Architectural Enhancement of HASIS 3D Hail Suppression Information System

Vladan Mihajlović[1], Bratislav Predić[1], Dejan Rančić[1], Slobodanka Djordjević–Kajan[1], Igor Antolović[1], Zoran Babić[2]

Abstract – **Previous system HASIS 3D is a high quality tool for tracking the clouds and measurement of some hail cell parameters, providing good visualization and automatic calculation of seeding parameters. Improvement of the system is proposed to provide visualization of different radar data types, at the same time, integration of scalar data gathered from different radars and reconstruction of wind vector gathered from three sources. That requests redesign of HASIS 3D architecture. The new architecture is proposed to be modular, flexible and extensible.**

Keywords – **software architecture, design patterns, data visualization, hail suppression**

I. Introduction

Modern meteorology is based on information systems, from simple ones that manage meteorological measurements to complex systems that process huge amount of data such as weather conditions monitoring systems [1]. Weather modification is field of meteorology that made great progress based on usage of information systems. Satellites and radars are two main sources for acquisition of data about atmosphere. However, information systems involved in hail suppression mainly use radars for gathering data [2, 3]. Hail suppression systems can be classified in three groups whether they use stationary radars, portable radars or both kinds [4]. Second classification is based on methodology used for seeding the cloud with hail potential. First group of systems use rocket and second use planes.

HASIS 3D (Three-dimensional Hail Suppression Information System) is specific information system developed to support hail suppression activities in Hydrometeorological Service of Republic of Serbia (RHMSS) [5, 6, 7]. The system uses stationary radars for data acquisition and rockets for seeding the clouds with hail probability with chemical reagents. HASIS 3D does not control the radar itself, but use data from other systems, particularly HASIS for Mitsubishi radars and Rainbow [7] for Gematronik radars. However, HASIS 3D is complete system that provide monitoring and tracking of cloud systems, measurement of hail cell parameters, extraction of cloud region that needs to be seeded, calculation of ballistic parameters of rocket and storing data about the whole process.

HASIS 3D system uses data from single radar for weather conditions monitoring. Problem is that topmost elevation of radar limits the part of space from which data can be acquired. Using data from other radar, this lack of data can be exceeded. System can provide more precise visualization of clouds using data from several radars. Also, integration of data from different radars can provide information about situation above the whole country. HASIS 3D system can visualize different types of data about atmosphere, reflectivity, wind speed and spectral width. Better insight into probability of hail can be obtained monitoring all this data types at same time. The nature of scanning of atmosphere using radars is limited to gather data about wind speed only in direction from radar through the point of interest. This is just a projection of real wind vector. To gather the real information about wind direction and speed it is needed to use the data from at least three radars. In this way it is possible to reconstruct the real vector and to create 3D grid with wind data. This grid can be used for visualization to provide new information about processes inside the cloud. Also, this data can be used to determine the real speed of the cloud with hail potential, which can be gathered easy in other way. This requests imposed the enhancement of the system HASIS 3D.

Extension of HASIS 3D architecture is described in following three sections. The second section describes methodology for cloud seeding that is supported by HASIS 3D system. The enhancement of system architecture is presented in third section. The final section summarizes the features of the proposed architecture and specifies the topics for further research.

II. HASIS 3D System Organization

The main tasks that hail suppression system based on cloud seeding using rockets needs to support are: detecting the processes in atmosphere that can generate a cloud with hail potential, measuring the parameters of the hail cells, automatic verification of criteria for seeding the cloud and automatic creation of cloud regions to be seeded, automatic calculation of ballistic parameters for launching the rockets and storing the data about the seeding process and creating different type of reports.

The configuration of HASIS 3D system [8, 9] is defined to support hail suppression methodology defined by meteorologist from RHMSS and approved in previously conducted researches [5, 6, 7]. According to this, the system consists of three subsystems (fig. 1): Main workstation, GIS workstation and Database workstation.

[1]Vladan Mihajlović, Bratislav Predić, Dejan Rančić, Slobodanka Djordjević-Kajan and Igor Antolović are with the Faculty of Electrical Engineering at University of Niš, Aleksandra Medvedeva 14, 18000 Niš, Serbia, E-mail: wlada@elfak.ni.ac.rs.

[2]Zoran Babić is with the Republic hydro meteorological service of Serbia, Kneza Višeslava 66, 11000 Beograd, Serbia, E-mail: zbabic2003@yahoo.com.

