Universal mobile cartographic systems for geospatial data collection

Igor Zakharov
Kharkiv National University of Radioelectronics
Kharkiv, Ukraine
newzip@ukr.net

Volodymyr Varvanskyi
"Geopraktik LLC"
Kharkiv, Ukraine
vv@geopraktik.com

Iryna Zadorozhna
National Scientific Center "Institute of metrology"
Kharkiv, Ukraine
iryna.zadoroghnya.nnc.metrology@gmail.com

Annotation — **The work of the mobile cartographic 3D scanning system Trimble MX 2 is considered. It is a spatial visualization complex that combines high-resolution laser scanning and precise positioning for capturing point clouds using georeferencing. Positioning accuracy is achieved through the combined use of GNSS and an Inertial Measurement Unit (IMU). The main components of the system are: the G360 high-resolution digital panoramic camera, which takes continuous color photography using five cameras located around the perimeter and one on top; laser system with one or two rotating lasers, which operate at a distance of up to 420 m, have a 360 ° viewing angle and allow data collection with an error of up to 3 mm; navigation subsystem Aplanix AP60 with a GNSS receiver and high-quality IMU, which are responsible for the accuracy of geolocation; odometer – a device for measuring distance in difficult GNSS conditions.**

Key words - 3D scanning; cartographic system; global navigation satellite system; inertial system; positioning accuracy

I.INTRODUCTION

Recently, in connection with the development of modern geodetic technologies, equipment for collecting geospatial data has received its further improvement.

The above data are the basis for the normal and high-quality operation of the following industries: architecture, industry, construction, road infrastructure, geodesy, cartography, communications planning, railways, tunnel boring, mine surveying, archeology.

3D scanning technologies are one of the most productive and accurate measurement methods today.

The Building Information Model (BIM) is a kind of library, or resource potential, with the help of which the basis for making decisions, on its restructuring, or support for normal operation is formed.

Let's consider the operation of mobile cartographic systems using the example of the Trimble MX 9.

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II.PRINCIPLE SCHEME OF OPERATION AND IMPLEMENTATION

Main components of the system are:

- high-resolution digital panoramic camera - a camera that takes continuous photography in color using five cameras located around the perimeter and one on top;
- laser system with one or two rotating lasers, which operate at a distance of up to 420 m and have a viewing angle of 360 °;
- navigation subsystems with a GNSS receiver and a high-quality IMU, which are responsible for the accuracy of geolocation;
- odometer, an instrument for measuring distances (DMI), under difficult GNSS conditions.

The system is installed on any moving device, be it: a car (Fig. 1), a railcar (railway platform) (Fig. 2), a boat or a tunnel trolley.

Fig.1. Scheme of Trimble MX 9 System and its vehicle mounting option

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Fig.2. Installation of a mobile cartographic system on a railcar

The principle of operation of the main devices of the scanning system:

• Rotating scanner (scanners) with a full 360-degree viewing range, the principle of which is based on sending out laser pulses and receiving signals reflected from objects. Based on the obtained data (points of laser reflections), a three-dimensional information field is created that simulates the surrounding space.

• GNSS system for tracking and accumulating data received from global positioning satellites. Observations can be made in two modes: real-time kinematics (RTK) and post-processing kinematics (PPK).

• High-precision inertial module, with which the obtained data are synchronized and which makes it possible to more accurately build the trajectory of the cartographic system during analysis.

• Color panoramic camera, which is a logical addition to the complex and allows you to get a circular panorama, and then superimpose photogrammetric data on the point cloud (Fig. 3).

• Odometer, which, in addition to GNSS data of the inertial system, makes it possible to painlessly coordinate hard-to-reach places with no view of the sky (tunnels, overpasses) with minimal loss of trajectory quality.

Fig.3. Urban survey data obtained while running the Trimble MX 9

Unlike standard shooting methods, 2 people are enough to work with the scanner (for example, a car): a driver and an operator. It is advisable to plan routes with travel in both directions, in opposite directions, for the accumulation of greater data density.

