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Improving Entoto Observatory Optical Telescope for Space Surveillance and Tracking Application

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Abstract- Currently, the Ethiopian Space Science and Technology Institute is endeavoring to enable the country to fully exploit the multidimensional benefits of space science and technology and address the challenges of the country using space technology research and development. One of the project plans of the institute is to deploy the space surveillance and tracking system using the existing infrastructure. To enhance Ethiopia's space situational awareness satellite research development and operation directorate aimed to improve EO telescope for space surveillance and tracking application in order to anticipate the influence of other space objects and take action to ensure continued and unimpeded operation of spacecraft. In order to improve the performance of the EO optical telescope, a new command and architecture of the system are designed and new components installed to extend the application of the telescope to space surveillance and tracking. Moreover, appropriate components (i.e. hardware and software) were integrated and installed on EO optical telescope to ensure that the telescopes are used for space surveillance and tracking application.

Index Terms: Optical telescope, space surveillance, space operation, satellite operation, space situational awareness, space objects, space debris

1 INTRODUCTION

Following the launch of Sputnik 1 in 1957, space has increasingly become a key enabler for nearly all military, governmental, commercial, and individual operation however, it is becoming an ever more congested and contested environment by active satellites, space debris and other discarded space object [1]. Hence, maintaining an awareness of the position and trajectory of these objects is very important to protect the earth and its inhabitants from catastrophic damage. The aim of this study is to improve EO telescope for space surveillance and tracking application in order to anticipate the influence of other space objects and take action to ensure continued and unimpeded operation of spacecraft. This include maneuvering spacecraft to reduce the probability of a collision with another object in orbit, tracking and cataloging of space debris and other discarded space objects. Space surveillance system is used to survey and track all objects above certain size and maintaining a catalogue with updated orbital and physical characteristics for these objects by scanning of deep space [2]. It also provides basic information that characterize space debris population, model the populations, determine the trajectory of a re-entering object and perform associated risk assessments on ground. In order to improve the performance of EO telescope, the command and architecture of ESSTI space surveillance and tracking system will be re-designed in order ensure that the telescope capable of tracking space objects. Furthermore, appropriate components (i.e. hardware and software) where integrated and installed on EO optical telescope to ensure that the telescopes are used for space surveillance and tracking application. In addition, certain activities should have to be carried out like dome robotizing; automation of weather station, dome and telescope rotation synchronization, and GPS data must also be available in the control room for time stamping of the images.

This research project is one part of an overall effort to improve the performance EO telescope for space surveillance and tracking application to strengthen Ethiopia's capacity in space surveillance and situational awareness. Space situational awareness is an important activity for national defense and for safe operation of spacecraft for economic purposes [3]. Many equate space situational awareness to satellite observing, but the topic is much broader, including all activities necessary to know what systems and debris are on orbit, exactly where they are at any specified time, where they are going, what they are doing, what their statuses of health are, and whether or not there will be potential conjunctions. Many nations, to varying degrees, rely on space systems for communications, intelligence, and indications and warnings of attacks. Therefore, the project is very important to safeguard Ethiopia's space assets from unknown collisions and other enemies and plays critical role in establishing future Ethiopia's space security.

2 STATEMENT OF THE PROBLEM

Space technology is critical to key areas of society, and it can be anticipated that the dependency on space-based assets will grow tremendously. These dependencies raise concerns since the degradation of space infrastructure could considerably impair the economy, safety and security of government, industry and general public [4]. The space around the Earth is filled with man-made objects, which orbit the planet at altitudes ranging from hundreds to tens of thousands of kilometers. Many of these objects' communication, navigation, military, or scientific satellites—are useful. Other objects are not so useful, and their increased number has become a threat to the safety of space operations, space travel, or even for the planet's surface, as many of these objects will, one day, fall back to Earth. These objects are also collectively known as Space Debris (SD). Keeping an eye on all the objects in Earth's orbit, useful and not useful, operational or not, is known as Space Surveillance, an activity that includes detection, tracking and propagation of orbital parameters of the space objects, followed by cataloguing and analysis. Space debris become a prominent concern for both military and commercial systems, largely due to increasing number of space assets [5]. For instance, antisatellite (ASAT) testing by India in 27th March of 2019 and china in 2007 and the 2009 collision of a non- operational Russian satellite with an operational Iridium satellite and future small satellite mega constellations planned to be launched in the near future raise concerns [5]. Researchers are currently tracking an estimated 22,000 artificial objects that are orbiting Earth, from small bits of debris to large satellites, which is expected to triple in the next 20 years, and is the major threat to space asset. As the matter of fact, a centimeter-sized piece of debris can cause considerable damage to crucial weather, communication, navigation satellites and other space technologies in space. With the increased information that it provides, officials will be able to better predict the path of debris and warn satellite operators of potential collisions. Hence, there is a need to improve the performance of EO optical telescope for the purpose of space surveillance and tracking application and other deep space exploration. EO optical telescope installed early in 2014 with a multipurpose facility to support teaching, research training, and science research in astronomy and space science. Currently, the telescope is not functional because of maintenance problem thus; the purpose of this study is to maintain and improve its performance and extend its application for space surveillance and tracking and to address the issue of space debris and space situational awareness.

