SPACE SYSTEMS

SOFTWARE SYSTEMS

SYSTEM INTEGRATION LABORATORY

VERIFICATION SOFTWARE INFRASTRUCTURE: (SDYA)

System Integration Laboratory Verification Software (SDYA) is a generic, real time, distributed simulation infrastructure (engine) software. SDYA allows verification of Flight Software, Ground Station Command and Control Software within a simulated laboratory environment. It replaces the real avionics equipment, and mimics their functional behavior. SDYA communicates with Flight Software (On-Board Software), and Ground Station Command and Control Software through real avionics interfaces (MIL-STD-1553, Serial, SpaceWire, Can Bus, etc.). It is used to apply integrated test scenarios in system integration laboratory.

SDYA provides infrastructure and tools that can be easily extended for new features and new technologies.

SDYA performs the following critical functions:

- Avionic hardware integration
- On-Board Software verification
- Verification of software and hardware interfaces
- Replacement of real equipment with simulation models
- Avionic system hardware and software acceptance tests
- Equipment failure detection

SDYA uses the following technologies and tools:

- Operating System: RT_preempt Linux and Windows
- Programming Language: C++
- Middleware: ZeroMQ
- User Interface Development Tool: Qt GUI toolkit
- Script Engine Language: Python

SDYA is developed in compliance with the following standards:

- CMMI Maturity Level 3
- RTCA DO-178B: Software Considerations in Airborne Systems and Equipment Certification Standard (as a verification tool)
- ESA ECSS-E-ST-10-11C(31July2008) Human Factors Engineering Standard
- 1553 interfaces compatible with MIL-STD-1553B
- ESA ECSS-E-ST-40C: Space Software Engineering Standard
- ESA ECSS-Q-ST-80C: Space Software Product Assurance Standard

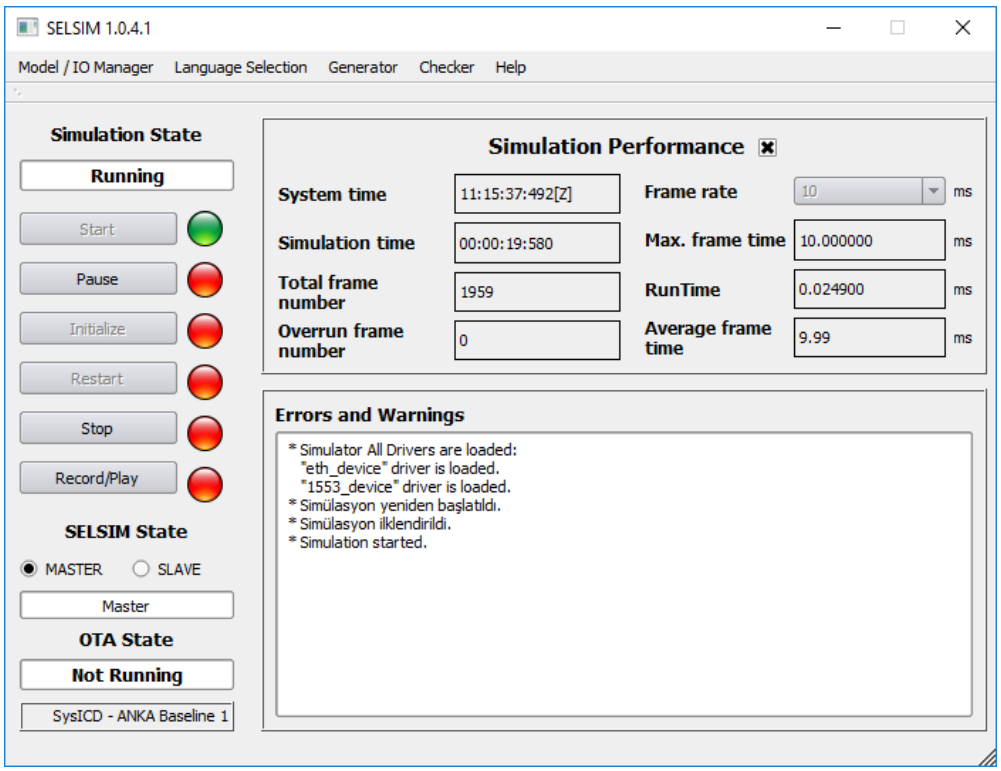
SDYA COMPONENTS

SDYA infrastructure consists of the following software modules:

- **SELSIM**

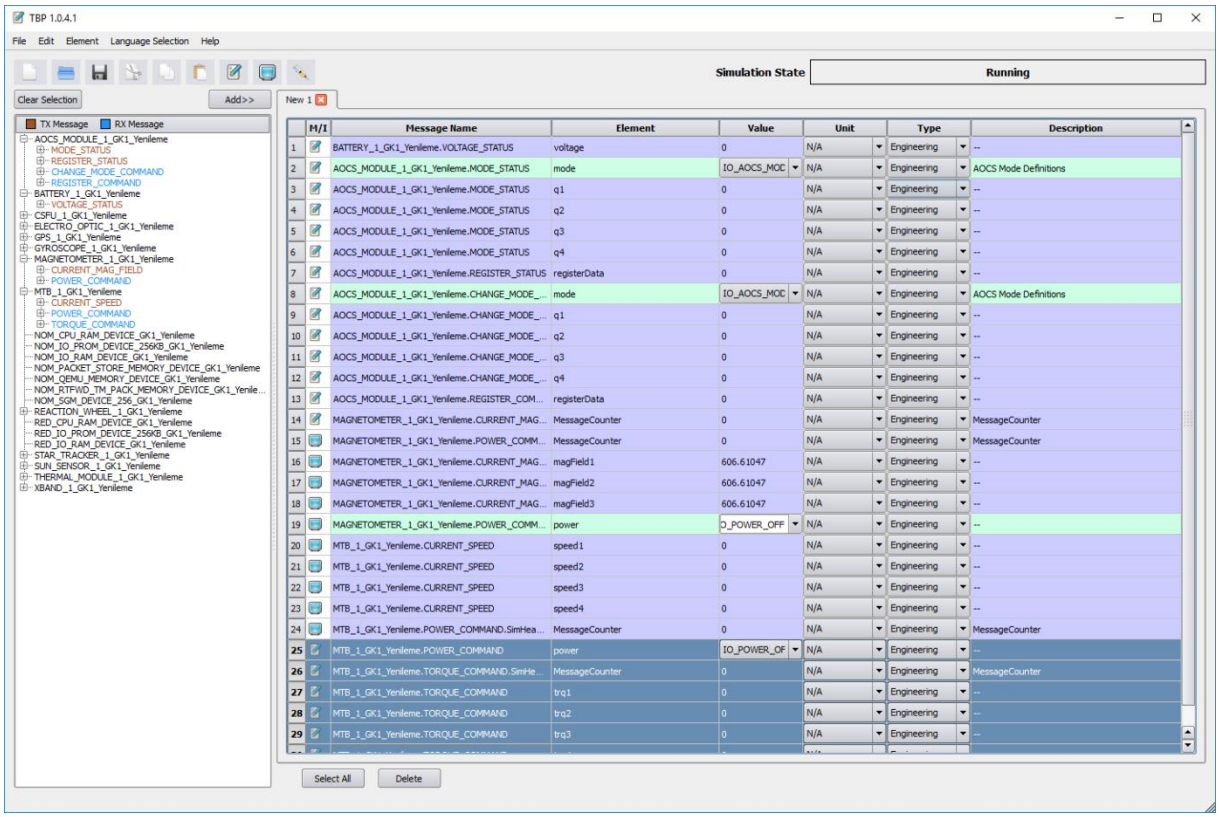
Contains all required simulation models and controls the scheduling of models.

