

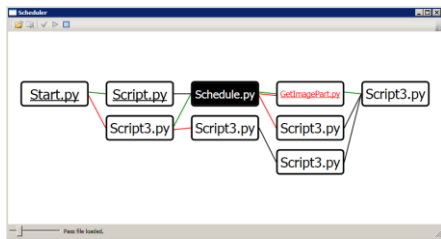
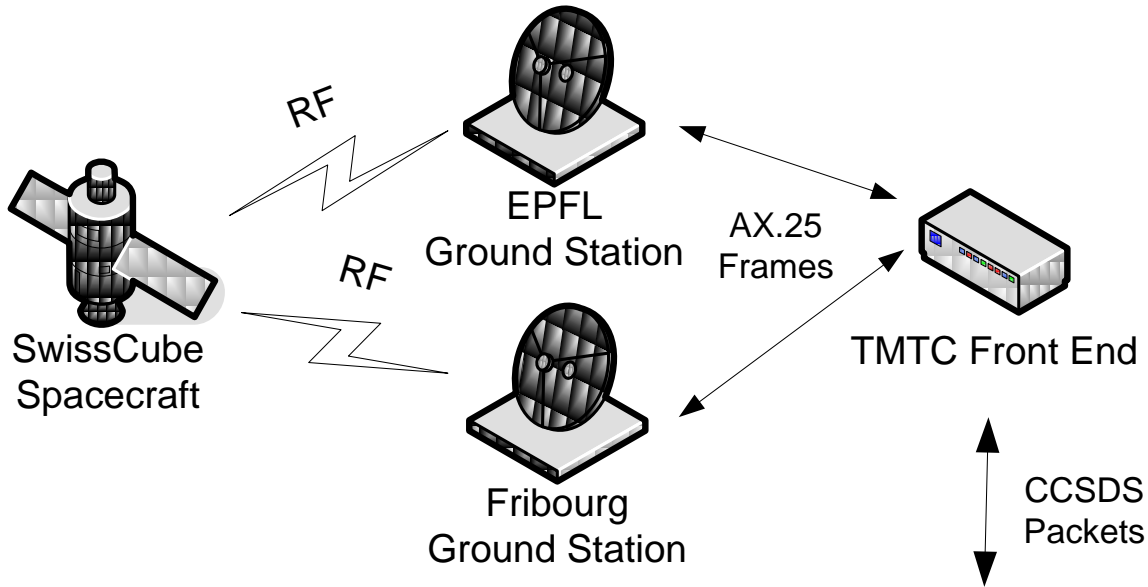
SwissCube Ground Segment Software

Florian George

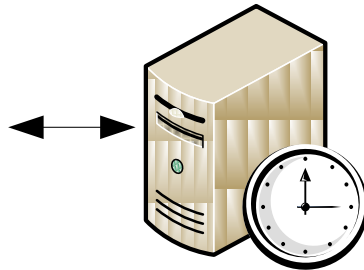
Driving Requirements for the Ground Segment

- Monitor and control the spacecraft during in-flight operation and spacecraft testing at system and subsystems level
- Use of compliant CCSDS/PUS packets
- Deliver payload data to the scientific team
- Interface to the space system
- The communication link with the spacecraft shall comply with the Amateur Radio requirements
- Provide graphical user interfaces useable by non-professional ground segment operators
- Can be operated remotely and securely