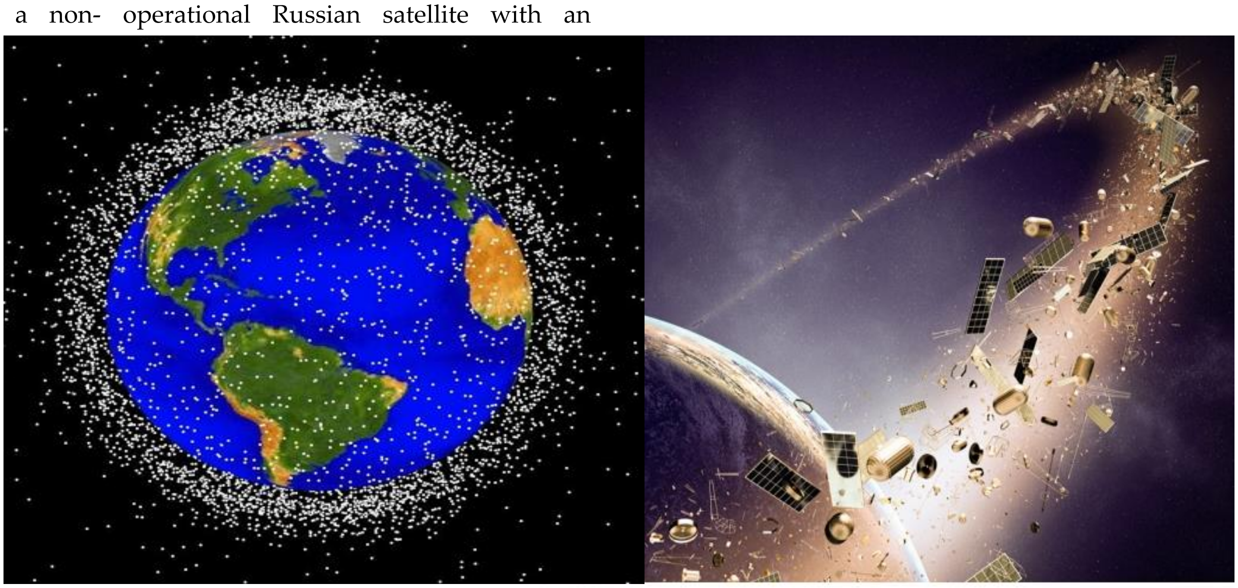

Figure 1: The space object population in the geosynchronous (GEO) region and its impact on spacecraft

2.1 LITERATURE REVIEW

Space Surveillance denotes the task of systematically surveying and tracking all objects above a certain size and maintaining a catalogue with updated orbital and physical characteristics for these objects. A previous study has reported that Space surveillance telescope is a 3.5m wide field of view system developed for DARPA (Defense Advanced Research Program Agency) by MIT Lincoln Laboratory to advance space situational awareness [6]. In addition to advancing SSA of the region MITLL believes that space surveillance telescope has the capability of detecting space objects on size scales as small as 5-10m and there is a growing concern for near earth asteroid identification and tracking. However, some research has been carried on space surveillance telescope; no studies have been found on improving 1m diameter optical telescope for space surveillance and tracking application. Hence, there is a need to improve EO optical telescope for detecting small objects or even faint objects in space for collision avoidance and warn re-entry of space objects to Earth atmosphere.

Space surveillance system is a combination of optical and radar sensors used to detect, track, identify and catalog all manmade objects orbiting the earth [7]. Space object identification analyzes signature data to determine satellite characteristics such as size, shape, motion, and orientation. The information is used to determine the operational status of various payloads and may forecast maneuvers or orbits. The process of using space object identification data, in conjunction with other intelligence resources, to determine the nature of unidentified payloads called mission payload assessment.

The space surveillance system is state-of-the-art optical instrument. The telescope images a patch of sky three larger than that covered by Ground-based Electro-Optical Deep Space Surveillance (GEODSS) and is sensitive to objects more than two magnitudes less [8]. The space surveillance telescope is able to cover the sky ten times faster than GEODSS and with its greater sensitivity, can detect roughly 100 times more objects during a given night of observation [9].

3 AIM AND OBJECTIVES

3.1 Aim

The aim of this project is to improve EO telescope for space surveillance and tracking application and enhance its detection capability to fulfill the better current and future Ethiopia’s space situational awareness requirements. The project also aimed to provide the facilities and supporting infrastructure necessary to support the operations of space surveillance and tracking system.

