

Advanced Integration & Test Services

Final Presentation

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2 June 2015



esa

TERMA[®]

SIEMENS

skytek



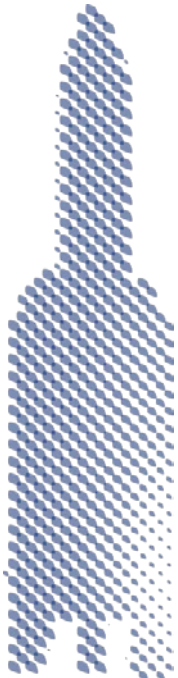
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Overview

Objectives, Tasks, Process, Technology,
Demonstrators

Objectives

- Develop **generic software components** that can be used for building Electrical Ground Support Equipment (EGSE) or Mission Control Systems (MCS) for launchers, orbital spacecraft, and satellites
- Primary **target use case Ariane 5 ME EGSE**



Project Setup

- **Customer:** ESA ESTEC
- **Prime contractor:** Airbus DS (DE)
- **Subcontractors:** Airbus DS (NL), Terma (NL/DK), Siemens (AT/CZ), Skytek (IE), DLR GSOC (DE)
- **Contributors:** Airbus DS (FR)
- Contract in GSTP frame (General Support Technology Programme)
- Objective is Technology Readiness Level 6: “System/subsystem model or prototype demonstration in a relevant environment”
- 2.9 M€ budget including 500 K€ Airbus DS R&T co-funding and pre-development activities
- Duration: Q4 / 2011 – Q1 / 2014, CCN: Q1 / 2015



Tasks

Task 1
Standards
Tailoring and
Planning

Task 2
Building Blocks
Design and
Development

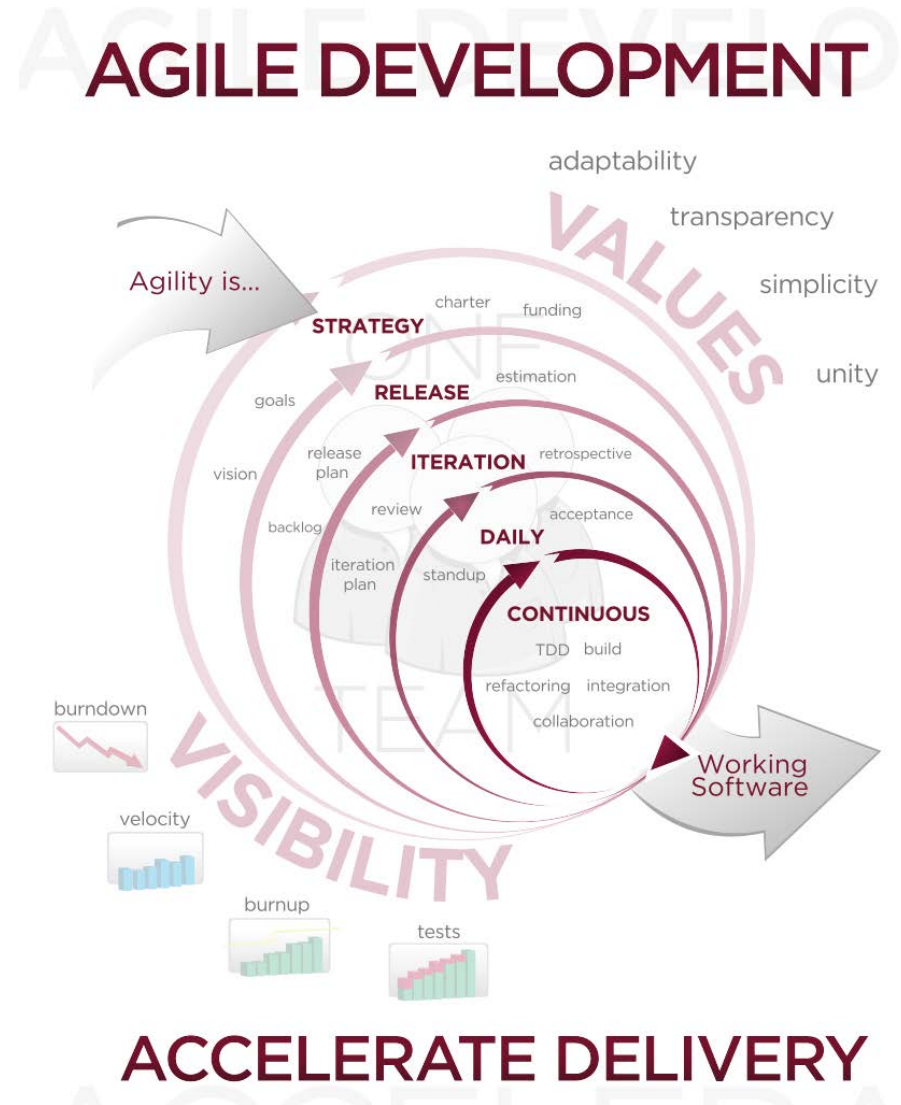
Task 3
System
Demonstrations

Task 1

Standards Tailoring and Planning

Lean and Agile Development Process

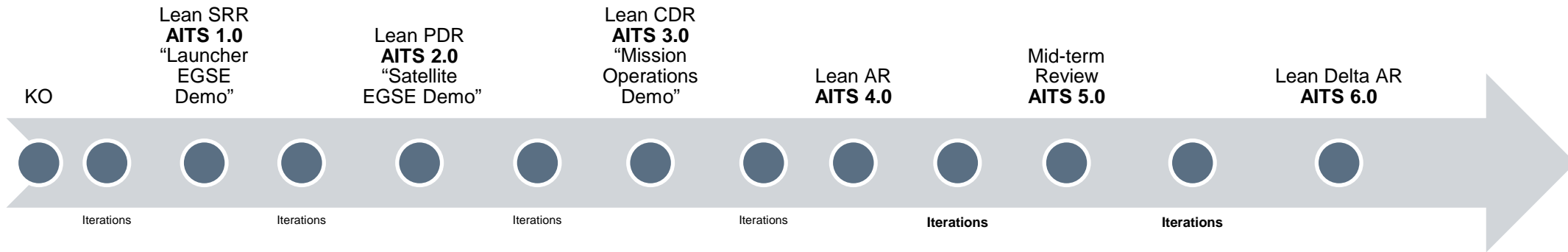
- Complex software system
- Changing requirements and priorities
- Product acceptance by end users critical for success
- Satisfy customer through early and continuous delivery of valuable software
- Process is
 - a combination of elements from Scrum, Kanban and XP with lean principles
 - adapted to ECSS E-40 / Q-80 and CMMI L3 requirements



Agile Manifesto Principles

-  Customer satisfaction by rapid delivery of useful software
-  Welcome changing requirements, even late in development
-  Working software is delivered frequently (weeks rather than months)
-  Working software is the principal measure of progress
-  Sustainable development, able to maintain a constant pace
-  Close, daily cooperation between business people and developers
-  Face-to-face conversation is the best form of communication (co-location)
-  Projects are built around motivated individuals, who should be trusted
-  Continuous attention to technical excellence and good design
-  Simplicity—the art of maximizing the amount of work not done—is essential
-  Self-organizing teams
-  Regular adaptation to changing circumstances