Ground Segment Architecture



Planning Tool



Scheduler



MCS

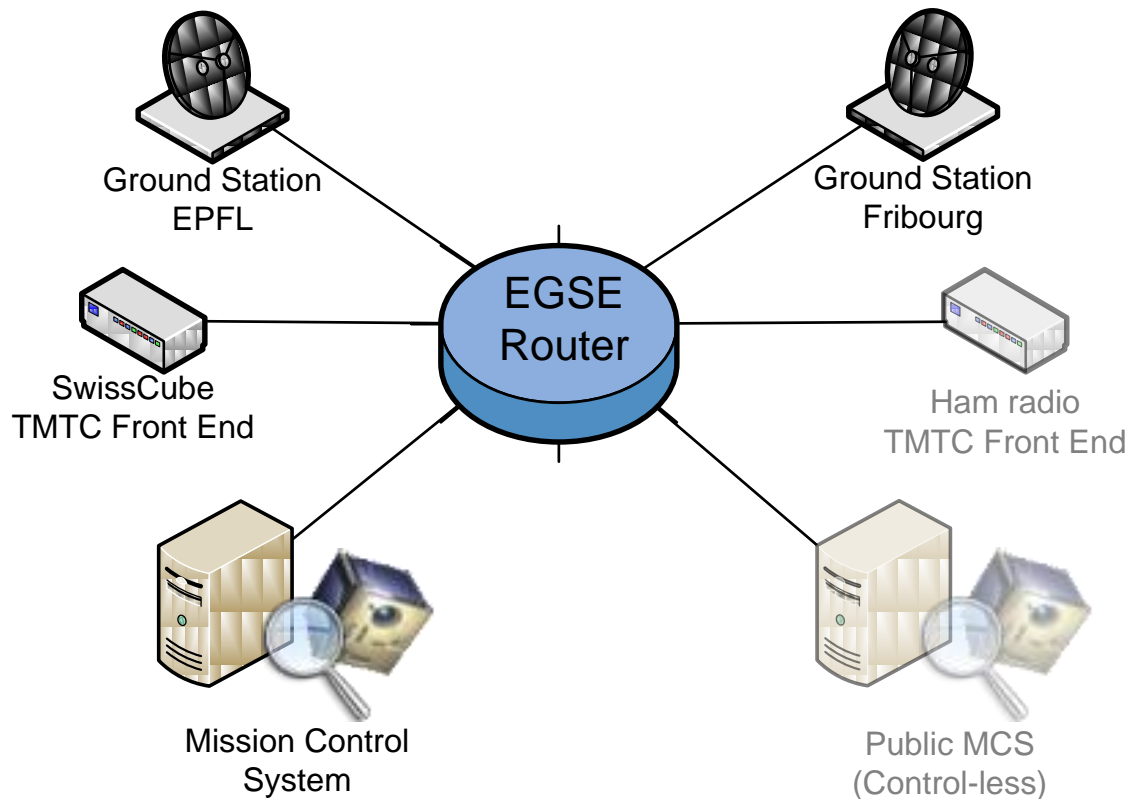
The screenshot shows the **Mission Data Client** interface, displaying a table of mission data. The table has columns for Name, Date, File, COT, Unit, and Value.

Name	Date	File	COT	Unit	Value
EPSC001	05/06/2007	09:08:46:46	156	mV	19324
EPSC002	05/06/2007	09:08:46:46	156	mV	20245
EPS Panel 1	05/06/2007	09:08:46:46	156	mV	56
EPSC003	05/06/2007	09:08:46:46	156	mA	56187
EPSC002	05/06/2007	09:08:46:46	156	mA	20291
EPSC003	05/06/2007	09:08:46:46	156	mA	20291
EPSC002	05/06/2007	09:08:46:46	156	mA	1710436914
ACDS001	05/06/2007	09:08:46:46	156	TpM	72263
ACDS002	05/06/2007	09:08:46:46	156		1809
PATSTAT	05/06/2007	09:08:46:46	156		1118
EPSC002	05/06/2007	09:08:46:46	156	mA	20291
EPSC002	05/06/2007	09:08:46:46	156	mA	20291
EPSC003	05/06/2007	09:08:46:46	156	mA	1710436914
ACDS001	05/06/2007	09:08:46:46	156	TpM	72263
ACDS002	05/06/2007	09:08:46:46	156		1809
PATSTAT	05/06/2007	09:08:46:46	156		1118

