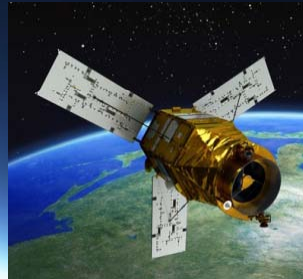


GSAW 2012

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



2012. 2. 29

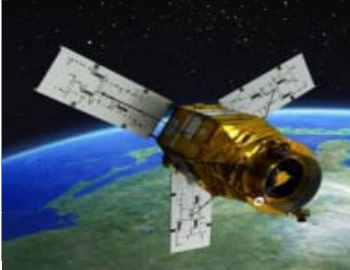
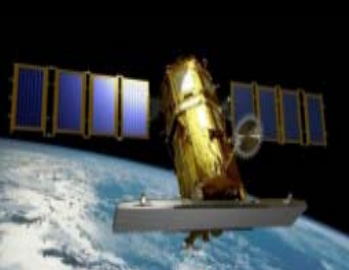
Byoung-Sun Lee

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Daejeon, Korea

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KOMPSAT and COMS

Satellite System					
	KOMPSAT-1	KOMPSAT-2	COMS	KOMPSAT-3(A)	KOMPSAT-5
Launch	1999 - 2007	2006	2010	2012(2014)	2012
Orbit Altitude	685 km	685 km	35786 km	685 km	550 km
Orbit Type LTAN	Sun-Synchronous 10:50	Sun-Synchronous 10:50	GEO (128.2deg.E) N/A	Sun-Synchronous 13:30	Sun-Synchronous 06:00Dawn-Dusk
Mission	Observation Electro Optical	Observation Electro Optical	Communications Oceanography Meteorology	Observation Electro Optical (Infrared)	Observation SAR mission
Satellite Control Center					
Computer O/S DBMS/Middle ware	HP-9000/J210 HP-UX Oracle/Orbix	HP-C3600,C3750 HP-UX Oracle/Orbix	PC MS-Windows none/MS.NET	PC MS-Windows/Linux MS-SQL/MS.NET	PC MS-Windows/Linux MS-SQL/MS.NET

KOMPSAT-1 MCE and KOMPSAT-2 MCE

■ 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

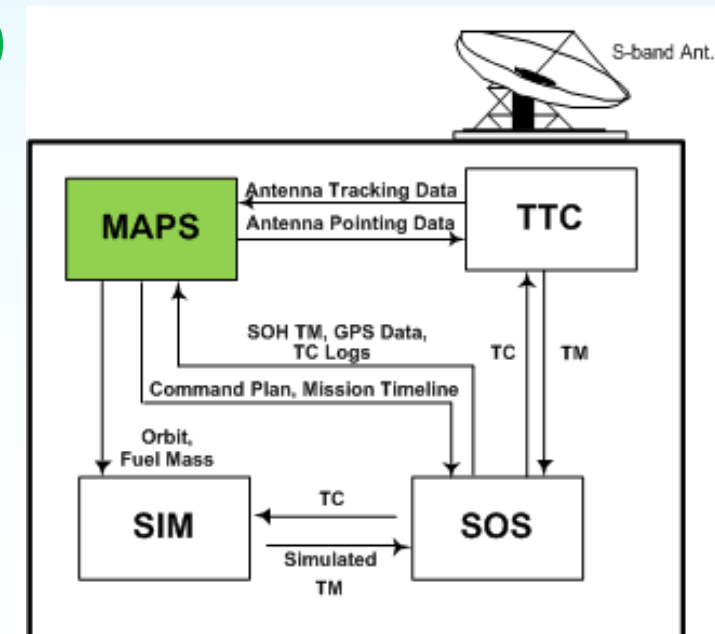
◆ Mission Analysis and Planning Subsystem (MAPS)

- Mission planning
 - ❖ mission scheduling
 - ❖ command planning
- Mission analysis
 - ❖ orbit determination and prediction
 - ❖ event prediction

◆ Satellite Simulator Subsystem (SIM)