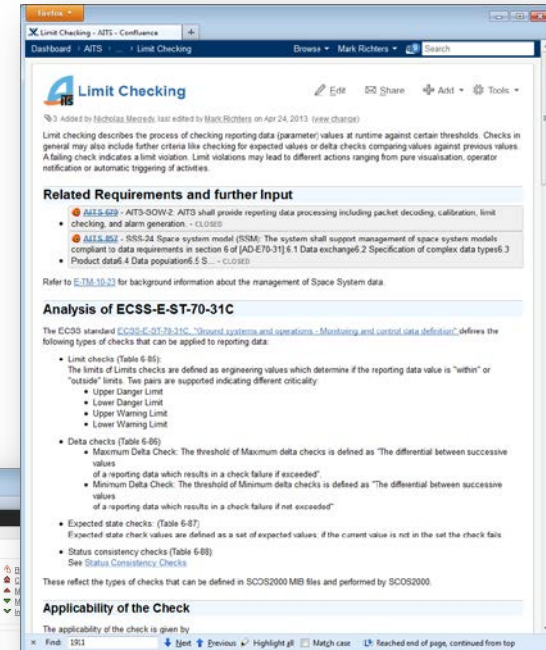
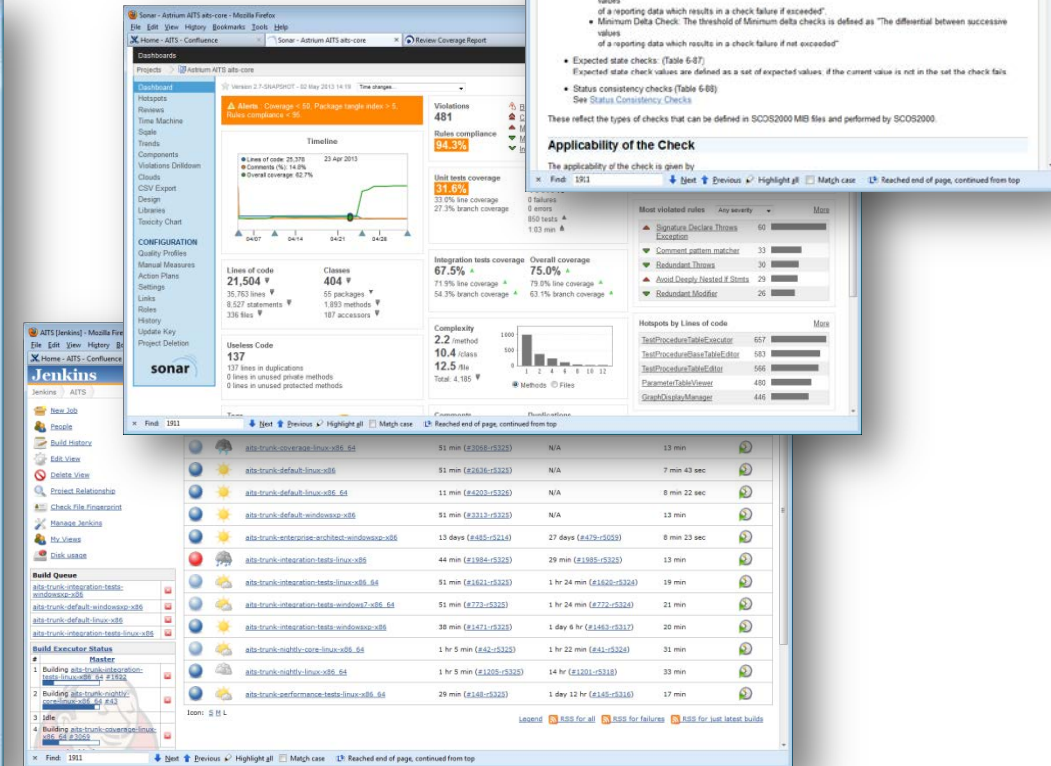
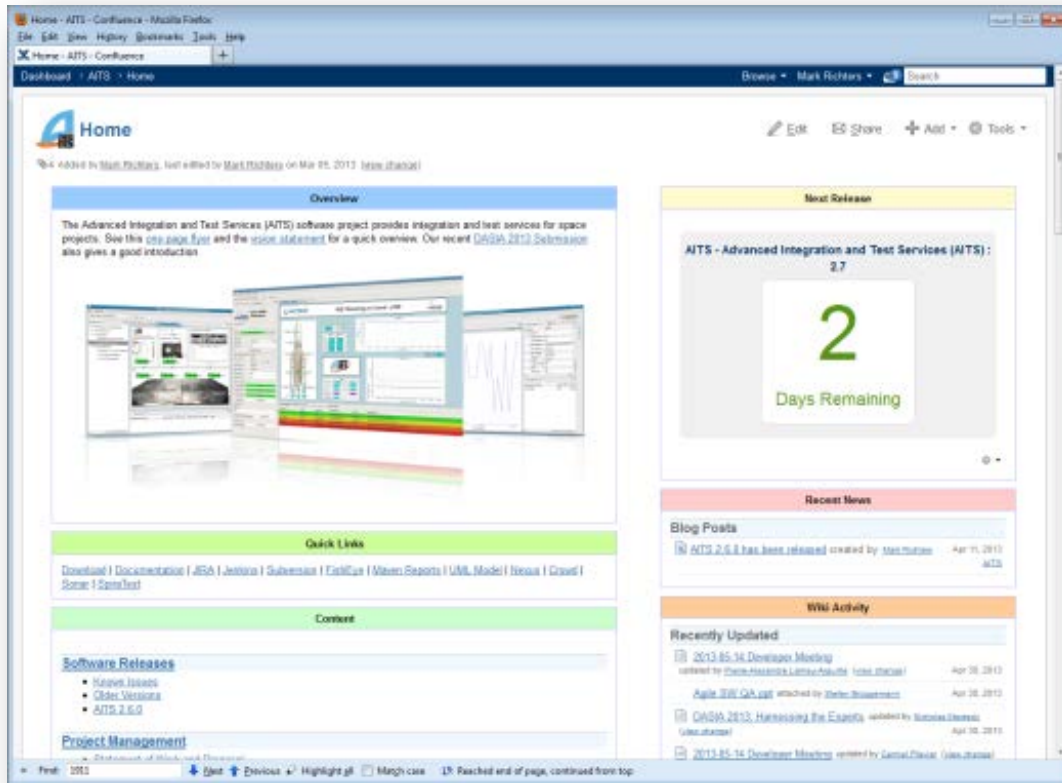
Phases and Milestones



- Standard ECSS Milestones tailored to agile process
 - Released software part of every major milestone!
 - Documentation incrementally extended and updated
- Small iterations between milestones
 - Three-week iterations with planning meetings, demo, and retrospective to inspect and adapt process
 - Weekly tech-meetings and requirement engineering workshops
 - Daily stand-up telecons

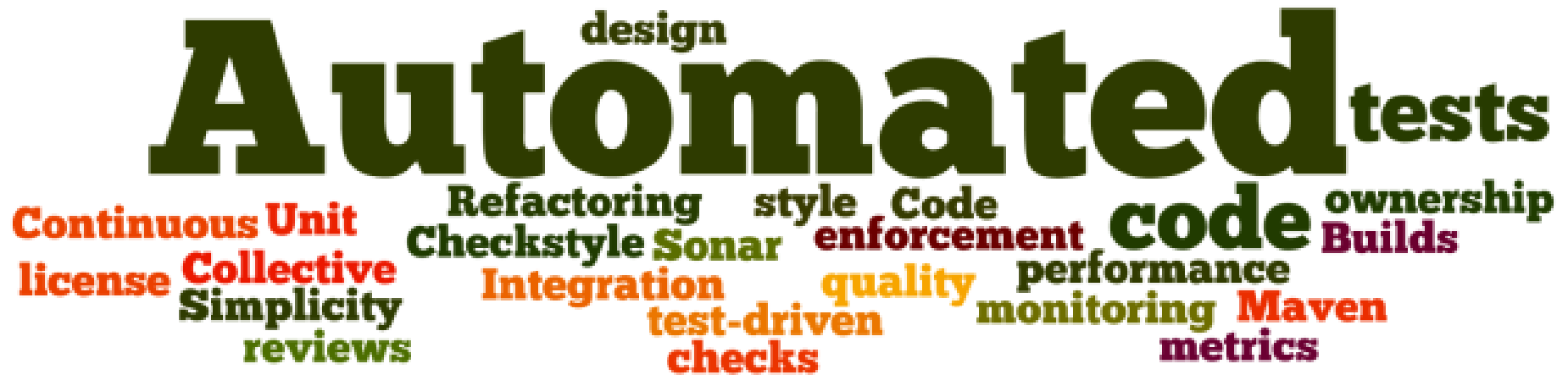
Pforge Collaboration Platform

- Integrated Wiki, issue tracker, repository, build server, quality monitor
- Easy and open access to all information and documentation in real-time



