Development of Mobile Cadastral Surveying System for Korean Cadastral Resurvey Project

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Key words: Mobile Cadastral Surveying System, RTK-GPS, Electric plane table, RF modem, WHIP antenna, YAGI antenna

SUMMARY

Developing the mobile cadastral surveying system is to integrate RTK-GPS surveying, electric plane table (Total Station + Pen computer + Software) surveying, high capacity wireless modem, control point database, and cadastral map database into one system, making it possible to automate cadastral surveying processes. The system could be also applied for various areas of surveying such as cadastral resurvey project and Location Based Service (LBS). The mobile vehicle surveying system is composed of one set of RTK-GPS equipment, RF Modem, WHIP antenna, YAGI antenna, AC&DC Power Supply, 19 inch LCD monitor, electric plane table, a wireless telegraph for both car and users and a four-wheel-drive vehicle.

The mobile surveying system is fitted with various RTK equipment so that it could minimize troublesomeness of connecting equipment and obtain mobility to enhance efficiency of surveying. As the cadastral map computerization project is completed, a new method of cadastral surveying is introduced by utilizing the electric file of cadastral map in this paper.

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1. INTRODUCTION

Korean cadastral surveying is divided into numerical cadastral surveying and graphical cadastral surveying, and 94 percent of the national land is the area where the graphical cadastral surveying is applied. From 1999 to 2003, all the paper cadastral maps were numerically filed by the cadastral map computerization project. However, the project was not accompanied by field survey and only each map was converted into numerical files. Due to map conjugation, differences of results from field surveying, and inconsistency between map and the lot, there is limitation of obtaining consistent cadastral surveying results. Korea Cadastral Surveying Corporation (KCSC) is demanded by the government that it should provide an enhanced service to the public by consolidating cadastral control points and developing GPS cadastral surveying.

KCSC is planning a cadastral resurvey project of national land as a new alternative for the Korean cadastral system, and has installed the Cadastral Resurvey Team at the headquarters to drive forward it efficiently. Currently, KCSC is focusing on enacting a special law of the cadastral resurvey project and also on R&D for developing the cadastral survey technology in order to carry out the cadastral resurvey project. In this paper, the mobile cadastral surveying system which could be applied for Korea is introduced.

2. DEVELOPMENT OF MOBILE CADASTRAL SURVEYING SYSTEM

RTK-GPS survey is physically divided into two parts, such as base station and rover. Correction data are created in base station and transmitted through various communication media. On the base of this, rover determines location on real-time basis. Therefore, stable data communication between base station and rover is very important. In the previous stage, experiment of correction data transmission was administered in three methods and it produced the most stable result when the method of RF modem (PDL) was used.

However, implementation of RTK-GPS survey system currently involves the complexity of having to interconnect independent supplementary equipments for operation by using complicated cables. Therefore, in this study, a single unified system was implemented by installing various equipments used in RTK-GPS survey in a vehicle. In implementing such a system, the RF modem as the means of correction data transmission to display the most stable result in the previous stage was combined with GPS receiver and installed in a vehicle.