- Satellite simulation
- Operator training

Integrated in one subsystem



KOMPSAT-3 MCE and KOMPSAT-5 MCE

■ 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

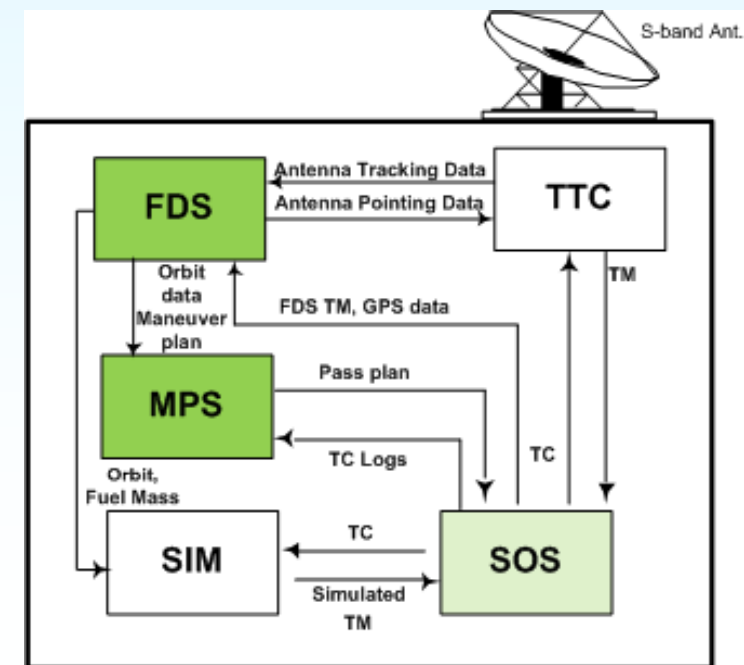
◆ Flight Dynamics Subsystem (FDS)

- Orbit determination and prediction

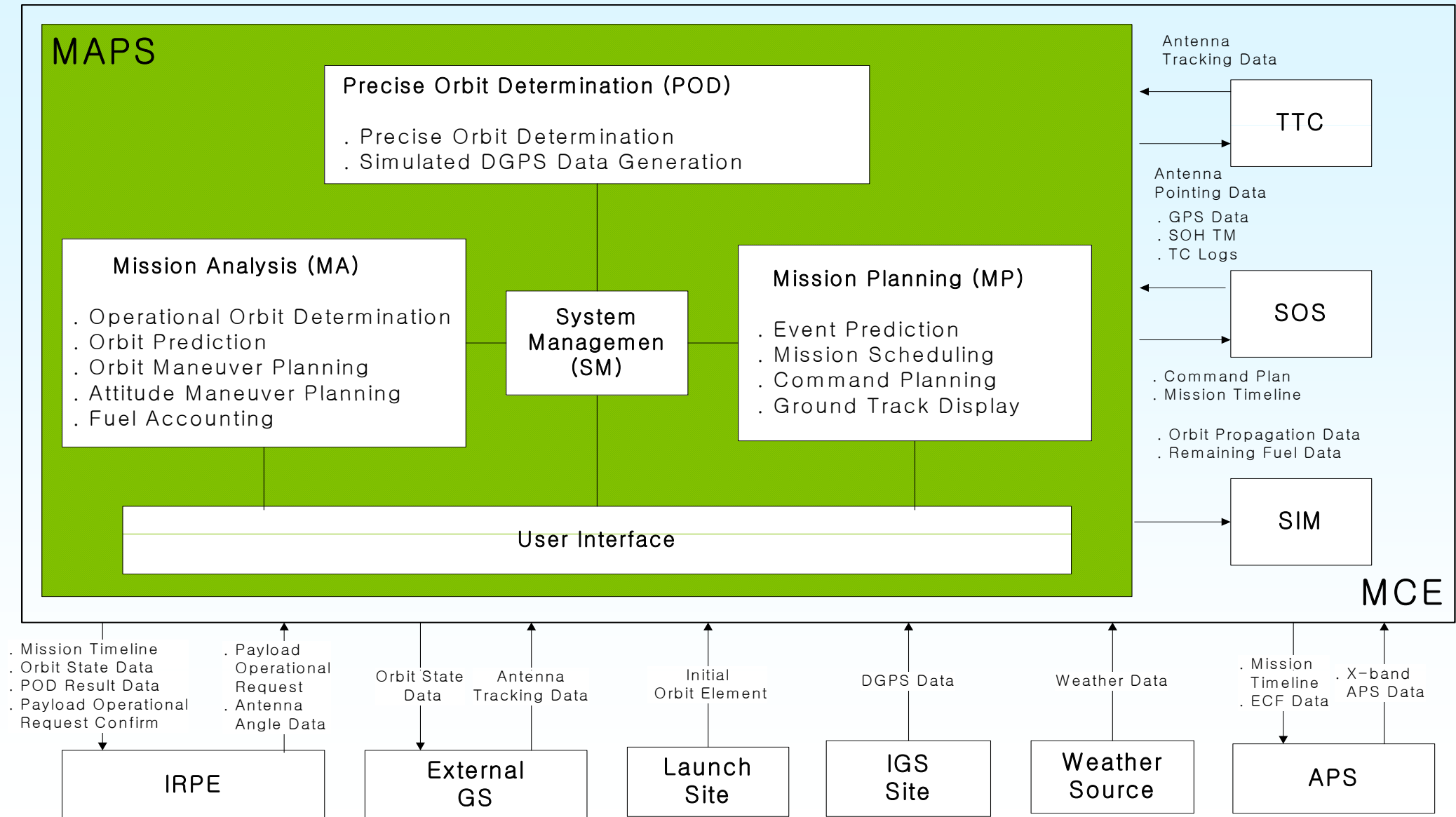
◆ Satellite Simulator Subsystem (SIM)