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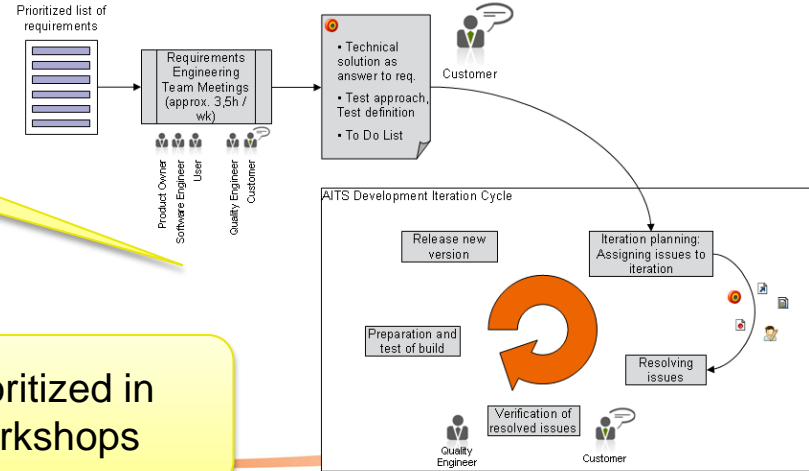
Agile Practices



Automation and simplicity is the key

Requirements Management

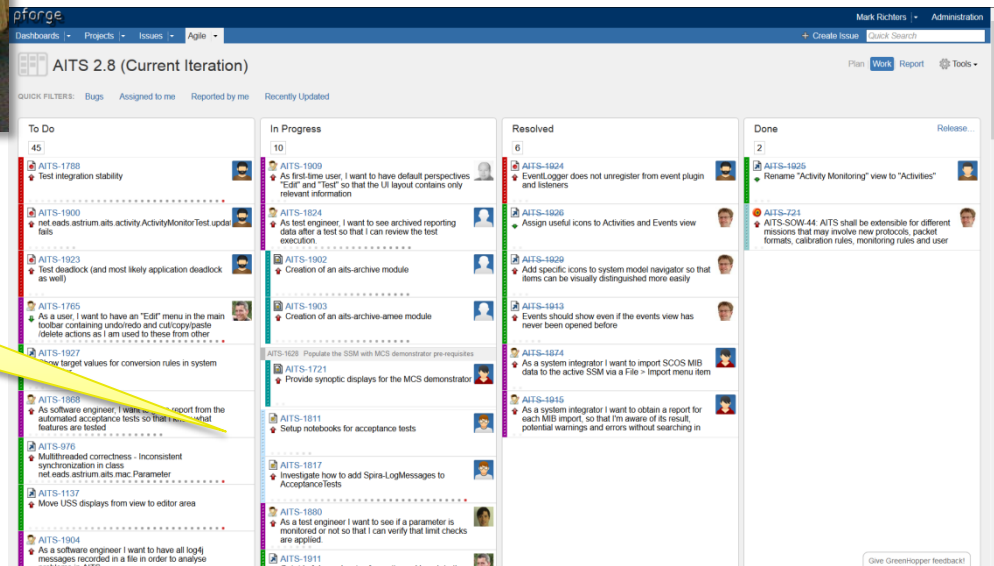
Processed in iterations



Prioritized in workshops



Managed in a backlog



Task 2

Building Blocks Design and Development

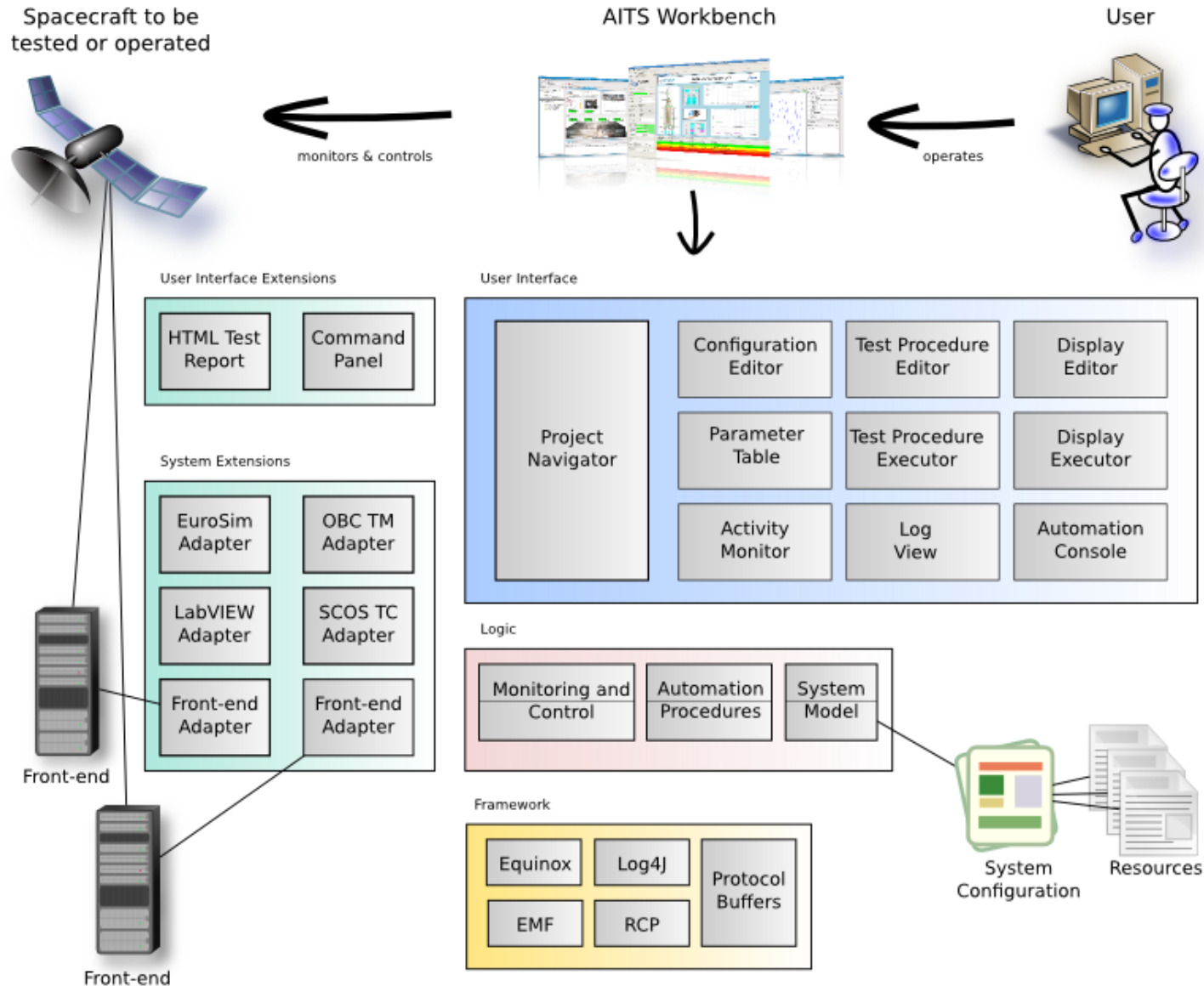
Main Features

- Workbench / Supervisor
- Monitoring and Control
- System Configuration (E-70-31 Space System Model)
- Synoptic Displays
- Manual Test Procedures
- Automated Procedures
- SCOE / Front-end Interface Protocol
- Adapters for Front-end Equipment and Simulators



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Building Blocks



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General Features

- Runs on all major platforms that support Java including Windows and Linux on x86-64 architectures
- Supports internationalization into other languages than English
- No runtime licenses
- Builds on open source components
- Unicode support
- Continuous unattended operation
- Easy installation