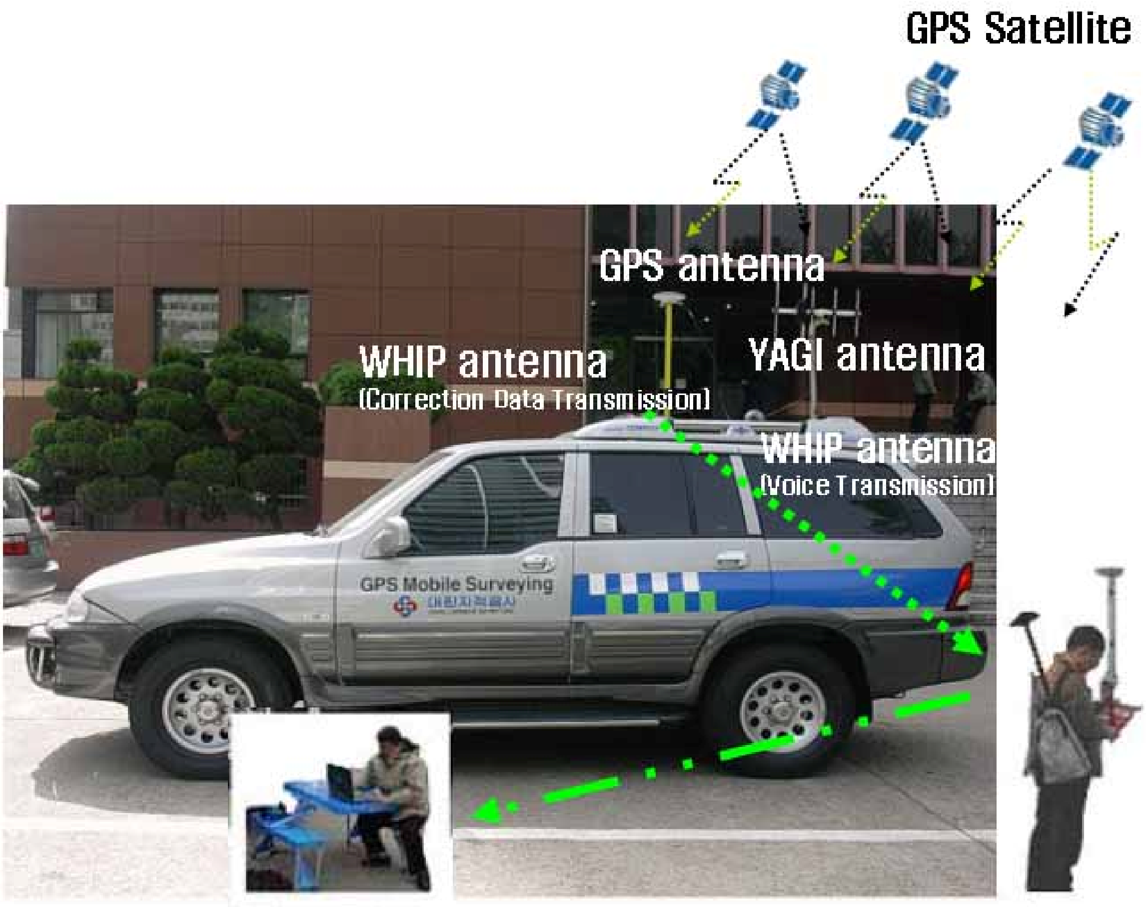
There are two main points in developing vehicle system exclusive for surveying. The first is to remove the troublesomeness of equipment connection and to secure mobility by installing the distributed RTK equipments into a vehicle and the second is to use RTK-GPS surveying as of the traditional method of plane-table surveying. In other words, the goal is to install a vehicle for surveying at a random point without a control point and having a rover determine the relative location while operating a base station, then drawing up status map by connecting measuring points with the use of electronic plane table and unifying results by overlapping the map and numerical cadastral map.

2.1 Development of Mobile Vehicle System

In relations to the mobile vehicle intended for development in this study, priority must be placed on physical surveying equipments distributed, that is, the process to unify RTK-GPS and its supplementary equipments into a single unit. In order for this, we have created and installed a steel box inside a 4-wheel drive Musso vehicle. Composition of equipments installed in the mobile vehicle is as of the following.

