Multi-Mission Support with WARP

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WARP – The Antenna M&C at Ground Station Weilheim
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Tests in L-, S- and X-Band
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S-Band Multi Mission

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Ku-Band Multi-Mission
S-Band Multi-Mission

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Tests in L-, S- and X-Band

Dedicated GEO-Support
WARP – The Antenna M&C at Ground Station Weilheim

- Different antenna hardware
  - transparent to OPS
  - transparent I/F to GSOC

- Need to configure the station
  - reliably
  - quickly \textit{typical slot of 20 minutes for configuration and internal tests}
  - frequently

- Hardware maintenance is done routinely between two passes
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Generalization

Ku-Band Multi-Mission
S-Band Multi-Mission
Ka-Band Multi-Mission
Tests in L-, S- and X-Band

Dedicated GEO-Support
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)

Consumers use/display information

Parameter Channels

MON

CMD

Generators provide information

Generators provide information

Consumers use/display information
A Generic M&C-System - Design Principle (2)
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Generators are necessary adapters to external devices
A Generic M&C-System - Design Principle (2)

GUI clients are specialized interfaces for human operations.
A Generic M&C-System - Design Principle (2)

Processors provide hierarchical structure of monitoring and internal logic.
A Generic M&C-System - Design Principle (2)

Logging serves as basis for reporting and analysis
Script engine (workflows) allows for high level commanding including verification of action.
WARP - Example: High Level Commanding

Parallel steps

Messages, command logging and monitoring checks

WF overloaded for particular mission

Skipped steps
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
Configuration Observation Processor - State Machine (2)

Antenna state: configuration okay?

Device state: hardware okay?
Antenna state: configuration okay?

Device state: hardware okay?
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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Functional Dependencies - Antenna Parameters

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

- Desired: 16 dB
- Desired: 7 dB
- Passive coupler: 3 dB
- Attenuation to be set?
Functional Dependencies - Antenna Parameters

- Different HPA have different working points
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Passive coupler: 3 dB

Desired: 16 dB
Desired: 7 dB

function
UC_Attenuation(a_hpa, a_uc)

Attenuation to be set?
Function $\text{DL-Frequency}(2268.0)$

\[
\begin{align*}
\text{Set DC: Frequency} &= 2268.0 \\
\text{Set TRK: Phase} &= \text{Calib}(2268.0) \\
\text{Set TRK: GainX} &= \text{Calib}(2268.0) \\
\text{Set TRK: GainY} &= \text{Calib}(2268.0)
\end{align*}
\]
Operation-Procedure 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.)
Statistical Analysis of Procedures - Cunningness

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Multiple Antennas
Connecting WARP Instances - The Grand Picture
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- Supported mission
- Antenna state
- Baseband assignment
Beyond Antenna-Control
"Trans-WARP"
Process Monitoring and Control - "Trans-WARP"
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Process Monitoring and Control - "Trans-WARP"
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!