Migrating from GSOC's SCOS derivate GECCOS to a distributed EGS-CC operations environment based on CCSDS MO/MAL

Michael P. Geyer[(1)], **Armin Braun**[(1)], **Stefan Gärtner**[(1)], **Philipp Hamacher**[(1)], **Leonard Schlag**[(1)], **Anne-Katrin Schroeder Lanz**[(1)], **Christian Stangl**[(1)], **Nico Trebbin**[(2)]

[(1)]Deutsches Zentrum für Luft- und Raumfahrt [(2)]LSE Space GmbH

Service Architecture

Space System Model

Standardisation

Automation

DLR

German Space Operations Center (GSOC) Oberpfaffenhofen

Launch Date		Mission Elapsed Times /			
17 Mar 2002	GRACE	+ 5491 / 02:28:25	07 Feb 2008	Columbus	+ 3338 / 16:04:05
01 Okt 2009	COMSAT Bw-1	+ 2736 / 02:50:25	22 Jul 2012	TET	+ 1711 / 16:07:05
21 May 2010	COMSAT Bw-2	+ 2504 / 02:48:25	29 Jan 2016	EDRS-A	+ 425 / 00:29:05
15 Jun 2007	TerraSAR-X	+ 3575 / 22:35:25	22 Jun 2016	BIROS	+ 280 / 18:53:05
21 Jun 2010	TanDEM-X	+ 2473 / 22:35:22	28 Jan 2017	H36W-1	+ 60 / 21:46:05

In 2017:
PAZ
EU:Cropis
GraceFO

2018:
EDRS-C

2019:
EnMAP

Motivation or: Why Change a Running System?

Why change a safe and secure operations system?

- More entities are interested in performing at least parts of satellite operations (e.g. payload operations)
- Establish a system scalable to mission with different degrees of operations complexity – keep multi-mission operations
- Closer interaction with satellite providers / AIT phase
- Provide systems or parts of them for supporting / performing operations at other sites
- Increase the maintainability and automation of the overall system (w.r.t interfaces/standards, flexibility, re-use / plug and play)

→ Convince sub-systems and operation guys that standardised services are a good idea

Overview

- Motivation - Modern Demands on a Spacecraft Control Center
- Sketch of new Possibilities using modern Technologies
- Our Ideas are work in progress: Achievements and what to do

Demands On a Spacecraft Control Center by AIT and Operations

GSOC develops and operates FOS in close collaboration with DLR internal and external partners. Experiences gained from…

- requirement engineering, system implementation and integration phases
- long-term nominal as well as off-nominal operations
- cooperation with spacecraft providers during assembly, integration and testing (AIT), system verification tests, LEOP & commissioning
- CCSDS and EGS-CC, ECSS

Demands On a Spacecraft Control Center by AIT and Operations

- **Modular:**
  - set up a FOS independent of where the individual functions and processes are executed

- **Scalable:**
  - scaling and support of non-demanding standard missions as well as complex, prototype-like missions; (w.r.t. including operations tasks)

- **Service Oriented:**
  - generalise internal and external interfaces making use of ECSS and CCSDS, respectively (e.g. CCSDS MO)