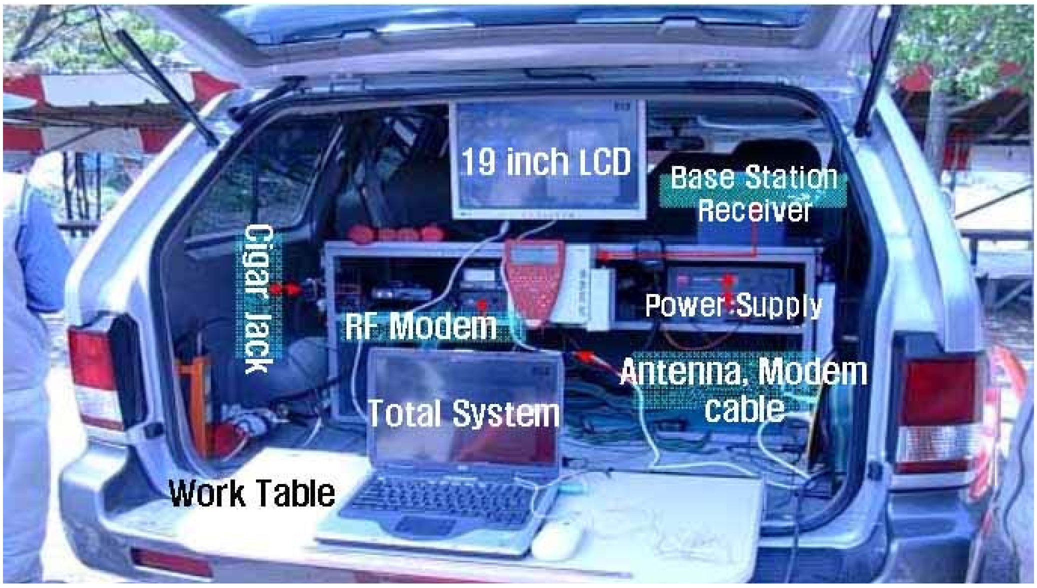
Of the composition mentioned above, YAGI antenna, the directional antenna, was installed for the purpose of secondary use in places with the failure of radio wave when transmitting correction data with directional antenna. Also, it has been designed to transmit the general correction data by using the non-directional whip antenna.

In order to enable use of the electricity of household use in onsite surveying, AC/DC inverter was installed. For all equipments to require power source, multiple power supply equipments were installed to enable direct use of the power equipment in vehicle (cigar jack). <Fig. 2-1> shows the system to administer onsite RTK-GPS surveying by using mobile vehicle as developed in this study.



<Fig 2-1> Surveying System using Mobile Vehicle (1)

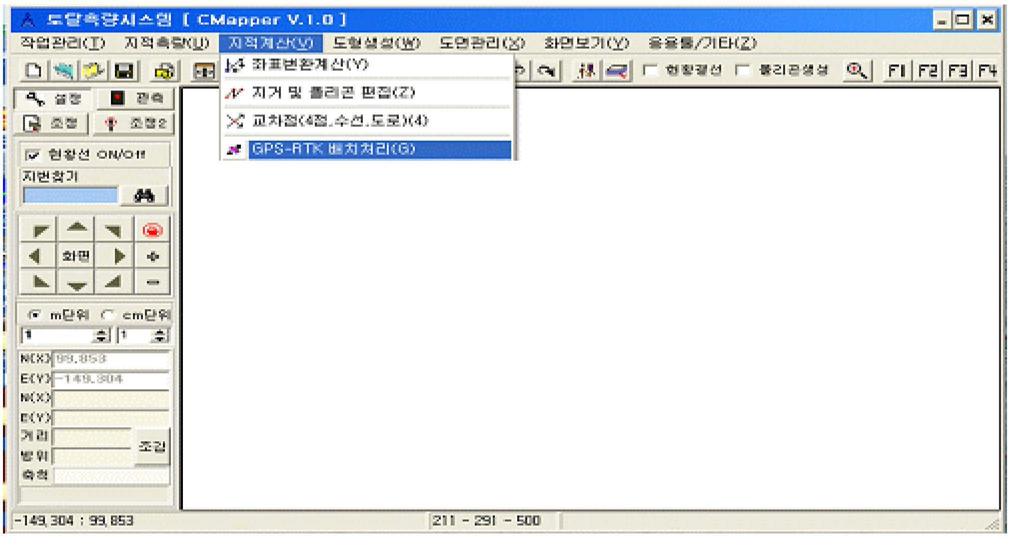
For convenience of on-site operation, a support was installed at the rear part inside the mobile vehicle to enable immediate onsite administration of data processing by a laptop computer, etc. <Fig. 2-2> shows the inside of mobile vehicle in which the distributed RTK equipments were installed in the vehicle for unification.



