

Readjustment of the Cadastral Map in the East Japan Earthquake Disaster Area

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Key words: Readjustment, Measure, Map

SUMMARY

1. Investigation of Land Parcel Distortion and its disastrous effects on properties caused by The East Japan Great Earthquake
The East Japan Earthquake caused land parcel distortion from which the movements of land boundaries, loose of their monuments etc. follow. We need readjustments of cadastral map. Now, we are preparing research documents on how to operate doing it, for example, on whether their movements are parallel to each other in wide-range area or locally irregular etc.
2. Block-based coordinate-transferring measure
Basically the block-based control points and boundary points are to transfer their coordinates holistically every block where they have moved to each other, and some irregular boundary points are to readjustment their coordinates according to their partially changed elements without changing elementary land right records
3. Newly readjustment measure
In the case that land parcel border points have mainly moved irregularly in a wide-range area, land parcel borders are to be adjudicated administratively according to the social and customary rules among land owners and both the land parcel registry records and their cadastral map records are to be revised.

Lot Boundary Movement by the Great East Japan Earthquake and Correction of Cadastral Maps

Regional Legal Affairs Bureau

1 INTRODUCTION

In the Great East Japan Earthquake of magnitude 9 that took place on March 11, 2011, the largest earthquake in Japan's recorded history, strong shaking continued for about 3 minutes and the ground rumbled as if it was being dislocated. The huge tsunami which is said to be once in 1,000 years caused the death and missing of a great number of people, while many towns along the coast were devastated and reduced to ruins instantly. In the inland areas also, buildings collapsed and the landslides or ground cracks resulted.

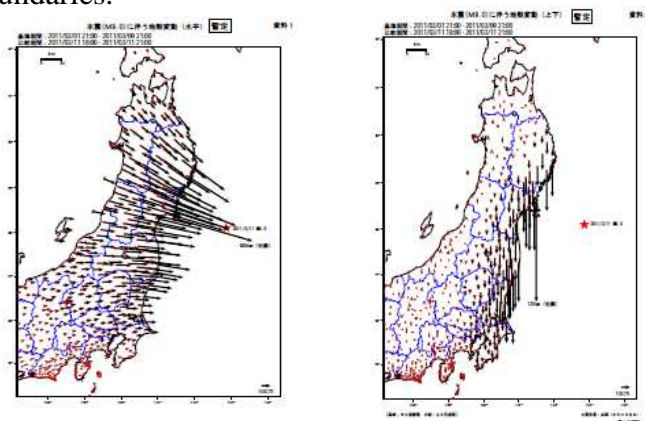
As this earthquake caused the earth's crust to move over 5 meters horizontally and the land boundaries became missing or dislocated, various cadastral measures need to be taken for restoration. In this paper, we report the current status of the disaster area and efforts being made towards the reconstruction from the standpoint of Land and House Investigators who are engaged in the onsite restoration operations as cadastral professionals.

2 TYPES OF LOT BOUNDARY MOVEMENT BY THE EARTHQUAKE

2.1. HORIZONTAL MOVEMENT

In an GPS based control stations observation by The Geospatial Information Authority of Japan, the largest movement of 5.85 m in east-southeast direction was confirmed in Onagawa Town of Miyagi Prefecture. Since the movement on the Coast of Sea of Japan was about a few dozens of centimeters to the east, the east-west width of Tohoku Area became about 5 m longer.

This horizontal movement has large influences on the control points survey, but the it has little effect on the land boundaries considering the relativity of the land surface movement. There have also been changes in the coordinates representing land boundaries.



Source:
The Geospatial
Information
Authority of
Japan's Website

2.2 SLOPE FAILURES, LANDSLIDES AND GROUND CRACKS

Such damages happened mainly in inland developed housing areas. In the housing area development, earth cutting and filling are conducted, and much damage took place especially in the earth filled locations. In Oritate Area in Sendai City where the north face of the mountain was developed for housing, a large-scale landslide took place in parts of the housing complex. A comparison between the topography before and after the development indicates that the landside locations used to be water channels (swamps). The damage in Sendai City took place in about 200 locations or 4031 blocks in the housing areas, wherein land boundaries are thought to have moved.



