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RESEARCH PAPER

SOXS spectrograph instrument control software

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ABSTRACT. Son Of X-Shooter (SOXS) is a spectrograph for the European Southern Observatory (ESO), recently installed at the New Technology Telescope at the La Silla Observatory, Chile. The main instrument goal consists of the characterization of transient sources, based on alerts. It covers from (partially) ultraviolet to visible and near-infrared bands, with a spectral resolution of $R \sim 4500$, using two separate, wavelength-optimized spectrographs. A scientific-grade visible camera, primarily intended for target acquisition, also provides a "light imaging" mode. We present the design of the SOXS Instrument Control Software, which is in charge of controlling all motors, calibration lamps, and detectors; monitoring sensors and components' status; coordinating the execution of exposures; and implementing all observation, calibration, and maintenance procedures. Given the extensive experience of the SOXS consortium in the development of instruments for the ESO Very

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Large Telescope, we decided to base the design of the control system on the same standards, both for hardware and software control. We illustrate the control network, the instrument functions and detectors to be controlled, the overall design of the SOXS Instrument Software and its main components. Then, we provide details about the control software for the most SOXS-specific components and peculiar features: the piezoelectric tip–tilt corrector used for active compensation of mechanical flexures of the instrument, the cryogenic piezoelectric slit exchanger for the near-infrared spectrograph, the co-rotator monitoring system, and the control of the commercial-off-the-shelf-based imaging camera.

Keywords: Son Of X-Shooter; instrument control software; software; spectroscopy; imaging; astronomy

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1 Introduction

Son Of X-Shooter (SOXS) is a new instrument[1–3] developed for the European Southern Observatory's (ESO) New Technology Telescope (NTT) at the La Silla Observatory, Chile. It is inspired by the X-Shooter spectrograph[4] at the Very Large Telescope (VLT). This new, transient-oriented facility[5–9] is mainly dedicated to several follow-up programs[10] for the characterization of sources based on alerts. These alerts come from "traditional" telescope surveys ranging from high-energy to radio astronomy, including neutrinos and gravitational wave experiments.[11] The wavelength coverage of the instrument spans from a part of the ultraviolet (UV) spectrum range to the visible and the near-infrared bands[12] (overall 350 to 2000 nm). The instrument has a spectral resolution of $R \sim 4500$. It is installed at one of the two Nasmyth foci of NTT, and it features two spectrographs: the first is optimized for the near-infrared wavelengths, and the second is optimized for visible wavelengths and the concerned ultraviolet range. Hereafter, we will refer to this part of the instrument as "visible spectrograph." An imaging camera also provides a scientific "light imaging" mode, as well as support for target acquisition.

The SOXS hardware is composed of several sub-systems[13,14] (see boxes in Fig. 1): the common path (CP),[15–17] the calibration unit (CU),[18] the acquisition camera (ACQ),[19–22] the near-infrared spectrograph (NIR),[23–27] the ultraviolet visible spectrograph (UV-VIS),[28–33] and the cryo-vacuum system (CVS),[34] which is considered as an auxiliary system. Here, we briefly