<Fig. 2-2> Mobile Vehicle System (2)

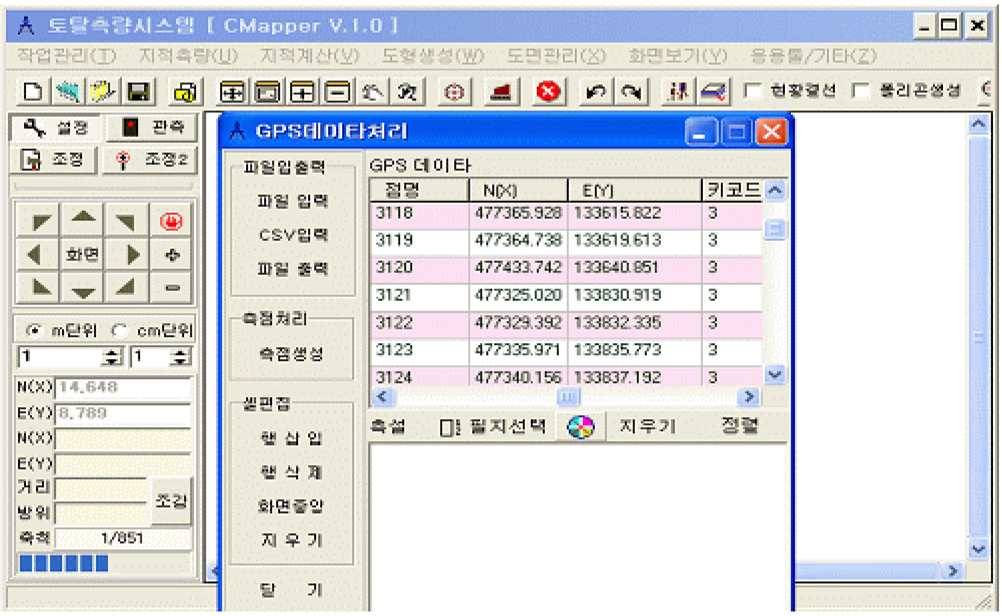
For the purpose of batch processing of data acquired with RTK-GPS, we developed and added a module within the total surveying system (electronic plane-table system hereafter) developed by KCSC. Data acquired through RTK-GPS surveying are represented with rectangular coordinates and saved in the flash card of receiver. The generally used data saving method of RTK-GPS equipments is compatible with the Excel file format of Microsoft. Therefore, it is possible to edit only the required data and save them in a different format.

Therefore, in this study, data format for input into electronic plane table was newly saved in the comma-separation method (csv), one of the data saving methods of Excel, to enable batch input to electronic plane table. Here, the data entered are measuring point numbers, names of points, rectangular coordinates and key codes, etc. <Fig. 2-3> shows the screen of executing RTK-GPS survey data input menu added as the sub menu of cadastral calculation in the initial screen of electronic plane table.



<Fig. 2-3> Initial screen of electronic plane table.

<Fig. 2-4> shows the screen to save and enter the sampled data as CSV file in order to find out whether the modules added to electronic plane table are normally executed.

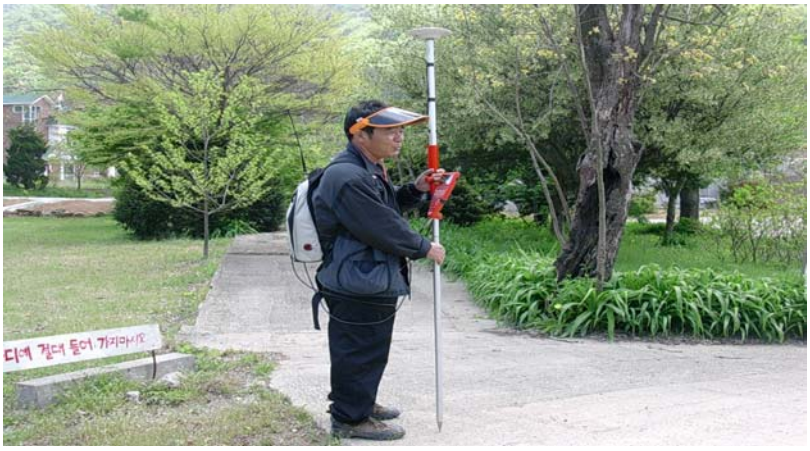


<Fig. 2-4>the screen to enter RTK-GPS data

For the mobile vehicle developed as of the above, it has been intended to increase the efficiency of operation by integration of the distributed RTK-GPS surveying equipments, the real-time movement surveying implementation function and the reinforced function of electronic plane table for on-site processing of the acquired data.