Deployment time from transport position takes about 20 minutes. The versatility of the system allows installation on almost any vehicle, eliminating the need to purchase specialized vehicle.

Cameral processing is carried out in several stages:

• calculation and adjustment of the system trajectory points

• formation of point clouds, automatic or custom classification by objects, noise cleaning, alignment of passages (in the case of paired passage).

• creation of a realistic model of the captured object from point clouds and panoramic images.

• if necessary, further upload to the network software or databank (exchange with other project participants, BIM systems).

Any of the above tasks can be independent, depending on the goals and technical specifications of a particular project.

TABLE I. SHORT CHARACTERISTICS OF THE TRIMBLE MX 9 SYSTEM

PARAMETER	VALUE
Scanning rate	500 scans/sec
Amount of laser scanners	2
LASER CLASS	1, EYE SAFE
Maximum range, target reflectivity	420 m > 80%
Accuracy / error	5 mm / 3 mm
Field of view	360° "full circle"
360° "full circle"	IP64 (sensor module)
Operating temperature range	from 0 °C to +40 °C
Built-in inertial GNSS system Accuracy without loss of GNSS signals:	AP60 Coordinates X, Y (m): 0,020 0,020 Coordinate Z (m): 0,050 0,050 Speed (m/s): 0,005 0,005 Roll and pitch (degrees): 0,005 0,015 Course (degrees): 0,015

III. UNIFIED SOLUTION FOR MANY TASKS

Mobile cartographic systems are designed to perform a number of tasks:

✓ **Road infrastructure:** high-precision surveying at all stages of road construction and repair.

The main feature is that there is no need to block roads for work, the vehicle can travel in general traffic, minimizing the risks associated with employees being on the highway. Accurate data enable the production of varying quantities of outputs using powerful dedicated software packages (Trimble Trident, Trimble MX Asset Modeler).

- digital relief models, elevation maps;
- complex GIS databases for BIM implementation;
- calculation of volumes and planning of earthworks;

- obtaining up-to-date information on the condition of the road surface with the isolation of problem and emergency sections, filtration of damage, defects;
- creation of a basis for certification, including lists of objects;
- determination of geometrical parameters of roads and related objects (length of a section, width of a roadbed, width of each lane, lateral evenness, slopes from axial ones, angle of an arc of turn).
- the ability to implement CAD projects (design and project documentation, data catalogs in conjunction with CAD projects)

The software assumes in its functionality automatic recognition: hatches, cracks in the road surface, curbs, marking lines, which significantly speeds up the process of filtration and processing (fig. 4).

Fig.4. Examples of point clouds for road construction

After construction is completed, the materials of the executive survey can be used in the BIM environment throughout the entire life cycle of the object.

✓ **Railway infrastructure**

- monitoring of slopes and embankments in places of soil subsidence;
- survey of junctions, bridges, overpasses for condition monitoring and inventory;
- creation of a dimensional corridor during the construction of railways (fig. 5);
- survey of wires and objects of contact network;
- monitoring the condition of tracks, design and reconstruction of road facilities;
- survey of railway tracks to create digital track models (DMP). Determination of the actual values of the geometric parameters of the railway infrastructure, monitoring the condition of tracks, design and reconstruction of road facilities (fig. 6).

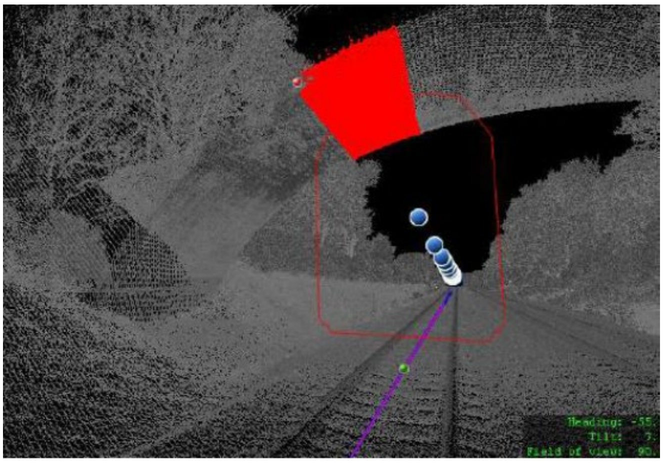

Fig.5. An example of the overall passage of a car with a display of the risk zone on the railway

