J. Astron. Space Sci. 26(4), 643–650 (2009) [Technical paper]

A Study on the Deriving Requirements of ARGO Operation System

Yoon-Kyung Seo†, Dong-Young Rew, Hyung-Chul Lim, In-Kwan Park, Hong-Suh Yim, Jung Hyun Jo, and Jong-Uk Park
Korea Astronomy and Space Science Institute, Daejeon 305-348, Korea
email: ykseo@kasi.re.kr

(Received August 12, 2009; Accepted September 28, 2009)

Abstract

Korea Astronomy and Space Science Institute (KASI) has been developing one mobile and one stationary SLR system since 2008 named as ARGO-M and ARGO-F, respectively. KASI finished the step of deriving the system requirements of ARGO. The requirements include definitions and scopes of various software and hardware components which are necessary for developing the ARGO-M operation system. And the requirements define function, performance, and interface requirements. The operation system consisting of ARGO-M site, ARGO-F site, and Remote Operation Center (ROC) inside KASI is designed for remote access and the automatic tracking and control system which are the main operation concept of ARGO system. To accomplish remote operation, we are considering remote access to ARGO-F and ARGO-M from ROC. The mobile-phone service allows us to access the ARGO-F remotely and to control the system in an emergency. To implement fully automatic tracking and control function in ARGO-F, we have investigated and described the requirements about the automatic aircraft detection system and the various meteorological sensors. This paper addresses the requirements of ARGO Operation System.

Keywords: satellite laser ranging, space geodesy, global positioning system, requirements

1. Introduction

Satellite Laser Ranging (SLR) uses lasers to measure ranges from ground stations to satellite borne retro-reflectors to the millimeter level (Pearlman et al. 2002). The SLR tracking method requires a pulsed laser source and a telescope to collect the reflected laser light on its return. The laser provides a detectable link between a SLR station and a distant satellite moving at a large velocity. The telescope and associated equipment determine a very precise location and velocity for both the satellite and station from the data provided by the laser beam. SLR is still the most accurate satellite tracking technique available with single shot positional accuracies under a centimeter and normal point corrected data able to precision of just a few millimeters. With many of the scientific applications that regularly use SLR data requiring continual improvements in data precision to advance modeling accuracy, SLR remains as the only currently available approach which satisfies this constant demand (Broomhall 2003).

Accurate Ranging system for Geodetic Observation (ARGO) is the name of Korean SLR program. It comes from the name of a ship on which a great group of heroes boarded to find the Golden

† corresponding author

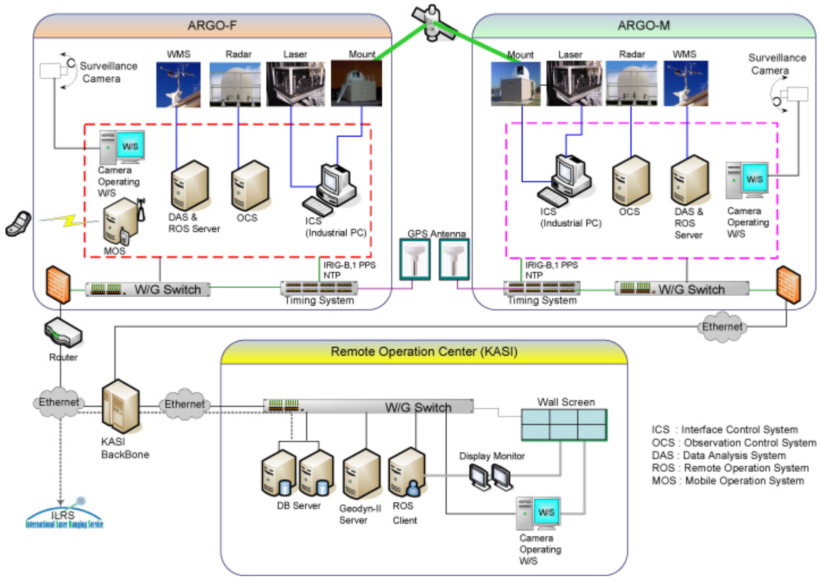

Figure 1. Block diagram of ARGO Operation System.

Fleece in the ancient Greek mythology and means a group of specialists to carry out a great mission (Park et al. 2008). The final goal of ARGO is to developing one mobile system (ARGO-M) and one stationary system (ARGO-F). ARGO system comprises five subsystems; Optics, Opto-Electronics, Laser, Tracking Mount, and Operation System (Lim & Lee 2009).

