Allocation of Satellite Mission Control Functions to Subsystems – Integration or Separation

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## KOMPSAT and COMS

<table>
<thead>
<tr>
<th>Satellite System</th>
<th>KOMPSAT-1</th>
<th>KOMPSAT-2</th>
<th>COMS</th>
<th>KOMPSAT-3(A)</th>
<th>KOMPSAT-5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Orbit Altitude</strong></td>
<td>685 km</td>
<td>685 km</td>
<td>35786 km</td>
<td>685 km</td>
<td>550 km</td>
</tr>
<tr>
<td><strong>Orbit Type</strong></td>
<td>Sun-Synchronous 10:50</td>
<td>Sun-Synchronous 10:50</td>
<td>GEO (128.2deg.E) N/A</td>
<td>Sun-Synchronous 13:30</td>
<td>Sun-Synchronous 06:00Dawn-Dusk</td>
</tr>
<tr>
<td><strong>Mission</strong></td>
<td>Observation Electro Optical</td>
<td>Observation Electro Optical</td>
<td>Communications Oceanography Meteorology</td>
<td>Observation Electro Optical (Infrared)</td>
<td>Observation SAR mission</td>
</tr>
<tr>
<td><strong>Satellite Control Center</strong></td>
<td>[Image]</td>
<td>[Image]</td>
<td>[Image]</td>
<td>[Image]</td>
<td>[Image]</td>
</tr>
<tr>
<td><strong>Computer O/S</strong></td>
<td>HP-9000/J210 HP-UX Oracle/Orbix</td>
<td>HP-C3600, C3750 HP-UX Oracle/Orbix</td>
<td>PC MS-Windows none/MS.NET</td>
<td>PC MS-Windows/Linux MS-SQL/MS.NET</td>
<td>PC MS-Windows/Linux MS-SQL/MS.NET</td>
</tr>
</tbody>
</table>
Four Subsystems in KOMPSAT-1 MCE and KOMPSAT-2 MCE

- **Telemetry, Tracking and Command Subsystem (TTC)**
  - S-band uplink and downlink
  - Tracking and ranging

- **Satellite Operation Subsystem (SOS)**
  - Command processing
  - Telemetry processing and analysis

- **Mission Analysis and Planning Subsystem (MAPS)**
  - Mission planning
    - mission scheduling
    - command planning
  - Mission analysis
    - orbit determination and prediction
    - event prediction

- **Satellite Simulator Subsystem (SIM)**
  - Satellite simulation
  - Operator training
Five Subsystems in KOMPSAT-3 MCE and KOMPSAT-5 MCE

- Telemetry, Tracking and Command Subsystem (TTC)
  - S-band uplink and downlink
  - Tracking and ranging

- Satellite Operation Subsystem (SOS)
  - Command planning
  - Command processing
  - Telemetry Processing and Analysis

- Mission Planning Subsystem (MPS)
  - Event prediction
  - Mission scheduling

- Flight Dynamics Subsystem (FDS)
  - Orbit determination and prediction

- Satellite Simulator Subsystem (SIM)
  - Satellite Simulation
  - Operator Training
KOMPSAT-2 MAPS Functional Structure

**Maps**
- Precise Orbit Determination (POD)
  - Precise Orbit Determination
  - Simulated DGPS Data Generation

**Mission Analysis (MA)**
- Operational Orbit Determination
- Orbit Prediction
- Orbit Maneuver Planning
- Attitude Maneuver Planning
- Fuel Accounting

**Mission Planning (MP)**
- Event Prediction
- Mission Scheduling
- Command Planning
- Ground Track Display

**System Management (SM)**

**User Interface**

**SOS**
- Command Plan
- Mission Timeline
- Orbit Propagation Data
- Remaining Fuel Data

**SIM**

**TTC**
- Antenna Tracking Data
- Antenna Pointing Data
- GPS Data
- SOH TM
- TC Logs

**IRPE**
- Mission Timeline
- Orbit State Data
- POD Result Data
- Payload Operational Request Confirm

**External GS**
- Orbit State Data
- Antenna Tracking Data

**Launch Site**
- Initial Orbit Element

**IGS Site**
- DGPS Data

**Weather Source**
- Weather Data

**APS**
- Mission Timeline
- ECF Data
- X-band APS Data

**ETRI**
KOMPSAT-2 MAPS Computer

Dual Display One Computer

MAPS

Mission Analysis and Planning W/S

HP-C3600

PC(CFI for APS)