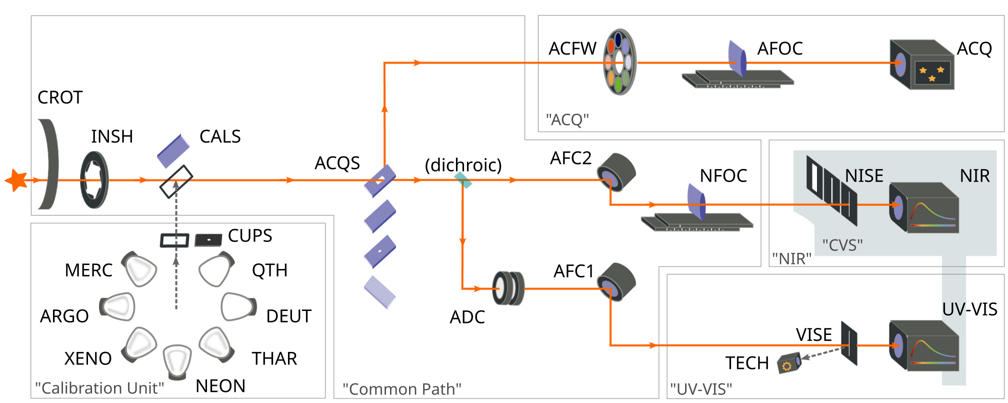

Fig. 1 Schematic view of the SOXS instrument and its sub-systems. Gray, quoted labels refer to sub-system names. The filled box includes the parts under cryogenics. Details of the components are described in Sec. 1. In particular, for clarity, only three of the NISE slit positions and one the VISE slit positions are displayed in the picture.

describe each one, focusing on the components that are controlled and monitored by the Instrument Control Software, and we summarize them in Table 1.

CP: responsible for receiving the $f/11$ light beam from NTT delivering a $f/6.5$ beam to NIR and VIS spectrographs. In doing so, the CP selects the wavelength range for the spectrographs using a dichroic and changes the focal ratio. A number of motor devices are present in the CP:

Table 1 SOXS devices and details. The upper section is related to motors, the middle section to lamps, while the lower section is related to sensors.

Name	Device	Options
INSH	Instrument Shutter	Two positions: Open, Close.
CALS	Calibration Slide	Two positions: Calibration Unit, Science.
CUPS	Calibration Unit Pinhole Slide	Two positions: Free, Pinhole.
ACQS	Acquisition Camera Slide	Four positions: Imaging, Spectroscopy, Pinhole, Pellicle.
AFC1-2	UV-VIS and NIR channels Actuator Piezos	Three modes: AUTO (continuous compensation of mechanical flexures based on look-up table), STAT (stopped on a position), REF (stopped on a reference position).
NFOC	NIR Focus Slide	Continuous.
ADC1-2	Dispersion Corrector Prisms	Three modes: AUTO (continuous compensation of atmospheric dispersion based on telescope position), OFF (stopped), REF (stopped in a reference position).
AFOC	Acquisition Camera Focus Slide	Continuous.
ACFW	Acquisition Camera Filter Wheel	Eight positions: SDSS *u*, *g*, *r*, *i*, *z*; Vimos *V*, Vimos *Y*, Free.
NISE	Near Infrared Slit Exchanger	Six positions: 0.5″, 1.0″, 1.5″, 5.0″ slits; pinhole, Multiple Pinhole, and BLANK (totally covered) position.
VISE	UV-VIS Slit Exchanger	Seven positions: 0.5″, 1.0″, 1.5″, 5.0″ slits; pinhole, Multiple Pinhole, Slit Viewer.
MERC	Hg Arc Lamp	Two states: On, Off.
ARGO	Ar Arc Lamp	Two states: On, Off.
XENO	Xe Arc Lamp	Two states: On, Off.
NEON	Ne Arc Lamp	Two states: On, Off.
THAR	Thorium-Argon Arc Lamp	Two states: On, Off.
DEUT	Deuterium Flat Field Lamp	Two states: On, Off.
QTH	Quartz Tungsten Halogen Flat Lamp	Two states: On, Off.
CROT	Co-rotator	Four readings: Is moving, Is touched, Is in Fault, Is Active.
CVTS	Cryo-Vacuum sensors	13 readings: 10 analog and 3 digital sensor readings from CVS.
IRTS	Infrared sensors	33 readings: 28 analog and 5 digital sensor readings from NIR.
CPTS	CP sensor	One reading: Temperature sensor on common Path.
THCU1-2	Thermal Control Unit 1 to 2 sensors	Five readings: Analog teperatures and flow rate from instrument cabinets.

