

# RTIBET RAILWAY SURVEYING USING MMT

Qingwu HU<sup>ab</sup>, Zhiyong Chen<sup>ab</sup>, Sheng GUO<sup>b</sup>

<sup>a</sup> School of Remote Sensing and Information Engineering, Wuhan University, No.129, Luoyu Road, Wuhan, P.R. China  
qwhu@leador.com.cn

<sup>b</sup> Wuhan Ledor Co., Ltd, Wuhan, P.R. China leader3s@leador.com.cn

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## ABSTRACT:

China Tibet Railways totalling 1956km in length which goes through mountains and frozen land, is constructed on the World's Ridge at the world's highest altitude. This paper provides the technological solution for surveying Tibet railways based on the Mobile Mapping Technology. It proposes a wide region position algorithm using precise ephemeris based on RTG that was successfully applied in the Tibet railway surveying project. Results show that this positioning technology can reach centimetre accuracy without base station control. In this way, various infrastructures on the railway was captured and inventoried to be used in integrative operation and control management system.

## 1. INTRODUCTION

Railway is a nationwide network that contains spatial information of various railway infrastructures including stations, lines, bridges, tunnels, locomotives, vehicles, communications, signals, power supply and water supply etc. These infrastructures further contain various operational information. For example, stations tell you arrivals of passengers, goods and rail car operation information. Rail lines involve vast amount of operational information. With the development of GIS applications in various industries, it is highly imperative to adopt information technology to further improve railway operational efficiency, lower operational cost and enhance market competence. The Railway GIS (R-GIS) is constructed on the basis of railway infrastructure data. It is an information system that realizes entire-line data share and operational information query and facilitates functionalities like emergency response, railway facility maintenance, optimization of operation organization, assisting scheduling and passenger data release.

Since manual work is prohibited on railways, the mobile mapping technology can be used to inventory road infrastructure facilities including railway centreline, affiliated facilities (road signs, km milestone, semi-km milestone, signal lamps...). Fast survey and inventory of railway assets are also made possible.

China Tibet Railways totalling 1956km which goes through mountains and frozen land is constructed on the World's Ridge at the world's highest altitude 960km of the railway stands above 4000m altitude with the highest point at 5072m. The railway sees only thin air, coldness and strong radiation where manual survey is impossible.

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RTG that was successfully applied in the Tibet railway surveying project. Results show that this positioning technology can reach centimetre accuracy without base station control. In this way, various infrastructures on the railway was captured and inventoried to be used in integrative operation and control management system.

## 2. METHODOLOGY

### 2.1 LD2000-RH MMS production for Railway Surveying

Place an MMS on a rail car or replace MMS wheels that can run on railway. Towed by the rail car, MMS can rapidly capture information of the railway and its affiliated facilities (distortion of railway or road surface, damages, signal lamps and driveway lamp) together with the status data of affiliated buildings, crossings, bridges and tunnels etc. All this information constitutes the basis of R-GIS. Figure 1 show LD2000-RH MMS in Tibet railway surveying project.

To realize GPS/IMU combined process of data, the speed information of the rail car should be connected to MMS.



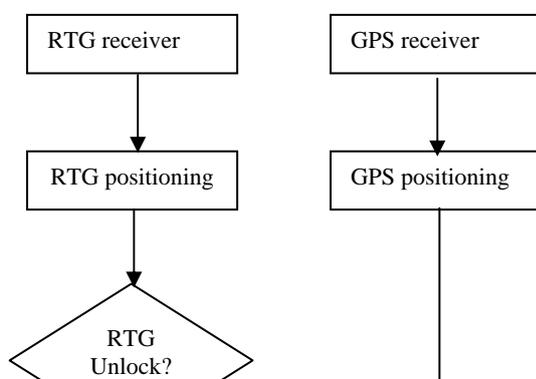
Figure 1 LD2000-RH MMS for Tibet Railway Surveying

## 2.2 RTG survey without base station

Conventional DGPS is considerably constrained in effective distance of differential corrections owing to the pertinence of error source resolution with the increasing distance between base and rover stations. During GPS dynamic survey, the distance between base and rover stations cannot exceed 100km. Considering that it is impossible to set up GPS base station on the high altitude of Tibet railway, RTG positioning and surveying method was adopted during MMS survey. RTG is a global dual-channel GPS differential positioning system based on the differential correction data provided through satellite communications. It requires no setup of base station but allows free usage of RTG receivers including dual-channel GPS survey data at any place of the world and acquires centimetre positioning accuracy. The system is consisted of reference station, data processing centre; transfuse station; earth sync satellite Inmarsat and user station.