- Satellite Simulation
- Operator Training

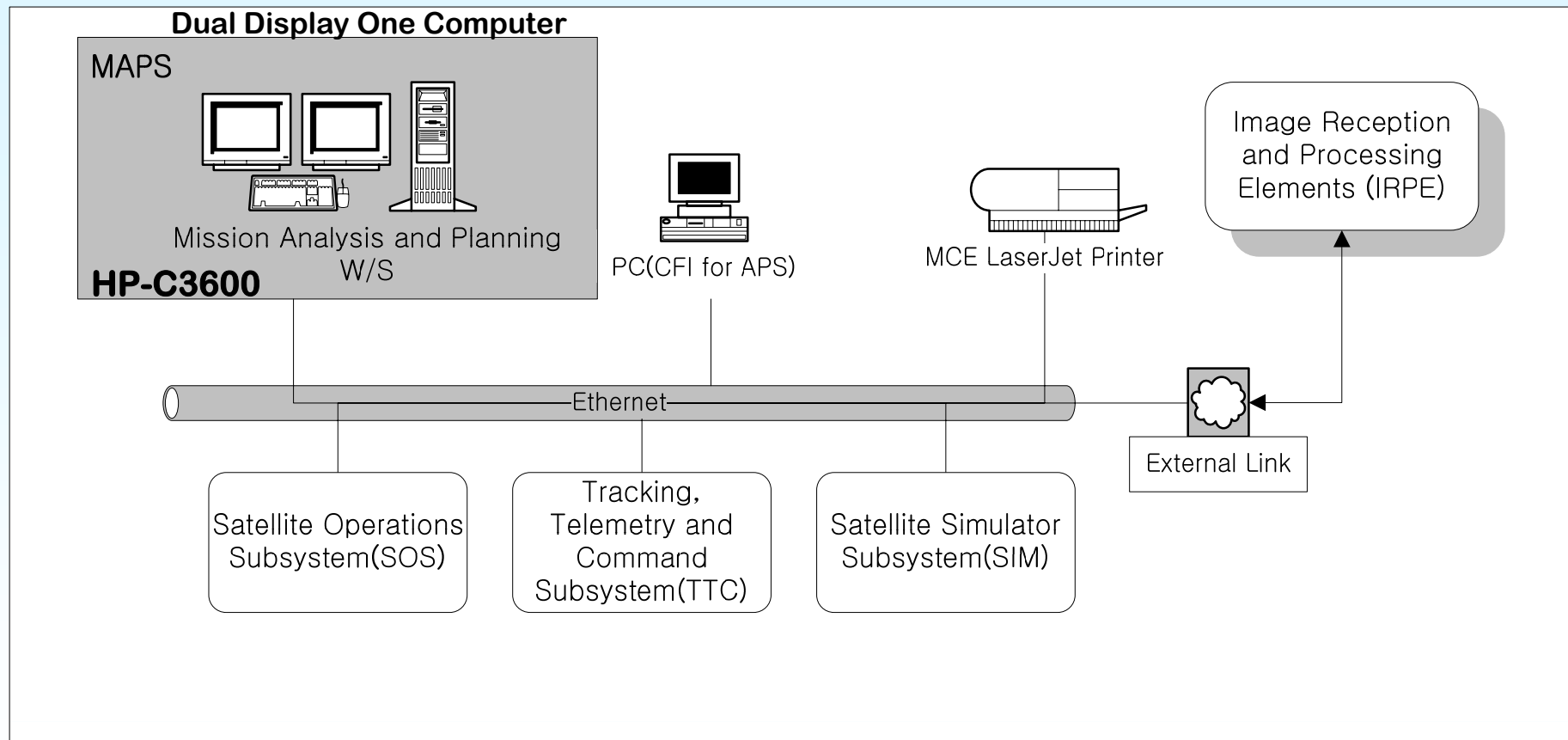
Separated to three subsystems



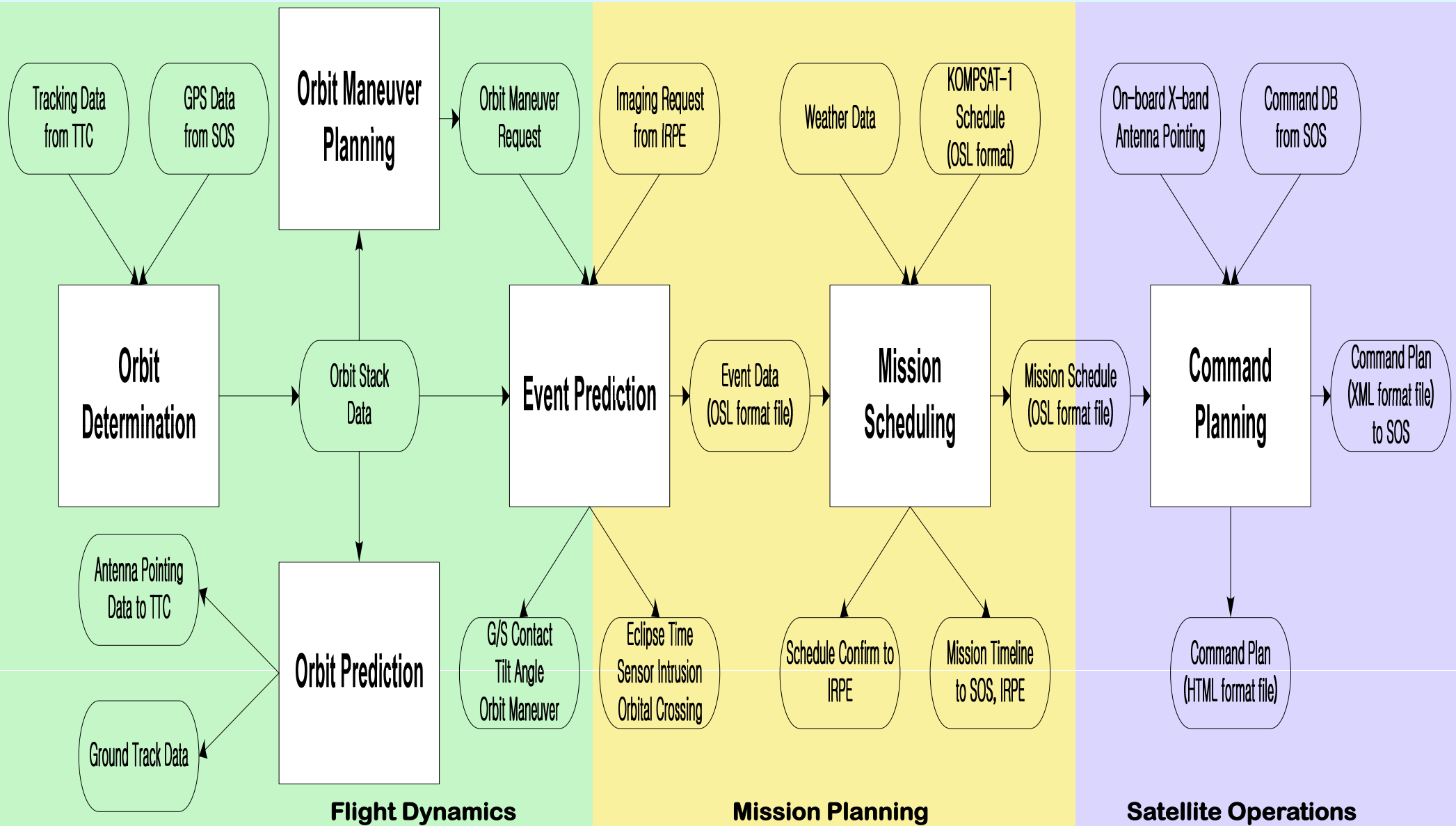
KOMPSAT-2 MAPS Functional Structure



KOMPSAT-2 MAPS Computer



KOMPSAT-2 MAPS Operational Flow



Event Prediction

Event Prediction

File Edit DB Option View Plot Help

Event Prediction Period & Epoch

Epoch Time : 2003 / 02 / 13 15 : 02 : 21.000
Start Time : 2003 / 02 / 14 00 : 00 : 00.000
Stop Time : 2003 / 02 / 15 00 : 00 : 00.000

Prediction Duration

☒ Daily ☐ Weekly
☐ Monthly ☐ Custom

Custom Option : Minute

Orbital Element

Semi-Major Axis [km] : 7045.671
Eccentricity [-] : 0.0012594
Inclination [deg] : 98.09382
RA of Ascending Node [deg] : 306.42033
Argument of Perigee [deg] : 24.09808
Mean Anomaly [deg] : 106.34662