- The entrance instrument shutter is used to let the telescope beam in or make the instrument light-tight when performing calibrations using internal light sources.
- A “calibration slide” linear motor allows the selection of the instrument input source, either the light coming from the target field on sky or the lamps of the calibration unit.
- Then, an “acquisition slide” linear motor directs the full beam either to the acquisition camera for imaging observations or splits it such that the central portion is transmitted to the spectrographs while the peripheral light is sent to the acquisition camera.[35] Two additional positions are used for calibration and maintenance.
- The light directed to the spectrographs is then split by a dichroic into near-infrared and visible components. Each of the two light paths reach a separate “active flexure compensators” (AFC1 and AFC2), piezo-electric tip–tilt mirrors responsible for compensating mechanical flexures due to the changing of the gravity vector during observations.[36]
- A “near-infrared focuser” linear motor, mounting an optical doublet, provides adjustment of the focus for the near-infrared light beam before reaching the corresponding spectrograph.
- The visible light beam passes through an “atmospheric dispersion corrector” composed of two counter-rotating prisms before reaching the corresponding spectrograph.[37]
- The SOXS instrument is attached to one of the NTT rotator adapter. A co-rotator motor (CROT) ensures that all instrument cables are properly counter-rotated before reaching the electronic cabinets.

CU: includes two sets of lamps and a linear motor responsible for selecting the appropriate calibration source:

- The fist set is composed of five arc lamps—mercury, argon, xenon, neon, and thorium–argon—used for wavelength calibration (MERC, ARGO, XENO, NEON, and THAR, respectively).
- The second set is composed of two continuum deuterium and quartz tungsten halogen lamps for flat-field calibration (DEUT and QTH, respectively).
- The “calibration unit pinhole slide” linear motor controls an insertable pinhole for alignment and maintenance procedure purposes.

ACQ: centers the source on the selected slit during target acquisition. The sub-system is composed as follows:

- The camera, which can also be used as a light imager to perform photometry and flux calibration, is a commercial Andor iKon-M 934 Series equipped with a deep-depletion charge coupled device (CCD), providing a $3.5' \times 3.5'$ field of view with a resolution of $0.205''/\mathrm{px}$.
- ACQ also includes an “acquisition camera focuser” linear motor for focusing and an “acquisition camera filter wheel” eight-position rotary motor provided with Vimos-V, Vimos-Y, sloan digital sky survey (SDSS) $ugriz$ filters, and a free position.

NIR: this sub-unit is composed of an echelle-dispersed spectrograph working in the 800- to 2000-nm wavelength range. It is enclosed in a cryostat supplemented by a cryo-vacuum controller. The system comprises the following:

- a Teledyne H2RG TM 2048×2048 px hybrid infrared array detector, its front-end electronics, the custom New General Detector Controller (NGC) developed by ESO, and a mechanical support
- a cryogenic, a piezo-mechanical “near-infrared slit eExchanger” with slits from 0.5 to $5''$, a pinhole, and a multiple pinhole position for calibration and alignment.

UV-VIS: based on a novel design in which the spectral band is split in narrow sub-bands, thus allowing the use of high-efficiency gratings that are optimized for a narrow wavelength range. Besides the fixed optics, it comprises the following:

- an E2V CCD44-82 2048×4096 px CCD detector, its front-end electronics, and the custom NGC controller developed by ESO
- a “visible slit exchanger” (VISE) linear motor with the same options as the NIR infrared slit exchanger (NISE), plus an additional mirror position
- the mirror position in the VISE redirects the light source to a technical camera (TECH) that was used during the assembly, integration, and verification (AIV) phase.

CVS: consists of all hardware and the electronics related to controlling and monitoring of the cryogenic functions for the two cryostats (enclosing the whole-NIR spectrograph and the only UV-VIS detector, respectively, as in the filled box in Fig. 1).

In this paper, we present in detail the SOXS Instrument Control Software, expanding and structuring the improvements described in a dedicated series of SPIE proceedings.[38–40]

The development and commissioning phase is shown in Sec. 2. We present the control network architecture in Sec. 3, and the overall design of the instrument software is in Sec. 4. Section 5 provides further details about the special devices: the active flexure compensation system (Sec. 5.1), the co-rotator (Sec. 5.2), the near-infrared slit exchanger (Sec. 5.3), and the ACQ camera software (Sec. 5.4). A brief description of the synoptic panel is given in Sec. 6, and conclusions are presented in Sec. 7.

