The ELT Control System: recent developments


European Southern Observatory
The ELT

The ELT Control Strategy

Control System Architecture

Local Control Systems

Central Control System

Conclusion

• More on paper and references:
  ➢ RTC and Adaptive Optics, The Minuscule ELT, Common Software Infrastructure
The ELT

- Large segmented telescope
- 5-mirror scheme
- 10000 tons, 25000 sensors, 15000 actuators
- M1 (39M): 800 1.4M segments
- M4 (2.5M): 5300 actuators
- 6 instruments
- Many distributed control loops: from 0.01Hz to kHz.
- Distributed control requiring synchronization to ms.
The ELT Telescope Structure

Main Structure holds the opto-mechanical units

Alt-Az mount points and tracks to compensate for target motion (earth rotation)

Environment: gravity, wind, thermal, atmospheric turbulence, earthquakes

Opto-mechanical units are jointly capable of re-aligning themselves, refocusing, stabilising the image, and compensating for external perturbations

Focal plane (on-sky) and embedded metrology systems measure the state of the telescope and of external perturbations (e.g. atmosphere); control system derives the commands sent to the units
Goal:
- diffraction limitable beam at each of the ELT Nasmyth foci

Challenge:
- keep wavefront within error ~10s of nm with perturbations in the range of mm

Control
- Deformable M4:
  - on-sky loop closed at rates up to 1 kHz.
  - limited stroke (100um)
- Feed forward control during blind phases
  - brings telescope within the acquisition range of on-sky sensors
- Feedback loops based on telescope internal metrology
  - M1 Figure Loop keep deformations within the capture range of M4
- Background stroke management

Control Strategy
The ELT Control System, MOBL01; ICALEPCS 2021
ELT CS architecture drivers

Architecture drivers:

- Subsystems contracted to industry.
- Instruments developed by consortia.
- De-coupling of subsystems
- Flexible at AIV/Commissioning
- Obsolescence management

Foundation's status, June 2021
Some ELT standards

- Communication: Ethernet, EtherCAT, PROFINET, PROFISAFE, UDP/TCP.
- Middleware: OPC/UA, DDS, ZeroMQ.
- Time synchronization: PTP and NTP.
- Runtime platforms:
  - Linux CentOS/Linux RT for WS applications.
  - Beckhoff PLCs (TwinCAT), SIMATIC S7 for LCS software.
- Safety: SIMATIC Safety Advanced, TwinSAFE.
- Languages:
  - C++, Java and Python,
  - Structured Text and Function Block Diagrams for PLC code,
  - MATLAB/Simulink, LabVIEW-G.
- Data serialization: Google Protocol Buffer
- State Machines: SCXML.
- GUIs: **TAURUS**, Qt (C++ and Python) for operators
  LabVIEW or touch panel HMI for Engineering UIs and hardware control panels.
Control System Overview
Local Control Systems

The ELT Control System, MOBL01; ICALEPCS 2021
Central Control System
Local Supervisors
High Level Coordination and Control
TREx and real-time control
Conclusions
Conclusions

- Reqs, architecture, design carried on in the past years.
- Most subsystems (LCSs) contracted out and in production.
- Technical infrastructure and prototypes have been developed.
- We are now moving to serial development of system components (HLCC, LSVs, RTC, AO).
- Requirements for TREx real time components are being collected and design will follow.
- Validation test benches (MELT) are operational
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Scientific First Light is foreseen for end 2027