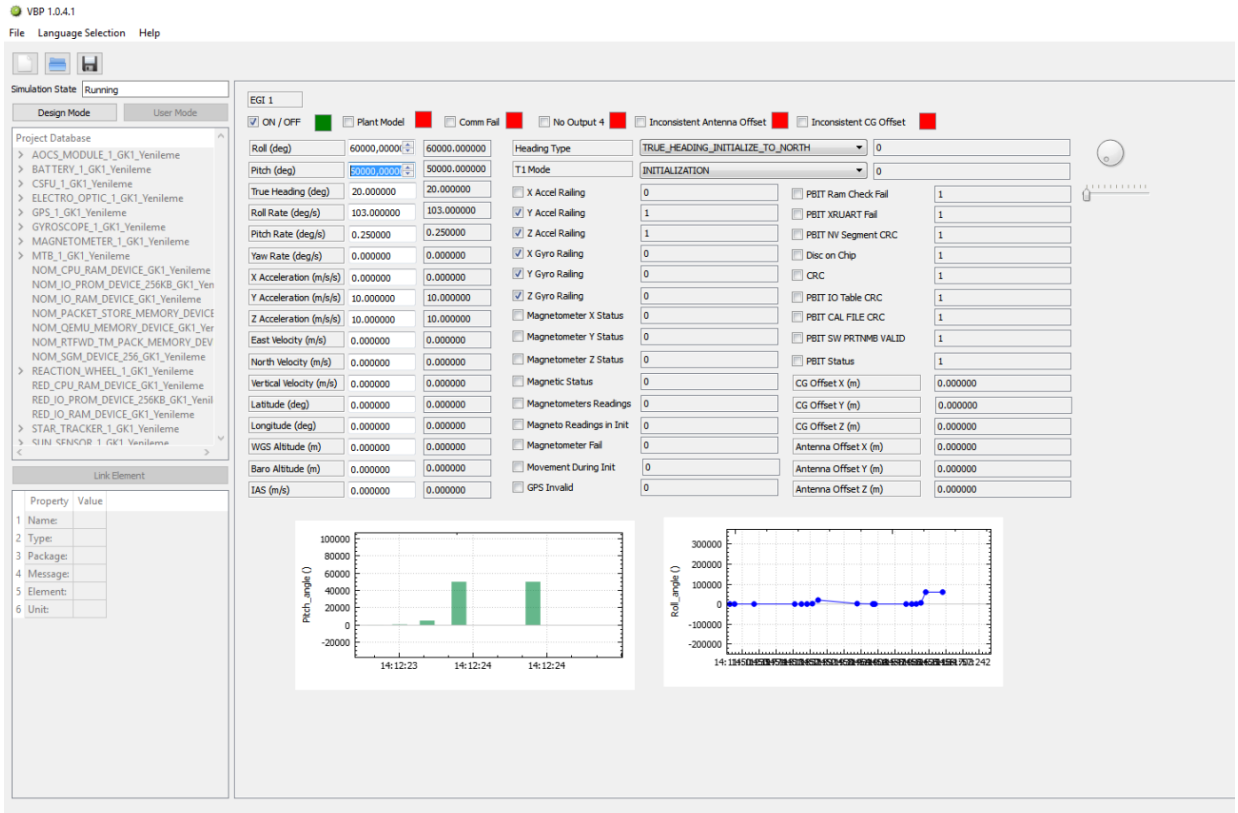
It publishes/subscribes information of simulation objects to the outside world i.e. Model User Interface. Communicates with real equipments over avionic data buses.



- **MODEL USER INTERFACE (MUI)**

SDYA includes user interface to allow simulator runtime behavior to be monitored and for data injection. The MUI can display the status of the simulated model (i.e. a spacecraft avionic) including all messages. The simulation environment displays error messages for all erroneous conditions. There is also a drag-and-drop feature to be display (avionic bus) data.


TBP 1.0.4.1
File Edit Element Language Selection Help
Simulation State
Running
Clear Selection
Add>>
New 1
TX Message
RX Message
Select All
Delete


