Multi-Mission Support with WARP

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WARP – The Antenna M&C at Ground Station Weilheim

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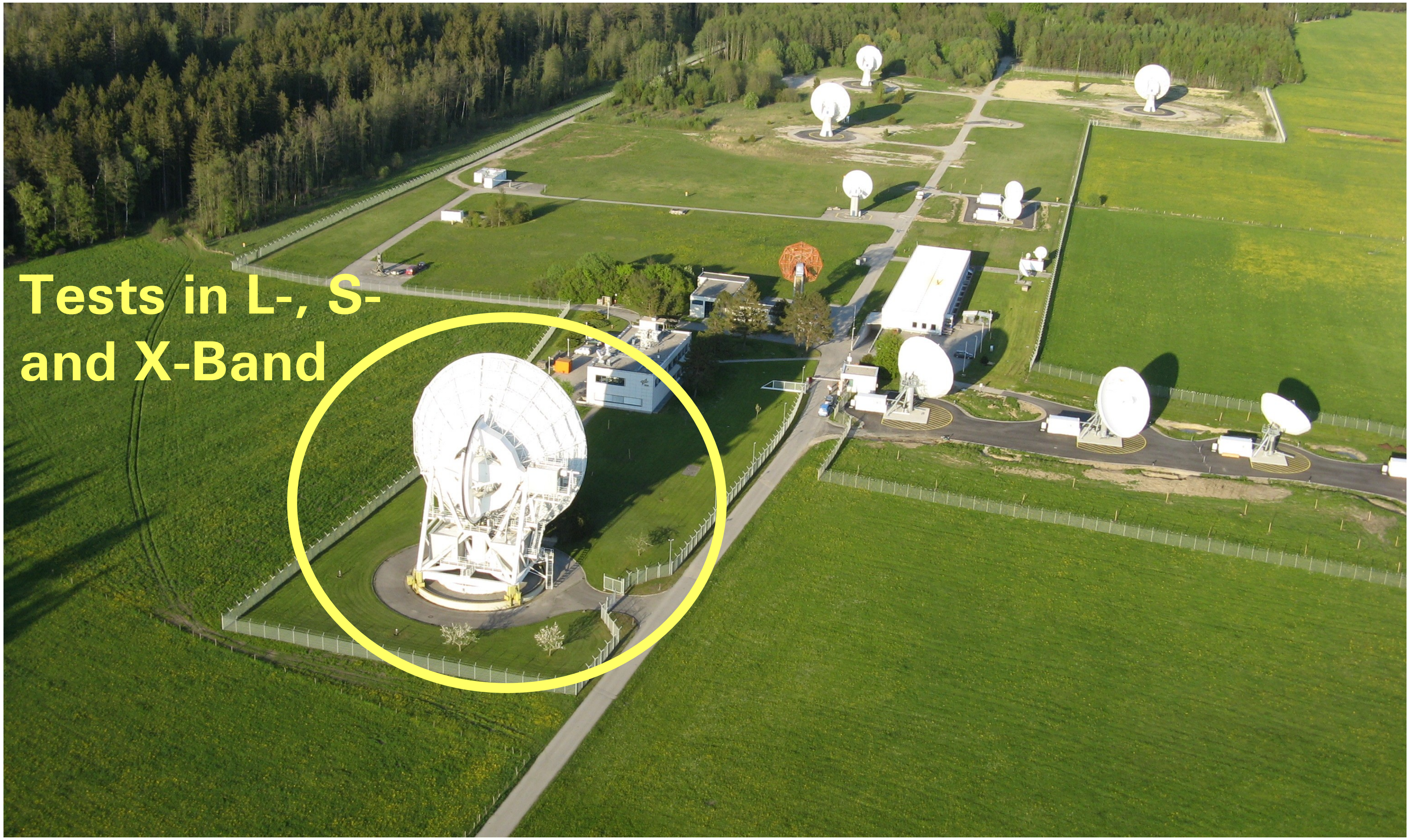

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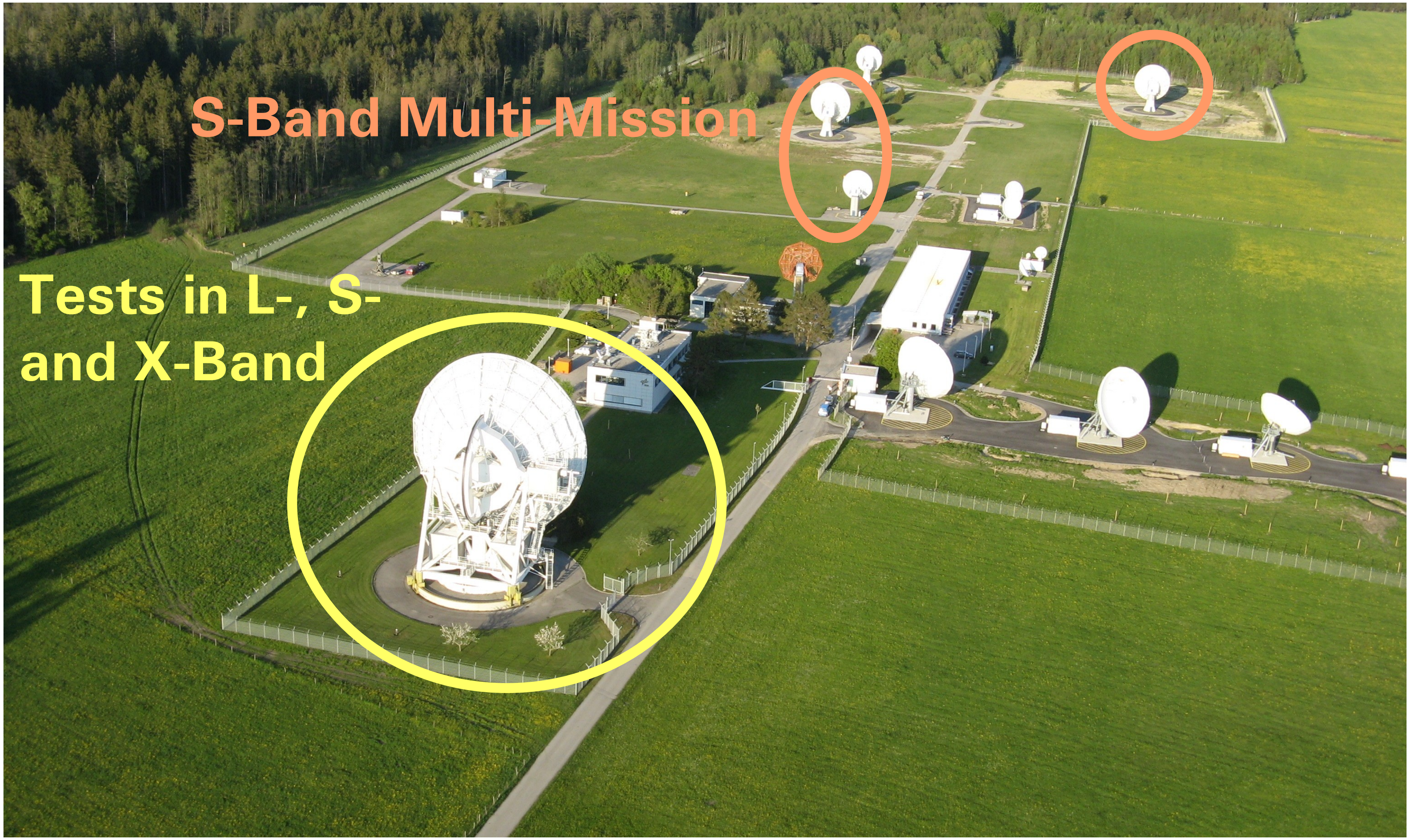

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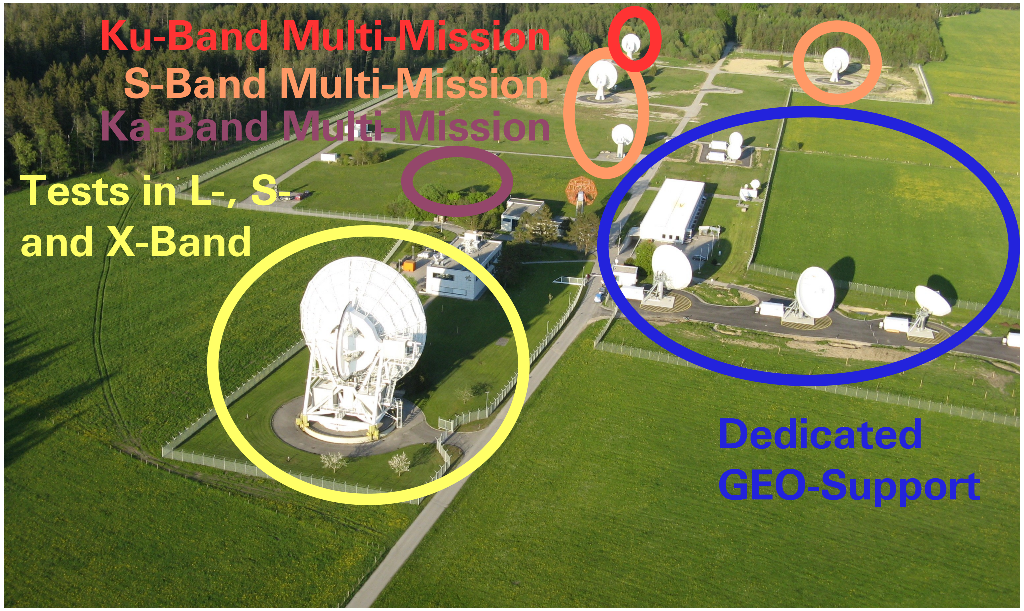
- Different antenna hardware
  - transparent to OPS
  - transparent I/F to GSOC
- Need to configure the station
  - reliably
  - quickly *typical slot of 20 minutes for configuration and internal tests*
  - frequently
- Hardware maintenance is done routinely between two passes



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- Different antenna hardware
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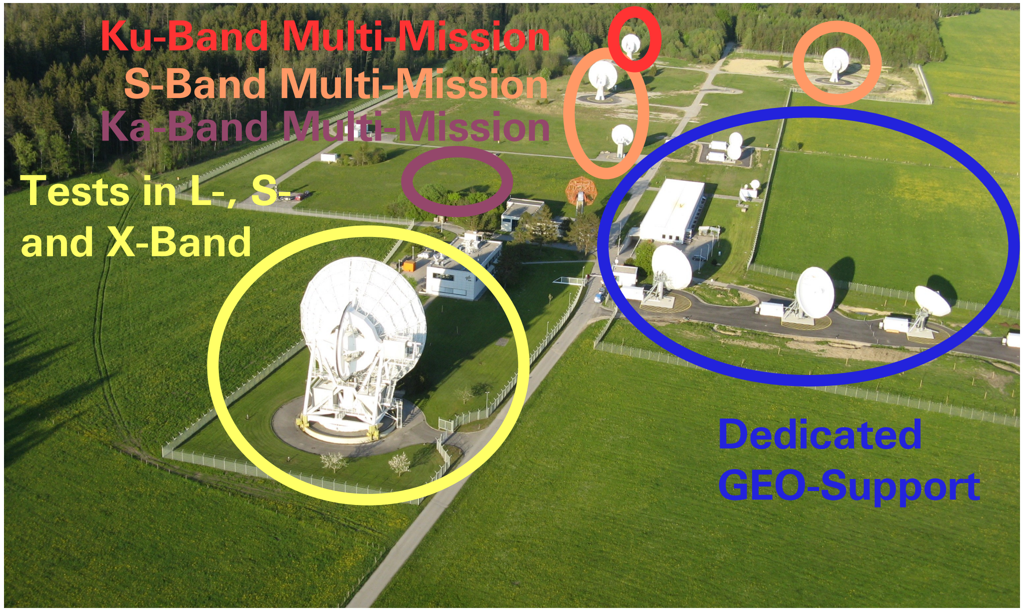
Generalization

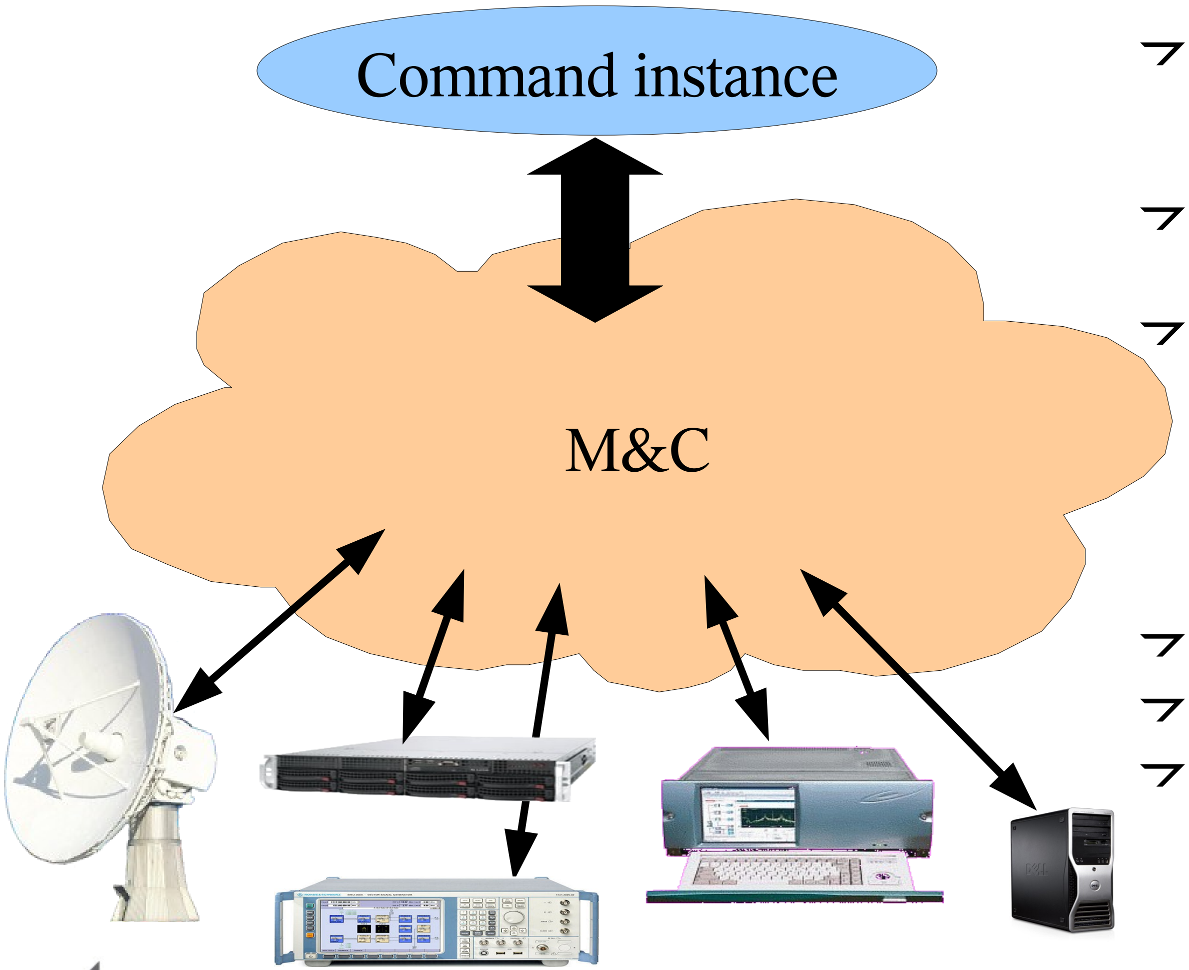
- Need to configure the station
  - reliably
  - quickly *typical slot of 20 minutes for configuration and internal tests*
  - frequently

