EOS situational data shared service mechanism

L Lv¹, Q Xu¹, C Z Lan¹, Q S Shi¹, W J Lu¹ and W Q Wu²

¹Institute of Surveying and Mapping, Information Engineering University, 66 Longhai Road, Zhengzhou, Henan 450001, China
²61243 Troops, Urumqi, Xinjiang 830006, China

E-mail: lvliangvip@163.com

Abstract. With the rapid development of aerospace and remote sensing technology, various high-resolution Earth Observation Systems (EOS) are widely used in economic, social, military and other fields and playing an increasingly prominent role in the construction of Digital Earth and national strategic planning. The normal operation of the system is the premise of high quality data acquisition. Compared with the ground observation mode, EOS itself and the surrounding environment are more complex, and its operation control mainly depends on all kinds of Space Situational Awareness (SSA) data acquisition and analysis. SSA data has more extensive sources, larger volume, stronger time-effectiveness and more complicated structure than traditional geographical spatial data. For effective data sharing and utilization, combined with the analysis of data types and structures, a SSA data sharing identity language SSDSML is designed based on the extensible mark-up language XML, which realizes a comprehensive description of satellites and their attributes, space environment, ground stations, etc. Then EOS situational data shared service mechanism is established and provides a powerful data support for the normal operation of the system.

1. Introduction
The normal operation of the system is the prerequisite to obtain data with high quality. Compared with other systems, EOS itself and the surrounding environment are more complex. So awareness data has more sources, greater amount, stronger timeliness, and more complex structure. Due to different programming languages and architectures, the integration becomes very difficult, and this contradiction is particularly obvious in the sharing of spatial situation data. Traditional data sharing mechanism is often limited in conversion between spatial data with different structure, which mainly includes intermediate data format conversion, the standard spatial data exchange format conversion and direct access method¹².

The fundamental way to solve the multi-source and heterogeneous spatial situation data sharing lies in the open expression of perceptual data in Web environment. Based on XML, GML and SVG, Zhou Wensheng, etc.³ created the expression system of open geospatial data. Distributed spatial data modeling and visual expression description language(DSDML) is proposed by Wang Peichao, etc.⁴ based on XML, KML and GML, which has the function of geographical annotation, vector, raster, DEM data loading and can provide roaming control and distributed data integration capabilities. Lunar spatial data description and integration method is established by Tan Li, etc.⁵ based on Digital lunar mark-up language(DLML), which can complete spatial data (including three-dimensional model) description, scientific results data description, geographic information tagging, scene roaming control
and distributed data integration description. Based on the detailed analysis of the data types and structures, this paper designs a kind of space situational data sharing mark-up language Space situational data shared mark-up Language (SSDSML) based on the syntax and format of extensible mark-up language XML. And then EOS situational data shared service mechanism is established through the network service, which provides a powerful guarantee for the normal operation of the system.

2. Situational awareness data analysis and modeling

2.1. Situational awareness data composition

Data is the main body of sharing and a comprehensive understanding of the composition and characteristics is the prerequisite for sharing. The complexity of the environment around EOS, the diversity of space objects and particularity of space activities make the situational awareness data elements more complex. Generally speaking, the data is divided into two parts including environmental elements and spatial entities. Figure 1 shows the composition of EOS situational awareness data elements.

![Situational awareness data composition](image)

Figure 1. Situational awareness data composition

The basic geographical space environment is the foundation of any space activities, including not only the remote sensing images, vectors, DEM and other geographical environmental data, but also the background data of the solar system and other stars. Space environmental factors refer to the natural environment around the spacecrafts, including the Earth's upper atmosphere, Earth's magnetic field, ionosphere and energetic charged particles. Spatial entities mainly involve space debris, satellites and many ground stations for EOS.

2.2. Situational awareness data modeling

There are kinds of situational awareness data whose type are complex. If the model is to be customized for each element, it is not only a huge workload, but also causes the redundancy of the system structure. Through the analysis of all kinds of data, what can be found is that all of them have certain spatial and temporal characteristics no matter Earth's atmosphere, magnetic field and satellites, while difference embodies in the different geometries. As Figure 2 shows, in this paper, all elements are abstracted to an object of the base class, which is composed of three elements, property, chronology and geometry.
Property is relatively simple, including the name of object, the color of logo and other information. Chronology information is responsible for the management of spatial-temporal data, which determines the position and attitude. Taking into account the multi-segments of ephemeris, ephemeris of track is syncopated according to the running time. Each section of the track also has its own characteristics, including the start time and the end time of track, the center of the object, the trajectory and its coordinate system, the rotation and its coordinate, etc. Geometric shapes can be divided into the arrow type, the bulletin board type, column type and so on according to the types of targets. Each one corresponds to a specific type of SSA data. The unified data organization method is simple in operation, convenient in management, great in expansibility and high in execution efficiency, and can ensure the reusability of the program.