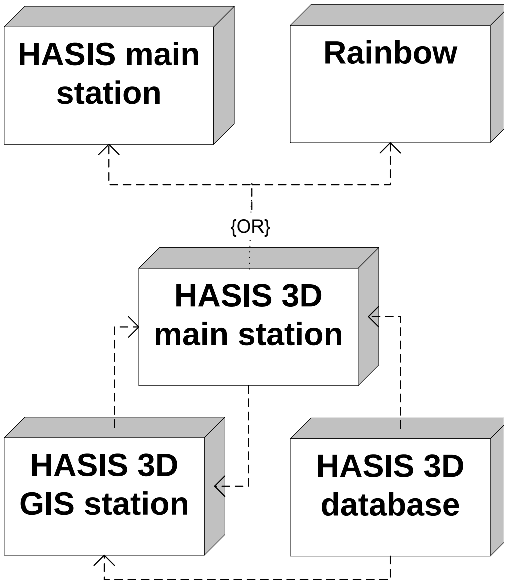

Fig. 1. HASIS 3D system

HASIS 3D Main station's main functionality is to represent situation in atmosphere. The radar data for visualization are transferred as being created on system that controls radar. The system represents the situation through two different views, 2D and 3D. The 2D representation is achieved using horizontal and vertical cross sections (fig. 2). In this view, it is possible to explore cloud configuration, size and structure using contour extraction. Different measurements of cloud parameters can be performed during 2D analysis. In 3D view, situation in atmosphere is represented using multiple isosurfaces. The value for calculation the surface can be dynamically changed providing better insight of cloud shape and dimensions. This way operator has complete support to analyze cloud and estimate cloud hail potential. System, also, helps providing automatic verification of seeding criteria.

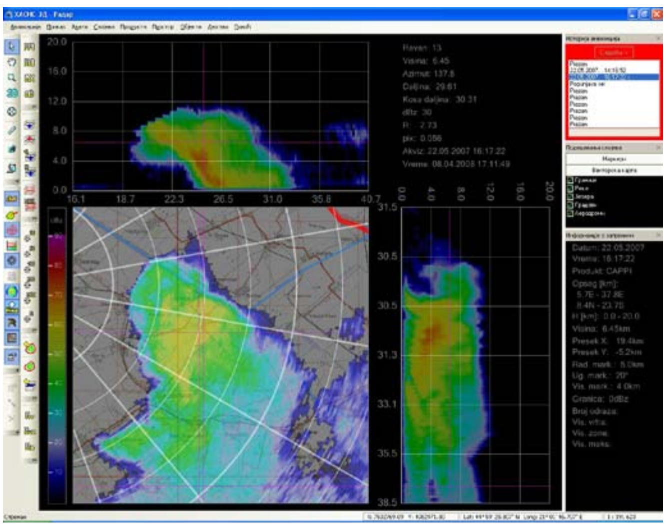

Fig. 2. 2D view on main HASIS 3D subsystem

The GIS workstation displays situation in the atmosphere in 2D and 3D view, but 2D view is limited to horizontal cross sections. The arrangement of launching station on the ground is visualized with their prohibitited zones. This subsystem provides possibility to define square regions where is prohibited to perform actions. According to type of the cloud with hail potential and zones of prohibition, the system automatically determines region in the cloud which need to be seeded. Using location of this region and positions of the launching stations system automatically calculates which stations will perform action and ballistic parameters of rockets for them (fig. 3). Seeding efficiency is, also the input parameter in the process of calculation.

The Database station provides support for storing data about weather conditions, process of cloud monitoring and seeding. These include data about ballistic parameters of rockets, location and status of the launching station and the types and amount of rockets in store. Data about cloud measurement are stored for further analysis. Ballistic parameters calculated by GIS subsystem are available to operator on this workstation, so he can issue command to perform action using radio link.