2.2 Performance Evaluation on Mobile Vehicle System

For overall performance evaluation of the mobile vehicle developed, RTK-GPS surveying was administered by using equipments installed in the vehicle. After the primary inspection on the operation status of equipments installed in the vehicle and the status of transmitting correction data by modem, etc., the mobile vehicle was set as the base station. Then, inspection was carried out on the operation status of receiver and modem in rover, in other words, whether the correction data were normally received from base station and were combined with the data collected from satellite to determine the location by fixing the measuring points concerned.



<Fig. 2-5> the site survey (Rover)

<Fig. 2-5> shows a Rover to survey current status of the test site by the mobile vehicle system developed. As the purpose of this experiment is to find out whether the vehicle system developed operates normally, the course of onsite calibration to accurately determine ITRF coordinates as the current result has been omitted. However, the 7 parameter of nationwide units established by Cadastral Research Institute (CARI, hereafter) attached to KCSC have been entered in the receiver of Rover in advance for application.

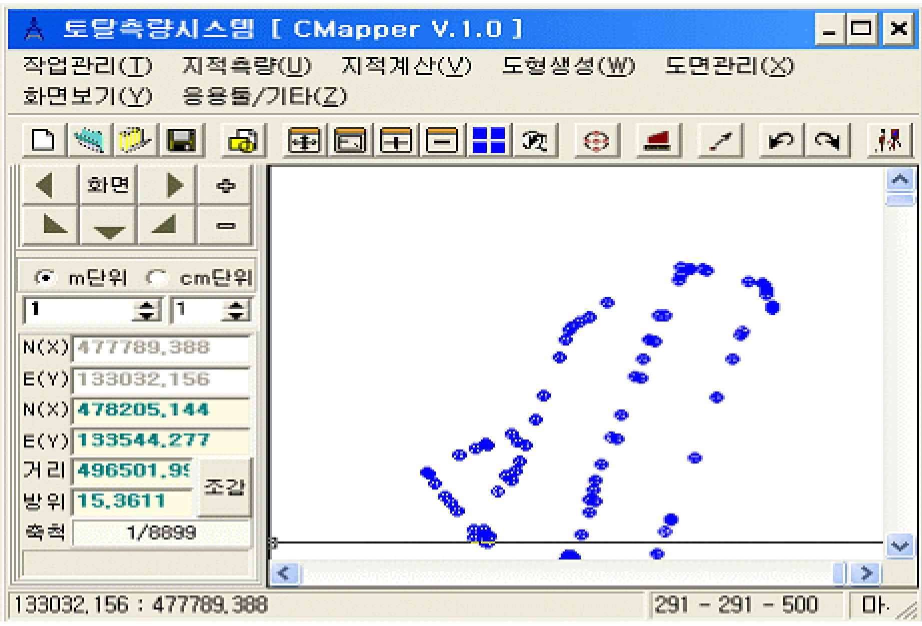
As such, the experiment to inspect receive operation status and modem transmission status, etc. produced the result that the mobile vehicle system developed was operating normally. Therefore, it could be concluded that the cables inside the vehicle to combine various physically separated equipments were properly connected. Next, performance of the modem drawn up for batch input into electronic plane table by editing raw data acquired by RTK-GPS surveying was administered. RTK equipment used for this experiment was Leica SR530, which is in possession by CARI. Some of the raw data obtained in this experiment are as of the following.

(For each point, this format file displays Point ID, Coordinates, CQ and Class.
On the next line is then the Coding Layer, Code ID and the Code Description. Note
also that this format is tab delimited.)

