OOOS: A hardware-independent SLR control system

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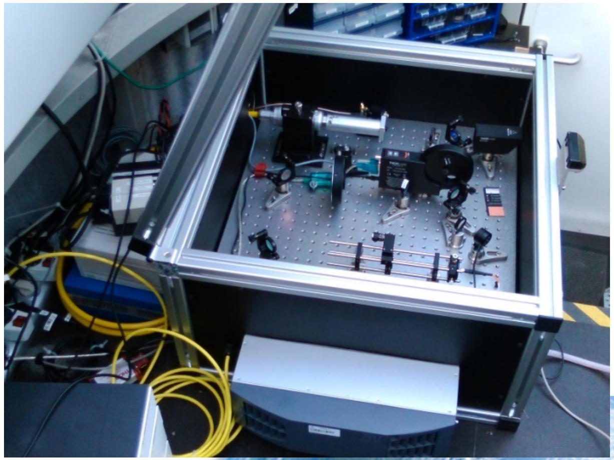
DLR

Stuttgart SLR Systems (I): UFO / UROL

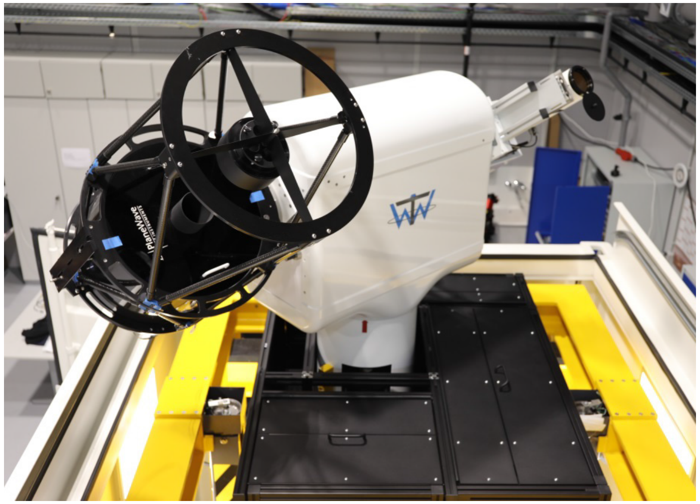
- Joined the ILRS in August 2017 (engineering station)
- Main features:
  - Small footprint / low cost
  - Fibre-transmission of laser pulses (no coudé path)
  - IR-Ranging (1064 nm)
  - High repetition ranging (~100 kHz)

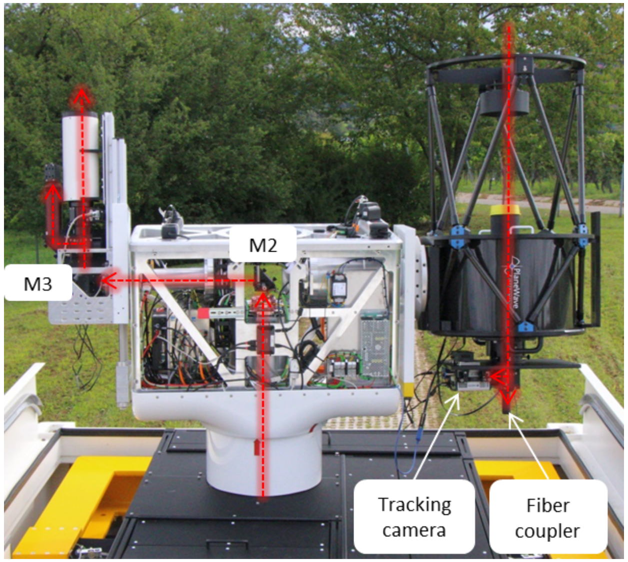


Stuttgart SLR Systems (II): STAR-C

- Currently in set-up phase near Stuttgart

- Main features:
    - Transportable (single container)
    - coudé path, strong laser
    - Main application: Space Debris Ranging



