Telescope Control System of the ASTRI SST-2M prototype for the Cherenkov Telescope Array

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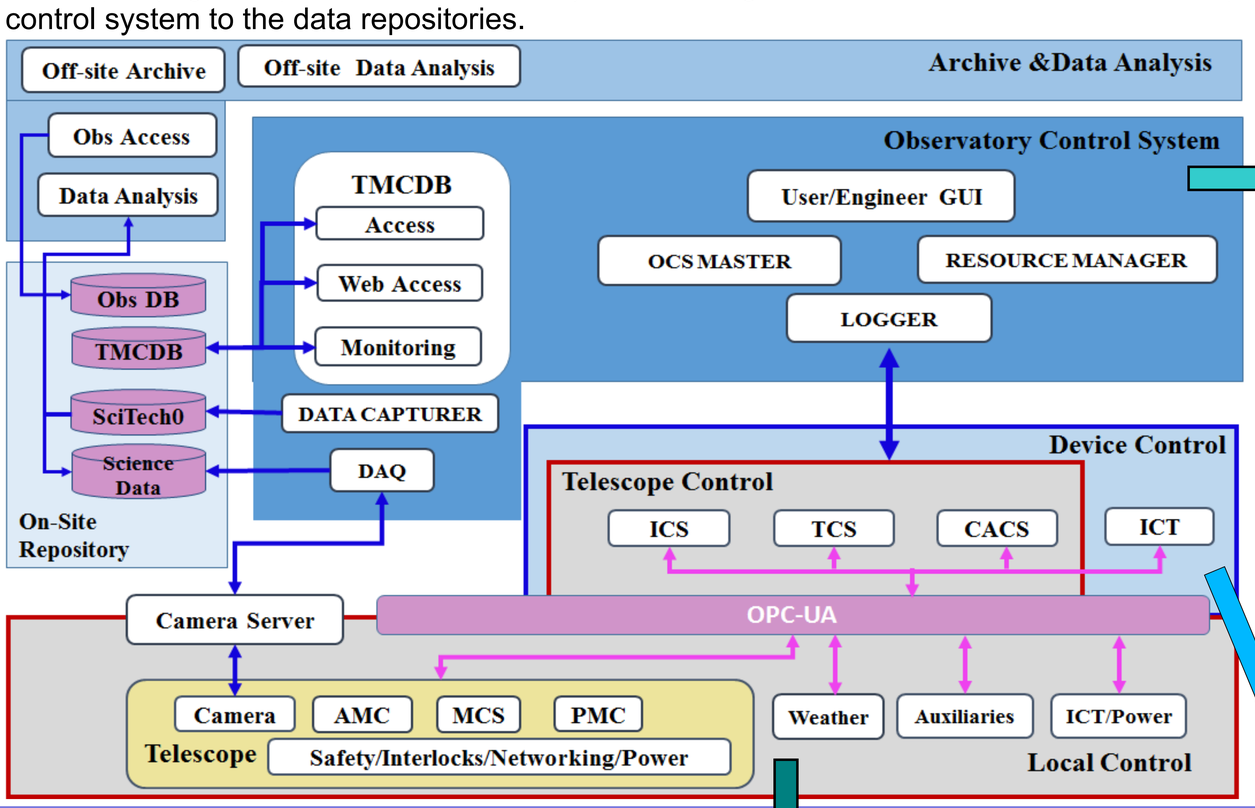
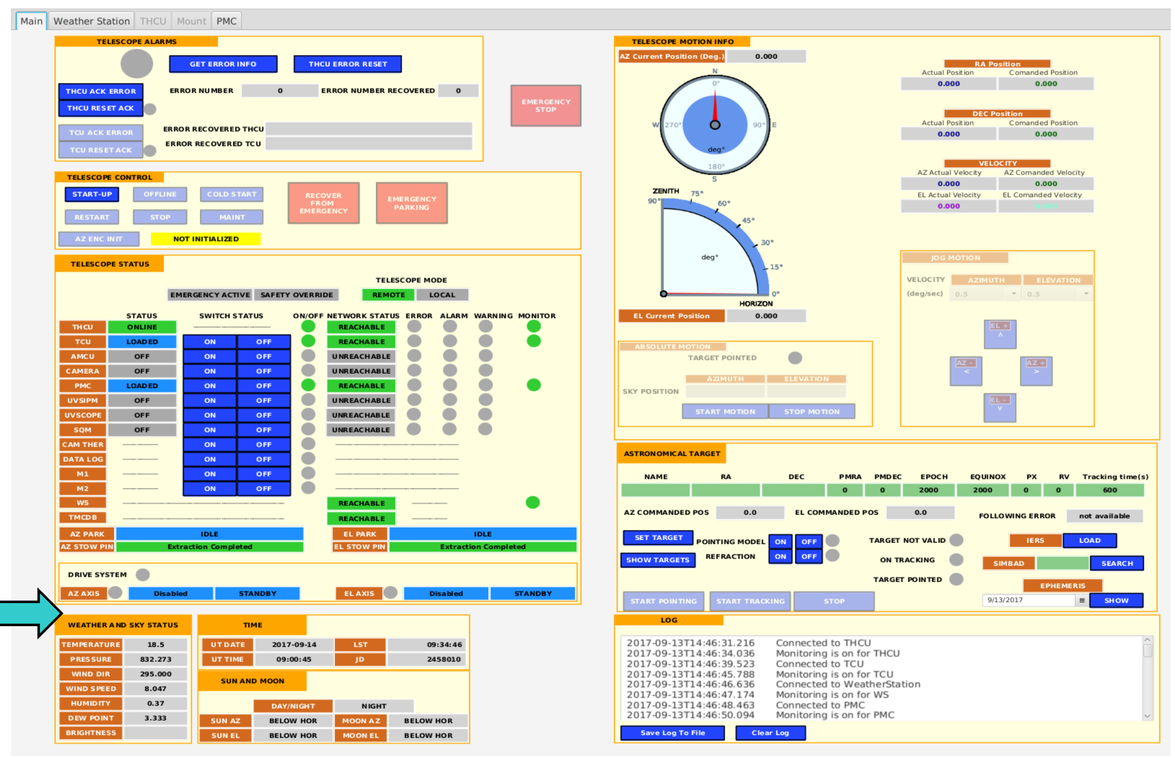
The ASTRI SST-2M telescope is an end-to-end prototype, installed on Mount Etna (Italy), proposed for the Small Size class of Telescopes of the future Cherenkov Telescope Array (CTA). The ASTRI prototype has already passed the mechanical commissioning and optical validation stages and it is currently undergoing the scientific verification stage. The first Cherenkov events have been successfully acquired in May 2017 and further runs for data taking are foreseen starting from fall 2017. A first set of nine ASTRI telescopes is planned to be produced for early implementation on the southern CTA site. The ASTRI Software, named Mini-Array Software System (MASS), provides several tools for making it possible to operate both the current ASTRI SST-2M prototype and the future ASTRI telescopes, under the requirements defined by CTA. As part of the MASS, The Telescope Control System (TCS) has the task of the coordination of the telescope hardware devices, performing of the observational functionalities and the maintenance, test and calibration activities. The ASTRI approach for the design, development and implementation of the TCS has made the ASTRI SST-2M prototype a stand-alone, intelligent and active machine, able to efficiently perform all the required engineering and operative functionalities, to receive commands, transmit monitoring data and eventually recover errors. Furthermore the ASTRI approach provides for a Telescope Control Software that can easily be integrated in the high-level control software system of the ASTRI telescopes under array configuration, as proposed for CTA.