VBP 1.0.4.1
File Language Selection Help
Simulation State
Running
Design Mode
User Mode
Project Database
Link Element
EGI 1
ON / OFF
Plant Model
Comm Fail
No Output 4
Inconsistent Antenna Offset
Inconsistent CG Offset
Roll (deg)
Pitch (deg)
True Heading (deg)
Roll Rate (deg/s)
Pitch Rate (deg/s)
Yaw Rate (deg/s)
X Acceleration (m/s/s)
Y Acceleration (m/s/s)
Z Acceleration (m/s/s)
East Velocity (m/s)
North Velocity (m/s)
Vertical Velocity (m/s)
Latitude (deg)
Longitude (deg)
WGS Altitude (m)
Baro Altitude (m)
IAS (m/s)
Heading Type
TRUE_HEADING_INITIALIZE_TO_NORTH
T1 Mode
INITIALIZATION
X Accel Railing
Y Accel Railing
Z Accel Railing
X Gyro Railing
Y Gyro Railing
Z Gyro Railing
Magnetometer X Status
Magnetometer Y Status
Magnetometer Z Status
Magnetic Status
Magnetometers Readings
Magneto Readings in Init
Magnetometer Fail
Movement During Init
GPS Invalid
PBIT Ram Check Fail
PBIT XRUART Fail
PBIT NV Segment CRC
Disc on Chip
CRC
PBIT IO Table CRC
PBIT CAL FILE CRC
PBIT SW PRTNMB VALID
PBIT Status
CG Offset X (m)
CG Offset Y (m)
CG Offset Z (m)
Antenna Offset X (m)
Antenna Offset Y (m)
Antenna Offset Z (m)
Pitch_angle ()
Roll_angle ()

- **DATA RECORDING AND ANALYSIS TOOL**

Allows storing of model messages to the file system on disk. Provides graphical analysis for stored messages.

- **AUTOMATED TESTING TOOL (ATT)**

Automated Testing Tool allows value injection and monitoring of element values that is used in simulation model. ATT provides an API (Application Programming Interface) to control SDYA from other applications. By this API, application developers or system testers can control features and capabilities of the SDYA infrastructure from their application. This API supports Python, C#, C++ programming languages.

- **NODE MANAGER**

Monitors other simulation tools (SELSIM, Model User Interface so on) status, collects health information which is basically a CPU and memory usage of simulation modules from other node managers, and sends open / close or master / slave commands to nodes.

ON-BOARD SOFTWARE

Turkish Aerospace On-Board Software (OBSW) is a mission/satellite independent data handling software. OBSW is based on ECSS-E-ST-70-41C - Telemetry and Telecommand Packet Utilization Standard (PUS version C). There are several standard services defined in PUS which provides common data interfaces between ground and satellite. Telemetry (TM) and telecommand (TC) transfer layer is based on CCSDS Packet Telemetry and Telecommand Standards.

OBSW contains 15 of 19 standard PUS services, 5 additional custom services based on PUS foundation model. These services allow to design operations according to client requirements without any additional software development.

Key Characteristics

- OBSW services have no dependency to satellite on-board computer and operating system thanks to the layered architecture
- Based on SAVOIR-OSRA (Space Avionics Open Interface Architecture – On-board Software Reference Architecture)
- Low coupling between OBSW services thanks to component based development approach
- Highly scalable thanks to component based development approach
- XML based TM/TC, equipment ICDs definitions
- Criticality category B according to ECSS-Q-ST-80C and ECSS-E-ST-40C
- Continuous improvement and development thanks to product line approach
- Adapted to LEON3 processor

OBSW Services

- **Standard services**
    - **Request verification** provides checks and validation on telecommands
    - **Device access** service provides commanding and acquiring data from on-board devices
    - **Housekeeping** service provides visibility of on-board parameters assembled in housekeeping and diagnostic parameter report structures
    - **Event reporting** service provides autonomous anomaly reporting
    - **Memory management** service provides capability for loading, dumping and checking the contents of memories
    - **Time management** service provides generation of time reports
    - **Time-based scheduling** service provides capability to command on-board application processes using requests pre-loaded on-board the satellite and released at their due time

- **On-board monitoring** service provides autonomy capability to monitor on-board parameters of groups of parameters and react to the violations of the related monitoring conditions by raising events.
- **Large packet transfer** service provides sending large TCs to satellite and receiving large TMs from satellite
- **Real-time forwarding** service provides capability to control the forwarding of TMs to the ground
- **On-board storage and retrieval** service provides capability to store TMs in packet stores and allow ground system to manage and downlink packet stores
- **Test** service provides capability to test functions implemented on-board and to report the test results
- **Event-action** service provides capability to define autonomously executable on-board actions when specific on-board events occurs
- **Parameter management** service provides capabilities for managing on-board parameters, including reading current values and setting new values
- **Request sequencing** service provides capability to manage the release of an on-board sequence of TCs and to load, control and report of on-board sequences

