THE TEST-BED TELESCOPES PROJECT: ISDEFE SCHEDULER

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ABSTRACT **Within the Space Situational Awareness (SSA) programme of ESA, the Test-Bed Telescopes (TBT) project will procure a validation platform for an autonomous optical observing system in a realistic scenario, comprising two telescopes located in Spain and Australia, to collect representative test data for precursor SSA services. The TBT scheduler will consist of two modules that will allow the autonomous planning of the night, performed by the ISDEFE scheduler, and the control of the real-time response of the system, done by the internal scheduler of the Robotic Telescope System-2 (RTS2). The combination of both systems will achieve the goal of obtaining a fully robotic system.**

The Test-Bed Telescopes Project

One of the main goals of the ESA Space Situational Awareness (SSA) programme is to create a European network of observatories to provide the services needed to acquire immediate and precise information regarding objects orbiting Earth. Ground-based optical sensors are the most efficient systems to detect and track faint objects in GEO and MEO regions. Within this context, the "Demonstration Test-Bed for the Remote Control of an Automated Follow-Up Telescope" is a GSTP project whose main purpose is to provide a telescope Test-bed for the realistic validation of all the development and operation aspects of the autonomous optical systems. Two identical observing systems will be deployed at two different ESA tracking stations, Cebreros and New Norcia, with the intention of being the precursor of the future SSA robotic optical network.

ISDEFE Scheduler

The ISDEFE scheduler is a web application for planning observing nights in optical observatories. Its goal is to provide a friendly interface where users can introduce and store all the sequence of exposures with the corresponding settings, check the viability of the observations in terms of visibility and telescope configuration, and produce a final output readable by the telescope control system. The scheduler was developed under the CESAR[(*)] project, an educational programme set up at ESAC by ESA, INSA and INTA, whose main purpose is to provide European students with hands-on experience in astronomy through two robotic optical telescopes (among other devices), that are being deployed at Cebreros and Robledo de Chavela tracking stations.
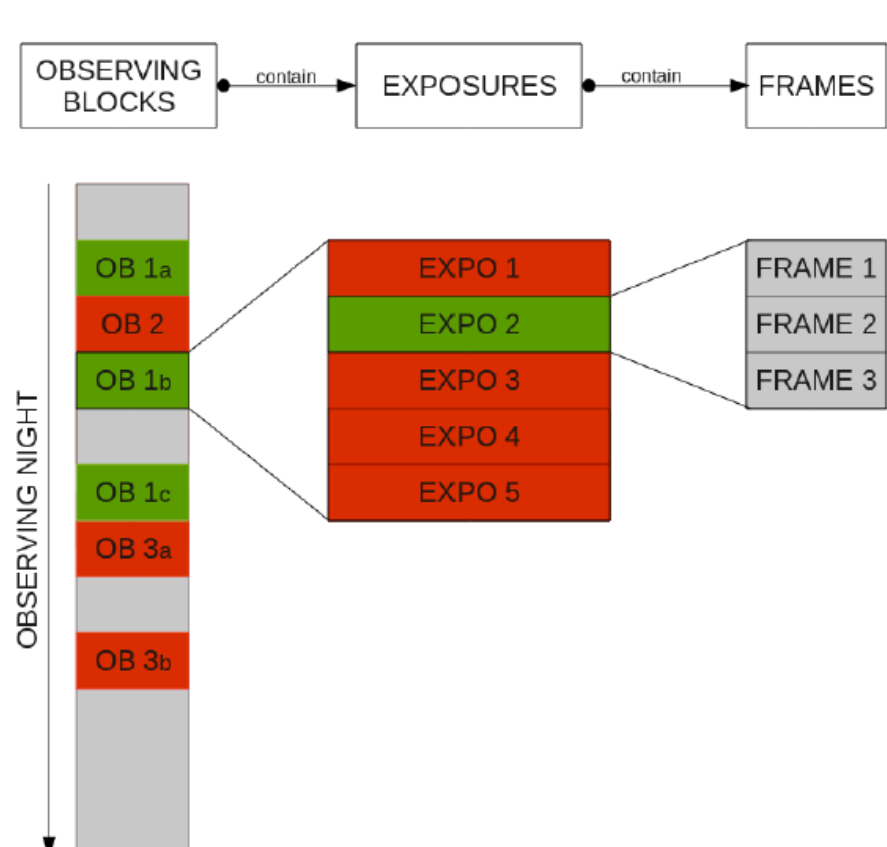

Figure 1. Structure of the Observation Blocks (OBs). Along the night, the OB can be repeated a given number of times with certain temporal interval.

