Cost Reduction in Cadastral Surveying Using 360-Degree Cameras to Produce Photogrammetric Orthophotos

Kenta ISHII, Japan

Key words: cadastral map, photogrammetry, orthophotos, 360-degree camera, cost reduction, 3D modeling, skills transfer

SUMMARY

The Ministry of Justice provides the public basis through the Article 14 map within the real property registration system, while MLIT develops cadastral survey outputs under the National Land Survey Act, and eligible results are supplied to the Legal Affairs Bureau. Because procedures are strictly prescribed by laws and operational guidelines, reliability is high, but methods tend to become conservative. By using GNSS, LiDAR, and photogrammetry as supplementary tools, labor can be reduced and 3D models can be applied to train successors. Slow progress is also constrained by heavy field burdens and coordination for landowner attendance, and improved recording capability is beneficial. Even without legal reform, meaningful effects can be expected in surrounding processes.

Cost Reduction in Cadastral Surveying Using 360-Degree Cameras to Produce Photogrammetric Orthophotos

Kenta ISHII, Japan

1. Introduction

In Japan, cadastral maps are developed and supplied mainly under the National Land Survey Act and the Real Property Registration Act. Land ownership is guaranteed as a property right by Article 29 of the Constitution of Japan, and the State has established a legal framework under which citizens may own a specific parcel of land and may use, derive profit from, and dispose of it, while also providing a system to publicly announce the existence and attribution of those rights. This public notice function is centrally carried out by the Ministry of Justice and its local offices (Legal Affairs Bureaus). The Real Property Registration Act publicizes rights concerning land and buildings in a manner enforceable against third parties, and the Article 14 map is an official map kept at registry offices that shows the location and parcels corresponding to registry information, thereby visualizing land ownership in real space. Alongside this, cadastral surveys under the National Land Survey Act have produced cadastral maps nationwide; overall development is about 50%, but only about 30% in Densely Inhabited Districts (DIDs) as of 2022. Although early development is crucial for land management, disaster prevention and mitigation, and protection of ownership rights, progress remains slow due to strictly prescribed procedures, heavy field burdens, and the time required for consensus-building with numerous land owners. Meanwhile, surveying technology is at a major turning point, with rapid advances in GNSS, LiDAR, and photogrammetry. However, their direct adoption in statutory cadastral map production is difficult because formal implementation requires institutional steps such as legal amendments and revisions to operational rules. By contrast, public surveying for public works has increasingly permitted deliverables produced with these technologies, including actual adoption of LiDAR-based outputs. As a Land and House Surveyor, the author conducts cadastral map production under the statutory framework while gradually incorporating GNSS, LiDAR, and photogrammetry in a supplementary and practical manner to reduce field labor and costs in a small office and contribute to the SDGs.

2. Relationship between the Article 14 Map Production Program and Cadastral Surveys

The Article 14 map production program is work that requires particularly advanced expertise and strict process control within Japan's surveying system. Because it publicly determines land boundaries and is used as foundational material for the real property registration system, extremely high accuracy and reliability are required for the work.

In practice, cases where the Legal Affairs Bureau independently produces new Article 14 maps are limited. In many cases, the cadastral maps and cadastral registers that are the results of cadastral surveys conducted by municipalities, etc. under the National Land Survey Act are, after meeting certain requirements, sent to the Legal Affairs Bureau and are kept as Article 14 maps.

The Article 14 map production program by the Legal Affairs Bureau is implemented with 100% national expenditure. In contrast, cadastral survey programs are implemented under the National Land Survey Act with role sharing among the national government, prefectures, and municipalities (Table1). As a typical cost-sharing structure, the national government bears 50%, prefectures 25%, and municipalities 25%. In this way, development of Article 14 maps is based on an institutional framework in which the Ministry of Justice, the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), and local governments cooperate.

In FY2024, the Ministry of Justice budget for the Article 14 map production program was approximately 5.0 billion yen, and the project achievement was 25.7 km². In contrast, the MLIT budget for cadastral survey programs was approximately 13.0 billion yen, and the project achievement was 692 km². The differences in scale and character between the two programs can also be confirmed numerically.

Table 1. Entities and Roles in Real Property Public Notice and Cadastral Surveying (Japan)

Entity	Role	Legal Basis
Ministry of Justice (Legal Affairs Bureaus)	Publicly disclose rights relating to real property; ensure transaction safety and stability of rights relationships	Real Property Registration Act
Ministry of Land, Infrastructure, Transport and Tourism (MLIT)	Develop the infrastructure to administratively and socially understand land as a spatial resource	National Land Survey Act
Municipalities	Implementing bodies of cadastral surveys	National Land Survey Act

3. Process of Article 14 Map Production Work

The cadastral survey work related to Article 14 map production consists of a series of processes that begin from the stages of project planning and project preparation, and then proceed through control point surveying, parcel investigation, cadastral detail surveying, land area measurement, preparation of cadastral maps and cadastral registers, public inspection and certification, and finally submission of deliverables to the registry office.