- **Additional custom services**

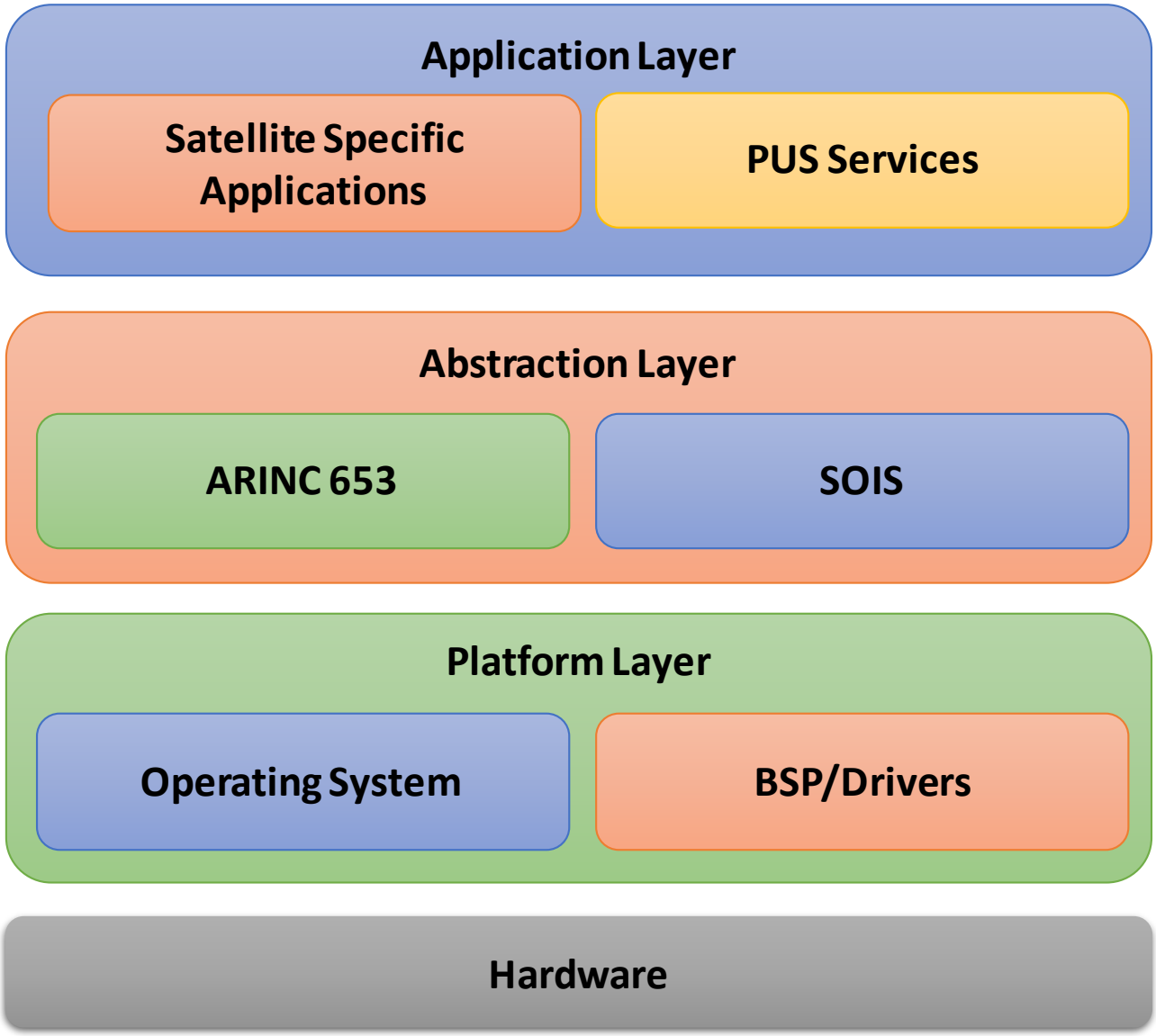
  - **Equipment and unit configuration management** service provides capability to manage on-board equipment and their configurations
  - **Mode management** service provides capability to manage on-board software, sub-systems and satellite modes
  - **Message router** service provides capability to route TCs and TMs to their destinations
  - **Software maintenance** service provides capability to update on-board software image completely and to apply patch