- Hardware maintenance is done routinely between two passes



The WARP Software

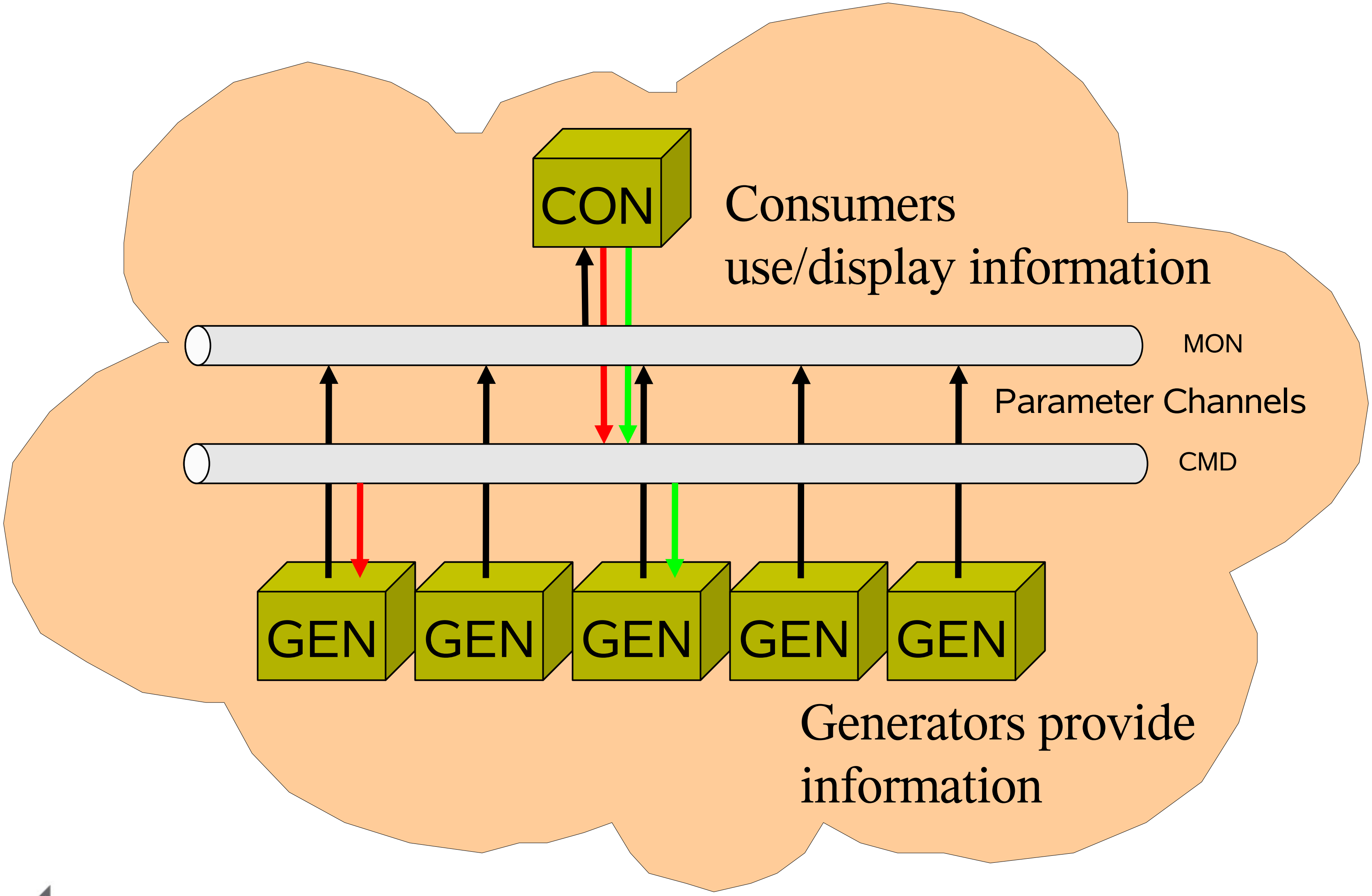
Requirements for a Generic M&C-System



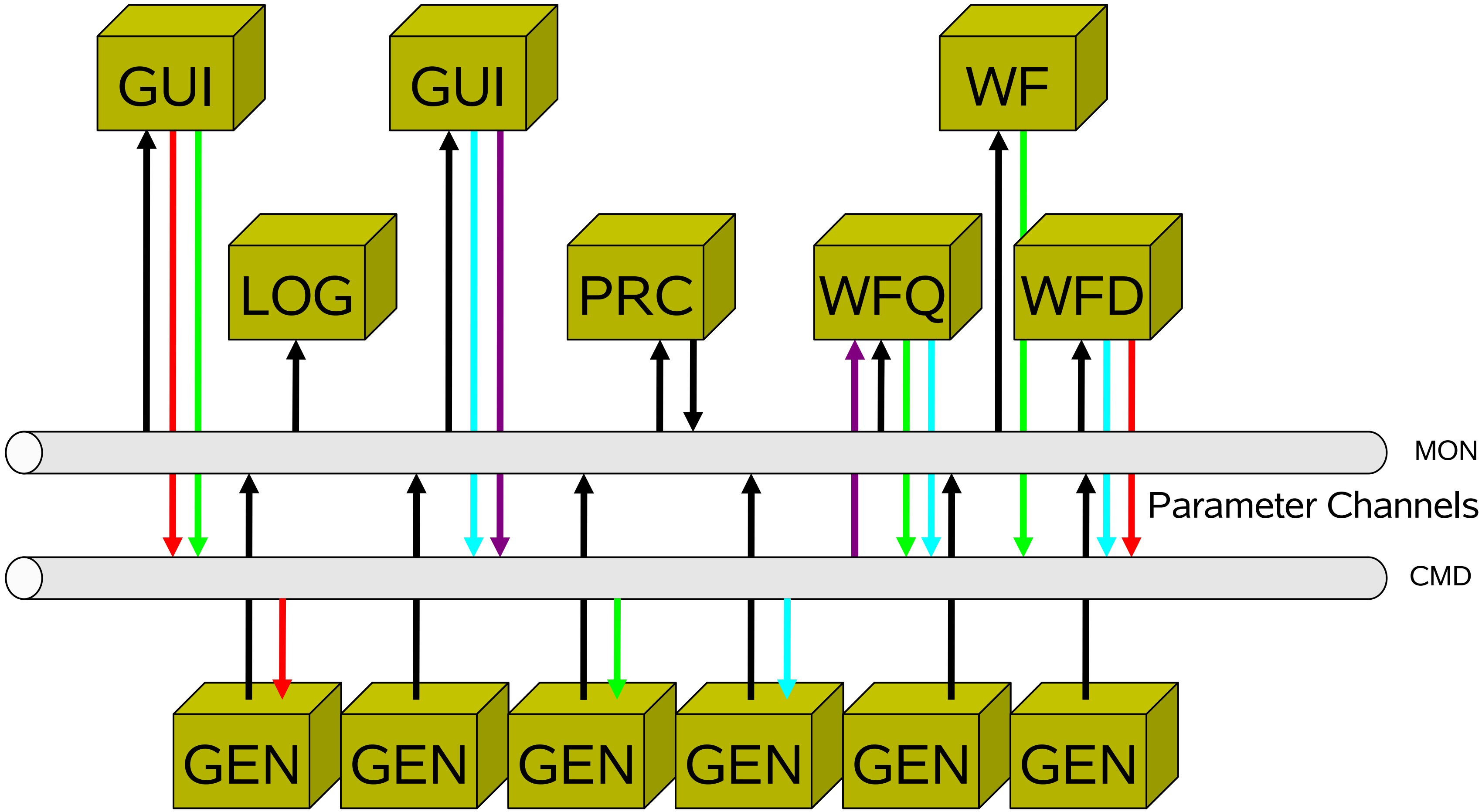
- Access to all hardware capabilities, especially all commands
- Hierarchical structure in monitoring and command
- Manually or automated

- Platform independent
- Scalable, distributed
- Fast and reliable

A Generic M&C-System - Design Principle (1)



A Generic M&C-System - Design Principle (2)



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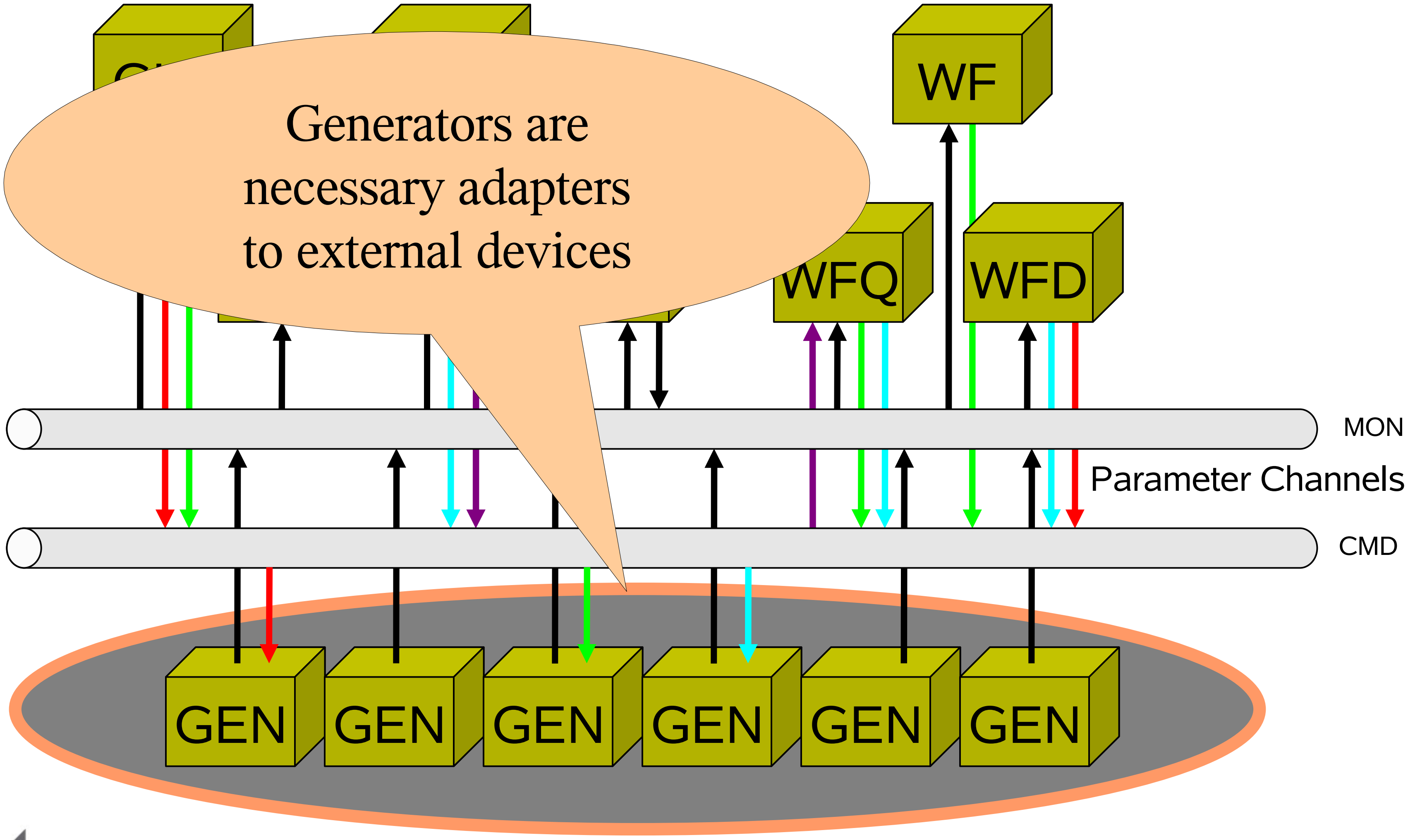

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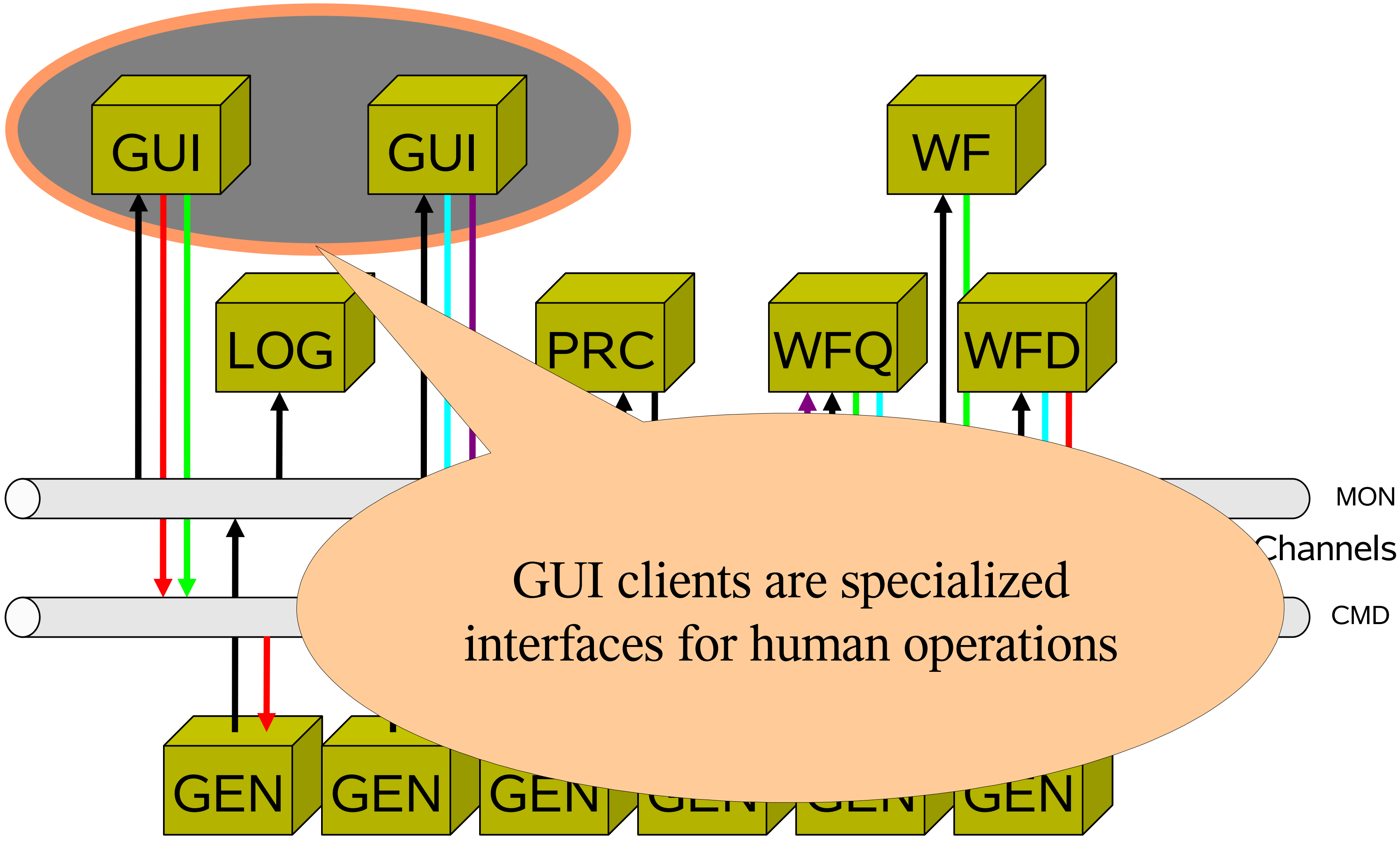

