Acta Scientific COMPUTER SCIENCES

Volume 5 Issue 1 January 2023

Research Article

Application of GIS Technology and Map4d Digital Map in Standardizing the Database of Transport Infrastructure Management

Bui Hong Trung[1], Phan Vinh Nguyen[2], Tran Anh Kiet[3], Nguyen Ha Huy Cuong[4] and Trinh Cong Duy[5]*

[1, 2] *Transportation Department of Da Nang City*

[3,4,5] *The University of Danang*

***Corresponding Author:** Trinh Cong Duy, The University of Danang, Danang, Vietnam.

Received: November 18, 2022

Published: December 08, 2022

Abstract

The task of digitizing the entire traffic infrastructure on a digital map for the construction and maintenance of traffic works, management traffic planning, and sharing for relevant agencies to exploit and use has been stated in the digital transformation project of the transportation sector of Da Nang city. But, in the truth, in the management and storage of information and data at the Department of Transport and its units in Da Nang city, it is still done relatively manually and sporadically. Currently, the majority of them still utilize paper or digitized records but still save them separately on personal computers for managing and storing information regarding infrastructure, modes of transportation. There are still inconsistencies and delays in the deployment of information reporting, management information, digitization, and the availability of exploitation channels. When it is necessary to handle and review the information of road transport vehicles, including registration information, vehicle registration, and information about traffic safety infractions, the program does not have connection or data sharing capabilities. The specificity of the data of each transport infrastructure project is that the data is very large, and has many different formats, the information is updated regularly every year according to the maintenance, renovation, and upgrading process, etc. Traditional storage and representation of data, like how database management systems and management software are used, will not meet the demand. In this paper, we propose a solution to build a centralized specialized database, have a specific organizational plan according to the specific characteristics of the industry, and be able to integrate data from specialized applications to connect and unify data between authorities.

Keyword: Management; Storage; Information; Transport; Exploitation Channels

Introduction

One of the six key pillars of a smart city is smart traffic, as can be shown. The intercity and urban road systems are both parts of the Da Nang municipal transportation network. Although there are aviation and train systems here, they mostly support local and interprovincial travel. Individual means of transportation, particularly motorbikes, are primarily used for urban transportation operations [1,4].

The peculiarity of the data of each transport infrastructure project is that the data is very large, and has many different formats, the information is updated regularly every year according to the process of maintenance, renovation and upgrading... if using the traditional way of storing and representing data, like how database management systems and management software are used, it will not meet the demand. Therefore, it is necessary to implement a solution to build a centralized specialized database, have a special organizational plan according to industry characteristics, and be able to integrate data from specialized applications to have

a connection, unifying data between authorities. This will serve as a platform for data sharing and exploitation for professional management work between authorities in the city and the whole country.

In this studying, we focus on researching database types and standardizing methods of database types in the field of transport infrastructure.

Transport infrastructure database

GIS - Geographic information system

An instrument used to map, store, and manipulate geographic data as well as analyze geographic locations is known as a Geographic Information System (GIS). Professor Roger Tomlinson is recognized as the inventor of geographic information systems (GIS) and the term has been in use since the 1960s of 20th century [5].

Figure 1: Geographic Information System GIS.

A well-organized system of hardware, software, databases, and people created to collect, archive, update, analyze, model, and present various types of geographical data in order to address planning and management issues [6].

GIS will dramatically change the rate at which geographic information is produced, updated, and distributed. As a set of thematic layers that can be connected by geographical attributes, GIS holds data about the real world [7,8]. This is a straightforward yet crucial tool that has proven to be highly helpful in resolving a variety of real-world issues, from planning the distribution routes of vehicles to creating reports. Reports in great detail for use in planning or modeling the global atmospheric circulation.