2 Development and Commissioning

ESO instruments such as X-Shooter have been developed mainly for VLT at Paranal Observatory,[41] following the VLT standards and guidelines in terms of hardware and software components. For what concerns INS, the software standard is the VLT Common Software (VLTSW), and the latest release of which is VLT2024.

SOXS development was not forced to closely follow the VLT stantards, being that it is intended for the La Silla Observatory.[42] However, SOXS shares similarities in design and in many operational procedures to X-Shooter. For that reason, we decided to take the existing X-Shooter INS as a baseline. Thus, during the design phase, we adapted the template instrument software provided by the VLTSW to the SOXS and configured standard software devices under the VLT2024 release.

Procedures for starting up and shutting down the software also follow the VLT rules. Automated tests have been implemented to the exercise software built from scratch: testing of the instrument functions, the detectors, and the software layers and scripts responsible for the coordination of all motors, lamps, and detectors to perform observation and maintenance procedures. Most of the instrument software development was carried out in advance using software device simulators provided by VLTSW, and the configuration was tested or adapted gradually with the hardware becoming available.

After the assembly, integration, and test (AIT) phase in INAF – Osservatorio Astronomico di Padova,[43–45] the instrument was shipped to La Silla where the AIV phase was carried out[46] to test the whole instrument at both engineering and scientific level. The preliminary operations at La Silla allowed us to validate the instrument performances with respect to the end-to-end simulations.[47–49]

The commissioning phase validated the dedicated scheduler,[50,51] preparing the real-time observation queue. The collected data are processed on-site, a Python reduction pipeline called `soxspipe`, which is also publicly available and easy to install, allowing users to set up custom reduction strategies.[52–54]

3 Network Architecture

The SOXS network architecture follows the typical configuration of VLT instrument control systems: through the instrument local area network (LAN) an Instrument Workstation (IWS) supervises several connected local controllers, mostly based on Gb Ethernet (see the left diagram in Fig. 2).

The detector controllers for the NIR and UV-VIS channels are the ESO NGCs. The respective Linux local control units are connected to the IWS via the instrument LAN.