Korea Astronomy and Space Science Institute (KASI) had a meeting for ARGO System Requirements Review (SRR) on September 5th, 2008. After having a SRR meeting, ARGO Operation System working group submitted the SRR documents which describe the subsystem definition, functional and performance requirements, and interface requirements to Project Management Office (PMO). In case of hardware part, we suggested the general requirements and some specifications. According to the planned development schedule of ARGO program, a second review meeting for ARGO-M system conceptual design, System Design Review (SDR), was held on May 14th, 2009. In this SDR, the system configuration and major functions needed for automatic tracking were reviewed more specifically. For analysis of the established requirements, Usecase Diagram was used and the results were fed back to the requirements again. Review and determination about the specification for selecting the proper equipments was made. For the interface requirements, survey about the interface and discussion between related subsystems were performed.

In this paper, we describe the development scope and concept for ARGO Operation System in §2. We briefly illustrate the requirements of each (sub-sub-) system that is comprised of ARGO Operation System in §3 and §4. And we conclude by summarizing and making some comments in §5.

2. Description of ARGO Operation System

ARGO Operation System controls other subsystems and several equipments, makes a total decision about observation conditions, and performs post-processing and transferring the data acquired

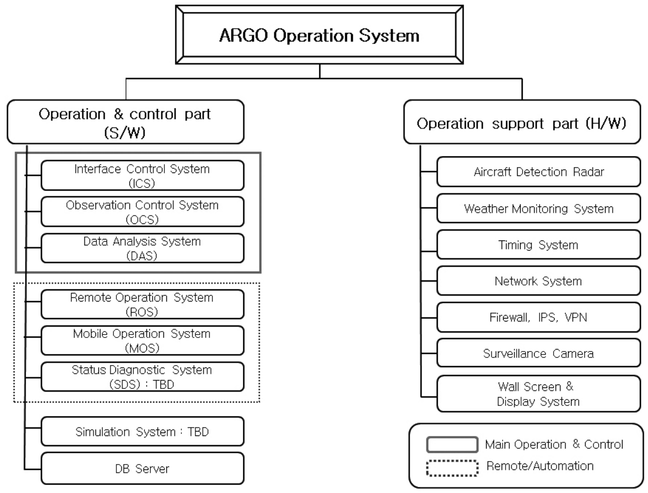

Figure 2. Configuration of ARGO Operation System.

through a laser observation. The block diagram in Figure 1 shows what subsystem or component is going to be installed to ARGO-F, ARGO-M, and Remote Operation Center (ROC). ARGO-M will have the same configuration as ARGO-F except for mobile server which is expected to be applied to ARGO-F firstly. This implies that ARGO-F can be controlled from ROC by using a mobile phone. A wall screen will be installed in ROC for displaying the progress status of observation and the image transferred from ARGO-F or ARGO-M.And ROC will have "Remote Operation System" for connection to ARGO-F or ARGO-M.

ARGO Operation System is classified into two categories, as illustrated in Figure 2: i) Operation and control part (software part), ii) Operation support part (hardware part). Interface Control System (ICS), Observation Control System (OCS), and Data Analysis System (DAS) in the solid box, are key components for satellite tracking and the acquired data processing in ARGO-F or ARGO-M sites. And Remote Operation System (ROS), Mobile Operation System (MOS), and Status Diagnostic System (SDS) in the dotted box are necessary for automatic and remote control function from ROC. ROC is planned to be set up inside KASI headquarters. ARGO-F and ARGO-M will be controlled remotely from this center. Operation support part is composed of several hardware systems necessary for an automatic SLR operation. A radar system and a part of weather monitoring sensors will be manufactured by order.

3. Requirements of Operation and Control Part

ICS has several interface cards with bus types of Industry Standard Architecture (ISA) or Peripheral Component Interconnect (PCI) for delivering the commands or calculated values to several subsystems or parts. The software runs under Real Time Operating System (RTOS). The main functions are tracking mount control, star camera control, laser control, timing synchronization, and collection of system status check value from related systems as in Figure 3.