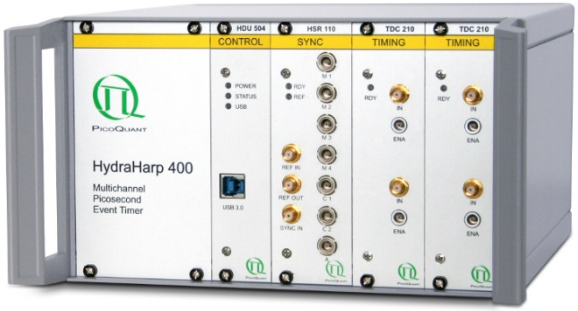


OOOS (Orbital Objects Observation Software)

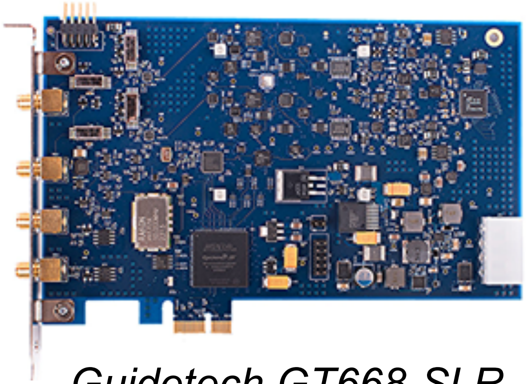
- Why hardware-independent?
    - Is used on UFO and on STAR-C
    - As engineering station, we change hardware quite a lot

- Why automatization:
    - Sometimes we need to gather data for verification
      -- but we have no personnel for routine observations
    - STAR-C is envisaged to operate autonomously at remote sites