Demands On a Spacecraft Control Center by AIT and Operations

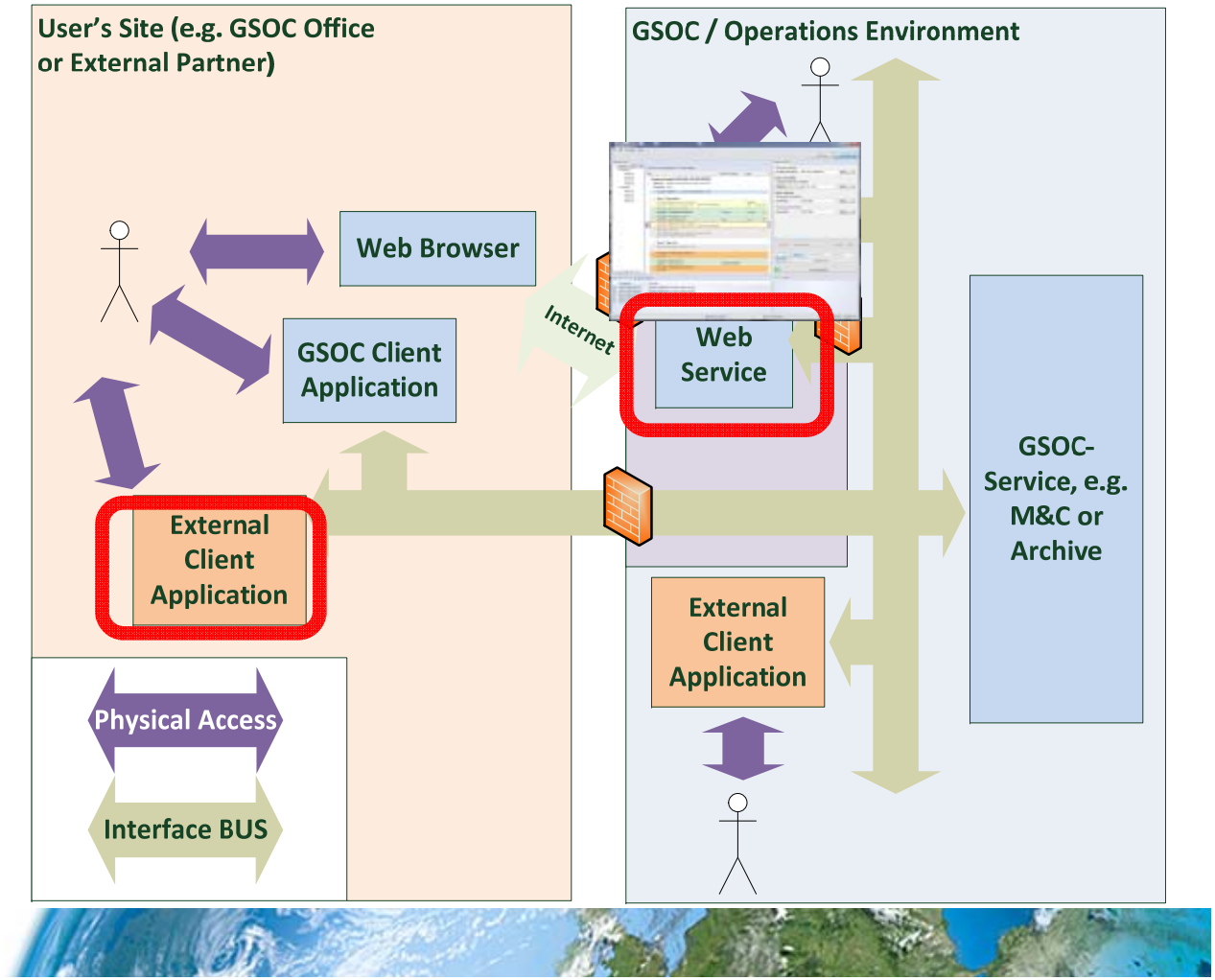
- **Multi-Mission:**
  - integration into GSOC's multi-mission environment -> mission independent services

- **Flexible:**
  - alter mission operations concept and system setups after mission start e.g. move payload commanding to an external partner

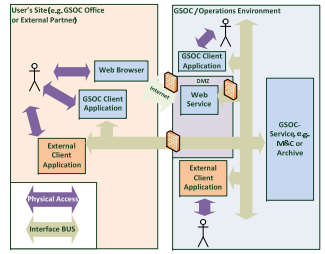
- **Distributed:**
  - *Securely* perform operations tasks, including monitoring and control, from locations inside and outside the GSOC internal operations environment.

Distributed Operations

applications of a distributed flight operation system



Benefits of Distributed Operations



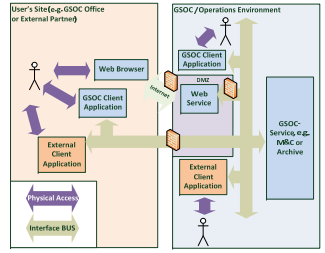
- Support satellite manufacturer by providing a central checkout system (CCS) - at customer's site or at flight operation system (FOS) site

- making use of other GSOC tools installed at the customer's site (AIT and/or ops) and vice versa with minimal adaptation / re-validation

- re-use validated operational mission data (e.g. mission database, flight and ground operations procedures) for operations at GSOC and also at possible external sites.

- separate payload and satellite BUS operations

Benefits of Distributed Operations



- mission wide usage of one complete operations data archive
- the end customer processes (parts) of the real-time and / or offline telemetry, and may also provide obtained products to his own customer.
- access to flight dynamics or mission planning services
- the customer may provide his own (existing) backup FOS or “control room”.

Support for all Mission Phases

- **Spacecraft AIT:**
  - Connections to simulators or engineering models at the spacecraft manufacturer's site.