OCS is the main system which reflects operator's decision and makes the real-time prediction and scheduling (McGarry et al. 1998). OCS shall perform star and ground calibration, and shall

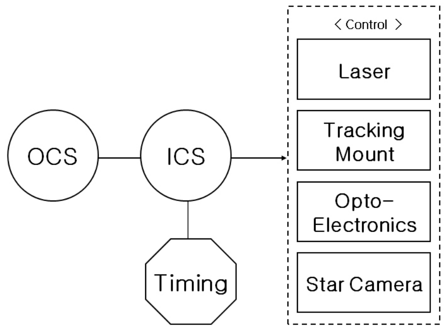

Figure 3. Interface diagram of ICS.

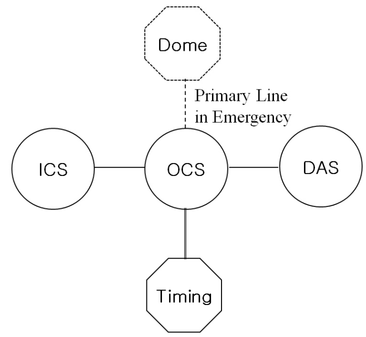

Figure 4. Interface diagram of OCS.

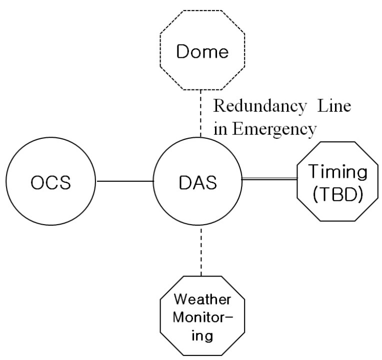

Figure 5. Interface diagram of DAS.

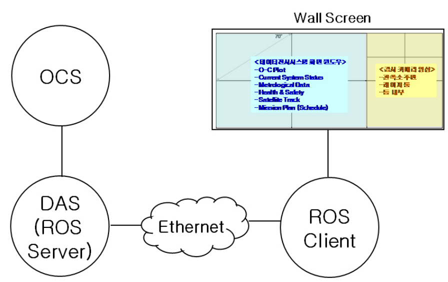

Figure 6. Interface diagram of ROS.

command the dome to close in emergency due to bad weather. The software shall be executed under non-RTOS. But, because OCS is supplied the time code signal from timing system, it shall be synchronized with ICS as in Figure 4. For ARGO system, OCS will be free of processing burden because ICS and Opto-Electronics subsystem will perform the measurement of the laser round trip time and many computation logics required in tracking in real-time.

DAS shall generate the final data product, commonly defined as normal point data, after observing one pass of satellite, and shall send generated normal point data to International Laser Ranging Service (ILRS) periodically. Normal points are sometimes referred to as quick-look data, because the normal points are generated very shortly after the satellite pass and transimitted rapidly (within a few hours) to the data centers (Pearlman et al. 2002). Normal point precision depends on satellite configuration, orbit parameters, etc. In the case of LAGEOS satellite, target precision of normal point is defined less than 5 mm RMS in the system level requirement (Lim & Lee 2009). Figure 5 represents DAS collect the meteorological data from WMS and system status data from several systems. DAS will have a redundant command line for closing the dome in emergency due to bad weather. DAS shall undertake a role of "Server" for remote access from ROC or shall be available anywhere through internet (McGarry et al. 1998).

ROS shall be able to monitor or control the observation process in real-time. ROS has server-

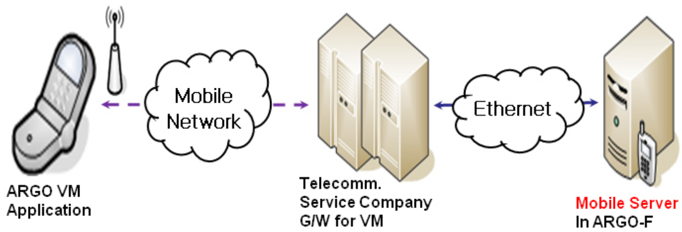

Figure 7. Interface diagram of MOS.

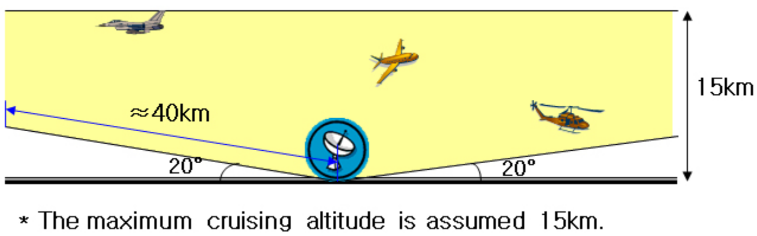

Figure 8. Coverage range requirements of Aircraft Detection Radar.

client structure as in Figure 6. The received observation data from the ROS server shall be displayed on a wall screen in ROC located in KASI headquarters.