Riga A033-ET

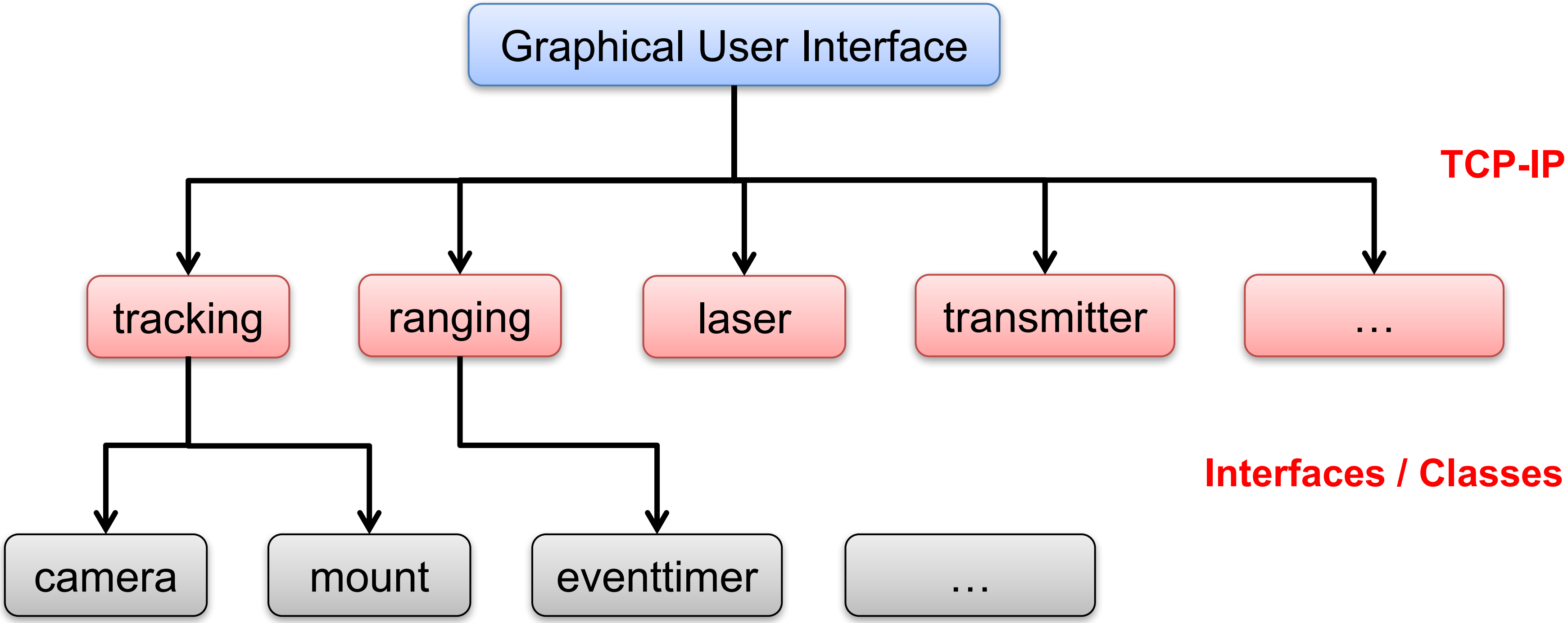


PicoQuant HydraHarp 400



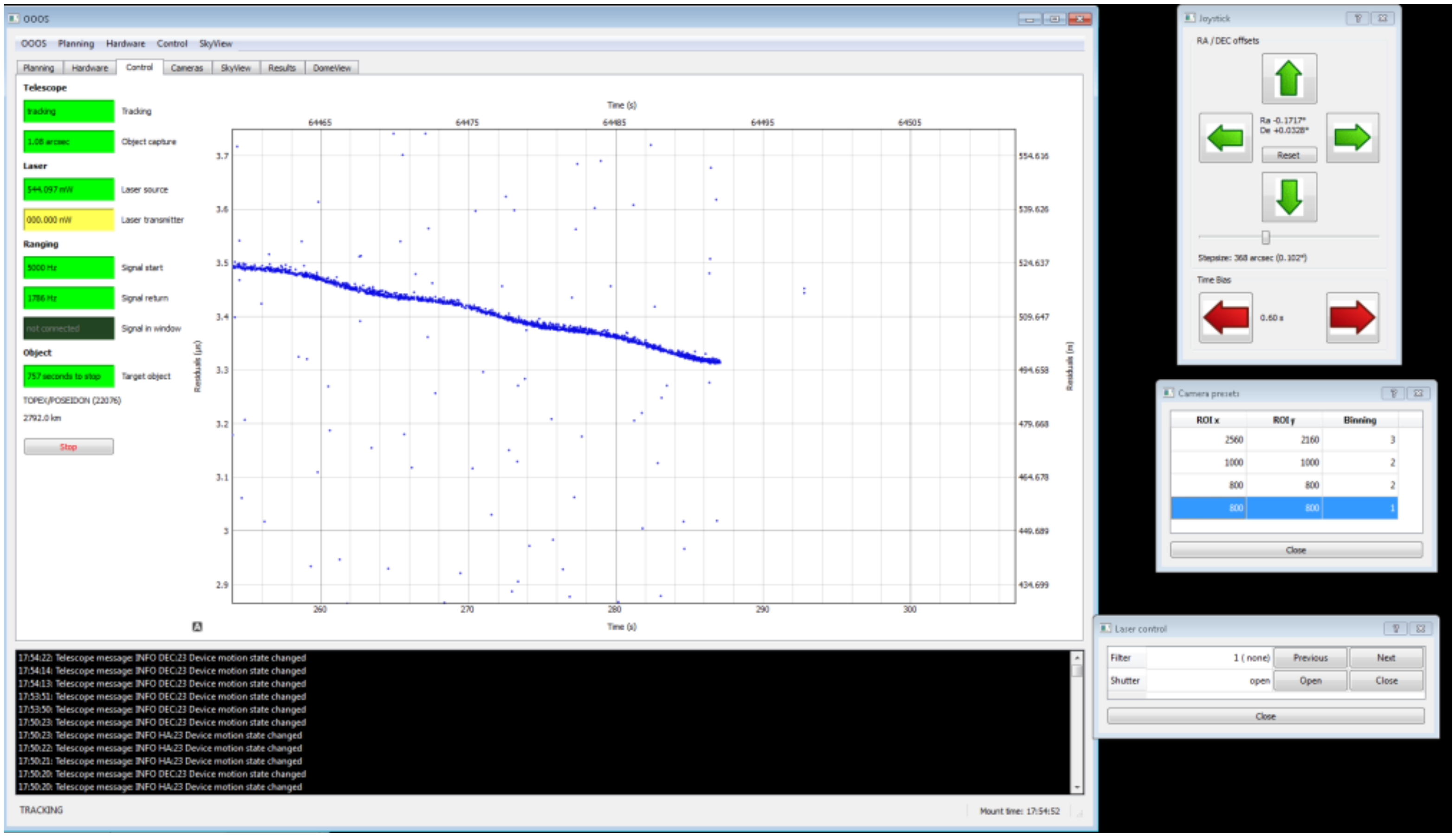
Guidetech GT668-SLR

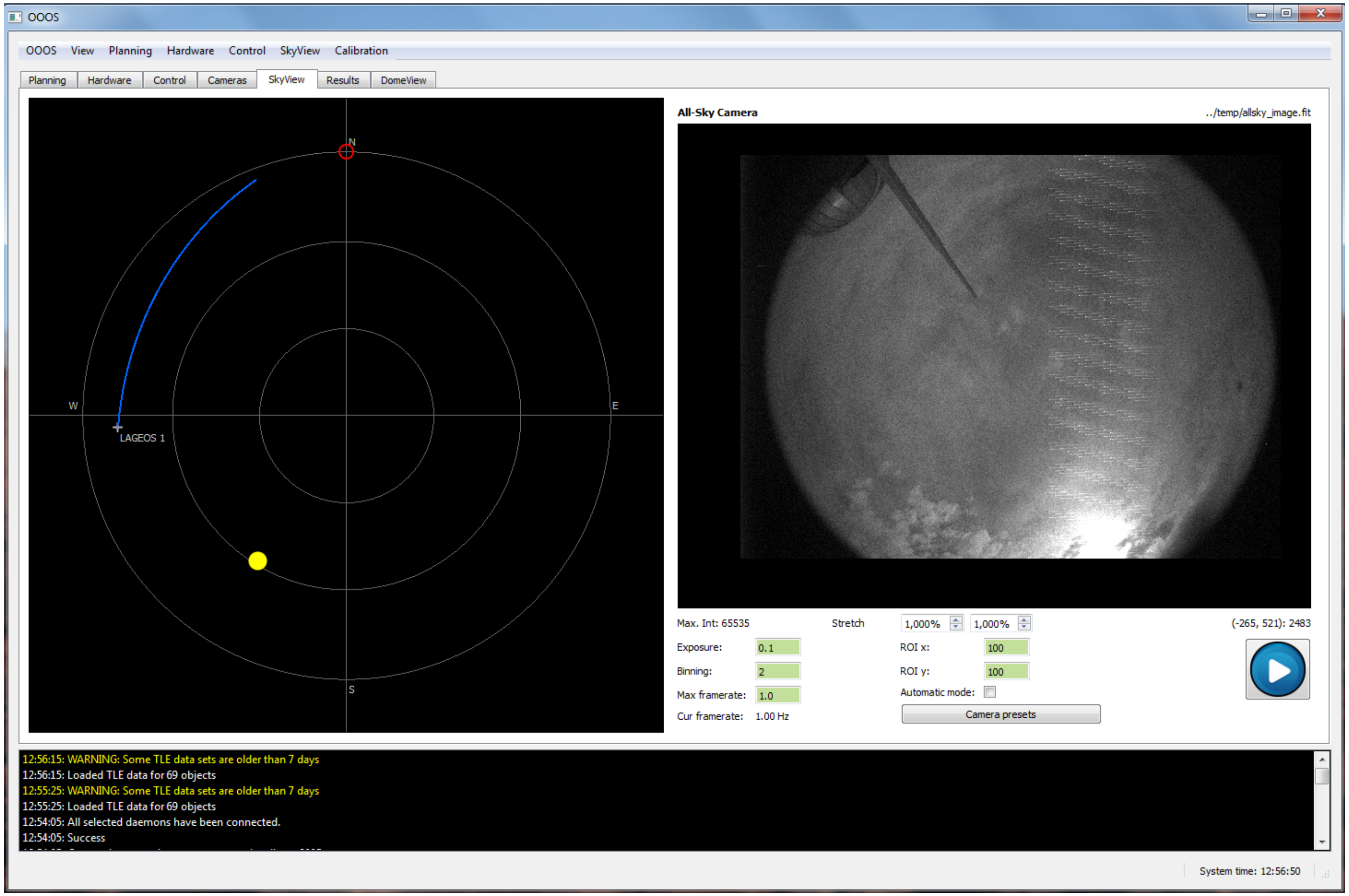
Modular 3-layer design



- Andor Zyla
- Point Grey
- Canon DSLR
- …

Streamlined User Interface




OOOS
OOOS View Planning Hardware Control SkyView Calibration
Planning Hardware Control Cameras SkyView Results DomeView
N
W
E
S
LAGEOS 1
All-Sky Camera