MCE LaserJet Printer

Image Reception and Processing Elements (IRPE)

Satellite Operations Subsystem (SOS)

Tracking, Telemetry and Command Subsystem (TTC)

Satellite Simulator Subsystem (SIM)

Ethernet

External Link
Event Prediction

Event Prediction Period & Epoch

Epoch Time: 2003 / 02 / 13 15:02:21.000
Start Time: 2003 / 02 / 14 00:00:00
Stop Time: 2003 / 02 / 15 00:00:00

Prediction Duration
- Daily
- Weekly
- Monthly
- Custom

Orbital Element
- Semi-Major Axis [km]: 7048.871
- Eccentricity [-]: 0.012594
- Inclination [deg]: 88.09382
- RA of Ascending Node [deg]: 308.42033
- Argument of Perigee [deg]: 24.08008
- Mean Anomaly [deg]: 106.34662

Mission Support Files
- Imaging Request (ID: 5000):
  - /home/kompasat2/maps/data/ms/schreq/SHF_IRPE_20020214_1.DAT
  - /home/kompasat2/maps/data/ms/schreq/SHF_USER_20020214_1.DAT

- Orbit Maneuver (ID: 6000):
  - /home/kompasat2/maps/data/om/result/orb_man_20020214.dat

Event
- All
- Eclipse Time (ID: 1001 - 1002)
- Sensor Intrusion (ID: 2001 - 2004)
- Orbital Crossings (ID: 3001 - 3003)
- G/S Contact (ID: 4000)

Ground Stations
Available:
- ID: 4321 GSO
  - Name: GSO
  - Latitude: 11.005
  - Longitude: 47.005

Selected:
- ID: 4441 TAEJON-S
  - Name: TAEJON-S
  - Latitude: 127.36
  - Log: 36.4

- ID: 4442 TAEJON-X
  - Name: TAEJON-X
  - Latitude: 127.36
  - Log: 36.4
### Mission Scheduling

**Schedule Item**  
<table>
<thead>
<tr>
<th>10 02</th>
<th>10 03</th>
<th>10 04</th>
<th>10 05</th>
<th>10 06</th>
<th>10 07</th>
<th>10 08</th>
<th>10 09</th>
<th>10 10</th>
<th>10 11</th>
<th>10 12</th>
<th>10 13</th>
<th>10 14</th>
<th>10 15</th>
<th>10 16</th>
<th>10 17</th>
<th>10 18</th>
<th>10 19</th>
<th>10 20</th>
<th>11 00</th>
<th>11 01</th>
<th>11 02</th>
<th>11 03</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1 Calendar</td>
<td>ECLIPSE</td>
<td>SENSOR4</td>
<td>POLE CROSSING</td>
<td>NODE CROSSING</td>
<td>ASPD CROSSING</td>
<td>CONTACT</td>
<td>TILE EVENT</td>
<td>TELECOM</td>
<td>Drum &amp; Head</td>
<td>Drum &amp; Head</td>
<td>Drum &amp; Head</td>
<td>X Contact Upload</td>
<td>X Contact Upload</td>
<td>Dump_20K</td>
<td>M8C</td>
<td>Dump_10 image</td>
<td>KOMPSAT 2×</td>
<td>Memory</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Conflict Schedule

<table>
<thead>
<tr>
<th>Type</th>
<th>Id1</th>
<th>Id1 Name</th>
<th>Id2</th>
<th>Id2 Name</th>
<th>Message</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-C</td>
<td>2</td>
<td>Eclipse</td>
<td>184</td>
<td>image</td>
<td>exclusive constrained calendar error, check the start time or stop time of constrained task</td>
</tr>
<tr>
<td>T-R</td>
<td>157</td>
<td>image</td>
<td>10</td>
<td>Memory</td>
<td>out of minimum value of resource, task cannot make current value of resource less than it's minimum value</td>
</tr>
</tbody>
</table>
Reason for Separation of MAPS Functions

Specialties in satellite operation people – one people not for all operations
  - Flight dynamics
  - Mission planning
  - Command operations

Intensive work required in KOMPSAT-2 mission planning due to many observations in the world – 1m resolution image
  - Inconvenient to share one MAPS computer by two operators (FD and MP)
  - One more MAPS computer installed – same functionality but different usage

Next satellite mission
  - KOMPSAT-3 is for EO mission with agility – New functionality required
  - KOMPSAT-5 is for SAR mission - New functionality required