3. SSDSML description function

3.1. SSDSML grammatical structure and rules
The syntax of SSDSML inherits from the XML standard and is defined using XML schema. The functional design refers to the DSDML[4]. SSDSML element design takes into account not only the composition of data elements, but also the operation of viewpoint and data integration. As shown in Figure 3, object is the base class element. Body element is the description for the target ontology model, which contains property, chronology and geometry. Viewpoint is used to control the position, attitude and posture of the field of view. Data integration element mainly considers three forms of access including database, network connections, and other services.

Figure 2. Situational awareness data modeling

Figure 3. SSDSML element definition
3.2. Spatial data description
In the last chapter, we analyse the structure of EOS situational awareness data and carry out the unified data modeling. The description of spatial data is fully included in SSDSML, including attributes, ephemeris and geometry. Property elements complete the description of the ownership, type, attribution and summary information and so on, which is a record of the fixed information.

The description of ephemeris elements is rather special, because it also contains certain characteristics of the motion of the target track in addition to general stationary or moving objects. The description of the spatial data is more complex, especially in the track which can be divided into fixed trajectory, model trajectory and point track. They correspond to the ground station stationary targets, the observation satellites and debris, ground and near-earth targets respectively. In addition, ephemeris elements need to record the object coordinates, including local and orbit coordinate systems.

SSDSML contains various geometric shape description. Due to the complexity of data, in addition to the basic shape such as point, line, surface, and polygon and so on, it also supports the description of the shape of arrow, bulletin board, ionosphere and geomagnetic field, particle system and so on. In 3D scene, MDL format is used to describe the model data, which contains the description of the components, the attitude, the size and the proportion coefficient of model.

3.3. Viewpoint control description
Taking into account the needs of the 3D scene browsing, SSDSML design fully considers roaming. In order to achieve the precise control of roaming process, viewpoint elements are defined to describe the position, attitude and view, which can supply solution to solve the user's multi angle, full range of observation.

3.4. Distributed integrated description
EOS data sharing mechanism should include support for other data sources. Through the network link, SSDSML integrates the local data, the network database, TCP, UDP, OGC services and other SSDSML data sources. Data are integrated to form a new data source, thereby serve the visual application.

4. Prototype system architecture and application
4.1. Application architecture
EOS situational awareness data sharing is a new direction, and the sharing level is still relatively low now. Most systems mainly use local data and their ability to integrate data is insufficient. Based on GIS data sharing mechanism, SSDSML is used for scene construction, viewpoint roaming and data integration and so on. It can greatly enrich the content of EOS guarantee and supply a powerful support for the system operational control. Figure 4 shows the application architecture of SSDSML, which is composed of application layer, platform layer, analysis layer and data layer. Data sharing mainly depends on parsing layer and has nothing to do with the specific platform. It is responsible for parsing SSDSML files or other operations and obtaining situational awareness data elements and viewpoint roaming requirements. Then the data is sent to specific situational awareness platform to complete the scene construction and viewpoint control, thus the typical application scenarios are completed.
4.2. Prototype system

In this paper, the original space situation visualization system InSpace is upgraded and improved based on the SSDSML. The original InSpace system has complete functions and can realize environmental factors (including planets and space environment, imagery, topographic, vector) and spatial entities (space debris, spacecraft and ground station) loading, display and fundamental analysis. However, the ability of data sharing is insufficient because it is a stand-alone version. After the update InSpace is constructed by C/S architecture under the support of SSDSML and can complete the integration of multiple distributed data sources, greatly improving the timeliness of the shared. Then it provides a strong support for the operation and control of EOS. Figure 5 shows the InSpace system main interface, Figure 6, Figure 7 shows the data visualization results.

**Figure 5. InSpace system main interface**
5. Conclusion
The control of EOS cannot be separated from the support of situational awareness data and the effective sharing of data can greatly improve the efficiency and accuracy of guarantee. The SSDSML provides the unified description of multi-source, multi-type situational awareness data. Experimental results show it can provide powerful support for all kinds of space applications and lay a solid foundation for the sharing mechanism. The kinds of elements of SSDSML will be extended based on development of the platform function constantly, and the description and analysis of the massive data will be researched next.

References
[1] Yu X 2011 Research on Spatial Data Sharing Based on GML3.1 (Wuhan: Wuhan University Press) pp 12-15
[2] Wang Y D, Gong J Y, Huang J T and Deng Y J 2000 Acta Geodaetica et Cartographica Sinica 29 143-144
[3] Zhou W S, Mao F, Hu P 2004 Geomatics and Information Science of Wuhan University 29 43-47
[4] Wang P C, Zhu X Y, Su K H, Chen J 2009 Geomatics and Information Science of Wuhan University 34 659-662
[5] Tan L 2011 Research on key technologies for digital Moon platform based on G/S model (Chengdu: Chengdu University of Technology Press) pp 51-68
[6] Lv Liang 2014 Research on space situational picture construction and visualization (Zhengzhou: Engineering in Information Engineering University Press) p 18