../temp/allsky_image.fit
Max. Int: 65535
Stretch
1,000%
1,000%
(-265, 521): 2483
Exposure:
0.1
ROI x:
100
Binning:
2
ROI y:
100
Max framerate:
1.0
Automatic mode:
Cur framerate:
1.00 Hz
Camera presets
12:56:15: WARNING: Some TLE data sets are older than 7 days
12:56:15: Loaded TLE data for 69 objects
12:55:25: WARNING: Some TLE data sets are older than 7 days
12:55:25: Loaded TLE data for 69 objects
12:54:05: All selected daemons have been connected.
12:54:05: Success
System time: 12:56:50

Implementation

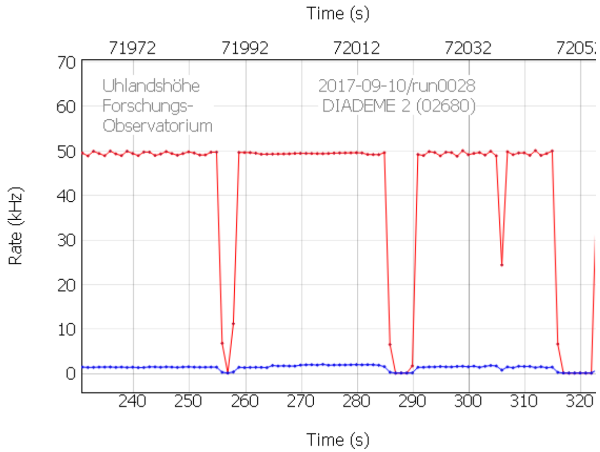
- Pure python (but using C libraries)
  - Simple installation
  - Quick debugging
- Cross-platform
- No real-time requirements (all real-time operations are done on hardware)
- Designed from scratch in 2016, no legacy code
- Multiprocessing to handle large data rates ("100 kHz ranging")
- Loose coupling between modules

