Architecture Design for the Space Situational Awareness System in the Preparedness Plan for Space Hazards of Republic of Korea

Eun-Jung Choi, Sung-Ki Jo, Jang-Hyun Park
Space Situational Awareness Center, Korea Astronomy and Space Science Institute, Korea

Abstract

In May 2014, Korea established the preparedness plan for space hazards according to the space development promotion act which is amended to take action with respect to hazards from space. This plan is composed of main three items such as system, technology and infrastructure. System includes the establishment and management of national space hazards headquarters at risk situation. Korea Astronomy and Space Science Institute (KASI) was designated as the space environment monitoring agency under the ministry of science, ICT and future planning (MSIP). Technology is supposed to develop the space situational awareness system that can monitor and detect space objects. For infrastructure, research and development of core technology will be promoted for capabilities improvement of space hazards preparedness such as software tools, application and data systems. This paper presents the architectural design for building space situational awareness system. The baseline architecture design includes integrated analysis system (IAS) and space objects monitoring system (SMS). IAS collects the status data from SMS and analyzes the space risk information through the data processing. For SMS, the all-sky surveillance camera, meteoroid surveillance sensor networks and radar system were considered. This system focuses on not only the threat of large artificial satellites and natural space objects such asteroids that crashed to the Earth but also the prediction of potential collisions between space objects.

1. Introduction

The threat posed by asteroids and comets has become one of the important issues. Furthermore, the growing quantity of space debris is a serious threat to satellites and other spacecraft, of which the risk is being damaged or even destroyed. There is a possibility that some have significant mass and will re-enter the Earth's atmosphere, a situation that is exacerbated when the debris contains toxic materials or has potentially hazardous size.
Recently, there has been rising interest in the risk of a disaster produced by the environment in outer space [1]. Jinju meteorite discovered in March 2014 has expanded the interest of the people of the fall of the natural space objects. Many countries also recognize the existence of space environment risk.
As defined by European Space Agency (ESA), space situational awareness (SSA) is the understanding and maintained awareness of the Earth orbital population, the space environment and possible threats to space assets [2].

In 2014, the Korean space development promotion act for promoting the peaceful use and scientific exploration of outer space has been revised with the establishment a plan to prepare risk is outer space every ten years and the designation of a specialize institution as the competent authority for this work [3]. The vision of this plan is the safety of the public and the protection from space hazards, and the main goal is to execute prompt action and forecast the space hazards with technology and relevant infrastructure. The three goal of this plan are 1) prompt action and forecasting about space hazards, 2) building up of national space hazards monitoring system, 3) enhancement of preparedness capabilities for space hazards. Following them, detailed subjects are decided including system, technology and infrastructure. System is to establish and manage of national space hazards headquarters at risk situation. Technology includes the development of monitoring equipment system prepared to crash and collision of space objects. For infrastructure, the detailed projects of this plan support the international cooperation, research and development for core technology and education for human resources.

According to this plan, in January 2015, the ministry of science, ICT and future planning (MSIP) designated Korea astronomy and space science institute (KASI) as the official "Space Environment Monitoring Agency". This agency plays a key role in the establishment and management of the national space hazards headquarter at space risk situation. In the events for Russian spacecraft Progress M-27M decaying on May 2015, the space environment monitoring agency operated the task force team by MSIP to prepare for any possible damage and played a key role in preparing for the space risks.

As a first deployment step for space hazards monitoring system, this paper presents the architectural design for the development of Korean space objects monitoring system. Fig. 1 shows the main functions and flow of Korean space situational awareness system. A crucial aspect of SSA activities is international cooperation. The development of SSA capability will assist to fulfil its responsibilities with regard to the compliance with international treaties, as well as providing independent resources to the international community.

