Revista Mexicana de Astronomía y Astrofísica Serie de Conferencias (RMxAC), **59**, 27–30 (2025)

https://doi.org/10.22201/ia.14052059p.2025.59.06

VII Workshop on Robotic Autonomous Observatories (October 16-20, 2023)
Editors: Maria Gritsevich, Alberto J. Castro-Tirado, Petr Kubánek, Shashi B. Pandey, and David Hiriart - DOI: https://doi.org/10.22201/ia.14052059p.2025.59.06

AUTONOMOUS TELESCOPE AND SCIENTIFIC INFRASTRUCTURE DEVELOPMENTS AT TUG

Orhan Erece[1,2], Yucel Kilic[1], and Kadir Uluc[1]

RESUMEN

En este estudio, se proporciona una breve descripción de los telescopios ubicados en el Observatorio Nacional TÜBİTAK (TUG). Se describe el software NightAssistant (NA), desarrollado como una aplicación de escritorio fácil de usar para controlar las operaciones del telescopio T100 y del observatorio. Además, se presenta la plataforma web denominada Occultation Portal (OP), que se ejecuta en servidores del TUG, con el fin de anunciar, recopilar y analizar observaciones de ocultaciones estelares que deseen realizar diferentes proyectos desde una plataforma compartida.

ABSTRACT

In this study, a brief overview of the telescopes located at the TÜBİTAK National Observatory (TUG) is provided. The NightAssistant (*NA*) software, developed as a user-friendly desktop application for controlling both the T100 telescope and observatory operations, is described. Additionally, the web-based platform named Occultation Portal (*OP*), running on TUG servers, is introduced for the purpose of announcing, collecting, and analyzing stellar occultation observations desired to be conducted by different projects from a shared platform.

Key Words: occultations — telescopes

1. INTRODUCTION

The TÜBİTAK National Observatory (TUG) is located in Bakırlıtepe, Antalya, in the southern part of Türkiye, at an altitude of 2500 m (latitude 36°49' N, longitude 30°20' E). Established in 1997, the observatory hosts four main telescopes, as well as other smaller telescopes and scientific instruments that actively participate in scientific observations. The 1.5-meter RTT150 and the 1.0-meter T100 telescopes are fully automatic and operated remotely from the TUG Administration Building in Antalya, while the 0.6-meter T60 telescope and the 0.45-meter ROTSE III-d telescope are fully robotic. To date, numerous software development studies have been undertaken to automate these telescopes and enhance astronomical data collection, processing, and data services.

In this paper, we will present the NightAssistant software, the main telescope and observatory control software for the T100 telescope and the Occultation Portal[3](Kilic et al. 2022), a web-based platform for data collection and analysis of stellar occultations, both developed at TUG.

2. T100 TELESCOPE AND NIGHTASSISTANT

The T100 telescope was installed in 2009 at the south peak of the Bakırlıtepe mountain. The telescope has a large field of view and is dedicated to wide-field imaging and high-precision photometric and astrometric observations, mainly used in multi-band photometric observations of variable stars, galaxies, exoplanets, minor planets, stellar occultations, as well as follow-up observations (see Table 1). The main software used for the T100 telescope was the ACE Connector running on Windows OS, developed by the company named ACE[4]. However, the ACE Connector did not fully meet our demands due to its complex modular structure. Consequently, we explored alternative solutions to enhance the performance of the T100 telescope and developed a new graphical user interface (GUI) called *NightAssistant* (*NA*) using PyQt5, a cross-platform Python binding of the GUI toolkit Qt[5]. The *NA* software consists of a single window with different tabs (see Fig. 1). It is capable of not only controlling telescope parts but also of assigning specific coordinates of the project for the night, creating nightly directories, setting saving paths, offsetting the telescope, generating ephemerides of minor planets, displaying

[1]The Scientific and Technological Research Council of Türkiye (TÜBİTAK) National Observatory, Akdeniz University, 07058, Antalya, Türkiye (orhan.erece@tubitak.gov.tr).
[2]Türkiye National Observatories, Antalya Campus, Antalya, Türkiye.
[3]`https://occultation.tug.tubitak.gov.tr`

[4]`https://www.astronomical.com`
[5]Qt, a widely-used GUI toolkit, provides a framework for creating cross-platform graphical user interfaces `https://www.qt.io/`

VII Workshop on Robotic Autonomous Observatories (October 16-20, 2023)
Editors: Maria Gritsevich, Alberto J. Castro-Tirado, Petr Kubánek, Shashi B. Pandey, and David Hiriart - DOI: https://doi.org/10.22201/ia.14052059p.2025.59.06