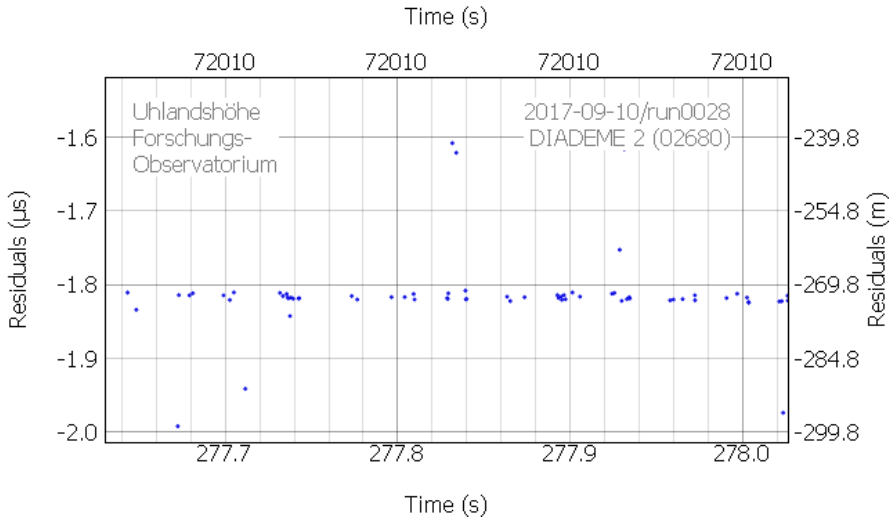
Message GUI → tracking daemon

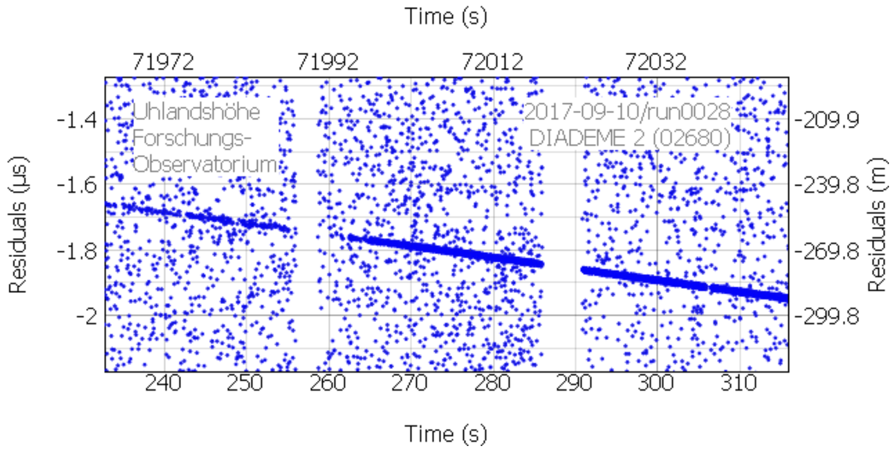
```
runnumber = 15
target_type = sat
target_name = ENVISAT
target_ID = 27386
target_RCS = 18.597
ILRS_name = ENVISAT
TLE1 = 1 27386U 02009A   17241.38234473  .00000005  00000-0  15333-4 0  9990
TLE2 = 2 27386  98.2252 283.5801 0001322  79.3709 280.7627 14.37901661811590
CPF_filename = Z:/data\2017-08-29\run0015\info/CPF_prediction1.txt
```

100 kHz Ranging

- Why?
  - Fibre transmitter can tolerate only low pulse energy
  - More statistics give better accuracy
- How?
  - Burst mode to avoid pulse collisions