Mission Data Client

EGSE Router

- Central software component in our ground infrastructure
 - Link the MCS, TMTTC Front End and Ground Stations together



Ground Stations

- Listen to beacon
- Establish RF link to spacecraft
- Transmit telecommand frames to the spacecraft
- Transmit received telemetry frames to TMTC Front End
- Modulation and demodulation of AX.25 Frames
 - Bit stuffing of AX.25 and frame error detection
- At Lausanne and Fribourg

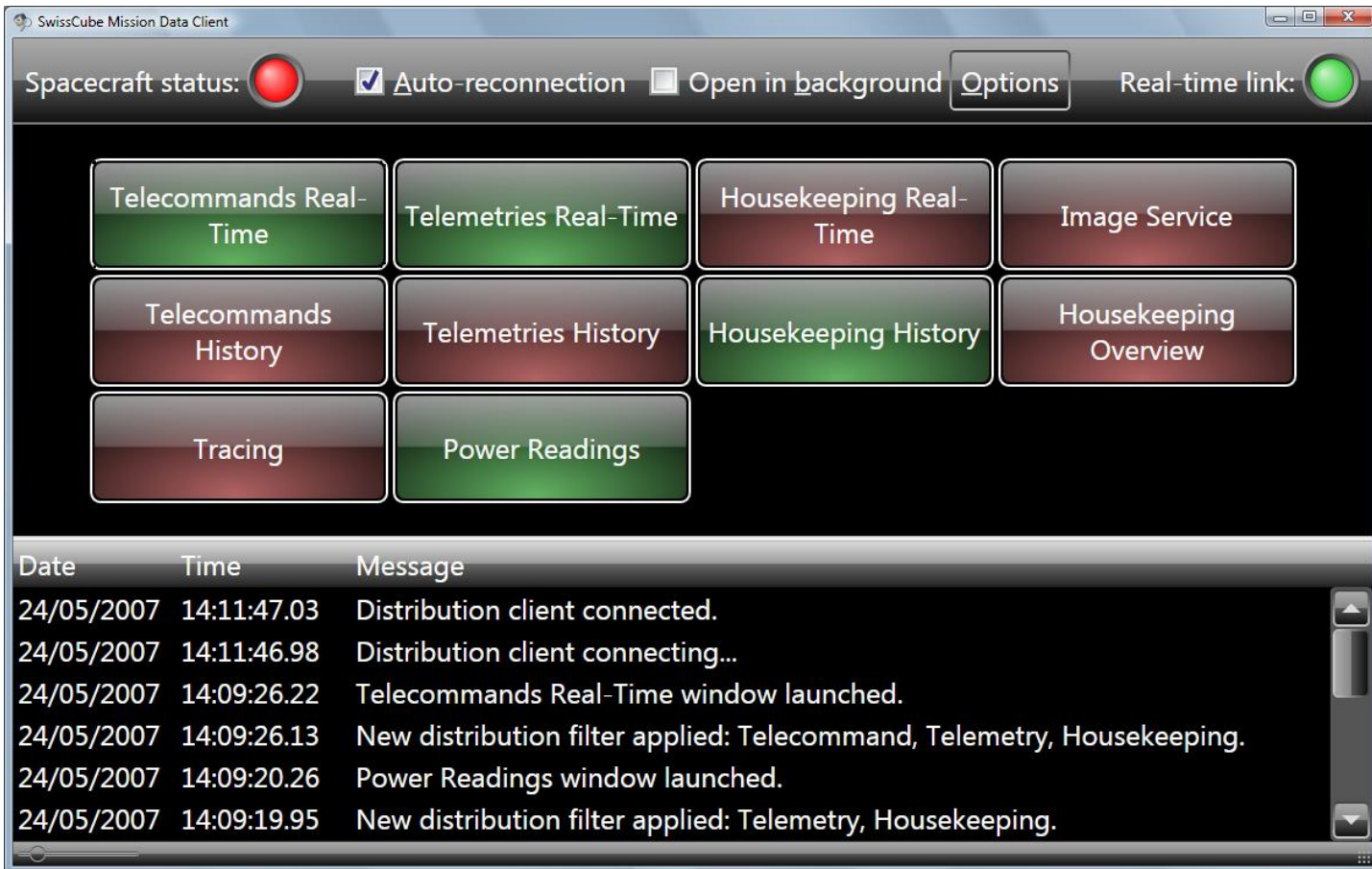
TMTC Front End

- Layer between the ground stations and the MCS
 - AX.25 Frames \leftrightarrow CCSDS Packets
 - Packets reconstruction from telemetry frames
- Archiving of raw telemetry
 - Replay functionality
- Connected to the GS and MCS through EGSE Router infrastructure
 - Not tied to SwissCube MCS, should work with any EGSE Router and CCSDS compliant MCS

Mission Control System (MCS)

- ESA Packet Utilization Standard support (CCSDS/PUS)
- Create and send CCSDS packet telecommands
 - Track their status (acknowledgements)