3.2 Objective

The project will develop an ESSTI space surveillance capability, enhance the global surveillance capacity, and provide an increased ability to track space debris. Hence, specific objective of the project is:

- ✓ To re-innovate the EO optical telescope in order to advance or expand space situational awareness initiatives and make sure that the modified telescope can able to detect space debris, catalogues objects, and determines and predicts their orbits.
- ✓ To increase Ethiopia’s capability to predict and avoid collisions with space debris, including the ability for real-time surveillance and collisions analysis on a limited basis.
- ✓ To secure timely access to orbital data essential to Ethiopia’s sovereignty and national security, which maintains a global catalog of, orbit elements for resident space objects (RSOs) by using space surveillance and tracking system
- ✓ To enhance Ethiopia’s capacity in space situational awareness that is composed of space surveillance and tracking, space weather and near-earth object segments.

4 RESEARCH MATERIALS AND METHODS

This study focuses primarily on improvement of EO optical telescope system for space surveillance and tracking application of GEO objects. From orbital parameter catalogue completeness point of view, it is shown that ground radar sensors must do LEO surveillance. However, optical sensor is not suitable for objects in very low orbits (the object must be illuminated by sun, while the telescope must be in the dark). Hence, the improving performance of EO optical telescope stresses on the mechanical, electrical and electronics, operational software and other networking facilities as necessary for GEO object surveillance and tracking application.

While many nations are gradually become aware of the risks to the space systems, which are very essential for modern societies to function, Ethiopia needs to acquire an efficient tracking service to protect its strategic space assets. The significance of this project is to provide an important opportunity to advance the understanding of space situational awareness, which is the ability to view, understand and predict the physical location of natural and manmade objects in orbit around the Earth, with the objective of avoiding collisions. The findings should make an important contribution to the field of space situational awareness and the data generated by space surveillance and tracking system can be used to predict hazards to operational spacecraft, such as a potential collision with a space debris, or to infrastructure on ground, such as from a re-entering object. It also plays significant role in protecting Ethiopia's economy, way of life and vital interests in space activities. Therefore, this study makes a major contribution to research on space surveillance by demonstrating EO optical telescope to provide satellite operators with a way to share controlled, reliable and efficient data for increased safety of satellite operations.

Space surveillance system monitor and understand the state of the space environment, including the ability to track, understand, and predict the

4.3 Approaches

The methodological approach taken in this study is utilized, improving the performance of EO optical telescope to establish ESSTI space surveillance and tracking system. This work takes the form of a case study of the hardware and software of EO optical telescope and space surveillance system. In order to improve the performance of EO optical telescope for space surveillance and tracking application, a new command and architecture of the system is designed and new components were installed as necessitous. Moreover, the technical specification of EO optical telescope and space surveillance telescope system were identified as to extend the application of the telescope to space surveillance and tracking. The step-wise approach used to carry out this activity are as the following:

- Identifying the technical specification of EO optical telescope and space surveillance system.
- Describe working principle and application of space surveillance system.
- Design command and architectural of ESSTI space surveillance and tracking system.
- Integrating and installing the appropriate components with EO optical telescope to ensure that the telescopes is used for space surveillance and tracking application.

4.3 Technical features of Space Surveillance Telescope

location of human generated and natural objects in orbit around the earth. Current deep space telescopes do not provide a comprehensive picture

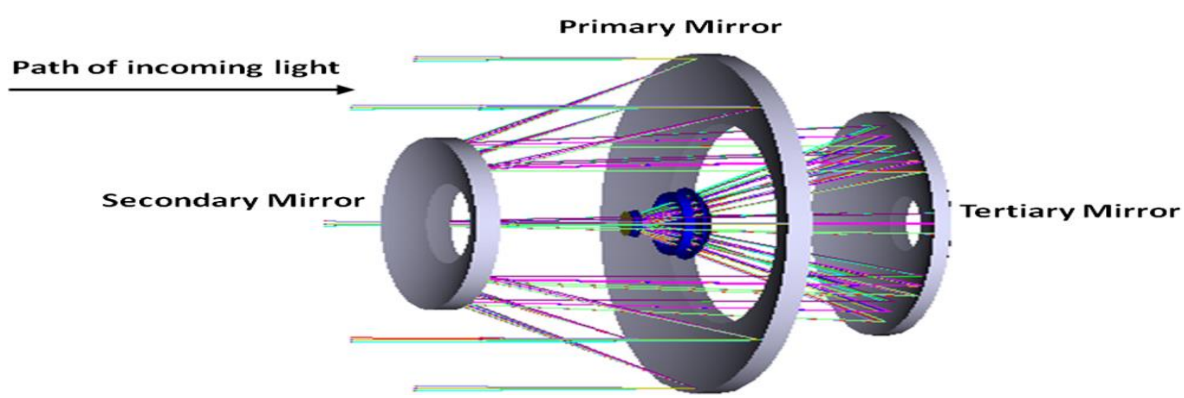

Figure 2: The optical configuration of Space Surveillance Telescope (SST).