All of these processes are strictly prescribed based on laws and operational rules. In particular, at the stages of parcel investigation and cadastral detail surveying, accurate understanding of the current situation and careful explanations to landowners are indispensable. The appropriateness of judgments and responses in these processes has a major impact on the efficiency of the overall work and the reliability of the deliverables.

4. Latest Surveying Technologies That Have Evolved in Recent Years

In recent years, surveying technologies such as GNSS surveying, LiDAR, and photogrammetry have evolved rapidly. In particular, photogrammetry using a 360-degree camera has a major feature in that it can record the field situation in an areal and three-dimensional manner and preserve it as three-dimensional point clouds and orthophotos.

With these technologies, it has become possible to comprehensively record, as numerical data, surrounding environments and spatial structures that were not targets for acquisition in conventional total station surveying.

5. Possibility of Introducing Latest Technologies into Article 14 Map Production Work

These latest surveying technologies do not directly replace statutory surveying deliverables in Article 14 map production. However, there is a possibility that they can contribute to rationalization of work by being used in supplementary purposes such as preliminary map drafting, explanation to landowners, and process planning.

In particular, the ability to comprehensively record the current situation at the time of surveying has important significance in Japan, where urban environments change in a short period. Even if the current situation changes after the survey is carried out, being able to re-check the situation at that time in a three-dimensional manner is also effective from the viewpoint of accountability.

6. Reduction of Labor Costs and Workload

By introducing the latest technologies in a supplementary way, effects can be expected such as reducing the number of field reconnaissance visits, shortening the time for preliminary map drafting, and reducing the labor required for explanation to landowners. These effects contribute not only to suppression of labor costs, but also to stabilization of the overall work and uniformity of deliverable quality.

In particular, in small surveying offices operated by a small number of people, supplementary use of these technologies can be an effective option as a means to reduce human burden and improve work safety at the same time.

7. Successor Development and Utilization of Three-Dimensional Models

One factor behind the lack of progress in developing cadastral maps is a shortage of personnel due to the aging of skilled cadastral surveyors, etc. Therefore, successor development is an urgent issue, and measures to increase its effectiveness are required.

From this viewpoint as well, it is important to generate three-dimensional models (point clouds, meshes, orthophotos, etc.) by inexpensive and rapid methods and throw them into education and training. Training environments using three-dimensional models can increase the quality and density of OJT (On-the-Job Training).

Because spatial relationships such as fences, buildings, passage widths, lines of sight, and height differences can be shared at high resolution—relationships that are difficult to share using only plan drawings and photographs—the decision-making process of "situation understanding—survey point planning—equipment setup—observation—explanation" can be repeatedly trained before field deployment, contributing to reduced judgment errors, more precise explanation procedures, and shorter field work time. In addition, it makes it possible to do "trial and error under safe conditions," which is difficult in actual field work, and by setting scenarios such as poor lines of sight, narrow spaces, fence changes, temporary structures, changes in current conditions due to rebuilding, failure to hold attendance, and discrepancies in explanations, it becomes possible to repeatedly instruct on recognizing signs and responding, revising explanation design, and key points for records, leading to the development of strategic judgment and response capability that goes beyond memorizing procedures.

Also, because the same "field site" under the same conditions can be shared, standardization of instruction becomes easier. If indicators such as the appropriateness of survey point planning, the accuracy of observation procedures, the logical structure of explanations, the completeness of records, and risk assessment are used, objective feedback is also possible. In recent years, with 360-degree cameras and photogrammetry, it has become realistic to create a three-dimensional model specific to the target field site in a short period and to conduct pre-training immediately before entering the site for difficult points (lines of sight, narrowness, fences, gaps between buildings, attendance routes, etc.). For these reasons, utilization of three-dimensional models can be an effective means for inheriting, at

high density, the core skills of skilled personnel (survey point planning, explanation design, risk management, and consensus building).

8. Conclusion

Procedures for cadastral surveying are essential to be strict in view of their public mission. However, such strictness must not be something that crushes the buds of technological innovation. Whether cadastral surveying technology and legal procedures will be further generalized and whether the scope of surveying will expand further depends not only on institutional design, but also on the enterprising spirit and practical efforts of each cadastral surveyor working in the field.

CONTACTS
Kenta ISHII
Registered Cadastral Surveyor (Tokyo No. 7358)
Ishii Land Surveying Co., Ltd.
kenta.ishii@gmail.com
https://machizukuri-1.jimdosite.com/