- **FOS implementation and system validation:**
  - integration of local simulators and simulators or engineering models at the spacecraft manufacturer's site; simulations for flight operations team training

- **Launch and early orbit phase (LEOP) and commissioning phase:**
  - support of large teams -> high demand on size of facilities
  - Switching from LEOP to commissioning: reduce flight ops and satellite team – however, provide remote access to the FOS by the spacecraft manufacturer's team

- **Routine Operations:**
  - shift of priorities to customer needs and e.g. mission planning
  - integration of payload operators at external sites
  - data distribution and information to a distributed ground segment

What we are already doing

- Virtualisation of nearly all missions and control rooms accomplished
- Forwarding of processed real-time telemetry to external engineers (Satmon@Home)
- Ground and spacecraft activities may be initiated by using GSOC's internet portal Opsweb (manual process)
- Sharing / importing flight procedures and TM/TC database with AIT (e.g. TanDEM-X radar satellite)
- Import of telemetry (files) from external control center (TDP project, demonstrating LEO to GEO optical communications links)
- commanding a payload via a remote control center (European Data Relay System (EDRS-A), high-speed communication service between ground stations and LEO satellites)

What we need to improve

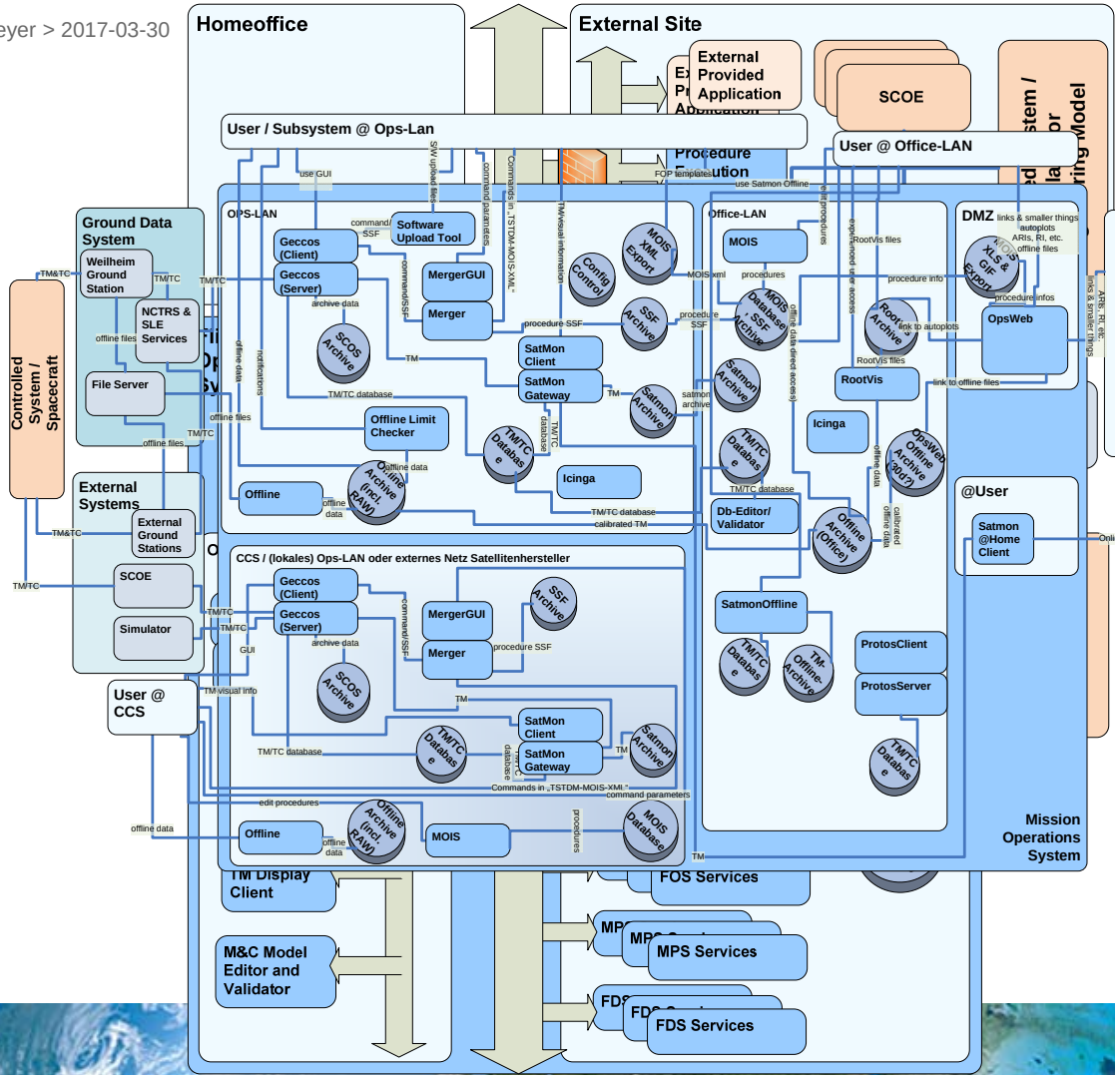
- Most applications are “individualistic” – w.r.t. interfaces and configuration
  - a more homogenous environment would ease handling and maintenance

