GIS for USU campus transportation asset management

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Abstract. Transportation infrastructures consume a large number of resources, and managing infrastructure assets is a big issue in the public sector. Transportation asset management is important to obtain optimal performance as a result of maintaining, upgrading, operating assets, and making decisions. This paper proposes a concept to support campus management to maintain transportation assets by using the GIS database for maintenance and rehabilitation concerns. Universitas Sumatera Utara (USU) was one of the biggest universities in North Sumatera, consist of 16 schools and faculties with total area + 120 ha. Transportation infrastructure at the USU Campus includes roads, pedestrian facilities, and parking areas. Transportation asset management based on GIS could combine with the budgeting system that supporting the decision-makers to recognize leads better outcomes for organizations.

1. Introduction
Asset management is an important issue in public sector organizations in Indonesia to obtain optimal results and according to function in line with organizational goals [1]. In its broadest sense, asset management is an emerging effort to maintaining, upgrading, and operating assets, combining engineering and economic principles to facilitate a more organized approach to making the decisions [2].

Transport Asset Management is the strategic and systematic process for operating, maintaining, upgrading, and will assist the determination of transport solutions by identifying the need for new investment and enabling maintenance of existing assets in a sustainable condition effectively throughout their life cycle [3]. It is focused on the business and engineering practices for resource allocation and utilization with the objective of better decision making based upon quality information and well-defined objectives. Transportation infrastructure at the Universitas Sumatera Utara (USU) Campus includes roads, pedestrian facilities, and parking areas, which is one become the important facilities.

Increasing the number of students who use motorized vehicles each year, will affect the road capacity and the need for the parking area. If there is insufficient parking space, the vehicle will probably use on-street parking, which will hamper the circulation of traffic flow in the campus area. USU has embraced sustainable transportation infrastructure concepts to meet current and future public expectations. In asset management, the problem that commonly occurs is the lack of data and is not updated. The absence of an appropriate management system can hamper the operational activities and can lead to inefficient financing of an institution [4]. Asset Management based on GIS could map out and describe transport facilities in detail and provide access for planners and decision-makers to recognize the campus features and their properties [5].

Transportation asset management serves as a key tool to manage existing assets in a way to better and efficiently operate and maintain all the transport assets. Managing Transportation assets is not a new concept, this paper proposes a concept to support campus management to maintain transport infrastructure asset and develop the budgeting system for maintenance concerns. An asset management system requires an asset registry (inventory and attributes) combined with a maintenance management system using a geographic information system.
2. Transportation asset management based on geographic information system (GIS)

Asset management is defined as a systematic process of maintaining, upgrading, and operating the physical assets cost-effectively. It combines engineering principles and economic theory to provide the tools necessary to facilitate a more effective, and leads to better outcomes for organizations [6].

As it applies to Transportation asset management, provides the systems that integrated the operation system and planning of the transportation infrastructure. It has an application that allows decision making based on a preliminary analysis of comprehensive information related to the conditions of pavement road, pedestrian, and parking area based on spatial data. GIS is an information system that presents information by using maps as an interface and composed of several layers [7] designed to work using data that has spatial information.

![Figure 1. Transport infrastructure asset information system](image)

Geographic data is composed of two components, namely spatial and attribute data. Spatial data is data with geographical references for objects representation on earth, contains interpretations and projections of phenomena on earth [8]. While the attribute data describes the characteristics of the phenomenon of an object in the map and has no relationship with the geographical position. Asset management for well-managed transportation facilities, the organization can get the following benefits (TRB, 2008):

- Better quantify the condition assets
- Collect the data to drive the organization’s decision making.
- Determine the use of funds
- Improve system performance

3. Universitas Sumatera Utara’s transport asset management

Universitas Sumatera Utara (USU) was one of the biggest universities in North Sumatera, consist of 16 schools and faculties with total area + 120 ha. Recently, students prefer to use motor vehicles as a means of transportation to go to campus for some reason. A study conducted in 2014 revealed that there was approximately a total of 62,000 units of motor vehicles on and around the USU campus on a day-to-day basis.

Transport infrastructure at the USU Campus includes roads, pedestrian facilities, and parking area. Infrastructure asset management at campus is often perceived as a technical issue. For strengthening the overall management of Campus Authority, develop an asset management system is important. While Campus Authority provides funding for the infrastructure assets that necessary to deliver public services, many are less cognizant of the need to properly maintain and utilize these assets.
3.1. Transportation planning and budgeting

The key functions associated with the maintenance and rehabilitation treatments include the range and average life span, and the performance improvement after the treatment in terms of the index values [9]. Transport infrastructure management requires proper planning and budgeting to ensure their success. Depending on the size, a road maintenance project can be quite resource intensive compared to the parking area and pedestrian. Even minor projects like the crack and pothole filling of a private driveway will still consume significant resources especially if you do not plan and budget properly before implementing the project. That is why you should always plan and budget properly and carefully before launching the project.