Flight dynamics functions
  - general functions can be added for different satellite missions

Mission planning functions
  - special functions should be replaced for different satellite mission

KOMPSAT-2 MAPS functions are separated and allocated to FDS, MPS, and SOS for KOMPSAT-3 MCE and KOMPSAT-5 MCE
K-2 MAPS          K-3 MPS            K-5 MPS

Mission Planning

- Command Planning
  - Performed by MP

- Ground Track Data
  - Generated by MA
  - Used by MP

FDS: Flight Dynamics Subsystem
MA: Mission Analysis
MP: Mission Planning
MPS: Mission Planning Subsystem
POD: Precision Orbit Determination
SAR: Synthetic Aperture Radar
SM: System Management
SOS: Satellite Operations Subsystem
XAPG: X-band Antenna Pointing data Generation

K2 MAPS
- MA
- MP
- POD
- SM

K3 MPS
- MP
- SM
- XAPG

Additional Functions
- Imaging Area Display
- X-band Antenna Pointing Data Generation
- Guidance Profile Generation
- Communication Coverage Analysis
  - Agility Management
  - Various Imaging Modes and scenarios

K5 MPS
- MP
- SM

Weather Source interface

K-3 MPS

Attitude Maneuver Planning

K-5 MPS

Removal of Weather Source Interface

Addition of SAR Imaging Planning
  - Removal of Attitude maneuver planning
  - Addition of SAR incidence angle planning
  - Addition of Imaging Planning Mode

Removal of X-band Antenna Pointing Data Generation
Flight Dynamics

AOPOD: Atmospheric Occultation POD
FDS: Flight Dynamics Subsystem
ILRS: International Laser Ranging Service
MA: Mission Analysis
MP: Mission Planning
MPS: Mission Planning Subsystem
POD: Precision Orbit Determination
SAR: Synthetic Aperture Radar
SM: System Management
SOS: Satellite Operations Subsystem
Development of K-3 and K-5 MCE

Design Characteristics

- Objected-oriented analysis and design methodology
- Heritages from KOMPSAT-2 MCE used for risk mitigation and cost reduction
- Co-work with AIT Team to develop the core modules in commanding and telemetry system

Development Environment

- Operating System
  - Windows (SOS, SIM) : co-work with AIT
  - Linux (MPS, FDS) : Re-use the heritage from K-2
- Language: C++ (SOS, SIM), FORTRAN, C++(MPS, FDS)
- DBMS: MS SQL Database (SOS), Binary File (SIM)
- Middleware: Microsoft .NET framework
- GUI Tool: Nokia(Trolltech) QT, Component One
- Design Tool: Star UML
Conclusions

Four Subsystems Structure Implemented for KOMPSAT-1 and KOMPSAT-2 Mission Control Element (MCE)
- Flight dynamics, mission planning and command planning functions integrated into Mission Analysis and Planning Subsystem

MAPS Functions Separated and Allocated to FDS, MPS, SOS for KOMPSAT-3 and KOMPSAT-5 MCE
- For convenient operation of the subsystem by operator specialties
- Due to different characteristics of FDS and MPS
  - FDS – general functionality satisfied for all satellite missions
  - MPS – special functionality required for each satellite mission

Five subsystems structure is now well established for KOMPSAT and COMS satellite mission control
- TTC, SOS, MPS, FDS, SIM for KOMPSAT Mission Control Element (MCE)
- TTC, ROS, MPS, FDS, CSS for COMS Satellite Ground Control System (SGCS)
COMS SGCS Functional Structure

Satellite Ground Control System (SGCS)

- Mission Planning Subsystem (MPS)
  - Mission Request Gathering
  - Mission Scheduling
  - Mission Schedule Reporting

- Real-time Operations Subsystem (ROS)
  - Telemetry Processing
  - Telemetry Analysis
  - Command Planning
  - Telecommand Processing

- Flight Dynamics Subsystem (FDS)
  - Orbit Determination and Prediction
  - Station Keeping and Re-location Planning
  - Satellite Event Prediction
  - Satellite Fuel Accounting

- Telemetry, Tracking, and Command (TTC)
  - Telemetry Reception
  - Command Transmission
  - Tracking and Ranging
  - Control and Monitoring

- COMS Simulator Subsystem (CSS)
  - Satellite Dynamic/Static Simulation
  - Command Verification
  - Anomaly Simulation