- Data and archives are distributed over various networks and have to be synchronized;
  - data exchange mostly file based with limited performance

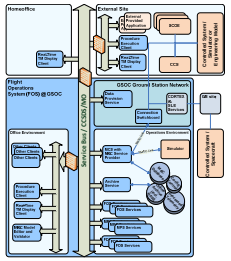
- Limited external access to offline historic telemetry data
  - E.g. a smart and performant interface for an off-site spacecraft support team would be helpful

Vision of a distributed service oriented Architecture

Sketch of a distributed, CCSDS-MO/MAL based FOS. The setup may be used for AIT support as well as LEOP, commissioning and nominal operations.



Scenario Examples

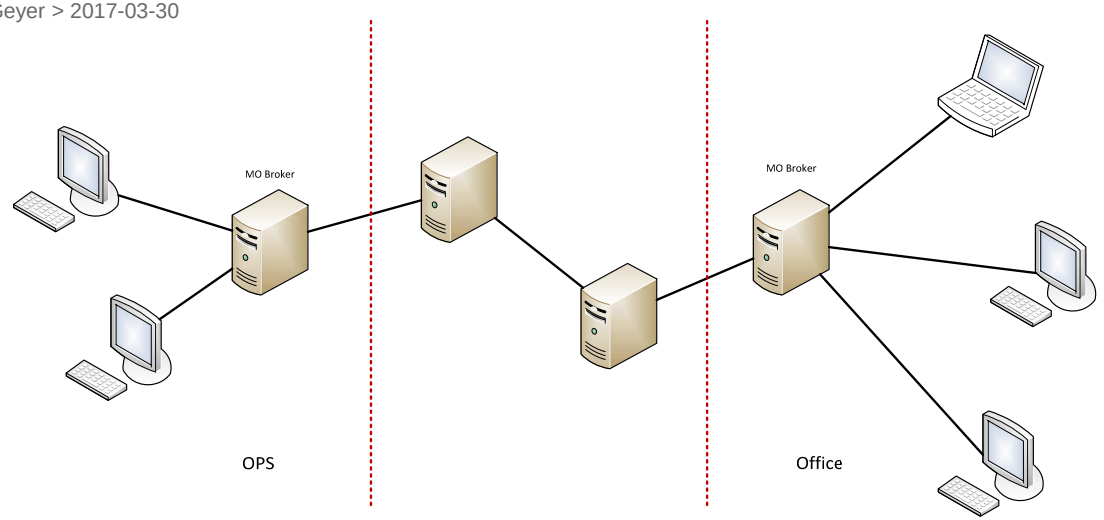


- Usage of the same validated client & server software at all sites and phases
- satellite manufacturer may use his own or GSOC client tools local at his site to develop and validate flight procedures and M&C databases
- routine operations where flight operations engineers may monitor and control the (payload) system from various (remote) locations. Services like mission planning or flight dynamics may be included.
- Support during anomalies: the FOS may be flexibly configured such that appropriate clients may be installed externally.
- Hand-over from a LEOP/commissioning control center to a distinct routine control center / re-use same tools, no doubled software implementation and verification
- EGS-CC ready by using MO and replace the MOS GECCOS (GSOC's SCOS based MCS)

Actual Status

- First prototype FOS setup in GSOC's operational environment
  - Handle all IT and operational security aspects like firewalls and DMZs
- Separation of GUI from GECCOS/SCOS kernel available and in use
  - Possible re-use for EGS-CC
- Setup of a virtual machine test environment including user setup and access
- Prototype of a messaging bus in a single network for connecting CCSDS/MO services via MAL.
- Prototype realization of a M&C service provider located on the external interface layer of the GECCOS M&C system (to be evolved to a EGS-CC prototype MO adapter)
- Start of integration effort EGS-CC / test setups