ASTRI MASS ARCHITECTURE

The Telescope Control package (grey boxes) includes low (Local Control) and high level (Device Control) software components. The **Local Control** system is dedicated to monitoring and control of the hardware devices on-board the telescope and of the auxiliary assemblies, together with the managing of safety standard functionalities. The **Device Control** group is in charge of the coordinated execution of the functionalities provided by the hardware controllers in order to perform scientific observations, tests and engineering actions, together with error handling and fault conditions recovery. The Open Platform Communications Unified Architecture (OPC-UA) is the interface protocol chosen between the high-level control software and the hardware assemblies, supporting rich data model while offering high compatibility with the Programmable Logic Controller (PLC) platform. At the highest level the **Operator Control System** (OCS) provides all the services necessary to operate the telescope (e.g. Graphical User Interface) and manage the data flow from the telescope control system to the data repositories.



GRAPHICAL USER INTERFACE (GUI)



The ASTRI GUI exploits directly the high-level software components in order to operate the telescope, thanks to a code generator able to create a specific engineering UI for each component. The GUI provides to an ASTRI user the possibility to perform scientific operations and also represents an easy interface for the engineering tests, calibration and maintenance activities. The Main panel of the ASTRI GUI allows the monitoring and control of the whole telescope, providing for example motion information (axes positions, velocities, accelerations) and showing the states of sub-devices. It provides access for automatic start-up and shut-down procedures and to command manual motion of the axes. The Main tab allows for easy pointing and tracking of a source simply inserting the coordinates or by selecting a target from a list of objects. In addition to the Main Panel, several dedicated panels (secure locked) give access to other functionalities specifically available for the maintenance and engineering purposes.

LOCAL CONTROL

The controllers are able to execute commands received from external controllers (e.g. GUI) and providing access to the monitoring. The Mount Control System (**MCS**) is dedicated to the motion of the mechanical structure together with the start-up and shut down procedures. The Active Mirror Control (**AMC**) is responsible for controlling of the position and tilt of the primary and secondary mirrors, while the **Camera** block provides for the Cherenkov camera detection and operations. A dedicated PLC takes care of the **Interlocks** logic chain and **Safety** functions, together with the health and telescope power consumption monitoring. MCS, AMC and the Safety functionalities are implemented via PC-based PLCs technology, using the Beckhoff TwinCAT 3 platform, in order to maximize the homogeneity and the real-time performance of the system, which provides also direct access via the OPC-UA protocol, through a dedicated server/client function. The auxiliary instrumentation, dedicated to the calibration purposes e.g. Pointing Monitor Camera (**PMC)** and **weather station,** is controlled directly through dedicated OPC-UA servers written in Java using the Prosys OPC UA SDK.

DEVICE CONTROL

The **Device Control** or **OCS** components do not include direct control of any telescope hardware, and are not responsible for any time-critical operations. All real time functions are performed at the Local Control level. The high-level components are implemented upon the ALMA Common Software (ACS) middleware, which provides common ways to access the hardware, such as OPC-UA protocol, together with monitoring, alarm, and logging services support. **TCS** coordinates the motion of the Telescope (MCS) and the active optic system (AMC) in order to perform a pointing or tracking and to obtain a stable image for the Camera. It is also in charge to monitor and control the Health and Safety status of the prototype. **Instrument Control System (ICS)** will oversees all monitoring and control operations of the ASTRI camera (configuration, command, housekeeping. **Calibration Auxiliaries Control System (CACS)** includes all the components dedicated to the monitoring of site conditions, both for safety and calibration activities.

RESULTS

The MASS software components have been successfully integrated and the package is currently installed at the telescope site (version V.0.2.0 has been released on July 2017). The ASTRI architecture provides for the TCS to be completely independent from the OCS, making the low-level hardware controllers completely transparent to the GUI. In this way the Telescope, from a software point of view, can be seen as a robotic and stand-alone machine, able to be fully operated by any other high-level controller which is ACS/OPC-UA compatible, simply excluding the OCS part of the MASS and defining a specific interface.

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