Landslide in Oritate Area
Building sliding over the road,
which used to be straight is curving now



Uplifted gutter

2.3 LOCAL MOVEMENT

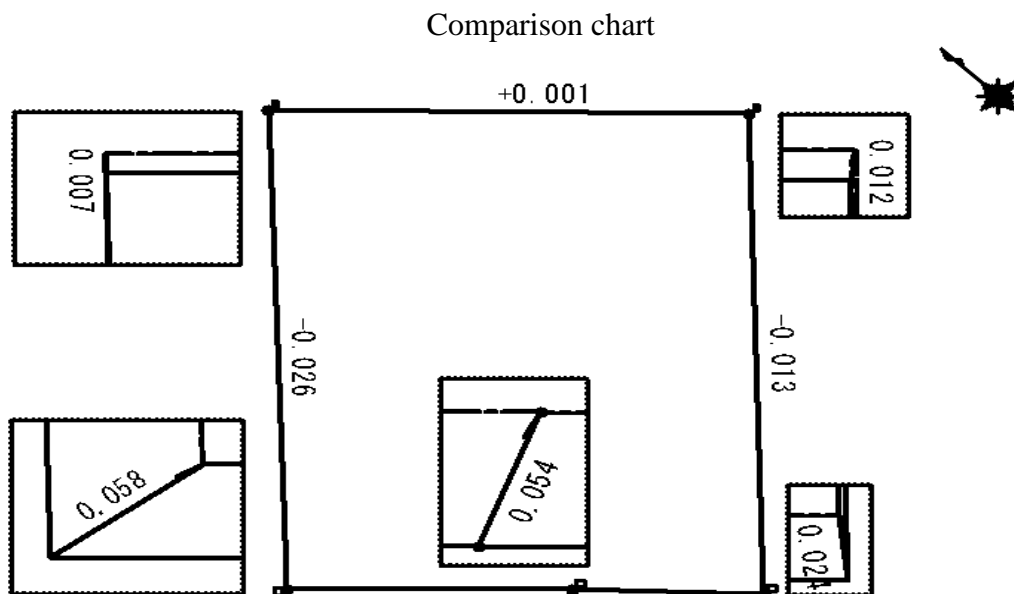
In addition to the horizontal movement, local boundary movement has been observed. The level of movement is such that land surveying can clarify, but it is considered to have happened due to the ground movement. As local ground conditions are involved, the direction and amount of movement is not constant.



Gap generated between block and pavement



Crack running in concrete retaining wall



Comparing the result of cadastral survey and the result of survey after the earthquake As you can see from the pictures, there are cracks around the wall. It is considered that the cracks made boundary move.

3 OPINION OF MINISTRY OF JUSTICE ON BOUNDARY MOVEMENT BY THE EARTHQUAKE

For the South Hyogo Earthquake that took place on January 17, 1995, where horizontal movement of the earth's crust was confirmed, Ministry of Justice decided to take the following measure.

“In case the land surface moved horizontally over a large area due to the crust movement caused by an earthquake, land boundaries shall be handled as they have also moved relatively. In cases of soil movement (landslide, etc) on a local land surface, land boundaries are handled as they did not move.”

Since the Great East Japan Earthquake caused far larger horizontal movement in an extended area than the South Hyogo Earthquake, similar procedures are decided to be taken to the South Hyogo Earthquake.

4 MISSING BOUNDARIES DUE TO THE TSUNAMI

One of the cadastral problems caused by the Great East Japan Earthquake is the missing land boundaries after the tsunami. The power of tsunami is devastating unlike simple waves, but it can be comparable to floodwater by heavy rain with gushing, turbid current from the river. Apart from reinforced concrete or steel frame structures, all other buildings were destroyed with only the foundations remaining. Concrete block walls indicating boundaries were mowed down as well. Concrete gutters and asphalt paved roads remain as

they were before the tsunami, so public-private boundaries can be recognized in some locations, but private boundaries are mostly missing.

Based on the lesson learned in the South Hyogo Earthquake, Ministry of Justice is asking for cooperation in leaving the boundary marks or identifying concrete block walls as much as possible when removing debris, but it is not actually followed.



Concrete block walls mowed down by the tsunami



Building foundation and block are remaining

5 REVISION OF CONTROL POINTS SURVEY RESULTS

Japan had used its own geodetic system (Tokyo Datum), but from 2000, a world geodetic system (The Japanese Geodetic System 2000) began to be used.

Upon confirmation of the crust's horizontal movement due to the Great East Japan Earthquake as observed at GPS control stations, The Geospatial Information Authority of Japan ceased publication of survey results, but announced the newly observed GPS based control stations on May 31 and new triangulation points survey results on October 31. This requires survey work after October 31, 2011 to be conducted in reference to the newly announced geodetic system. In order to differentiate the newly system from the pre-earthquake system, it is called Japanese Geodetic Datum 2011. For the control points not revised or re-calculated, the coordinates after the movement are calculated by parameter conversion for cost reduction reasons.

6 DISASTER STATUS INVESTIGATION OF LAND BOUNDARIES

This project is carried out for investigating the status of land boundaries that are missing or have moved irregularly in order to designate areas for which restoration of the boundaries and correction of the maps provided at registry offices need to be implemented after the investigation.

The project is executed by Ministry of Justice, but the onsite work has been consigned to Land and House Investigators.