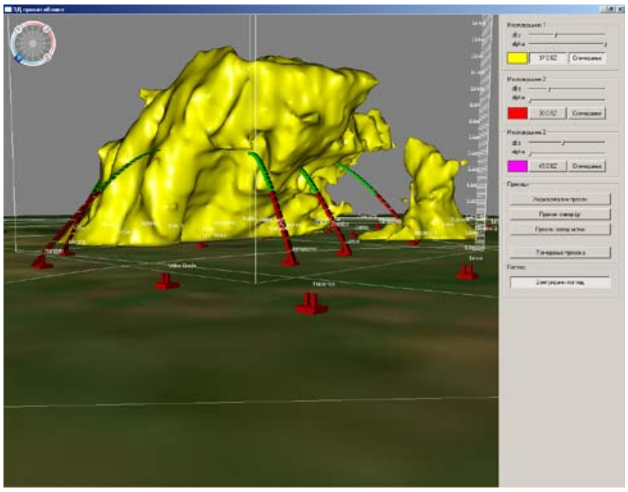

Fig. 3. 3D view on GIS HASIS 3D subsystem

III. Enhancement of HASIS 3D Architecture

New ideas mentioned earlier influenced enhancement of existing architecture of HASIS 3D and some reconstruction. The main reasons that demanded modifications are visualization of different radar data at the same time, using data from several sources and visualization of vector data types. The most important classes of the new system are *DataLayer*, *DataIntegrator*, *Renderer*, *Observer* and *Manager* (fig. 4).

DataLayer is basic class that manages products that radar collects. There are three types of products: reflectivity, wind speed and spectral width. The basic functionalitie of this class is to prepare data for visualization. Also it can perform different types of data analysis. The radar data are stored in cylindrical coordinate system.

The major task of *DataIntegrator* is to process the data gathered from two or more radars. This class uses the data stored in several *DataLayer* classes. The processing of data is quite different for raster and vector data which would be implemented as *ScalarIntegrator* and *VectorIntegrator*. The scalar data are complete and their integration is performed by

