Development status of the SOXS instrument control software

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ABSTRACT

SOXS (Son Of X-Shooter) is a forthcoming instrument for ESO-NTT, mainly dedicated to the spectroscopic study of transient events and is currently starting the AIT (Assembly, Integration, and Test) phase. It foresees a visible spectrograph, a near-Infrared (NIR) spectrograph, and an acquisition camera for light imaging and secondary guiding. The optimal setup and the monitoring of SOXS are carried out with a set of software-controlled motorized components and sensors. The instrument control software (INS) also manages the observation and calibration procedures, as well as maintenance and self-test operations. The architecture of INS, based on the

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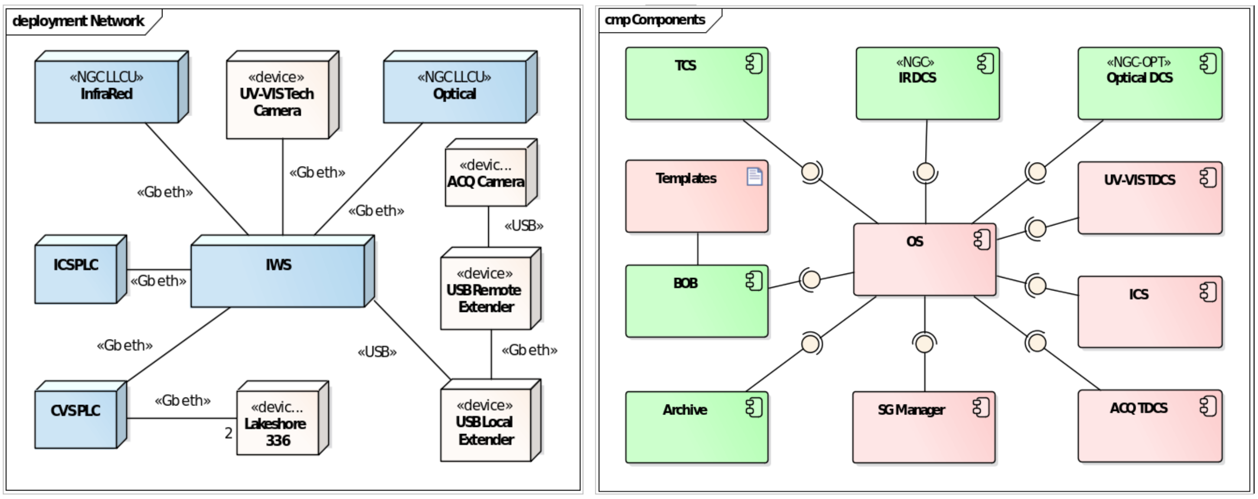

Figure 1. Left: Network control architecture of SOXS. Right: Components of the SOXS software; red boxes represent software requiring custom configuration or development, green boxes represent VLTSW components that will be used without modifications.

latest release of the VLT Software (VLT2019), has been frozen; the code development is in an advanced state for what concerns supported components and observation procedures, which run in simulation.

In this proceeding we present the INS current status, focusing in particular on the ongoing efforts in the support of two non-standard, "special" devices. The first special device is the piezoelectric slit exchanger for the NIR spectrograph; the second special device is the piezoelectric tip-tilt corrector used for active compensation of mechanical flexures of the instrument. For both, which are commanded via a serial line, specific driver and simulators have been implemented.

Keywords: SOXS, Instrument Control Software, Software, Spectroscopy, Imaging, Astronomy

1. INTRODUCTION

The SOXS instrument *"Son Of X-Shooter"*, a forthcoming facility[1] for the European Southern Observatory (ESO) New Technologies Telescope (NTT) telescope at the La Silla Observatory, Chile, successfully passed the Final Design Review (FDR) process on July 2018, and it is approaching the Assembly, Integration and Test (AIT) phase of its several subsystems:[2–13] 1. The Common Path (CP); 2. The Visible spectrograph (UV-VIS); 3. The Near-Infrared spectrograph (NIR); 4. The Acquisition Camera (AC); 5. The Calibration Unit (CU).

This paper is part of a series of contributions[14–27] describing the current development status of the SOXS subsystems. In particular, we present the progresses in the status of the Instrument control Software (INS) following the last dedicated proceedings[3] and we focus on two special devices which required a custom development: the Near Infrared Slit Exchanger (NISE) and the Active Flexure Compensator (AFC).

The control network architecture and software design architecture are presented in Sect. 2. The development of the NISE is shown in Sect. 3, while the development of the AFC is treated in Sect. 4. Conclusions are presented in Sect. 5.

2. NETWORK AND SOFTWARE ARCHITECTURE

The SOXS network architecture follows the typical configuration of VLT Instruments control systems: an Instrument Workstation (IWS) supervises through the instrument LAN several connected local controllers, mostly based based on Gb Ethernet (see Fig. 1 left).