Deutsches Zentrum für Luft- und Raumfahrt e.V. in der Helmholtz-Gemeinschaft

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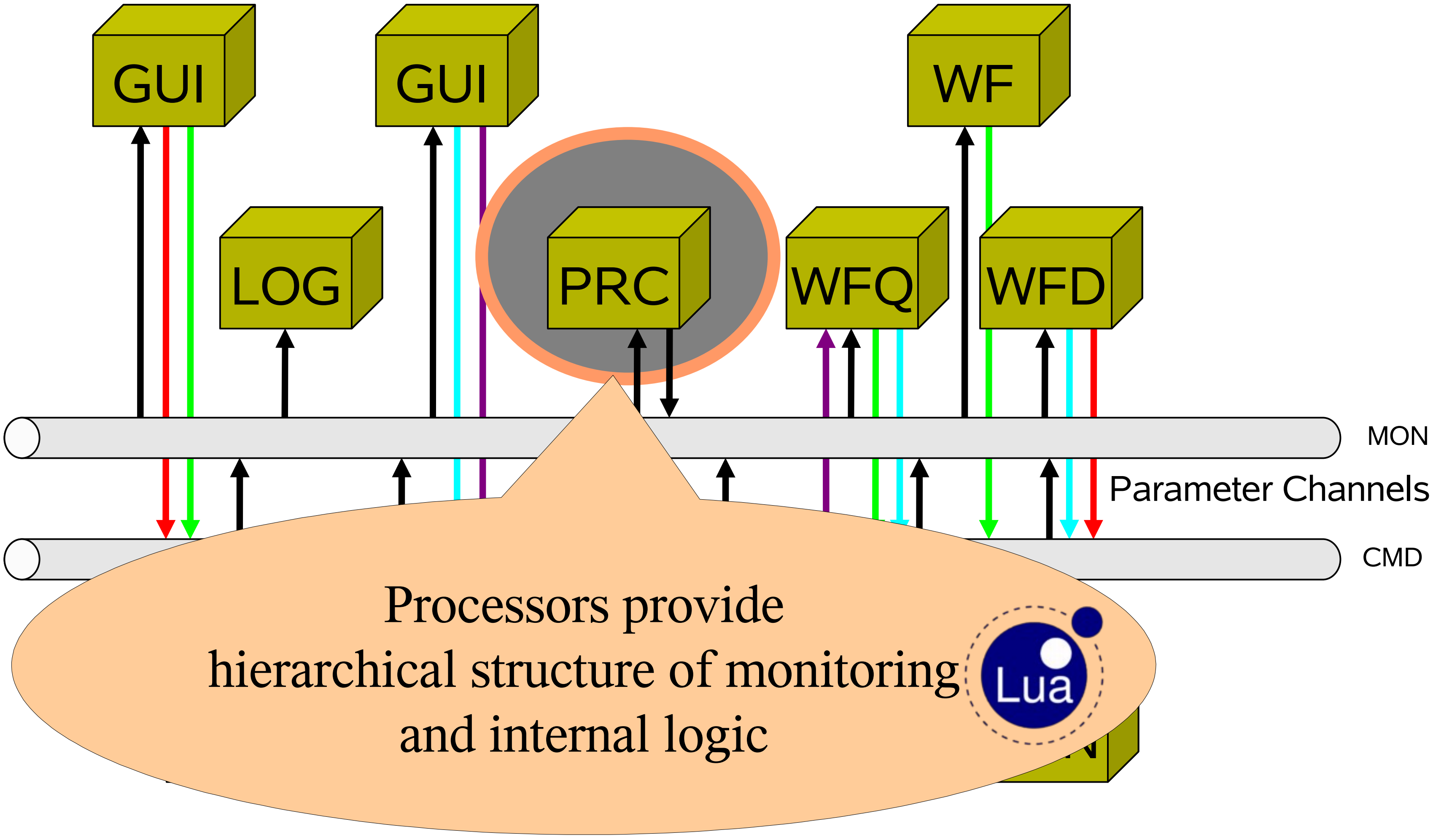

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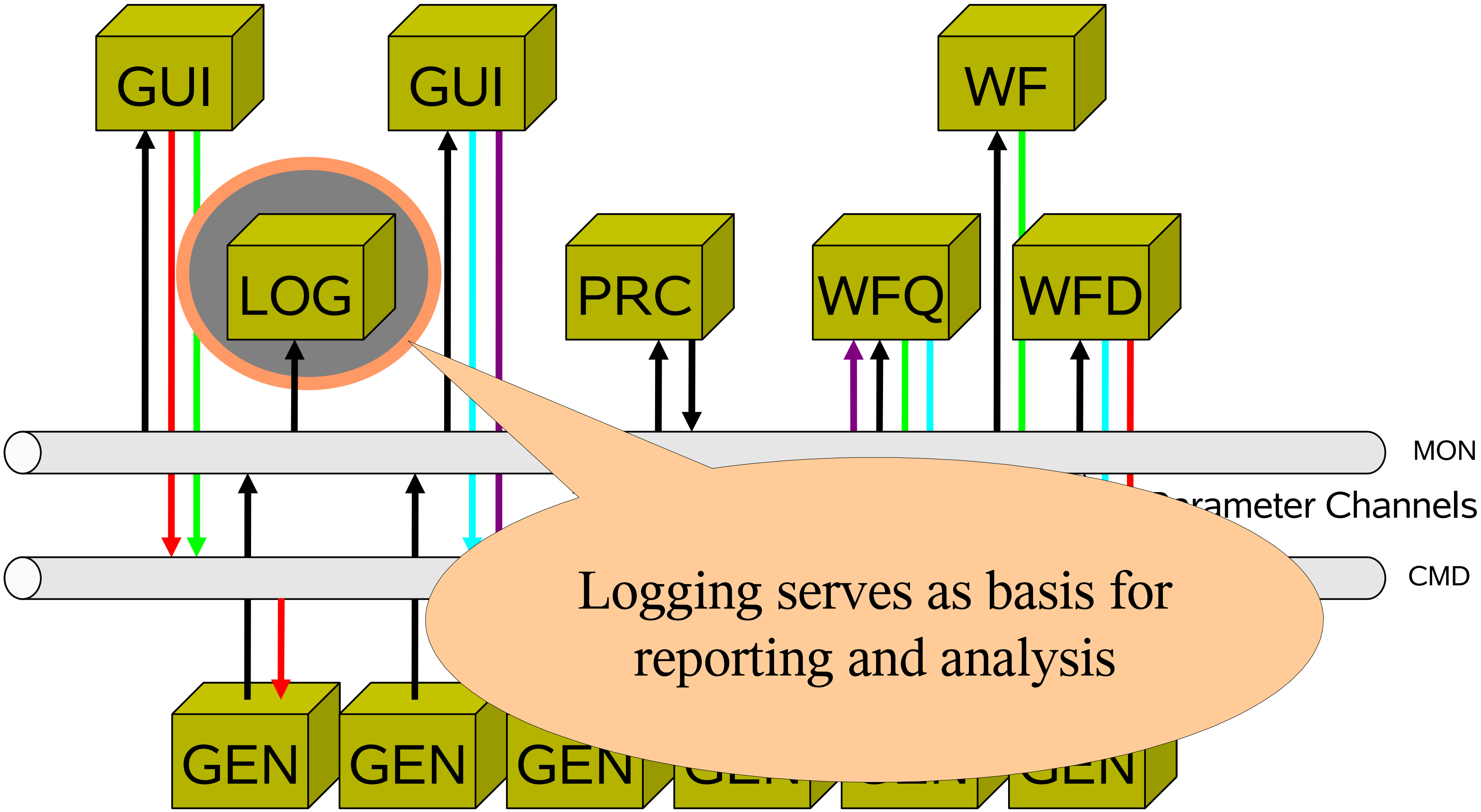

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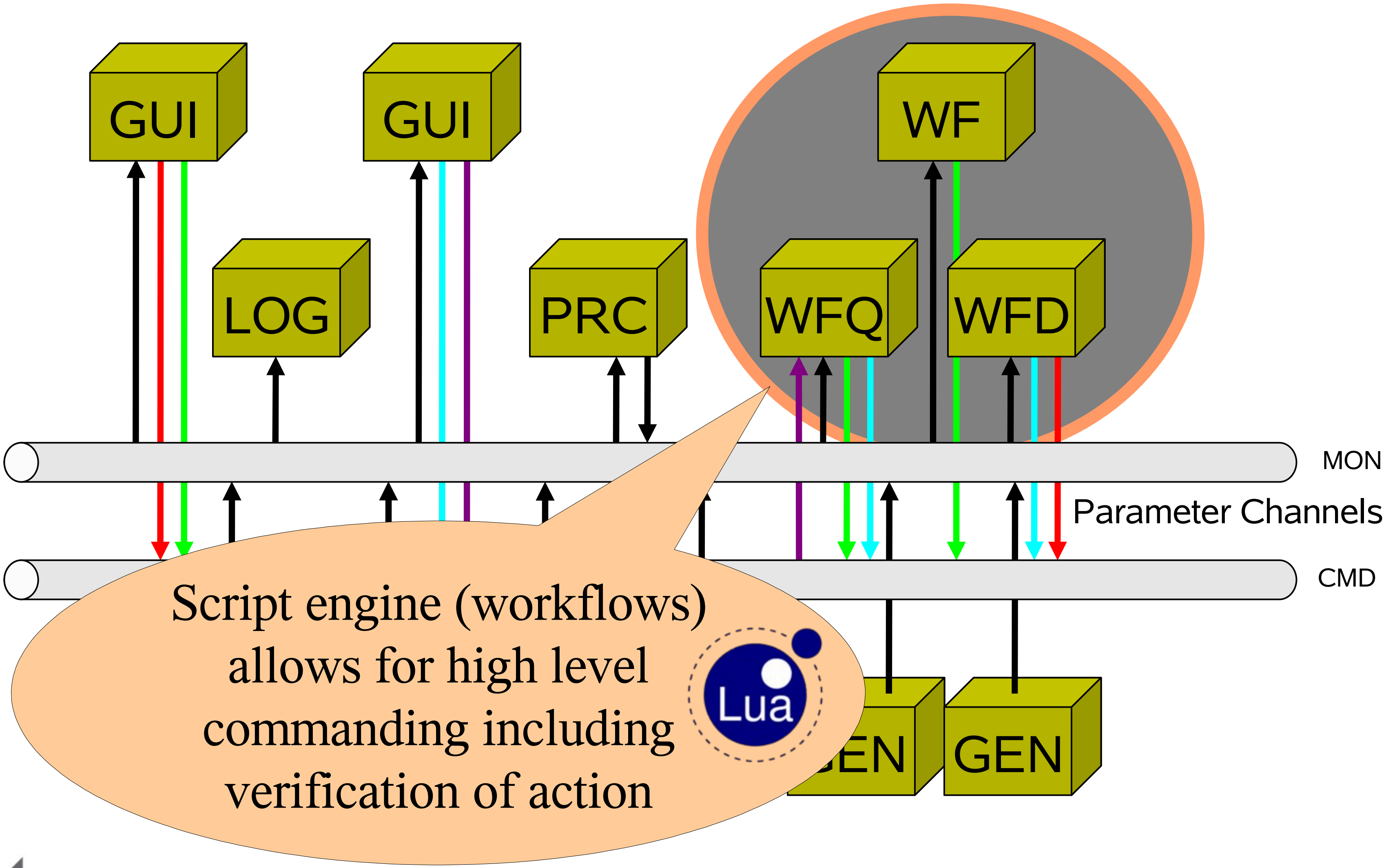
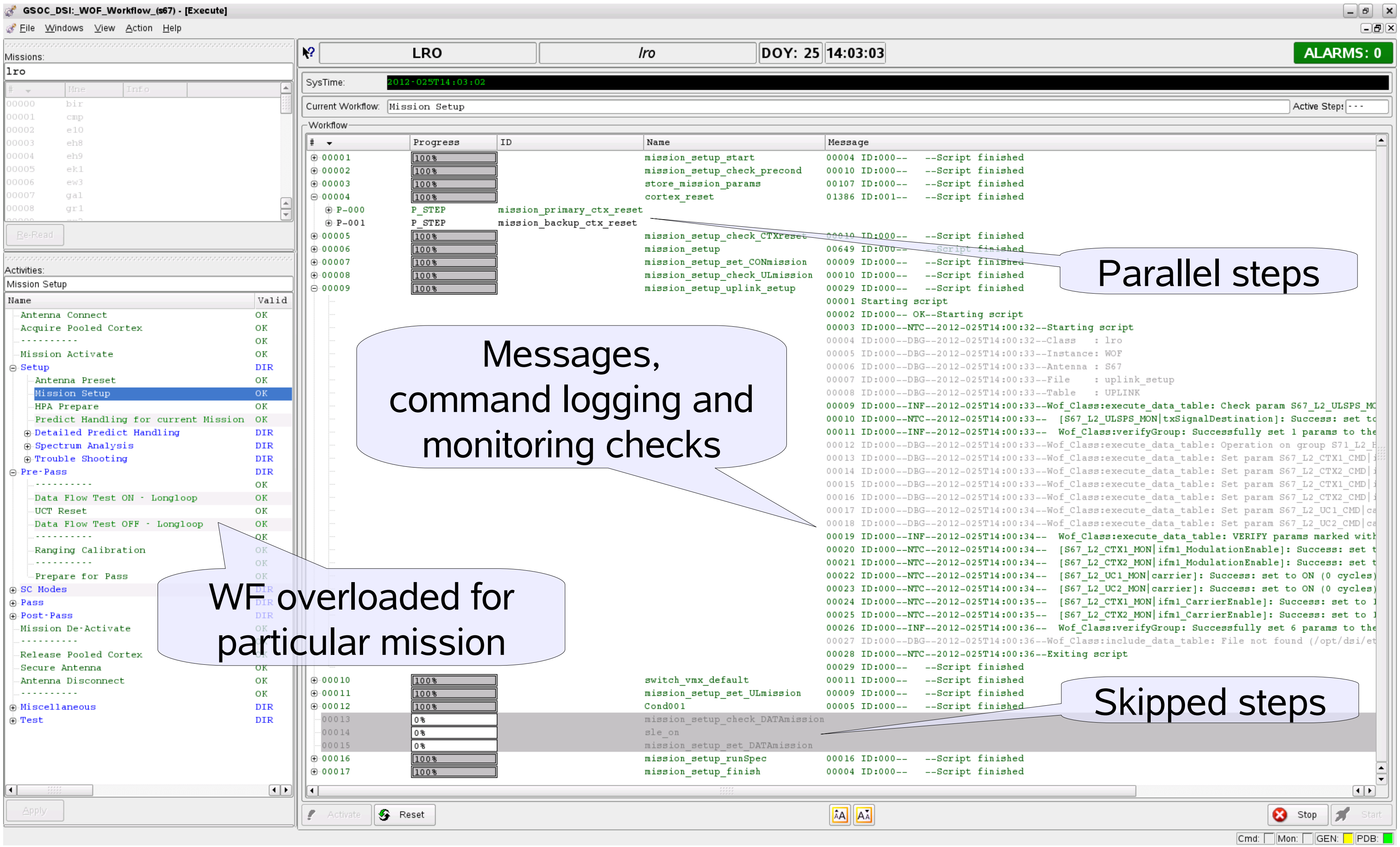
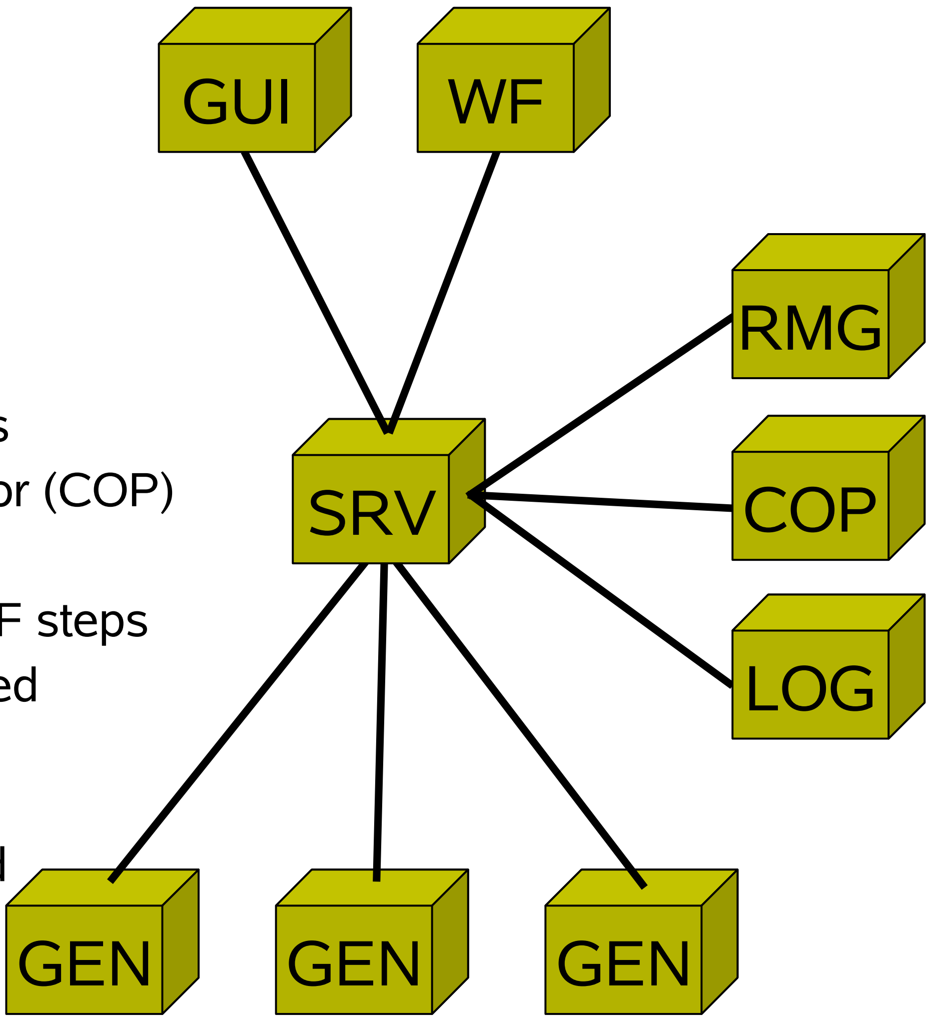