OBSW Architecture

- **Layered Architecture**
  - High reuse
  - Easy adaptation to different platforms
  - Easy maintainability
  - Simply modifiable

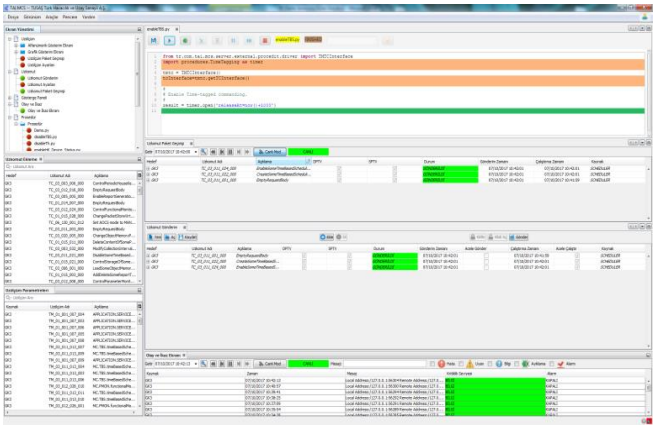
- **Resource Abstraction**
  - Operating System through ARINC653
  - Hardware through Spacecraft
  - Onboard Interface Services (SOIS)

- **Application Layer**
  - Component Based


Application Layer
Satellite Specific Applications
PUS Services
Abstraction Layer
ARINC 653
SOIS
Platform Layer
Operating System
BSP/Drivers
Hardware

MONITORING AND CONTROL SOFTWARE

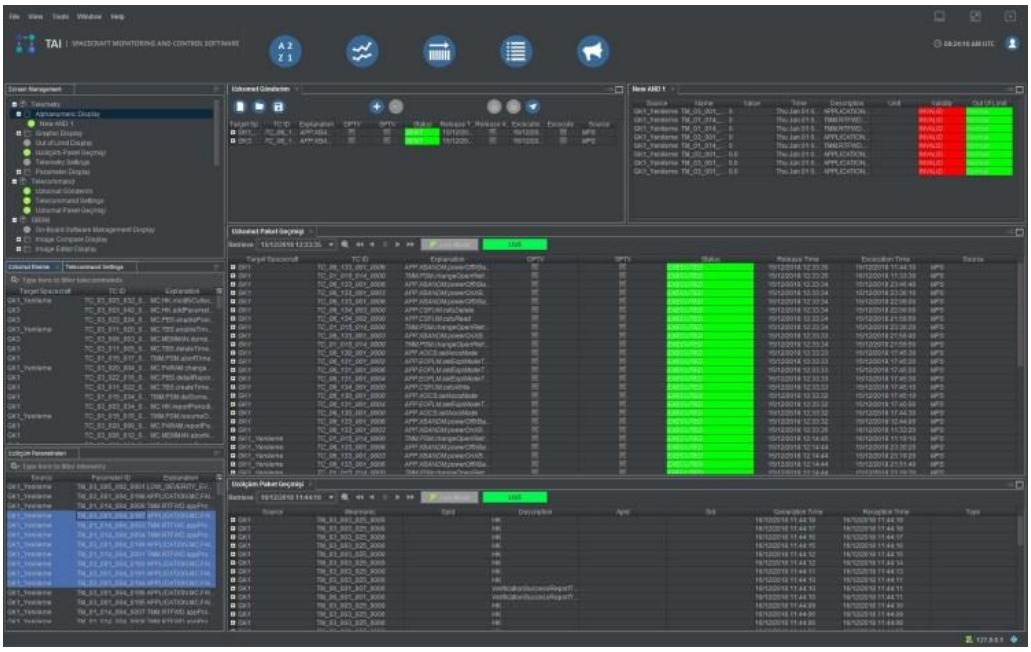
Monitoring and Control Software carries out observation and control activities of satellite and electronic ground support equipments . In another words, this software is detecting problem situations, sending commands to solve satellite problems by tracking satellite health data and uploading plans which are prepared by Mission Planning Software to the satellite.