TABLE 1

T100 TECHNICAL SPECIFICATIONS

Optical design	Ritchey-Chrétien
Main Mirror diameter	1000 mm
Focal Length	10000 mm
Focal Ratio	f/10
Resolving Capacity	0.11”
Plate Scale	20”/mm
Field of view	21’x21’
CCD Camera	SI 1100 4Kx4K

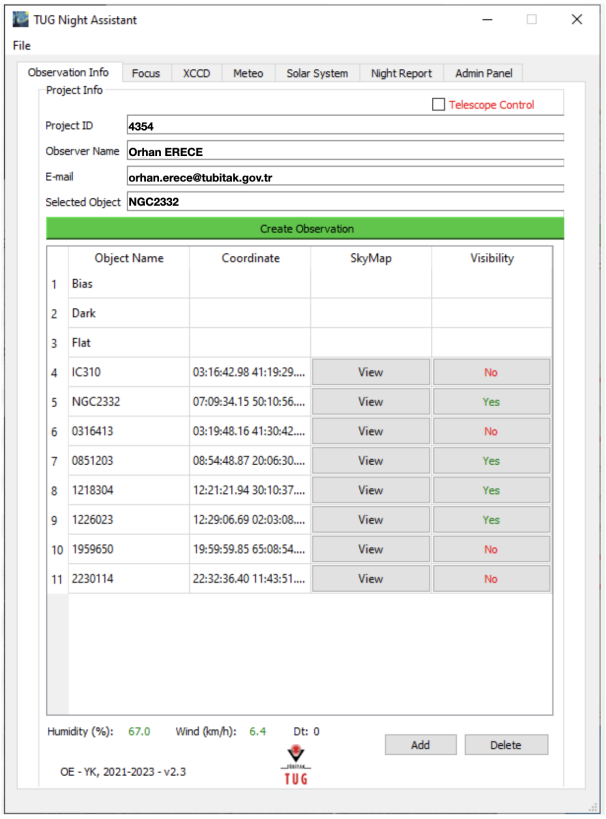

Fig. 1. The *NA* software *Observation Info* tab

instant meteorological values and all-sky camera images, and automatically creating and sending nightly reports to the database.

The *NA* employs the ACE Connector as an interface to manage and control various telescope components. The other information is obtained either through functions embedded within the software or from real-time data retrieved from the web. It consists of seven tabs at the top of the GUI, as seen in Fig. 1, designed for different purposes. On the *Observation Info* tab, observers can slew the telescope by clicking on one of the listed coordinates after activating the telescope control checkbox located in the top right of the tab. Additionally, the dynamically updated visibility of the coordinates is indicated as ”Yes” in green or ”No” in red, along with the visibility chart and the sky map of the coordinates.

Another notable functionality of the *NA* is its automated focusing capability. Within the *Focus* tab, a distinct focusing model is presented for each filter, determined on the basis of the telescope’s altitude. The *NA* promptly retrieves the current altitude of the telescope. Consequently, when the auto-focus checkbox, located on the bottom left, is enabled, the *NA* optimizes the focus to its ideal setting during the observation sessions. This streamlines the process for observers and contributes to improved telescope performance. The *NA* offers also the option to specify an offset value for observers interested in conducting defocused observations. Additionally, real-time images from the all-sky camera at the observatory are visible within this tab (see Fig. 2).

On the *XCCD* tab, users can provide an offset value for minor adjustments. Once coordinates are selected in the *Observation Info* tab, they are displayed on the *XCCD* tab. The sole task remaining is to input the physical coordinates corresponding to specific points on the image, indicating the starting and ending corner positions. On the *Meteo* tab, real-time wind and humidity values are displayed. These values are presented in green if they fall within predefined limits; otherwise, they appear in red to indicate conditions outside the acceptable range.

On the *Solar System* tab, ephemerides can be generated for all small objects, found in the *JPL/Horizon* database[6]. These ephemerides include instantaneous equatorial coordinates and apparent magnitudes, along with related data obtained from this database. Such information encompasses the object’s sky motion and direction, which can be depicted in the sky image.

On the *NightReport* tab, the nightly report is automatically generated and sent to the database. It includes information such as observers, technicians, night assistants, weather conditions, comment sections, and the number of total hours of observations. In the *Admin Panel* tab, tasks such as specifying the file path for the focus model, selecting the weather station for weather information, defining weather condition limits, and determining the path for storing scientific data can be carried out. We showcase all the tabs of the *NA* on *GitHub*[7].