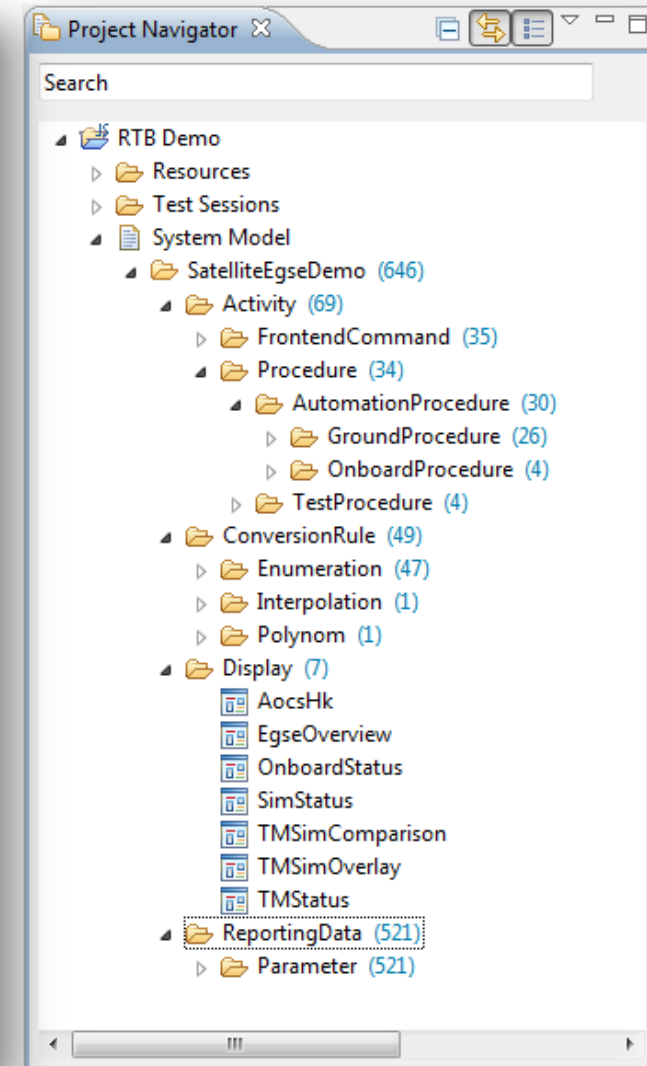
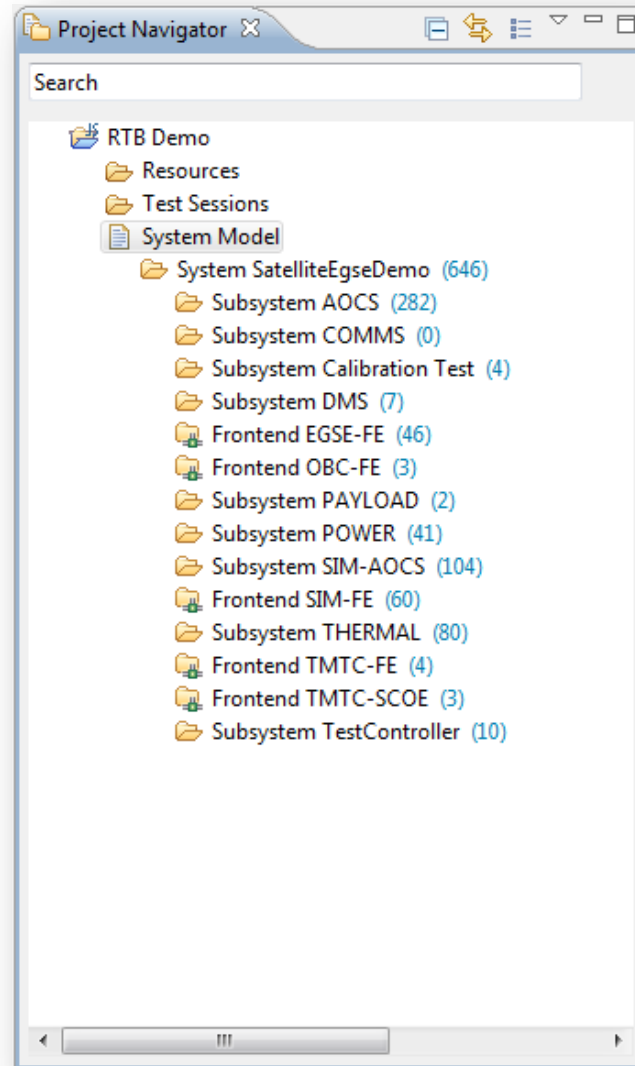
Features: Monitoring and Control

- Send telecommands to a spacecraft
- Receive telemetry from a spacecraft or launch vehicle
- Process, calibrate and check telemetry against various limits
- Generate and process events
- Control front-end equipment
- Supports standard packet and parameter processing (PUS, CCSDS, MIL-STD 1553)
- Open interfaces to other operations systems (ground stations, mission planning, flight dynamics, etc.).
- Time stamping of all data

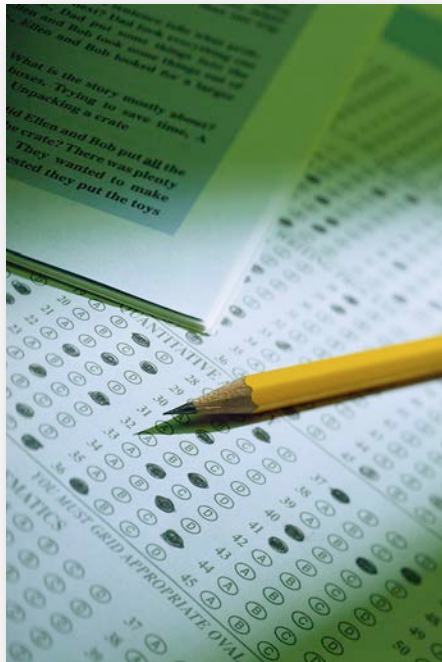


Features: System Configuration

- Central system model based on ESA ECSS E-70-31 standard used for preparation and at runtime
- Configuration stored in XML for easy exchange and versioning
- Versioning with an external tool like Subversion
- Functional model with hierarchical system elements
- Model size only limited by available memory
- Consistent cross-references



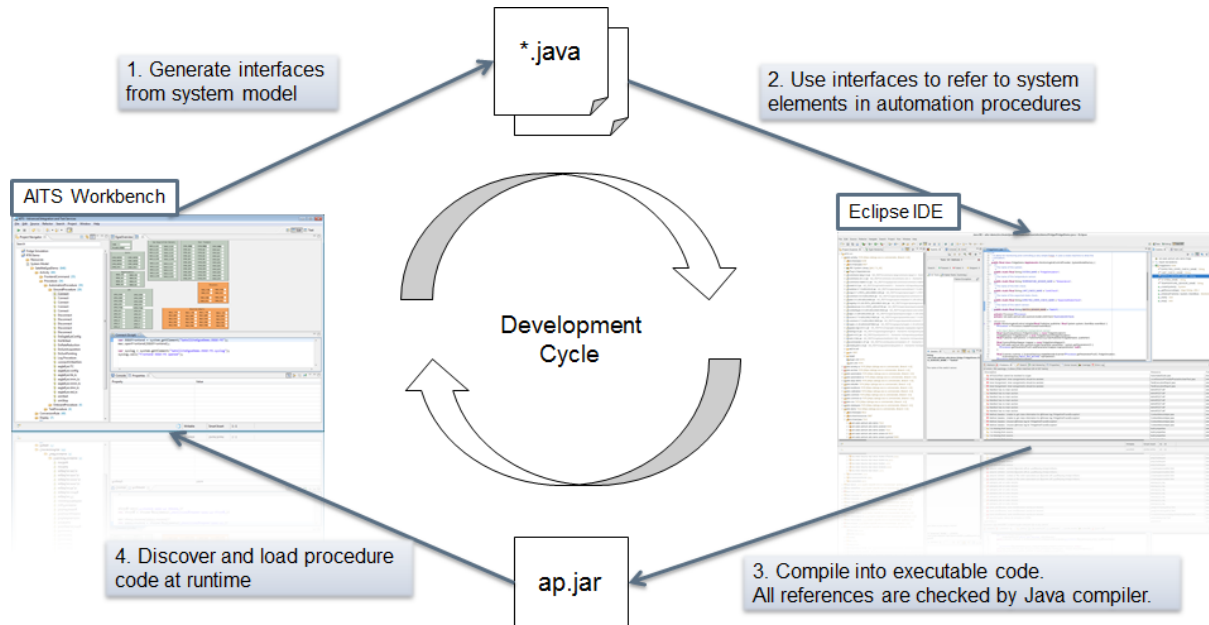
Features: Test Management



- Test execution and test reporting
- Manual and automated test procedures
- Hybrid test procedures combining manual and automated steps
- "Live" monitoring of parameters in test steps
- Archival of test sessions