WARP - Example: High Level Commanding



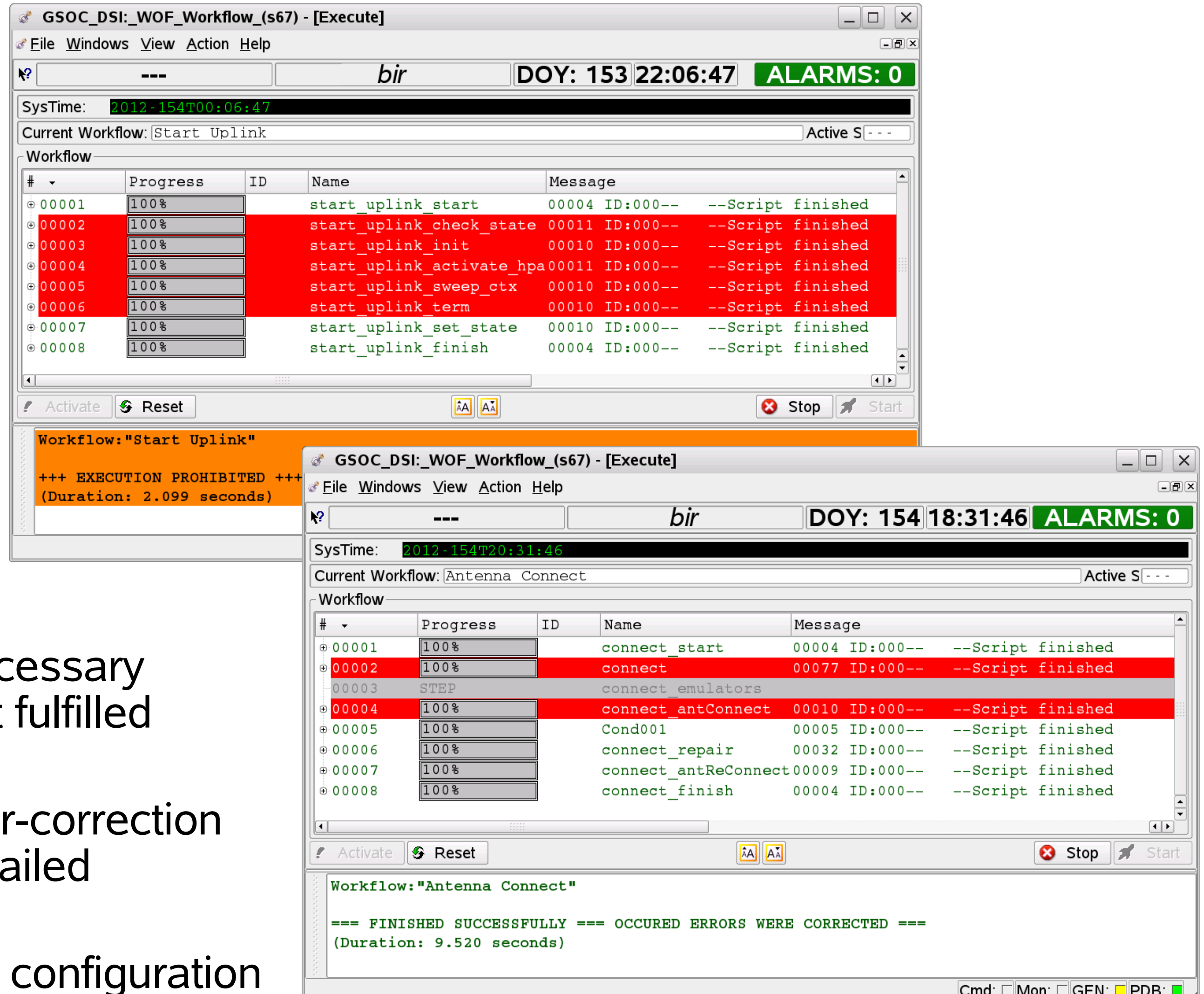
WARP - Toolkit

- Resource Manager (RMG)
  - Declares devices as
    - present
    - maintained
    - faulty
  - Informs WFs to ignore devices
- Configuration Observation Processor (COP)
  - State machine
  - Allows/Forbids WFs and/or WF steps
  - Reports deviations from desired settings
- Reporting
  - Fills a template (LaTex) based on parameter logging
  - Automatically generated



Configuration Observation Processor - State Machine

- Keeps track on actions and provide antenna state
  - globally
    - setup
    - pass
    - …
  - functionally
    - UL/DL
    - …
- Prevents action if necessary preconditions are not fulfilled
- Allows to initiate error-correction if needed/execution failed
- Continuously checks configuration



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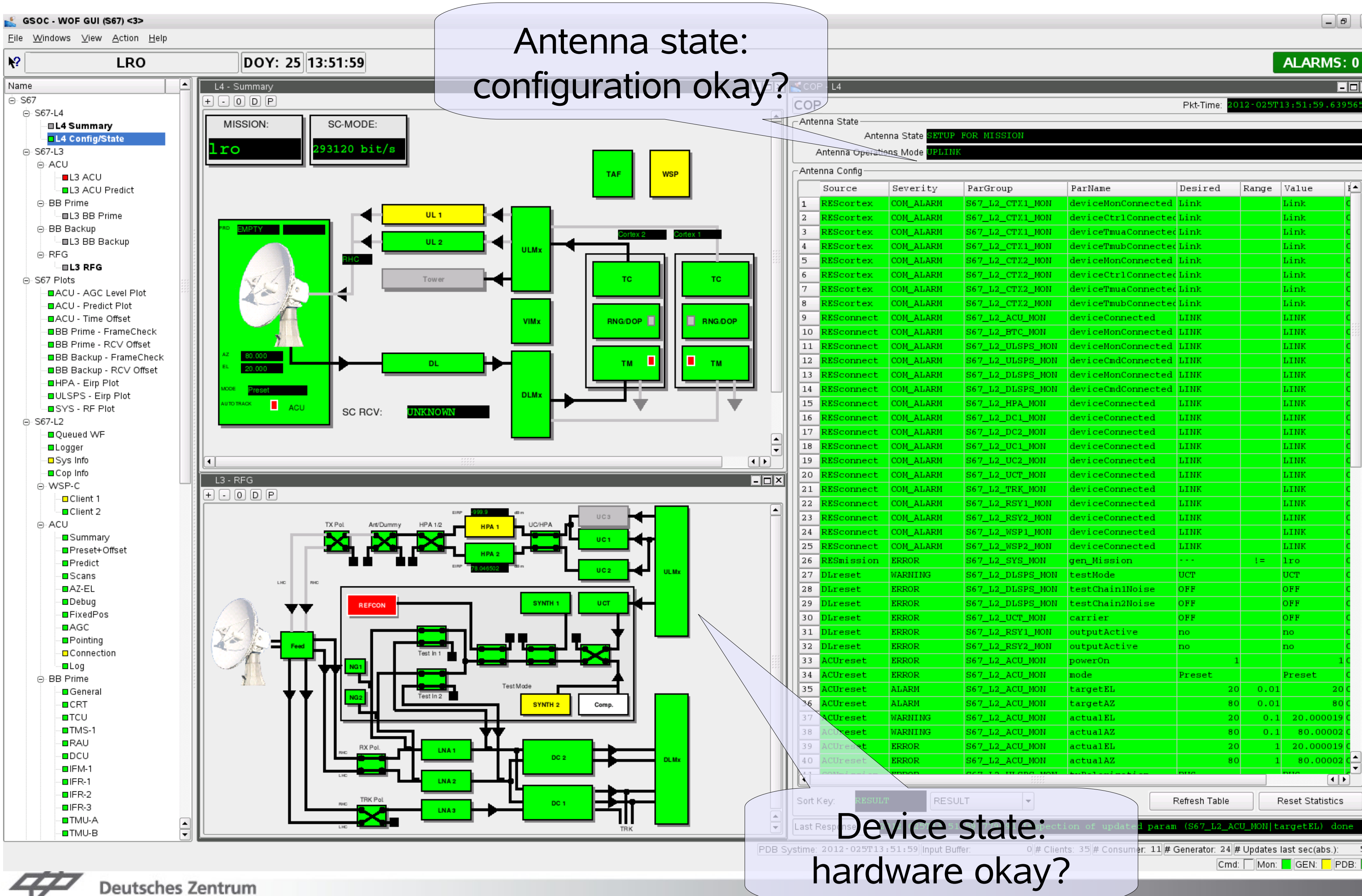