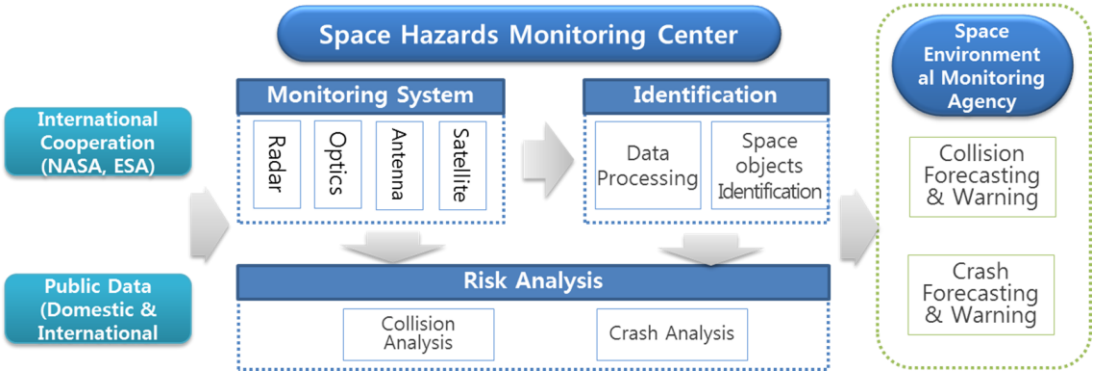

Fig. 1. Main functions and flow of space situational awareness system

2. Design of Korean Space Situational Awareness System

Korean space situational awareness system consists of two main segments such as space objects monitoring system and integrated analysis system. The purpose of space objects monitoring system is to detect and monitor the movement of space objects. Although individual observation system is able to operate independently, these systems will be correlated in order to achieve the performance of space object monitoring system. Fig. 2 shows the conceptual design of Korean space situational awareness system. The threat posed by near-Earth objects such as re-entry and collision of space objects is considered. Space objects monitoring system is composed of observation sensors including optical telescopes, all-sky camera, passive and active radar system to detect new objects in space and re-detect already seen objects.

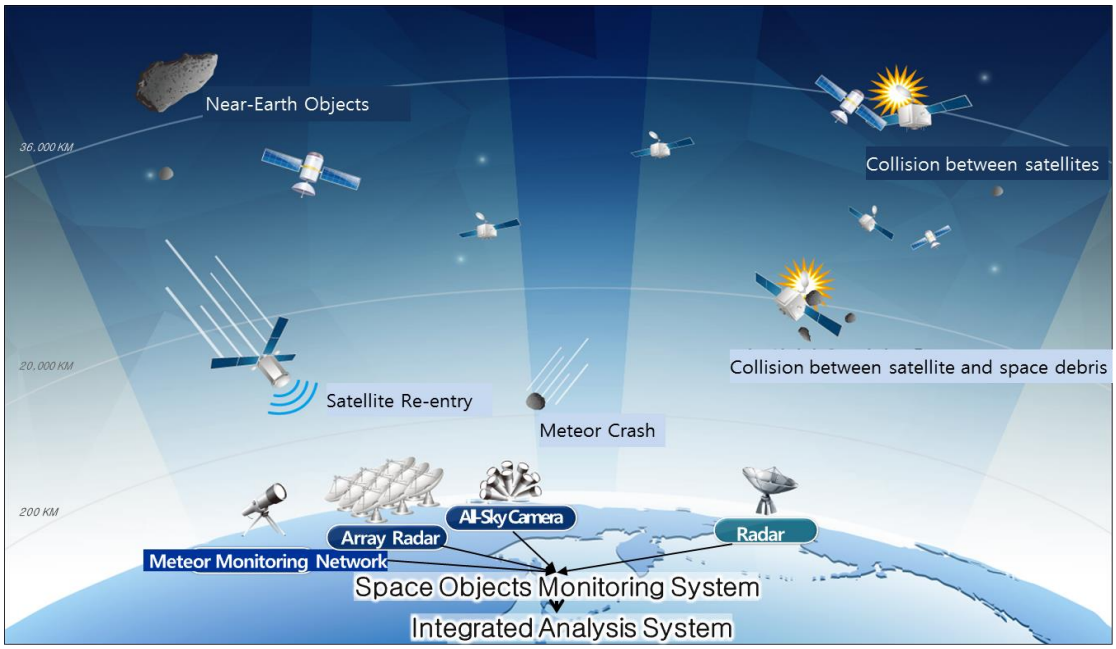

Fig. 2. Conceptual design of Korean space situational awareness system

The baselines of space information are the data obtained from international cooperation and existed facilities, OWL-Net (Optical Wide-field patroL) network. OWL-Net is first Korean space situational awareness facilities with five small wide-field telescopes. The new proposed space objects monitoring system are concentrated on the detection of space objects. The optical system and radar systems are all considered. The overall configuration of space objects monitoring system and integrated analysis system is shown in Fig. 3.
Currently, the source for all space objects is limited to the published data of the U.S. Joint Space operation Center (JSpOC). The scope of information to be acquired through the system and the provided public data is shown in Fig. 4. However the required performance of this system is currently under evaluation. The data generated through this space objects monitoring system can be used to actively protect domestic space-based infrastructure from colliding with the space debris and detect when large pieces of space objects reenter the atmosphere which pose a risk to people and national infrastructures.