Mission Support Files

☒ Imaging Request (ID : 5000)
/home/kompsat2/maps/data/ms/schreq/SRF_IRPE_20020214_1.DAT
/home/kompsat2/maps/data/ms/schreq/SRF_USER_20020214_1.DAT

☒ Orbit Maneuver (ID : 6000)
/home/kompsat2/maps/data/om/result/orb_man_20020214.dat

Add Remove

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

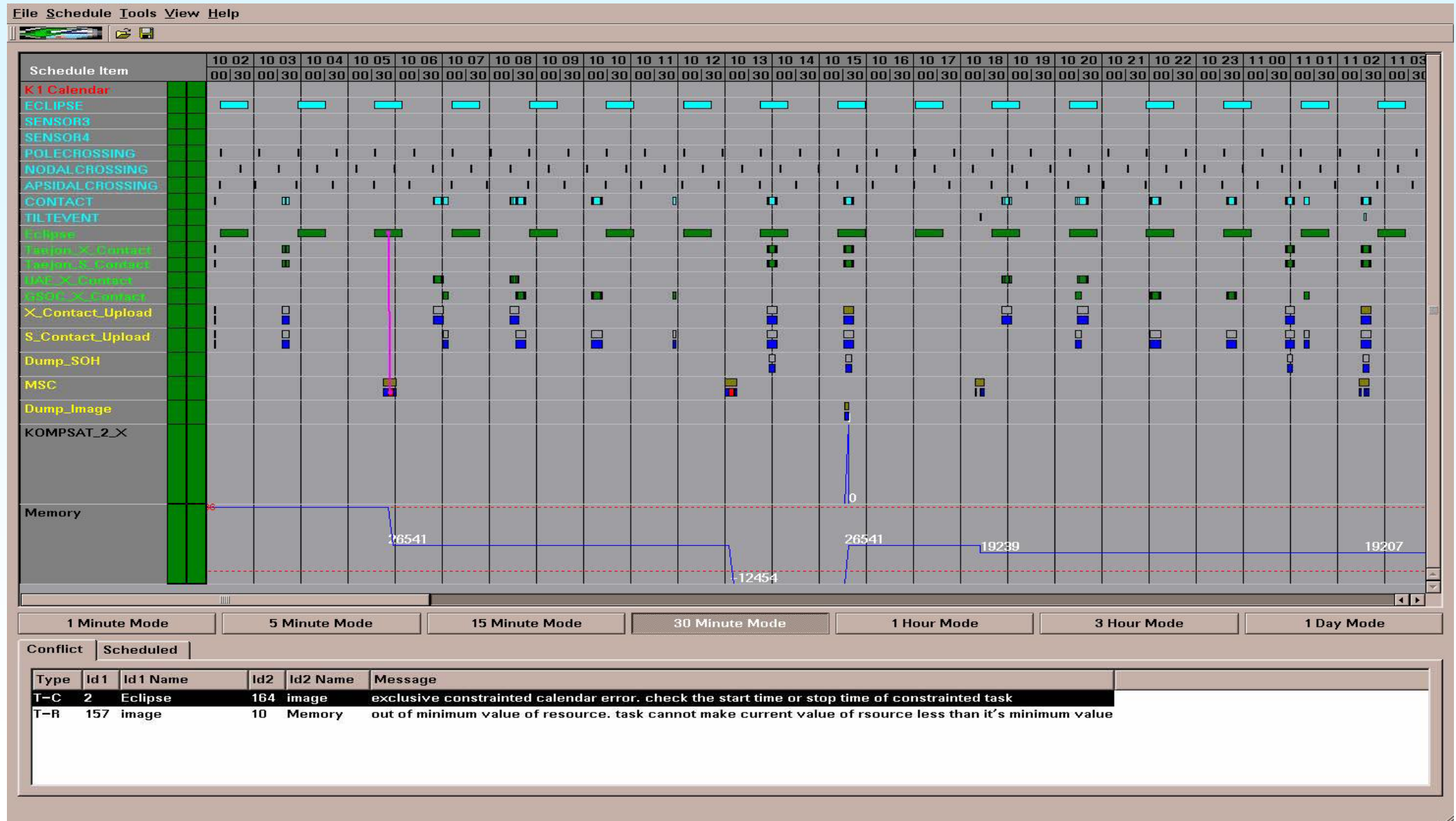
ID	Name	Latitude	Long
4321	GSOC	11.085	47.88
4443	USER	127	37

