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Data handling and control of the European Solar Telescope

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Abstract. We describe some aspects of the facility operation that have been considered for the design of the data handling and control of the European Solar Telescope. The main subsystems of the EST relevant for the control are summarized, together with some information on current solar data models.

Key words. Data handling – Control – Large telescope

1. Introduction

The EST (European Solar Telescope) is a 4-m class telescope optimized for studies of the magnetic field and dynamics, from the deep photosphere to the upper chromosphere of the Sun (Collados et al. 2010a). The EST will be equipped with a suite of instruments to perform spectropolarimetric and imaging observations in many wavelengths of visible-NIR range simultaneously, with a much better accuracy and spatial resolution than achievable at present. Together with the ATST (Advanced Technology Solar Telescope, Keil 2010), EST will represent a major step towards the understanding of some fundamental astrophysical processes, e.g. the mechanisms of magnetic field generation and removal, and of energy transfer from the surface to both the upper solar atmosphere and heliosphere.

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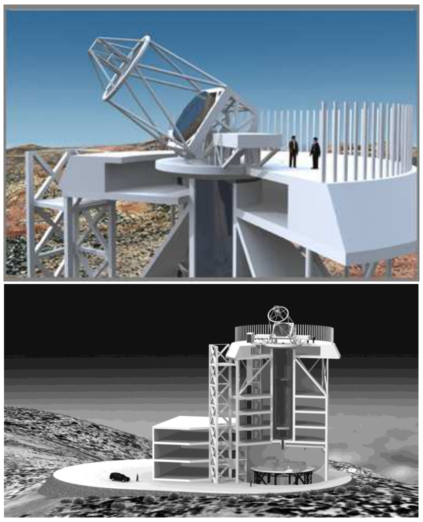

Fig. 1. Schematic views of the current design of the EST observatory.

The EST project is promoted by the European Association for Solar Telescopes (EAST), a consortium with the aim, among others, of undertaking the development of the telescope, to maintain Europe in the forefront of Solar Physics. The conceptual design study of the EST, aimed to demonstrate the scientific, technical and financial feasibility of the project, started on February 2008 with funding by the European Commission and it is presently close to completion. This study, which involves 29 partners and 9 collaboration institutions from 15 countries, covers all key aspects of EST design, from optical configuration to building and enclosure. An overview of the status of the project and a summary of the current baseline of the various sub-systems of the EST are given by Collados et al. (2010b). Figure 1 shows a schematic view of the EST observatory. We focus here on the control and data-handling of the EST. In particular, we describe some aspects of the facility operation that have been considered for the definition of both sub-systems. The main functional and technical requirements planned for their definition, and an overview of their current design, are given by Ermolli et al. (2010).

2. Observatory operation

Given the expected array of instruments and the requirements that they have to operate simultaneously, the EST appears uniquely suited to address very challenging scientific topics. The complexity of simultaneous operation of the instruments involves careful planning of control operations concerning the telescope, instruments, and data handling sub-systems. Definition of realistic scientific use cases provides constraints to control system design, especially if one can envision demanding use cases that push the telescope operation to its limits in capabilities. To this end, a general template based on a science use case requiring a multi-instrument approach has been developed for the design of the data handling system and subsequent applications by the project. This template consists of three sections: 1) the observing proposal that includes a scientific justification and a description of both the observation and general experiment strategy; 2) the observational details where the desired observations are detailed in terms of their spectral and spatial sampling, cadence, data rate, calibrations, data processing, targets, telescope setup, etc.; 3) the experiment definition, which provides the configuration for the observations, including their temporal sequence.

3. Requirements and functionalities

Based on the current baseline, the main subsystems of the EST relevant for the control are: telescope mount, primary mirror with the active compensation system, secondary mirror with the fast tip-tilt and fast- focus capabilities, heat stop, transfer optics, adaptive optics and multiconjugate adaptive optics, polarization optics, auxiliary full-disk telescope, broad-band imager, narrow-band tunable filter spectropolarimeter, grating spectropolarimeter, and enclosure. In addition, for proper system operation, the control sub-system of EST has to manage information provided by the EST sub-systems for temperature monitoring, the site monitoring in charge of delivering detailed weather and environmental information, the time distribution system, the alarm and

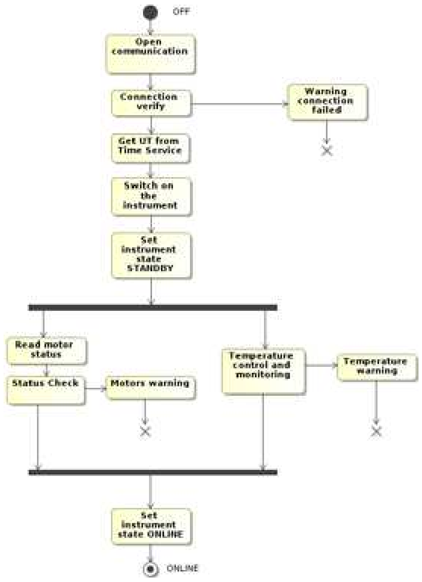

Fig. 2. Diagram of the start-up function for instrument control.