- When geographic data is referenced, either contains explicit georeferences (such as longitude, latitude, or country grid coordinates), or contains hidden georeferences (such as addresses, postal codes, electricity, census tract names, forest area identifiers or street names). Geocoding is an automated process commonly used to generate visible georeferences (multiple locations) from implicit georeferences (which are descriptions, such as addresses). Georeferences allow location of objects (such as forest areas or commercial sites) and events (such as earthquakes) on the earth's surface for analysis purposes.
- Geographic information systems work with two fundamentally different types of geographic data models - vector models and raster models. A vector model encodes and stores information about points, lines, and regions as a collection of x,y coordinates. A single pair of x and y coordinates can be used to describe the position of a point object, like a borehole. Roads and rivers are examples of line objects that can be preserved as a set of point coordinates [9]. A closed loop of coordinates is used to store an area feature, such as a trading region or a watershed area. Things with continuous transitions, such as soil types or the expected expenses of hospitals, are better described using vector models, which are more suitable for expressing discrete objects. For the purpose of replicating such continuous things, the raster model was created. A raster image is made up of a grid of cells. Geographic data is stored using both vector and raster models, each of which has advantages and downsides. Both can be managed by modern GISs.

Figure 2: Two models of GIS - geographic information systems.

Application of GIS in the transport industry

Geographical information system GIS has many applications if people know how to use and exploit their potential. GIS improves people's ability to intuitively, accurately, and rapidly perceive their surroundings. In particular, GIS has significant applicability in the transportation sector.

The planning and maintenance of transport infrastructure is a practical application, but now there is interest in a new area of navigation applications in maritime transport, and electronic charts. This type of feature requires the support of GIS [11,12].

The transportation system is a fundamental element that meets people's travel demands and aids in the continuous and smooth operation of the industrial process. In our country, transportation is more and more focused. To support its economic, cultural, and social activities, our nation has been constructing a transportation infrastructure that is more complete and developed than ever before.

The following are the categories of information that need to be managed in a GIS database: To guarantee the exchange and sharing of information for the system among sectors, municipalities, nationally as well as internationally, the GIS database must be constructed on international geographic data standards and essential procedures [5]. All urban data is managed through an open system called the national GIS database. Data sources created with various hardware and software systems can be used to obtain GIS data. The GIS database usage policy's guidelines must be followed in order to access a GIS database.

In Vietnam, most applications today still use the Google Map platform as a base map and the APIs provided by Google to connect and place their location data. Map data is the sole property of Google and is located on Google's servers, there is no guarantee that Google will not collect and exploit this data, which is inconsistent with the confidential data of businesses or governments [9]. Additionally, Google Map only allows developers to have restricted access to places; they cannot read area data or outline maps, making it unsuitable for use in project and transportation infrastructure management. Besides, there is also another foreign commercial platform, Arcgis of ESRI Corporation [13]. ArcGIS is a software system that offers a solution for geographic information systems. It includes numerous different modules used to store and edit information about GIS in the fields of land, geographical information, and other fields. However, since this is a commercial platform, the cost of copyright is relatively expensive. ArcGIS is mostly used to manage GIS data within a small access region of an agency or organization in Vietnam in general and Da Nang in particular.

Additionally, none of the aforementioned systems allows the representation of 3D objects; they can only handle 2D maps. This is a significant barrier to the management and simulation of visualization for transport infrastructure and urban infrastructure management projects.

Proposed solutions

The Master Architecture of the Smart City in Da Nang describes the project's contents and implementation roadmap in the transport field in great detail [2-4]:

- Smart traffic monitoring and control center: Connect and monitor the public transportation system, connect to the traffic signal system, remotely control traffic lights according to real-time traffic, identify objects, vehicles, and microprocessors, and set up a network of smart surveillance cameras, traffic flow sensors, speed measurement devices, cruise monitoring devices, and vehicle activity monitoring devices. The facility was constructed using the Traffic Signal Operation Center's and public transportation's already-existing infrastructure (existing).
- Transport industry database: Create a database for the transportation sector to serve as a central data repository and a platform for intelligent traffic applications (including transportation infrastructure GIS databases).
- Traffic Portal Application: Building a GIS-integrated traffic portal with features including data on public parking lots, warnings for traffic separation, alerts for congestion on approaching routes, payment of traffic penalties via mobile applications, payment of bus fares, and payment of parking fees via mobile applications (including providing bus information).
- Parking monitoring: In conjunction with the parking monitoring system, the camera system and sensors keep an eye on the status of parking on the streets and in parking

lots, identify parked cars by their license plates, and find unlawfully parked cars. System for finding parking spaces, making reservations, and collecting parking fees.