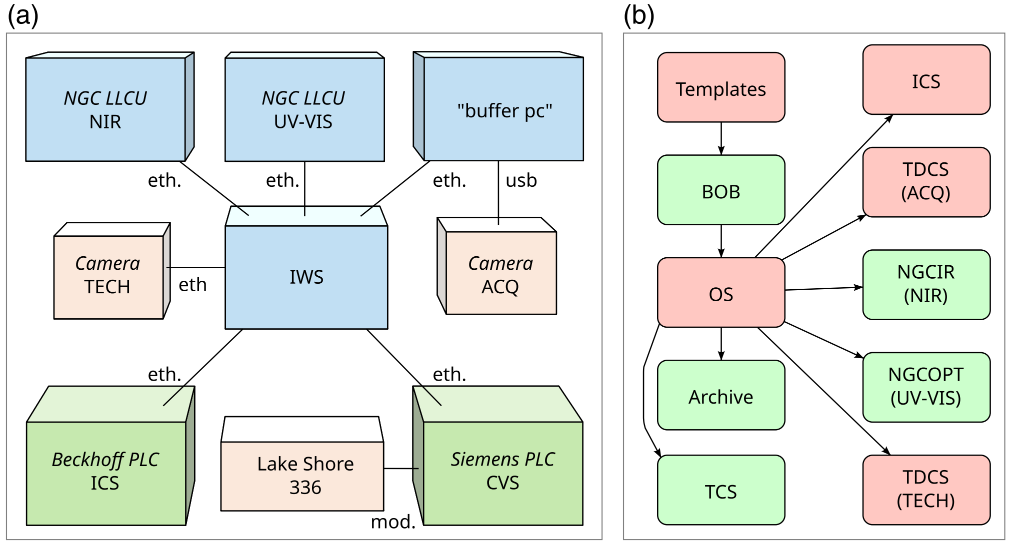

Fig. 2 (a) SOXS network architecture, showing workstations in blue, PLCs in green, and other devices in pink. USB, Ethernet, and Modbus communication protocols are also shown. (b) SOXS software architecture. The VLTSW components depicted in light green have been reused without any modification. The components in light red have been developed by the SOXS team, starting from the VLTSW base software provided for each type of component.

Following the recently introduced VLT standard, a single Beckhoff programmable logic controller (PLC) is responsible for the control of all instrument functions,[55–57] i.e., motors, lamps, and most of the SOXS sensors. A separate Siemens S7 PLC is responsible for the CVS functions and sensors. The CVS is an autonomous system, and SOXS INS is not in charge of controlling but only monitoring it. In particular, NIR and UV-VIS temperatures are controlled and monitored by means of a Lakeshore 336 controller connected to the Siemens PLC via the Modbus protocol.

On the other hand, the ACQ camera is based on a commercial-off-the-shelf (COTS) component, providing an integrated controller with a Universal Serial Bus (USB) interface.

The baseline design routed the USB connection to the IWS through the observatory LAN by means of a commercial USB extender. However, we found on site that this led to timeout errors, impacting the proper functioning and performance of the system. Therefore, we decided to directly USB-attach the camera to a separate fanless personal computer (PC) mounted on the SOXS flange, which we call "buffer PC," which is connected to the SOXS network via the Instrument LAN. This buffer PC also runs the VLT2024 release to easily set up a "standard VLT way" for software installation, maintenance, and communication between the camera and the IWS.

Finally, an additional Camera Link TECH, physically placed in the UV-VIS spectrograph sub-system, is also linked via Gb Ethernet. This camera is not used in normal operations and is manually connected to the LAN only for maintenance and diagnostics.

4 Software Architecture

The SOXS INS [see Fig. 2(b)] is developed using the latest VLT software release (VLT2024). The architecture follows the standard partitioning of VLT Instrument software applications. It is in charge of controlling all instrument functions and monitoring all sensors:

Instrument Control Software (ICS): Instrument Control Software manages all instrument functions. This component supports a large number of "standard devices," such as linear stages, shutters, and lamps. No code development is necessary for these devices, and it is enough to provide configuration information (location and type of signals, motor control parameters, etc.). Non-standard devices are required to properly interface with ICS, developing a function block (FB) software at the PLC level and a "special device" driver at the IWS level. These devices are detailed in Sec. 5.

DCS: the NIR and UV-VIS spectrograph detectors are controlled by instances of the Detector Control Software. These are "standard detectors," and the ICS is required to only provide configuration information and voltage parameters for readout modes and detector regions of interest.

TDCS: the ACQ and the TECH cameras are based on instances of the Technical Detector Control Software Development Kit (SDK),[58] which has been part of the VLT Common Software since the VLT2016 release.

OS: operations are coordinated by a central component, the Observation Software, which is also in charge of managing external interfaces. All observation, calibration, and maintenance procedures are implemented as template scripts using the Tool Command Language, which are executed by the Broker of Observation Blocks through commands sent to the OS.

Telescope Control Software (TCS): the Telescope Control Software is an external interface, running the VLT2010 release. Its control software has been recently adapted to host SOXS as an NTT instrument.

Finally, OS also manages an additional external interface, the archive, through another standard component provided by the VLTSW: the OS Archiver. It is in charge of producing the files to be archived. In particular, it merges all partial headers, coming from ICS and TCS, with the header of the image file produced by the DCS. The ICS partial header contains information about the instrument functions, whereas the TCS partial header contains information about pointing, ambient, and observing conditions.

