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Verification and validation guidelines for HD Maps

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Foreword

This is a guideline regulated and published by the Taiwan Association of Information and Communication Standards (TAICS) with the approval of the TAICS council.

This guideline does not suggest all the safety precautions. The related safety maintenance and health operations shall be established and the relevant regulations shall be obeyed before applying this standard.

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Introduction

With the development of Intelligent Transport Systems (ITS), autonomous vehicles will become a new mean of transportation in the future. According to the studies on safe driving of advanced vehicles, the navigation systems shall be improved to reach the accuracy above the sub-meter level, so as to meet the use requirements of autonomous vehicles. For the sake of safety needs and hardware costs, apart from the integration of INS/GNSS (Inertial Navigation System/Global Navigation Satellite System) positioning and orientation system and other spatial sensing units, the usage of High-Definition maps (HD maps) with vehicle navigation information to provide reliable and known environmental information is important to the operation of autonomous driving technology. And, most of all, the quality of High-Definition map is closely related to practical application and the assurance of safe driving of autonomous vehicles is the first principle of High- Definition map production. Therefore, the accurate verification and quality control process shall be established as the basis of High-Definition maps checking and verification for the surveying and mapping industry. According to this guideline, academic institutions or associations with expertise in geomatics surveys and studies are assigned as verification bodies to ensure that the mapping data being generated by ~~in~~ the surveying and mapping industry in fulfilling the requirements with ~~of~~ plane accuracy of 20cm, three-dimensional accuracy of 30cm and mapping data-attributes for autonomous vehicles.

1. Scope

The High-Definition mapping quality verification process and product verification requirements set out in this guideline are based on TAICS TR-0010 “HD Maps Operation Guidelines ” and TAICS TS-0024 “HD Maps Data Contents and Formats Standard”. The architecture of the high definition map supply chain applicable to this guideline is obtained by using mobile mapping systems for static map data collection, map data production, operation quality check and finished product verification of high definition maps. The applicable scope is shown in the dotted box in Figure 1.

In this guideline, the items under check are operation planning, outcomes of control survey~~,~~ and operation results of mobile mapping; the verification item shall include ~~is~~ data post-processing with the data quality of point clouds and vector layers as major focus. The purpose is to effectively control high definition map data quality.

Data standards, analytical application and format conversion for HD maps data content circulation are excluded in this guideline.

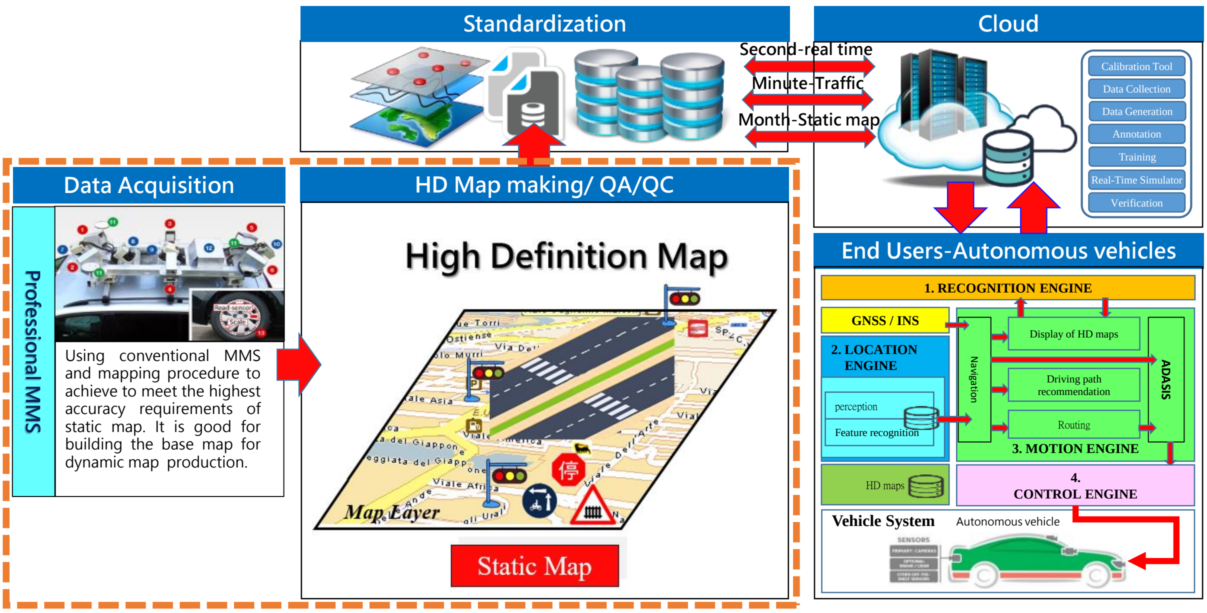

Figure 1 High definition maps supply chain architecture

2. Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes the requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

[1] TAICS TR-0010 HD Maps Operation Guidelines

[2] TAICS TS-0024 HD Maps data contents and formats standard

[3] Act Governing the Punishment of Violation of Road Traffic Regulations (2011)

[4] The Regulations for Road Traffic Signs, Markings, and Signals (2017)

3. Terms and definitions

All terms defined below are applicable to the guideline.

3.1 Land Surveying and Mapping Industry

Refers to profession engineering agencies, companies and/or technical consultant firms engaging in surveying and mapping business under the Land Surveying and Mapping Act. As for the scope of surveying and mapping business, “surveying” means taking land as the target to collect, analyze, calculate, add value to, integrate and manage geographic data with spatial distributive characteristics on, above and below the surface of the earth, and “mapping” is to show landforms, ground features or various natural or cultural data based on surveying results.

3.2 High Definition Maps (HD Maps)

Refers to static basic base map data, providing reliable and robust environmental prior information for operation of autonomous driving technology to help mobile computers to make driving decisions. The mapping data, layer categories, characteristics, attributes and metadata can be fully used by vehicle navigation systems. The two-dimensional absolute accuracy should be less than 20cm, and the three-dimensional absolute accuracy should be less than 30cm.

3.3 Global Navigation Satellite System (GNSS)

Refers to a global independent timing and spatial positioning system which users obtain real-time satellite information by their satellite signal receivers to calculate their positions (longitude, latitude and altitude) and the accurate time. There are global positioning systems, such as the Global Positioning System (GPS) of the United States, the GLObal NAvigation Satellite System (GLONASS) of Russia, the Galileo of Europe and the BeiDou Navigation Satellite System (BeiDou) of China, and regional navigation satellite systems of Japan (QZSS) and India (IRNSS).

3.4 Inertial Measurement Unit (IMU)

Inertial Measurement Unit (IMU) are devices to measure objects' inertia, such as triaxial angular rate and acceleration, including three-axis gyroscopes and triaxial accelerometers.

3.5 Inertial Navigation System (INS)

Inertial Navigation System (INS) integrates inertial measurement units and calculating units, and can directly calculate objects' navigation information such as relative positions and attitude information in real time.

3.6 The Real-Time Kinematic Positioning System of the National Land Surveying and Mapping Center (e-GNSS)

It is the name of the high-precision electronic global satellite real-time kinematic positioning system constructed by the National Land Surveying and Mapping Center. It is basically defined as the satellite real-time kinematic positioning system based on Internet communication and wireless data transmission technology. Real-time kinematic positioning technology refers to an immediate addressing technology in which a joint network comprised of multiple consecutive master satellite observation stations is used to estimate positioning errors within covered areas and mobile stations correct errors based on the observed data and estimates of adjacent master stations. A master station is a physical ground base station, making consecutively static satellite positioning survey; while a mobile station is a coordinate point to be calculated which consecutively moves relative to the master station.

3.7 Virtual Base Station Real-Time Kinematic (VBS-RTK)

It means that a GNSS network comprised of multiple satellite positioning reference stations is used to estimate positioning errors within their covered areas, combined with the observed data of the nearest physical base station, to produce a virtual base station as the RTK master station, so as to calculate the data of the virtual base stations nearby any mobile station for ultra-short baseline RTK positioning calculation.

3.8 Post Processed Kinematic, PPK

It means that the satellite observation data is combined with the VBS virtual satellite observation data obtained at all levels of basic control points by the real-time kinematic positioning system, by the On-The-Fly (OTF) integer cycle ambiguity solution technique, for RTK post processed kinematic positioning coordinate calculation.

3.9 Position Dilution of Precision (PDOP)

It is used to measure the influence of spatial geometric distribution of observation satellites on positioning precision, that is, the more ideal the geometric distribution of satellites is, the smaller the position dilution of precision will be and the higher the theoretical positioning precision will be. The position dilution of precision in the vertical direction is called the Vertical Dilution of Precision (VDOP).

3.10 Light Detection and Ranging (LiDAR)

Refers to an optical remote sensing technology that calculates the accurate distances from sensors to objects based on the time interval between the pulse laser and its reflected signals. If the pulse laser's emission angles are additionally provided, the relative two-dimensional or three-dimensional coordinates of object points can be calculated. The outputs are generally called point clouds.

3.11 Odometer

Odometer is a sensor calculating vehicle velocity based on tire revolutions to calculate vehicle driving distances. 。

3.12 Total Station

Also known as electronic total station. As a modern photoelectric measuring instrument integrating theodolite, electronic distance measuring instrument and calculator system, it can directly measure the angle difference and distance between an observation point and an observed object, including measurements such as horizontal angle, vertical angle, distance and difference in elevation.

3.13 Check Points

Check points refer to the points with known coordinates but excluded in the mapping calculation, and they are used to calculate mapping errors and analyze accuracy.

3.14 Control Points

Control points refer to the points with known coordinates and included in the mapping calculation, and they are used to provide absolute coordinates and reduce measurement errors.

3.15 Description of Station

It is a data graph to record geodetic points in geomatics, containing point name, data, surveying date, surveying unit, location, point sketch and surrounding environment.

3.16 Absolute Accuracy

The difference between measurement calculation results and known truth values is error. The larger the error is, the lower the accuracy will be, and vice versa. The absolute accuracy is the result of statistical analysis of the above error.

3.17 Relative Accuracy

The difference between measurement calculation results and known truth values is error. The larger the error is, the lower the accuracy will be, and vice versa. The relative accuracy is the ratio between the above error and the measurement.

3.18 Discrepancy

It is the difference between two measurement results.

3.19 Adjustment

It is an operation to use redundant measurements to estimate the most probable values of unknown parameters (such as point coordinates) by the least squares method, so as to estimate the overall observation accuracy. 。

3.20 LAS format

LAS is a standard file format developed and maintained by the American Society for Photogrammetry and Remote Sensing (ASPRS) for point cloud data exchange and storage. It can record the attribute data obtained from LiDAR mapping, including three-dimensional coordinates of scanning points, reflection strength, number of echo and GPS TIME.

3.21 SHP format (Shapefile)

Environmental Systems Research Institute Shapefile (ESRI SHP), as known as Shapefile, is a spatial data format. It is a vector graphic format to describe position information of geometric objects such as points, broken lines and polygons, and can store attribute information of objects.

3.22 Well-Known-Text (WKT)

WKT is a format developed by the Open Geospatial Consortium (OGC) to record coordinates in text, commonly used to represent vector data and geographic coordinate systems.

3.23 Feature Block

Refers to the mapping range containing one or more feature points (or interest points), such as landmarks, mark lines and other final products of high definition maps.

3.24 Road

A road, as defined in the “Regulations on Administrative Penalties for Road Traffic”, is a highway, street, alleyway, square, arcade, corridor or place for the public to pass through.

3.25 Lane

A lane, as defined in the “Regulations on Administrative Penalties for Road Traffic”, is part of a road divided by dividers, guardrails or mark lines, and a road for vehicle traveling.

3.26 Lane Line

A lane line, as defined in the "Rules for Setting up Road Traffic Signs, Sign Stripes and Signals", is used to lay out a lane and guide a driver to travel on the lane.

3.27 Lane Center Line

It is a center line determined based on the lane lines on the left and right sides of a lane.

3.28 Road Edge

A road edge refers to the edge of an asphalt road. For any road with curbs, the edge of the curbs is considered as the road edge.

3.29 Crosswalk

As defined in the "Regulations on Administrative Penalties for Road Traffic", it refers to a place laid out by mark lines on a road for pedestrians to cross the road.

3.30 Stop Line

As defined in the "Rules for Setting up Road Traffic Signs, Sign Stripes and Signals", it is a boundary used to instruct a moving vehicle to stop. When a vehicle stops, its front overhang shall not exceed this line.

3.31 Parking Space

It indicates the location and range for a driver to park his or her vehicle, and is marked by stop lines.

3.32 Sign

As defined in the "Rules for Setting up Road Traffic Signs, Sign Stripe and Signals", various signs are laid out on roads, including warning signs, prohibition signs, instruction signs and assisting signs.

3.33 Signal

As defined in the "Rules for Setting up Road Traffic Signs, Sign Stripes and Signals", signals are lighting facilities laid out on roads for traffic control, including traffic control signs, pedestrian signs and special traffic signs.

