The Production of Assets Inventory by using a 360-degree Camera Mobile Mapping System in Langkawi, Malaysia

S Abdullah¹, K N Tahar², M F A Rashid³, M A Osoman⁴, F Abdullah⁴

¹Centre of Studies for Surveying Sciences and Geomatics, Department of Built Environment Studies and Technology, Universiti Teknologi MARA, Perak Branch, Seri Iskandar Campus, Seri Iskandar, 32610 Perak, Malaysia
²Centre of Studies for Surveying Science and Geomatics, Faculty of Architecture, Planning and Surveying, Universiti Teknologi MARA, Shah Alam, 40450, Malaysia.
³Centre of Studies for Town and Regional Planning, Department of Built Environment Studies and Technology, Universiti Teknologi MARA, Perak Branch, Seri Iskandar Campus, Seri Iskandar, 32610 Perak, Malaysia
⁴Geoinfo Services Sdn Bhd, 30, Jalan Bandar 2, Taman Melawati, 53100, Kuala Lumpur, Selangor, Malaysia

suzan156@uitm.edu.my

Abstract. Asset management system is a crucial element of a utility project because it helps a company to inspect the asset inventory systematically. Besides, it improves productivity and proficiency of companies to position them better and increases their return on investment. The traditional system of data collection is very tedious in producing an asset inventory system. This study offered a mobile mapping system (MMS) by using 360-degree cameras to reduce the time and cost involved in data acquisition. The aim of this study was to locate, digitise, measure, and tag the assets along the street network. The efficiency of these 360 technologies was investigated to obtain asset data for a 3D street view utility mapping and provide important information. The obtained image will be used to determine the location of observed asset. The digitising process was required to label the detailed asset information as well as map the asset. This technology consists of a combination of camera, Global Navigation Satellite System (GNSS), and Inertial Measurement Units (IMU). The efficiency of this technology was tested by mounting it on a vehicle such as car or motorcycle. The geo-referenced images were derived by using sensor models and were pro-cessed to produce a 2D information mapping for utility purposes. The study resulted in producing a digital map with Geographical Information System (GIS) spatial data and 360-degree imagery. Having such a system in place allowed to track the overall achievements of asset inventory, and thus utilised efficiency.

1. Introduction

Asset inventory management is generally made in an infrastructure project for any property maintenance. Typically, the maintenance and updating process involve the longest duration and project cost [9]. The cost required for repairing and replacing the asset is very high and very tedious in acquiring data for the assets management system development. Therefore, with an integrated system of the 3D mobile mapping system, the process of maintaining and updating the asset is more manageable with an
appropriate format for documenting the asset inventory. Moreover, the system will reduce data acquisition time significantly [10].

At present, 3D mobile mapping system is considered as the most advanced technology for land survey [1]. It has become a very popular survey method in many science and engineering applications especially in transportation [3]. This technology is a common integrated system that allows survey sensors to be mounted on a vehicle such as a car or motorcycle. Conventionally, the information for asset inventories (or other related utilities), include a manual, automated, semi-automated and remote collections [2], such as global positioning system (GPS) and total stations to record the spatial data of assets. This traditional way requires more time for data acquisition, and thus it is very timely to look at other options like the 3D mobile mapping technology. Other than that, the large amount of raw data collected requires some processes to detect the asset types, such as lampposts and traffic signals. The asset needs to be categorised and information about its dimension, condition, and location requires extraction [4].

A strategic and systematic processes to manage, maintain, and enhance physical asset is through the collection of accurate spatial and attributes data information, focusing on quality data. It is important to determine that the asset management structure will achieve and maintain the desired repair conditions with minimum practical cost. In general, the asset inventory management was implemented in previous studies such as roadway and engineering construction projects [1]; [8]; [11]; [6]; [5] by using several mobile mapping technologies such as laser scanning, Light Detection and Ranging (LiDAR), Global Positioning System (GPS), and total stations. Recent advances in digital mapping and GIS technology have improved the competency and efficiency of asset inventory management. Inspired by this, the current study demonstrates the application of the 3D mobile mapping with a 360-degree camera for the production of assets inventory by integrating it with Inertial Measurement Units (IMU), and Global Navigation Positioning Satellite System (GNSS). With those attempts, it will significantly reduce the data acquisition time with an appropriate sensor setup that allows a maximised data collection process.