- -Process CCSDS packet telemetry
 - Calibration and monitoring of housekeeping
- Data distribution to scheduler and other clients even through Internet
- Application to configure the mission (MIB)
 - Import/export in progress

Mission Data Client



SwissCube Mission Data Client

Spacecraft status: ● Auto-reconnection Open in background Options Real-time link: ●

Telecommands Real-Time Telemetries Real-Time Housekeeping Real-Time Image Service
Telecommands History Telemetries History Housekeeping History Housekeeping Overview
Tracing Power Readings

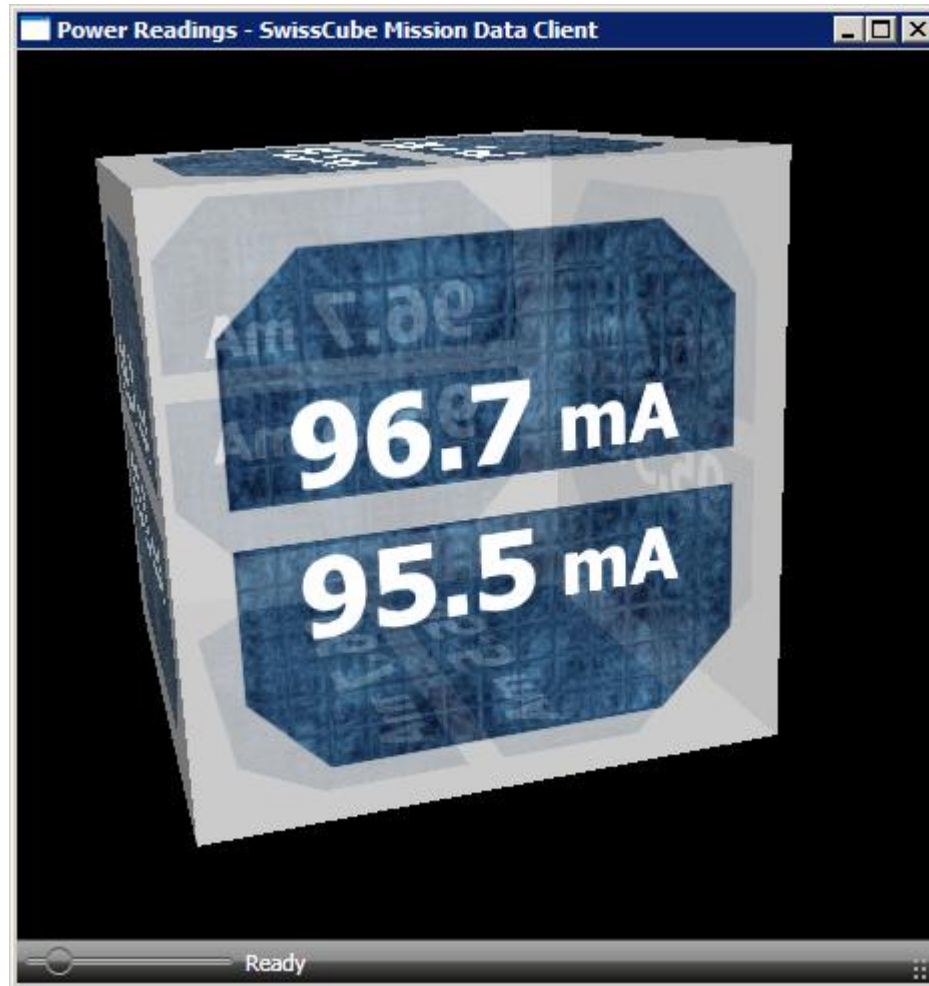
Date	Time	Message
24/05/2007	14:11:47.03	Distribution client connected.
24/05/2007	14:11:46.98	Distribution client connecting...
24/05/2007	14:09:26.22	Telecommands Real-Time window launched.
24/05/2007	14:09:26.13	New distribution filter applied: Telecommand, Telemetry, Housekeeping.
24/05/2007	14:09:20.26	Power Readings window launched.
24/05/2007	14:09:19.95	New distribution filter applied: Telemetry, Housekeeping.