3.34 Sign Stripe

As defined in the "rules for setting up road traffic signs, mark lines and signals", mark lines are all kinds of warning, prohibition and instruction marks laid out on roads, and laid out on roads or other facilities by lines, graphs, words or other guiding devices for traffic control.

3.35 Traffic Island

A traffic island is a special area between lanes, to distinguish traveling directions, separate slow and quick lanes, direct traffic flow, provide temporary refuge for pedestrians and lay out traffic control facilities. Raised islands, recess zones, marks, curbs, mark lines or other setting methods can be adopted. Traffic islands are classified into the following four categories according to their functions: divisional islands (also known as traffic islands), channelizing islands, refuge islands and circular central islands.

3.36 Tunnel

A tunnel is an artificial passageway where a traffic route or water channel is under ground, such as a mountain tunnel, an underground tunnel or a subsea tunnel, with the purpose of avoiding steep slopes and excessive bending on routes and shortening the distance. The clear height of a tunnel shall be based on the maximum vehicle height, with a minimum slope of 0.2%, to facilitate drainage. Long tunnels shall be ventilated.

3.37 Bridge

A bridge is used to span a river, waterway, railway, highway, urban road and overhead road, consisting of abutments, piers and girders.

4. Checklist for verification and validation

In this section, based on the operation items of listed in the checklist of high definition map operation process and outputs of TAICS TR-0010 “Mapping Guideline for HD Maps”, check items and contents are defined, checked and verified, and this checklist is revised as shown in Table 1.

Table 1 Checklist for high definition map check and verification

Work items		Verification items	Verification contents
Check items	Operation planning	Function test and calibration report of INS/GNSS positioning and orientation integrated system	Specifications and system parameters of IMU and GNSS as well as absolute accuracy test results of IMU/GNSS.
		Operation plan	1. Description of specifications for scanners of surveying vehicles. 2. Scan planning. 3. Scanning parameter for each planned route. 4. GNSS geometric condition evaluation and GNSS base station distribution.
	Control survey	Control survey outcome and report (including distribution and coordinates of control points and check points)	Control points, check points and new GNSS base stations shall have the absolute plane accuracy of less than 10cm and absolute three-dimensional accuracy of less than 15cm.
	Operation results	Mobile Mapping System surveying report.	1. Check the GNSS base station distribution and GNSS satellite observation period to confirm whether the geometric conditions and time recording meet the requirements. 2. Check whether scanning parameters conform to those in the operation planning. 3. Check whether operation tracks are consistent with each planned route.

<table>
<tr><td></td><td></td><td>Raw data from scanners</td><td>1. Raw data of INS, GNSS and odometers.
2. Range data of vehicle-borne laser scanners.
3. Raw Image data.</td></tr>
<tr><td rowspan="4">Verification items</td><td rowspan="2">Point cloud data</td><td>Point density</td><td>Check whether the point density submitted by the submission unit meets the requirements of application scenarios.</td></tr>
<tr><td>Verification of relative errors of scanning routes (internal accuracy verification)</td><td>The internal accuracy of point clouds shall be less than 10 cm.</td></tr>
<tr><td rowspan="2">Vector layer</td><td>Geometric accuracy and shape correctness</td><td>1. Check whether vector object shapes and quantity are correct.
2. The absolute accuracy discrepancy and plane position discrepancy of vector objects shall be less than 20cm, and the three-dimensional discrepancy shall be less than 30cm.
3. The relative position discrepancy and plane position discrepancy of vector objects shall be less than 10 cm, and the three-dimensional discrepancy shall be less than 15 cm.</td></tr>
<tr><td>SHP data attribute format</td><td>1. Rationality of pixel spatial phase relations.
2. Logic consistency of vector layer data.</td></tr>
</table>

5. Operation planning verification

This section describes the check items of data collection in the planning stage including scanner types and specifications of mobile mapping systems, function test of INS/GNSS positioning and orientation integrated systems and mapping operation planning. The submitted data, contents and methods, and acceptance criteria for item check are described as below.

5.1 Document for submission

The operation plans of surveying vehicle for fields under survey shall be submitted with the following items being included:

(a) Function test and calibration report for the INS/GNSS positioning and orientation integrated system: with IMU and GNSS specifications, system parameters and accuracy of test results provided.

(b) Scanner specifications of surveying vehicles with IMU, GNSS, LiDAR and cameras included.

(c) Scanning plan of field coverage.

(d) Scanning parameters of each planned route, including point density, viewing angles, laser emission frequencies and scanning frequencies.

(e) GNSS geometric condition evaluation: the distribution of GNSS base stations shall be provided with calibration data of GNSS receivers.

(f) Control points distribution plan.

5.2 Verification contents and methods

(a) Function test and calibration report for the INS/GNSS positioning and orientation integrated system: the system shall be recalibrated once the relative relations of instruments are changed after each disassembly. The calibration report shall contain information such as system calibration method, date, location, calibration raw data, calculation process record (including key software processing screen) and result accuracy description. System types and specifications in detail shall be recorded for checking. IMU can measure with absolute specification accuracy through its test and calibration process, and GNSS can verify the absolute positioning accuracy with static test in baseline fields.

(b) Scanner specifications of surveying vehicles: Submitted document shall be checked for compliance.

(c) Scanning plan of field coverage: The scanning plan shall be checked in full~~y~~ coverage~~s~~ of the surveying area.

(d) Scanning parameter setting for each planned route: Submitted document shall be checked for compliance, and the point density shall be defined in according to the grades of accuracy as specified in the mapping guideline.

(e) GNSS geometric condition evaluation: the GNSS base stations distribution will be checked. On a scanning route, at least one GNSS base station shall be allocated within the range of 5 km for ~~to~~ simultaneously receiving of GNSS measurements. The GNSS receiver shall be dual-frequency or multi-frequency and receive~~s~~ at least one set of data per second~~,~~ with the PDOP and VDOP of ground GNSS base station less than 3.

(f) Control point layout plan: check whether control points are laid out in accordance with the grades and specifications of inertial measurement units and the density of auxiliary ground control points recommended in TAICS TR-0010 “Mapping Guideline for HD Maps”.

5.3 Acceptance criteria

All data shall meet the above requirements, otherwise the submission unit will be consulted for correction.

6. Control survey verification

This section describes the control survey outcome check. The e-GNSS real-time kinematic positioning system, post-processing positioning or total stations constructed by the National Land Surveying and Mapping Center are adopted to verify different situations. According to the accuracy results announced by the National Land Surveying and Mapping Center, when the virtual base station real-time kinematic positioning (VBS-RTK) service is adopted, the positioning accuracy can reach the centimeter level, which meet the mapping accuracy requirements for autonomous vehicles. Therefore, in the case of good transparency in the surveying area (no shielding above the satellite elevation of 15 degrees), the result can be checked directly by the e-GNSS real-time kinematic positioning system. The submitted data, verification sample units and size, contents and methods, and eligibility criteria for item check are described as below.

6.1 Document for submission

The control survey report shall contain: control survey description, field record sheet, point coordinates (.xls files), description of station and point distribution map (including control points, check points and new GNSS base stations).

6.2 Check sample units and amount

All data will be verified. The number of control survey acceptance shall be based on the control survey report as submitted:

(a) Control points: Single sampling is adopted, with a sampling size of 10%. At least 5 points shall be sampled, and all samples shall meet the accuracy requirement.

(b) Check points: There are at least 10 check points shall be set in each survey area. If a surveying area is more than 5 km, two check points shall be added for every 1 km extra. The coordinates of the used check points shall be evenly distributed in the surveying area, and the accuracy of the point cloud results shall be checked. Single sampling is adopted, with a sampling proportion of 10%. At least 5 points shall be sampled, and all samples shall meet the accuracy requirement.

(c) GNSS base stations: on a scanning route, at least one GNSS base station shall be set within the range of 5 km to receive GNSS measurements simultaneously. All GNSS base stations will be verified.

6.3 Verification contents and methods

(a) Accuracy requirements:

(1) Control points, check points and GNSS base stations shall have the absolute two-dimensional of less than 10 cm and the absolute three-dimensional accuracy of less than 15cm.

(b) Check methods:

(1) The e-GNSS real-time kinematic positioning system, post-processing positioning and total stations are adopted for check. In case of good transparency in the surveying area, the e-GNSS real-time kinematic positioning system is preferred; in case of poor transparency in the surveying area, total stations are used for assistance.

(2) Coordinate conversion and overlay: the coordinate system of the e-GNSS positioning system shall be converted, because it is different from the legal coordinate system in Taiwan. In order to omit the complicated procedure of coordinate system conversion, the National Land Surveying and Mapping Center respectively transfer the seven-parameter conversion model, residual network correction model and grid interpolation calculation method to receiving stations, so as to help VBS-RTK survey results to convert into the legal coordinate system in real time (only those higher than version RTCM 3.1 are supported, if not, conversion coordinates can be obtained through online post-processing on the website of the National Land Surveying and Mapping Center).

(3) Temporary control points are set up for surveying assistance: if ambiguity-fixed high accuracy satellite positioning results cannot be obtained due to poor transparency or other factors at survey points, temporary control points can be set up by the VBS-RTK positioning technology for surveying, combined with total stations.

i. According to the “mapping control survey” of the “operation manual for encryption control and mapping control survey by the real-time kinematic positioning technology at virtual base stations” issued by the National Land

Surveying and Mapping Center, the grade of mapping control points shall be surveyed by the VBS-RTK positioning technology, so as to set up temporary control points.

ii. If total stations are combined with temporary control points to survey point coordinates, the radiation method or traverse method can be adopted. If the traverse method is adopted, the overall error of horizontal angular closure shall not be greater than $20''\sqrt{N}$, where N is the total points of traverses (points to be measured), and the error of position closure shall be less than 1/5000.

6.4 Acceptance criteria

All data shall meet the above requirements.

7. Operation result Verification

This section describes the data collection result verification. The results from the integrated INS/GNSS positioning and orientation system and the raw data from the mobile mapping system without post-processing are verified. The submitted data, contents and methods, and eligibility criteria for item check are described as below.

7.1 Document for submission

(a) Surveying vehicle scan report: includes scanning parameters, GNSS track (including coordinate and time, and time shall be recorded in GPS WEEK and GPS TIME and stored in ASCII files or other general formats), GNSS base station distribution and GNSS base station satellite observation PDOP map. The INS/GNSS positioning and orientation integration system result calculation report and dip scanning charts shall be attached for the verification units to refer to in the future.

(b) Raw data: Raw data of INS, GNSS and odometers, range data of mobile mapping system, as well as image data are included.

7.2 Verification contents and methods

(a) Surveying vehicle scan report:

(1) GNSS geometric conditions: The GNSS base station distribution and GNSS satellite observation period are checked to confirm whether the geometric conditions and time recording meet the requirements. On a scanning route, at least one GNSS base station shall be located within the range of 5 km to receive GNSS measurements simultaneously. The GNSS receiver shall be dual-frequency or multi-frequency and receives at least one observation of data per second.

(2) Scanning parameters: Scanning parameters shall be described with surveying routes and the conformance with the operation planning shall be checked.

(3) Consistency between operation tracks and planned tracks: Whether surveying routes are consistent with planned routes shall be checked according to the GNSS trajectory. In case of shielding caused by tunnels or cities in the surveying area, it is

recommended to provide INS/GNSS integrated solution trajectory or scanning trajectory for description.

(b) Raw data: Check whether the items meet the requirements of submitted data, and whether the surveying date and time of raw data are consistent with those in the surveying vehicle scan report. The verification units shall keep the raw data for reference.

7.3 Acceptance criteria

All data shall meet requirements.

8. Point density and internal accuracy verification

This section describes the point cloud verification which is designed for the quality of post-processing results of point cloud data. The submitted data, contents and methods, and eligibility criteria for item check are described as below.

8.1 Document for submission

Point cloud data: adjusted point clouds in LAS format shall be submitted. The data shall include three-dimensional coordinates of scanning points, intensity, File Source and GPS TIME. Flying points shall be eliminated, the submitted point cloud data shall be determined whether to colorize images with photographic true colors according to the application requirements.

8.2 Point density verification

The point density will be totally verified to ensure that the point cloud density of the LiDAR point cloud data meets the requirements. The point density is classified into three grades according to different accuracy requirements, as shown in Table 2. The number of grids (low-density areas) below the required point density shall be less than 5% of the total number of grids in the survey area. If failing to meet the requirement, the submission unit will be asked for correction, and rescanned if necessary.

Table 2 Classification of point cloud density by grade

Point cloud density grade	Application scenarios (three-dimensional positioning accuracy)	Point cloud density (pt/m^2)
Grade 1	Active Control (0.1 m)	2500-10000
Grade 2	Where in Lane (0.5 m)	400-2500
Grade 3	Which Lane (1.5 m)	100-400

(a) Verification contents and methods: the point density is verified. Point cloud samples are in 1×1 m2, and all samples will be verified. The data range is extended outward by 1 m from the road edge.