The observations are structured in a hierarchical schema, thus allowing flexibility to implement all kind of observing strategies within this predefined general structure. An observation is identified by the Observation Block (OB), only defined by the instrument and target. Each OB contains different exposures, where the instrument settings are specified: filter, exposure time, offsets and number of frames. Finally, frames are those consecutive captures, with the same instrumental configuration and exposure time, generally used to increase the signal-to-noise ratio of the image.

The following activities encapsulating one or more scheduling tasks are already implemented:

- Create a new observing night using the parameters of date, location and observer
- Visualize the observations scheduled for a night
- Create a new Observation Block based on the target and instrument
- Check visibility constraints: Sun, Moon, horizon

- Calculate the instrument overheads
- Create a plot with the elevation of the target along the night
- Repeat an observing block
- Delete an observing block.
- Save the observations scheduled.
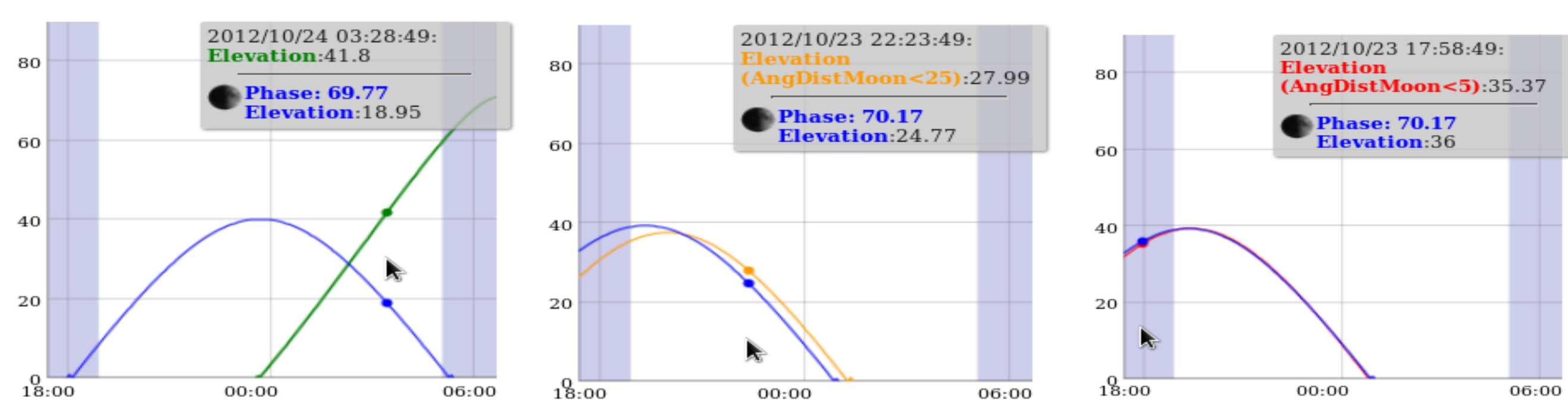- Send the readable output to the telescope control system.

