Azerbaijan Journal of High Performance Computing, Vol 6, Issue 1, 2023, pp. 3-18
https://doi.org/10.32010/26166127.2023.6.1.3.18

Research on Database Types and Methods to Standardize Database Types in the Field of Transport Infrastructure

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Abstract

In truthfully, managing and storing information and data at the Department of Transport and its units in Da Nang city is still done 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, etc. (.doc, .xls, .pdf files, Autocad, Video, Audio, Images, ...). Storing, maintaining, looking up, and discovering information is greatly hampered by this. There are still inconsistencies and delays in the deployment of information reporting, management information, digitization, and the availability of exploitation channels. In line with the Ministry of Transport's strategy, information technology should be used to manage transportation activities. Organizations and units in the transportation industry across the nation have developed and implemented various specialized software to assist in managing road transport. Software solutions have offered management information, enhancing professional management effectiveness. The deploying units use each software system separately, storing and handling specialized data in various ways. 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 a connection or data sharing capabilities. To access and compare data, expert employees must look for information and data on each software system to retrieve and compare data. 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 data representation, 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. This will be a platform for sharing and exploiting data for professional management between authorities in the city and the whole country. The people and state management agencies highly appreciate this solution, which has been researched and implemented experimentally in Danang City.

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

1. 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 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 (Nguyen, H. H. C., & Nguyen, T. T., 2014, November).

According to Da Nang Department of Transport statistics, until January 2015, there were 1143.5 km of roads throughout the city, excluding alleys in residential areas and internal roads. The road in the urban area is 838.2 km, accounting for 73% of the total road length in the city's entire network. National highways, provincial roads, district roads, and commune roads have lengths of 119.3 km (10%), 75.21 km (7%), 64.65km (6%), and 46.1km (4%).

In truth, managing and storing information and data at the Department of Transport and its units in Da Nang city is still done 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, etc. (.doc, .xls, .pdf files, Autocad, Video, Audio, Images ...). Storing, maintaining, looking up, and discovering information is greatly hampered by this. There are still inconsistencies and delays in the deployment of information reporting, management information, digitization, and the availability of exploitation channels. In line with the Ministry of Transport's strategy, information technology should be used to manage transportation activities. Organizations and units in the transportation industry across the nation have developed and implemented a variety of specialized software to assist in managing road transport. Software solutions offer management information, enhancing the effectiveness of professional management (Nguyen, H. H. C., Solanki, V. K., Van Thang, D., & Nguyen, T. T., 2017; Sossa, M. A. R., 2016). The deploying units use each software system separately, storing and handling specialized data in various ways. 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 a connection or data sharing capabilities. To access and compare data, expert employees must look for information and data on each software system to retrieve and compare data (Stillwell, M., Schanzenbach, D., Vivien, F., & Casanova, H., 2010).

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 (Walsh, W. E., Tesauro, G., Kephart, J. O., & Das, R., 2004, May). 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 study, we focus on researching database types and standardizing methods of database types in transport infrastructure.

2. Related Work

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 the 20th century (Xiao, Z., Song, W., & Chen, Q., 2012).

Spatial data and their attributes are represented and interpreted using GIS software and data. Programs create maps in non-technical terms. Depending on the data available and the application, it can draw any map it wants. The GIS attaches data to physical features such as roads, houses, lots, and waterways. Rensema et al., 2000; Mel Nick, 2002 store this information in a database that is easily accessible through a GIS (Baidal, C. S., Arreaga, N. X., & Padilla, V. S., 2020; Papaioannou, I. V., Tsesmetzis, D. T., Roussaki, I. G., & Anagnostou, M. E., 2006, April; Lai, Y., & Zeng, J., 2013).

For example, a plot of land has a physical location on earth, but looking at it alone does not provide details about it. Aside from where it is in relation to the earth, it doesn't indicate its owner, composition, zoning restrictions, or any other information regarding its area. In Appendix A, you will find a GIS-based map of Bakersfield, California (Feddaoui, O., Toufouti, R., Jamel, L., & Meziane, S., 2020; Pickles, J. Ed.; United House Representatives., n.d.). The city of Bakersfield provided community development information more effectively using GIS technology because of its visual presentation capabilities. In addition, the city demonstrated and recognized the benefits of GIS technology to its stakeholders. Communicating and collaborating with planners, architects, developers, and interested parties through workshops were improved.