Selected

ID	Name	Latitude	Log
4441	TAEJON-S	127.36	36.4
4442	TAEJON-X	127.36	36.4

Output Reload Execute

Mission Scheduling



Command Planning

Load Mission Scheduling Data

Ground Station Contact Plan

Pass Number	Station Contact Start Time	Station Contact End Time	Duration	Elevation angle
16303	2003/01/10 02:10:01.000	2003/01/10 02:10:24.000	23	0
16304	2003/01/10 03:37:13.000	2003/01/10 03:45:27.000	494	0
16310	2003/01/10 13:54:25.000	2003/01/10 14:07:15.000	770	0
16311	2003/01/10 15:31:35.000	2003/01/10 15:44:07.000	752	0
16317	2003/01/11 00:54:05.000	2003/01/11 01:06:11.000	726	0
16318	2003/01/11 02:30:30.000	2003/01/11 02:43:35.000	785	0
16324	2003/01/11 12:53:04.000	2003/01/11 12:59:51.000	407	0
16325	2003/01/11 14:27:31.000	2003/01/11 14:41:07.000	816	0
16326	2003/01/11 16:05:37.000	2003/01/11 16:16:09.000	632	0
16331	2003/01/11 23:54:28.000	2003/01/12 00:00:08.000	340	0
16332	2003/01/12 01:26:30.000	2003/01/12 01:30:57.000	708	0

Loaded Mission

Start Time	Name
Sat Jan 11 14:27:31 2003	X_Contact_U
Sat Jan 11 14:28:45 2003	Dump_Image
Sat Jan 11 14:33:46 2003	Dump_Image

->

<-

Remove Mission from Scheduling

OK

Selected Mission

Start Time	Name
Fri Jan 10 13:00:00 2003	MSC
Fri Jan 10 18:19:10 2003	MSC
Sat Jan 11 02:28:25 2003	MSC
Sat Jan 11 02:30:30 2003	X_Contact_Upload

Make Clear Selected Mission

Cancel

Command Planning Result List

Pass Number : 16311

Ground Station : TAEJON-S

Contact Mode : PB

Contact Time	AOS	LOS	Duration
ANT-TRACK	2003/01/10 15:31:35.000	2003/01/10 15:44:07.000	12 min 32 sec
CMD	2003/01/10 15:32:56.000	2003/01/10 15:42:45.000	09 min 49 sec
TLM	2003/01/10 15:34:06.000	2003/01/10 15:41:36.000	07 min 30 sec
X-TLM	None	None	None

NUM	Execute Date Time	Command Type	Command Mnemonic	Argument / Address	Description
1		RT	CCLRCIB		For ATC OBC Buffer Clear
2		RT	ACLRCIB		For ATC RDU Buffer Clear
3		RT	ECLRCIB		For ATC ECU Buffer Clear
4		RT	KPD_q_cmd_5_Q1	value=0.0	
5		RT	KPD_q_cmd_5_Q2	value=0.0	
6		RT	KPD_q_cmd_5_Q3	value=0.0	
7		RT	KPD_q_cmd_5_Q4	value=0.0	
8		RT	KPD_q_cmd_6_Q1	value=-0.019373	
9		RT	KPD_q_cmd_6_Q2	value=0	
10		RT	KPD_q_cmd_6_Q3	value=0	
11		RT	KPD_q_cmd_6_Q4	value=0.999812	
12		RT	KPD_q_cmd_7_Q1	value=0.0309215	
13		RT	KPD_q_cmd_7_Q2	value=0	
14		RT	KPD_q_cmd_7_Q3	value=0	
15		RT	KPD_q_cmd_7_Q4	value=0.999522	
16		RT	AXRCBCRC		
17		RT	ADMPMEN	add=1e78 leng=48	
18		RT	ADMPSET		
19		RTCS	PB_MSC	OBC=31	None
20	2003/1/10 13:0:1	4	ARTCSEXC	B_RTCSID=#181	Execute RDU RTCS
21	2003/1/10 13:6:1	1440	CRTCSEXC	B_RTCSID=#241	Execute OBC RTCS
22	2003/1/10 13:6:12	44	AS1ATEN	B_SADA_TRKANG=0.0	Enable SADA Axis Track Using GRND An
23	2003/1/10 13:8:12	480	ACMDLVLH	B_SC_QUAT=5	Select Commanded LVLH Quaternion
24		RTCS	PB_MSC	OBC=32	None
25	2003/1/10 18:19:11	4	ARTCSEXC	B_RTCSID=#181	Execute RDU RTCS
26	2003/1/10 18:25:11	1440	CRTCSEXC	B_RTCSID=#241	Execute OBC RTCS
27	2003/1/10 18:25:22	44	AS1ATEN	B_SADA_TRKANG=145.734	Enable SADA Axis Track Using GRND An
28	2003/1/10 18:27:22	480	ACMDLVLH	B_SC_QUAT=6	Select Commanded LVLH Quaternion
29		RT	CXOCBCRC		
30		RT	CDMPRTCS	OBC=31	
31		RT	CDMPRTCS	OBC=32	