The following areas are given higher priority for investigation due to the urgent needs for disaster reconstruction;

- 1) Areas where buildings are severely damaged by the tsunami and restoration work is

needed.

- 2) Areas of residential allotment where retaining walls restoration and other measures are needed.
- 3) Areas specifically requested by local municipalities

The investigation areas are in Miyagi, Iwate and Fukushima Prefectures that suffered substantial damage, and the collective area extends over 29,000 km².

To start with, various maps are collected to grasp the disaster status for selection of investigation areas. 300 meter meshes are plotted in the selected areas for surveying distances and areas of 4 points around and 1 point in the center of each mesh, to judge whether the error is within the cadastrally allowable range. Based on the results, the necessity of cadastral map correction is judged for the 3 levels of “Comprehensive correction,” “partial correction” and “Not Necessary.” The project is to be completed in March 2012.

Although about 50% of the cadastral maps in Japan have been given coordinates, in Tohoku area, about 80% is controlled with coordinates due to a quicker progress in the survey work. In Sendai City, however, cadastral survey has not been done in city center or urban areas, so most of the 4031 residential blocks that suffered damage are presumably not eligible for map correction.

REFERENCE DATA

ARTICLE 1 PURPOSE

The purpose of this Guideline is to provide methods for investigating the status of disaster regions of the Great East Japan Earthquake where the land boundaries became unclear or moved irregularly, and thus help to collect documents necessary to identify areas for which lot boundary restoration and registry office maps correction need to be executed after the necessary status investigation.

ARTICLE 2 WORK CONSIGNMENT

The status investigation work commissioned in this Guideline shall be consigned to Land and House Investigators. The Legal Affairs Bureau staff, however, cooperates in requesting for cooperation and information gathering from local municipalities.

2.1 REQUESTING COOPERATION FROM LOCAL MUNICIPALITIES

- 1) Sharing information on areas or locations affected by the earthquake and tsunami.
- 2) Sharing digital maps owned by local municipalities as the basis for investigation.

2.2 REQUESTING COOPERATION IN SHARING MAPS AND AERIAL PHOTOS OWNED BY GEOGRAPHICAL SURVEY INSTITUTE OF JAPAN, INDEPENDENT ADMINISTRATIVE AGENCIES, OR PRIVATE CORPORATIONS

Requesting Geographical Survey Institute of Japan, independent administrative agencies, or private corporations to share maps and aerial photos owned by them as the basis for organizing information on disaster areas maps.

ARTICLE 3 CONTENTS OF WORK CONSIGNMENT

3.1 BASIC DOCUMENT IN VESTIGATION

3.1.1 Collection of information

- 1) Information owned by Legal Affairs Bureau
 - Map information (on Ministry of Justice format, paper-based)
 - Cadastral survey maps
 - Control point information, etc.
- 2) Information owned by local municipalities (prefectural, city, ward, town and village government offices)
 - City planning maps (DM data, shape, paper maps of 1/1000 to 1/2500)
 - Road register and road register maps
 - Information on locations of repaired roads and water channels
 - Information on locations of damaged water pipes
 - Information on landslides, ground subsidence, and ground cracks
- 3) Information owned by Geographical Survey Institute of Japan
 - Information on displacement of triangulation points and benchmarks
 - Aerial photos before and after the earthquake disasters
- 4) Information owned by independent administrative agencies and private corporations
 - Information on residential maps and topographical maps
 - Information owned by electric power utilities or telecommunications enterprises
 - Information by gas utilities

3.1.2 Preparation of “Disaster Investigation Overview Report”

In the aforementioned basic document investigation, the disaster status as grasped by national institutions, each of the local municipalities, private corporations shall be given in the Disaster Status Investigation report together with documents that can verify the damage status. Such documents shall be attached to the Disaster Status Investigation Report as supplementary documents.

The disaster status shall be categorized into the following 8 types; 1) Tsunami damaged area, 2) Ground crack, landslide, collapsed area, 3) submerged area, 4) liquefied area, 5) fault area, 6) local upheaval or subsidence area, 7) washed away area, 8) other area (retaining walls collapse area or buildings collapse area), and the

documents that specify such areas shall be obtained to the extent possible.

3.1.3 Preparation of “Disaster Status Investigation Manuscript Map”

On a topographical map at a scale of about 1/25,000 (issued by Geographical Survey Institute of Japan) the disaster areas and disaster categorization (8 categories mentioned above) reported in “Disaster Investigation Overview Report” shall be described.

3.2 EXAMINATION BY PREPARATION OF MAP CLASSIFICATION CHART AND DISASTER STATUS MAP

3.2.1 Preparation of “Map Classification Chart”

Map Classification Chart shall be prepared on a 1/25,000 topographical map by cross-checking with the Japan basic land use maps (1/2,500 to 1/5,000) with the map information system, extracting the areas for each map type and classification and color-coding those areas.