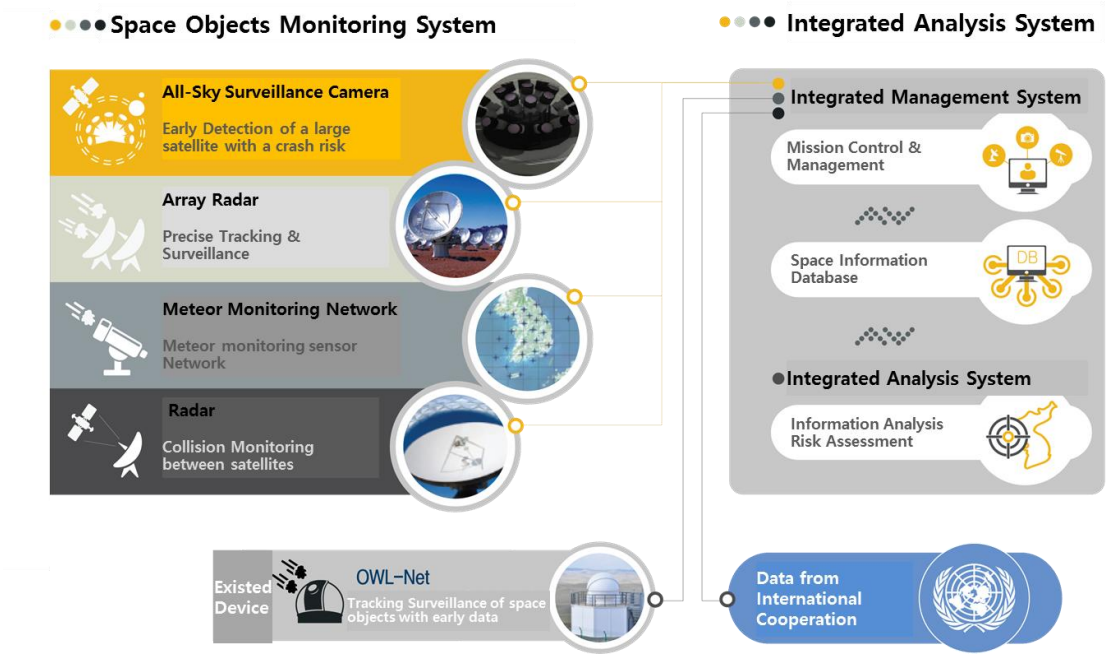

Fig. 3. Configuration of Space Objects Monitoring System and Integrated Analysis System

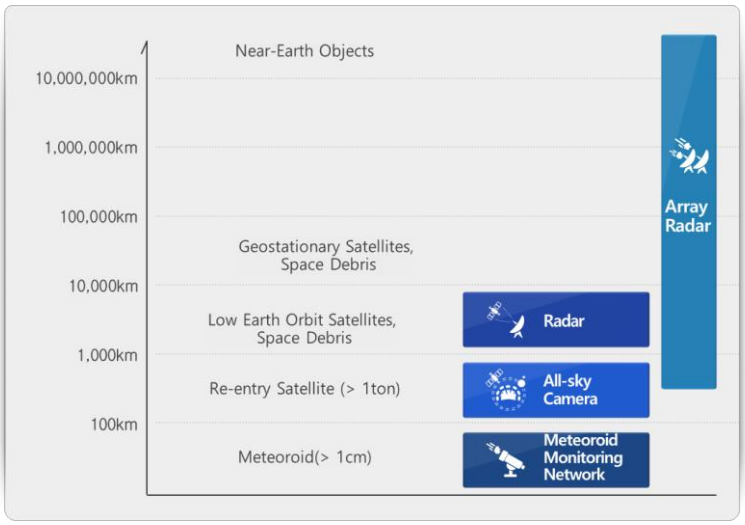

Fig. 4. Scope and response sensor equipment of space objects monitoring system

The key to the overall performance and the main system design will be identified. Especially, the risk assessment of falling more than 1 tons of satellites and space objects with the potential to cause collisions with the domestic operating satellites will be focused on the main goals. The observation sensors of the space objects monitoring system cannot be expected to provide the same performance for all orbital regions. Therefore the actual performance of this system will be calculated, together with the design and development of the observation sensors that are necessary to scan the skies for potential hazards.