of all objects in orbit around the Earth and existing search telescopes have relatively narrow fields of view and cannot reliably detect and track faint objects, including small objects in geosynchronous orbits (roughly 22,000 miles high). Space surveillance and tracking system offers improvements in determining the orbits of newly discovered objects and provides rapid observations of events that may only occur over a relatively short period, like a supernova. The telescope system has three-mirror Mersenne-Schmidt optical design with a 3.5-meter primary mirror as shown in Figure 2 which is designed to rapidly scan space objects, particularly along the geosynchronous belt, approximately 36,000 km above earth [8]. The secondary mirror, seen on the left, is 1.8-meters in diameter and the tertiary mirror is approximately 2.3-meters in diameter. The designs three-mirror of telescope are known for high image quality and wide fields of view, but normally project their final images onto curved focal surfaces and the image is formed between the secondary and tertiary mirrors, where a field stop is placed here to eliminate direct stray light outside the field of view. Space surveillance telescope has an unusually short focal ratio of F/1.0 and employs a camera composed of curved charge-coupled devices (CCD) to match the telescope's inherent field curvature. The camera mosaic of 12 charge-coupled devices (CCDs) employs curved substrates built to the shape of the telescope's focal surface tiled across a six square degree field-of-view (FOV). Most telescopes using charge-coupled device (CCD) imaging detectors have flat focal planes, as CCDs are normally flat. A unique feature of the space surveillance telescope is the use of a curved focal surface complete with curved CCDs. This design feature was to allow for the elimination of the large, heavy and expensive refractive corrector lenses found in other telescope designs. In addition, space surveillance telescope was designed to be agile, sensitive and cover a wide field of view and is a single telescope with the dual abilities. First, the telescope is sensitive enough to allow for detection, also, of small, dimly lit objects (low reflectivity). Second, it is capable of quickly searching the visible sky. The innovative design of space surveillance telescope allows for a short focal length, wide field of view, and a compact optical train. It encompasses improvements in detection sensitivity, has short focal length, wide field of view, and improvements in step-and-settle abilities. Table 1 shows the space surveillance system parameters, including the optical system and the camera.

Table 1: Space surveillance system parameters, including the optical system and the camera.

Telescope	
Diameter (actual)	3.50 m
Diameter (effective)	2.90 m
Effective focal length	3.49 m
Nominal field-of-view	3×2 deg
Camera	
Sensors (thinned, backside illuminated)	2 K×4 K CCD
Pixel size	15 μm 0.89 arcsec
Mosaic	6×2 chips
Effective size	12288×8192 pixels
Readout time	0.65 to 1.30 s
Exposure time	0.025 to 10 s
Filter	Open (0.4 to 1.0 μm)
Image rotator	None

4.4 System requirements and its applications

Space based systems have become indispensable for a wide spectrum of applications critical to key areas of society, and it can be anticipated that the dependency on space-based assets will grow rapidly in the short term [4]. Space surveillance and tracking system is intended to strengthen the global surveillance ability to identify, track, and characterize space assets and debris. This will contribute to the global public good by providing the information required by both military and civilian satellite operators to respond to potential threats. This includes the ability to provide satellite operators around the world with warnings of possible collisions between space objects, thereby reducing the danger posed by increasing congestion and space debris to space capabilities upon which many civilian and military functions rely.

Moreover, space surveillance and tracking system provides the operators of space-based capabilities the ability to anticipate the influence of other space objects and take action to ensure continued and unimpeded operation of spacecrafts. With the very long lead times and huge costs often associated with placing satellites into orbit, the capability to predict and avoid potential collisions is extremely valuable. The applications of space surveillance and tracking system to be realized are numerous and have to be prioritized [10] as:

- ✓ Orbital parameter catalogue maintenance: space surveillance and detection of objects, cold start of a catalogue with defined coverage requirements, maintenance of a catalogue with given accuracy constraints. This function may be split into several sub-functions such as; orbital parameter estimation, maneuvers identification, break-ups identification and new launches detection.
- ✓ Determination of collision risks: conjunction analysis, refinement of the analysis and screening of user provided ephemerides
- ✓ Detection and characterization of In-orbit Fragmentations: screening of newly detected objects for those correlating from a common originator, identification of the originator objects and characterizing the event, issuing warning bulletins.
- ✓ Prediction of atmospheric re-entries: identification of risk objects that are close to a natural uncontrolled re-entry, prediction of re-entry location and epoch (with uncertainty information), refinement of the analysis in order to achieve the required prediction accuracy.
- ✓ Object and maneuver/Mission characterization: monitoring of objects to identify active spacecraft, data screening for orbit changes, and characterization of orbit changes.
- ✓ Special mission support: follow-up of the object of concerns, highly accurate orbit determination, observation of object release, observation of orbit changes.
- ✓ Characterization of sub-catalogue debris: use of a limited amount of sensor time to characterize the sub-catalogue debris environment, databases with derived statistical information.