Mission Data Client – Telecommand view

Token	Date	Time	DoY	APID	ST	SST	R	G	T	O	A	S	C	Data
3171	23/05/2007	12:24:57.97	143	693	128	4	●	●	●	●	●	●	●	00-03-0A
3170	23/05/2007	12:24:57.56	143	684	128	1	●	●	●	○	●	●	●	
3169	23/05/2007	12:24:57.56	143	684	11	4	●	●	●	○	●	●	●	00-11-DD-69-00-1A-AC-C7-7D-00-04-8F-80-01-81-E7
3168	23/05/2007	12:24:57.46	143	686	128	4	●	●	○	○	○	○	○	00-03-0A
3167	23/05/2007	12:24:57.14	143	684	128	1	●	●	●	○	●	●	●	
3166	23/05/2007	12:24:57.13	143	684	11	4	●	●	●	○	●	●	●	00-11-DD-69-00-1A-AC-C7-7B-00-04-8F-80-01-0C-06
3165	23/05/2007	12:24:56.84	143	688	128	4	●	●	●	●	○	○	○	00-03-0A
3164	23/05/2007	12:24:56.46	143	684	128	1	●	●	●	○	●	●	●	
3163	23/05/2007	12:24:56.46	143	684	11	4	●	●	●	○	●	●	●	00-11-DD-69-00-1A-AC-C7-79-00-04-8F-80-01-87-46
3162	23/05/2007	12:24:56.19	143	687	128	4	●	●	●	○	○	○	○	00-03-0A
3161	23/05/2007	12:24:55.81	143	684	128	1	●	●	●	○	●	●	●	
3160	23/05/2007	12:24:55.81	143	684	11	4	●	●	●	○	●	●	●	00-11-DD-69-00-1A-AC-C7-77-00-04-8F-80-01-07-E5
3159	23/05/2007	12:24:55.48	143	688	128	4	●	●	●	●	○	○	○	00-03-0A
3158	23/05/2007	12:24:55.10	143	684	128	1	●	●	●	○	●	●	●	
3157	23/05/2007	12:24:55.10	143	684	11	4	●	●	●	○	●	●	●	00-11-DD-69-00-1A-AC-C7-75-00-04-8F-80-01-8C-A5
3156	23/05/2007	12:24:54.80	143	688	128	4	●	●	●	●	○	○	○	00-03-0A
3155	23/05/2007	12:24:54.44	143	684	128	1	●	●	●	○	●	●	●	
3154	23/05/2007	12:24:54.43	143	684	11	4	●	●	●	○	●	●	●	00-11-DD-69-00-1A-AC-C7-73-00-04-8F-80-01-01-44
3153	23/05/2007	12:24:54.13	143	690	128	4	●	●	●	●	●	○	○	00-03-0A
3152	23/05/2007	12:24:52.67	143	684	128	1	●	●	●	○	●	●	●	

Telecommands loaded.