MOS shall be able to control ARGO-F remotely by using mobile-phone.[1)] MOS shall consist of "server" in ARGO-F and "mobile-phone" for user, which needs cooperation with a telecommunication service company in order to use the mobile network shown in Figure 7.

4. Requirements of Operation Support Part

Because we are considering to use the Neodymium-doped Vanadate (Nd: Van) laser which is not eye-safe, it is necessary to establish the RF radar and other devices for detecting aircrafts to prevent hazardous conditions (Beam does harm to the pilot's eyes.). The radar system shall detect military and civilian aircrafts including helicopter and hang-glider to avoid any dangerous situation by laser. The available data shall be angular position of detected aircraft. And the period of data transmission shall be controlled manually by an operator. The radar shall be able to cover airspace above 20 deg elevation and the maximum length of target detection shall be about 40 km where maximum altitude of aircraft is assumed to be 15 km as in Figure 8. The radar shall be able to receive the orientation data from OCS and synchronize two orientations, the laser beam and radar pointing. The radar shall be able to recognize the Start/Stop signal from OCS. The radar shall not be pointed below the horizontal level. Before the radar is installed, RF analysis shall be needed to prevent interference or damage to Opto-Electronics detector and other electronic equipments. The radar shall be installed at a place which is not harmful to other subsystem.

For autonomous system, we are going to install several kinds of sensors to acquire meteorological data as in Figure 9. Pressure, temperature, and humidity sensors will be used to adjust refraction

[1)] http://cddis.gsfc.nasa.gov/lw11/index.html

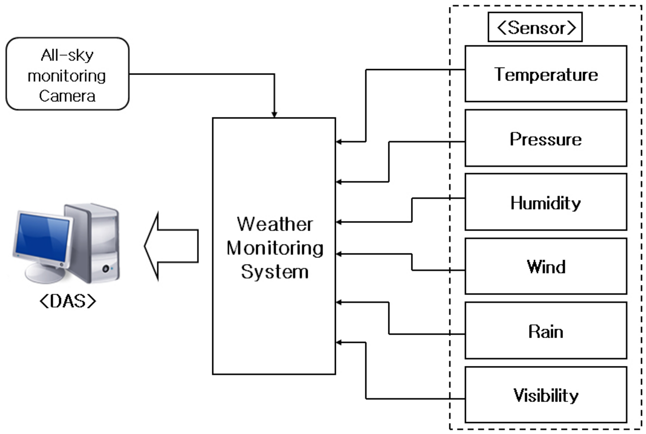

Figure 9. Weather Monitoring System.

Table 1. General requirements for timing system.

Components	Requirements
GPS Antenna & Receiver	- GPS antenna with over-voltage protector - GPS antenna operating temp.: $-50°C \sim +80°C$ - 12 channel GPS receiver - Acquisition time: cold start $<$ 20 min. - 1Pulse Per Second (PPS) output accuracy: UTC (USNO): $\pm$30 ns rms 100 ns peak - Frequency output accuracy: 1×10^{-12} @ 1 day
Oscillator	- Maintain the accuracy over 5 days without GPS signal
Output& Distribution	- UTC in Inter Range Instrumentation Group-B (IRIG-B) format - 1 PPS - Selectable frequencies (1, 5, 10 MHz)
NTP	- Client time accuracy $\leq$ 10 ms
Interface card	- Support to RTOS system

which is used in range measurements. Precipitation, fog, and wind sensors will be used for system health and safety (ex. dome closing). A visibility sensor and an all-sky monitoring camera are needed for a fully autonomous system.[2)] The output from each sensor shall be processed and displayed to an operator all at once by using a total integrated solution. The operator can control the sampling rate of data from several meteorological sensors.

If ARGO-M can connect to a network of the closest facility equipped with internet conditions, ARGO-M shall be allocated minimum 3 static Internet Protocol (IP) from facility nearby. ARGO-F shall be connected to a new and dedicated network with the considering the minimum construction cost after ARGO-F site is selected. ROC shall be located in KASI and shall follow the disciplines of KASI networking and communication security.

A timing system is needed for synchronizing the system time with the reference time from Global Positioning System (GPS). Table 1 (Seo et al. 2009) represents the timing system which is composed of several equipments, GPS antenna and receiver, oscillator, Network Time Protocol (NTP) server and client, and interface card for receiving the distributed time signal in computer system.