5 Special Devices

In SOXS, special devices requiring custom implementation of the function block at the PLC level and device driver at the ICS level are AFCs, CROT, and NISE. Details of the development of these special devices are given in Secs. 5.1–5.4.

We have included the Andor camera in this section because it is not a standard VLT component. Its control software is an application based on the TDCS and is a special feature of SOXS.

In Secs. 5.1–5.4, we describe the implementation, giving some details about the classes that manage these devices, and their inheritance. The ones prefixed with `sx`- are SOXS-specific implementations, whereas the ones prefixed with `ic0fb`- are VLTSW natives.

5.1 Active Flexure Compensation

As SOXS is installed on the Nasmyth rotator adapter, which will track the sky during an observation, it changes its orientation with respect to the gravity vector. This results in some flexures between the spectrograph and the common path system, which move the target with respect to the spectrograph slit. For this reason, two piezo-actuated tip–tilt mirrors (AFC1 and AFC2) are located in the CP and are used to correct for the flexures.

Flexures displace the target in relation to NISE and VISE. To address this issue, AFCs are commanded by INS through the instrument PLC via analog signals (one per axis). As the AFCs are not a VLT standard actuator, a "special device" has been developed. During observations, this component operates as a "tracking axis," updating in a closed-loop the position of the devices depending on the rotator angle.

As the expected loop frequency is $\sim$1 Hz, timing constraints are not tight. It has been decided to implement this tracking loop using a look-up table entirely in the IWS.

The AFCs are controlled by two `PI S-330` two-axis actuators. Each actuator is controlled by a `PI E-727.3SDA` three-channel digital piezo controller, which is commanded through the instrument PLC via serial line. The AFC system operates in the following modes:

- Mode AUTO, in which the correction is periodically computed and applied (about every minute) by the software on the basis of a "pointing model." The pointing model requires a calibration procedure, and the computation of corrections requires information about the rotator position.

- Mode STAT, in which the AFCs are kept at a fixed position, sent via a SETUP command.
- Mode REF, which puts the AFCs at a fixed, pre-defined position required for the alignment of the system.

A dedicated device VLTSW driver class, in this case `sxiafcDevDrv`, is derived from `ic0fbDevDrvBase`, and methods are developed to implement the device-specific behavior. In particular, method `controlLoopUser` encapsulates the logic for AFC positioning. The method is called periodically by the underlying ICS framework code. If the AFC has been set up with a fixed position (either specified by the user or the reference one), the (fixed) positioning command is "refreshed." If the device must compensate for flexures, a new AFC command is computed for the current position of the de-rotator and applied. The loop period can be set in the device configuration.

In the case of the AFC, commands are sent to the device via the serial line. On the PLC side, we developed a function block which uses the library `FB_RS232` provided by ESO, which was recently updated under our suggestion to take into account the rotator offset. A device simulator (`sxiafcDevSim`) allows the software to operate in simulation.

Two custom widgets in the ICS panel allow the operation mode to be changed and, if STAT is selected, the selection of a custom position.

5.2 Co-rotator

During operations, the rotation of the whole instrument would also affect cabling in several devices. For that reason, a co-rotator system has been set up to compensate for the de-rotator. Moreover, to prevent the risk of damaging the harnesses in case of misalignment between the co-rotator and the de-rotator, a security system based on an interlock chain has been set up.

Two linear potentiometers (Tekkal TR-25) have been mounted on an interface flange between the instrument and the co-rotator to check the relative rotation among them. These signals, which correspond to the relative displacement between the two systems in the rotation, give the feedback to the servo motor driver. The potentiometers adapter accepts these signals as inputs and returns their difference as output. The adapter board output is an input for a motor driver (Lexium 32C), which controls the speed and the direction of rotation of the co-rotator motor to match the NTT Nasmyth rotator. A safety switch (Omron ZCQ2255) is connected and is inserted in the telescope interlock chain to disable the rotator when the co-rotator is in an offline state. If the switch is reached, the interlock signal is raised, and the final stage that gives power to the servo motor is disabled. A manual repositioning of the co-rotator is needed to disable the interlock and reactivate the final stage. When the final stage is disabled and the co-rotator is not working, the active output signal is low. The special device driver is controlled via digital and analog input/output:

- Two analog inputs give information to the driver about the relative rotation between the instrument and the co-rotator.
- A digital input, coming from a safety switch, stops the motor in case of emergency/safety risks.
- Two digital input signals, coming from the Beckhoff PLC, control the activation and reset of the driver: ENABLE (enable the power stage) and FAULT RESET (reset error message).
- Two digital output signals interface with the Beckhoff PLC (ES2004 and ES1004 modules), giving information about the state of the driver: ACTIVE (indication of the operating state) and NO FAULT (indication of the fault condition).

Again, the custom widget in the ICS panel allows changing the state of the special device, and to monitor the above flags.

5.3 Near Infrared Slit Exchanger

The NISE is a cryogenic actuator controlled via a Micronix MMC-110 crontroller, connected to the SOXS PLC through a serial line of type RS232. As the Micronix controller is not directly supported by the VLT Software, a special device needs to be developed.

A dedicated device driver class named `sxiniseDevDrv` was derived from the VLTSW class `ic0fbDevDrvBase`. Methods were developed to implement the device-specific

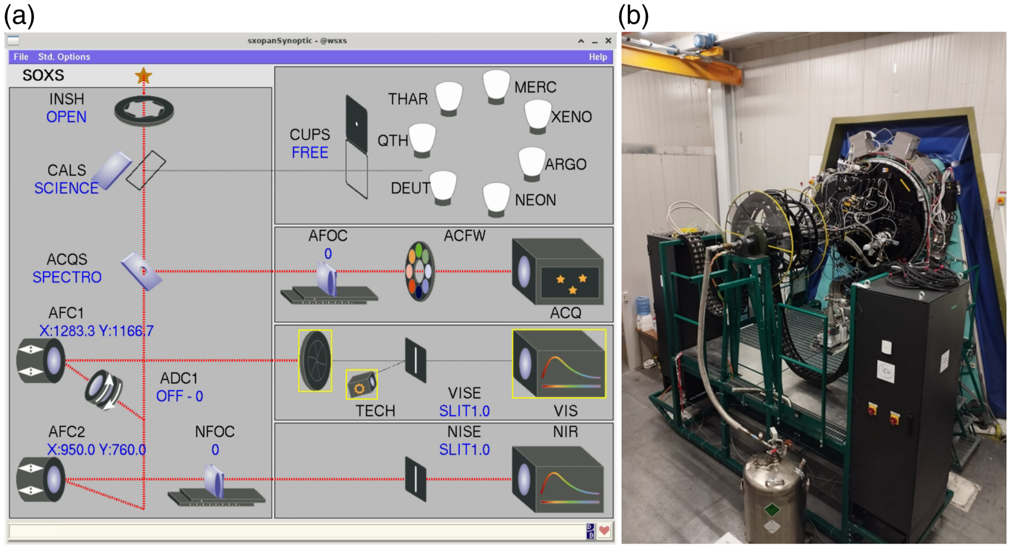

Fig. 3 (a) SOXS synoptic panel. Device names are shown in black, and corresponding state or positions are shown in blue. In this image, yellow borders indicate that a component is simulated. The red path indicates the light flow into the instrument. (b) Picture of the SOXS instrument installed at NTT.

behavior. State change handling methods handle setting up the communication with the controller. The setup handling method is overloaded to transform setup requests into commands for the Micronix controller. The status handling method is overloaded to retrieve status information from the Micronix controller, returning it as a command reply and storing it in the database to be displayed in Graphical User Interfaces (GUIs).

The device server `sxiniseDevSrv`, i.e., the process that hosts the driver code, is based on the standard server class `ic0fbDevSrv` and makes use of standard communication interfaces `ic0fbsiaOpcUa` and `ic0fbIfCcs` to communicate with the driver or the simulator.