Figure 2. Elevation versus time plot. Angular distance of the selected target to the Moon is colour codified following the following observing constraints. (Left) larger than 25º, (Center) between 5º and 25º, (Right) less than 5º.
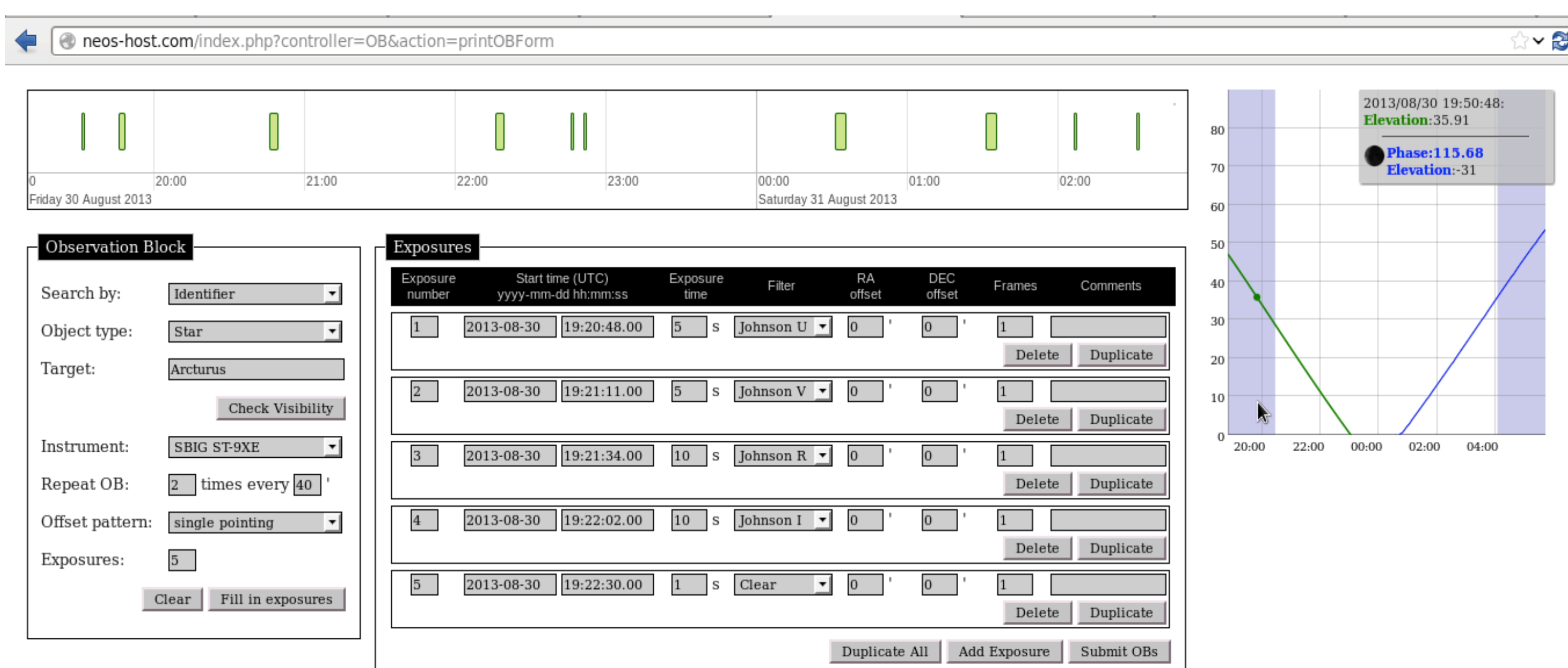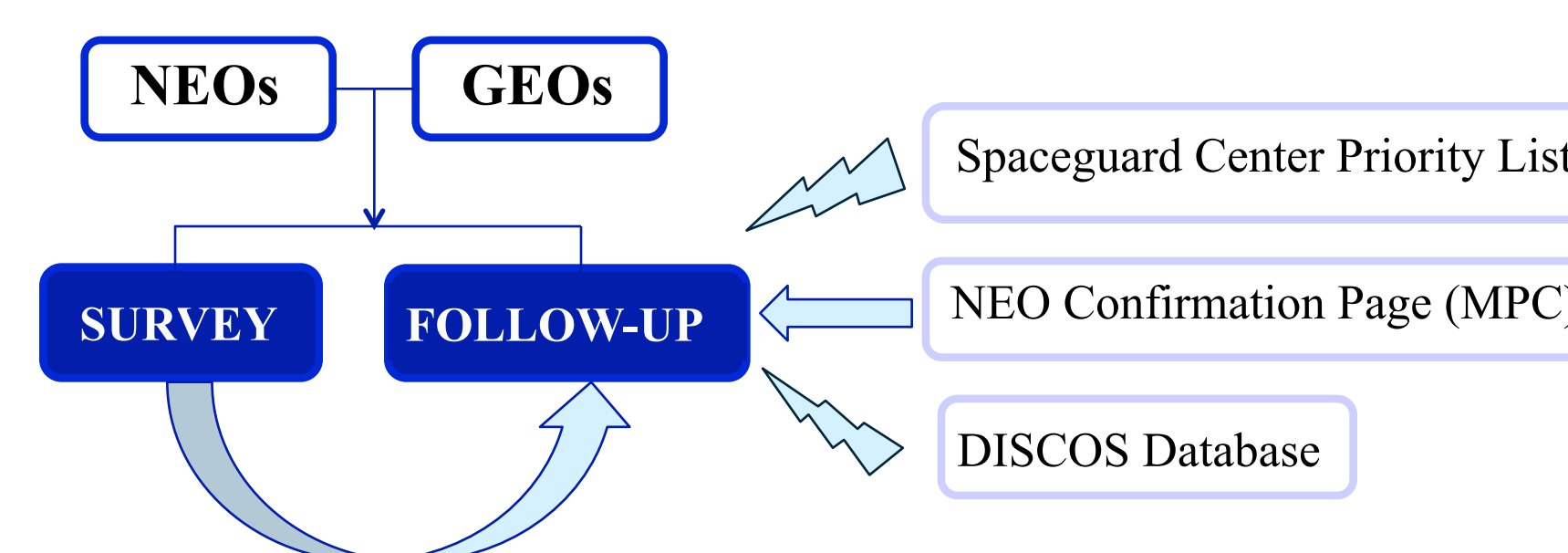