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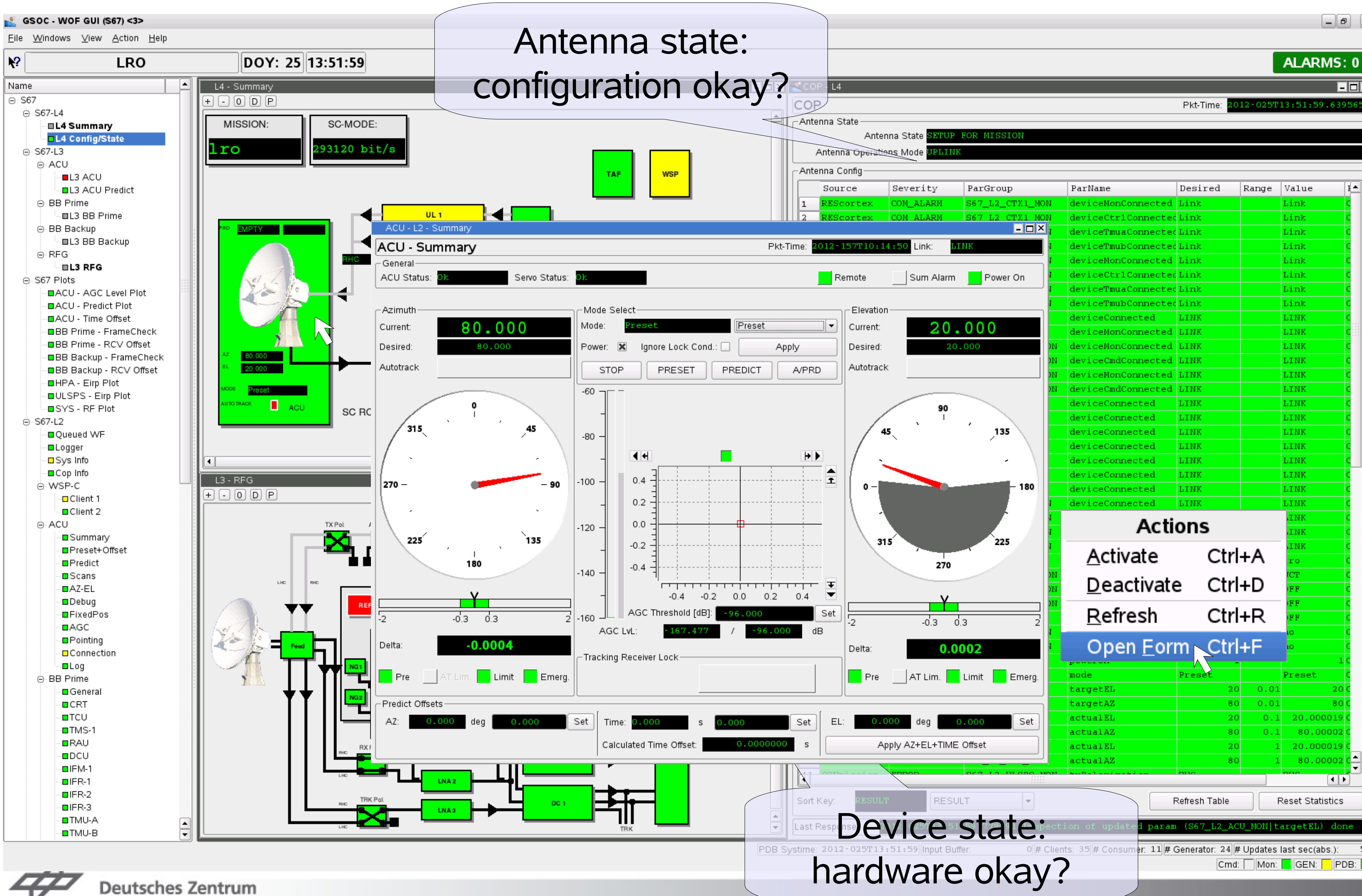
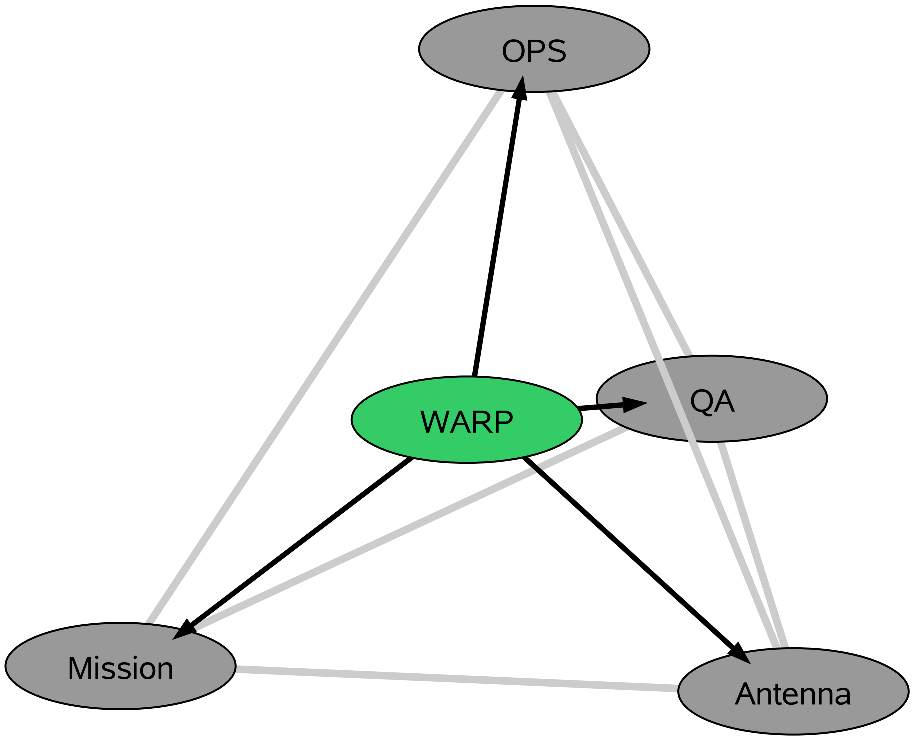


Multi-Mission Support with WARP

WARP - An Object Oriented Design for Operations

- Mission Definition
  - Abstract parameters like
    - Frequencies
    - Bitrates
- Antenna Definition
  - Applicable devices
    - Do's and dont's
    - Calibrations
    - Parameter ranges
- Operations Concept
  - Unified procedures for
    - ✔ Various antennas
    - ✔ Various missions
- QA
  - Few inputs
  - Checkable against settings



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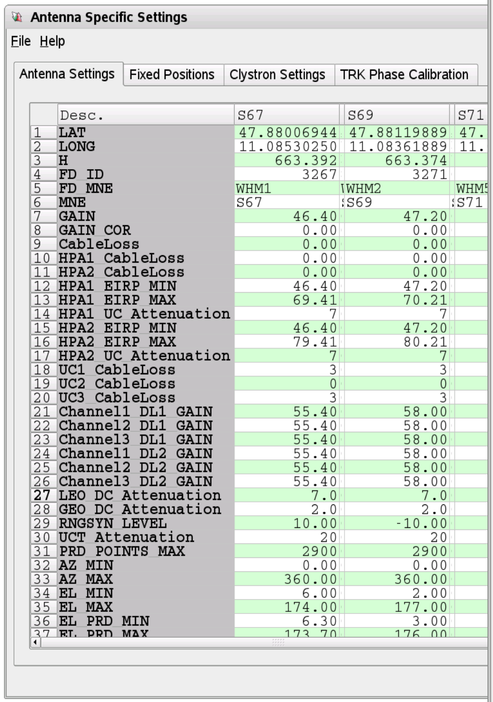
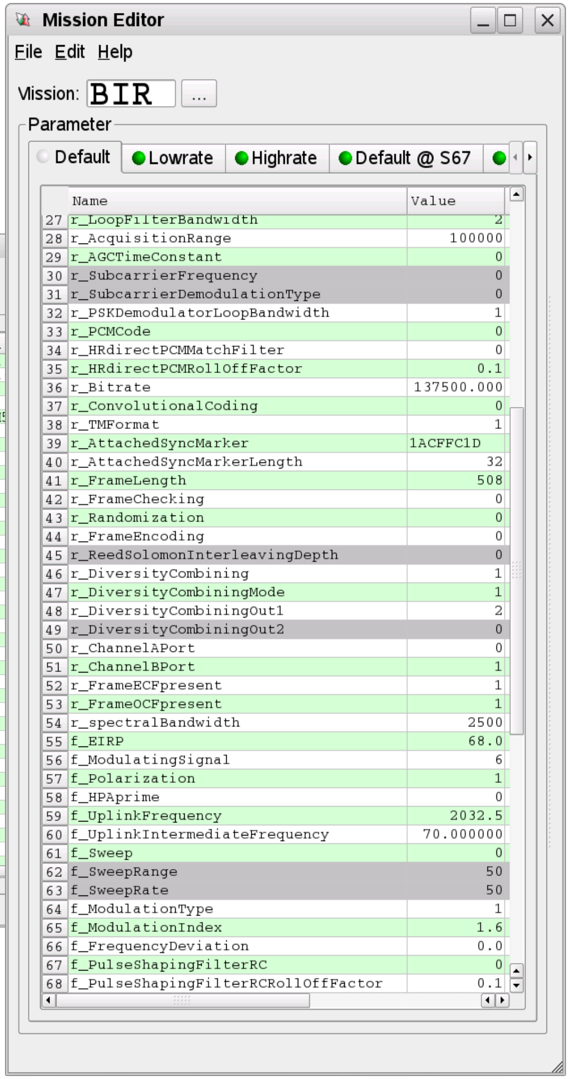


	Desc.	S67	S69	S71
1	LAT	47.88006944	47.88119889	47.
2	LONG	11.08530250	11.08361889	11.
3	H	663.392	663.374	
4	FD_ID	3267	3271	
5	FD_MNE	WHM1	WHM2	WHM5
6	MNE	S67	S69	S71
7	GAIN	46.40	47.20	
8	GAIN_COR	0.00	0.00	
9	CableLoss	0.00	0.00	
10	HPA1_CableLoss	0.00	0.00	
11	HPA2_CableLoss	0.00	0.00	
12	HPA1_EIRP_MIN	46.40	47.20	
13	HPA1_EIRP_MAX	69.41	70.21	
14	HPA1_UC_Attenuation	7	7	
15	HPA2_EIRP_MIN	46.40	47.20	
16	HPA2_EIRP_MAX	79.41	80.21	
17	HPA2_UC_Attenuation	7	7	
18	UC1_CableLoss	3	3	
19	UC2_CableLoss	0	0	
20	UC3_CableLoss	3	3	
21	Channel1_DL1_GAIN	55.40	58.00	
22	Channel2_DL1_GAIN	55.40	58.00	
23	Channel3_DL1_GAIN	55.40	58.00	
24	Channel1_DL2_GAIN	55.40	58.00	
25	Channel2_DL2_GAIN	55.40	58.00	
26	Channel3_DL2_GAIN	55.40	58.00	
27	LEO_DC_Attenuation	7.0	7.0	
28	GEO_DC_Attenuation	2.0	2.0	
29	RNGSYN_LEVEL	10.00	-10.00	
30	UCT_Attenuation	20	20	
31	PRD_POINTS_MAX	2900	2900	
32	AZ_MIN	0.00	0.00	
33	AZ_MAX	360.00	360.00	
34	EL_MIN	6.00	2.00	
35	EL_MAX	174.00	177.00	
36	EL_PRD_MIN	6.30	3.00	
37	EL_PRD_MAX	173.70	176.00	



	Name	Value
27	r_LoopFilterBandwidth	2
28	r_AcquisitionRange	100000
29	r_AGCTimeConstant	0
30	r_SubcarrierFrequency	0
31	r_SubcarrierDemodulationType	0
32	r_PSKDemodulatorLoopBandwidth	1
33	r_PCMCode	0
34	r_HRdirectPCMMatchFilter	0
35	r_HRdirectPCMRollOffFactor	0.1
36	r_Bitrate	137500.000
37	r_ConvolutionalCoding	0
38	r_TMFormat	1
39	r_AttachedSyncMarker	1ACFFC1D
40	r_AttachedSyncMarkerLength	32
41	r_FrameLength	508
42	r_FrameChecking	0
43	r_Randomization	0
44	r_FrameEncoding	0
45	r_ReedSolomonInterleavingDepth	0
46	r_DiversityCombining	1
47	r_DiversityCombiningMode	1
48	r_DiversityCombiningOut1	2
49	r_DiversityCombiningOut2	0
50	r_ChannelAPort	0
51	r_ChannelBPort	1
52	r_FrameECFpresent	1
53	r_FrameOCFpresent	1
54	r_spectralBandwidth	2500
55	f_EIRP	68.0
56	f_ModulatingSignal	6
57	f_Polarization	1
58	f_HPAprime	0
59	f_UplinkFrequency	2032.5
60	f_UplinkIntermediateFrequency	70.000000
61	f_Sweep	0
62	f_SweepRange	50
63	f_SweepRate	50
64	f_ModulationType	1
65	f_ModulationIndex	1.6
66	f_FrequencyDeviation	0.0
67	f_PulseShapingFilterRC	0
68	f_PulseShapingFilterRCRollOffFactor	0.1

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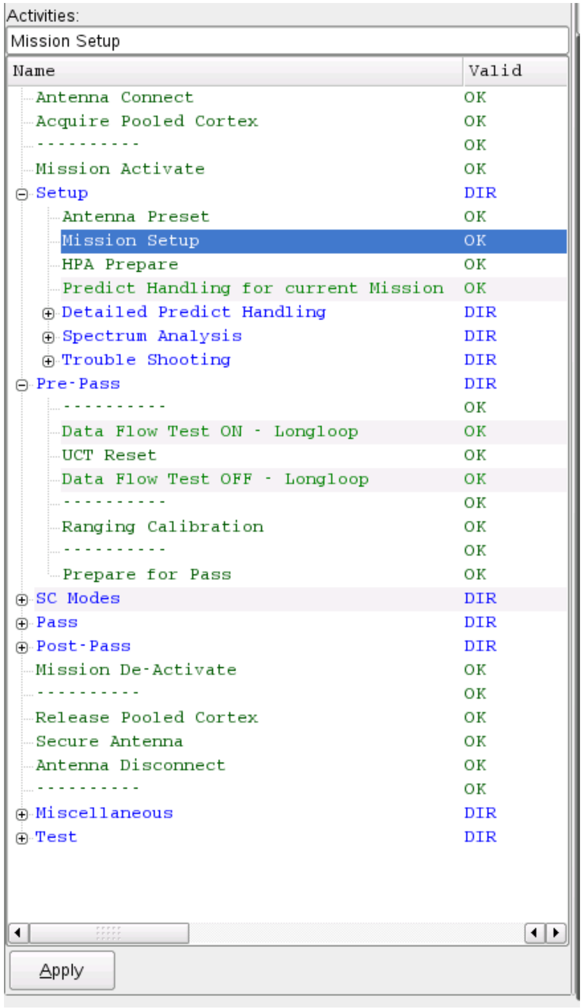
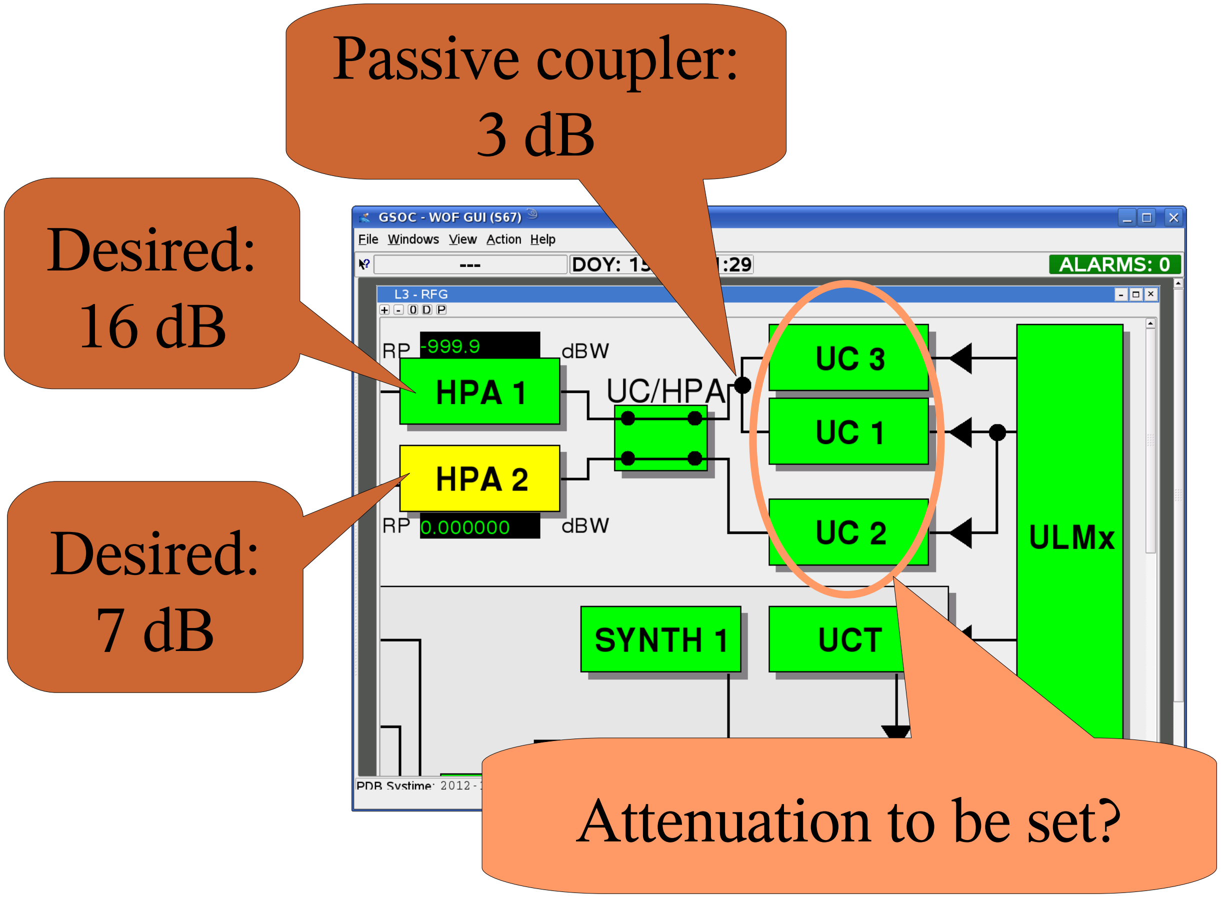