2. Methodology

2.1 Study Area

In this study, a case study was selected for the asset inventory images. It was located along a street in Chenang District, in Langkawi (6° 17’ 56.17 N latitude, 99° 43’ 17.89” E longitude) (Figure 1). The study area was allocated as one of the country’s top destination for tourism development due to its abundant natural resources. Moreover, the location has potential to be harnessed to maintain its attractiveness, comfort and satisfaction for tourists. Therefore, the government and private agencies need to provide or improve the asset inventory and other facilities for tourism.

Figure 1. The Study Area
2.2 3D Mobile Mapping Technology
In this study, mobile mapping system was used to obtain a high-resolution image and provide high flexibility in feature extraction, analysing and displaying geospatial data. This technology is equipped with IMU, a high-precision GNSS and a 360-degree camera that is capable of capturing the position of assets and any relevant surrounding information efficiently. Camera Vector (CV) technology is provided by Iwane Laboratory from Japan. The mobile mapping system installation was also designed to make it flexible for mounting on all types of vehicles such as a sedan, pickup truck, and small car land cruiser, which can run quickly. Figure 2 shows the 360 mobile mapping system equipped in a small car (Perodua).

![Figure 2. The 3D Mobile Mapping System Equipped with a 360-degree Camera](image)

2.3 Data Acquisition Process
Several processes were involved in data acquisition (Figure 3). The survey operations began by setting the instruments of GPS, camera and IMU mounted on a specific location on the survey vehicle roof (Figure 4). To avoid unobstructed satellite signals it was essential to consider the stability of platform for GPS antenna, camera and IMU position throughout data acquisition [9]; [7]. Position and orientation of the camera can be determined by using GPS and IMU devices mounted on the survey vehicle, which helped in determining the coordinates of points captured by the camera sensor in mapping coordinate system.

![Figure 3. Data Collection Process using a 360-degree Camera Mobile Mapping System](image)
Upon installation, the calibration process was acquired before conducting the site survey or inventory. HELI calibration is a process to determine the base position between camera and GPS, the sensors before they were deployed. It is important to make it a robust system which enables the sensors to work and collect data accurately. This process requires adjustment of the GPS position to be parallel to the camera position during data collection. Besides, the setting of known target points is also required to determine the desired coordinates of captured images. In this situation, the survey vehicle needs to stay at one place for 5 min to 6 min before starting and finishing the data collection. Figure 5 shows the process during data collection: (a) the process of configuration and setting satellite position, (b) process of collecting asset information along the street road, and (c) end of data collection process. Observations and all visible targets were collected into a data input file with x and y coordinates.

2.4 Data Processing

In this study, the raw data was processed by using the Camera Vector (CV) Image Creator software. Figure 6 shows the raw data captured by a 360-degree camera mobile mapping system. Moreover, several processes needed implementation to obtain the final results.
The detailed process is shown in Figure 7. The modelling procedures were divided into eight processes, such as creating mask, creating IGA, GPS tracking, calculation CV, image enhancing, producing movie, digitising process, and result of 3D data.

All images captured by the 360-degree camera mobile mapping system were uploaded to the CV image creator software. The first process was masking the image for unnecessary data surrounding. This process was required to remove the shooting vehicle and surrounding the mask range. The next process was to create the IGA (IsoGeometric Analysis) file which was to locate the position of GPS Antenna. The GPS track log was needed to match the GPS time and images. The GPS time should be synchronised with the GPS time of Garmin and IMU for high-precision position.

Then, to create both project files, the masking file and GPS antenna file were put together. In this situation, the images captured from the 360-degree camera mobile mapping required the x and y positions from GPS data. The CV calculation was one of the processes to obtain the score of CV graph. The graph must show a calculation range of 80% and above, which is based on the GPS data. If the graph gets a value of below 80%, the CV calculation needs correction. This is important to remove the vibration in image and output to avoid from error distortion. Image enhancement is an important process to enhance the brightness and colour of image in order to maintain the quality of video produced.

3. Result and Discussion
Upon accomplishment, a movie about the site was produced. Then, it was used for extracting features (desired images or asset) by using the ALV software. ALV is the web-based server which has an
extension to the ArcGIS software platform. ALV for GIS is an advanced and sophisticated software designed for the analysis and management of spatial data obtained by MMS. ALV for ArcGIS offers a powerful extension for ArcGIS Desktop to connect directly with the geodatabase that visualise the geospatial data. To provide the asset inventory management, the feature extraction is implemented by ALV software that provides a direct link with the GIS database. This software provides a linkage with 2D map and geodatabases that is can import data from GIS databases, such as the location of x, y, z for assets and features as lines, points, and polygons.