(b) Eligibility criteria: the number of unqualified grids in the surveying area shall be less than 5% of the total number of grids. If failing to meet the requirement, the submission unit will be asked for correction, and rescanned if necessary.

8.3 Verification of relative errors of scanning routes (internal accuracy verification)

In order to ensure that the point cloud adjustments have effectively corrected the systematic errors between each scanning routes, the point cloud relative errors shall be verified to ensure the internal geometric accuracy of point clouds less than 10cm after correction. If failing to meet the requirement, the submission unit will be asked for correction, and rescanned if necessary.

(a) Relative accuracy verification and methods:

(1) Calculation of relative elevation deviation of scanning routes:

i. Firstly, a position on the corresponding road is taken every 100m in the surveying area as the verification position. And then, a 5×5 m^2 area centered on this position is taken and the road point clouds that overlap in this area are selected to calculate the optimal point cloud plane. Therefore, the elevation of the plane center is the estimated. In this way, the estimated elevation of each scanning route at the same position can be obtained, and the relative elevation deviation between scanning routes can be calculated. For two overlapped scanning routes, the difference of estimated elevations between them is the relative elevation deviation; and for multiple scanning routes, the difference between the maximum and minimum estimated elevations is the relative elevation deviation.

ii. Point cloud profile: 5 places are randomly selected in the surveying area as verification positions. 5×5 m^2 areas centered on these positions are taken and the road point clouds that overlap in this block are captured. A point cloud profile is used to show the relative elevation deviation between surveyed scanning routes.

(2) Calculation of the relative plane deviation of scanning routes: the point clouds of sign boards, poles or refuge islands on a corresponding road in the surveying area are taken every 1km as the verification positions, and at least five places shall be selected. On this basis, the centers of the optimal planes of the sign boards on scanning routes are calculated, so as to obtain the relative plane deviation between scanning routes. For two overlapped scanning routes, the estimated plane discrepancy between them is the relative plane deviation; and for multiple scanning routes, the difference between the maximum and minimum estimated plane discrepancies is the relative plane deviation.

(3) Internal accuracy estimation: the internal geometric accuracy of the surveying area shall be less than 10cm, that is, the estimated relative elevation discrepancies and estimated relative plane discrepancies of scanning routes at all effective verification positions shall be less than 10cm.

(b) Acceptance criteria: the internal geometric accuracy (plane/elevation) of the surveying area shall be less than 10cm, otherwise the submission unit will be asked for correction.

9. Vector map verification

This section describes the vector map verification and is designed to ensure the quality of vector map of high definition maps. The submitted data, check sample units and size, verification of geometric accuracy and shape correctness of vector layers, and SHP data attribute format for item check are described as below.

9.1 Document for submission

The high definition map vector files submitted shall be in three-dimensional vector SHP files. The layer items to be submitted shall be in accord with Appendix A and TAICS TS-0024 "HD Maps Data Contents and Formats Standard".

9.2 Verification sample units and amount

The check sample units of vector files are single feature blocks, and the sampling quantity is classified into three grades according to the accuracy requirements of different application scenarios. Any unqualified feature block shall be sent back to the submission unit for correction.

Table 3 Classification of sampling quantity by grade

Sampling grade	Application scenarios (3D positioning accuracy)	Sampling size
Grade 1	Active Control (0.1m)	Totally verified.
Grade 2	Where in Lane (0.5m)	Single sampling is adopted, with a sampling proportion of 50%. All sampled feature blocks shall meet the standards.
Grade 3	Which Lane (1.5m)	Single sampling is adopted, with a sampling proportion of 10%. All sampled feature blocks shall meet the standards.

9.3 Verification of geometric accuracy and shape correctness of vector layers

The points for vector layer verification are geometric accuracy and digitized shape correctness. The check contents are as below:

(a) Check standards:

Determine whether vector object shapes and quantity are correct. Those meeting the following standards are deemed qualified: as for the absolute accuracy, the two-dimensional shall be less than 20cm and the three-dimensional discrepancy shall be less than 30cm; as for the relative accuracy, the plane position discrepancy shall be less than 10cm and the three-dimensional discrepancy shall be less than 15cm.

(b) Check items:

The following are only the names and illustrations of geometric accuracy check items for vector layers. Please refer to Appendix A and "HD Maps Data Contents and Formats Standard" for the detailed definitions and drawing descriptions of all items.

(1) Roads: include lane lines and road edges (Figure 2).
(2) Lanes: include lane center lines (Figure 2).
(3) Sign stripes: include stop lines, parking spaces, mark lines, mark area and mark graphs (Figure 3, Figure 4). Mark area includes crosswalks (Figure 5), bicycle crossing lines (Figure 6), waiting areas for bicycles and motorcycles (Figure 7), waiting areas for turning bicycles and motorcycles (Figure 8) and grid lines (Figure 9).
(4) Objects: include speed humps and traffic islands (Figure 10). The object types and codes of the "HD Maps Data Contents and Formats Standard" shall be taken as reference. Trees do not need to be drawn.
(5) Tunnels and bridges.
(6) Signs, signals (Figure 11), signal faces and poles.

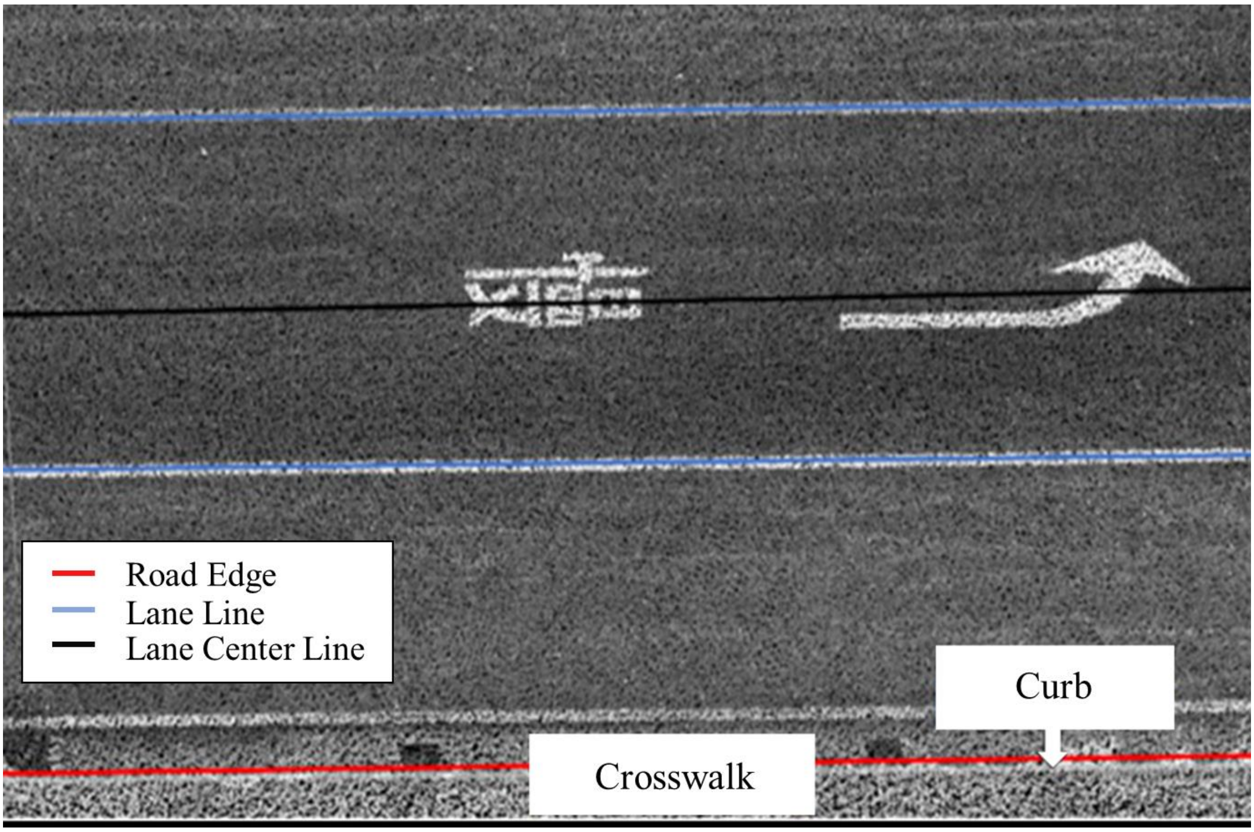

Figure 1 Illustration of a lane line, road edges and a lane center line

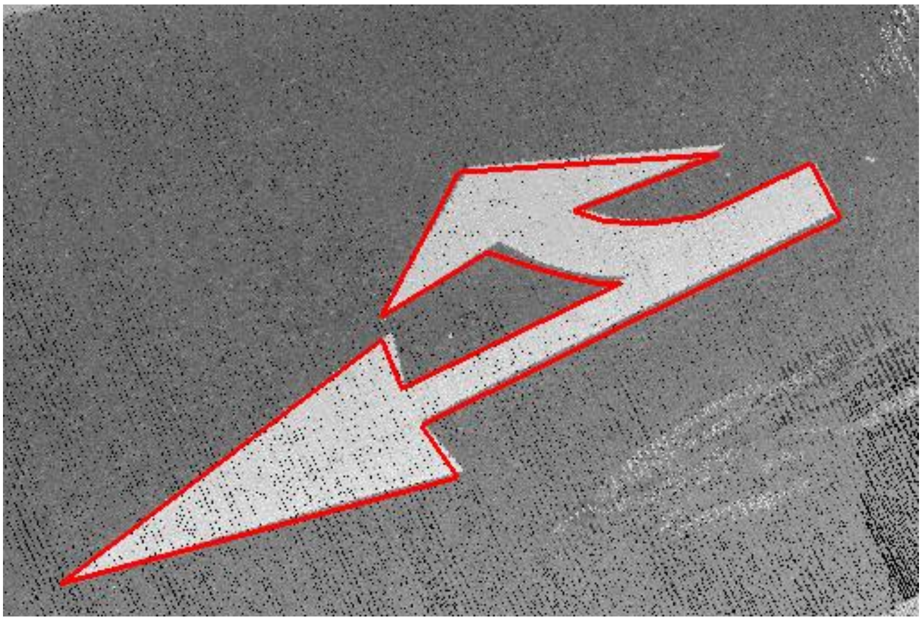

Figure 2 Illustration of a mark graph (guiding line)

Figure 3 Illustration of a mark graph (word)