Using RTG for survey is rather time-consuming in initialization. Re-initialization is required when signal is completely unlocked. If outline coordinates before GPS initialization position are given, the time period for initialization can be shorten in case of completely unlocked. Therefore, a combination of RTG and GPS can bring into play advantages of both and overcome their disadvantages. Using GPS to initialize RTG can considerably shorten the time period and achieve high (centimetre) accuracy. At the same time, when GPS Ambiguity Resolution is unlocked or communication fails periodically, RTG will continue to provide positioning service to overcome the “pause period” and the accuracy still maintains within centimetre level. When GPS tracking or communication is restored, RTG positioning result can be used as the starting point to search and resolve Ambiguity Resolution.

The following graphic shows the methodology of rover DGPS during MMS survey of Tibet Railway.



## Figure 2 Improved rover DGPS position methodology With RTG

Improved DGPS position methodology applies in the unlocked situations during surveying process to form a dual-mode positioning survey. The survey results of both modes can examine and verify each other. After being processed with proper survey adjustment, the accuracy and reliability of rover DGPS can be improved. The result of Tibet railway survey shows that rover DGPS survey based on RTG proves to be highly efficient with the accuracy reaching centimetre level.

## 2.3 Geo-referenced and Mileage Coding

As the railway facilities are usually coded with mileage, the geo-referenced should be done together with mileage coding to image data, signal lamps, railway facilities etc. To do mileage coding, the km milestone and semi-km milestone should be surveyed together mile number as a key attribute of object, as Figure 3 shown.

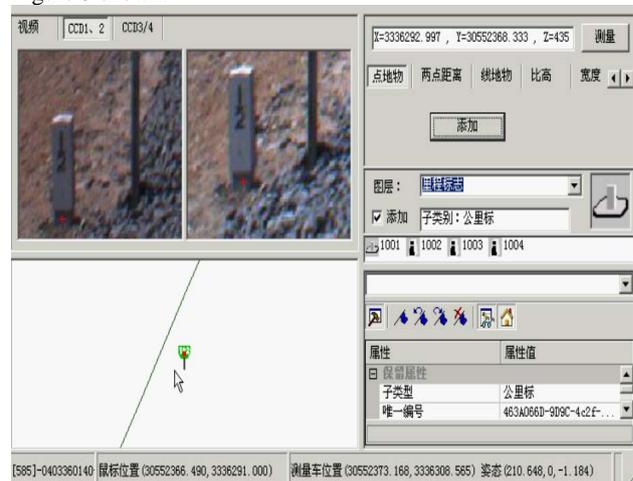


Figure 3 Milestone surveying for mileage coding

All milestones have position information and mileage attribute, thus the centreline of railway can be projected with mileage information. Once an object is surveyed, it is projected to railway centreline using its coordinates using interpolation, thus the mileage can be calculated, as Figure 4 shown.

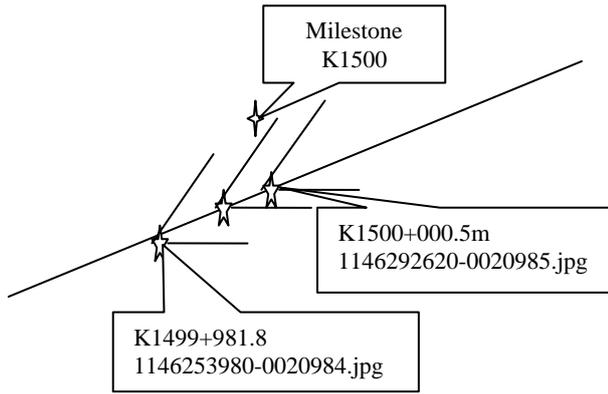


Figure 4 Object mileage coding with coordinates interpolation

### 2.4 Inventory of facilities

Railway facilities can be surveyed from MMS image together with mileage using mile coding centreline. Add all these facilities are stored in the database for R-GIS applications, as Figure 5 shown.

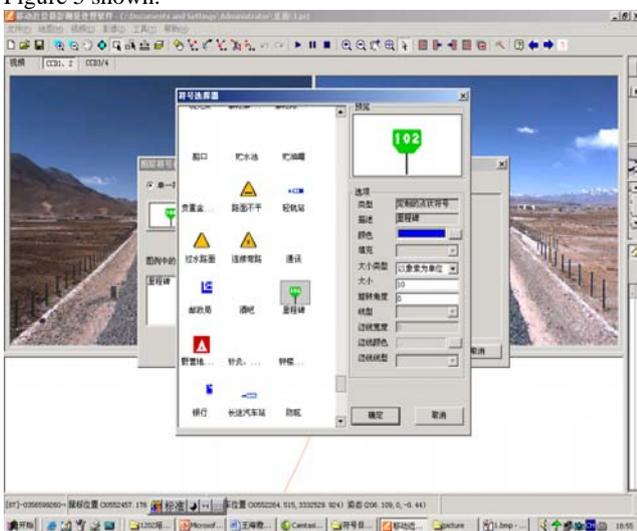


Figure 5 Railway facilities database

## 3. APPLICATIONS

Land-based MMS for railway surveying have advantages as high efficiency, high accuracy non-tactile. The railway is georeferenced with permanent complete image record. These digital measurable images can be used in many railway information systems.