[2)] http://cddis.gsfc.nasa.gov/lw12/index.html

Table 2. General requirements for surveillance camera.

Components	Requirements
Surveillance camera	- Available in night time - Automatic zooming & focusing control - Pan: $\pm 170°$, max speed 100°/sec - Tilt: $-30° \sim 90°$, max speed 90°/sec - Remote control from ROC (KASI)
Installation & Housing	- Operating temperature: $-20°$C $\sim 50°$C - Including fan & heater & waterproof - Exposed wire shall be covered with shielding tube.
Operating Workstation & Software	- The imaging data shall be transmitted by wire/wireless network (Wireless is optional). - Monitor & store the minimum 4 cameras simultaneously - Image storage capacity: within 1TB in a week (4 Cameras) - Image replay using Moving Picture Expert Group (MPEG-4) media player - Image capture according to preset time interval - Auto-scheduling function which is changeable by surveillance object, purpose and method

Table 3. General requirements for wall screen and display system.

Components	Requirements
Wall screen	- Resolution per cell: more than 1,400×1,050 - Luminance accuracy: more than 95% - Screen gap: within 1 mm
Wall controller	- Maximize, minimize and Picture-in-picture (PIP) control - Hybrid duplex composition with RGB matrix switcher - Quadrant viewer
RGB matrix switcher	- Video input/output signal is controlled by Local Area Network (LAN) or RS-232
PC interface	- Branch off the video signal to RGB Matrix Switcher without a loss
Integrated control system	- Supplys touch panel for operator's console - Changes the display layout easily

A surveillance camera is needed for securing ARGO facilities and for preventing the hazard during the system operation. Table 2 (Seo et al. 2009) represents the components of the surveillance camera and their principal requirements. We are going to install $4 \sim 5$ web cameras in ARGO-M and ARGO-F separately. These web cameras will be controlled from ROS remotely by operator.

A wall screen and display system will display the status of the observation which will be processed in ARGO-F or ARGO-M in real-time. The image transferred from the surveillance camera is displayed on the wall screen in Table 3 (Seo et al. 2009).

5. Summary

In this paper, the development scope and concept of ARGO Operation System have been suggested. ARGO Operation System is classified into two categories as Operation and control part (software part) and Operation support part (hardware part). ICS, OCS, and DAS in Operation and control part are key components for satellite tracking and the acquired data processing in ARGO-F or ARGO-M sites. Operation support part is composed of several hardware systems necessary for an automatic SLR operation. Combination of these two parts will be developed to satisfy the system level requirements.

Also in this paper, the requirements about function, performance, and interface of each (sub-sub-) system in ARGO Operation System are summarized. In case of software part, the functional requirements and interfaces between the related subsystems have been illustrated mainly. In case of hardware part, the general requirements, or performance specifications have been described in outline. These derived requirements were analyzed more specifically using Usecase Diagram in the step of system conceptual design. The results of analysis were fed back to the requirements again and will be used as a foundation in preliminary design phase.

Acknowledgements: This work was supported by the Korea Astronomy and Space Science Institute through the SLR system development program for space geodesy funded by the Ministry of Education Science and Technology (MEST).

References

Broomhall, M. A. 2003, MS Thesis, Curtin University of Technology

Lim, H. C. & Lee, J. Y. 2009, Korea Astronomy and Space Science Institute Project Document (ARGO-M System Design Review), ARGO-SDR-601-001

McGarry, J., Conklin, B., Mann, A., Sadeghighassami, M., Perry, M., Cheek, J., Mallama, T., Ton, N., & Ricklefs, R. 1998, NASA/GSFC SLR2000 Software Design Document

Park, J. U., Lim, H. C., Seo, Y. K., Kim, Y. S., Park, J. H., Son, Y. S., & Kim, Y. K. 2008, in 16th International Workshop on Laser Ranging proceedings, New and Upgraded Stations, Extended Facilities (in press)

Pearlman, M. R., Degnan, J. J., & Bosworth, J. M. 2002, Advances in Space Research, 30, 135

Seo, Y. K., Lim, H. C., Yim, H. S., Park, I. K., Ryu, J. H., & Lee, H. J. 2009, Korea Astronomy and Space Science Institute Project Document (Operation System Requirements Document for ARGO-M), ARGO-REQ-660-F00