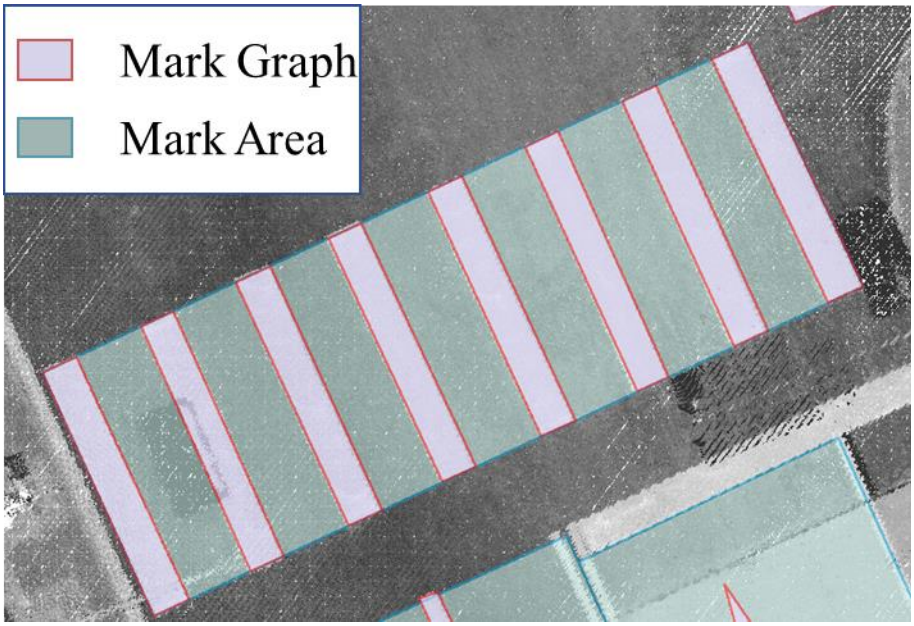

Figure 4 Illustration of a crosswalk

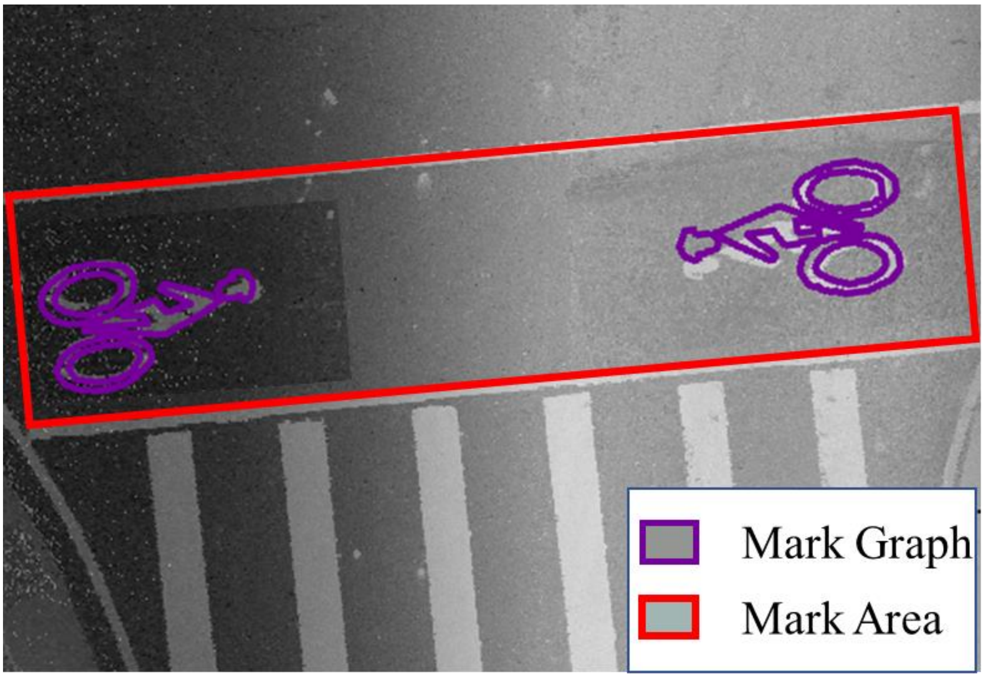

Figure 5 Illustration of a bicycle crossing line

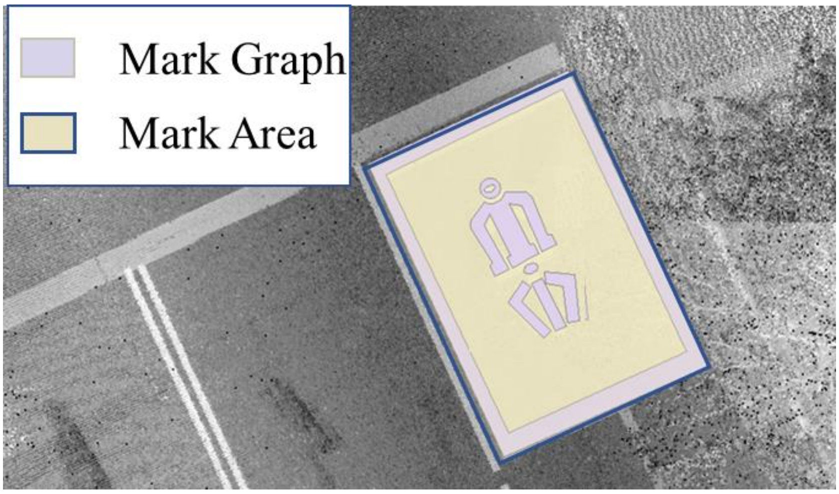

Figure 6 Illustration of a waiting area for bicycles and motorcycles

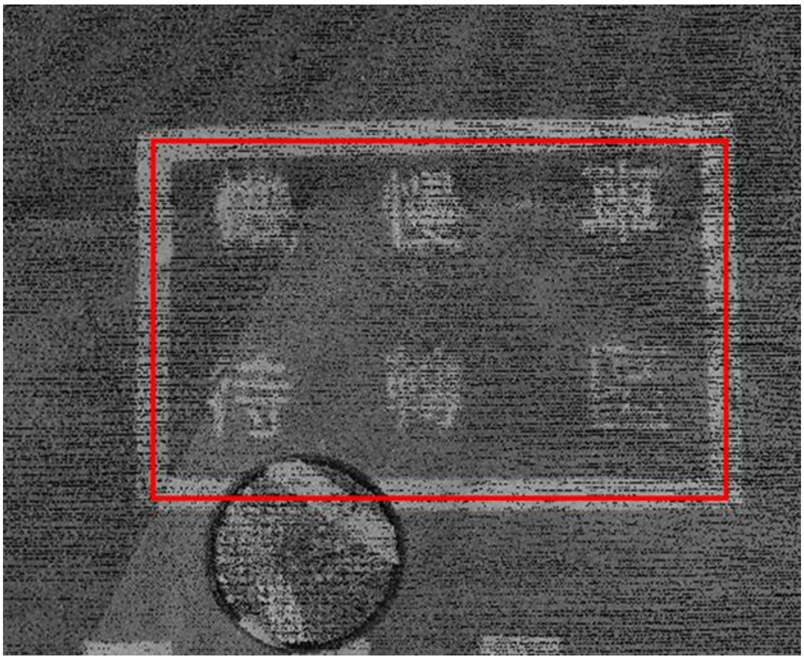

Figure 7 Illustration of a waiting area for turning bicycles and motorcycles

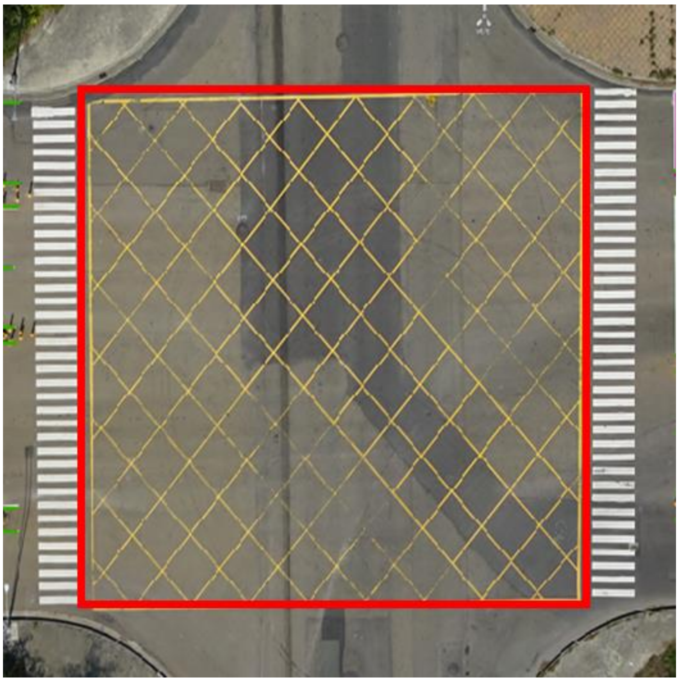

Figure 8 Illustration of grid lines

Figure 9 Illustration of a traffic island

Figure 10 Illustration of a sign, a signal, and a signal face

(c) Verification methods:

(1) Roads (lane lines): the digitized lane lines submitted by the submission unit will be compared with the lane lines presented by point clouds to obtain the discrepancy between them, so as to verify whether the item meets the requirements of relative accuracy. As shown in Figure 12, the red line is the digitized results provided by the submission unit, and the blue line is the position of the lane lines presented by point clouds. Point clouds and images shall be used to assist in checking whether digitized shapes and quantity are correct.

(2) Roads (road edges): road edge lines are the boundaries below curbs. The red line is the digitized results provided by the submission unit, and the blue line is the position of the road edge lines presented by point clouds. The discrepancy between both lines is measured to verify whether it meets the requirements of relative accuracy, as shown in Figure 13. The red line is the digitized results provided by the submission unit, and the blue line is the position of the road edge lines presented by point clouds. Point clouds and images shall be used to assist in checking whether digitized shapes and quantity are correct.

(3) Lanes (lane center lines): a lane to be verified is selected, digitized to be a rectangle about 20m, and then skeletonized to get a lane center line. The result is compared with the digitized lane center line submitted by the submission unit to verify whether it meets the requirements of relative accuracy, as shown in Figure 14. Point clouds and images shall be used to assist in checking whether digitized shapes and quantity are correct.

(4) Sign stripes (stop lines): a stop line to be verified is selected, digitized to be a rectangle, and then skeletonized to get a stop line. The result is compared with the digital stop line submitted by the submission unit to verify whether it meets the requirements of relative accuracy, as shown in Figure 15. Point clouds and images shall be used to assist in checking whether digitized shapes and quantity are correct.

(5) Sign stripes (parking): the digitized area is compared with the actually field surveyed results to verify whether the discrepancy between both meets the requirements of absolute accuracy, as shown in Figure 16. Point clouds and images shall be used to assist in checking whether digitized shapes and quantity are correct.

(6) Sign stripes (mark graphs): the digitized real feature corner points are compared with the actually field surveyed results to verify whether the discrepancy between both meets the requirements of absolute accuracy, as shown in Figure 17. Words and complex graphics will be checked with point clouds to check whether their template text and quantity is correct.

(7) Sign stripes (mark area): the digitized area is compared with the actually field surveyed results to verify whether the discrepancy between both meets the requirements of absolute accuracy, as shown in Figure 18. Point clouds shall be used to assist in checking whether digitized shapes and quantity are correct.

(8) Objects: the digitized objects are compared with the actually surveyed objects to verify whether the end-point or linear discrepancy meets the requirements of absolute accuracy, as shown in Figure 19. Point clouds and images shall be used to assist in checking whether digitized shapes and quantity are correct.

(9) Tunnels and bridges: point clouds shall be used to check whether the relative accuracy and quantity of digitized positions are correct.

(10) Signs, signals, signal data and poles: the verification unit will obtain the positions of central points through digitized, and measure the digitized results of the drawing unit to verify whether the requirements of relative accuracy are met. Point clouds shall be used to check whether the relative accuracy and quantity of digitized positions are correct, as shown in Figure 20 and Figure 21.

(d) Eligibility criteria: sampled SHP files shall comply with the regulations, otherwise the submission units will be asked for correction.