Functional Dependencies - Antenna Parameters

- Different HPA have different working points
- Different signal paths have different losses
- Dynamic assignment UC/HPA must be possible



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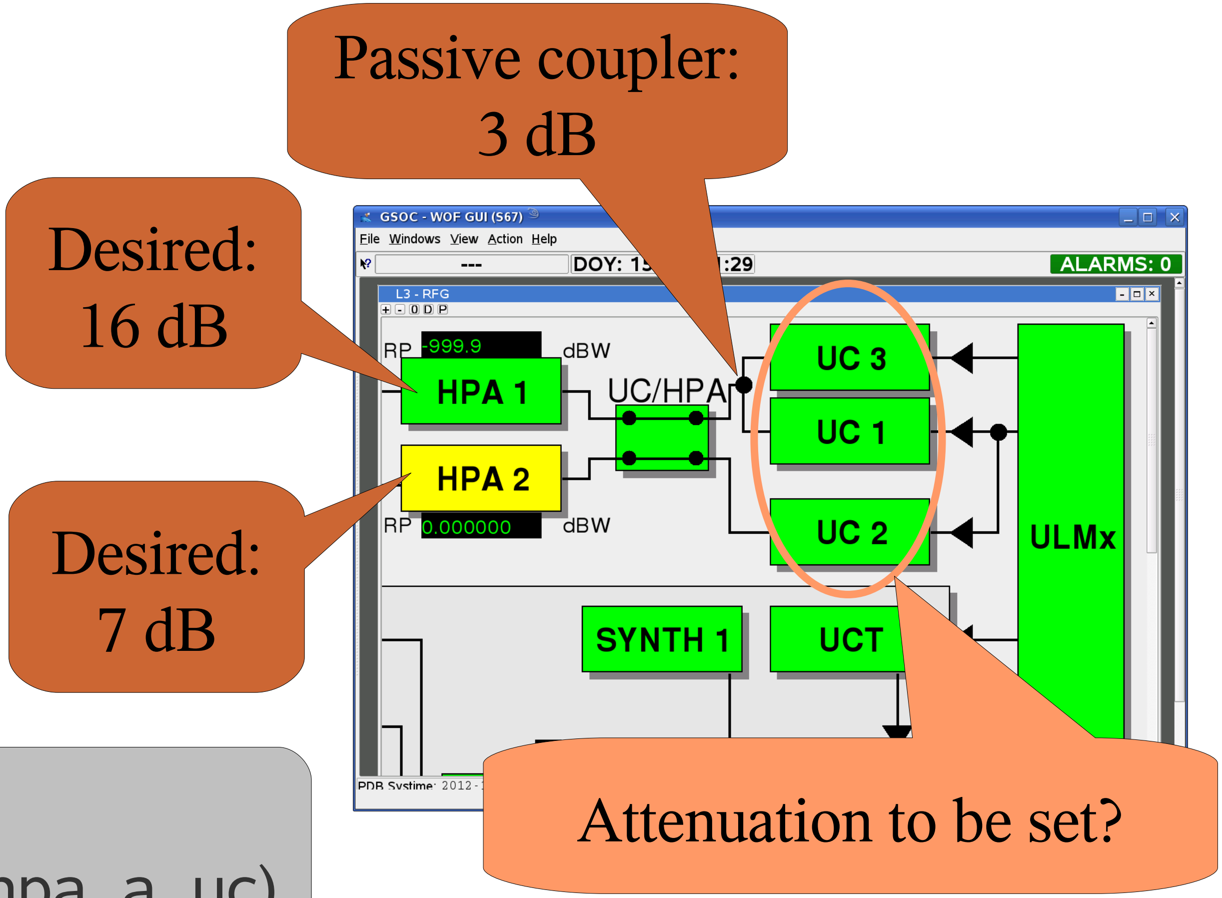
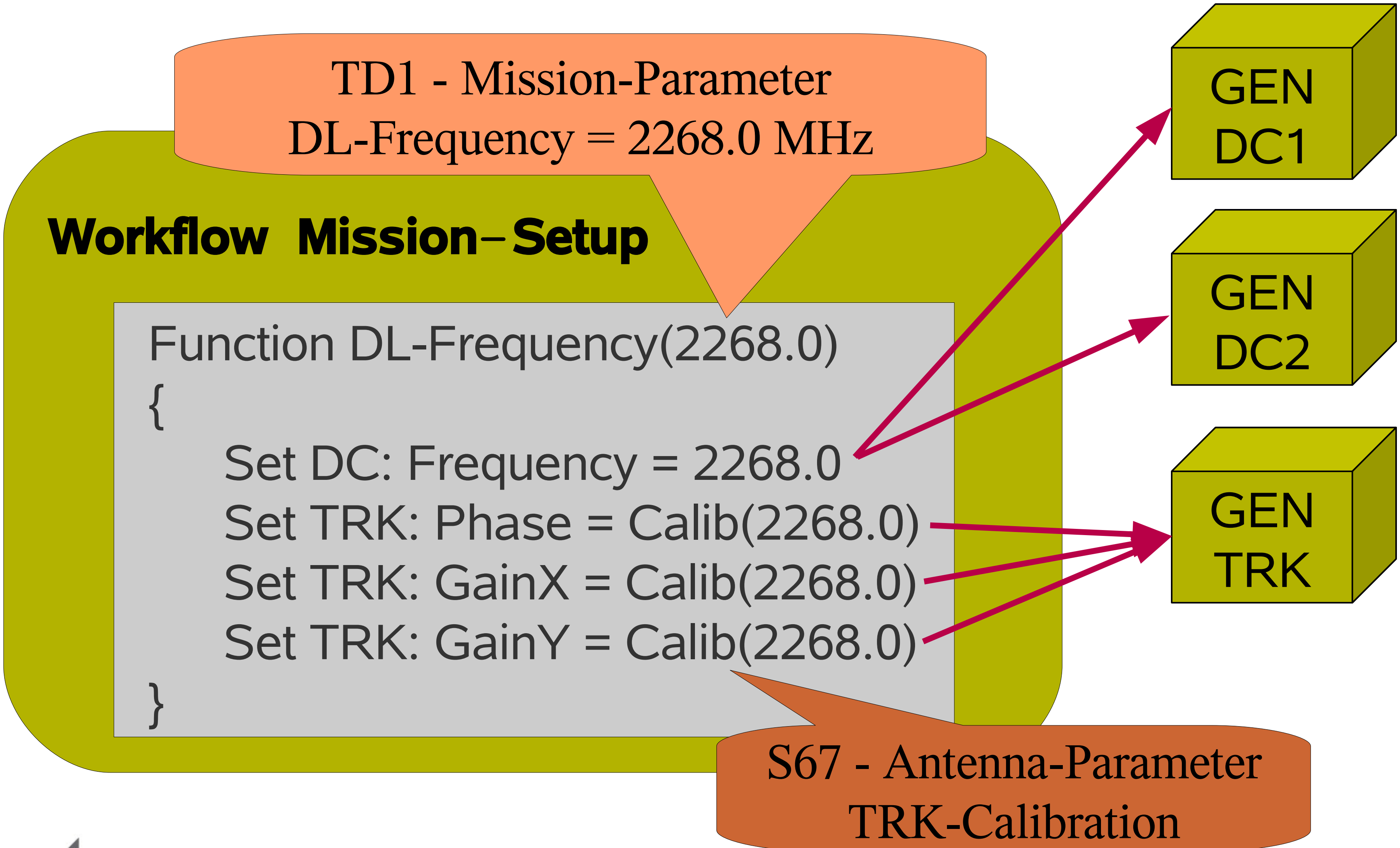


function UC_Attenuation(a_hpa, a_uc)

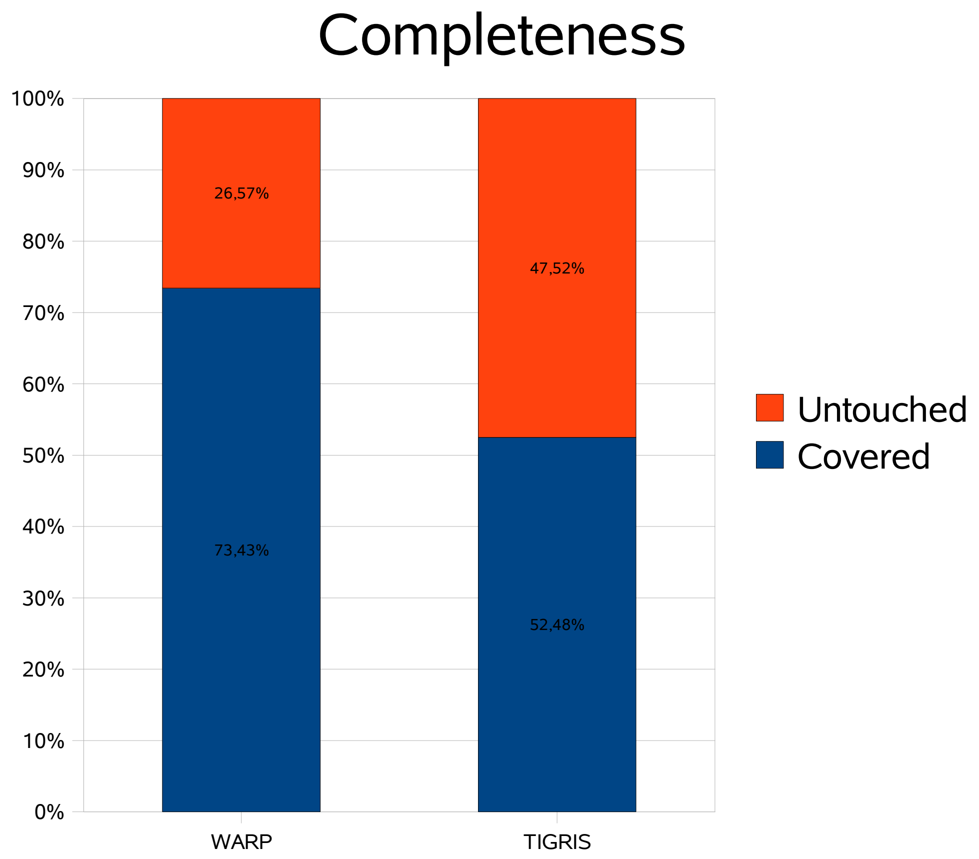
Functional Dependencies - Mission Parameters



Operation-Procedures within WARP

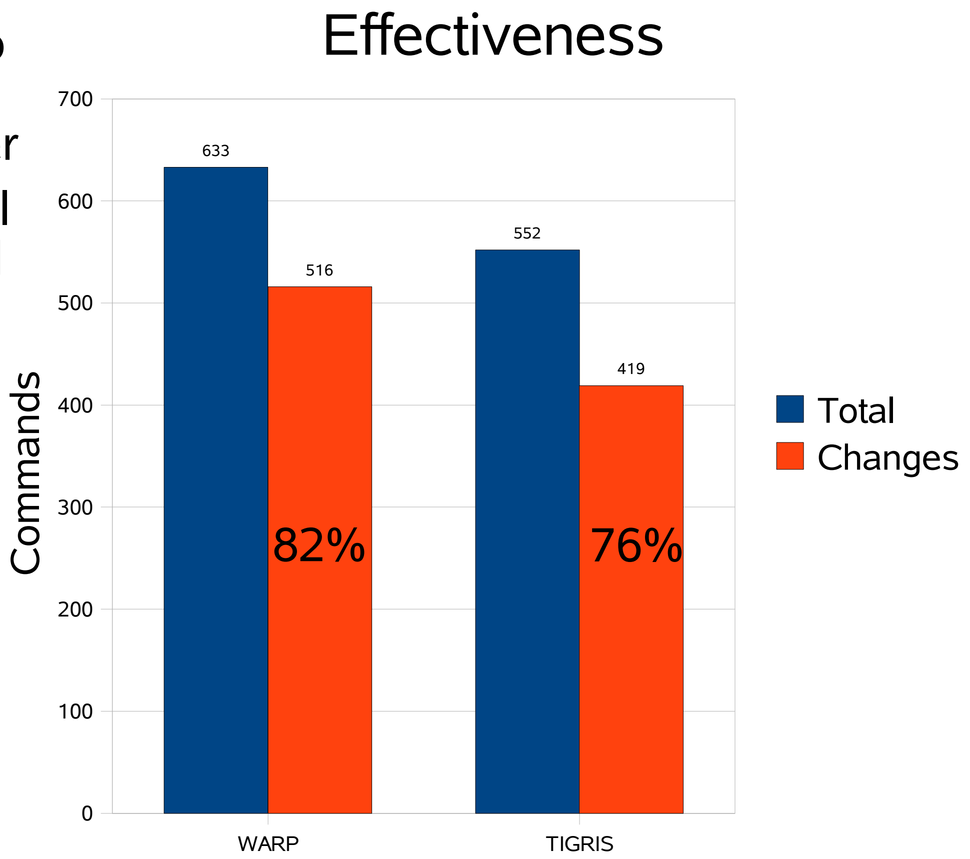
Statistical Analysis of Procedures - Completeness

- Relates existing command parameters (1189) to the ones actually used
  - Untouched parameters give room for potential misconfiguration
  - Total number corrected for static parameters like TCP/IP configuration
- Some (trigger-)commands not used on purpose
- Same hardware in test assures compatible results



Statistical Analysis of Procedures - Effectiveness

- Compares commanded values to the ones sent with the last command on the same parameter
  - Keeping the antenna in well defined states should avoid commanding identical values multiple times
  - Requirements are met, not established
- Some (trigger-)commands have no meaningful value at all
- Same hardware in test assures compatible results



Statistical Analysis of Procedures - Cunningness

- Relates number of send commands to the number of changed parameters for several configurations
  - Reach the desired state with the least possible commands
  - Prefer switch A→C over sequence A→B→C
- Temporary states may be needed (A→B→A)
- Starting with a global "reset" contradicts the idea of cunningness

Considered states:

(1) **Setup**
Antenna is configured to support a given mission or perform end-to-end testing

(2) **Prepass**
Antenna points to the ascending point of the spacecraft, data recordings are activated, uplink is ready to be set

(3) **Uplink**
Antenna is "green for command", spacecraft receivers are locked to idling (PLOP-2)

(4) **Stop**
Support is completed, antenna is secured (HPA off, ACU park etc.)