Figure 3. General View of the Scheduling Tool main page. At the top of the page the timeline bar shows the OBs already scheduled and saved on the Database for the specific observatory and date. On the left-hand side the "Observation Block" parameters are selected. The "Exposures" box allows the user to set the exposure parameters (start time, exposure time, filter, frames). Finally, on the right-hand side is the Visibility Plot (elevation vs time) of the selected target.

Observing Strategies

The planning tool will implement two general observing strategies: SURVEY and FOLLOW-UP both for man-made objects and Near Earth Objects (NEOs). The implementation of the strategies will be tailored to the characteristics of the target population. Additionally, it will also allow the user planning a custom-made observation with the freedom to modify or generate a new strategy in a system where a night plan is defined as a set of individual Observing Blocks (Fig 2). An overview of the scientific goals of the SSA-TBT can be seen seen below:

The strategy is defined according to the expected combined performance for both systems the upcoming night (weather, sky brightness, object accessibility and priority) and the time allocated for the two main tasks (NEO follow-up and space-debris catalogue updating).

TBT Scheduler

The TBT scheduler is part of the SSA-TBT software solution. It cooperates with other parts of the system- control software and processing modules (Fig 4). It is responsible for the global observing and planning strategy of the whole system. The main tasks of the software are:

- Generation of the Short Term Plan (STP) of each telescopes, defined as the observing plan of a particular night 1-2 days in advance.
- Implementation of survey strategies both for NEOs and man-made objects
- Implementation of follow-up strategies for both NEOs and man-made objects
- Management of the global observing strategy of the SSA-TBT system.