Figure 2. Campus of Universitas Sumatera Utara

Figure 3. Transport Infrastructure lifecycle in USU
USU is currently faced with the need to fund many more transportation assets than the available funding (budget constraint). So, it is essential that USU maximize the effectiveness of funding sources available, and make certain that all USU funding is well utilized.

3.2. Cost estimation of transportation asset maintenance

Cost estimation is an essential component of infrastructure projects and increases toward the end of the project due to detailed and precise information [10, 12]. A maintenance cost estimation is required Campus Authority in the budgeting stage to keep the transportation asset in good condition. The total maintenance cost depends on the quality of the transport infrastructure condition and how much maintenance it requires.

Additional data not included in the spatial attribute tables are required for estimating quantities and costs. The non-spatial attribute tables of maintenance are grouped into three as follows:

| Table 1. The unit price for each construction element. |
|-----------------------------------------------|
| No | Cost Item | Unit cost | Unit Price (IDR) |
|----|-----------|-----------|-----------------|
| 1  | Road network |            |                 |
|    | Patching   | M3        | 1,355,618.40    |
|    | Road marking| M2        | 339,000.00      |
|    | Overlay    | Ton       | 1,093,209.00    |
| 2  | Pedestrian |           |                 |
|    | Paving blocks | M2     | 265,000.00      |
|    | curb       | M3        | 301,000.00      |
|    | Painting   | M2        | 37,000.00       |
|    | Roof installation | M2     | 363,000.00      |
| 3  | Parking area |          |                 |
|    | Road marking| M2        | 339,000.00      |
|    | Access gate | Unit      | 4,000,000.00    |
|    | Roof installation | M2  | 450,000.00      |

The detailed data like unit costs and unit price in the prepared non-spatial attribute tables are used for estimating cost. Unit price is a calculation of cost items in a particular quantity and quality. Cost estimation of the transportation asset as the owner estimates are required at the early stages of a project used to describe the process of predicting a project’s cost before project construction through the tender process. Gould defined estimate as an appraisal, an opinion, or an approximation as to the cost of a project before its construction [11, 13].

4. Result and discussion

GIS tool has capabilities to interface with the database and the map component (spatial attribute). One of the key aspects of developing Asset Management is data collection. Data collection and condition assessment exercise was conducted in 2019.

4.1. Transport asset spatial data

USU Campus’s transportation infrastructure covers the construction, maintenance, and operation of:

- 7.34 kilometers of roads
- 13.62 kilometers of pedestrian
- 7129 square meters of the parking area

Asset management should enable management graphical and attribute information about the transport infrastructure, as shown in figure 4.
4.2. Transport asset cost estimation
The spatial analysis involves two types of processes, namely retrieval of spatial data and quantity estimate. The quantity estimate requires different spatial attributes such as coordinate, area, perimeter, length, and width. The quantity estimate requires different spatial attributes such as coordinate, area, perimeter, length, and width.

An example of GIS implementation regarding an estimate of the construction cost, campus plans to connect all pedestrian facilities, as can be seen in figure 5.

Figure 4. Campus’s transport infrastructure.
Figure 5. Location of pedestrian work plan.

For pedestrian development plans, work volume, and location can be seen in the GIS, but the unit price was taken from external sources and entered manually. Calculation of the pedestrian area from the GIS attributes and the price of installing paving, curb, and painting, the total cost estimated is IDR 746,499,200 for 1,052 square meters of the pedestrian.

5. Conclusions
USU as an agency needs to develop an asset management system, with goals of cost-effectiveness, efficiency and public accountability will be at the forefront. The proposed system in this study could improve asset management planning processes based on the information of integration of the spatial, and non-spatial data.

Users can estimate for maintaining and upgrading the transport asset, with two main functions: estimating the construction cost and visualizing in GIS application. Integrated transport asset mapping with planning and budgeting tools so that operational, and maintenance expenses can be centrally managed and accounted for.

Forecasting processes depend on accurate predictions that are based on real conditions and plan development. Unavailability of transport asset information is an obstacle for the budgeting process. GIS gives accurate information, that enables the user to understand the whole situation early, then decision making can be more effective.

The integration of asset information, planning, and budget information make it easier for the asset manager to monitor and control the transport asset development. GIS provides a wide range of information and an effective tool for integrating and managing various types of information such as spatial and non-spatial data required for the transport asset management system.

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