Features: Automation

- General purpose language
- Access to full system model
- Automation procedures in any language supporting the Java scripting API (e.g. JavaScript, Groovy, JPython)
- Modular architecture allowing extensions for other languages like Tope, PLUTO, if needed
- Java procedures with additional compile time consistency checks



Features: Front-end Interface Protocol

- Control front-ends, simulators and the product under test
- Front-end servers can be implemented in Java, C++, C and more.
- Full end-to-end specification of protocol covering all layers
- Modular adapter architecture, allowing extensions for other protocols if needed



Features: Archive and Logging



- Store all test data in a common archive (raw data, engineering values, ground and onboard logs, command history)
- Data interface to existing archive products (AMEE, SIG@RE)
- Detailed logs in standard log4j format

Features: Supervisor Workbench

- Workbench for preparation, execution and runtime
- Start/stop monitoring and control kernel
- System model navigator for configuration browsing and start of activities

User interfaces for:

- **configuration:** navigator, properties view, text editors
- **procedures:** text editors, runtime console, activity monitor
- **displays:** synoptic displays, table views
- **analysis:** line, step and strip graphs for parameters
- **events:** event view with operator confirmation
- **activities:** monitor status
- **Reporting:** browser view



Features: Framework

- Open Source approach
- Extensible plugin architecture based on OSGi standard
- API to easily adapt to any data source
- Extensible and adaptable system model through model-based code generation
- Integrated workbench that can be adapted to individual preferences and workflows



Task 3

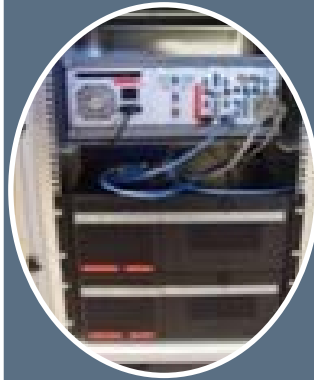
System Demonstrations and Applications

Demonstrators and Applications



Launcher EGSE

Ariane 5 VEB
UCTM
Telemetry and
MIL-STD 1553



Satellite EGSE

ESTEC Real-Time
Bench with Eagle
Eye Mission
PUS-based
Telemetry and
Telecommanding,
EuroSim simulator



Mission Control

Columbus and
TerraSar-X,
Monitoring and
Control, SCOS
MIB database
import



A5/M51 DECOM-NG

Telemetry front-end



Demonstrator for Military Purpose
Migrate existing procedures to AITS procedures



ISF / ISF Evolution

Ariane 5 test bench



Avionic-X

Next Generation Launcher Avionics



Shefex-III

DLR Sharp Edge Flight Experiment



DEOS

DLR Robotics Servicing Mission



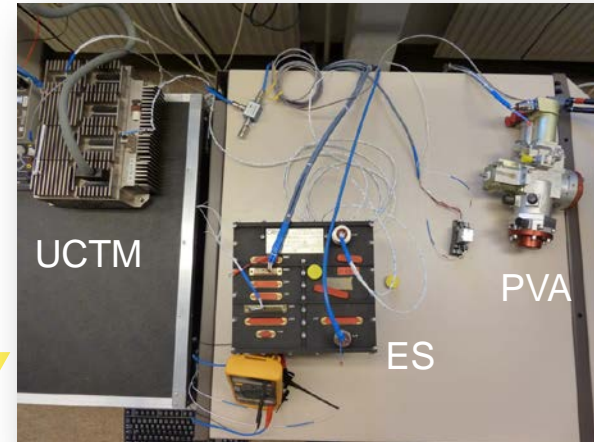
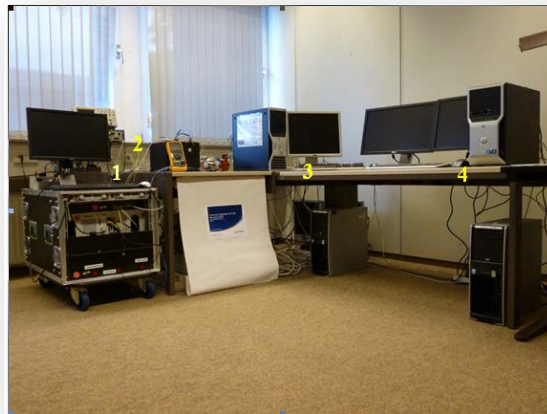
A5ME TCM