The classification shall be made for the following 9 types:

- 1) Cadastral maps (pursuant to Real Estate Registration Law 14.1)
- 2) Cadastral maps (pursuant to Real Estate Registration Law 14.4)
- 3) Land improvement location maps (pursuant to Real Estate Registration Law 14.1)
- 4) Land improvement location maps (pursuant to Real Estate Registration Law 14.4)
- 5) Land readjusting location maps (pursuant to Real Estate Registration Law 14.1)
- 6) Land readjusting location maps (pursuant to Real Estate Registration Law 14.4)
- 7) Other maps (pursuant to Real Estate Registration Law 14.1)
- 8) Other maps (pursuant to Real Estate Registration Law 14.4)
- 9) Old land ledger annex maps (pursuant to Real Estate Registration Law 14.4)

3.2.2 Preparation of “Disaster Investigation Overview Map”

A map describing the disaster status shall be prepared in reference to the information owned by the prefectural and other municipal governments. If possible, the information on the “Disaster Status Investigation Manuscript Map” shall be described on the above “Map Classification Chart.”

3.3 ONSITE INVESTIGATION

3.3.1 Selection of investigation districts

Preparation of “Map Disaster Investigation Report”

The information described on the “Disaster Investigation Overview Map” and “Disaster Investigation Overview Report” prepared by the work provided in the above 1 and 2 shall be consolidated into “Map Disaster Investigation Report” in

order to select the investigation districts. The selection shall be done according to the necessity for map correction and the level of emergency. The following factors shall be taken into consideration for example;

- a. Urban district
- b. District where topographical damage is large
- c. Necessity for restoration projects is large
- d. Requested by local residents

In addition, investigation shall be also conducted to some extent in the districts located at a certain distance from the selected districts

3.3.2 Verification of Map Precision

This Status Investigation is executed for the areas where the map pursuant to Real Estate Registration Law (The 2004 Law No. 123) Article 14.1 is provided, but the precision shall be verified in advance before the inspection survey for district selection by confirming the year, methods, and precision level of map preparation and incorporating such information into “Map Disaster Investigation Report” to be the basis for analysis of inspection survey results.

3.3.3 Inspection Survey in the Investigation Districts

- 1) Designation of selected districts
Survey shall be conducted lot boundary points and areas in the selected investigation district in the units of 300-meter mesh. Survey point shall be designated in consideration of the ratio of 4 points near the circumference of a 300-m mesh and one point near the center.
- 2) Preparation of “Disaster Area Designation Map”
“Disaster Area Designation Map” shall be prepared by plotting the designated 300-m mesh and the 5 observation points on the Japan basic land use map and Real Estate Registration Law 14.1 map overlaid on each other.
- 3) Checking documents for inspection survey
A document for onsite investigation shall be prepared by organizing control point survey results, record, and lot boundary coordinates list of the vicinity of the selected 5 points.
- 4) Execution of Inspection Survey
Lot boundary point and control point shall be sought and a few locations of in-between points of appropriate lot boundaries shall be surveyed to be described on the “Map Disaster Investigation Report.” Also by using a land lot specified by the few observation points, the area accuracy shall be checked.

- 5) Preparation of supplementary materials for “Map Disaster Investigation Report.” “Observation Points Detailed Map” whereby the observation points and land lots used in the survey shall be prepared as a supplementary material for “Map Disaster Investigation Report” (see Fig. 4) and a photograph of the vicinity of the observation points shall be attached.

3.4 SUBMISSION OF ”MAP DISASTER INVESTIGATION REPORT” AND ”DISASTER AREA DESIGNATION MAP”

3.4.1 Summary of “Disaster Area Designation Map”

The status of movement of lot boundaries shall be analyzed by examining the “Map Disaster Investigation Report” and “Disaster Area Designation Map” wherein the document investigation and inspection survey results are arranged and thus the areas for which map correction is necessary shall be designated to be recorded on “Disaster Area Designation Map.”

3.4.2 Submission of “Map Disaster Investigation Report”

The Land and House Investigators shall describe, at the end of “Map Disaster Investigation Report” wherein the inspection survey results are given, the necessity for map correction on the levels of “Comprehensive Correction,” “Partial Correction (Block Correction)” or “Not Necessary” as judged according to the investigation results, and submit it to the responsible Legal Affairs Bureau staff.

3.5 DECISION ON LOCATIONS NEEDING MAP CORRECTION BY LEGAL AFFAIRS BUREAU

3.5.1 Preparation of “Map Correction Necessity Locations List”

Based on “Map Disaster Investigation Report” submitted by the Land and House Investigators, “Map Correction Necessity Locations List” shall be prepared in reference to “Disaster Area Designation Map” that specifies the locations or demarcations of the areas for which the land boundary need to be restored or the maps need to be corrected.