Mission Data Client – Custom module



Mission Data Client - Web

SwissCube Web Mission Data Client - Telecommands - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://edelweiss.wg.estec.esa.nl/MissionDataClient/Telecommands.aspx

openSUSE Getting Started Latest Headlines

SwissCube Telecommands

1 2 3 4 5 6 7 8 9 10 ...

Token	Date	Time	APID	SF	SC	ST	SST	R	G	T	A	S	0	1	2	3	C	Data
3171	23/05/2007	12:24:57	693	3	151	128	4	o	o	o	o	o					o	00-03-0A
3170	23/05/2007	12:24:57	684	3	1917	128	1	o	o	o	o	o					o	-
3169	23/05/2007	12:24:57	684	3	1916	11	4	o	o	o	o	o					o	00-11-DD-69-00-1A-AC-C7-...
3168	23/05/2007	12:24:57	686	3	156	128	4	o	x									00-03-0A
3167	23/05/2007	12:24:57	684	3	1915	128	1	o	o	o	o	o					o	-
3166	23/05/2007	12:24:57	684	3	1914	11	4	o	o	o	o	o					o	00-11-DD-69-00-1A-AC-C7-...
3165	23/05/2007	12:24:56	688	3	178	128	4	o	o	o								00-03-0A
3164	23/05/2007	12:24:56	684	3	1913	128	1	o	o	o	o	o					o	-
3163	23/05/2007	12:24:56	684	3	1912	11	4	o	o	o	o	o					o	00-11-DD-69-00-1A-AC-C7-...
3162	23/05/2007	12:24:56	687	3	162	128	4	o	o	x								00-03-0A
3161	23/05/2007	12:24:55	684	3	1911	128	1	o	o	o	o	o					o	-
3160	23/05/2007	12:24:55	684	3	1910	11	4	o	o	o	o	o					o	00-11-DD-69-00-1A-AC-C7-...
3159	23/05/2007	12:24:55	688	3	177	128	4	o	o	o								00-03-0A
3158	23/05/2007	12:24:55	684	3	1909	128	1	o	o	o	o	o					o	-
3157	23/05/2007	12:24:55	684	3	1908	11	4	o	o	o	o	o					o	00-11-DD-69-00-1A-AC-C7-...
3156	23/05/2007	12:24:54	688	3	176	128	4	o	o	o								00-03-0A
3155	23/05/2007	12:24:54	684	3	1907	128	1	o	o	o	o	o					o	-
3154	23/05/2007	12:24:54	684	3	1906	11	4	o	o	o	o	o					o	00-11-DD-69-00-1A-AC-C7-...
3153	23/05/2007	12:24:54	688	3	158	128	4	o	o	o	x							00-03-0A