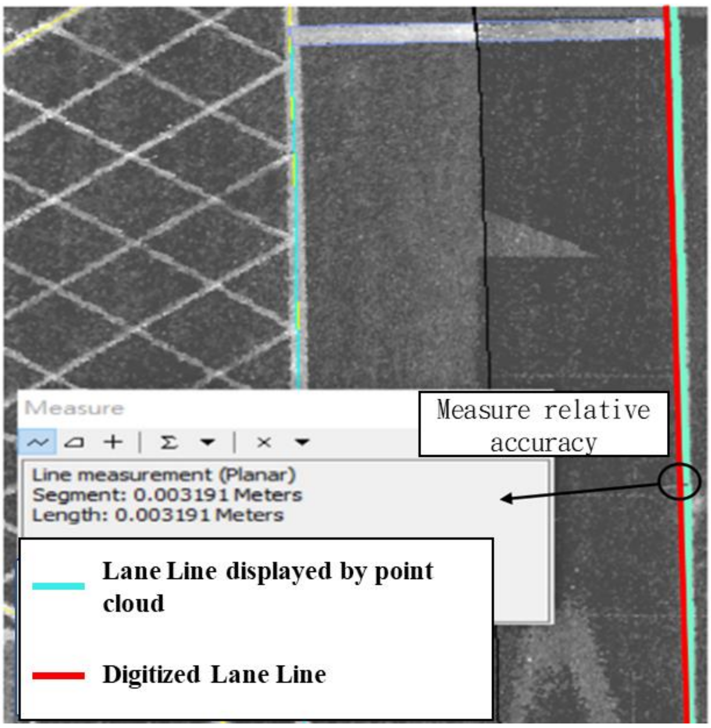

Figure 11 Illustration of lane line verification

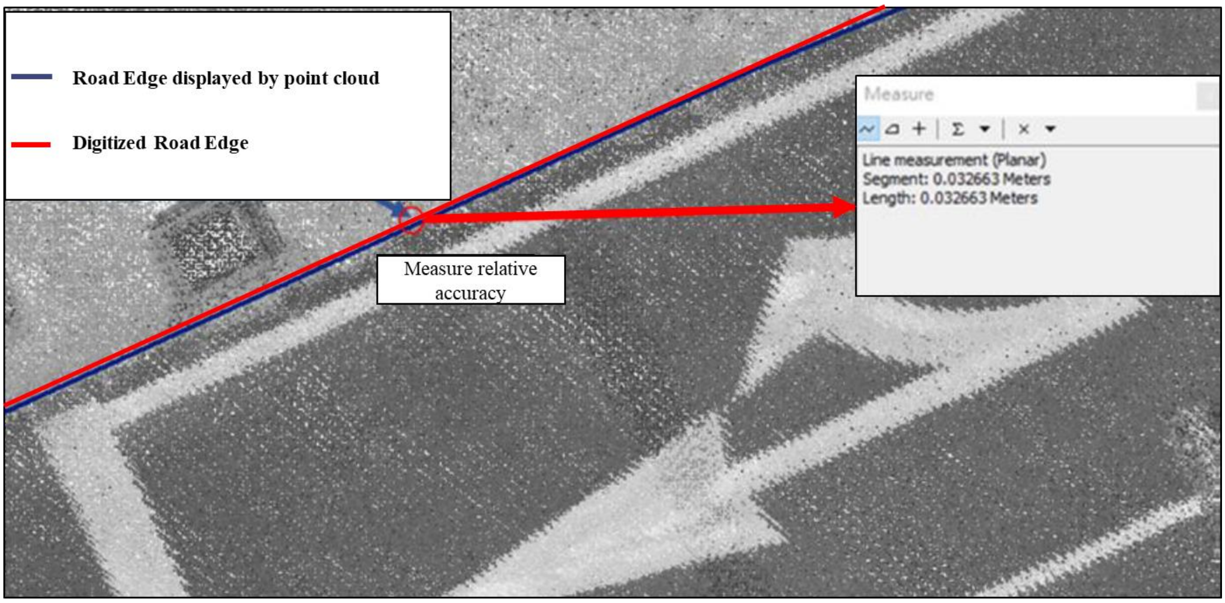

Figure 12 Illustration of road edge verification

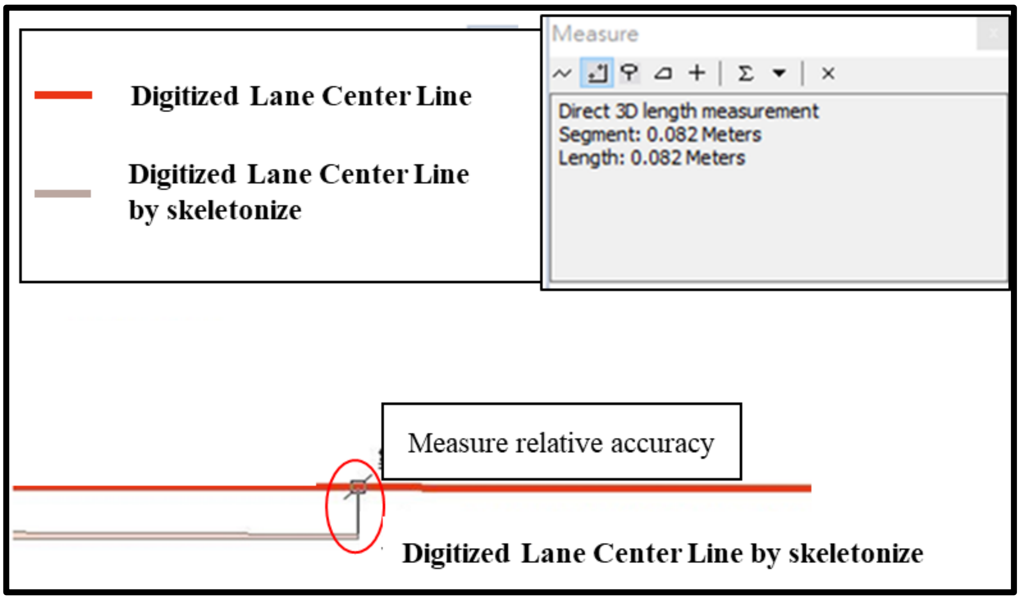

Figure 13 Illustration of lane center line verification

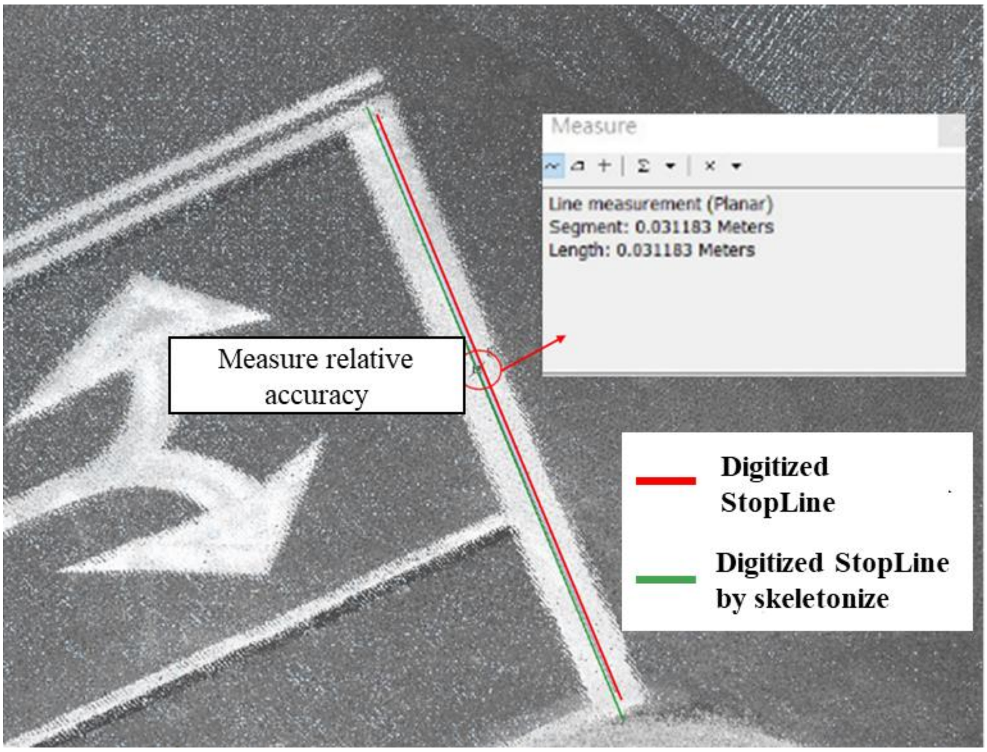

Figure 14 Illustration of stop line verification

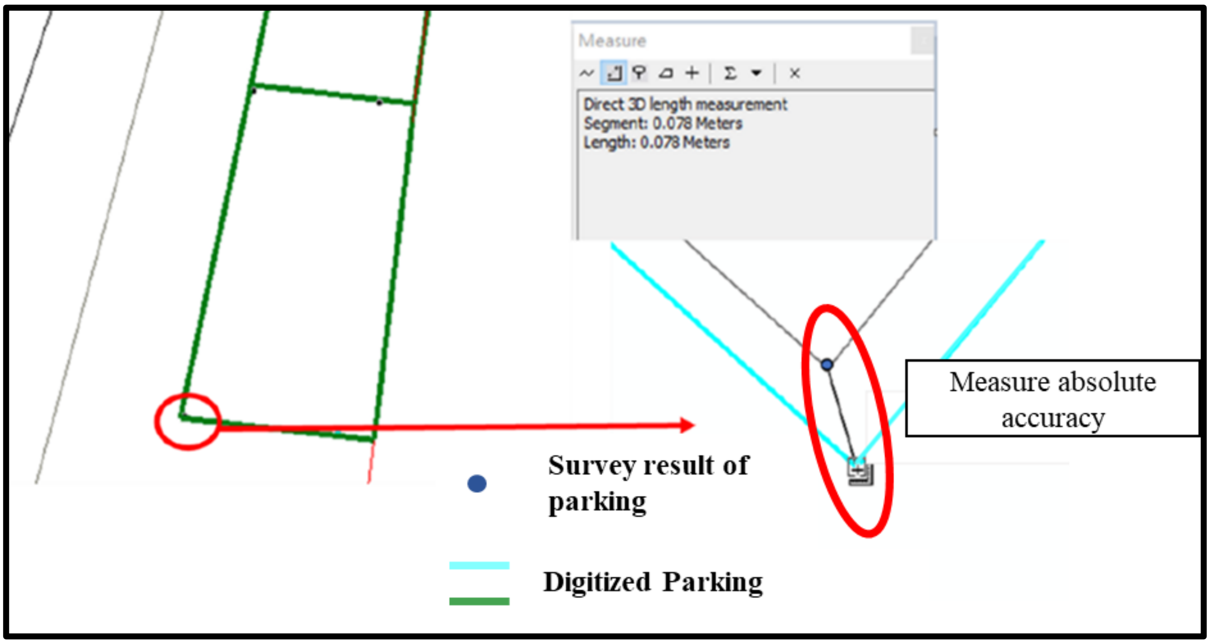

Figure 15 Illustration of parking space verification

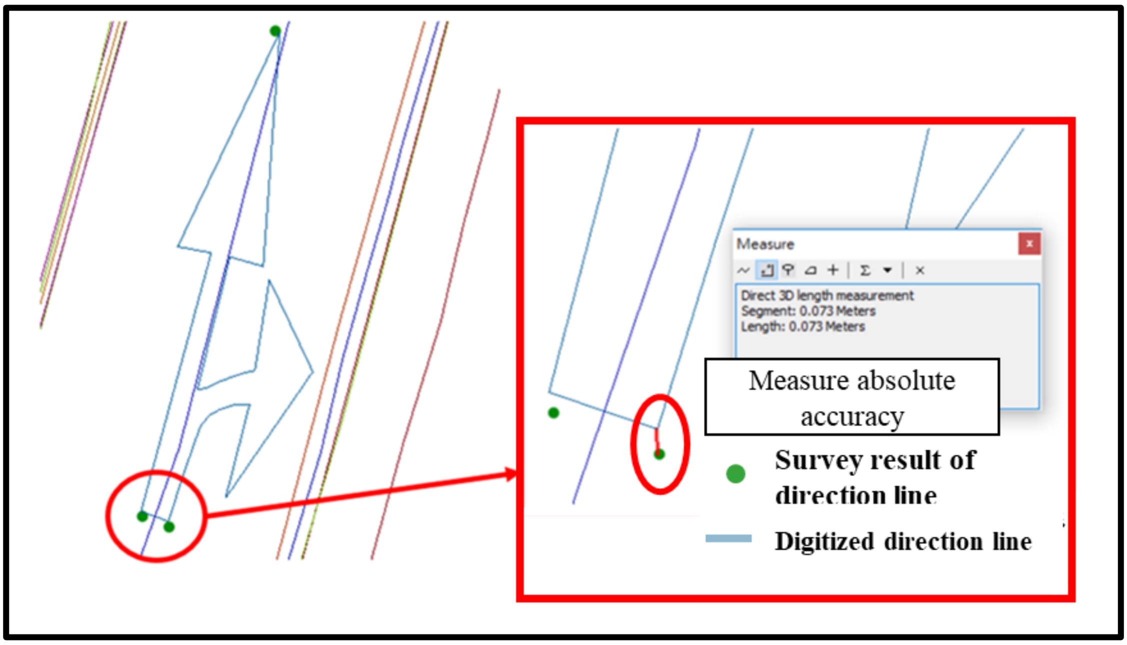

Figure 16 Illustration of mark graph (direction line) verification

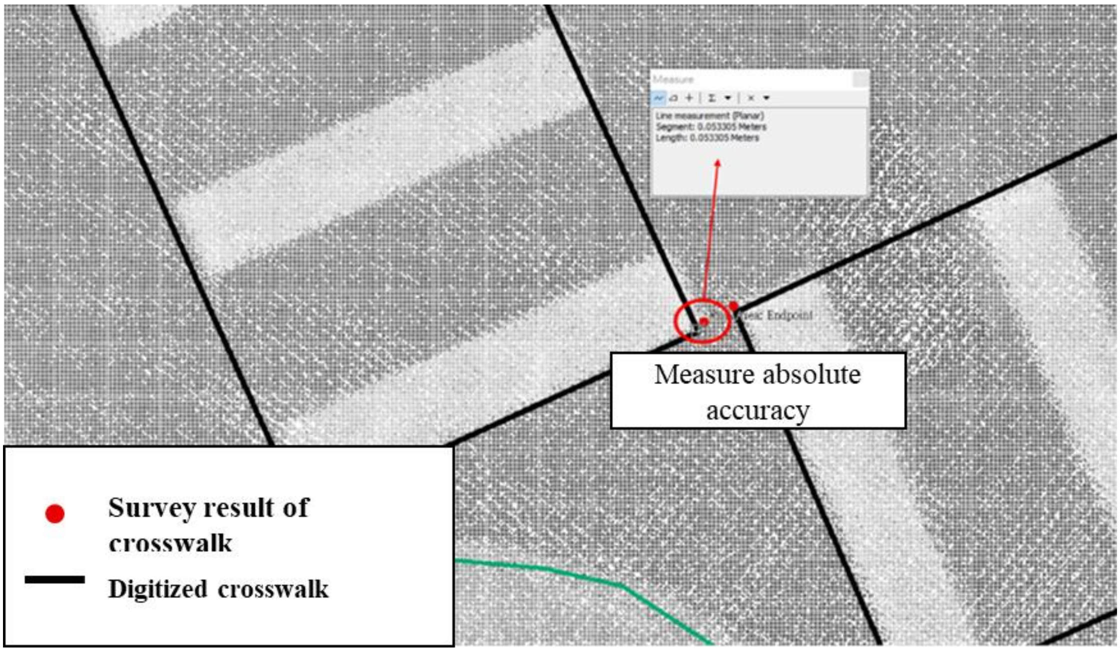

Figure 17 Illustration of mark area (crosswalk) verification

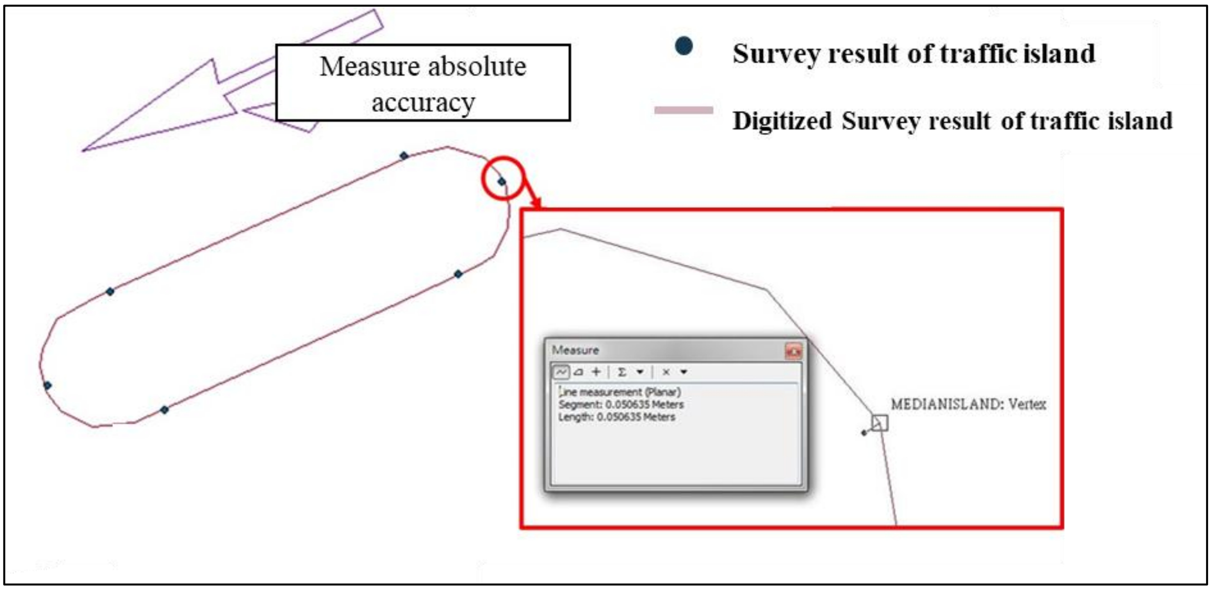

Figure 18 Illustration of object (traffic island) verification

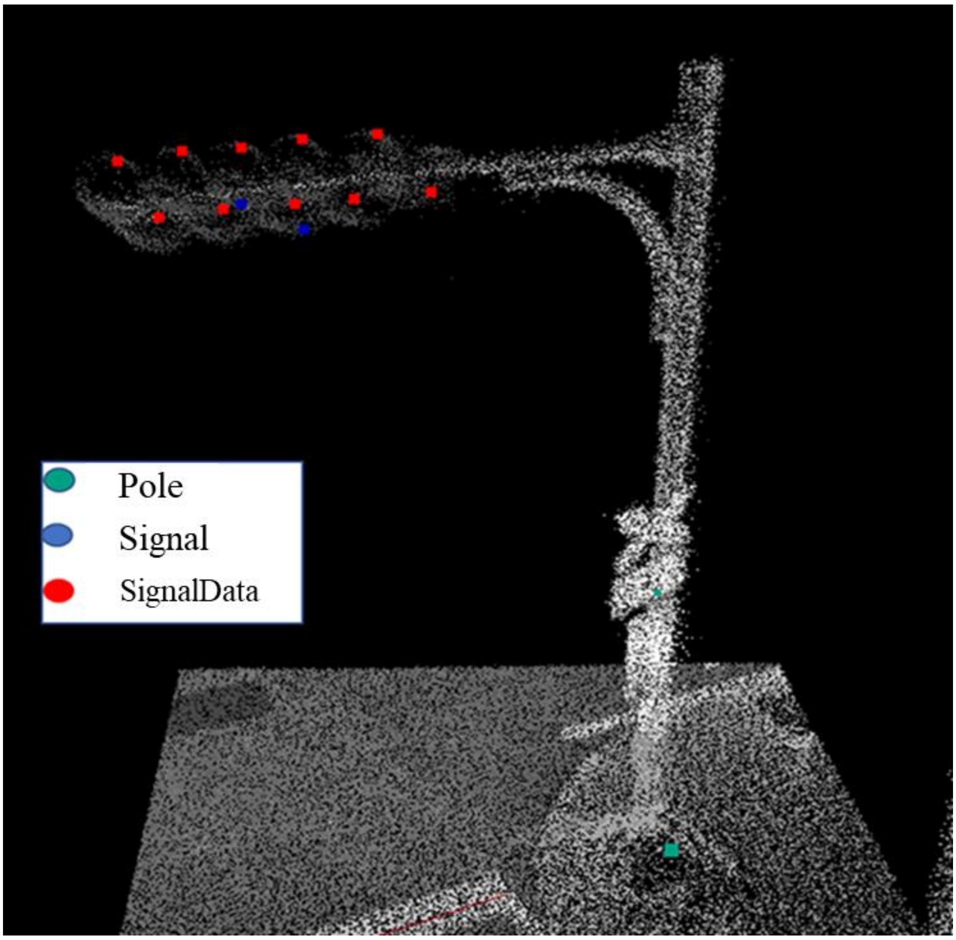

Figure 19 Illustration of a signal, a signal data and a pole

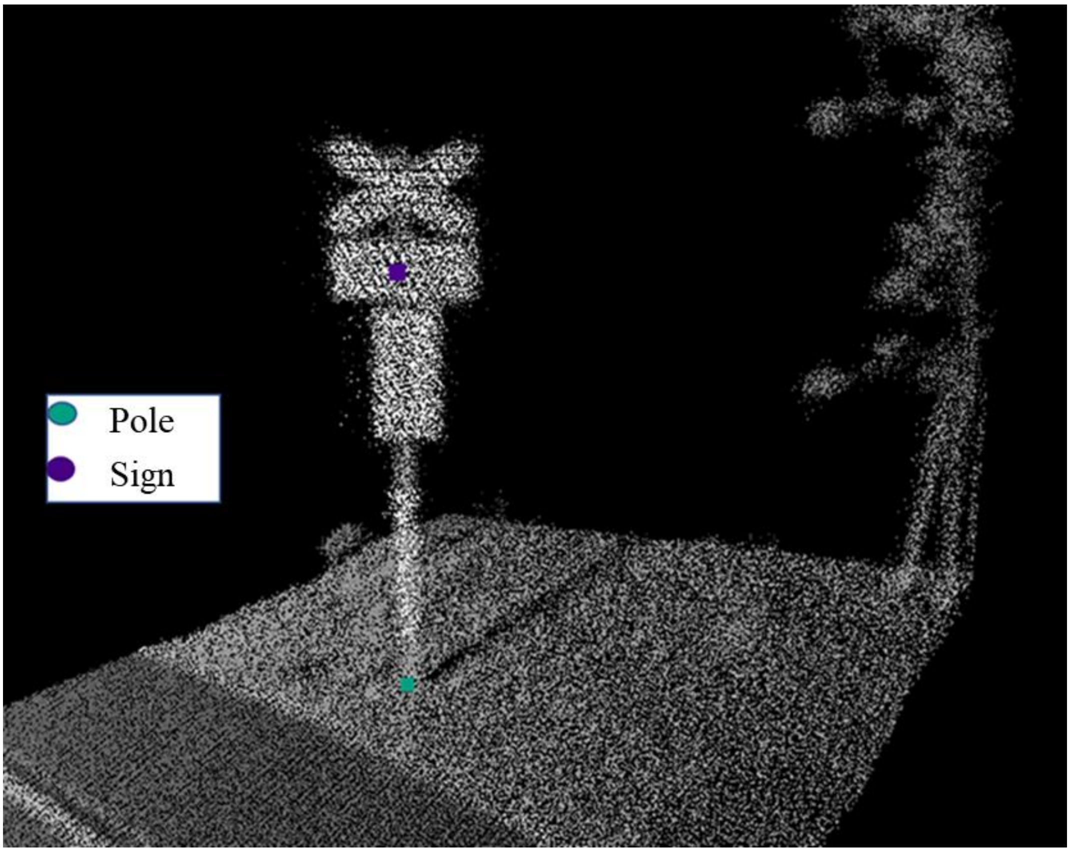

Figure 20 Illustration of a sign and a pole

9.4 SHP data attribute format verification

In order to ensure that the data of SHP files submitted by the submission unit conform to the “HD Maps Data Contents and Formats Standard”, SHP files will be verified whether the following contents are included. Please refer to Appendix A for details and descriptions.

(a) Rationality of pixel spatial phase relations: the phase relation check is to determine the spatial relation between feature blocks of vector layers to select the feature blocks that may have errors.

(1) Single layer phase check: the feature blocks in the same layer shall not be overlapped, intersected or self-intersected.

(b) Logic consistency of vector layer data: check whether layer names and files are complete and whether the formats of all fields conform to the requirements in the appendix. The values of all required fields shall not be null. The attribute data to be included in SHP files are shown below:

(1) Road:

i. Reference Line: id, junction, rule, predecessor, successor, type, startNode, endNode

ii. Roadedge: id, startNode, endNode

iii. Lane Line: id, type, color, code, width, startNode, endNode

iv. Node: id

(2) Lane:

i. LaneCenterLine: id, type, width, predecessor, successor, startNode, endNode

ii. Waypoint: id

(3) Sign stripe:

i. StopLine: id, code, signaled, width