The construction of information systems on technical infrastructure, urban development in the transportation sector, and the goal of creating e-government and innovative city all necessitate significant investment. These actions are also urgently required to ensure national information security by the Law on Cyber Security and to significantly aid in the smooth and complete management of information by state management agencies in people's homes [4]. For Da Nang city to be ready to implement the goal of becoming a smart city, notably smart traffic - one of the crucial core components, and the best of a smart city - a comprehensive synchronous data infrastructure is being prepared.

The peculiarity of the data of each transport infrastructure project is that the data is very large, and has many different formats, the information is updated regularly every year according to the process of maintenance, renovation and upgrading… if using the traditional way of storing and representing data, like how database management systems and management software are used, it will not meet the demand. Therefore, it is necessary to implement a solution to build a centralized specialized database, have a special organizational plan according to industry characteristics, and be able to integrate data from specialized applications to have a connection, unifying data between authorities. This will serve as a platform for data sharing and exploitation for professional management work between authorities in the city and the whole country.

In addition to having unique characteristics in terms of kind, size, etc., transportation data also has unique properties, therefore big data storage and analysis solutions are required (BigData). A standard digital map is required for the management, representation, and exploitation of these data, which allows the visualization and modeling of traffic infrastructure items and their features plainly visible. Traffic infrastructure data is significant information that belongs to the country and must be kept confidential. It cannot be uploaded to a map platform that is under the control of another nation, so the base map must be the foundation of Vietnam, managed by the Vietnamese.

Solutions to organize GIS data for transport infrastructure

The transportation system is a fundamental element that meets people's travel demands and aids in the continuous and smooth operation of the industrial process. In our country, transportation is more and more focused. To support its economic, cultural, and social activities, our nation has been constructing a transportation infrastructure that is more complete and developed than ever before.

GIS database in traffic management

GIS database serving traffic management includes two components:

- Spatial database
- Generic Attribute Database

The following are the categories of information that need to be managed in a GIS database: To guarantee the exchange and sharing of information for the system among sectors, municipalities, nationally as well as internationally, the GIS database must be constructed on international geographic data standards and essential procedures. All urban data is managed through an open system called the national GIS database. Data sources created with various hardware and software systems can be used to obtain GIS data. The GIS database usage policy's guidelines must be followed in order to access a GIS database.

Traffic information layer in GIS database:

Spatial facilities include:

This space layer is represented and managed by the following objects:

- Line Object
- Roads
- Railways
- Waterway
- Point Objects
- Small concrete bridge
- The bridge is not solid
- Area Objects

- Bus station
- Stations
- Waterport
- Text Objects
- Names of roads
- Names of yards, stations, and ports

The attribute database of this object class has the following structure:

Line objects

Number	Targets	Field name	Data type	Width	Unit
1	Name	Ten_gtd	Char	30	
2	Total length	Dodai_gtd	num	10	Km
3	Width	Dorong_gtd	num	5	M
4	Road level	Cap_gtd	Char	15	
6	Type of road	Loai_gtd	Char	15	
7	Current status	Htrang_gtd	Char	15	

Table 1: Example attribute data of road object.

Point objects

Number	Targets	Field name	Data type	Width	Unit
1	Name	Ten_gtd	Char	30	
2	Object type	Loaidt_gtd	num	30	
3	Length	Dodai_gtd	num	5	M
4	Width	Rong_gtd	num	5	M
5	Weight	Knang_gtd	Char	5	Ton
6	Level	Cap_gtd	Char	15	
7	Current status	Htrang_gtd	Char	15	

Table 2: Example of attribute data of a point object.

Area objects

Number	Targets	Field name	Data type	Width	Unit
1	Name	Ten_gtd	Char	30	
2	Object type	Loaidt_gtd	num	30	
3	Length	Dodai_gtd	num	5	M
4	Width	Rong_gtv	num	5	M
5	Weight	Ddiem_gtv	Char	15	
6	Level	Cap_gtv	Char	15	

Table 3: Example of attribute data of a area object.