Done

- Home
 - Telemetries
 - Housekeeping
 - Telecommands
 - Image Service

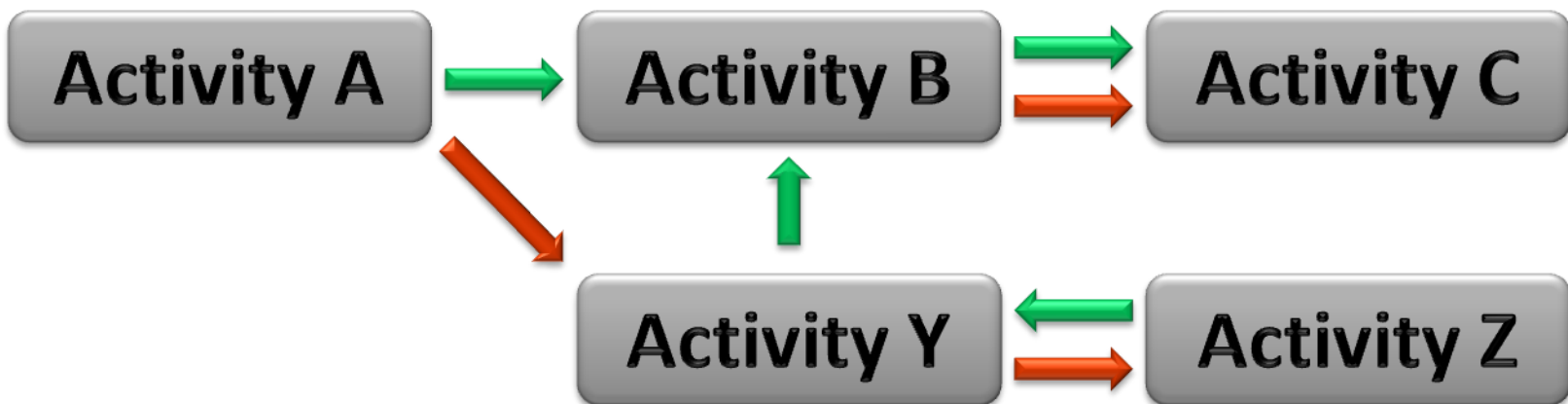
Logged as fgeo
Logout

Scheduler

- Window of visibility small (few minutes per pass), all the actions taking place during the passes must be planned in advance.
 - To have no decision taken on-the-fly by the control operator
- Execute plans that contain the actions happening before/during/after a pass.
- Connected to MCS (Uplink and Distribution)
 - Need link state, acknowledgements and housekeeping to make flow decisions
- Plan execution reporting

Scheduler

- XML files containing a plan of activities
 - An activity execution can be successful or not (boolean)
 - Another activity is referenced for each of the two possible outcomes
- An activity is a script that access real-time telemetry and uses the telecommand service exposed by the MCS



Technologies

- Microsoft .NET Framework 3.5
 - Windows Communication Foundation
 - Unifies Inter-Process Communication mechanisms
 - Windows Presentation Foundation
 - Vector-based hardware-accelerated GUI

- Microsoft SQL Server 2005
 - Runs on the Express Edition which is free even for commercial use

- Microsoft Message Queuing (MSMQ)
 - Decoupling of MCS Core and Distribution

Current State

- EGSE Router
 - Complete and in use for the tests of the other components
- Mission Control Software
 - Almost complete, missing time correlation integration
- Ground Stations software
 - Almost done
- Scheduler / Planning tools
 - Prototype with Python scripting
- TMTC Front End
 - Complete and tested
- User interfaces
 - MIB Configuration
 - Real-time Mission Data Client and Web Mission Data visualization

SwissCube Ground Segment Software in Remote Electrical and Data Verification (REDV)