ARTICLE 4 MANAGEMENT OF INVESTIGATION WORK

4.1 PROGRESS MANAGEMENT

The Legal Affairs Bureau shall check upon the status of work progress as needed based on the reports submitted by the consigned Land and House Investigators and provide replies to the inquiries from those Land and House Investigators.

4.2 MEETINGS FOR WORK REPORTING

In order to promote smooth progress of the consigned work operations, meetings shall be held periodically so that the Legal Affairs Bureau can receive reports from the consigned Land and House Investigators.

ARTICLE 5 SUBMISSION OF INVESTIGATION RESULTS

The consigned Land and House Investigators shall submit the final investigation results to the Bureau.

ARTICLE 6 ADDITIONAL CLAUSE

This Guideline shall come into effect on August XX, 2011.

7 Cadastral Map Correction

Based on the disaster status investigation, cadastral maps need to be corrected for each land lot so that the maps provided at registry offices and the onsite as well as registered information can be matched, which will facilitate the regional reconstruction by safe and secure transactions of real properties that are citizens' assets.

The following two correction methods are provided for areas where cadastral map correction is recognized as necessary.

a. Block correction method

In case the status investigation reveals that several locations or parts of boundary points in a block have moved irregularly, block points are observed to identify the boundary points in a block.

Only the block points are to be surveyed and each boundary point in a block is to be corrected by such methods as Helmert conversion.