4.5 ESSTI space surveillance and tracking system architecture

Space surveillance is gaining increased importance as the operational safety of spacecraft is depending on it [10]. The proposed command and architecture of the ESSTI space surveillance and tracking system will be based, on the federation and existing and available national assets, together with newly developed and procured elements. In fact, there are driving constraints have also to be taken into consideration for system design. They are: Non-homogeneous distribution of objects is space, size of objects and system autonomy. According to (Therese, T. et al. 2014) demands of ESA space surveillance system minimum size of objects requirements are 10 cm in LEO and 1m for GEO orbits while the future ESSTI space surveillance system minimum requirements is 1m for GEO orbits because the optical sensor is not suitable for objects in very low orbits (the object must be illuminated by the sun). The system must be autonomous, i.e. the system shall not depend on inputs from external catalogues. In general, the final goal of a proposed ESSTI space surveillance and tracking system is to give Ethiopia for guarantying the operational safety of its space assets and enhance its capability in space situational awareness. In order to propose the design characteristics of such a system, system requirements are derived and they address the The proposed ESSTI GEO space surveillance and tracking system will consist of major segments:

1. space surveillance and tracking user interface
2. Data management system
3. Telescope
4. Command and control unit

following points: system functions to be implemented and system constraints to be taken into consideration

These segments are largely independent in terms of services, availability needs and associated user groups. However, in terms of development, the space surveillance and tracking and Near-Erath Objects segments can potentially share (at least in some parts) the same design for the optical sensors, sensor network and data processing software. The command/architecture of ESSTI space surveillance and tracking system is shown as Figure 3.