5.4 Acquisition Camera Control

The imaging camera of SOXS is a COTS component, provided with a USB 2.0 interface for external connection. As the SOXS IWS is located in the data center of the La Silla Observatory, ∼3 km from the NTT where SOXS and the ACQ are installed, whereas USB cable connections are limited to a few meters, we initially decided to use a commercial, switchable USB extender (Icron 2304GE-LAN) to route the connection through the La Silla LAN and then to the IWS. This solution, while it did not present any issue during the AIT phase in Padova, has not been validated in La Silla. This led to random, unpredictable timeouts.

Therefore, we switched to a fall-back design where an intermediate computer, called "buffer PC," is installed on the instrument. Communication from the "buffer PC" to the IWS happens through the Instrument LAN. This PC is close to the camera and can be connected directly to it via USB. Provided with the VLT2024 software release and specific SOXS modules, the "buffer PC" runs the ACQ and is responsible for passing the information toward the IWS.

The ACQ camera control is based on TDCS[58] SDK, and its core consists of a class providing the "communication interface" with the camera. This class directly interfaces with the Andor camera via USB, directly calling the vendor-supplied driver functions.

6 Synoptic Panel

The synoptic panel [see Fig. 3(a)] is a custom-developed GUI showing the current configuration of the instrument in a graphical way.

This panel displays the light path, the current position/status of the motors and lamps, and if any of these components are in simulation mode.

ESO recently requested the synoptic panel for recent instruments, such as SPHERE, to have a quick look at their status. SOXS is the first La Silla instrument to provide it, and we have received positive feedback from both ESO/La Silla operators and SOXS users.

In general, this kind of panel follows the opto-mechanical design of the instrument, where components and the light path are reproduced to mock their "real" position (see a picture of the whole instrument in Fig. 3 on the right). For SOXS, we decided to change the approach toward a "subway map" concept, to improve the operator's readability.

In particular, most of the gif icons animate depending on their status (shutter OPEN or CLOSE, calibration unit lamps ON or OFF, type of the slits, and position of the mirrors), and the light path is set to suggest where the light is "flowing" into the instrument. This is particularly useful in the case of the UV-VIS shutter, which is autonomously controlled by the corresponding NGC. Finally, simulated devices are bordered to improve awareness. Given the positive feedback from the team, we decided to broaden this approach also for the ESO VLT ERIS instrument and for the LBT SHARK-NIR coronagraph.[59] Feedback also suggested the panel to be interactive, i.e., allow click-and-setup of single components instead of bare monitoring. This intriguing option, which is already available in SOXS "traditional" engineering panels developed for each sub-system, will be explored in the framework of the next telescope instruments.

7 Conclusion

We presented the general software architecture of the SOXS instrument for the NTT, a double spectrograph for near-infrared and visible observations. For the acquisition camera, which is available for "light imaging," we described the peculiar features in terms of hardware (acquisition camera and camera connection) and software solutions (special devices).

The instrument software is based on the VLT Common Software for the management of standard devices and on custom software for the management of special devices, i.e., the piezo-electric actuators for flexure compensation, the co-rotator device, the piezo-mechanic slit exchanger for the near-infrared spectrograph, and the acquisition camera.

Spectrograph detectors are managed using ESO NGC controllers, and the COTS imaging camera is managed through a custom software based on the VLTSW TDCS component.

Other peculiarities in the development of the SOXS Instrument Control Software include the synoptic panel for the quick look of the instrument status and setup. During the installation, an on-site major change in the design was necessary to overcome timeout errors due to the USB extender initially used for the acquisition camera communication.

Observation and maintenance software have been completed, and SOXS is successfully in operation.

Disclosures

The authors declare that there are no financial interests, commercial affiliations, or other potential conflicts of interest that could have influenced the objectivity of this research or the writing of this paper.

Code and Data Availability

Data sharing is not applicable to this article. There is no software code associated with the main claims of this paper. This paper does not rely on supporting data.

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