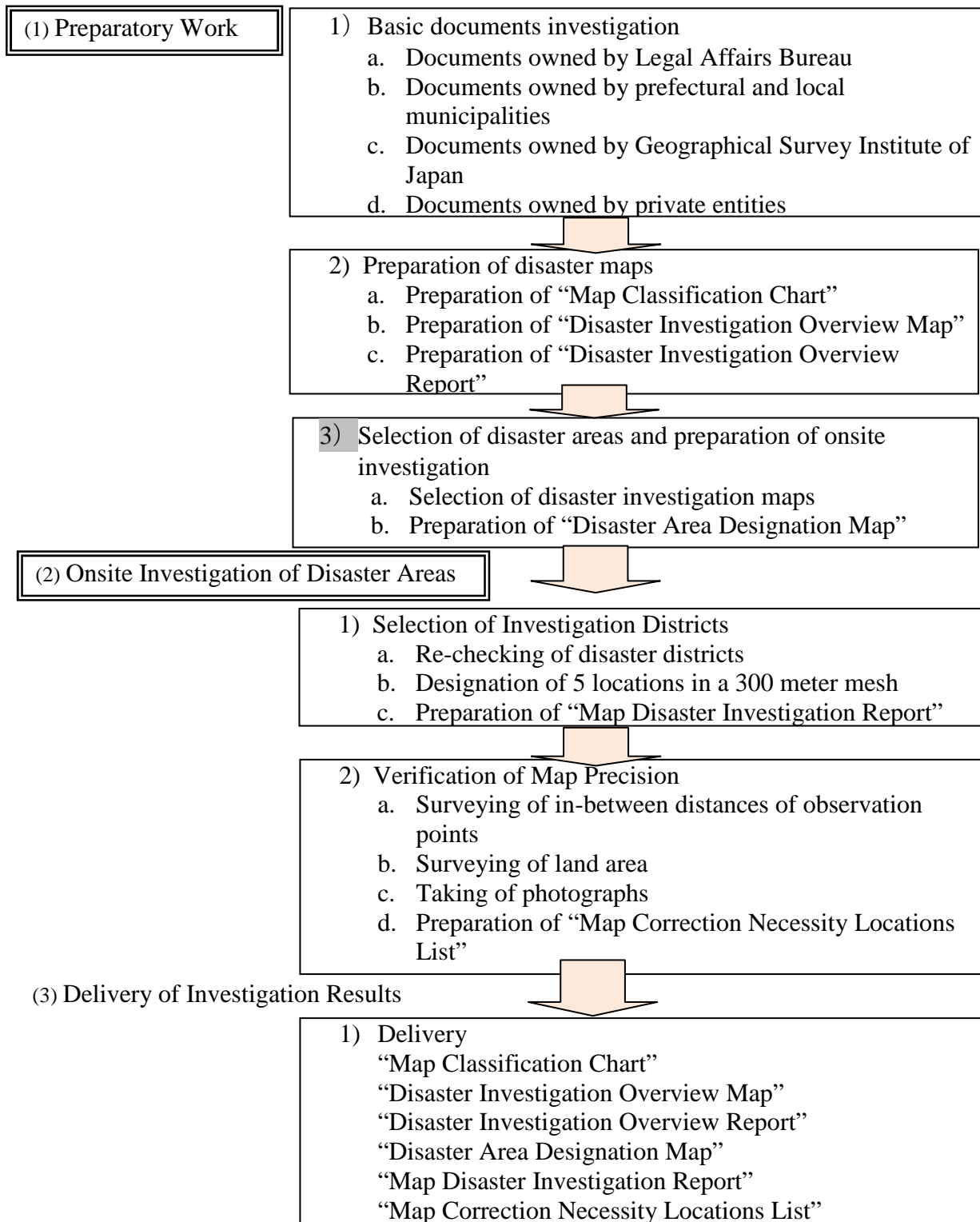
b. Cadastral map regeneration method

In case the status investigation reveals that boundaries have moved irregularly, block points and boundary points are surveyed to identify the boundary points for correcting the maps.

This method requires the same load of work for standard cadastral survey, much more time and cost than the block correction method, but it is necessary to use this method for areas with much boundary movement.

REFERENCE DATA

Work Flow of Ministry of Justice Map Status Investigation for the Great East Japan Earthquake



Guideline for Map Correction (Map Regeneration Method) (Draft)

ARTICLE 1 PURPOSE

The purpose of this Guideline is to provide methods of correcting maps upon identification of lot boundary points by surveying block points and lot boundary points which are found in the land status investigation to have moved irregularly.

ARTICLE 2 WORK CONSIGNMENT

The map correcting work designated in this Guideline shall be consigned to Land and House Investigators. The XXX_ Legal Affairs Bureau, however, issue requests for cooperation and information gathering from local municipalities as well as related organizations while the Bureau staff render cooperation in this regard as needed.

2.1 REQUESTING COOPERATION FROM LOCAL MUNICIPALITIES

1/2,500 white maps, city planning maps, maps showing disaster damage status, etc, public-private boundary confirmation work, boundary identification maps for roads and water channels

2.2 MINISTRY OF LAND, INFRASTRUCTURE, TRANSPORT AND TOURISM, AND GEOGRAPHICAL SURVEY INSTITUTE OF JAPAN

Acquisition of information on revised or re-surveyed control points, aerial photos, etc.

2.2.1 Others

Collection of maps and documents owned by independent administrative agencies and private corporations

ARTICLE 3 CONTENTS OF CONSIGNED WORK

3.1 BASIC DOCUMENTS INVESTIGATION

3.1.1 Collection of information

- a. Information owned by Legal Affairs Bureau
Maps managed by Legal Affairs Bureau, certificates of all registered matters, cadastral survey maps, lot boundary point coordinates book, control point triangulated maps, control point coordinates book, land status investigation reports, etc.
- b. Information owned by local municipalities
1/2,500 white maps, city planning maps, maps showing disaster damage status,

boundary identification maps for roads and water channels

- c. Information owned by Geographical Survey Institute of Japan
Record and coordinates book of re-surveyed, revised (parameter converted) and newly installed control points
- d. Other information
Aerial photographs, etc.

3.1.2 Documents organization

- a. Preparation of land chart (lot number, land classification, cadaster, land owner address and name)
- b. Preparation of investigation manuscript maps (lot number, land classification, cadaster, land owner name, lot boundary number(not to be described in case the coordinate is not in existence))
- c. Organization of Control point triangulated maps, control point coordinates
- d. Transcription of control point locations, etc on 1/2,500 white maps or aerial photographs

3.2 **ONSITE INVESTIGATION**

3.2.1 Onsite investigation and work plan

- a. Onsite investigation: entering current status on an investigation manuscript map (locations of control points, conditions of block points, current status of each land parcel and lot boundary points, etc)
- b. Work plan: planning for arranging register control points, surveying block points, and lot boundaries
- c. Process plan: planning for the entire process of the consigned work

3.2.2 Basic survey

- a. Selection, surveying and coordinate calculations of register control points
- b. Surveying of current status of block points (current status investigation survey for restoring block points)

3.2.3 Land parcel survey

- a. Surveying and coordinate calculations of lot boundary points

3.2.4 Lot boundary inspection survey

- a. Extraction inspection survey (about 20%)

ARTICLE 4 PREPARATION OF INVESTIGATION RESULTS

(1) Investigation manuscript	1 set
(2) Land chart	1 set
(3) Registered control points, registered auxiliary control points survey field book	1 set
(4) Registered control points, registered auxiliary control points survey calculation book	1 set
(5) Registered control points, registered auxiliary control points triangulated maps	1 set
(6) Block points survey field book and coordinate calculations book	1 set
(7) Lot boundary points survey field book and coordinate calculations book	1 set
(8) Lot boundary confirmation document	1 set
(9) Maps	1 set
(10) Lot boundary points number list	1 set
(11) Side length maps	1 set
(12) Precision management chart	1 set

ARTICLE 5 MANAGEMENT OF INVESTIGATION WORK

5.1 PROGRESS MANAGEMENT

The Legal Affairs Bureau shall check upon the status of work progress as needed based on the reports submitted by the consigned Land and House Investigators and provide replies to the inquiries from those Land and House Investigators.