As shown in Figure 8, the movie was produced by processing the raw image data into zic or izic format. The product was seen in ArcGIS by using the Active Link Version (ALV) plug-in software. The process involved data processing from the raw data until a video product, which was a movie produced as the basis of assets inventory database.

The video product was used to extract the asset along the street road by using ArcGIS software. The digitising and extracting processes were required to locate the assets and tag information along the street road, such as electricity pole, fire hydrant, and signboard. It was also capable of measuring and recording the asset conditions along the street road based on the implemented elements such as georeferenced video, data management of the video and navigation. Figure 9 illustrates digitising and extracting result of assets from the video product that was produced. All asset information along the street road was kept.
in shapefile database. The uniqueness of this system is its ability to digitise asset information by using 3D (video/movie), which was more efficient than other methods that use 2D to digitise the asset data.

![Image](image.jpg)

**Figure 9.** Digitising and Extracting 3D Spatial Data by using ALV for ArcGIS Software.

4. **Conclusion and Recommendation**
This paper has successfully demonstrated the application of a 360-degree camera mobile mapping system which is the assets inventory. As compared to the conventional methods, such as by using handheld GPS or total station technology, this method is more efficient because it reduces cost and manpower to conduct data collection. It has proven its capability as an alternative solution in producing the detailed asset inventory management. Moreover, this system has many advantages over the traditional data systems such as time-efficient in data acquisition, comprehensive, and more importantly, it can replace the conventional site surveys which involve many weeks in a high-risk location. Besides, the system can do a verification of attribute and spatial data through the precise position of an asset. Future research will focus on buildings and street roads of a UAV-based mobile mapping system to screen and control the conditions of a city infrastructure. It will also develop more automated feature extraction methods to improve the cost processing in an asset management system.

**References**

[1] Al-Bayari, O. (2019). Mobile Mapping Systems in Civil Engineering Projects (Case Studies). *Applied Geomatics, 11*(1), 14. https://doi.org/10.1007/s12518-018-0222-6

[2] Association, W. R. (2018). Method and Technology options for Data Collection. In *Asset Management Manual* (pp. 1–14). PIARC.

[3] Johnson, S. D., Bethel, J. S., Supunyachotsakul, C., Peterson, S., & Peterson, S. (2016). *Laser Mobile Mapping Standards and Applications in Transportation*. https://doi.org/10.5703/1288284316164

[4] Kargah-Ostadi, N., Waqar, A., & Hanif, A. (2020). Automated Real-Time Roadway Asset Inventory using Artificial Intelligence. *Transportation Research Record, 2674*(11), 220–234. https://doi.org/10.1177/0361198120944926

[5] Kingston, T., & Larouche, C. (2007). An Integrated Mobile Mapping System for Data Acquisition and Automated Asset Extraction. In N. E.-S. A. Vettore (Ed.), *The 5th International*
Symposium on Mobile Mapping Technology (pp. 1–5). Padua, Italy: ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. Retrieved from http://www.isprs.org/proceedings/XXXVI/5-C55/papers/kingston_tara.pdf

[6] Leslar, M., Perry, G., & McNease, K. (2010). Using Mobile LiDAR to Survey a Railway Line for Asset Inventory. American Society for Photogrammetry and Remote Sensing Annual Conference 2010: Opportunities for Emerging Geospatial Technologies, 1, 526–533.

[7] Rieger, P., Studnicka, N., Pfennigbauer, M., & Zach, G. (2010). Boresight Alignment Method for Mobile Laser Scanning Systems. Journal of Applied Geodesy, 4(1), 13–21. https://doi.org/10.1515/jag.2010.002

[8] Sairam, N. (2016). Development of A Mobile Mapping System for Road Corridor Mapping. Master of Science. Florida Atlantic University.

[9] Sairam, N., Nagarajan, S., & Ornitz, S. (2016). Development of Mobile Mapping System for 3D Road Asset Inventory. Sensors (Switzerland), 16(3), 19. https://doi.org/10.3390/s16030367

[10] Sestic, M. (2018). Hands-on Building Your Own Mobile Road Mapping Software Solution (Part One). Retrieved from http://www.linkedin.com/pulse/hands-on-building

[11] Warren, J. (2014). Mobile Digital Imagery Mapping 2500kms Roadway Asset Inventory Snohomish County, Washington, U.S. In XXV INTERNATIONAL FEDERATION OF SURVEYORS CONGRESS (p. 19). Association of Authorised Land Surveyors Malaysia, PEJUTA. https://doi.org/ISBN 978-87-92853-21-9