ii. Parking: id, code, access, width

iii. MarkLine: id, code, color, width, type

iv. MarkArea: id, code

v. MarkGraph: id, code, color, width

(4) Object:

i. Object: id, type, dynamic, zTop

(5) Tunnel:

i. Tunnel: id, type

(6) Bridge:

i. Bridge: id, type

(7) Sign:

i. Sign: id, poleid, code, angle, bboxMin, bboxMax

(8) Signal:

i. Signal: id, poleid, code

(9) Signaldata:

i. Signaldata: id, signalId, code, angle, bboxMin, bboxMax, radius

(10) Pole:

i. Pole: id, type, zTop

(c) Attribute data correctness: the data correctness of attribute fields such as codes and types can be determined according to the actual situations of point clouds and image data.

(d) Eligibility criteria: sampled SHP files shall comply with the regulations, otherwise the submission units will be asked for correction.

Annex A
(Normative)
HD MAP data attribute (SHP format)

A.1 Roads

A.1.1 Reference lines

A road consists of sections. A road is divided into many sections when lane attributes or number of lanes change or when it is connected to a stop line. A reference line[1], a directional a three-dimensional spatial line with a start node and an end node, is recorded for each road. At a road junction, even if there is no lane line on the road, a reference line available shall still be drawn. For example, in Figure A-1, to connect the reference line id 1 to the reference lines id 8, id 9 and id 10, the reference lines at the road junction shall be drawn, namely, the reference lines id 2, id 3, id 4, id 5, id 6 and id 7.

[1] Reference lines are the basic type of OpenDRIVE architecture. There is no requirement on the directions of reference lines, but all road connections shall be covered.

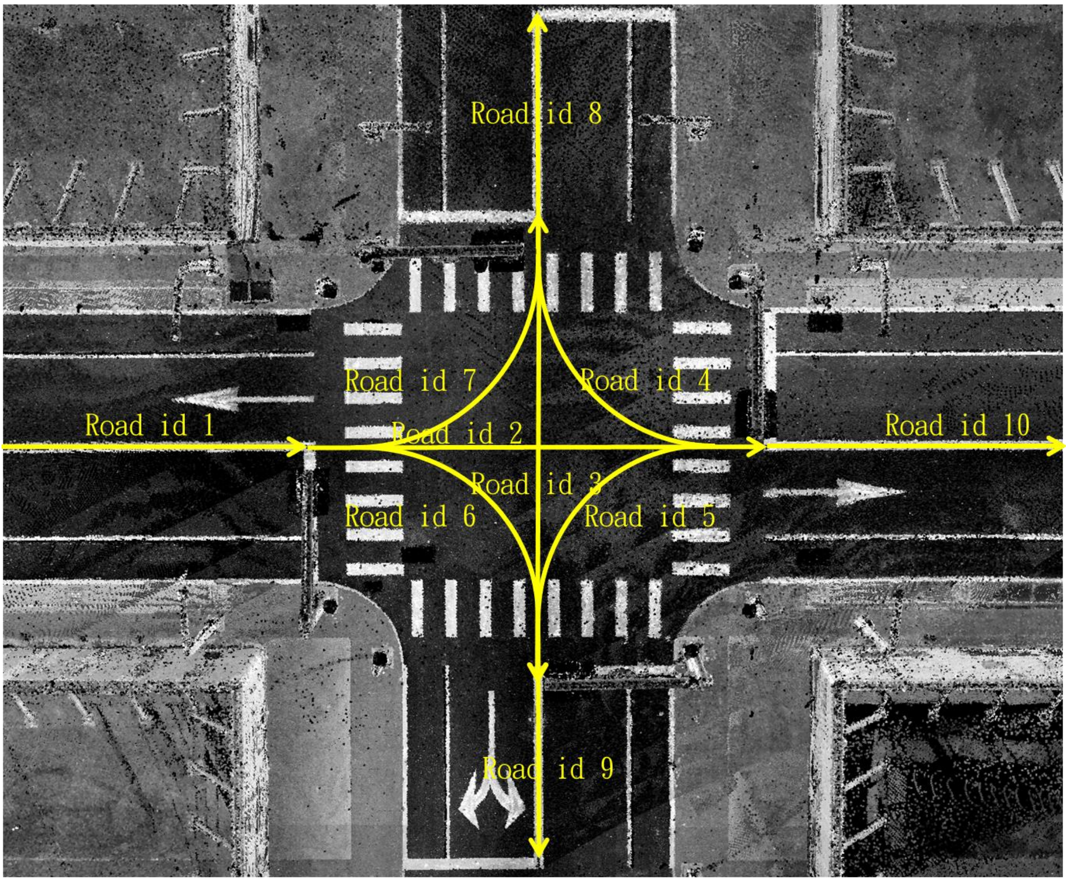

Figure A.1 Illustration of a reference line

Moreover, in dividing roads, reference lines, road edges and lane lines shall be divided[2]. In road mapping, reference lines can be selected according to actual road situations. For example, with the dividing limit line or lane-dividing line in the middle of a road as the reference line, the lane line close to the divisional island can be selected as the reference line if there is a divisional island in the middle of the road, while the road edge or lane line can be used as the reference line if it is a one-way road.