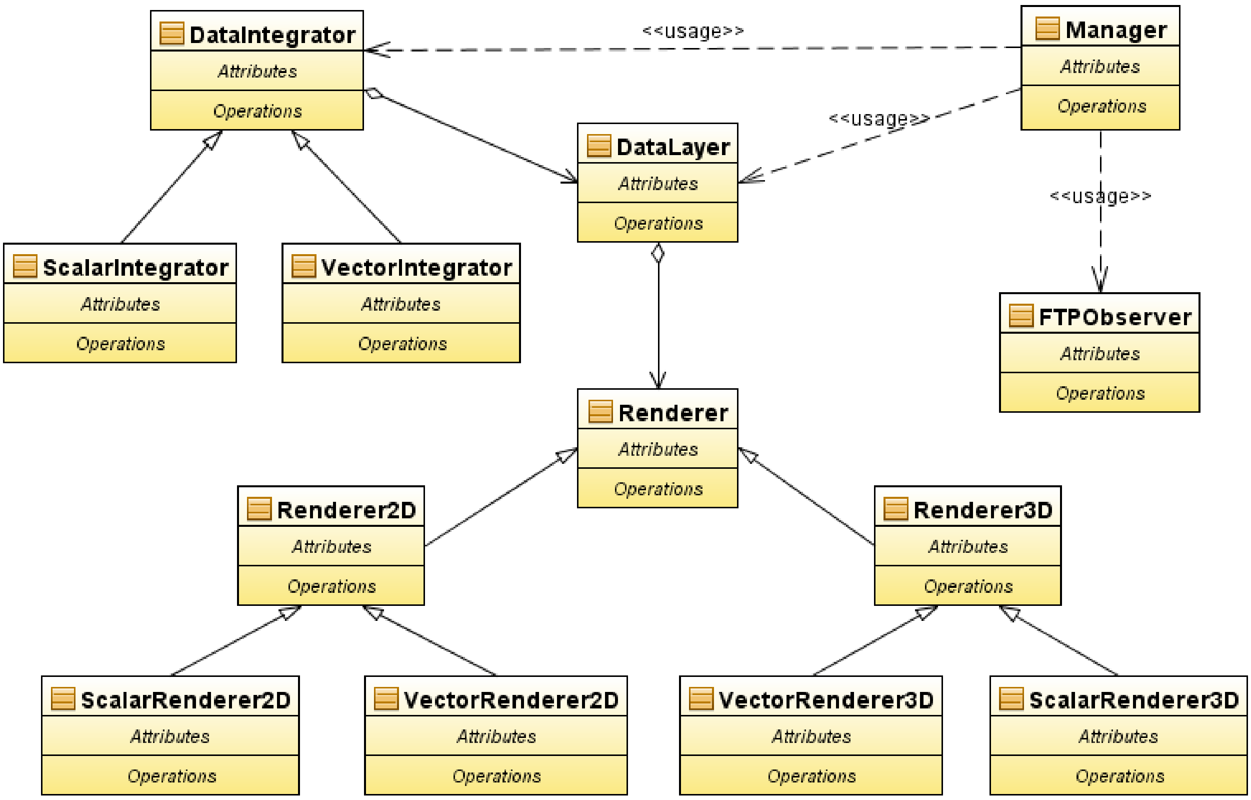

Fig. 4. Class diagram of HASIS 3D enhancement

choosing the most recent or most precise data at particular point in data grid or using some method for averaging. On the other side, vector data gathered from single radar are incomplete because they represent only the projection of real vector on the imaginary line connecting the radar with the particular point in space. Therefore, for calculation of real vector it is required to have data from three radars. However, because radars are positioned on larger distances the good approximation on vector in horizontal plane can be achieved using two radars. The vector reconstruction has inherent error and it is expected that it would need different algorithms which will differently threat this problem. This possibility of using different methods for scalar and vector data integration is imposed Decorator design pattern [10] as solution for *DataIntegrator* to provide simple modification and flexibility.

Quality visualization is primary requirement for cloud tracking and good estimation of situation in atmosphere. *Renderer* is the basic class that performs this task. Two inherited classes visualize radar data in 2D and 3D view. First class has methods for representing the data on horizontal and vertical cross section. The class *ScalarRenderer2D* provides the basic method visualization using color spectra to represent scalar values. Beside this method scalar data can be visualized using contours for specific values. This offers a possibility to combine different radar products in the same picture (cross section). *VectorRenderer2D* and *VectorRenderer3D* have purpose to represent vector data in 2D and 3D view. The simple method to do this is to use regular data grid with vectors in its points. These classes provide vector visualization using streamlines. *ScalarRenderer3D* represents cloud throw multiple isosurfaces for particular values. The values that can be dynamically adjusted to give better insight into cloud parameters. To support simple replacement of method used for visualization, *Renderer* classes are designed using Strategy design pattern with *DataLayer* as a context class.

Significant modification is performed on *Observer* component. The requirement to monitor and gather data from several sources require creation of a new class *ObserverManager*. This class creates and controls several instances of *FTPObserver* components. Each component is configured independently to connect to the workstation which controls the radar. To isolate influence of data acquisition these components work in different threads. *ObserverManager* can add or remove data sources while the system is running.

Besides handling data acquisition the class *Manager* controls data processing and visualization (fig. 5). The class *LayerManager* defines which data will be displayed and which method will be used. This component also specifies how to combine different data layers in the view. Handling data integration is, also, task that this component performs. *AcqusitionManager* is the part of the system that cooperates with *ObserverManager* to properly manage the incoming data. This component allocates different *DataLayer* to accept data and update the history of arrived radar products. The layers that use data from different sources must register with *AcqusitionManager*, so it can inform them whenever new data form source they use are transferred. This way layer that performs data integration can refresh its contents and preserve representation correctness. This functionality is designed using Observer design pattern.

IV. Conclusion

Requirement to get better insight into situation of atmosphere invoke improvement of HASIS 3D system. The purpose is to provide simultaneous monitoring several parameters of clouds and better estimation of its hail potential. This will be provided using:

1. Simultaneous visualization of different types of radar data: reflectivity, wind speed and spectral width either in 2D or 3D view.
2. Processing data from several data sources to the gaps in part of the space that cannot be reached by single radar and to improve the accuracy in the part that are covered with several radars.
3. Reconstruction of real vector of wind speed, which will bring new information about processes in the cloud and more accurate calculation of speed cloud motion.