In particular, for SOXS, two ESO New General Detector Controllers (NGC) are responsible of the UV-VIS and NIR detectors, while the commercial AC camera, providing an integrated controller with USB interface, is

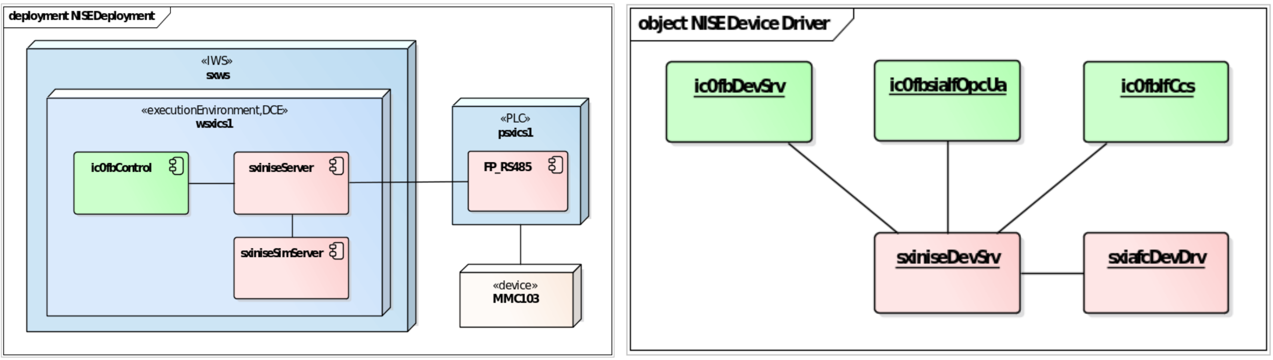

Figure 2. Left: NISE special device deployment diagram. Right: NISE Device Driver object diagram.

linked to the IWS through a commercial ICRON USB extender. An additional Cameralink Technical Camera (TECH), physically placed in the UV-VIS spectrograph subsystem, is also linked via Gb Ethernet.

A single *Beckhoff* Programmable Logic Controller (PLC)[28] is responsible for the control of all instrument functions, while a separate *Siemens* S7 PLC autonomously controls Cryo-Vacuum functions and the privately Ethernet-connected *Lakeshore* 336 temperature controller.

The SOXS INS (see Fig. 1 right) is developed using the latest VLT Software release (VLT2019). It is in charge of the control of: 1. all instrument functions (ICS); 2. the UV-VIS and NIR spectrograph detectors, controlled by instances of Detector Control Software (DCS); 3. the AC and the TECH cameras, basing on instances of the Technical DCS Software Development Kit (SDK);[29] 4. the observation procedures via the Observation Software (OS), managing observation, calibration and maintenance procedures implemented as templates and executed by the Broker of Observation Blocks (BOB); 5. the external interfaces such as the Telescope Control Software (TCS), and the Archive. Currently, all these components have been configured and developed, as well as control panels for and user interfaces, and run in simulation under the VLT Software environment.

The most of the ICS SOXS components are natively supported as "standard devices" and it is sufficient to provide configuration information. For non-standard devices, it is required to properly interface them with ICS, developing a Function Block (FB) software at PLC level and a "special device" driver at IWS level.

In SOXS, these special devices are the cryogenic piezo-mechanic stage for slit positioning in the NIR spectrograph and the piezo-actuated tip-tilt mirrors used for Active Flexure Compensation. Details of the development of these two special devices are given in following sections.

3. NEAR INFRARED SLIT EXCHANGER

The NIR Infrared Slit Exchanger (NISE) is a cryogenic actuator controlled via a Micronix `MMC-103` crontroller, connected to the SOXS PLC through a serial line of type `RS485`. Since the Micronix controller is not directly supported by the VLT Software, a special device needs to be developed. The design of the NISE is shown in Fig. 2 left. A dedicated device driver class named `sxiniseDevDrv`, shown in Fig. 2 right, was derived from `ic0fbDevDrvBase`. Methods were developed to implement the device specific behavior. State change handling methods handles setting up of 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 in order to be displayed in GUIs. As shown in Fig. 2 right, 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`, in order to communicate with the driver or the simulator.

4. ACTIVE FLEXURE COMPENSATION

Since SOXS will be installed at the Nasmyth focus of the NTT, during an observation it will change its orientation with respect to the gravity vector. This will result in some flexures which might move the target with respect to the spectrographs slit. For this reason, two piezo-actuated tip-tilt mirrors (TTM) are located in the common path and will be used to correct for this effect.

The TTMs will be commanded by INS through the instrument PLC via analog signals (one per axis). Since the TTMs are not a VLT standard actuator, a "special device" has been developed. During observations, this component will operate as a "tracking axis", updating in a loop the position of the TTM depending on the rotator angle.

These TTMs, placed in the Common Path, will assure Active Flexure Compensation (AFC) of the UV-VIS (AFC1) and the NIR (AFC2) arm, respectively. They are controlled by two `PI S-330` two-axis actuators. Each actuator is controlled by a `PI E-727.3SDA` 3 channel digital piezo controller, which is commanded through the instrument PLC via serial line. The active flexure compensation system operates in the following modes: 1. 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. The TTM in the visible arm will also correct for ADC "wobbling" (if necessary), so will also take the ADC prism angle in input. 2. Mode STAT, in which the TTM is kept at a fixed position, sent via a SETUP command. 3. Mode REF, which puts the TTM at a fixed, pre-defined, position required for the alignment of the system.

The design of the AFC special device is similar to the one of the NISE Fig. 2. A dedicated device driver class, in this case `sxiafcDevDrv`, is derived from `ic0fbDevDrvBase`, methods will be developed to implement the device specific behavior. In particular, method `controlLoopUser` encapsulates the logic for TTM positioning. The method is called periodically by the underlying ICS framework code. If the AFC has been setup with a fixed position (either specified by the user or the reference one), the (fixed) positioning command is "refreshed". If the AFC must compensate for flexures, a new TTM 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 TTM via serial line. On the PLC side we developed a function block which uses the library `FB_RS232` provided by ESO to handle the serial connection. A device simulator (`sxiafcDevSim`) allows to operate the SW

5. CONCLUSION

We presented the progresses in the development of the Instrument Control Software of the forthcoming SOXS instrument, based on the VLT Software. We focused on the software development of the two non standard devices: the Near Infrared Slit Exchanger and the Active Flexure Compensation system. Further configuration, development and tests are ongoing in order to complete the AIT phase of the several subsystems, which is starting in these months.

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