EGSE Test Control Management



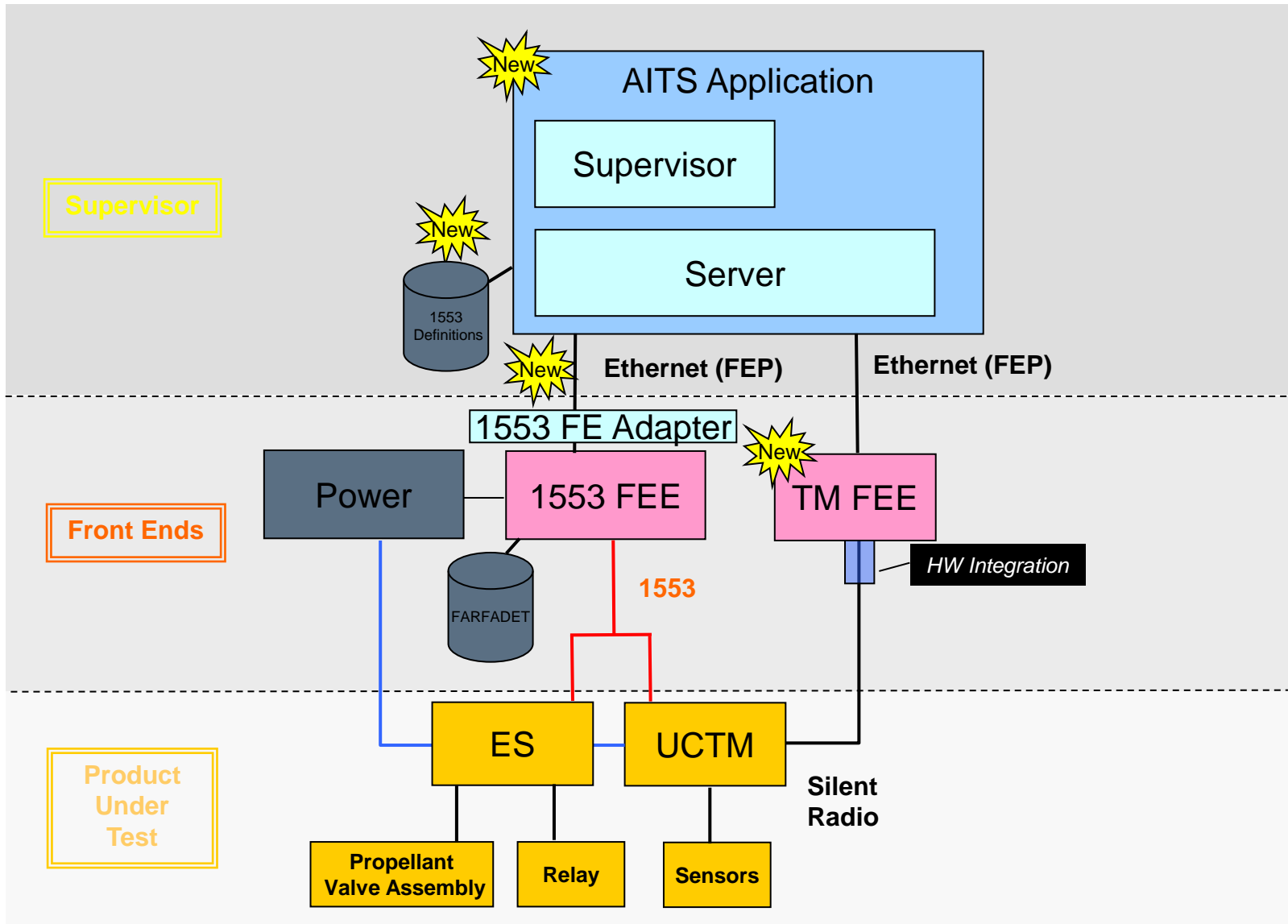
Launcher EGSE Demonstrator

- Show connectivity to silent radio link of existing flight representative hardware
- Show real time decommutation of TM frames through new I/F boards
- Demonstration of end-to-end scenario with a set of engineering sensors
- Real time visualization of TM parameter raw values and engineering values



1. Flight representative model of:
 - UCTM (central telemetry device in the Ariane 5 upper stage)
 - ES (Électrique Séquentielle)
 - Propellant Valve Assembly
2. A set of resistors, a thermal sensor and a signal generator simulating electrical sensor input
3. TM Front-end PC
4. The AITS Supervisor PC

Launcher EGSE Demonstrator - Architecture



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Launcher EGSE Demonstrator - Test Supervisor

Views

- Explorer
- Displays
- Properties
- Quick Graph
- Parameter

Perspectives

- Task-oriented
- Customizable

The screenshot shows the AITS interface with the following components:

- Explorer:** A tree view of parameters including M1MG000, M2MG000, M3MG000, M4AC509, M4AC510, M4AC511, M4AC513, M4AC514, M4AC515, M4MG501, M4MG502, M4MG503, M4MG504, M4MG505, M4MG506, M4MG507, M4MG508, M4MG509, M4QN511, M4QN512, M4QN513, M4TC509, M4TC513, M4TC514, M4TC515, M4TC516, M4TC518, and M4TC566.
- UCTM Test Data:** Displays test data for various components, including a Temperature Sensor on M4TC509 (24,17 dg.C), a PT100 Simulator on M4MG506 (21,70 dg.C), and a Sine Wave Generator on M4MG500. It also shows a large image of a test rack with several temperature readings: 40,00 dg.C, 39,50 dg.C, 36,50 dg.C, and 38,50 dg.C.
- Properties:** A table showing properties for a selected parameter (M1MG000):

Property	Value
Calibration	FP1
Calibration Size	8
Description	
Max Range	255
Min Range	0
Mnemonic	M1MG000
Offset	0
Program Name	A5
Rate	0
Structure	TM
Sub Structure	CASE
- Quick Graph:** A line graph showing the value of parameter M4MG506 over time. The y-axis ranges from 241,999996 to 242,000005. The x-axis shows time from 16:40 to 16:44 on 22 Jun 10. The current value is 242,00.
- Parameter Table:** A table showing parameter details:

Parameter Name	Raw Value	Raw Type	Eng. Value
M2MG000	128	Integer	128.0
M4AC511	128	Integer	128.0
M4AC513	128	Integer	128.0
M4AC514	128	Integer	128.0
M4AC515	128	Integer	128.0
M4MG501	255	Integer	255.0
M4MG502	242	Integer	242.0
M4MG503	244	Integer	244.0

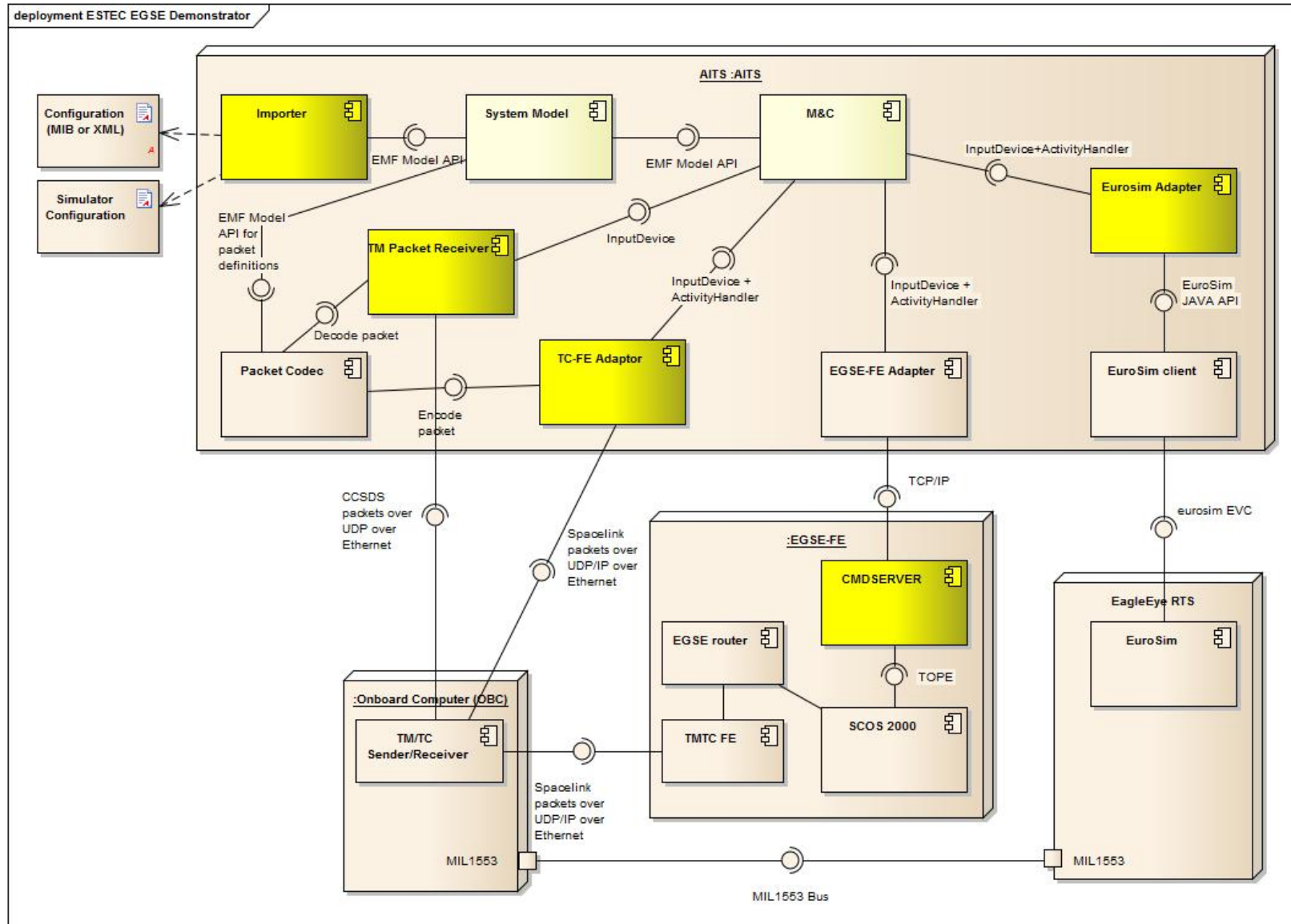
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Satellite EGSE – ESTEC Avionics System Test Bench

- EuroSim/SMP2 based full dynamics and avionics equipment Real Time Simulator, using a Concurrent iHawk computer
- SCOS2000-based EGSE Reference Facility for the Central Monitoring and Control part
- LEON2 RASTA assembly (processor board and TM/TC board) running the Eagle Eye CSW and connecting via a MIL1553 bus to an AIM-APX1554 PCI board in the RTS host
- OpenIGS 3D visualisation software