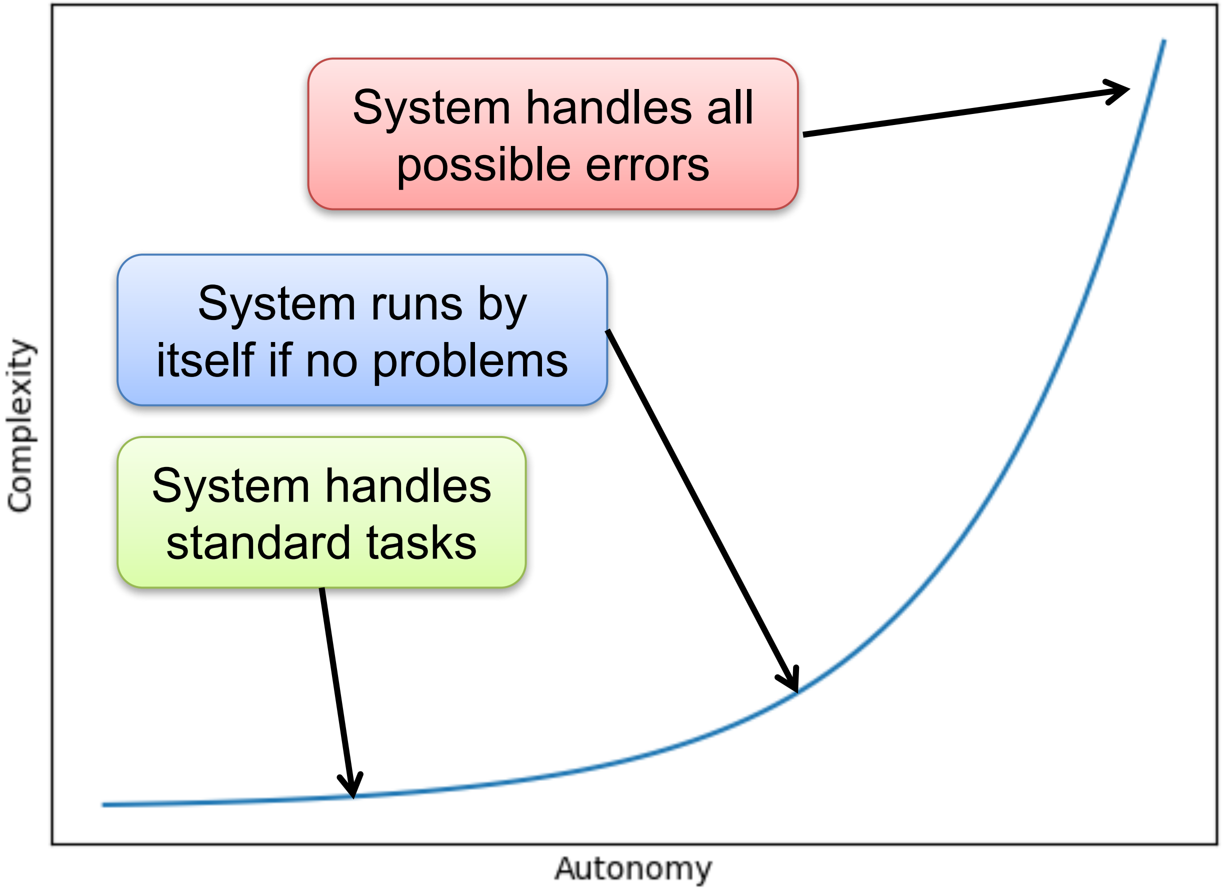






Automatization: How much is useful?

- Can mean different things: Remote, robotic, autonomous, …



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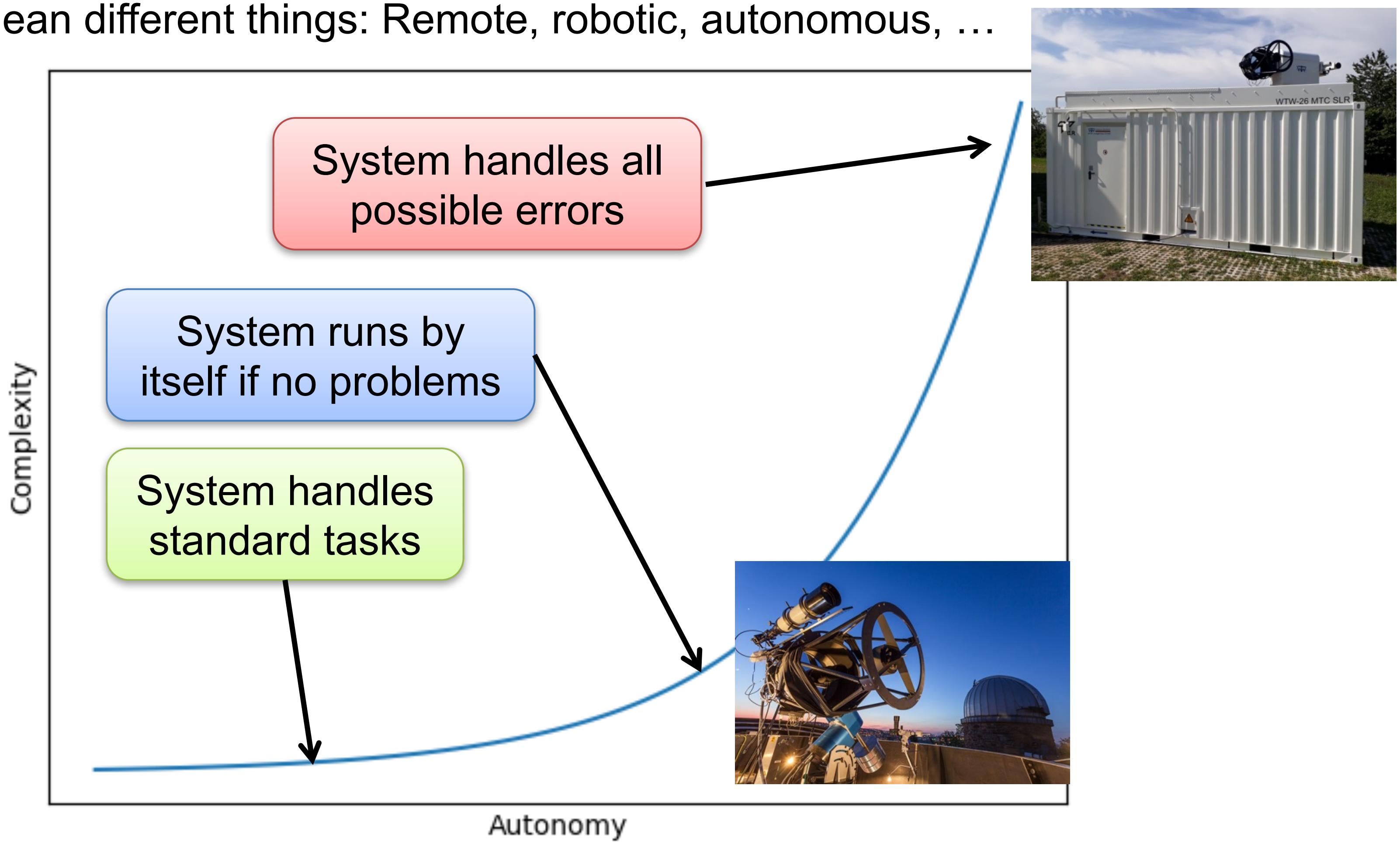


