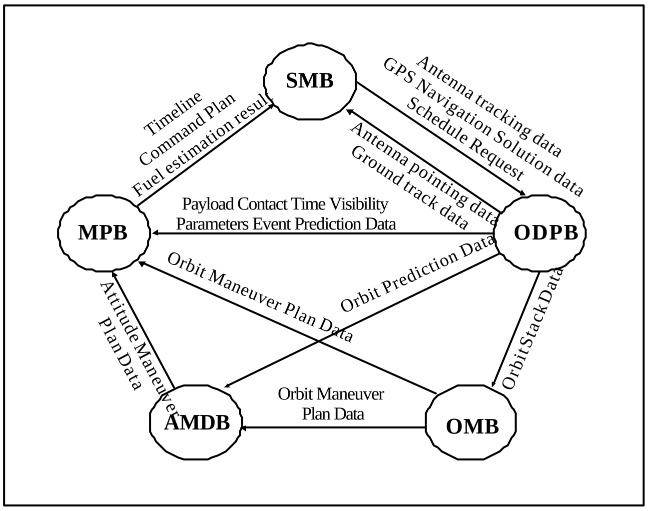

Fig. 15. MAPS interanl interfaces.

V. TESTING AND VERIFICAITON OF MAPS

The MAPS Test is designed to demonstrate that the capabilities of the MAPS satisfy the MAPS specification. The SMB, MPB, and AMDB function test have been performed. On the other hand, ODPB and OMB performance test have been done by comparing the results with various other softwares.

The functions of AMDB have been tested via analysis and simulations. The fuel accounting module of the MPB has been tested by analysis, and the Mission Planning Support Module and Mission Planning Module have been tested using STK4.0. Because of the nature of SMB, it' s functions have been tested by demonstration. Internal and External interfaces also have been tested by demonstration. All the results have been satisfactory.

The orbit prediction module (OPM) has been tested by comparing the results with the Indian Remote Sensing Satellite (IRS) propagator. IRS is a low earth orbit remote sensing satellite operated by ISTRAC of India [10]. The difference between the OPM propagator and IRS propagator came out to be less than 1 m for the semi-major axis and on the order of 10^{-5} degrees for the inclination after seven days. Similarly, the orbit determination (ODM) has been compared using the real ground antenna tracking data and orbit determination software from ISAC. The difference was on the order of 10 m for the semi-major axis and on the order of 10^{-3} degrees for the inclination. The ODM has also been tested using data simulated using an independent orbit propagator developed by the Yonsei University [11]. The differences came out to be less than 1 m for the semi-major axis using the simulated GPS data and on

Table 2. OMB tolerance.

	Tolerance		
	Delta velocity	Burn time	Fuel
Change semi-major axis by 1 km	0.001 m/s	0.1 s	0.001 kg
Change inclination by 0.1 deg	0.02 m/s	0.5 s	0.005 kg

the order of 10^{-5} degrees for the inclination. From the simulated antenna tracking data, the difference came out to be less than 1 m for the semi-major axis and on the order of 10^{-4} degrees for the inclination. We conclude that the MAPS ODM compares favorably with other independent software.

The Orbit Maneuver Block also has been tested using STK4.0, analysis, and Navigator. The orbit propagation module has been compared with the STK4.0 propagation results. After 2 days of propagation the semi-major axis showed the difference of less than 2 m and the inclination showed the difference of less than 5.6×10^{-4}. Note that these results are worse than the ODPB results for a seven day propagation. This is due to the fact that OMB's propagator is not as accurately modeled as the ODPB's propagator. For the Coarse Targeting Module, the solutions are calculated by analysis and the results were compared. The tolerances given in Table 2 were satisfied for two sample maneuvers. For the coarse fine iteration targeting, where the orbit is integrated while being maneuvered for greater precision, the results were compared with the commercially available software, Navigator™ [12]. For a manuever within 1 km semi-major axis change, 0.001 eccentricity change, and 0.1 deg inclination change, the results satisfied the tolerance of 0.05 km, 0.00001, and 0.01 deg respectively. Also MAPS has been tested for the Y2K anomaly.

VI. CONCLUSIONS

This paper discusses the design, integration and testing of KOMPSAT MAPS in detail. The MAPS consists of five blocks, SMB, MPB, ODPB, OMB, and AMDB.

The SMB performs the system management functions of MAPS. It consists of a start-up module, a block management module, an external interface module, a database management module, an exception handling module, and a shutdown module. The MPB shall be capable of performing mission timeline generation and fuel budget accounting for the KOMPSAT-I operation. The ODPB provides orbit determination, orbit prediction, and scheduling support. The orbit determination module provides a GPS based solution as the primary solution and a ground based solution as the backup. The orbit prediction module provides an ephemeris of the future spacecraft location. The mission planning support module provides various information for the mission planning. The OMB performs the analysis and plans orbit maneuvers necessary to maintain its mission orbit. The OMB consists of a coarse targeting module, a fine targeting module, and a propagation module. The AMDB shall be capable of planning various attitude maneuvers in normal situations. It also provides the attitude determination results using down-linked telemetry data.

The MAPS has been designed based on the top-down approach and modular programming method to ensure ease of modification and expansion. Furthermore, it followed recently developed system engineering concepts. In conclusion, the MAPS is ready to be used for the KOMPSAT-I which will be launched in 1999.

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