Satellite EGSE – Architecture

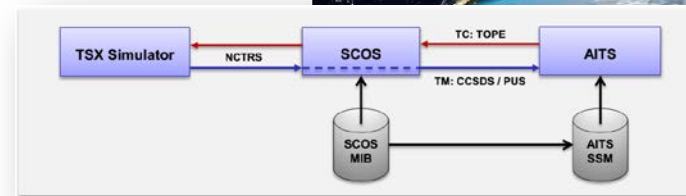
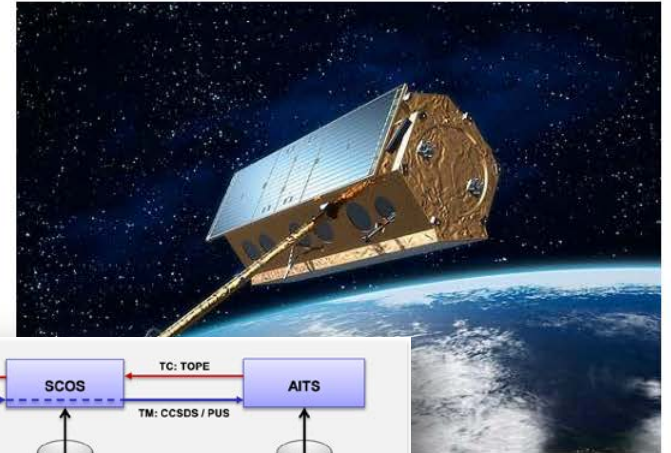


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MCS Demonstrator

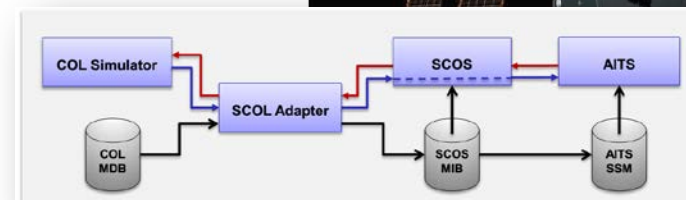
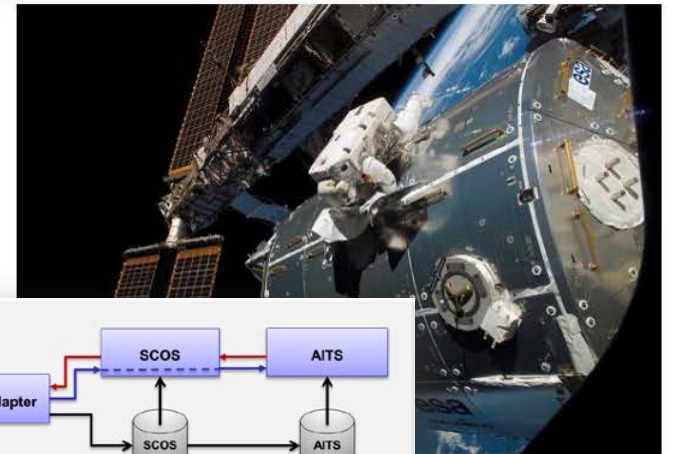
TerraSAR Demonstration

- Simulator Initialization
- Mode Transition ASM-RD to NOM-RH
- Left-looking Maneuver
- Autonomous Housekeeping Dump

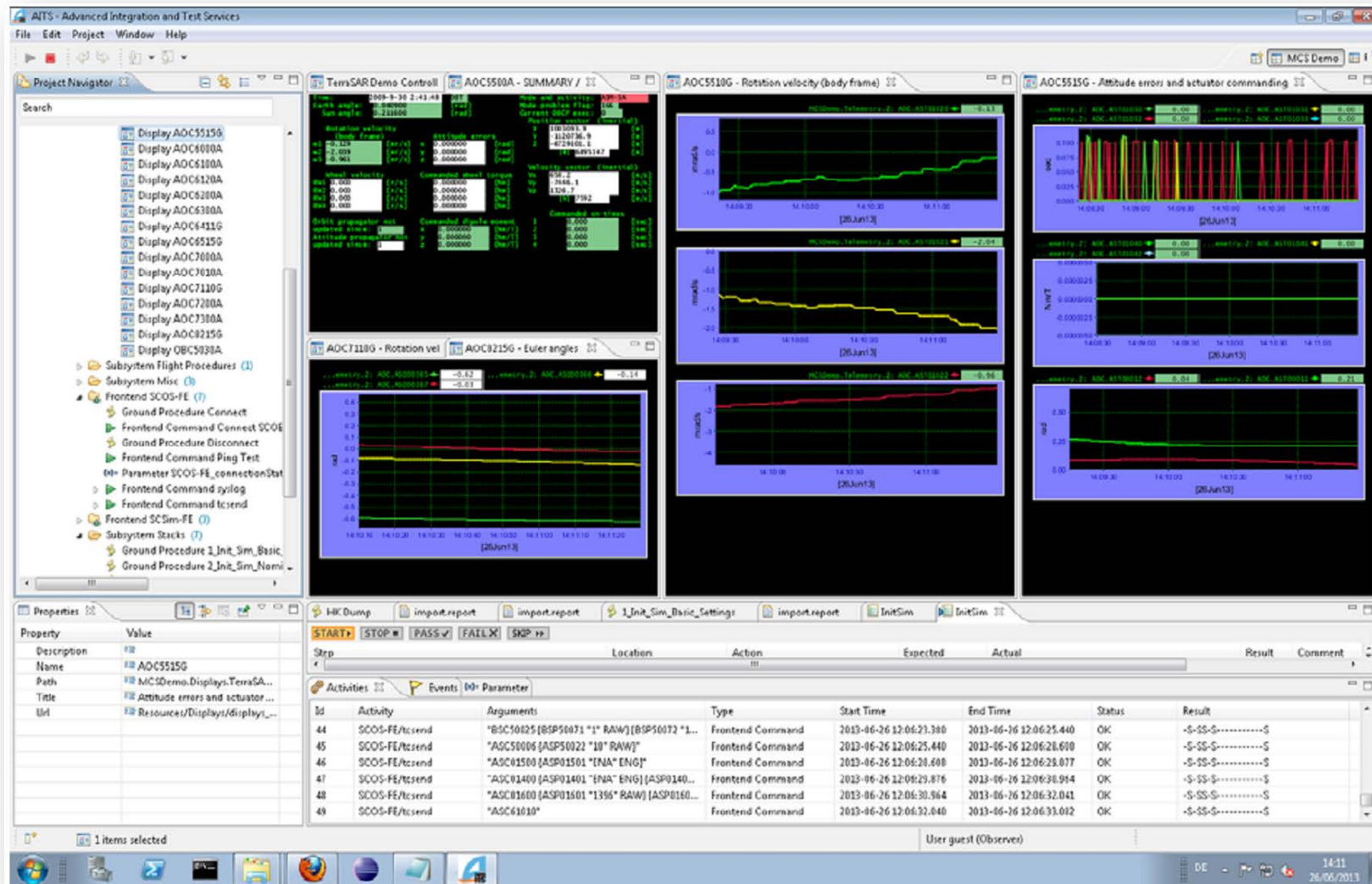


Columbus Demonstration

- Receive Columbus Telemetry
- Send Telecommands
- Execute simple Flight Procedure