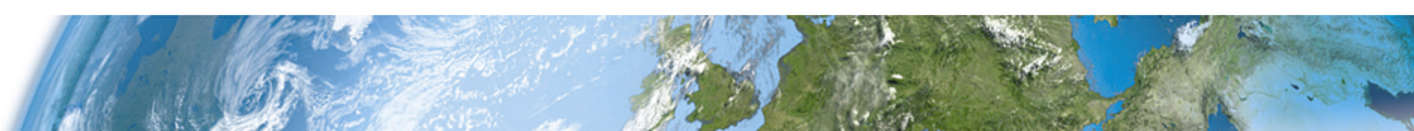
Automatization with OOOS

- Separate programming from procedures
    - Better maintenance
    - Better testing (with simulation classes)
    - Flexibility

➔ Define procedures in XML

```
<run>
    <check class="hardware" method="cloud_sensor" on_problem="stop">
    <check class="hardware" method="all_sky_cam" on_problem="stop">
    <check class="hardware" method="detector" on_problem="restart_component">
    <check class="hardware" method="laser" on_problem="shutdown_system">
</run>


<stop>
    <task class="hardware" method="switch_roof" parameter="close" target_machin
    <task class="hardware" method="switch_mount" parameter="off" target_machine
</stop>
```



Summary

- Hardware-independent control system offers
  - High flexibility
  - Fast hardware integration
  - Good reliability
- 100 kHz ranging is possible (and reasonable)

Backup

Stage 1 (“Robotic”)

- What for?
  - Safe budget on human observer crews
  - There is quick and easy access to the system

- Manual scheduling
- Handling all standard observation tasks, e.g.
  - Start tracking, trigger, event timer, open shutter
  - Fine-tune experiment parameters based on returns, e.g.
    - Laser-direction
    - Energy setting

- Fail-safe weather observation, roof close mechanism

- Remote signalling of errors, e.g. email or SMS

Stage 2 (“Autonomous”)

- What for:
  - No easy access to the system (e.g. remote location)

- Automatic scheduling (incl. calibrations, etc.)
  - Possibly weather dependent

- Handle errors
  - restart hard- or software
  - Adjust settings
  - Continue running if non-essential hardware is missing

- Pre-process data and send it somewhere

- Complete remote access