[2] This requirement is for the subsequent conversion to OpenDRIVE.

Table A.1 Reference line attribute

Item No.	Type	Name	中文名稱	Specification	Data type	Description	Requirement
1.	Reference Line	name	名稱	Name of reference line	Char		Optional
2.		length	長度	xy plane length of a reference line	Char	m	Optional
3.		id	識別碼[3]	Reference line identifier	Char		Required
4.		junction	交叉路口	A reference line is at a road junction or on a general road	Char	road junction	Required
5.		rule	規則	Driving on the right or left	Char	RHT for Taiwan	Required
6.		predecessor	前一參考線識別碼	Identifier of the previous reference line	Char		Required
7.		successor	下一參考線識別碼	Identifier of the next reference line	Char		Required
8.		type	道路類型	Road type	Road type code	Appendix B[4] road type code.	Required
9.		speed	速限	Speed limit	Integer	Unit: km/h	Optional
10.		startNode	起始節點	Start node identifier of a reference line.	Char	Identifier corresponding to the node layer	Required

[3] The layer identifier rules have not yet been defined, and the layer identifier shall remain unique in the field.

[4] For "Appendix A" and "Appendix B" in the instruction, please refer to the appendix code in "HD Maps Data Contents and Formats Standard".

Item No.	Type	Name	中文名稱	Specification	Data type	Description	Requirement
11.		endNode	結束節點	End node identifier of a reference line.	Char	Identifier corresponding to the node layer	Required
12.		geometry[5]	幾何坐標	Three-dimensional linear coordinates of a reference line.	3D Shapes linestring, curve		Required

A.1.2 Road edges

A road edge refers to the edge of an asphalt road. For any road with curbs, the outside of the curbs is considered as the road edge.

Table A.2 Road edge attribute

Item No.	Type	Name	中文名稱	Specification	Data type	Description	Requirement
1.	Road Edge	id	路面邊緣識別碼	Road edge identifier	Char		Required
2.		geometry	幾何坐標	Three-dimensional linear coordinates of a road edge	3D Shapes linestring, curve		Required
3.		startNode	起始節點	Start node identifier of a road edge.	Char	Identifier corresponding to the node layer	Required
4.		endNode	結束節點	End node identifier of a road edge.	Char	Identifier corresponding to the node layer	Required

[5] The layer geometry attribute is spatial data and does not need to be created as an attribute.

A.1.3 Lane lines

Lane lines are border lines on both sides of a lane. If mark lines have been drawn for a road as the lane lines, there are width, color and type of lane lines[6]. The three-dimensional coordinates are regarded as its geometric coordinates, and the center line of the lane line is taken in road mapping. According to the regulations of the Ministry of Transportation and Communications, different colors and types stand for different traffic rules. Lane lines shall be drawn on both sides of the lane at a road junction.

Table A.3 Lane line attribute

Item No.	Type	Name	中文名稱	Specification	Data type	Description	Requirement
1.	Lane Line	id	車道線識別碼	Lane line identifier	Char		Required
2.		code	標線代碼	Mark line code	Mark line code	Appendix A codes of warning, prohibition and instruction mark lines	Required
3.		color	車道線顏色	Lane line mark color	Road mark color code	Appendix B codes of road colors and types.	Required
4.		type	車道線類型	Lane line mark type	Road mark type code	Appendix B road mark type code.	Required
5.		material	車道線材質	Mark line material of a lane line	Char		Optional
6.		width	車道線寬度	Lane line width	Double	m	Required
7.		startNode	起始節點	Start node identifier of a lane line.	Char	Identifier corresponding to the node layer	Required

[6] Type, color and style are optional for lane lines without mark lines.

Item No.	Type	Name	中文名稱	Specification	Data type	Description	Requirement
8.		endNode	結束節點	End node identifier of a lane line.	Char	Identifier corresponding to the node layer	Required
9.		geometry	幾何坐標	Three-dimensional linear coordinates of a lane line	3D Shapes linestring, curve		Required

A.1.4 Nodes

Table A.4 Node attribute

Item No.	Type	Name	中文名稱	Specification	Data type	Description	Requirement
1.	Node	id	識別碼	Node identifier	Char		Required
2.		geometry	幾何坐標	Three-dimensional point coordinates of a node	3D Shapes point		Required

A.2 Lanes

A.2.1 Lane center lines

A lane center line is a directional three-dimensional spatial line with a start node and an end node. It is a virtual line. In road mapping, a lane center line is determined according to the lane lines on both sides of a lane. The attributes of lane center lines are including road materials, speed limits, width, and height, as well as start nodes and end nodes.

Table A.5 Lane center line attribute

Item No.	Type	Name	中文名稱	Specification	Data type	Description	Requirement
1.	Lane Center Line	id	車道識別碼	Lane identifier	Char		Required
2.		type	車道類型	Lane type	Lane type code	Appendix B lane type code	Required
3.		predecessor	前一車道識別碼	Identifier of the previous lane	Char		Required
4.		successor	下一車道識別碼	Identifier of the next lane	Char		Required
5.		width	車道寬度	Lane width	Double	m	Required
6.		material	車道路面材質	Lane surface material	Char		Optional
7.		speed	車道速限	Lane speed limit	Integer	Unit: km/h	Optional
8.		restriction	車道使用限制	Driving and use limit for lanes	Char	Appendix B restriction type code	Optional
9.		height	高度限制	Lane height limit for lanes	Double	m	Optional
10.		weight	重量限制	Lane weight limit for lanes	Double	kg	Optional
11.		startWaypoint	起始節點	Start node identifier of a lane center line.	Char	Identifier corresponding to WayPoint layer	Required
12.		endWaypoint	結束節點	End node identifier of a lane center line.	Char	Identifier corresponding to WayPoint layer	Required
13.		dir	方位角弳度	Radian of the angle between the north and the vector of a lane center line	Double	Radian	Optional
14.		geometry	幾何坐標	Three-dimensional linear coordinates of a lane center line.	3D Shapes		

Item No.	Type	Name	中文名稱	Specification	Data type	Description	Requirement
15.		tunnelId	隧道識別碼	Identifier of the tunnel where a lane center line is located	Char		Optional
16.		bridgeId	橋梁識別碼	Identifier of the bridge where a lane center line is located	Char		Optional

A.2.2 Waypoint

A lane center line has a start node and an end node, and its three-dimensional point coordinates and identifier are to be recorded.

Table A.6 Lane center line node attribute

Item No.	Type	Name	中文名稱	Specification	Data type	Description	Requirement
1.	WayPoint (Lane center line node)	id	識別碼	Node identifier	Char		Required
2.		stoplineid	停止線識別碼	Stop line identifier	Char	Nodes shall be produced at a stop line and an identifier is required.	Optional
3.		geometry	幾何坐標	Three-dimensional linear coordinates of a node.	3D Shapes point		Required

A.3 Mark lines

All mark lines defined in the "Rules for Setting up Road Traffic Signs, Sign Stripes and Signals" by the Ministry of Transportation and Communications are designed in a number of different layers (data types) according to their features. Stop lines and parking spaces are separately recorded in two different layers due to their special attributes. In addition, all other mark lines can be recorded in three types of spatial layers. The descriptions are as follows:

A.3.1 Stop lines

As defined in the "Rules for Setting up Road Traffic Signs, Sign Stripes and Signals", boundary of the stop line is used to instruct a moving vehicle to stop. When a vehicle stops, its front overhang shall not exceed this line. A stop line is recorded as a three-dimensional line, and the center line of a stop line shall be determined according to its width.

Table A.7 Stop line attribute

Item No.	Type	Name	中文名稱	Specification	Data type	Description	Requirement
1.	Stop Line	id	停止線識別碼	Stop line identifier	Char		Required
2.		code	標線代碼	Mark line code	Mark line code	Appendix A PH001 for prohibition mark lines	Required
3.		signalid	行車號誌識別碼	Traffic signal identifier related to a stop line	Char		Required
4.		width	停止線寬度	Stop line width	Double	m	Required
5.		geometry	幾何坐標	Three-dimensional linear coordinates of a stop line	3D Shapes linestring		Required

A.3.2 Parking spaces

A parking space is a place for parking a vehicle, and its range is determined by the stop lines defined in the "Rules for Setting up Road Traffic Signs, Sign Stripes and Signals". The spatial range of a parking space is defined by corner points with three-dimensional coordinates, and the sequence of corner points satisfies the closure conditions.

Table A.8 Parking space attribute

Item No.	Type	Name	中文名稱	Specification	Data type	Description	Requirement
1.	Parking (Parking space)	id	停車格識別碼	Parking space identifier	Char		Required
2.		code	標線代碼	Mark line code	Mark line code	Appendix A IA014 for restriction mark lines	Required
3.		access	停車格的使用規定	Restrictions on use of parking spaces	Char	all car women handicapped bus truck electric residents	Required
4.		width	車輛停止線寬度	Stop line width	Double	m	Required
5.		geometry	幾何坐標	Three-dimensional space of a parking space	3D Shapes polygon		Required

Except for stop lines and parking spaces, all the other marks can be classified into two types of space layers for recording.

A.3.3 Mark lines

Lines with width are used to represent the positions of mark lines, such as various lane lines, no parking lines and no temporary parking lines. Identifiers, mark line codes and three-dimensional line positions shall be recorded for this type of lines.

Table A.9 Mark line attribute

Item No.	Type	Name	中文名稱	Specification	Data type	Description	Requirement
1.	Mark Line (Sign Stripes)	id	標線識別碼	Mark line identifier	Char		Required
2.		code	標線代碼	Mark line code	Mark line code	Appendix A codes of warning, prohibition and instruction mark lines	Required
3.		type	車道類型	Lane type	Lane type code	Appendix B lane type code	Required
4.		color	標線顏色	Mark line color	Road color code	Appendix B codes of road colors and types.	Required
5.		width	標線寬度	Mark line width	Double	m	Required
6.		geometry	幾何坐標	Three-dimensional linear coordinates of a mark line	3D Shapes linestring, curve		Required

A.3.4 Mark area and mark graphs

If a mark line is not linear but drawn as an area, a word or a graph, it will be recorded as a mark graph. For example, obstruction approach mark lines, roadside obstruction lines, channelizing lines, grid lines, exclusive vehicle lane lines, exclusive motorcycle lane lines and waiting area lines for bicycles and motorcycles are drawn as areas, graphs or words.

An area is used to represent the position of a mark line, and the graph is recorded as a mark graph, such as the green area of the guiding line in Figure A-2. Words used for auxiliary instructions on roads are drawn as mark graphs and integrated into an object, so that relevant words can be input. For example, the strokes of "禁止機車 (no motorcycle)" shall be recorded as several three-dimensional spaces and then integrated into one piece of data, and the word "No Motorcycle" shall be filled in the character attribute [7].