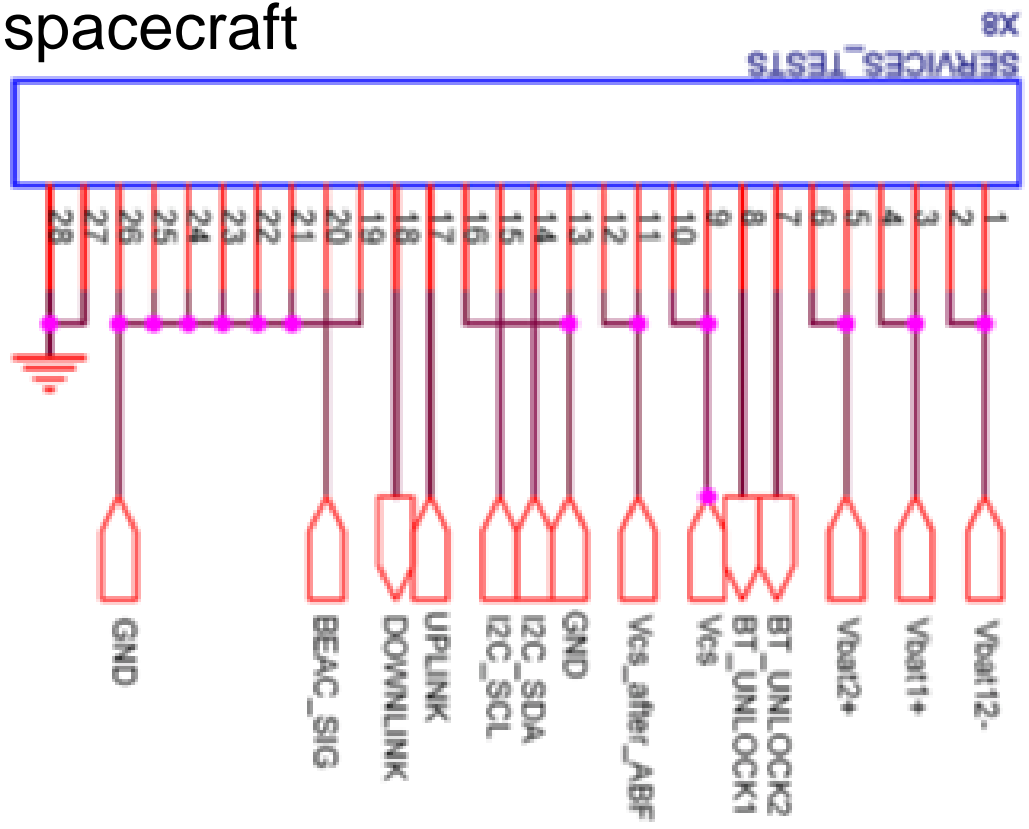
Yann Voumard

Remote Electrical and Data Verification (REDV)

- Thermal cycles / Vibrations / ...
 - Not always on-site (Bern, Berlin, ...)

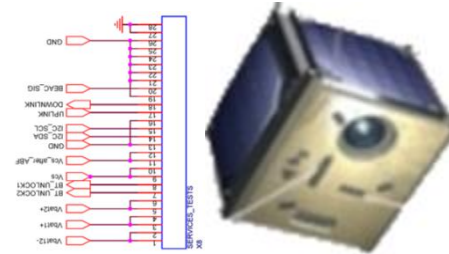
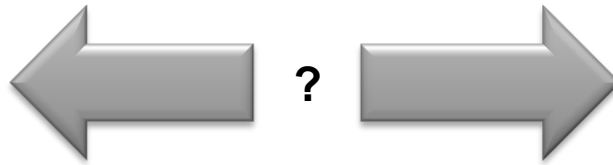
■ Service Connector on the spacecraft

- Digital signals
 - Uplink
 - Downlink
 - Beacon
 - I²C BUS
- Analog signals
 - Batteries voltage



How to monitor the satellite during REDV tests?

- Send commands (uplink)
- Analyze data (downlink)

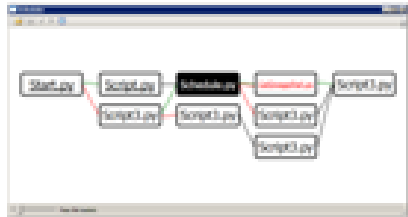


SwissCube with its service connector

- Send telecommands manually
- Read raw data (hex values, analog instruments, ...)

=> Use the existing Ground Segment Software capabilities!

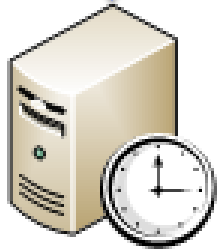
Tests Set-Up



Script display



Mission Data Client



Scheduler



SwissCube MCS



TMTCC Front End



Test Bridge/Board



Same softwares as during the mission

Thank you for your attention