Solutions for application of Map4D map background in Da Nang city traffic infrastructure GIS data deployment

In recent years, in Vietnam, the IOTLink Map4D digital map platform is a mapping platform that is being evaluated by businesses, organizations, and ministries as suitable for urban infrastructure management projects and smart cities... The Vietnamese team independently developed, tested, and perfected this solution, which is its most remarkable quality. No other unit from outside of Vietnam was involved in any way. In line with the policy of "Made in Vietnam" with the goal that technology enterprises will "Create in Vietnam, Made in Vietnam, Designed in Vietnam." The following are some differences between the proposed IOTLink Map4D technology platform for application in the traffic infrastructure representation and data exploitation that the project proposes to implement:

- Currently, there are few similar solutions in the world. In Vietnam, this is the only 4D digital mapping platform to date designed, deployed, and wholly owned in Vietnam.,
- Is the only map in Vietnam that can display 4D (3D space and the fourth dimension is time and sensors) on the map quickly,
- Located in Vietnam and map data is completely owned, so security and confidentiality are guaranteed,
- Is a wholly Vietnamese solution that complies with the Law on Cybersecurity requirements,
- The base map is updated continuously and is not dependent on any third party, so the data will be updated faster and more accurately with foreign map platforms,
- High accuracy, compatible with popular coordinate systems in the world and Vietnam (WGS84, VN2000, HN72),

- The system is ready to use the newest technologies, including VR, Machine Learning, and WHO, and is capable of integrating IoT technology solutions for all items on the map, integrating BIM for construction projects, and more,
- Provide a complete SDK so that third parties can create 4D map applications for commercial products.

For major national projects in Vietnam, such as the Map Module under the Project of Vietnamese Digitization Formatting System, this map platform has been chosen as the basis map system. The Fiotlis Land Management project's base map replaces the Vilis version, and the vPostCode National Postal Address Code project's mapping platform has been launched and put into use.

Conclusions and Recommendations

In this paper, we conduct research and make recommendations for organizing traffic infrastructure data combined with digital maps to suit application requirements. In addition to having unique characteristics in terms of kind, size, etc., transportation data also has unique properties, therefore big data storage and analysis solutions are required. Traffic infrastructure data is significant information that belongs to the country and must be kept confidential. It cannot be uploaded to a map platform that is under the control of another nation, so the base map must be the foundation of Vietnam, managed by the Vietnamese. IOTLink Map4D is the 4D digital map platform we advise employing. The IOTLink Map4D map platform differs from other platforms in that it also permits the depiction of 3D objects, which other platforms do not. This technology is ideally suited to represent and simulate the reality of smaller objects. Roads, bridges, trees, electricity poles, traffic signs, buildings, constructions, and other urban features on the map assist in visually managing the metropolitan region. In addition, managing things over time is a crucial technology for controlling the life cycle of objects and their status over time.

Bibliography

1. Government of Vietnam, Decision No. 749/QD-TTg of the Prime Minister: Approving the "National Digital Transformation Program to 2025, Orientation to 2030". (2020).

2. Ministry of Transport, Decision No. 2269/QD-BGTVT of the Minister of Transport. "The Program on Digital Transformation of the Ministry of Transport until 2025". (2020).

3. Da Nang City, Decision 2870/QD-UBND 2021 of the Chairman of Da Nang City People's Committee. "Digital Transformation Project in Da Nang City to 2025, Orientation to 2030". (2021).

4. Department of Transport of Da Nang City. "Digital Transformation Plan of Da Nang Transport Sector". (2021).

5. Goodchild Michael F. "Twenty years of progress: GIScience in 2010". *Journal of Spatial Information Science* (2021).

6. Jump up to: a b c Heywood I, Cornelius S, Carver S. An Introduction to Geographical Information Systems, Essex, England: Prentice Hall (2006).

7. Chang, KT. "Introduction to Geographical Information Systems". New York: McGraw Hill. (2008).

8. Longley PA., *et al*. "Analysis of errors of derived slope and aspect related to DEM data properties". *Geographic Information Systems and Science* (2005).

9. Maliene V., *et al*. "Geographic information system: Old principles with new capabilities". *Urban Design International* (2011).

10. Ramm Frederick., *et al*. "OpenStreetMap: Using and Enhancing the Free Map of the World". UIT Cambridge (2011).

11. Lardinois Frederic. "For the Love of Mapping Data". (Interview) TechCrunch, (2014).

12. Chang Kang-tsung. "Introduction to Geographic Information Systems (9th ed.)". McGraw-Hill, (2016).

13. "The 50th Anniversary of GIS". ESRI (2013).