Edit Command

Delete Command

Insert Command

\$1.start.atc

Insert RTCS

Load Command Plan

Store Command Plan

Generate Transfer File

Generate Report File

Transfer Data

Close

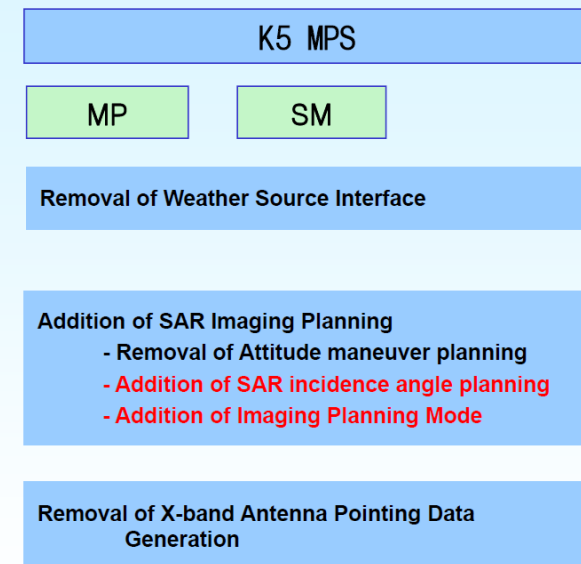
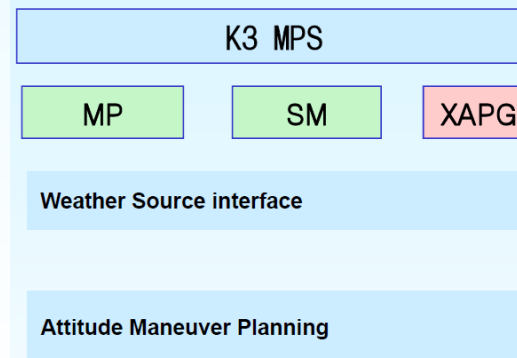
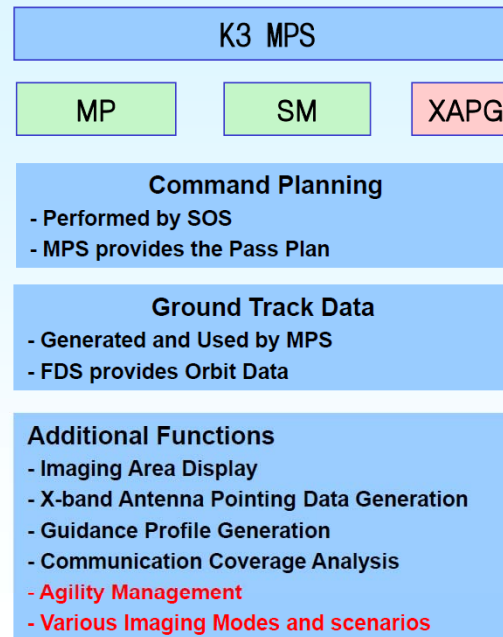
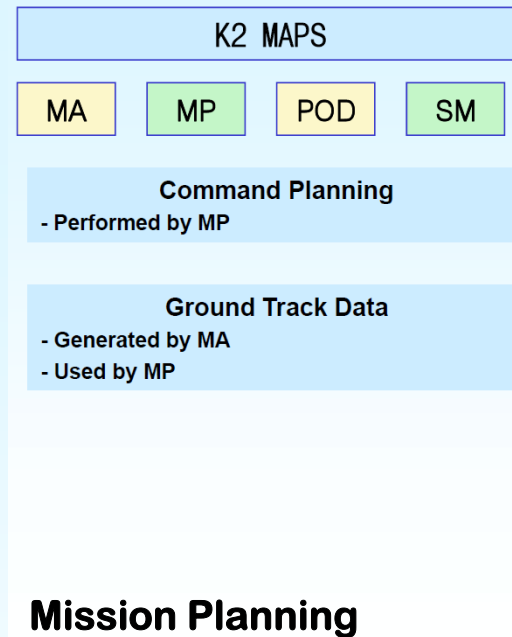
Reason for Separation of MAPS Functions