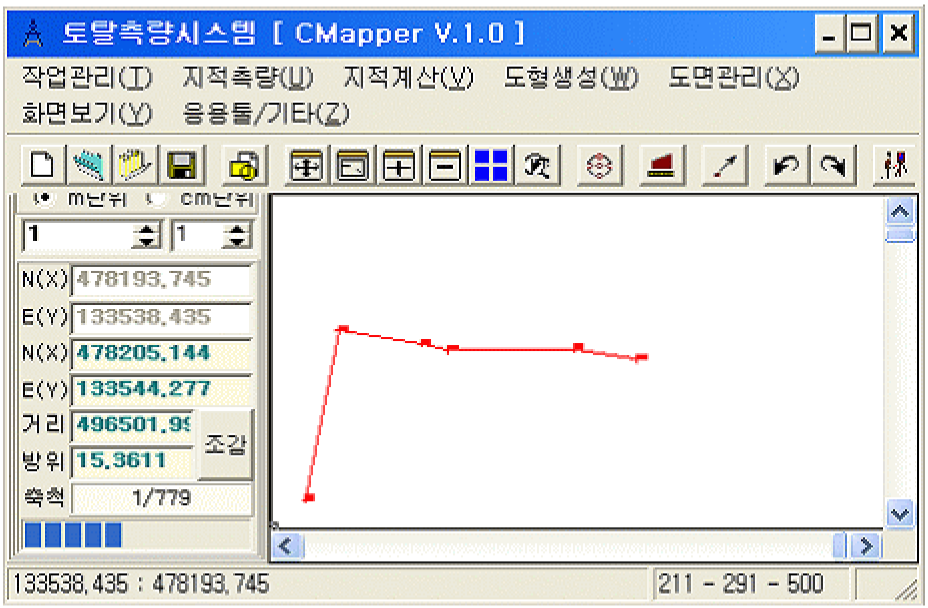
1	163600.755	456361.085	-66.869	0.017	MEAS
2	163474.684	456475.036	-66.938	0.017	AVRG
3	163504.600	456466.277	-66.696	0.019	MEAS
4	163550.614	456426.244	-66.488	0.018	MEAS
5	163593.879	456398.000	-66.965	0.020	MEAS
6	163592.918	456409.514	-66.508	0.017	MEAS
7	163591.236	456439.959	-66.744	0.026	MEAS
8	163582.065	456470.770	-66.931	0.019	MEAS
9	163582.028	456488.039	-66.881	0.018	MEAS
10	163614.325	456537.727	-66.646	0.018	MEAS
11	163570.377	456567.117	-66.480	0.017	MEAS
12	163557.195	456285.621	-66.974	0.016	MEAS
13	163545.851	456581.967	-66.838	0.022	MEAS
14	163515.765	456602.165	-67.073	0.015	MEAS
15	163470.588	456632.574	-66.828	0.014	MEAS
16	163472.898	456637.147	-66.958	0.017	MEAS
17	163482.474	456630.988	-66.943	0.016	MEAS
18	163556.313	456582.677	-66.381	0.018	MEAS
19	163584.459	456564.578	-66.502	0.018	MEAS
20	163612.424	456547.005	-66.756	0.018	MEAS
21	163620.657	456547.301	-66.604	0.014	MEAS
22	163638.638	456558.271	-66.532	0.019	MEAS

23	163495.654	456341.706	-67.172	0.017	MEAS
24	163649.349	456558.927	-66.517	0.019	MEAS
25	163660.215	456555.297	-66.717	0.015	MEAS
26	163668.770	456545.500	-66.659	0.022	MEAS

Only the data required for input into electronic plane table by editing in Excel were extracted and saved. In particular, the x and y coordinate system of Leica receiver is different from what is in use by us. Therefore, it is necessary to make adjustments to fit the current survey coordinate system. <Fig. 2-6> shows the enlarged measuring points created by entering the acquired data into electronic plane table.