Additionally, because the map became a repository of existing and proposed projects, a GIS-based project was developed to store all the information about the project, which increased efficiency, accuracy, and productivity by extrapolating and integrating it into other applications. Geospatial data are also analyzed and manipulated with GIS systems. Randall et al., 2005) argue that good GIS also serves as a Decision Support System (Pickles, 1995; Baidal, C. S., Arreaga, N. X., & Padilla, V. S., 2020; Rensema, T., Erickson, C., & Herda, S., 2000; USGS Science for a Changing World Geographic Information Systems).

3. Transport Infrastructure Database

3.1. GIS - Geographic Information System

Fig. 1: Geographic Information System GIS

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

GIS will dramatically change the rate at which geographic information is produced, updated, and distributed. Additionally, GIS altered how geographic data was analyzed. Two significant benefits of GIS over paper maps are as follows::

- Easy to update geographical data.
- Effectively combines many data sets into one database.
- As a set of thematic layers that geographical attributes can connect, GIS holds data about the real world. This straightforward yet crucial tool has proven to be highly helpful in resolving various 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 (Yazir, Y. O., et al., 2010, July; Zhan, F. B., 1997).

When referenced, geographic data either contains explicit georeferences (such as longitude, latitude, or country grid coordinates) or 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 the 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 (Nguyen, H. H. C., Nguyen, D. H., Nguyen, V. L., & Nguyen, T. T., 2020). A closed loop of coordinates stores 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. To replicate such continuous things, the raster model was created. A raster image is made up of a grid of cells. Geographic data is stored using vector and raster models, each with advantages and downsides. Modern GISs can manage both.

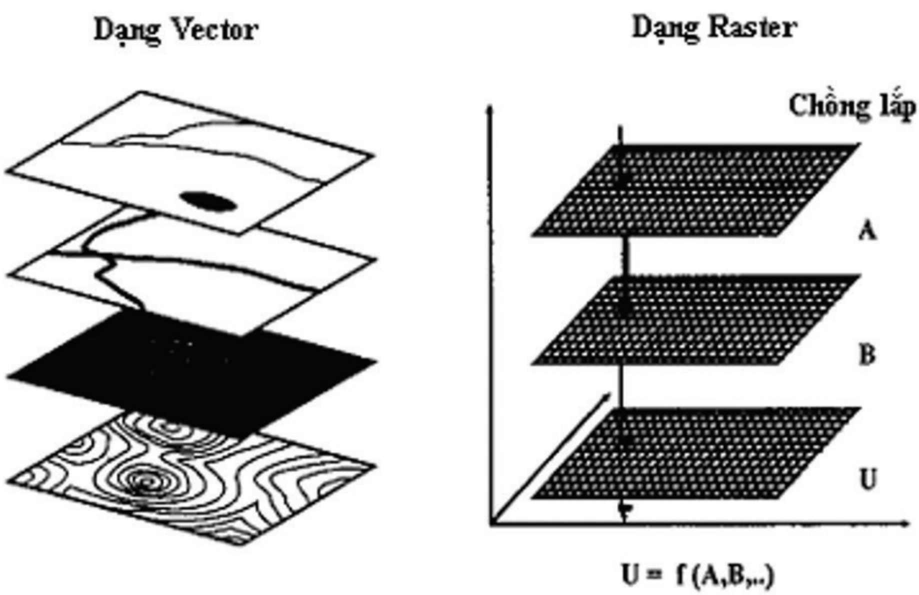

Fig. 2: Two models of GIS - geographic information systems

The GIS-based database consists of 2 parts:

- Spatial database (base map)

- Generic Attribute Database

* Base Map

A base map is a map that includes only the geographic base element. It serves as the foundation for locating things in specialized data geographically. A map's geographical basis expresses additional map contents by using hydrology, transportation, population, national borders, administrative boundaries, place names, and terrain as a foundation.