3. Architecture Design for Integrated Analysis System

Integrated analysis system for space situational awareness performs collection, storage, management and analysis the space surveillance information from observation sensors and international cooperation as shown in Fig. 5. Integrated management system includes the following functions:

- observation data interface : interface for observation data acquisition from observation sensors
- mission control : manage and control the observation system, transmitting the information related to the observed trajectory command to perform observation missions to observation system and receiving the state information of observation system
- mission planning : schedule for special feature of the day-to-day tasks and duties
- data preprocessing : preprocess of the information obtained from the observation system
- data management : integrated management of the obtained data from international cooperation, catalogued data and observed data
- Infrastructure status display : real-time display for monitoring of observation system status and integrated analysis system

Integrated analysis system includes the following functions:

- data post-processing : post-process for determining the object information through the preprocessed data
- space objects identification : extract space object information such as source, orbital parameters, confidentiality attribute, etc.
- space objects orbit determination : determine the position and velocity vector of the time
- crash risk analysis : predict the fall time and location and analyze a height change at any time
- collision risk analysis : predict the trajectory at a certain time and analyze the impact time and location
- risk assessment : comprehensive risk assessment function and generate the mission priority

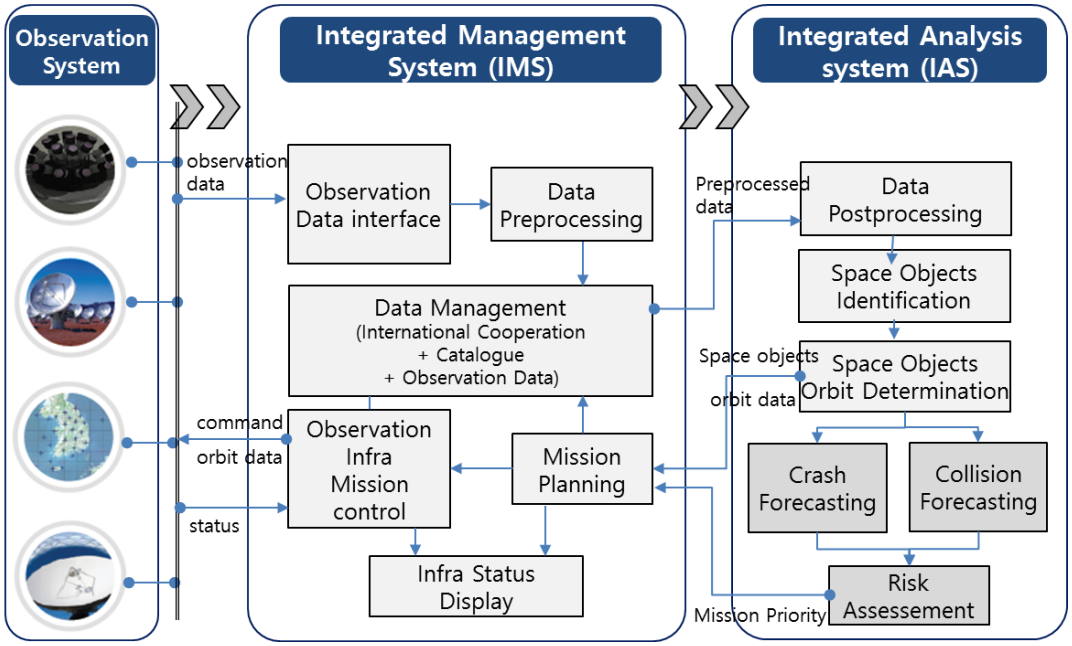

Fig. 5. Architecture Design of Integrated Analysis System

4. Conclusions and Future Work

Korean is preparing for the development of space objects monitoring system for space situational awareness. Space environment monitoring agency plays a key role in the establishment and management of the national space hazards headquarter at space risk situation. The research and development of space objects monitoring system and integrated analysis system has been conducting according to the plan.

This paper has presented the architecture design for space situational awareness system according to the preparedness plan for space hazards. As a first deployment step for space hazards monitoring system, two main segments such as space objects monitoring system and integrated analysis system were described. The space objects monitoring system is observation sensors for detection and monitoring the movement of space objects such as all-sky camera, meteor monitoring network and passive and active radar systems. The integrated analysis system divided into two sub-parts, integrated management system and integrated analysis system. Integrated management system has the functions for collection, storage and management for the observed data from space objects monitoring system and the obtained data from international cooperation. Integrated analysis system generates a comprehensive risk assessment using the preprocessed data from the space objects monitoring system.

A crucial aspect of SSA activities is international cooperation, which is becoming increasingly important. Through the research and development of the architecture design for Korean space situational awareness system, it is expected that the development of SSA capability will be based on international collaboration.

During the next phase of this system, the performance of this architecture will be confirmed and detailed, with the final goal of preparing space hazards.

5. References

1. Tsujino, T., Space Situational Awareness to Mitigate Disastrous Risks from Space, Science & Technology Trends Quarterly Review, No. 45, 17-29, 2012

2. Donath, T., Schildknecht, T., Martinot, V., Del Monte, L., Possible European Systems for Space Situational Awareness, Acta Astronautica, Vo. 66, 1378-1387, 2010

3. Choi, E., et. al., Preparedness Plan for Space Hazards in Republic of Korea, technical presentation of UN COPUOS 2014,