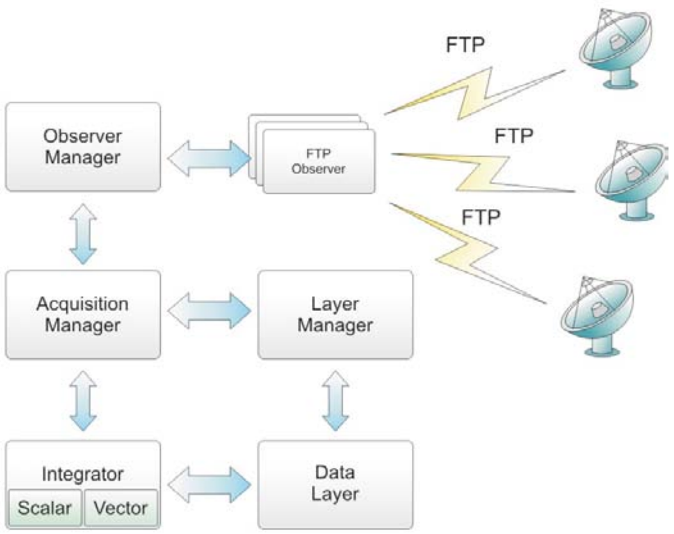

Fig. 5. Radar data management

Enhancement of HASIS 3D system is designed to maintain existing framework. The extension is developed to clearly separate component that control, process and visualize the data. The new part of architecture provides changeability and extensibility of the system. This will enable addition of different methods for data processing, integration and visualizations. To achieve this, different design patterns are used in development of extension HASIS 3D architecture.

The extension of HASIS 3D will provide the base for data integration and visualization. It is expected that improvement of basic methods will invoke development of new methods that better suites in particular cases. Beside, this system use data converted in Descartes coordinate system which contains inherent error. The improvement of precision of data analysis and visualization processes could be provided using data in spherical coordinate system, which is native to radar data acquisition.

Acknowledgement

Research presented in this paper is partially funded by Serbian ministry of science and technological development and Republic hydrometeorological service of Serbia as part of the project “Integrated hail suppression information system – HASIS 3DI”, ref. no. TR-12003.

References

[1] L. A. Treinish, “Visual data fusion for applications of high-resolution numerical weather prediction”, IEEE Proceedings of the conference on Visualization '00, 2000, pp. 477 - 480.

[2] J. Johnson, et al., “The storm cell identification and tracking algorithm: an enhanced WSR-88D algorithm”, Weather and Forecasting 13, 1998, pp. 263-276.

[3] T. Johnson, C. Barrere, M. D. Eilts, N. Kuhnert, M. Mathis, D. Axisa, “Weather modification operations with NEXRAD level-II data and products”, Proceedings of 16th Conf. Inadvertent and Planned Weather Modification, San Diego, USA, 2005

[4] TITAN (Thunderstorm Identification. Tracking, Analysis, and Nowcasting) radar processing software, http://www.rap.ucar.edu/staff/vidal/titan/

[5] S. Djordjević-Kajan, B. Milovanović, D. Rančić, A. Kostić, Z. Stanić, L. Stoimenov, "Hail Suppression Information System of a Radar Centre", Proceeding of the Conference GIS/LIS'96 Central Europe, Market Driven Developments, Budapest, Hungary, June 12-14, 1996, pp.102-111

[6] D. Rančić, M. Smiljanić, S. Đorđević-Kajan, A. Kostić, P. Eferica, P. Vuković, Z. Vučinić, “Radar data processing for cloud seeding in hail suppression information system”, RADME 98 - Theoretical, Experimental and Operational Aspects of Radarmeteorology, Rome, Italy, 1998, pp. 137-149.

[7] Z. Babić, D. Rančić, V. Mihajlović, I. Antolović, B. Predić, P. Eferica, “Three-dimensional Clouds Modeling for Hail Suppression Information System”, Ninth WMO scientific conference on weather modification, Antalya, Turkey, October 2007.

[8] Rainbow 5.0 application software, http://www.gematronik.com/website/selex/pdf/datasheets/rainbow.pdf

[9] D. Rančić, V. Mihajlović, B. Predić, I. Antolović, P. Eferica, A. Milosavljević, “Clouds Visualization for Hail Suppression Purposes”, Proceedings of the Sixth IASTED International Conference on Visualization, Imaging and Image Processing, Palma de Mallorca, Spain, 2006, pp.116-121.

[10] V. Mihajlović, S. Djordjević-Kajan, D. Rančić, B. Predić, I. Antolović, P. Eferica, Z. Babić, “Architecture of HASIS-3D System Designed for Hail Suppression Purposes”, Proceedings of the XLII ICEST Conference, Ohrid, Macedonia, June 2007, pp.403-406.

[11] E. Gamma, R. Helm, R. Johnson, J. Vlissides, *Design Patterns: Elements of Reusable Object-Oriented Software*, Addison Wesley, 1995