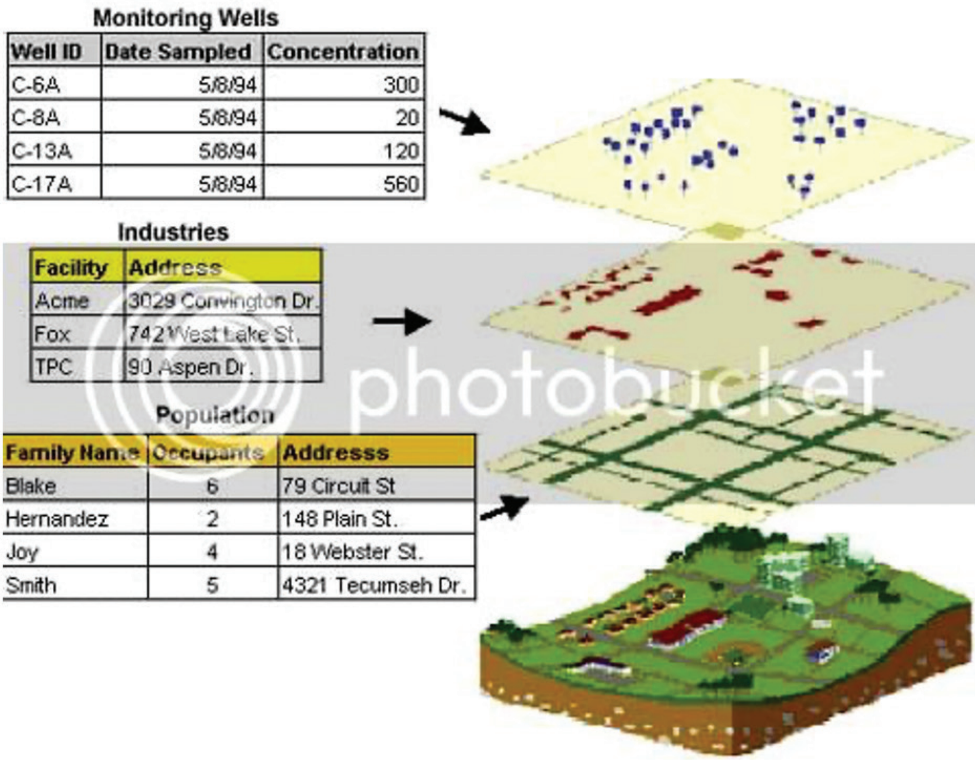

Fig. 3: Base map in GIS

Base maps are divided into two groups: general geography maps and thematic geographies:

A general geography map is a map showing all geographical objects and phenomena of the earth's surface, including a full range of economic, cultural, and social objects and phenomena such as hydrology, topography, vegetation, land, population, transport, industry, agriculture, forestry, culture, and administration-politics. The general geography map content level may be more or less detailed depending on the map's scale. However, a general geographic map generally depicts all objects and phenomena with the same level of detail, so avoid focusing on one aspect or underestimating another when looking at a map at a particular scale.

The thematic geographical map has a division between the main content and sub-content. The main content is thematic map content, while the secondary content is the basis of geographical elements, also known as the base map. Since thematic maps show chosen content in connection to other components of the geographical environment landscape, they cannot be created without simply thematic content. As a result, thematic content displayed on the base map is used to build themed maps. Thus, one of the crucial steps in developing themed maps is creating the base map database.

3.2. 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 (Sofian, H., Ming, J. C., Muhammad, S., & Noor, N. M., 2019).

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 serving traffic management includes two components:

- Spatial database
- Generic Attribute Database

The following categories of information need to be managed in a GIS database: To guarantee the exchange and sharing of information for the system among sectors, municipalities, nationally, and 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 to access a GIS database (Feddaoui, O., Toufouti, R., Jamel, L., & Meziane, S., 2020; Baidal, C. S., Arreaga, N. X., & Padilla, V. S., 2020).

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. Additionally, Google Maps only allows developers restricted access to places; they cannot read area data or outline maps, making it unsuitable for project and transportation infrastructure management (Papaioannou, I. V., Tsesmetzis, D. T., Roussaki, I. G., & Anagnostou, M. E., 2006, April).

In addition to Google Maps, MapBox, OpenStreetMap, Here, Apple Map, Bing Map, MapInfo, and a few other map platforms are utilized in Vietnam. These platforms all share Google Maps as a standard feature. However, compared to Google Maps, the data and convenience still need to be better, and these platforms' limitations make them unsuitable for the state's programs to manage the data for its urban infrastructure.

In Vietnam, there is also another foreign commercial platform, ArcGIS of ESRI Corporation (Environmental et al. Institute). ArcGIS is a software system that offers a solution for geographic information systems. It includes numerous modules that store and edit information about GIS in the 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 (Lai, Y., & Zeng, J., 2013; Melnick, A. L., 2002). It is typically installed on an internal network or a single employee's PC. Due to the high deployment costs of software licensing and server infrastructure, as well as the extremely specific requirements for the ability to integrate other applications, it is very challenging to use ArcGIS to deploy systems that serve multiple users on the Internet in the form of a Web interface or to integrate into mobile software similar to Google Map or OpenStreetMap platforms. Another significant issue is that because this program is proprietary and closed source, altering it to meet customer needs is exceedingly challenging.