[6] https://ssd.jpl.nasa.gov/horizons/
[7] https://github.com/orhanerece/nightassistant-

VII Workshop on Robotic Autonomous Observatories (October 16-20, 2023)
Editors: Maria Gritsevich, Alberto J. Castro-Tirado, Petr Kubánek, Shashi B. Pandey, and David Hiriart - DOI: https://doi.org/10.22201/ia.14052059p.2025.59.06

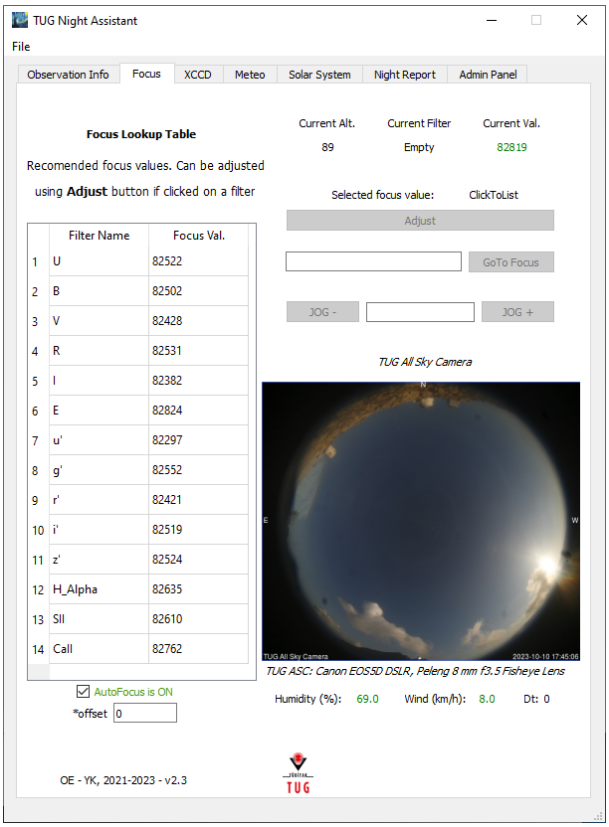

Fig. 2. The *NA* software *Focus* tab

3. OCCULTATION PORTAL

A stellar occultation is a celestial event that occurs when a Solar System object obscures a source from the perspective of an observer (Kilic et al. 2022). When this event is recorded simultaneously from more than two locations across the occultation path, it becomes possible to obtain detailed information about the foreground object (Braga-Ribas et al. 2013; Souami et al. 2020). However, coordinating different observers and collecting data from them posed challenges. To address these issues, the *Occultation Portal*[8] (*OP*) was developed at TUG (Kilic et al. 2022), as shown in Fig. 3. Currently, the *OP* manages campaigns for the *ERC Lucky Star*[9], *Across*[10] and *Gaiamoons*[11] projects and efficiently gather and analyze data from many contributing observers distributed along the occultation path. Through its coordination of occultation observations for various projects, the *OP* encompasses occultation events involving a range of objects within the Solar System, from NEAs (Near-Earth

[8]https://occultation.tug.tubitak.gov.tr/
[9]https://lesia.obspm.fr/lucky-star/
[10]https://lagrange.oca.eu/fr/home-across
[11]https://www.oca.eu/fr/gaiamoons

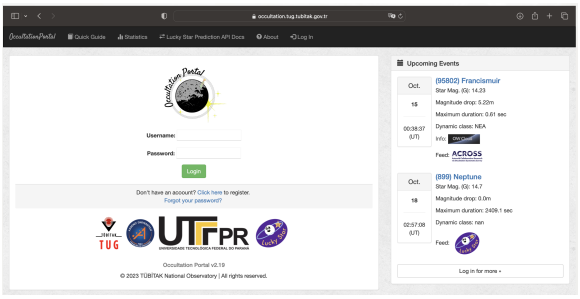

Fig. 3. The login screen of the *OP* website

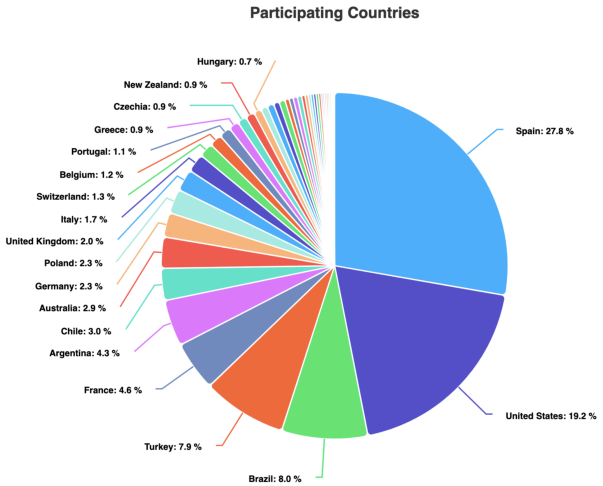

Fig. 4. The percentage of participating countries on the *OP* platform

Objects) to TNOs (TransNeptunian Objects). As a result, the *OP* contributes significantly to numerous scientific endeavours aimed at exploring the physical and dynamic characteristics of objects throughout the Solar System.

