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VII Workshop on Robotic Autonomous Observatories (October 16-20, 2023)
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DON: AUTOMATION OF THE VATICAN ADVANCED TECHNOLOGY TELESCOPE

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RESUMEN

El telescopio Alice P. Lennon y la infraestructura astrofísica Thomas J. Bannan, conjuntamente conformando el Telescopio de Tecnología Avanzada del Vaticano (VATT), fue inaugurado hace algo más de 30 años en el Monte Graham, en Arizona. Se trata de un telescopio gregoriano con un primario de f/1 y un sistema óptico completo a f/9. Ya presentamos las modernizaciones completadas y planificadas del VATT en un congreso anterior (AstroRob 2017, ver Swindell 2019). El propósito de este artículo es presentar los últimos avances. En particular, contratamos a la empresa ProjectSoft HK (República Checa) para revisar el sistema de control. El nuevo sistema, denominado `Don`, utiliza PLC. La revisión del diseño ha concluido, el sistema se está montando en ProjectSoft HK y se realizó una prueba de aceptación en fábrica en enero de 2024. El sistema se instaló y puso en marcha en abril-mayo de 2024. `Don` permite un funcionamiento por script, sin necesidad de operadores in situ. También estamos trabajando en la colimación y el enfoque automatizados.

ABSTRACT

The Alice P. Lennon Telescope and the Thomas J. Bannan Astrophysics Facility, informally the Vatican Advanced Technology Telescope (VATT), was dedicated 30 years ago on Mount Graham in Arizona. It is a Gregorian telescope with an f/1 primary and an f/9 full system optics. We presented the completed and planned upgrades of the VATT at the AstroRob 2017 (Swindell 2019). The purpose of this paper is to present the latest developments. In particular, we have contracted ProjectSoft HK (Czech Republic) to overhaul the control system. The new system, named `Don`, uses PLCs. The design review was completed, the system was assembled at ProjectSoft HK, and a factory acceptance test was carried out in January 2024. The system was installed and commissioned in April and May 2024. `Don` allows for scripted operation based, with no need for on-site operators. We are also working on automated collimation and focusing.

Key Words: Vatican Advanced Technology Telescope — VATT — automation — control system — ProjectSoft

1. INTRODUCTION

The 1.8m diameter Vatican Advanced Technology Telescope (VATT)'s M1 primary mirror was a proof-of-concept project by the team of J. Roger Angel at what was to become Steward Observatory's Mirror Laboratory at the University of Arizona: the first mirror to be made in a spinning furnace and the first mirror to be lap-stress polished at f/1.0 (Blanco 1990; West 1997). The mirror's and the telescope's success paved the way to the production of larger mirrors of similar optical speed and a new generation of telescopes (WIYN, MMT, Magellan, LBT, GMT).

While there have been numerous upgrades over the years, VATT's control system still runs on the original hardware from the early 1990s. Steward Observatory and the Vatican Observatory agreed on a concept of an Arizona Robotic Telescope Network (ARTN) in 2013 (MOU signed in 2016), intended to include the Bok 90-inch Telescope on Kitt Peak, the Kuiper 61-inch Telescope on Mt Bigelow, and the VATT.

We presented the completed and planned upgrades of the VATT at the 2017 AstroRob (Swindell 2019). Changes at Steward Observatory led both parties to recognize that an outside contractor was needed to complete the VATT's automation. The Vatican Observatory Foundation contracted ProjectSoft HK to carry out the work (Table 1).

2. DON

The VATT's new automated control system is named `Don` (Fig. 1) in honor of Donald M. Alstadt (1921-2007). Designed and built by ProjectSoft HK, it is modular, based on Beckhoff industrial PLCs (Programmable Logic Controllers; Fig. 2), absolute Renishaw encoders and ELMO drives. The mount control ought to achieve pointing precision of 4 to 8 arcsec rms.

Apart from the telescope's mount, `Don` also controls numerous support systems: the weather sta-

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TABLE 1

TIMELINE OF THE VATT AUTOMATION EFFORT

1993	dedication	
2010	remote-operation capable	
2012	received first automation quote from ProjectSoft	
2013	Steward's attempt at VATT's automation begins	Steward intends ARTN
2016		Steward-Vatican MOU
2022	ProjectSoft contract signed, financing secured	
2024	commissioning of Don	

Fig. 1. The Don figurine played an important role in our fundraising. Credit: Robert Macke, S.J.

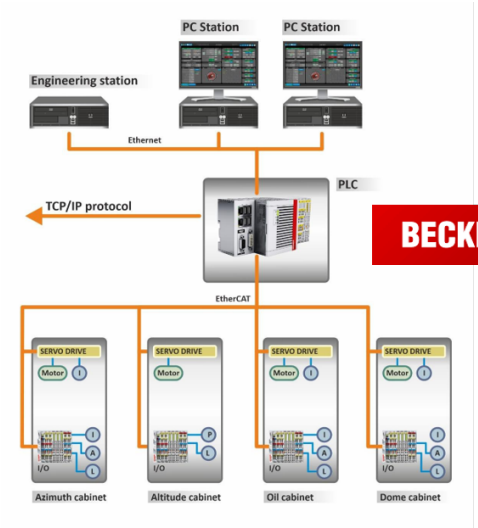

Fig. 2. Don's architecture is based on PLCs by Beckhoff. Credit: ProjectSoft.

tion, the dome and the dome slit shutters, the hydraulic oil system of the Azimuth's axis hydrostatic bearing, the primary mirror's cooling system, etc. The units communicate within Don by EtherCAT and externally by TCP/IP (Transmission Control Protocol/Internet Protocol).