The TBT scheduler is conceive as a high-level planning tool for the manual and automatic observation planning that will be executed by the control software of the Test-Bed telescopes project under the ESA SSA program. The scheduler will generate the STPs, thus it will be responsible for the definition and management of the global strategy for the SSA-TBT observatories, and will rely on the RTS2 internal scheduler for the real-time response and monitoring of the system.
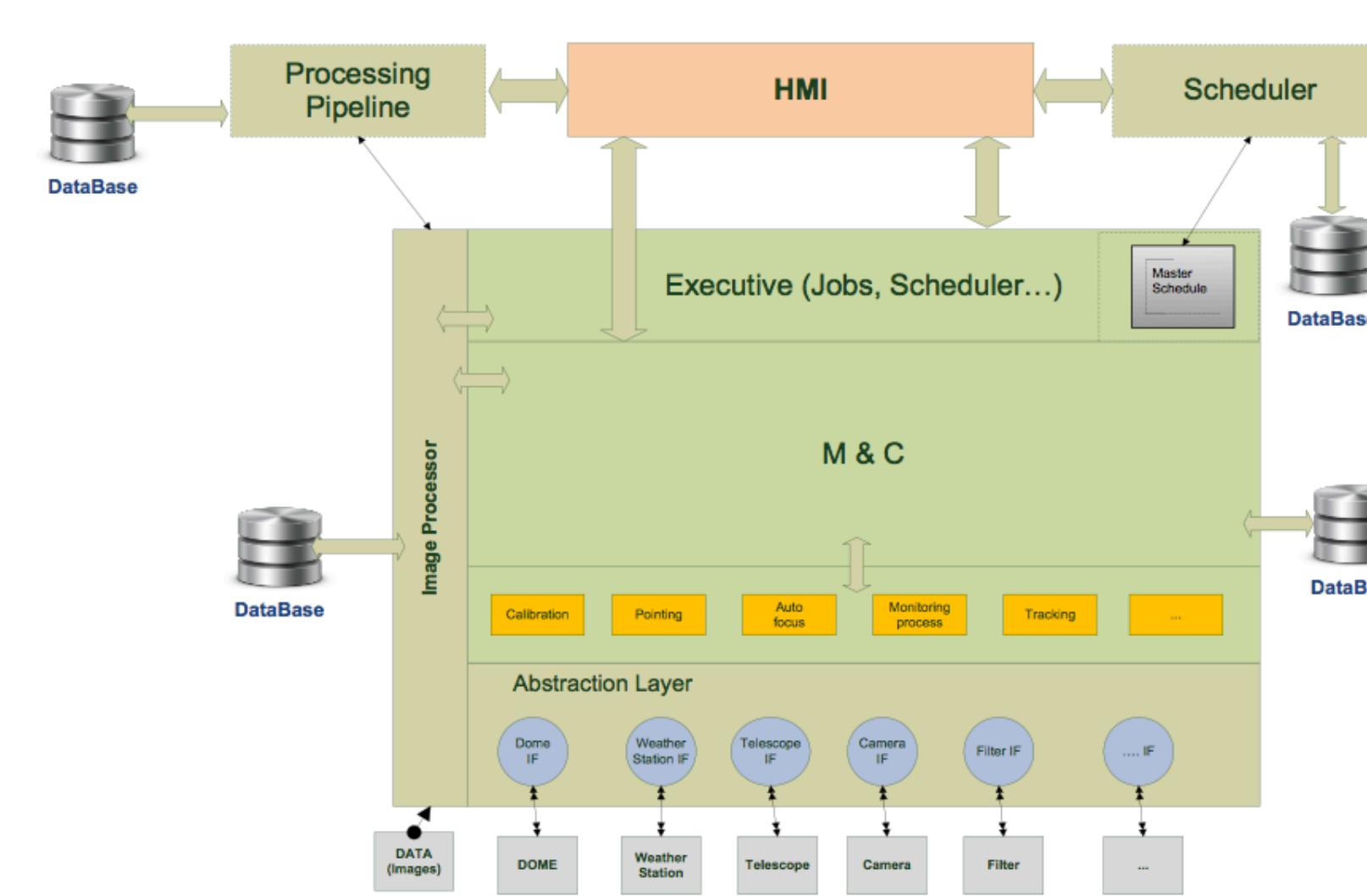

Figure 4. Logical software high-level architecture

The overall SW system is based on four main modules: control, scheduling, processing and HMI. Each module is based on existing software to be tailored according to ESA requirements. Furthermore, the modules must interact among them in order to provide the observation system a high level of automatization.

Technical Aspects

The scheduling interface is a web application, thus it possesses clear advantages from the user point of view compared to any other type of implementation, namely, its maintenance, portability (the only requirement is internet/intranet connection) and usage. The application is mainly running at the web server, consuming few resources at the user's computer (thin-client). It is also independent from the operating system (multiplatform).