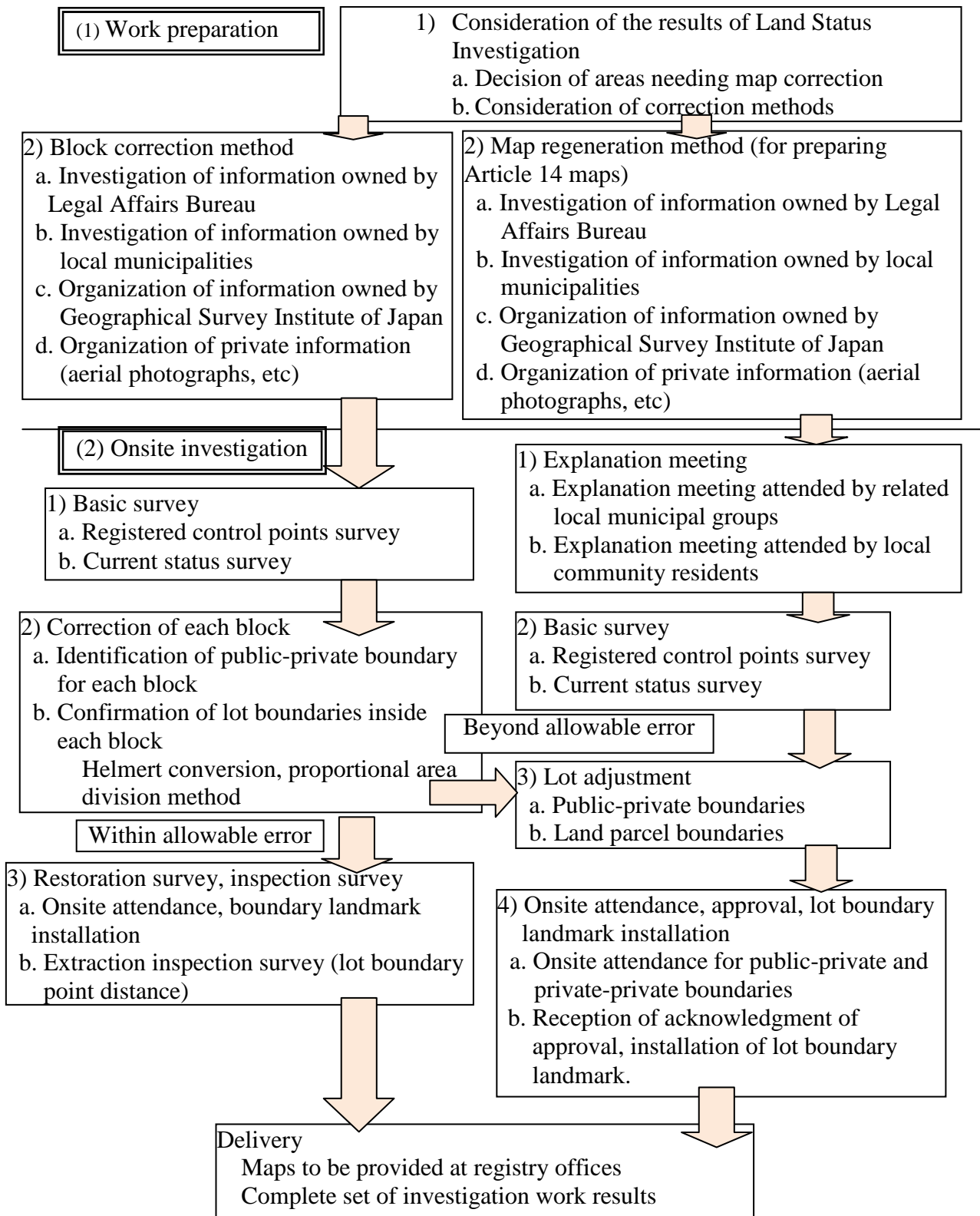
5.2 WORK REPORTS

In order to promote smooth progress of the consigned work operations, the consigned Land and House Investigators shall periodically report to the Legal Affairs Bureau on the progress.

5.3 WORK CONSULTATION

In case the consigned Land and House Investigators have questions regarding the attached work specifications or this Work Guideline, they shall request a consultation with the Legal Affairs Bureau staff while the Bureau staff shall accept such a request, arrange a consultation and take appropriate measures thereof.