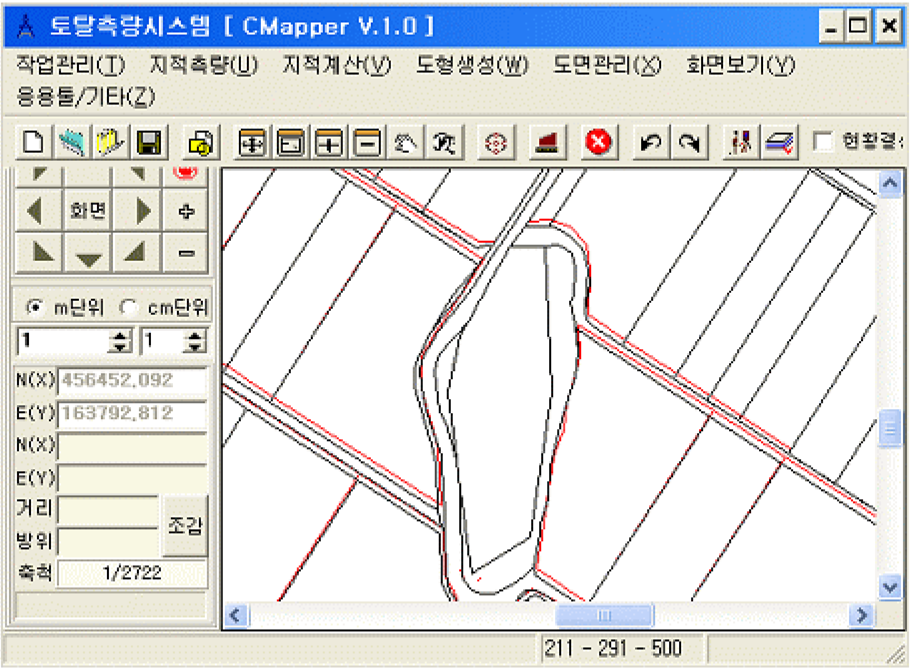
<Fig. 2-6> Distribution of measured points



<Fig. 2-7> Connection of measuring points

<Fig. 2-7> illustrates the course of drawing up site map by the points entered. For the method to connect measuring points, there is the method for the surveyor to personally connect each point or the method to automatically connect the points by designating point numbers of a fixed range. By overlapping the site map drawn up in the above methods with the drawings of cadastral computing files, their application of them in actual operation was examined.

In this experiment, the base station was not installed at an accurate base point, but at a location easily approachable by mobile vehicle to administer RTK-GPS surveying with the position of antenna installed on top of the vehicle. Therefore, the site map drawn up does not hold the absolute coordinates of the current cadastral surveying system. So, this experimental surveying is as if to install a plane table at a random point in an area without a control point, to prepare drawing by site surveying and to adjust the cadastral map by overlapping it on top of the drawing. We overlapped the site map by moving digital cadastral map with the use of orientation function of electronic plane table.



<Fig. 2-8> the result to adjust cadastral map and natural boundaries

The result is shown in <Fig. 2-8> and, as can be seen here, if adjustment is carried out with the parcel boundary on the bottom left hand corner as the base, curved areas do not correspond to other parcel boundaries. This is because, as of other surveys, different results can be produced according to which part of the site boundaries is measured by surveyor at the time of RTK-GPS surveying.

This experiment was carried out in order to evaluate the overall performance of the mobile vehicle system developed in this study. Especially, detailed inspection was administered on the defect status and operation status of various cables according to connection of the distributed RTK equipments installed in a vehicle. Also, through the actual implementation of RTK-GPS surveying, the problems to occur in the course of it were also examined. Together with inspection on data input module drawn up for processing of follow-up operation by the acquired data in electronic plane table, drawings were prepared by using the test data and accuracy of results was evaluated by overlapping the drawings.

In the area of cadastral survey, RTK-GPS surveying, due to the characteristics of cadastral surveying, was not activated. However, recently, its use is being gradually increased as RTK surveying is applied to actual operations in open land, for land adjustment or land consolidation.

3. ISSUES IN THE NEAR FUTURE

The ultimate objective of developing mobile cadastral surveying system by vehicles is to more effectively use RTK-GPS system in cadastral surveying. This study focused on the experiment carried out in relations to RTK surveying. However, the final goal of implementation pursued by this study is the integration of RTK-GPS surveying and mobile technology. Therefore, this study aimed at developing physical integration device required for realization of mobile surveying. In other words, this study pursued physical integration of RTK equipments and experiment on correction data communication media as a means to realize the integration with mobile technology.

In the near future, we intend to administer studies on the methods to transmit data acquired from a Rover to the electronic plane table of a base station on a real-time basis by using wireless communication (wireless network and wireless modem, etc.) and on development of modules for inspection and quality management on RTK survey data. The current method to inspect results surveyed with RTK requires a great length of time because it uses the method of on-site re-surveying on the same point with T/S.

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