

Research Result Report

ICRR Inter-University Research Program 2025

Research Subject: Development of the CTA/LST telescope control system
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Summary of Research Result : This project is dedicated to the implementation of the high-level telescope control system (TCS) for the Large Sized Telescopes (LSTs) of the next-generation CTA Observatory. Compliant with CTAO array control framework, the TCS system developed here in FY2020-2024 automates regular telescope operations and allows LST collaboration and Observatory personnel to treat LSTs like “black boxes”, responding to the predefined high-level commands. The system also enables robotic operations, including remote control from the partner institutions in Japan. In FY2025 developers from ICRR and the University of Geneva have upgraded TCS following the updated CTAO requirements and continued the integration tests with the CTAO array control and data acquisition (ACADA) system. Corresponding LST/TCS team achievements in FY2025 are summarized below. <u>LST-1 TCS implementation</u> • automated recovery procedures have been extended to a broader list of known problems; • the underlying Alma Control Software (ACS) framework and telescope control API have been updated to the latest version agreed with CTAO. These updates provide bug fixes and extended functionality to efficiently control LSTs with CTAO ACADA system; • continuous integration pipeline has been extended to cover further TCS use cases. Available unit tests have been refactored to increase the TCS source code coverage; TCS code itself has been verified to comply with the CTAO- and industry-accepted programming standards; • on-line code documentation has been prepared. This documentation was set up to be generated automatically from the TCS source code in order to always remain up-to-date; • support for encrypted connections to the telescope subsystems has been added. Its aim is to protect LSTs from unauthorized access even from within the internal telescope network; • communication API between TCS and the telescope subsystems has been updated following the LST collaboration request. <u>TCS adaptation to LSTs 2-4</u> • initial support for LSTs 2-4 has been added, enabling TCS configuration for the

specific telescope without the software re-compilation. TCS was refactored to allow its multiple instances, controlling separate telescopes, to co-exist and use a common ACS configuration space as required by CTAO/ACADA team.

- preliminary centralized TCS deployment procedure for all LSTs has been agreed upon.

CTAO/ACADA integration

- support for the ACADA configuration database has been added using the official CTAO libraries. While the database itself is under development on CTAO side, LST TCS was configured to use a separate proxy layer, translating CTAO-compliant API to the requests to the temporary database used for LST-1 commissioning. This ensures LST-1 TCS remains fully operational and at the same time ready for the future integration with the CTAO ecosystem.
- several CTAO/ACADA – LST/TCS integration tests campaigns have been further conducted in FY2025 (limited by the LST-1 availability) to ensure the coherent developments on both CTAO and LST ends. In FY2025 these tests have been conducted as a part of the broader Joint Commissioning Team effort lead by the CTAO and LST collaboration representatives.
- LST team has shared the TCS code and its testing environment with CTAO/ACADA to start the common ACADA + TCS automatic off-site integration verification.