To date, there are 953 observation sites from 46 different countries registered in the *OP* (see Fig. 4). Considering the brightness of the occulted star in the observation campaigns announced to date, the number of stars brighter than the 14th magnitude is %55.5[12]. This statistic is quite noteworthy, as it demonstrates that telescopes participating in the campaign can be operated with amateur-level equipment. From this perspective, the contribution of the *OP* to citizen science is also highly significant.

The high-precision stellar occultation predictions enabled by the European Space Agency's (ESA) star-mapping satellite *Gaia* and its high astrometric accuracy (Gaia Collaboration 2021) contribute significantly to the increase in successful occultation event observations (Braga-Ribas et al. 2019; Fer-

[12]https://occultation.tug.tubitak.gov.tr/statistics/

VII Workshop on Robotic Autonomous Observatories (October 16-20, 2023)
Editors: Maria Gritsevich, Alberto J. Castro-Tirado, Petr Kubánek, Shashi B. Pandey, and David Hiriart - DOI: https://doi.org/10.22201/ia.14052059p.2025.59.06

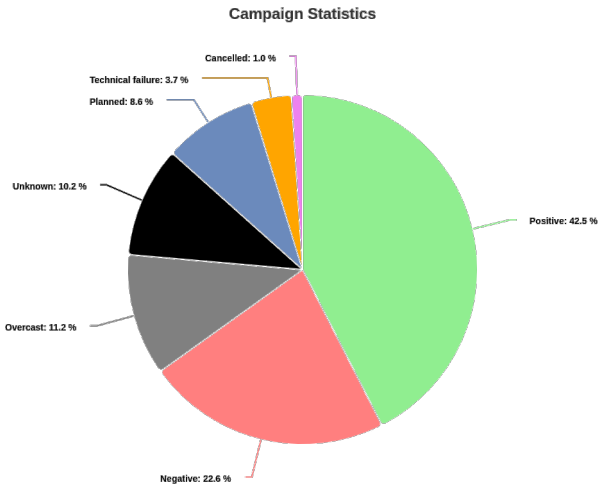

Fig. 5. The percentage of campaigns conducted through the *OP* platform

reira et al. 2022). As expected, the positive observation rates in the OP are higher, and they continue to rise during overall organized campaigns, as shown in Fig. 5. So far, after reviewing all the campaigns organized within the *OP*, it has been discovered that 42.5% of occultation events were observed positively, 22.6% were negative, and 10.2% were unknown. The total percentage of observers who planned to observe, but experienced technical difficulties, bad weather, or cancelled their observations has been approximately 25%.

4. CONCLUSION

In conclusion, the TÜBİTAK National Observatory (TUG), located in Bakrltepe, Antalya, has been a leader in advancing astronomical observations since its creation in 1997 in Türkiye. Equipped with a range of telescopes and scientific instruments, including the fully automated T100 and RTT150 telescopes along with the robotic T60 and ROTSE telescopes. After a significant amount of work in software development, the NightAssistant (*NA*) software has streamlined the telescope operations and data collection processes, increasing efficiency and accuracy of astronomical studies.

Moreover, the development of the Occultation Portal (*OP*) demonstrates TUG's commitment in promoting collaborative research efforts. By providing a centralized platform for announcing, collecting, and analyzing stellar occultation observations, the *OP* has made coordinated observations straightforward, thus encouraging international cooperation. Observers from 46 countries have participated in this global engagement, highlighting the significance of TUG's contributions to professional research and citizen science initiatives.

TUG's dedication in advancing astronomical research and promoting international collaboration is evident from the development of the *NA* software and *OP* platform, among others.

REFERENCES

Braga-Ribas, F., et al. 2013, ApJ, 773, 26
Braga-Ribas, F., et al. 2019, JPhCS, 1365, 012024
Ferreira, J. F., et al. 2022, A&A, 658, A73
Gaia Collaboration, Brown, A. G. A., et al. 2021, A&A, 649, A1
Kilic, Y., et al. 2022, MNRAS, 515, 1346
Souami, D., et al. 2020, A&A, 643, A125