- **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



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

K-2 MAPS

K-3 FDS

K-5 FDS

K2 MAPS

MA

MP

POD

SM

K3 FDS

MA

POD

SM

Additional function

- Osculating to Mean Orbit Conversion

Additional function

- Mean Orbit Propagation

Additional function

- Semi-autonomous function for POD

K3 FDS

MA

POD

SM

K5 FDS

MA

POD

SM

Addition of Ground Track Maintenance
Maneuver

Addition of Ground Track Deviation Prediction

Addition of POD by AOPD Dual Freq GPS Raw
Data

Addition of POD by SLR Data
-ILRS Site Interface

Flight Dynamics

AOPD: 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

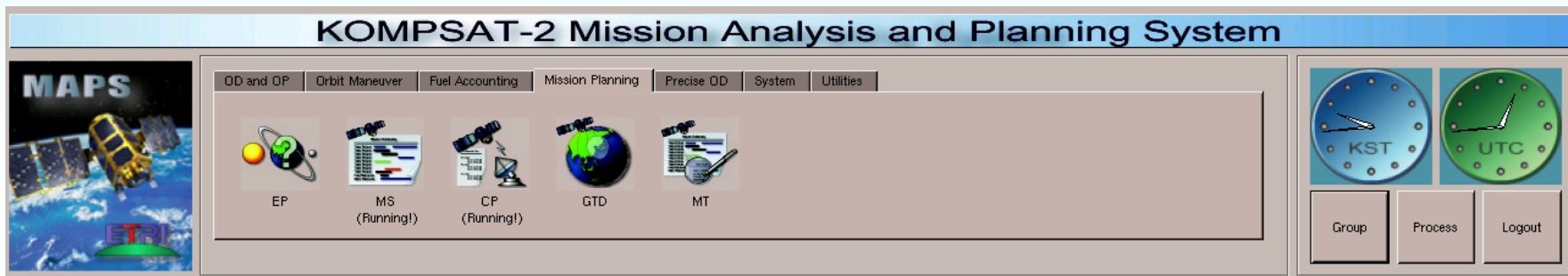
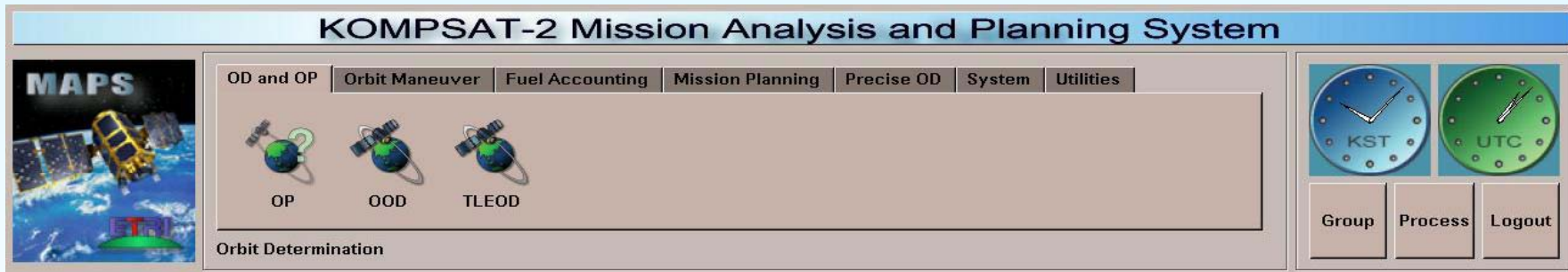
Design Characteristics

- 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

KOMPSAT-1 MAPS and KOMPSAT-2 MAPS



K-3 MPS K-3 FDS K-5 MPS K-5 FDS

Kompsat3 MPS System

Mission Planning | System | Utilities | ETC

DM EI SYNCH HELP

KST UTC

Group Process Logout

Kompsat3 FDS System

OD and OP | Orbit Maneuver | Event Prediction | Fuel Accounting | Precise OD | GTD | System | Utilities

OP OOD TLEOD OSMEAN MOP GTS

Two Line Element OD

KST UTC

Group Process Logout

Kompsat_5 MPS System

Mission Planning | System | Utilities | ETC

EP MS GTD MT

KOMPSAT-5 MPS Event Predictor

KST UTC

Group Process Logout

Kompsat5 FDS System

OD and OP | Orbit Maneuver | Event Prediction | Fuel Accounting | Precise OD | System | Utilities | ETC

OP OOD TLEOD OSMEAN MOP GTS

Two Line Element OD

KST UTC

Group Process Logout

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