CCSDS MO



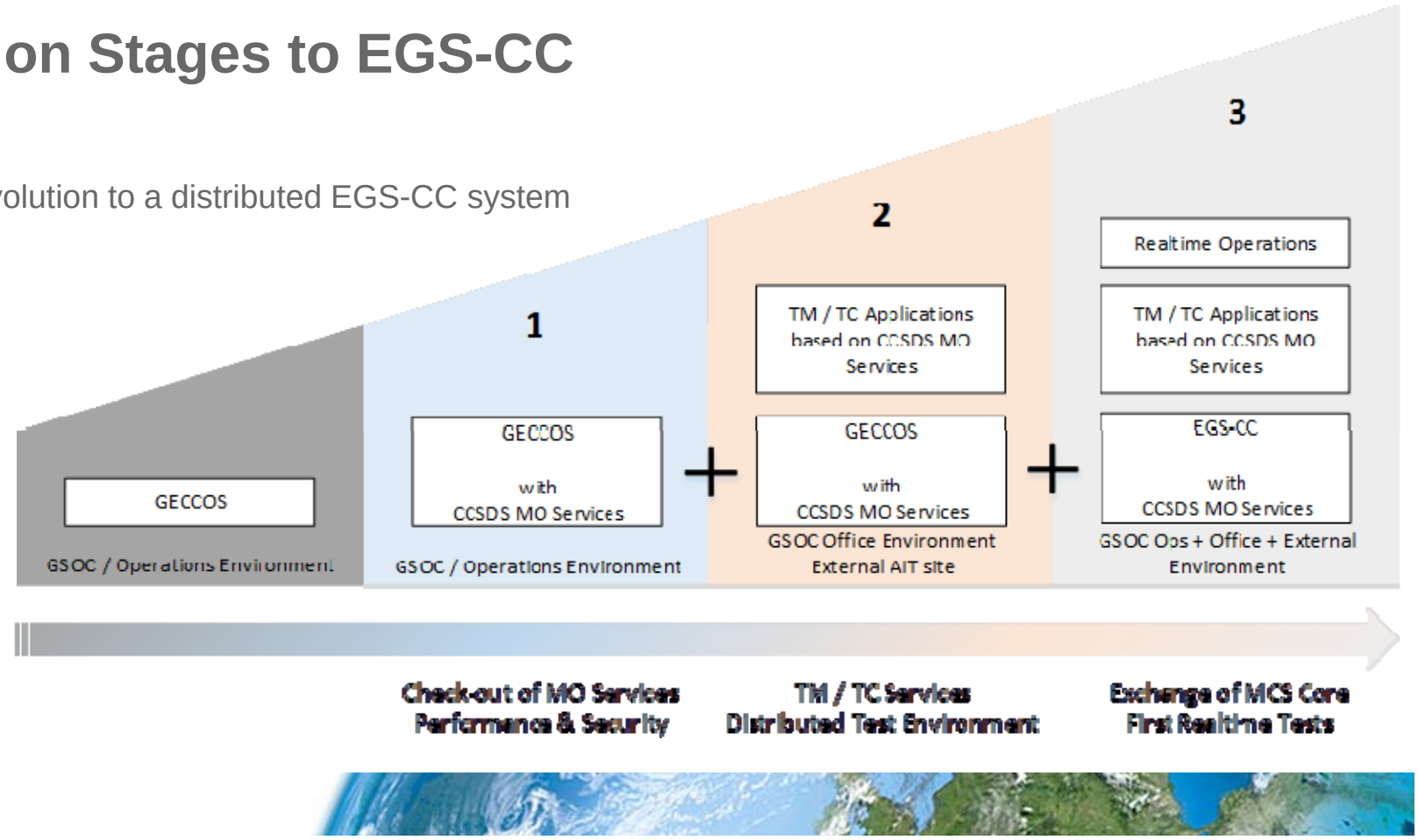
- Decision to use CCSDS MO/MAL for our future service oriented architecture
- need for a secure way to traverse network boundaries / firewalls in a defined and controlled way
  - Make use of message broker
- filtering of data stream - users will be allowed to receive only a subset of information / perform only a defined subset of activities
- Need for adequate logging on different levels for security and tracing purposes

Next Steps

- Finalizing MO / messaging setup for further distribution of M&C services also to distinct networks, e.g. the GSOC office environment and an external partner
- Verify CCSDS MO/MAL performance
- Find a solution for yet not finally defined CCSDS MO/MAL services
- direct real-time commanding of an engineering model using clients outside GSOC
- Check operational aspect of parallel commanding
- Exchange GSOC GECCOS / SCOS based kernel with EGS-CC using an MO adapter

Evolution Stages to EGS-CC

GECCOS evolution to a distributed EGS-CC system



Thanks for your attention!