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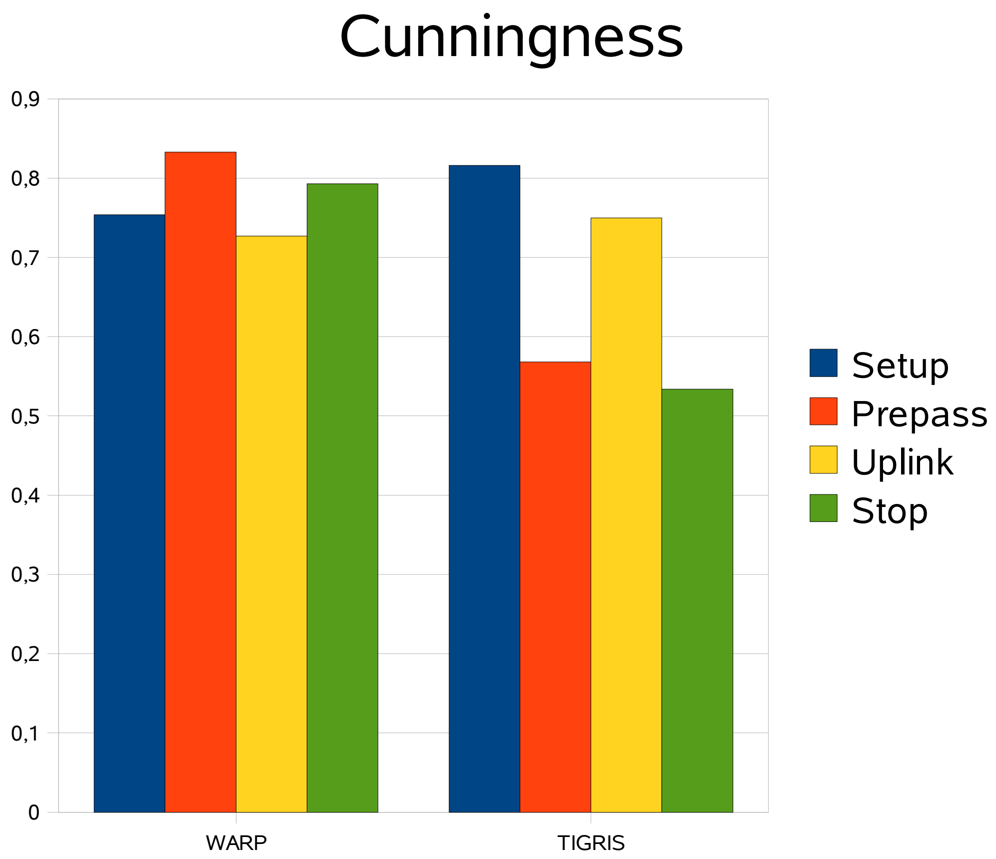
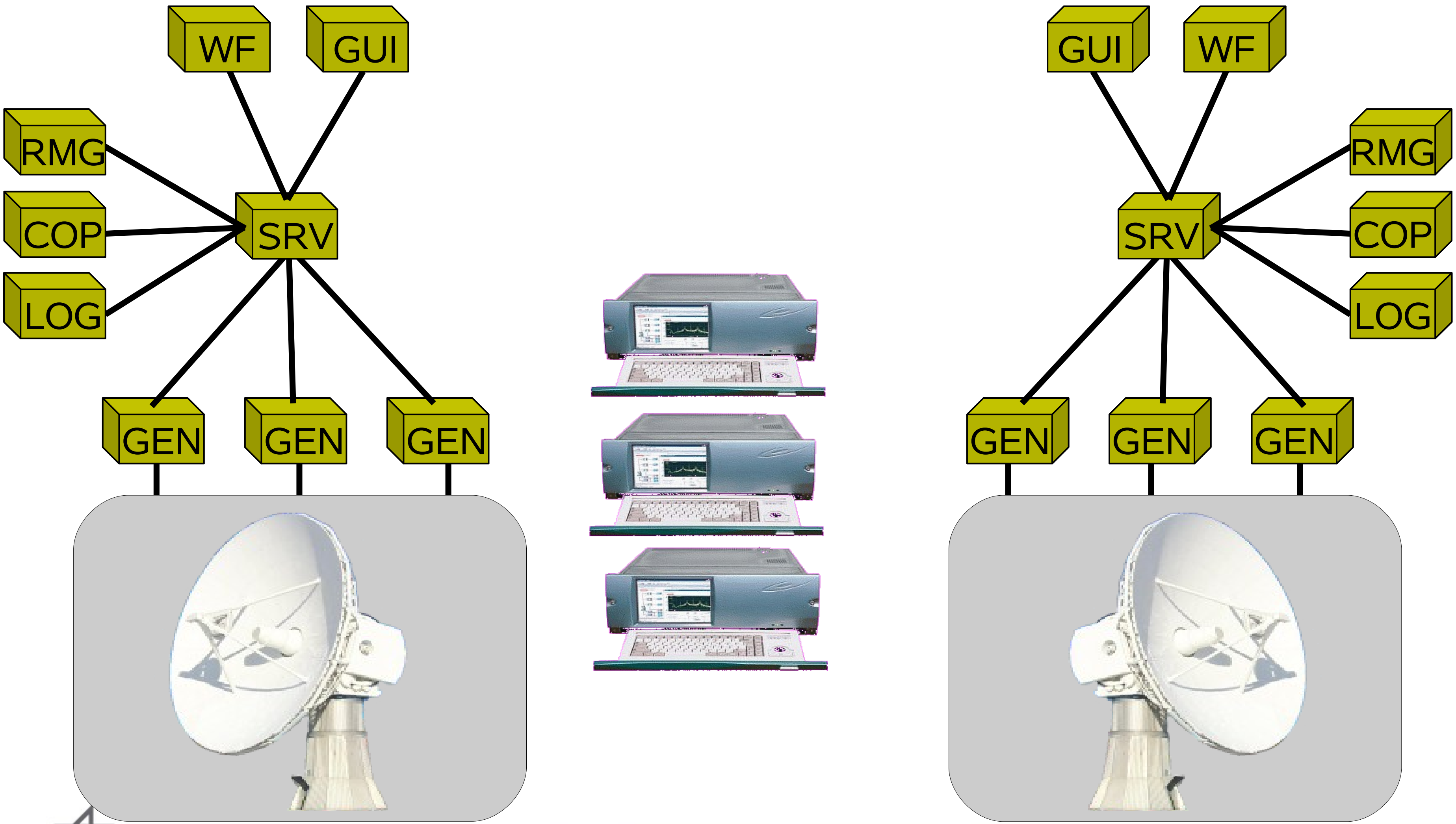


Multiple Antennas

Connecting WARP Instances - The Grand Picture



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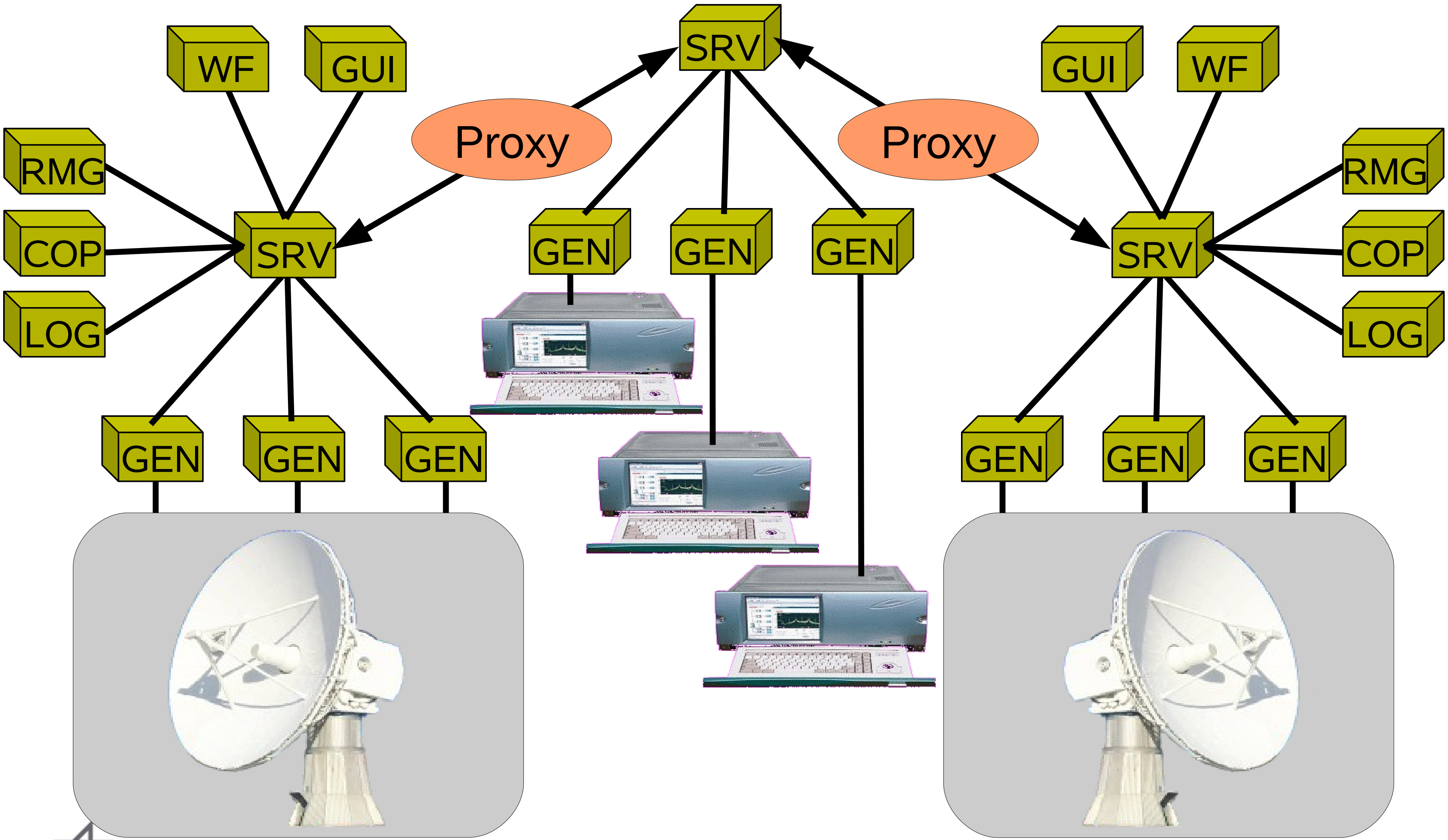

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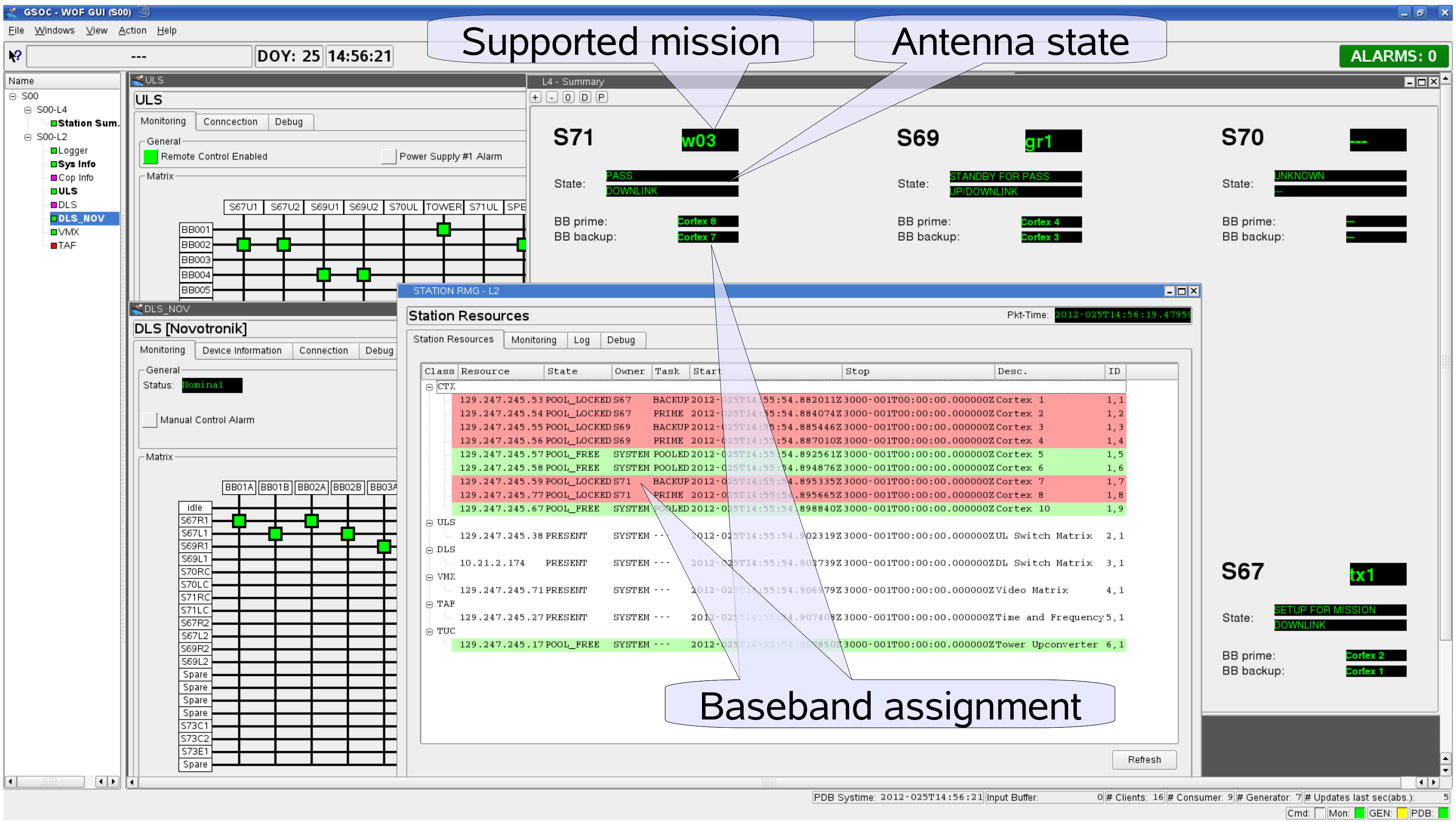
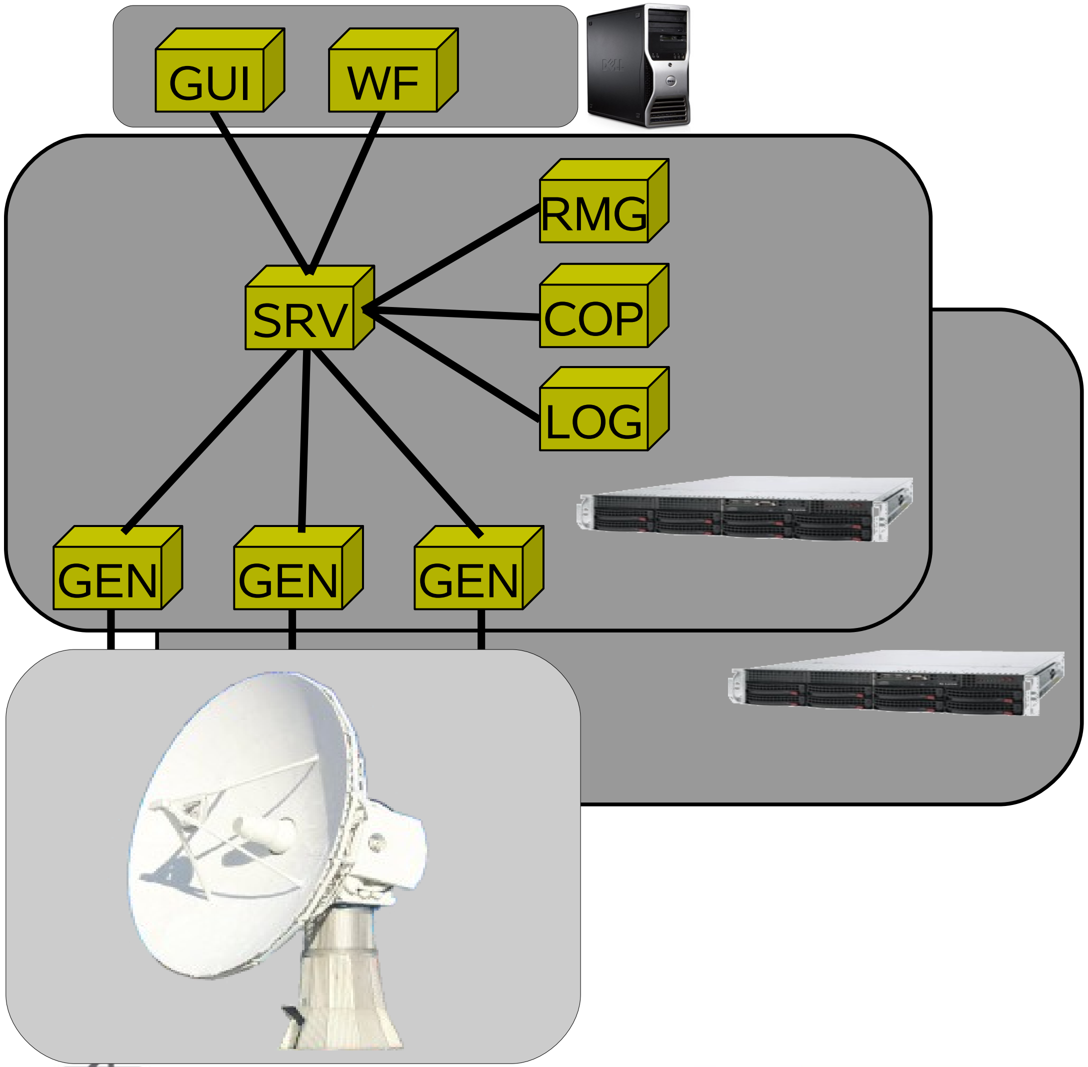