Don's operational modes include a legacy mode with fully automated startup and shutdown, a local mode, a remote mode, and a scripted mode. In Don's first months, users will be using the VATT in the legacy mode, on site or remotely, while developing scripts for their own science cases.

While Don itself, i.e., the control system, runs on Beckhoff PLCs, Don's GUI (Graphical User Interface) is ProjectSoft's TomPack (Fig. 3) running exclusively on Windows. TomPack makes a minimal use of Windows libraries, which renders it stable across OS updates. Although TomPack would allow us to run the facility from a laptop, for added security, we shall use a remote sessions on a rack-

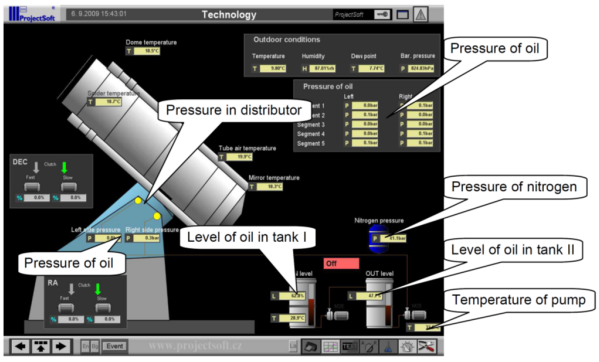

Fig. 3. Don's GUI is TomPack. The illustration show a sample page. Credit: ProjectSoft.

mounted Windows server residing on-site.

Don can be run from the command line using ProjectSoft's ASCOL (AStronomical COmmunication Language). It is based on the TCP/IP protocol, and the commands are ASCII strings. Don also contains an implementation of ASCOM/Alpaca.

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3. OTHER SYSTEMS

In addition to the installation of `Don`, other systems running at the VATT include:

- the secondary mirror (M2) Physik-Instrumente hexapod (see Sec. 4),
- the instrument interface (so-called Guide Box) with smart motors positioning a stage carrying a flip-in tertiary mirror and a U-shaped offset guiding mirror, the three filter wheels, and the three axes of the translation stage supporting the guider camera,
- guider camera and guider software (PHD2), and
- the scientific instruments, i.e.,
  - the VATT 4k CCD Imager,
  - the VATTspec spectrograph with its optomechanical systems and its CCD camera,
  - the GUFI-Marana CMOS camera, and

Currently, these systems have their own GUIs, user-end software, and can be operated using various TCP/IP-based protocols (e.g., the GUFI-Marana camera uses Andor's SOLIS proprietary software; the 4k CCD Imager and the VATTspec use the AzCam camera control software, and, in addition, the frames are displayed in DS9, exported to a data server, and they can be inspected and analyzed using IRAF). Some of these systems will be adjusted so that they can be operated within the same platform as `Don`.

4. AUTOMATED COLLIMATION

Service and/or engineering algorithms are being developed as ready-to-use scripts. In particular, the f/1 primary calls for an alignment with the secondary mirror at the micron and arcsec level (Fig. 4). While M2 can be positioned with a repeatability at the micron level thanks to a hexapod by PhysikInstrumente, the mutual position and orientation of the primary mirror and the focal plane instrument are fixed. This means that the alignment is not a simple geometry problem with a unique solution but rather an optimization problem. We are developing a collimation routine, intended to be deployed periodically. During ordinary operations, the alignment is maintained by monitoring the thermal expansion of the struts, the mechanical sag of the struts with elevation, as well as the changes in M1's position (6 axes monitored) and compensating for these perturbations by adjusting M2's position and orientation in a 1 Hz loop.

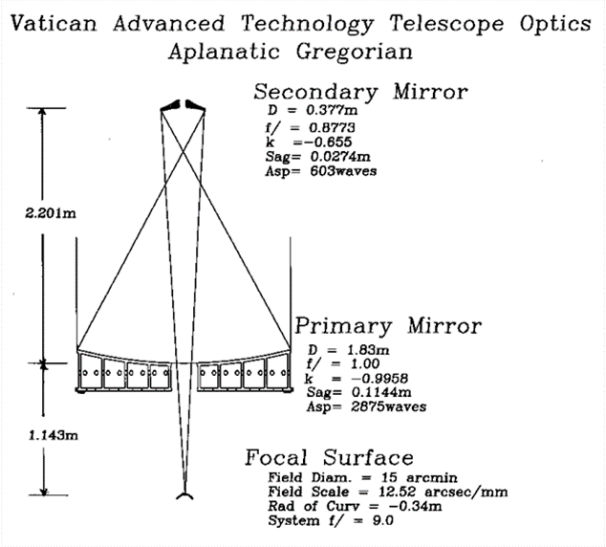

Fig. 4. VATT's optical layout.

5. CONCLUSION

By way of a conclusion, here is the status of the project as of September 2024, the last update of this manuscript. `Don` has passed a Factory Acceptance Test on January 17. It was installed and commissioned in April and May. The Final Acceptance Protocol was signed on June 3. We continue working on the automated collimation, on configuring the software environment for the astronomical instruments (mostly ASCOM/Alpaca), as well as working towards fully autonomous operations (which will require some experience with various weather conditions, tuning environmental triggers for automated shutdown).

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Fig. 5. Moonlit VATT in winter, view from the East. Credit: Paul Schulz.

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