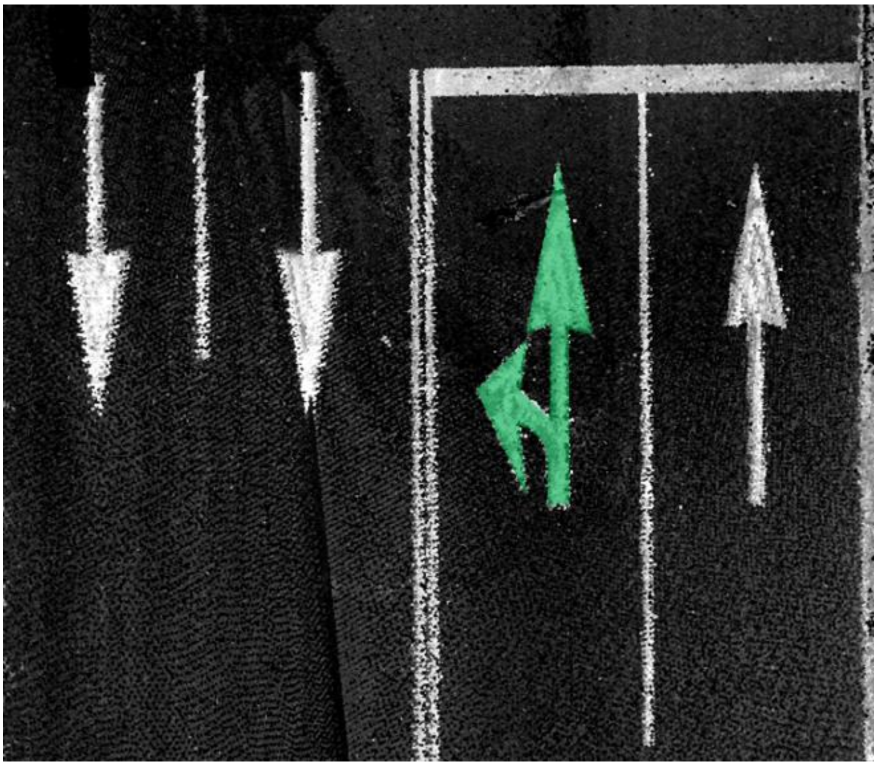

Figure A.2 Illustration of the area of a guiding line

In addition, there are clear and important boundaries of the spaces around the mark lines such as crosswalks, bicycle crossing lines, waiting areas for bicycles and motorcycles, waiting areas for turning bicycles and motorcycles, and grid lines, so mark areas shall be drawn besides mark graphs. For the crosswalk shown in Figure A-3, the mark area is in red and the mark graph is in

[7] Templates can be used in digitizing of words and complex graphics. If data is converted into shp formats, it indicates that words or graphs representing the same meaning shall be integrated into one piece of data. For example, "No Parking" shall be one piece of data.

green. If a pedestrian crosses a road in an X-shaped path, the X-shaped path is drawn as one pedestrian crossing a road instead of two.

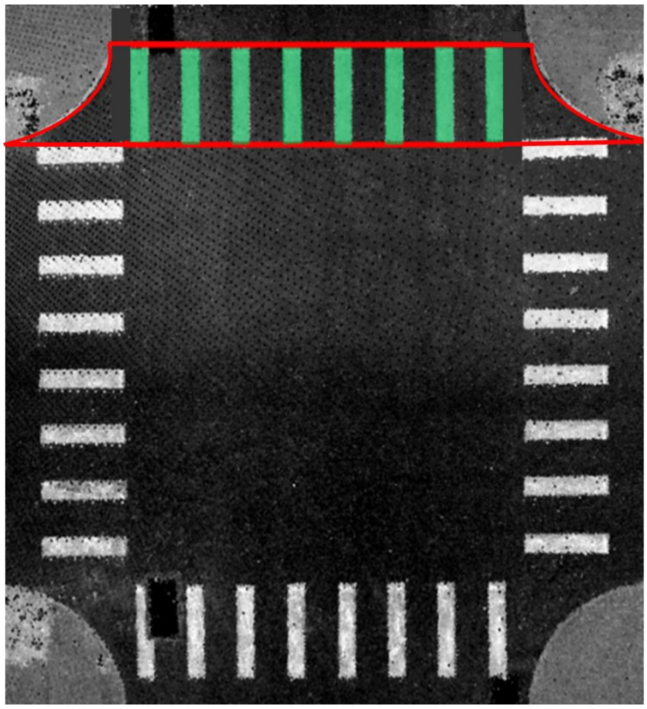

Figure A.3 Illustration of the area of a crosswalk

Table A.10 Mark area attribute

Item No.	Type	Name	中文名稱	Specification	Data type	Description	Requirement
1.	Mark Area (Mark area)	id	標線範圍識別碼	Mark area identifier	Char		Required
2.		code	標線代碼	Mark line code	Mark line code	Appendix A mark line code. Crosswalk: IH001, IH002, IH003 Bicycle crossing line: IH004 Waiting area for bicycles and motorcycles: PA006 Waiting area line for left (right) turning bicycles and motorcycles: IA015 Grid line: PA003	Required
3.		geometry	幾何坐標	Three-dimensional space of a mark area	3D Shapes polygon		Required

Table A.11 Mark graph attribute

Item No.	Type	Name	中文名稱	Specification	Data type	Description	Requirement
1.	MarkGraph (Mark graph)	id	標線圖形識別碼	Mark graph identifier	Char		Required
2.		code	標線代碼	Mark line code	Mark line code	Appendix A codes of warning, prohibition and instruction mark lines	Required

Item No.	Type	Name	中文名稱	Specification	Data type	Description	Requirement
3.		color	標線顏色	Mark line color	Road color code	Appendix B codes of road colors and types	Required
4.		character	標字	Words are recorded as characters	Char	Required in drawing words	Optional
5.		geometry	幾何坐標	Three-dimensional space of a mark line or a word	3D Shapes polygon		Required

A.4 Objects

The three-dimensional spaces at the bottom and ellipsoidal heights can be recorded for various other roads or roadside objects, except for rod-shaped objects. Trees and vegetation are not required.

Table A.12 Object attribute

Item No.	Type	Name	中文名稱	Specification	Data type	Description	Requirement
1.	Object	type	物體類型	Object type	Object type code	Appendix B object type code	Required
2.		dynamic	物體是否為動態	An object is dynamic or not	string	yes stands for a dynamic object, and no stands for a static object	Required
3.		name	物體的名稱	Object name	Char		Optional
4.		id	物體的識別碼	Object identifier	Char		Required
5.		geometry	物體的底部範圍	Bottom range of an object	3D Shapes polygon	This is a spatial attribute field	Required

Item No.	Type	Name	中文名稱	Specification	Data type	Description	Requirement
6.		zTop	物體頂點的橢球高	Ellipsoidal height at the top of an object	Double	m	Required

A.5 Tunnels

The lane area covered by a tunnel is recorded as a space, which is defined by corner points with three-dimensional coordinates. The sequence of corner points satisfies the closure conditions. Names and relevant lanes shall be recorded.

Table A.13 Tunnel attribute

Item No.	Type	Name	中文名稱	Specification	Data type	Description	Requirement
1.	Tunnel	id	隧道識別碼	Tunnel identifier	Char		Required
2.		name	隧道名稱	Tunnel name	Char		Optional
3.		geometry	幾何坐標	Three-dimensional space of a tunnel	3D Shapes polygon		Required
4.		access	限制車種	Vehicle type limit for tunnels	Char		Optional
5.		limitHeight	限制車高	Vehicle height limit for tunnels	Char	m	Optional
6.		limitWeight	限制車重	Vehicle weight limit for tunnels	Char	kg	Optional
7.		type	隧道類型	Tunnel type	Tunnel type code	Appendix B tunnel type code	Required

A.6 Bridges

The bridge coverage is recorded as a three-dimensional space, which is defined by corner points with three-dimensional coordinates. The sequence of corner points satisfies the closure conditions. Names and relevant lanes shall be recorded.

Table A.14 Bridge attribute

Item No.	Type	Name	中文名稱	Specification	Data type	Description	Requirement
1.	Bridge	id	橋梁識別碼	Bridge identifier	Char		Required
2.		name	橋梁名稱	Bridge name	Char		Optional
3.		geometry	幾何坐標	Three-dimensional space of a bridge	3D Shapes polygon		Required
4.		access	限制車種	Vehicle type limit for bridges	Char		Optional
5.		type	橋梁類型	Bridge type	Bridge type code	Appendix B bridge type code	Required

A.7 Signs

The center of a sign board is recorded with three-dimensional point coordinates, and the angle between the normal vector of the sign board and the true north, sign-related pole and sign types shall be recorded. Moreover, the lower left and upper right coordinates of the bounding rectangles that can cover the sign shall be recorded.

Table A.15 Sign attribute

Item No.	Type	Name	中文名稱	Specification	Data type	Description	Requirement
1.	Sign (Sign)	id	標誌識別碼	Sign identifier	Char		Required
2.		Pole id	桿識別碼	Sign pole identifier	Char		Required
3.		code	標誌代碼	Sign code	Sign code	Appendix A codes of warning, obeying, prohibition, restriction, instruction and assisting signs	Required
4.		angle	標誌牌面角度	Angle between the normal vector of a sign board and the true north [8]	Double	Radian	Required
5.		geometry	幾何坐標	Three-dimensional spatial coordinates of the central point of a sign board	3D Shapes point		Required

[8] It is, looking down from the top, the angle between the normal vector and the north, calculated clockwise from the north.

Item No.	Type	Name	中文名稱	Specification	Data type	Description	Requirement
6.		Bbox Min	包圍矩形左下坐標	Three-dimensional lower left coordinates of the bounding rectangle	WKT		Required
7.		Bbox Max	包圍矩形右上坐標	Three-dimensional upper right coordinates of the bounding rectangle	WKT		Required

A.8 Signals

A separate piece of data shall be recorded for a signal, and the lamp cap and lamp holder of the signal are recorded as poles. The position of the central point of the signal lamp cap is represented by three-dimensional point coordinates, and the signal identifier, pole identifier and signal type are recorded. All signal faces are recorded as signal data.

Table A.16 Signal attribute

Item No.	Type	Name	中文名稱	Specification	Data type	Description	Requirement
1.	Signal	id	號誌識別碼	Signal identifier	Char		Required
2.		Pole id	桿識別碼	Signal pole identifier	Char		Required
3.		code	號誌代碼	Signal code	Signal code	Appendix A codes of traffic control, pedestrian and special traffic signals	Required
4.		geometry	幾何坐標	Three-dimensional spatial coordinates of the central point of a signal lamp cap	3D Shapes point		Required

A.9 Signal data

A separate piece of data shall be recorded for each signal face, and its geometric coordinates are represented by three-dimensional point coordinates. The meaning of the signal face, the radius of the signal surface and the identifier of the associated sign are recorded.

Table A.17 Signal face attribute

Item No.	Type	Name	中文名稱	Specification	Data type	Description	Requirement
1.	Signal data	id	燈面識別碼	Signal face identifier	Char		Required
2.		Signal Id	關聯號誌識別碼	Associated sign identifier	Char		Required
3.		code	燈面代碼	Signal face code	Signal face code	Appendix A signal face code	Required
4.		angle	燈面鏡面角度	Angle between the normal vector of a signal face and the true north [9]	Double	Radian	Required
5.		radius	半徑	Radius length covering the signal face	Double	m	Required
6.		geometry	幾何坐標	Three-dimensional spatial coordinates of the central point of a signal face	3D Shapes point		Required
7.		bboxMin	包圍矩形左下坐標	Three-dimensional lower left coordinates of the bounding rectangle of a signal face	WKT		Required
8.		bboxMax	包圍矩形右上坐標	Three-dimensional upper right coordinates of the bounding rectangle of a signal face	WKT		Required

[9] It is, looking down from the top, the angle between the normal vector and the north, calculated clockwise from the north.

A.10 Poles

It is used to represent poles of signs, signals, street lamps or other objects, and the bottom coordinates and ellipsoidal heights of rods shall be recorded.

Table A.18 Pole attribute

Item No.	Type	Name	中文名稱	Specification	Data type	Description	Requirement
1.	Pole (Pole)	id	桿識別碼	Pole identifier	Char		Required
2.		code	桿柱代碼	Pole code	Char	Pole type (pole Type)[10]	Required
3.		geometry	桿底部中心坐標	Three-dimensional spatial coordinates of the center at the bottom of a pole	3D Shapes point		Required
4.		zTop	桿頂部 z 坐標	Ellipsoidal height of a pole	Double	m	Required
5.		lamp	路燈燈面中心坐標	Three-dimensional point coordinates of the center point of the surface of a street lamp	WKT	Required in drawing street lamps	Optional

[10] Please refer to the code in the data section of “HD Maps Data Contents and Formats Standard”.

Reference

(1) 內政部地政司(2016-2017)，LiDAR 技術更新數值地形模型成果檢核與監審工作案(105-106)

(2) 內政部國土測繪中心(2010)，內政部國土測繪中心採用虛擬基準站即時動態定位技術辦理加密控制及圖根測量作業手冊

(3) 內政部國土測繪中心 e-GNSS 即時動態定位系統入口網站，http://www.egps.nlsc.gov.tw/index.html

(4) 經濟部中央地質調查所(2010-2012)，莫拉克災區 LiDAR 高解析度數值地形製作之檢核與監審

(5) 經濟部中央地質調查所(2013-2015)，非莫拉克災區與特定事件(颱風豪雨或地震等事件)後 LiDAR 高解析度數值地形製作之檢核與監審

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