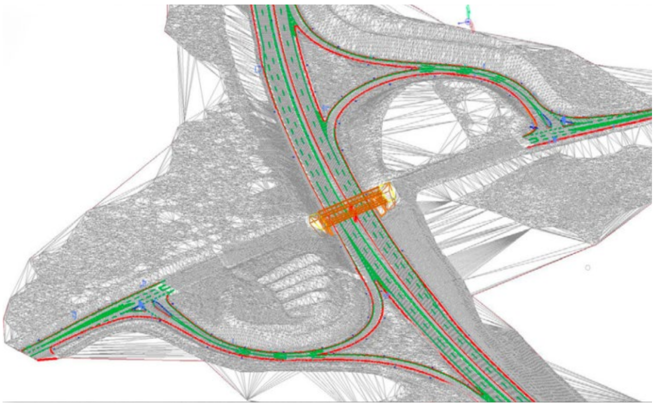

Fig.6. Displaying the road junction after connecting the processing vectors

✓ **Urban infrastructure**

For large cities, in a rapidly developing rhythm, constant control over all urban processes is very important. Data obtained from mobile cartographic systems can be used for the following purposes:

- creation of 3D models of cities;
- inventory of trade objects (LFA), traffic lights, road signs;
- planning of repairs and inventory of buildings and structures for the architecture service;
- assessment of the current state of bridges, overpasses, junctions;
- assessment of the state of contact lines of urban land transport;
- assessment of the state of the tracks of urban land-based road transport.

For the full cycle of urban planning, mobile mapping systems allow you to efficiently create layers for GIS and working drawings in CAD.

Surveying large utility systems in a short time frame creates a unique environment for project planning, providing the basis for qualitative and quantitative analysis and prompt decision-making. Inventory and updating of the data of existing objects is carried out using special software procedures that provide communication with existing databases and schemes. Thanks to the convenient data exchange system, processing times are significantly reduced.

✓ **Other branches**

- determination of the volumes of production or stripping for quarries and ore mining and processing enterprises. Monitoring of subsidence of soil and rocks, control of boards;
- monitoring of slopes and movements of retaining walls on mountain roads;
- design and repair of overpasses, definition of security zones;
- survey of water infrastructure objects of hydroelectric power station, dams, berths, locks, canals. Inventory of port cranes and structures;
- survey of power lines (inventory, sagging of wires, assessment of damage to towers), distribution substations, glades.

Full use of cartographic mobile systems with the help of special software assumes a full cycle of data exchange with all city services. In this case, the street panorama is scanned, after processing and modeling, the obtained data is uploaded to the server, where each service will be able to work with filtered profile data for personal access.

RESULTS AND DISCUSSION

With the ability to use mobile cartographic systems, large-scale survey projects that were previously too complex and costly for many organizations are now feasible.

Comparing traditional methods on the example of a road, where a team of 3 people can take a total station or GNSS receiver survey up to 4 kilometers per work shift, during the same period of time using a mobile cartographic system, it is possible to capture up to 100 km. roads with the surrounding situation.

This eliminates the high costs of traditional field crews. Having received a colossal amount of data, the risks associated with finding workers in hazardous field conditions are avoided. The work of the scanning system does not require stopping traffic or blocking roads, it makes it possible to work with inaccessible dangerous objects without risking the health of employees.

The ability to integrate the scanned results into network server programs allows you to optimize the work of any services and departments, avoiding additional costs in a well-defined time frame.

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