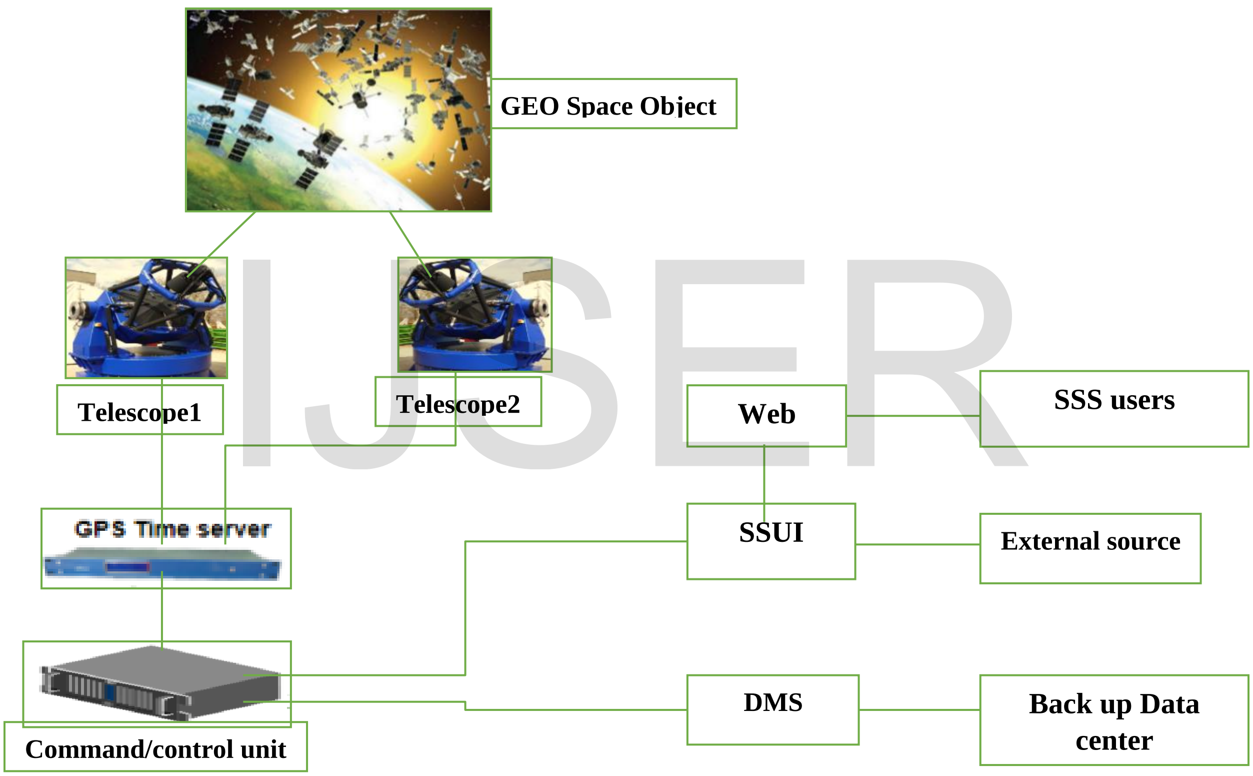

Figure 3: command/architecture of ESSTI space surveillance and tracking

4.6 EO optical telescope

4.6.1 Mechanical Components of the Telescope

The 1.0m telescope T1000-5950 is an Alt-Az mounted high-precision instrument equipped with the latest technology to ensure trouble free operation for a long time with the optical system is a Ritchey-Chretien-Nasmyth design. The use of state-of-the art drive technology with latest developments in telescope control software allows the operation of this telescope in a safe and efficient way [11]. The configuration of the EO optical telescope system is prime focus, secondary or Nasmyth configuration with rotating M3 mirror (2 focal ports) and field derotators available for each port with wide field multi optical tube arrays. The major mechanical components of EO optical telescope are:

1. Nasmyth flanges: There is one Nasmyth flange on each of the two Nasmyth optical

ports. One of these flanges is equipped with an ASTELCO field derogator. At the other one, the pickup Mirror-Unit is mounted.

2. Field derotators with instrument flange: At one of the Nasmyth flanges, a field derotator is attached. The field derotator accepts customer-supplied instrumentation.
3. Shack-Hartmann / Pickup-Mirror-Unit: To measure the current accuracy of M1, a shack-Hartmann sensor is mounted at one Nasmyth-port (in the Pickup- Mirror unit). It is controlled by software only. No manual movement is foreseen.
4. Active Optic Actuators: active optics actuators support the M1 mirror. The actuators are motorized and controlled by software only. No manual movement is foreseen.
5. M2 Focusing Unit: The fine focusing of the telescope is accomplished by axially moving the secondary mirror M2 along the optical axis. This is done by a high-precision linear drive, controlled by software only. The focusing accuracy is 5μm over the whole range.
6. M3 Rotation: the use both of the Nasmyth ports of the telescope, the tertiary mirror M3 is mounted on a rotatable unit that switches between the two Nasmyth ports. This is done motorized and controlled by software only. No manual movement is foreseen.
7. Mirror Doors: The M1 and M3 mirrors are protected from dust by a motorized mirror door unit. These mirror doors are controlled by software only. In case of power failure, the internal UPS of the control cabinet closes the mirror door automatically.
8. Machined reference surfaces: At each side of the top and bottom side of the center, frame two machine reference surfaces are located. At each of these surfaces, a customer instrument can be attached. The maximum weight of each side is about 50Kg.

4.6.2 Software, drivers or API

A modular AsTELOS (version 1.5.2) software is a control solution that can provide control units for the telescope system, dome and observatory system (control cabinets, switch panels, keypads and emergency switch systems). The inter network communication of EO optical telescope is as shown if Figure 3:

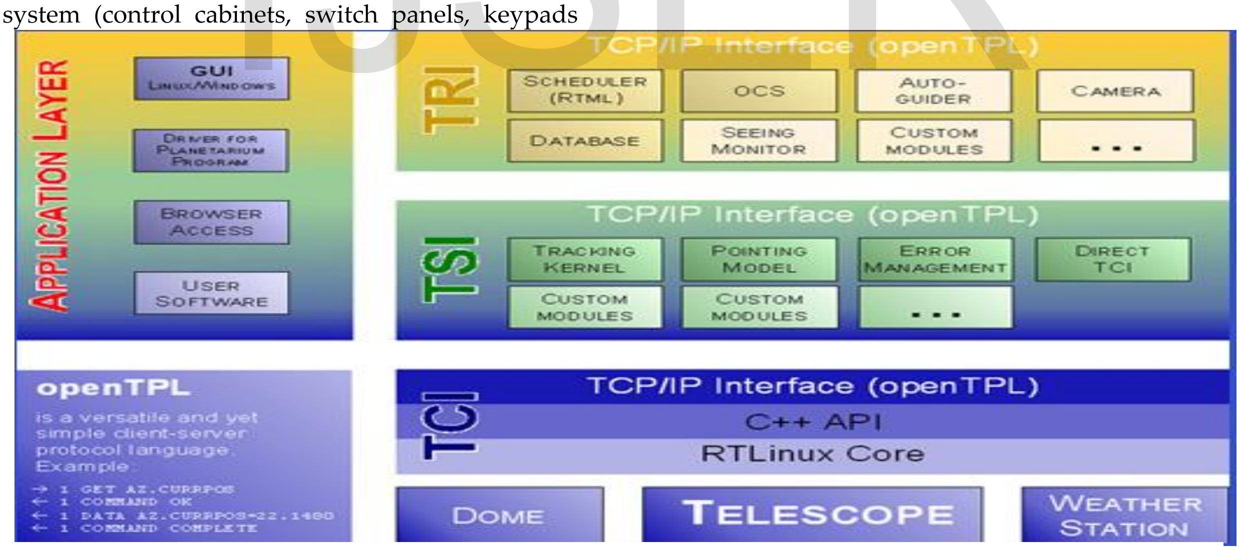

Figure 4: Inter network communication EO optical telescope

4.6.3 General working conditions and overview of EO optical telescope

The telescope T1000-5950 (ESSS) and its control cabinet are designed for clean and non-aggressive environments. Telescope: Humidity between 0% and 95% (non-condensing), temperature from -15°C to +35°C, altitude up to ~5.000m (~17.000 ft.) above sea level. Control cabinet: Humidity between 0% and 70% (non-condensing), temperature from +10°C to +35°C. In case the temperature in the inner of the control cabinet gets below approximately +5°C and the control cabinet is connected to a working power supply, the internal heating system will go ON (even if the main switch of the cabinet is turned OFF). In case the power supply to the cabinet is or has been OFF and the temperature is below 5°C, the power must be restored again first and a minimum time of 1 hour must be kept before the cabinet shall be switched ON. This is necessary to allow enough time for the internal heating system to bring the inner of the cabinet up to operating temperature. It is recommended to keep the control cabinet ON at all times and not to switch it OFF without special need to do so. The control cabinet is designed for permanent operation, and keeping it ON will ensure that the temperature never goes below the required temperature of +5°C in the inner of the cabinet. Table 2 gives a list of edited features of EO optical telescope at a glance:

Table 2: Overview of edited features of EO optical telescope

Feature	**Comment**
Speed	≥ 20°/sec, acceleration ≥ 2°/sec2
Pointing	By pointing model for precise pointing and tracking
Pointing accuracy	≤ 10 arcsec RMS with pointing model
Tracking accuracy	< ±1.0 arcsec / 30min with pointing model < ±0.3 arcsec / 90sec with pointing model
Load and torque (instrument load) on Nasmyth flange	Load Capacity: approx. 250kg Torque: approx. 250Nm
Safety	Pressure brakes that stop any movement within less than 0,5 sec if an error occurs
Emergency stop	Emergency switches distributed around the telescope and control cabinet
Network interface	Fully OpenTSI (V1) compliant TPL2 network interface

4.6.4 EO telescope Optical layout and general description

The EO telescopes, equipped with four CCDs and echelle spectrograph, will be used for observations with a free aperture of 1000mm, a total number of three mirrors and a 2-lens-corrector on a system

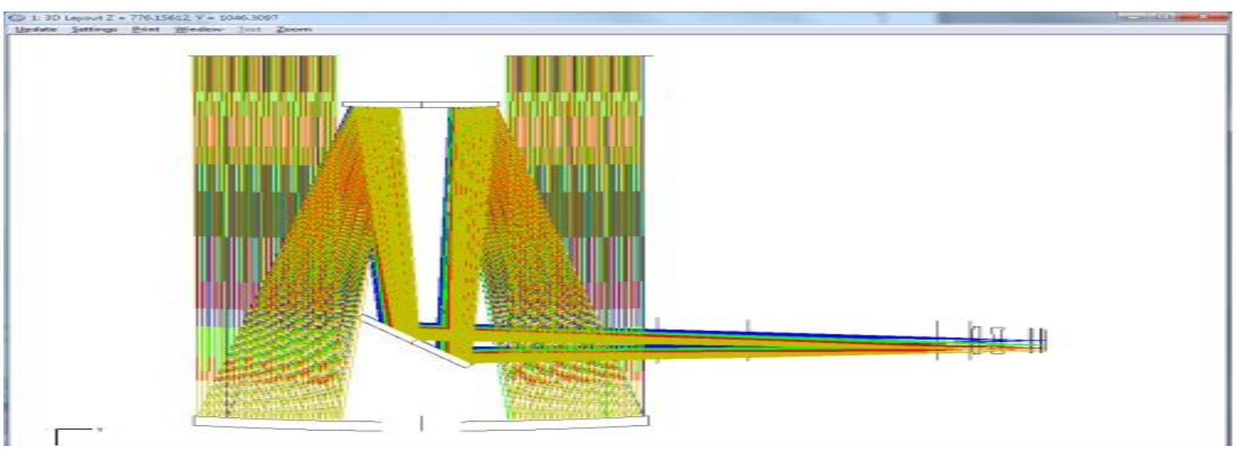

Figure 5: Optical layout of the EO telescope

of the different types of variable stars, X-ray binaries, double stars, star clusters, exo-planets etc. The optical system is a Ritchey-Chretien Design focal ratio of F/8. The thickness of M1 is about 50mm at the edge and its total weight is approximately 100Kg. It is made of SCHOTT

Zerodur zero expansion ceramics. The thickness of M2 is 55mm in the center and its weight is approximately 13Kg. It also made of SCHOTT Zerodur zero expansion ceramics. The thickness of M3 is 60mm and its weight is approximately 9Kg. it is made of LZOS ASTRO SITALL zero expansion glass ceramics.