In Da Nang city, in recent times, the collection and management of map data have been mainly implemented based on ArcGIS and Google Maps software. The Department of Natural Resources and Environment manages cadastral data using ArcGIS. However, data sharing is still challenging because most data is kept internally on the department's server. Other units share data primarily by copying files and emailing the original data, which results in many areas for improvement in data synchronization when there is a new update. The same issue arises when dealing with the traffic infrastructure data of the Hai Chau District (Zhan, F. B., 1997; Nguyen, H. H. C., Nguyen, D. H., Nguyen, V. L., & Nguyen, T. T., 2020). In 2015, the district conducted measurements and data storage into ArcGIS; however, because this data is stored on the Department's local system and is difficult to share with other units, the only option at the moment is to send the entire data file which cannot be divided or limited in the data shared. Most data has not been updated or supplemented since 2015, although traffic infrastructure data is constantly changing and updated often. These are also the problems that the topic will focus on solving based on inheritance and overcoming these limitations.

Additionally, those mentioned above systems need to allow 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.

4. Proposed Solutions

According to Decision No. 164/QD-UBND dated January 11, 2018, the People's Committee of Da Nang City issued the Master Architecture of Smart City in Da Nang City, which outlines the principles, architecture, technology, following the World's Standards and the current IT and socio-economic status of Da Nang; ensure synchronous, compatible, efficient, and economical deployment (Stillwell, M., Schanzenbach, D., Vivien, F., & Casanova, H., 2010; Nguyen, H. H. C., Nguyen, D. H., Nguyen, V. L., & Nguyen, T. T., 2020; Baidal, C. S., Arreaga, N. X., & Padilla, V. S., 2020). Likewise, for 17 areas requiring implementation, an ICT application's architectural model has been presented in the Master Architecture of the Smart City in Da Nang. This project describes the project's contents and implementation roadmap in the transport field in great detail:

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—a 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 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 (Melnick, A. L., 2002; Zhan, F. B., 1997; Sofian, H., Ming, J. C., Muhammad, S., & Noor, N. M., 2019). 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.

In truth, managing and storing information and data at the Department of Transport and its units in Da Nang city is still done 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, etc. (.doc, .xls, .pdf files, Autocad, Video, Audio, Images ...). Storing, maintaining, looking up, and discovering information is greatly hampered by this. There are still inconsistencies and delays in the deployment of information reporting, management information, digitization, and the availability of exploitation channels. In line with the Ministry of Transport's strategy, information technology should be used to manage transportation activities. Organizations and units in the transportation industry across the nation have developed and implemented a variety of specialized software to assist in managing road transport. Software solutions have offered management information, enhancing professional management effectiveness. The deploying units use each software system separately, storing and handling specialized data in various ways. 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 a connection or data sharing capabilities. To access and compare data, expert employees must look for information and data on each software system to retrieve and compare data.

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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 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 under another nation's control, so the base map must be the foundation of Vietnam, managed by the Vietnamese.

4.1. 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 serving traffic management includes two components:

- Spatial database
- Generic Attribute Database

The following categories of information need to be managed in a GIS database: To guarantee the exchange and sharing of information for the system among sectors, municipalities, nationally, and 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 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

Table 1: Example attribute data of road object

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 2: Example of attribute data of a point object

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 3: Example of attribute data of an area object

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	

4. 2. Solutions for the 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 has been a mapping platform that businesses, organizations, and ministries evaluate 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.,

- It 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 wholly owned, so security and confidentiality are guaranteed,
- It 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 that 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 third parties can create 4D map applications for commercial products.

This mapping platform has been chosen as the basis map system for major national projects in Vietnam, such as the Map Module under the Project of Vietnamese Digitization Formatting System. The Fiotlis Land Management project's base map replaces the Vilis version, and the postcode National Postal Address Code project's mapping platform has been launched and put into use. In addition, several significant partners are researching and implementing this platform into large enterprise solutions, including Mai Linh; Batdongsan.com.vn; VnPOST; VNPT Ho Chi Minh; collaborate with Viettel;

5. Conclusions and Recommendations

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 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 under another nation's control, 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 platform's ability to display maps with all their features, just like other map platforms like Google Maps, OpenStreetMap, HereMap, Mapbox, Arcgis, AppleMap, and BingMap, reflects the project's 4D component. 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. This is also the fourth D of this platform (4D).

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Submitted: 09.11.2022
Accepted: 27.02.2023