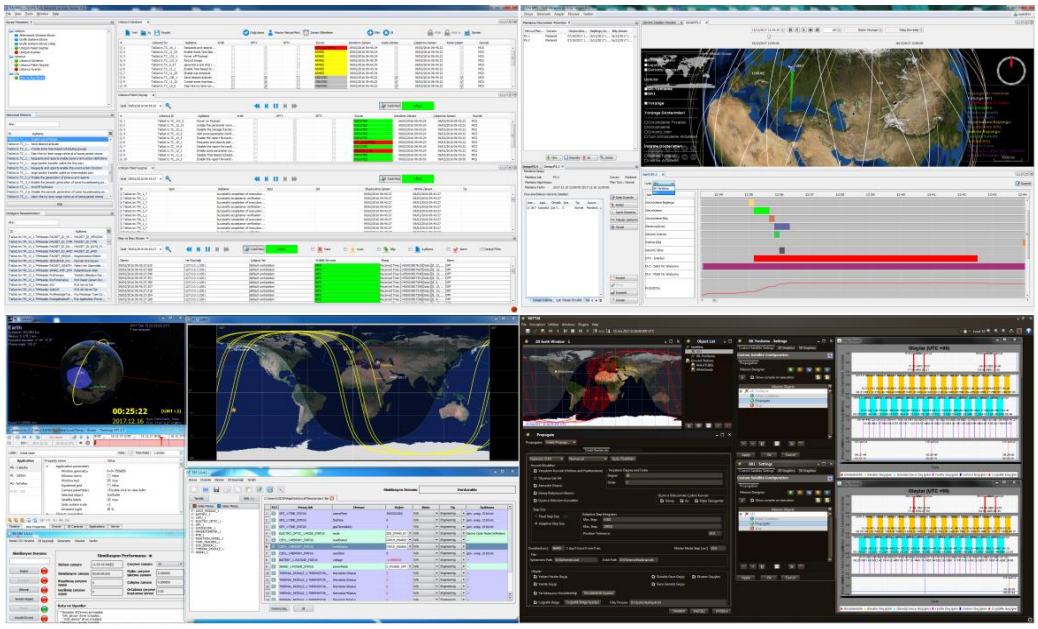


HIGHLIGHTED FUNCTIONS

- Satellite independent
- High reusability
- Client-Server architecture
- Use of new generation technology
- Designed to support for multiple satellites
- Support of various interfaces which is need by different configuration units
- Constellation support
- User workspace support
- Access control for operations
- Internalization support
- User interface theme support
- Operating System independent
- Easy maintainability
- Receive, process and archive Telemetry
- Prepare, send and archive Telecommand
- Manage satellite interface information
- Analyze and report events (alarm, log etc.)
- Analyze and report based on Telemetry/Telecommand/Event archives
- Automatic procedure support
- Communication and coordination between ground stations
- SLE (Space Link Extension) protocol support
- XML Telemetric & Command Exchange (XTCE) compatible Satellite Data Model definition

- Developed in compliance with following standards:
  - CMMI Maturity Level 3
  - ESA ECSS-E-ST-40C: Space Software Engineering Standard
  - ESA ECSS-Q-ST-80C: Space Software Product Assurance Standard





MISSION PLANNING SOFTWARE

Mission Planning Software generates mission plans for satellite's guidance sensing and downlink while considering current position of the satellite, satellite constraints, payload constraints, environmental factors. Due to the limited life time of a satellite, effective usage is vital. Mission planning software is responsible for providing maximum imaging and downlink under those constraints.