The programming architecture follows the Model-View-Controller (MVC) schema, that separates the application data operations from the representation of the information. The Controller manages user's requests done through the View, triggering actions to the Model and processing its answer to send changes to the view.
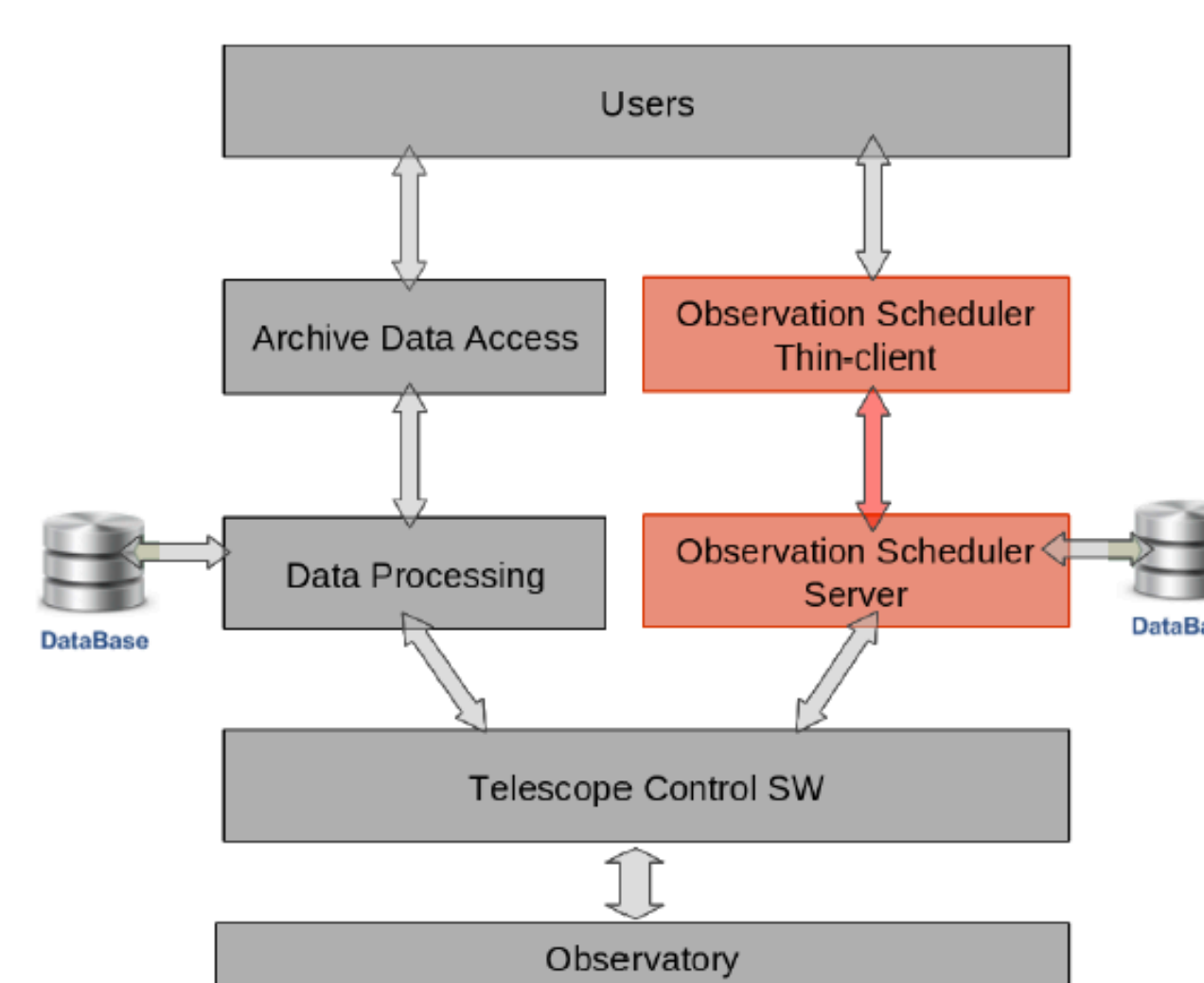

Figure 5. Communication diagram

In this kind of schema, the view represents a thin-layer interface in the client side, whose communications with the server side, where data are processed, are done via AJAX [(**)] requests, received in the server side by the Controllers.

Models and Controllers are programmed in PHP5 using object-oriented programming. Therefore, all the code is highly modular and simple to maintain. Dynamism in the webpage is is implemented via JavaScript and AJAX, allowing to update Views efficiently with bidirectional asynchronous communications between client and server sides, where the information is packed as JSON (JavaScript Object Notation) objects. Finally, Views are programmed in HTML4 under the standards of the W3C (World Wide Web Consortium).

(*) Cooperation through Education in Science and Astronomy Research
(**) Asynchronous JavaScript And XML