Beyond Antenna-Control "Trans-WARP"

Process Monitoring and Control - "Trans-WARP"



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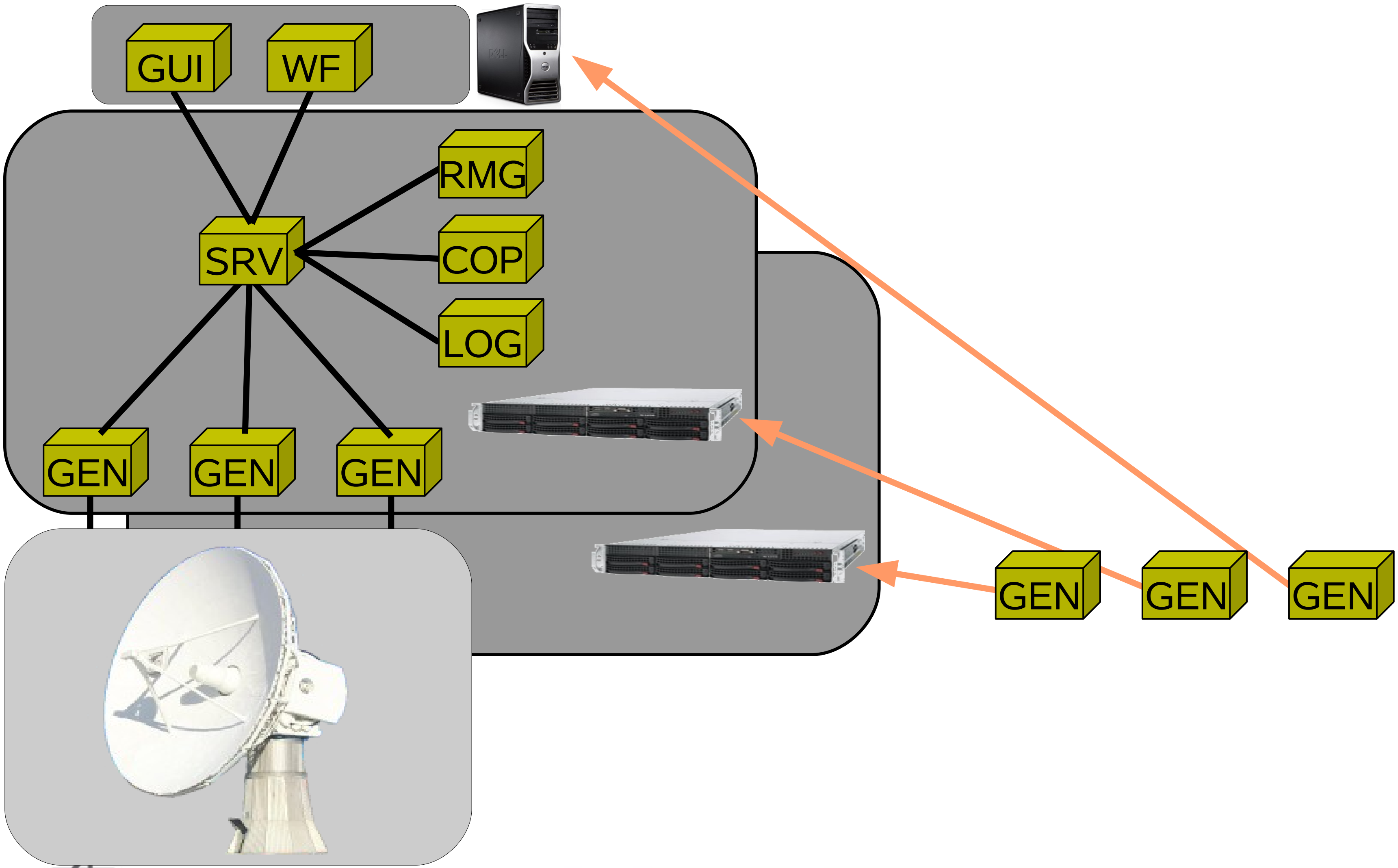

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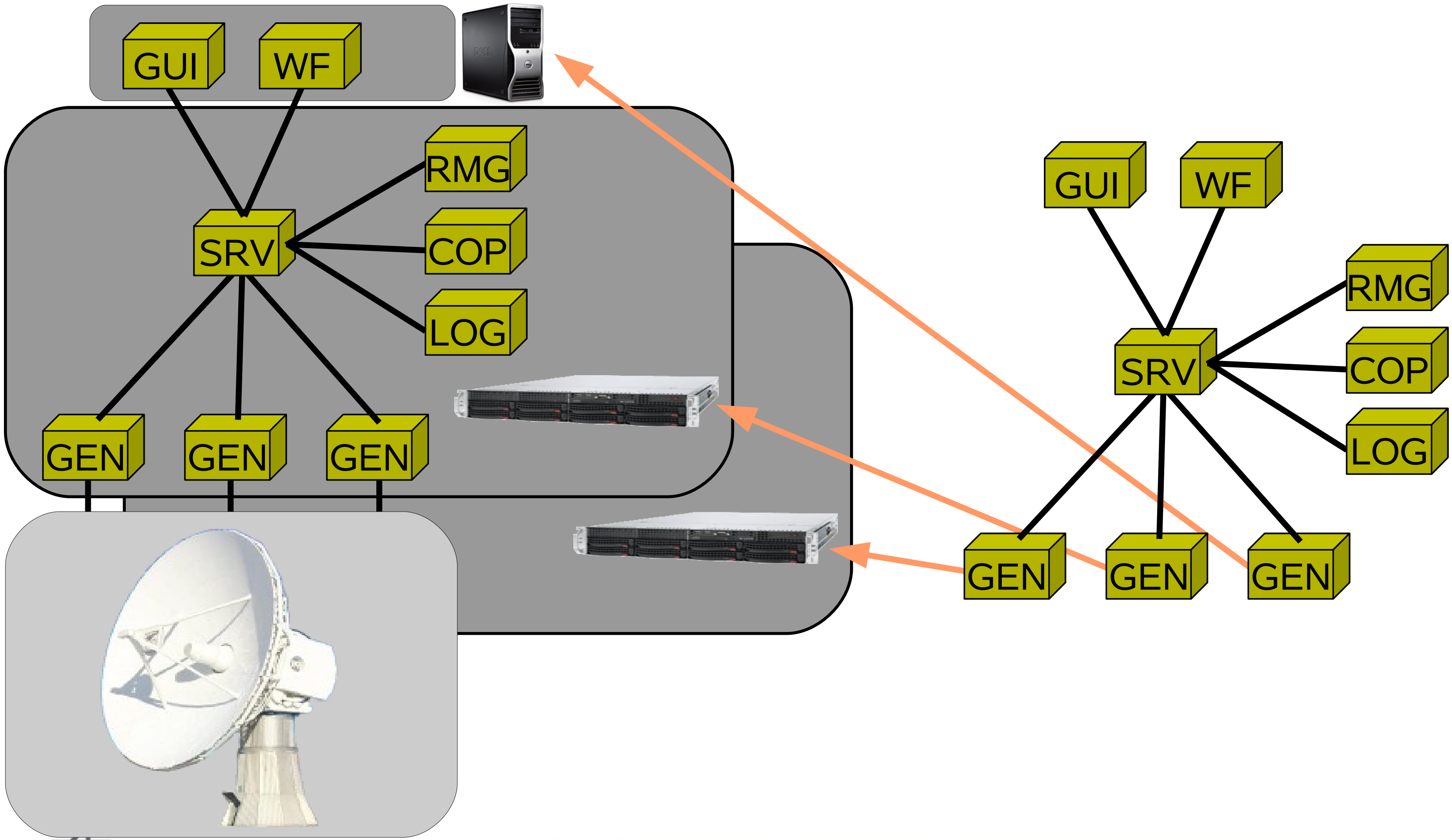

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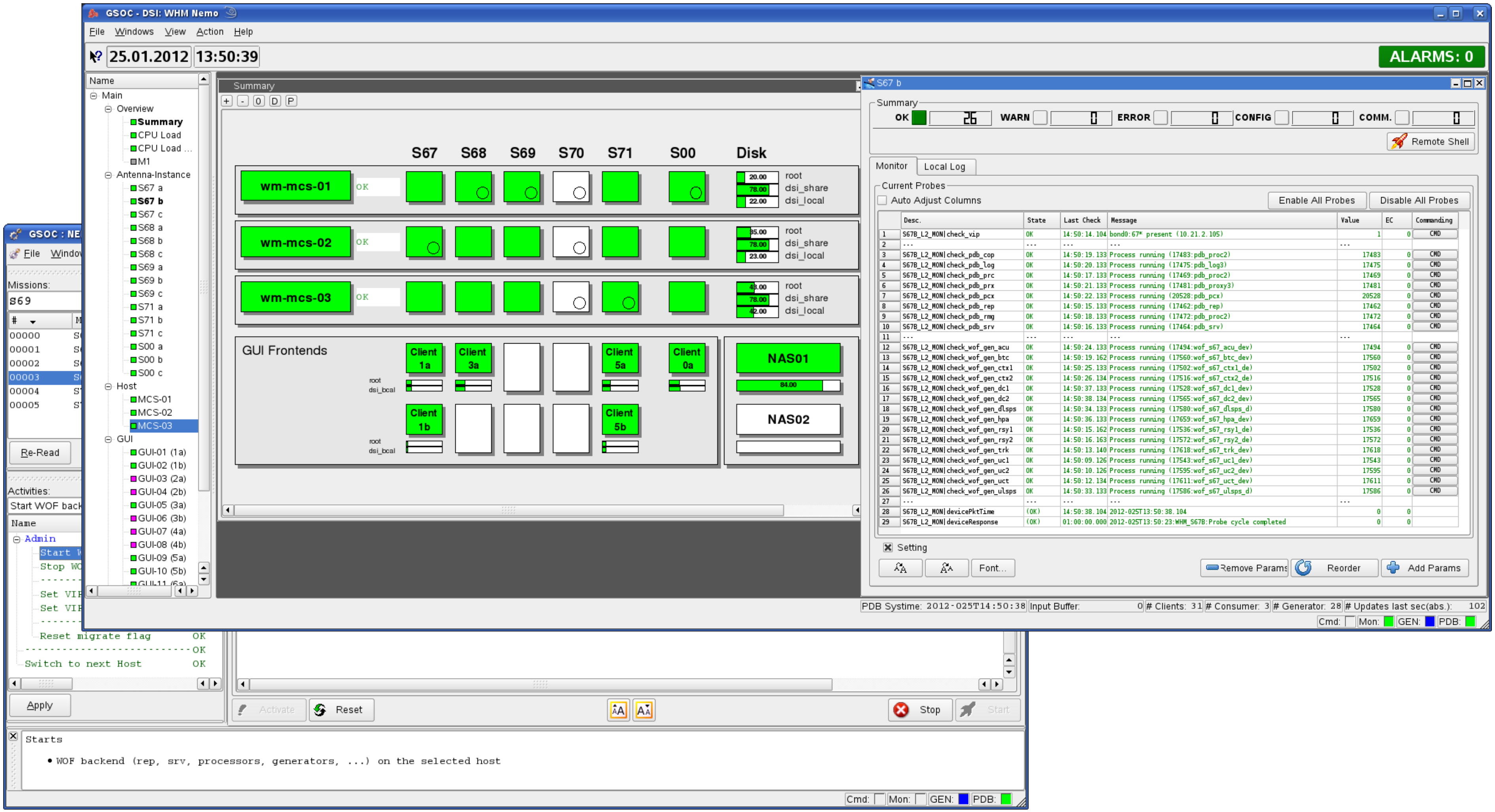

Conclusions

Conclusions - Our Goals for WARP

- Detection of errors before they become relevant
  - Commands are immediately verified within workflows
  - Discrepancies from desired state are detected and reported

- Errors are real errors
  - Break if verification fails
  - The system communicates with the operator
  - → Clear definition how to proceed

- No implicit assumptions
  - All possible command parameters are set to a default first

- Clearly and uniquely defined conditions of all antennas
  - Shifting switches at well defined points

- Commanding antenna hardware and M&C-software redundancies with the same tools

Conclusions - Our Goals for Operation with WARP

- Standardizing Procedures
  - Actions do look alike on different hardware
  - Mission specifics are handled in generic or overloaded workflows

- Apply changes at single points only
  - Separation between
    - Antenna description
    - Abstract mission definition
  - Define actual values by functions of all relevant variables

- Sources of trouble shall be located easily
  - Failure indications can be traced down to device level
  - Distinction between hardware state and configuration helps to identify reason of failure

- New missions can be included with minimal effort

Conclusions - Outlook

- WARP is well prepared for automation
  - Slowly change the role of Weilheim's operations personal
- WARP enables summarized monitoring of
  - ✔ Several antennas
  - ✔ Antenna hardware, M&C software and IT-hardware
  - Ground station and control center (end-to-end service)
- Promising features maybe need to be applied more consequently
  - Improvements in mission parameter definition
  - Standardization of mission description

Helm, Maximum Warp! Engage!