4.6.5 Camera drivers and setting parameters

To gain high quality images and get best results an exact and stable fixation of the camera is necessary. The 1-m telescopes, equipped with four CCDs: SBIG STL 11000M(4000 × 2672,9μm), SBIG STL 1001E(1024×1024,24μm), ANDOR iXon3-888 (1024×1024,13μm) and FLI PL 4301E-1 (2048 × 2048,24μm) as well as with Fibre Linked Echelle Astronomical Spectrograph (FLECHAS) with spectral range from 389 to 762nm (on CCD detectors
of 2048 × 2048 pixels, 15μm pixel size) and Spectral peak resolution R($\lambda/\Delta\lambda$)~ 37000, are ideal tools for studying variable stars, binary stars, X-ray binaries, star clusters, exoplanets, structure and kinematics of the disk and halo of our Galaxy etc. The table 3 below shows the specification of camera of EO optical telescope.

Table 3: Specification of camera of the telescope.

S/N	Name	Model	Description
1	SBIG	STXL 11002	Full Frame Monochrome Camera Size: 36 mm x 24 mm Pixel Array: 4008 x 2672 pixels @ 9u CCD Size: 36 x 24.7 mm Total Pixels: 11 Million Pixel size: 9 x 9 microns
2	SBIG	STXL 6300e	Pixel Array: 3072 x 2048 pixels @ 9u CCD Size: 27.65 x 18.48 mm Total Pixels: 6.3 Million Pixel Size: 9 x 9 microns
3	FLI	Pro line	Sensor Cooling: up to 70°C be below ambient CCD size: up to 50mm x 50mm Interline Sensor Operation: at 12 MHz (16bit) Full Frame Sensor Operation up to 14 MHz
4	Andor	---	Active pixels: 1024 x 1024 Pixel size: 13 x 13 μm Active area pixel well depth: 80,000 e- Gain register pixel well depth: 730,000 e- Maximum readout rate: 10 MHz Frame rate: 8.7 - 4,205 fps Read noise: < 1e- with EM gain Maximum cooling: -95°C

5 CONTRIBUTION AND FUTURE WORK

The project will enhance Ethiopia's deep space and small object surveillance and advance capabilities of the nations in space situational awareness. It will also support the strategic vision of ESSTI for identification and tracking of solar system objects, which may pose hazards to human primarily by planetary impact. The operation of ESSTI space surveillance and tracking system will provide Ethiopia an assured to information on satellites and space debris in support of national sovereignty and operational mission. Therefore, the future work is to implement the project and prepare the phases of activities to be carried out and perhaps readying the project paper for publication. At large scale the project may be developed to establish Ethiopian space security. Hence, for the implementation, satellite research development and operation directorate, ESSTI closely work in collaboration with ArianeGroup, France and any other respective organization carrying out space surveillance activities.

6 RECOMMENDATIONS

In order to upgrade the telescope and that should be managed by Astelco the following activities will be recommended:

- ✓ Dome opening need to be robotized in order to be automatic and remotely controlled by a computer.

- ✓ Automation of the weather station is needed in order to check weather before dome opening by the remote computer.
- ✓ Dome and telescope rotation synchronization need to be implemented.
- ✓ Cover dust on the secondary mirror need to be removed, prefer the use of a mechanical device (like on the primary mirror).
- ✓ Camera cable length need to be fixed and need to be available in the control room, this shall be performed whatever type of camera attached to the telescope and shall not disturb the movements of the telescope.
- ✓ GPS data must also be available in the control room for time stamping of the images. Filter wheel cable length need to be long enough to be controlled through the control room.

CONCLUSIONS

Space Surveillance denotes the task of systematically surveying and tracking all objects above a certain size and maintaining a catalogue with updated orbital and physical characteristics for these objects. This project is to realize a substantial improvement in the detection frequency of small objects in GEO using 1m EO optical telescope with common software tools, target extraction and for faint object detection. The establishment of ESSTI space surveillance project provides an important opportunity to advance the understanding of space situational awareness, which is the ability to view, understand and predict the physical location of natural and manmade objects in orbit around the Earth, with the objective of avoiding collisions. The system also provides satellite operators with a way to share controlled, reliable and efficient data for increased safety of satellite operations, which would bring the resources of the nations most advanced for object detection and orbit determination.

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