Map Correction Work Flow for the Great East Japan Earthquake



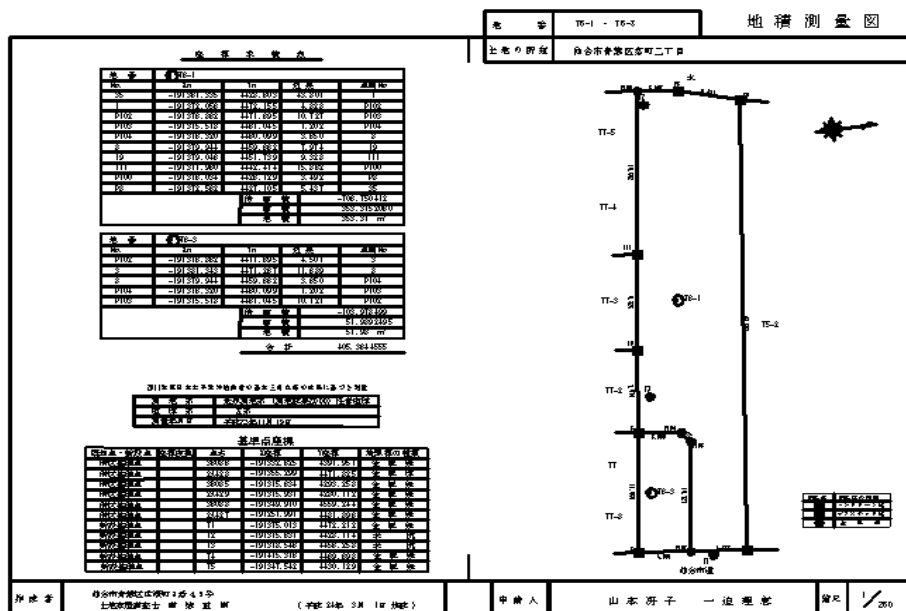
c. Correction of cadastral map drawing lines

Apart from the above cadastral correction, the coordinates of the drawing lines of cadastral maps are being corrected. The correction of the drawing lines in the tsunami submerged areas requiring expedient restoration has been already completed, and the correction for inland areas is scheduled to begin in April 2012.

8 CADASTRAL SURVEY MAPS AFTER THE EARTHQUAKE

The Real Property Registration Law obligates registry offices to be equipped with cadastral maps and a set of survey maps for a land lot to be submitted for applications for lot registration or cadastral revision registration. The maps shall contain such information as quadrature chart, distances between boundary points, types of landmarks, date of survey, geodetic system used, and coordinates of each point of the land lot. The official coordinates need to be used in principle, and newly cadastral survey maps prepared should be made with Japanese Geodetic Datum 2011 announced after the earthquake. However, the control points announced by the Geospatial Information Authority of Japan are only GPS based control stations and triangulation points, and thus 3rd class or 4th class control points used in survey of land lot units are not revised. Therefore, survey is conducted by using the Japanese Geodetic System 2000 indicating that the survey results are based on the 2000 System or the results are parameter-converted to be compatible with the 2011 System.

Having said the above, the cadastral maps provided at registry offices are available in one of the 3 types of the former Tokyo Datum, the Japanese Geodetic System 2000 and the Japanese Geodetic Datum 2011.



9 EARTHQUAKE DISASTER RECONSTRUCTION AND LAND BOUNDARY

One year has passed since the earthquake and the reconstruction has been in progress steadily. Currently, reconstruction measures are being implemented whereby each local municipality has formulated its own reconstruction plan while engaging in specific activities.

In the tsunami submerged areas, a variety of projects are planned such as restriction on building new houses, local governments' purchase of residential lots in the submerged areas, group moving to high locations safe from tsunamis, transference of railways along the coast to inland areas, restoration of damaged houses through use of public funds, etc. Also, many land sales contracts are being made by citizens in the tsunami submerged areas for moving to safe locations, and many houses are being built in inland areas. What is indispensable for implementing these projects is the identification of land boundaries that have been missing due to the tsunami and moved due to the crustal movement as well as the correction of cadastral maps. The land boundaries are limit lines of rights, and therefore it will be a difficult project to restore the boundaries not only technically but to promote mutual adjustments between the land owners.

It is necessary to carry out boundary identification speedily to promote quick reconstruction and safe, secure land sales transactions.

10 CONCLUSION

The Japan archipelago is one of the most earthquake hit areas in the world with crustal movements caused by earthquakes. Observations of GPS based control stations confirm the crustal movements by plate tectonics by dozens of centimeters every 10 years. Such movements show varying directions and amounts. In order to carry out a coordinate-based control of cadastral maps and land boundaries, the crustal movements need to be monitored always to take appropriate measures.

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