### 3.1 Railway network collection

It can be used for railway network surveying to construct the R-GIS database with DMI for railway planning and design applications, as Figure 6 shown.

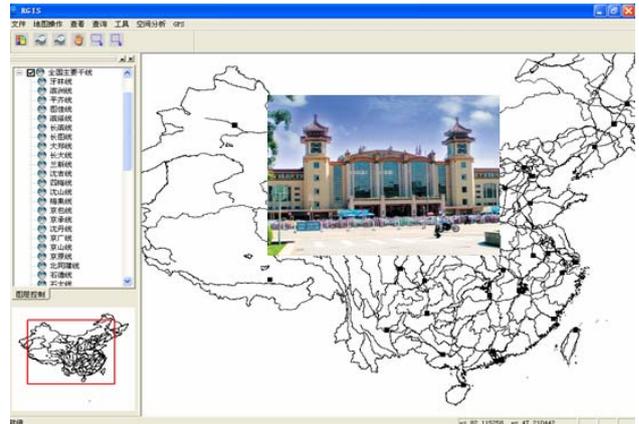


Figure 6 Railway network for R-GIS database

### 3.2 Railway GIS application

All objects such as building and traffic sign are encoded by railroad mileage and recorded in railway GIS database, as Figure 7 shown.

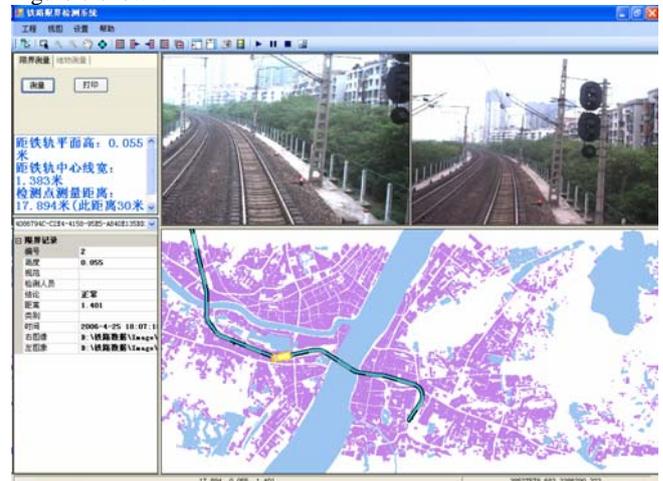


Figure 7 R-GIS application with DMI

### 3.3 Railway Facilities Management

DMI can provide visible images of railway facilities, which are linked to geographic coordinate. The information can be imported directly to facility management system and realize visible railway facility management, as Figure 7 shown.

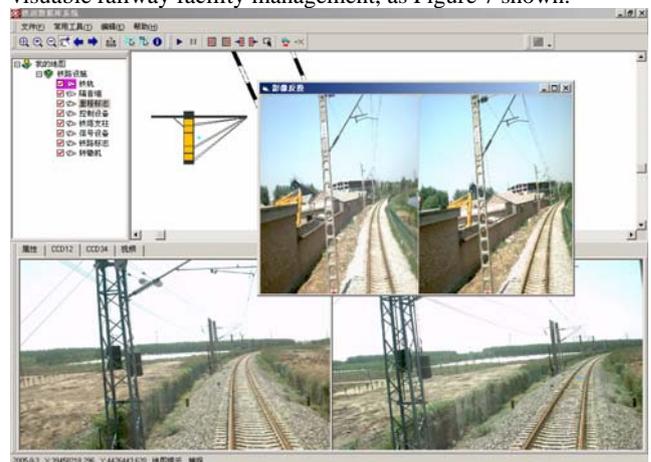


Figure 8 Visible Railway Facilities Management

#### 4. CONCLUSIONS

The conventional surveying methods can not meet the railway geography data collection. For the Tibet railway with average evaluation above 4500m, the conventional surveying methods can not finish the task in time with low cost. RTG can be used to reduce DGPS based station work. MMS finish 1956 km Tibet surveying task only in on week. The data is used in Tibet railway visuable GIS for safety monitoring, facilities management and railway planning.

#### References:

Kealy, A. Fraser, C. Leahy F, Butcher, G. & Judd, M. (2001), An Integration Method for Automating Railway Asset Management for Queensland Australia. Proceedings 3rd International Symposium on Mobile Mapping Technology, 3rd-5th January, Cairo, Egypt

Leahy, F. Kealy, A. & Fraser, C. (2000), An Automated Kinematic Surveying and Mapping System for Railway Asset Management. Proceedings ION 2000 GPS conference, 19th-22nd September, Salt Lake City, USA.