HIGHLIGHTED FUNCTIONS

- Satellite independent
- High reusability
- Client-Server architecture
- Use of new generation technology
- Designed to support for multiple satellites
- Support of various interfaces which is need by different configuration units
- Constellation support
- Show plan result on Gantt chart and the 3D world view
- User interfaces to configure parameters which can vary from satellite to satellite
- Flexibility in planning time interval
- Automatic planning support
- Minimum operator support in the planning
- User workspace support
- Access control for operations
- Internalization support
- User interface theme support
- Operating system independent
- Easy maintainability

INDEPENDENT VERIFICATION AND VALIDATION SERVICE

IV&V is a systematic approach for ensuring that a product is being built correctly and the correct product is being built.

Our services range from point–in-time assessments to a full-time multidisciplinary role, and can scale to suit the size and scope of any implementation. Services include:

- **Service Management:** activities related to the planning and coordination of IV&V tasks.
- **Engineering Activities:** focused mainly in the preparation and contribution to the technical documentation related to IV&V activities (VCDs, engineering and IV&V plans, test specifications, test procedures, …) and performing the corresponding verification and validation testing campaigns according to the agreed plans.

SERVICE MANAGEMENT

- Planning, monitoring and control of the services to be provided.
- Distribute tasks and actions to the key persons/service team members for the performance of the service.
- Prioritise tasks in coordination with the Customer Technical Officer.
- Ensure the Quality Assurance (QA) of the delivered service.

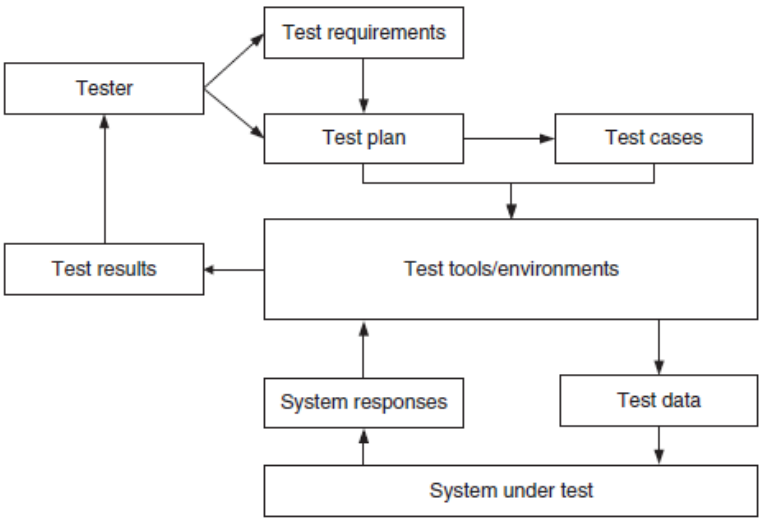
ENGINEERING ACTIVITIES

The typical activities under this service cover (but not be limited to) the following:

- Verification Control: for the requirements to be verified by test propose/define the testing activities. Ensure the scope is in line with the expected versions and that the testing activities can be scheduled within the foreseen timeframe.
- Identification of test tools and test data needed (and plan any necessary development of test tools and the tuning/modification of test data).
- Writing test specifications.
- Based on initial test specifications and other relevant documents (lower level test docs, user manuals, etc), write detailed test procedures.
- By successive iterations, refine the test procedures until they are in a status ready to be executed.
- Set up the test tools and refine the test data.
- Analysis of problems and management of anomalies.
- Scheduling and executing of all the integration and verification activities in close coordination with Customer, including requesting use of common resources.
- Performing the verification and validation activities and testing according to the plans, procedures and arrangements taken in the relevant readiness review, undertaking any required analysis of the results/issues and recording the outcome in relevant reports, and anomaly reports where necessary.

- Establishing the most suitable software test infrastructure according to the project/product requirements, providing the necessary hardware and software and, if requested, delivering them to the customer at the end of the project.

Automation is an issue that we attach great importance to in the creation and operation of test environments. For this reason, we build infrastructures to support the most basic test automation process (Figure 1) for the services we provide.



Automated Testing Process

LOCATION OF THE SERVICE

The service shall be provided, mainly, at the Turkish Aerospace's premises. (If requested) Part of the work covering integration and testing in the operational environments may be performed at Customer site.