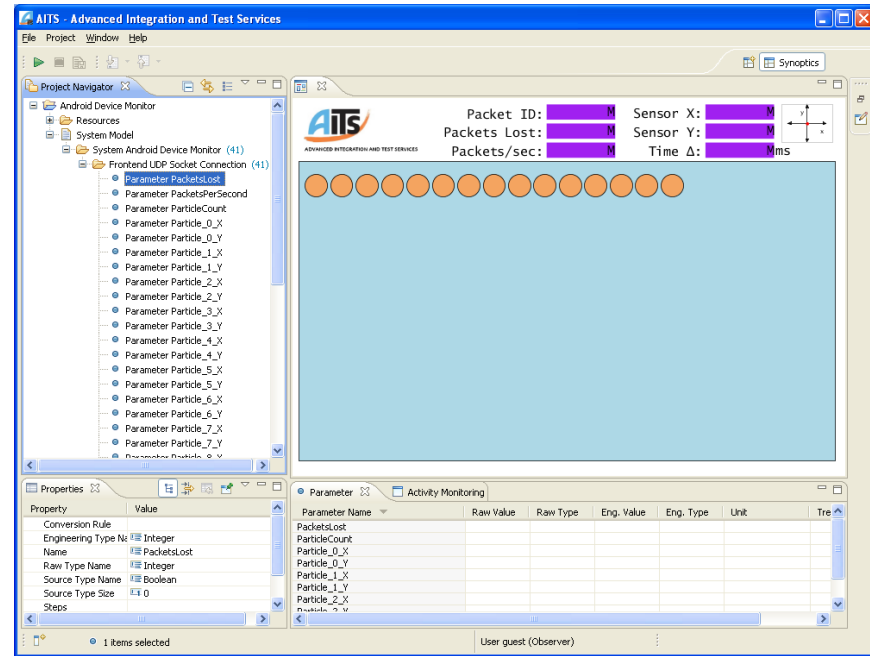
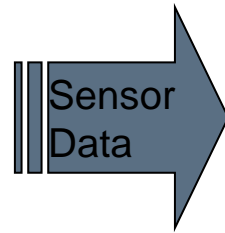


MCS Demonstrator - TerraSAR-X Simulator



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Live Demo – Mobile Device



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What the Mobile Device Demo Shows

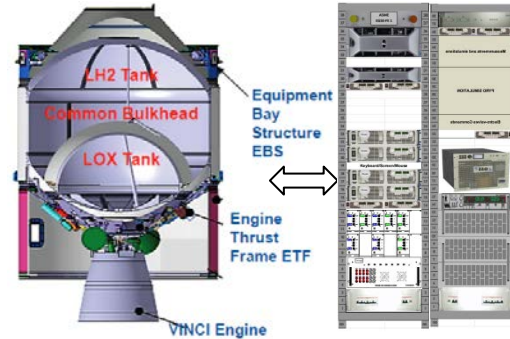
- Ability of AITS to run on small devices
- Soft real-time performance
 - Low latency even over Wifi
 - Fast and flexible animation with synoptics
 - Low CPU load
- Low effort for new projects
 - Less than 200 lines of code for system model and network adapter
 - Less than two days for whole application
 - 1/3 AITS extension and model setup
 - 1/3 learning and developing the Android application
 - 1/3 integration and getting the network configuration right
- Open system
 - Adapt to any device that can send data, even a mobile phone
 - Open to use any protocol that fits the purpose
 - Offers choices: Synthetic parameters, display computations, internal parameters implemented in a plug-in
- Building blocks that can be combined in surprising ways to create new kinds of applications
- Using AITS can be a lot of fun :-)

Ariane 5 ME EGSE – Test Control and Management

Mission: Provide test control and management system of the EGSEs used for development and test of the new A5ME upper stage.

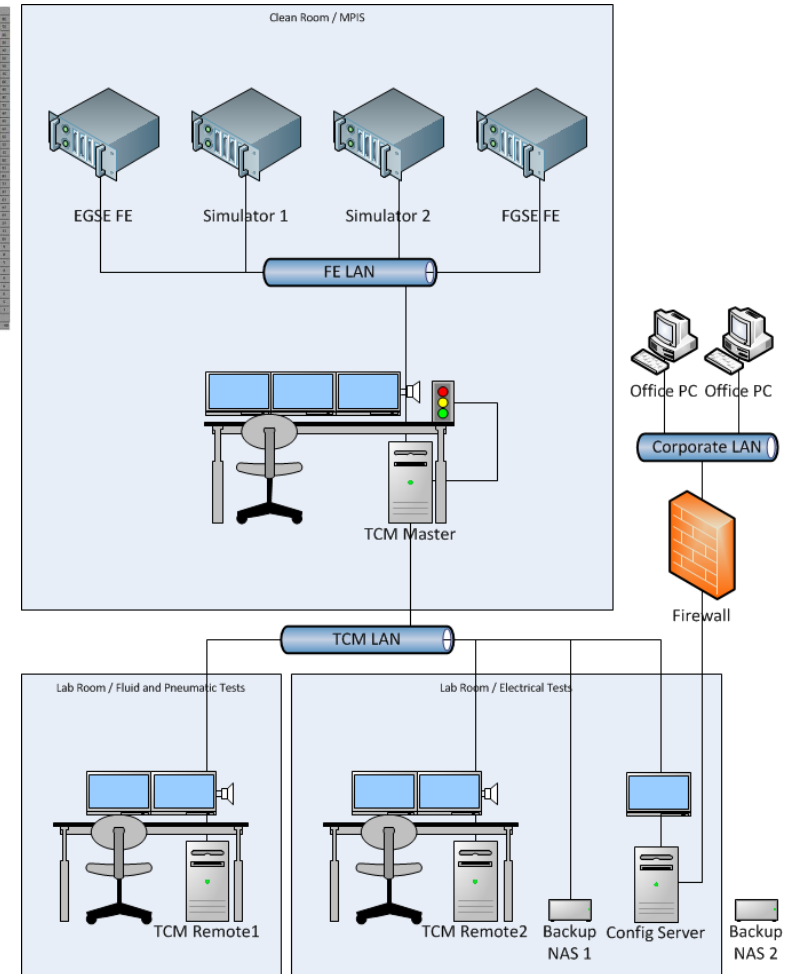
Project

- Internal customer and users
- Kick-off in June 2014
- Planned delivery in June 2015
- EGSE FE made by ETCA Belgium



Technology

- Re-use of AITS
- New front-end protocol GESI



Lessons Learned and Conclusions

AITS and EGS-CC (European Ground Systems – Common Core)

- AITS was running when EGS-CC started
- AITS schedule compatible with needs for Ariane 5 ME EGSE
- AITS project contributed to the EGS-CC definition and the Airbus DS integration preparation
 - AITS specification is one of the inputs for the EGS-CC URD
 - AITS agile ECSS software process tailoring provided lessons learned and best practices to the EGS-CC project
 - AITS provided input to technology selection, SDE, and Java automation procedures
 - AITS team members support the EGS-CC System Engineering Team in all reviews

Lessons Learned from Agile Lean Process

Challenges

- Effective communication in a distributed team
- Aiming for production quality in a TRL 6 project
- Right balance for planning and design up-front
- Finding good Key Performance Indicators
- Formal contract / scope vs. Flexibility

Strengths

- Process allows team members to bring in their individual strengths
- Working product at all times
- No unneeded functions built
- Flexible and open design
- Good quality
- Iterations expose and solve problems faster
- Early feedback and buy-in from customer, users and decision makers

Summary and Conclusions

- Lean / Agile tailoring of E-40 / Q-80
 - Productive and efficient process
 - Motivated team members enjoying to work on the project
 - Continuous improvement and early risk mitigation
 - Excellent results in CMMI Level 3 assessments

- Building Blocks
 - All major blocks required for building EMCS systems implemented
 - Open and flexible architecture to adapt to any system to be monitored and controlled

- Demonstrators
 - Building blocks validated with demonstrators from major application domains

Outlook

Process

- Airbus DS standard for agile projects
- Contributions to new ECSS-E-HB-40-01A "Agile software development handbook"

Building Blocks

- No operational application in Ariane 5 ME (has been cancelled end of 2014)
- Ariane 6 is currently planned as one of the pilot applications for EGS-CC
- Know how contributions to EGS-CC and Airbus DS integration project of EGS-CC
- AITS continues to be used for Ariane Avionic-X test bench in Les Mureaux
- AITS building blocks and platform planned to be reused for robotics missions
- AITS system model component reused in TDMS (Test Data Management System) project for MPCV-ESM