interlock management, the database management system, i.e., the system devoted to control the organization, storage and management of the data useful for observatory control. All the sub-systems listed above have been analysed in terms of their main functionalities and of their prefigured hardware devices in order to render functional guidelines for the system designers from the awaited capabilities of the EST. As an example, the observatory operation has been investigated by describing the typical user interaction with the facility, from the experiment preparation to the processes of telescope scheduling, program execution, and post-execution. In addition, the most important operations of both the telescope and instruments have been studied in terms of several use cases by using the UML (Unified Modeling Language) adopted in the field of software engineering. Each use case has been investigated by its definition, pre-conditions, basic course, post-conditions, and exception course. The telescope functions analysed to date are: mode switching, presetting, pointing modeling, tracking, guiding, control of various sub-systems (mount, primary mirror, secondary mirror, AO, etc.), management of interfaces with other sub-systems (weather and monitoring stations, enclosure, time service, instruments, etc.). The instrument operations were investigated in terms of the following functions: start-up, shutdown, inizialization, temperature control and monitoring, calibration, mode switching. For instance, Figure 2 shows the diagram state of the start-up function for instrument control.

4. Data model

The science goals of EST require the simultaneous operation of the instruments and of a large number of detectors. This leads to a projected data flux that will be technologically challenging and exceeds that of most other astronomical projects. Therefore, the quality of the information available on the data generated by the EST will be key-ingredient for the efficient use this major facility.

The three major types of instruments at the Coudé focus of the telescope will be the most significant source of data and metadata generated by the EST. On the other hand, other sub-systems of the observatory will generate data to store and display real-time for observatory operations. As an example, the telescope mount will report continuously on its status, as well as the additional systems not directly related to the light feed utilized for the monitoring of both environment and enclosure. As a consequence, there will be a set of metadata that have to be efficiently recorded, including instrument-specific parameters essential for the data analysis and the general information on the facility status suited for real-time monitoring or engineering tasks. Note that the crucial role of the metadata stored for the accurate processing of the data may be unclear at the time of their acquisition. For instance, if an instruments wavelength calibration is dependent on the temperature of the observing room, then such information becomes crucial for the interpretation of the data. Conversely, the same set of metadata recorded may be accessed by different users of the facility for a variety of purposes. To date, solar observations suffer from the lack of standard descriptions. IVOA (International Virtual Observatory Alliance) is currently devoted to night-time observations, with most of the solar data holding metadata in their FITS header. Although no standard exists, the thesaurus of FITS keywords developed in the framework of the YOHKOH, SOHO, and THEMIS projects and available at the BASS2000 site (http://bass2000.bagn.obs-mip.fr/New2003/Pages/thesaurus2001.html) is now widely used by the solar community, so that it also represents a reference for the standard to come. The publication of data into the VO (Virtual Observatory) requires, mainly for the interoperability purposes also envisaged for the EST archive, that the public data generated by the telescope are described with metadata which comply with a protocol common to a given field of astrophysics, or to similar observations on various astronomical objects. In the USA, the VSO (Virtual Solar Observatory) is already having such capabilities. In Europe, a unified model for solar metadata was devised in the frame-work of the EGSO (European Grid of Solar Observations) project (see http://www.egso.org/documents/). Builing on this early work, the HELIO (Heliophysics Integrated Observatory) project financed by the European Commission is expected to deliver, within two years, a suitable model for solar and heliospheric data, for standard use by all the new instruments for heliophysics to come. In particular, a provisional list of UCDs (Unified Content Descriptors) for data of solar features has been produced and will be further elaborated by the end of 2010. The definition of this standard is based on IVOA data models, so that VO tools will be fully applicable to the heliophysic data adopting this model. The time-line of the two projects will allow EST to take full advantage of the results derived from the HELIO.

5. Conclusions

The design of the control and data handling sub-systems of the EST requires a detailed analysis of the foreseeable usage and operation of the facility. We have summarized here some aspects concerning the facility operations. The conceptual study of the Control and Data Handling sub-systems of the EST will be completed by the end of this year with the selection of the general software architecture, the description of the interfaces between the various sub-systems handled by the control and data-handling, the analysis of synchronization, alarm, and message requirements, as well as of data reduction and data visualization requirements and of relevant technologies.

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