UNIVERSITAS GADJAH MADA

The Role of Positioning Infrastructure and Mapping Surveys in 3D Cadastre Implementation for Mass Rapid Transport Infrastructures – Indonesia Case

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Overview

Introduction
Existing Positioning Infrastructures in Indonesia
2D & 3D Cadastral Mapping Surveys in Indonesia
Case Studies
Conclusions and Recommendations

Introduction

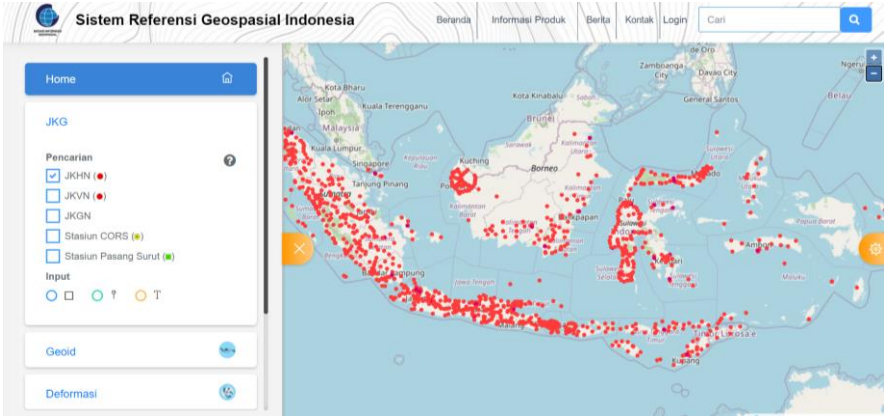
- The use of 3D space above and below land surfaces in Indonesia is increasing.

- The Indonesian government regulates the use of 3D space through Law no. 14/2020.
- Details of regulations are stipulated through Government Regulation no. 18/2021

- This paper discusses challenges regarding coordinates shift, inconsistencies between 2D and 3D parcels, missing height references and lack of coordinate redefinition of GPS coordinate services.

- MRT is considered as a solution to overcome transportation problems faced by big cities in Indonesia.

Positioning Infrastructures



Zero and 1st Order Horizontal Ground Survey Marks

2nd, 3rd and 4th Order Horizontal Ground Survey Marks

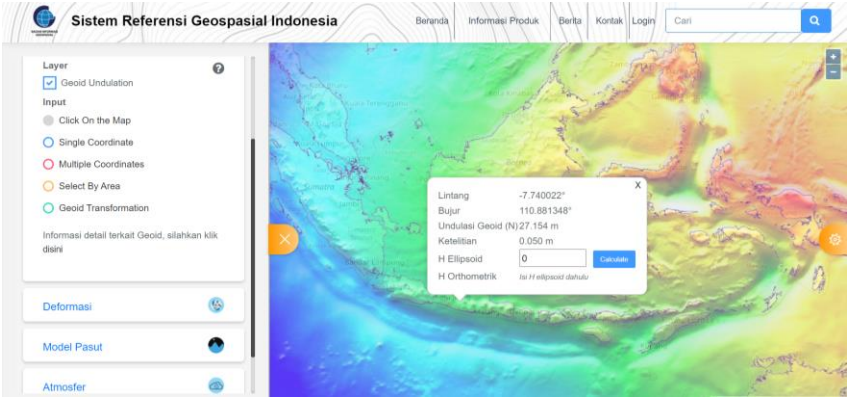
Order	Interdistance (km)	Control Points
0	500	National geodetic control points
1	100	Regional geodetic control points
2	10	Local geodetic control points
3	2	Densification control points
4	0.1	Mapping control points

- **Established in the early 1990s** by the National Mapping Coordination Agency (Bakosurtanal) and National Land Agency (BPN)
- Total number of zero and 1st order control points are 1,266 points of which 363 points also have height coordinates and serve as vertical control points.
- **Formerly** used geodetic datum is **DGN95** (WGS84, realized using International Terrestrial Reference Frame 1991 (ITRF91) 1992.0.
- In 2013, **zero and 1st order** control points were updated to new datum, **SRGI 2013** (referred to ITRF08 2012.0)
- **2nd, 3rd and 4th** order control points are approximately **10,000 points**. All these control points are **still** in **DGN95**

Existing Horizontal Ground Survey Marks in Indonesia

Vertical Ground Survey Marks

- **Established in the early 1990s** by the National Mapping Coordination Agency (Bakosurtanal).
- Defined by **precise levelling** and **terrestrial gravity survey**.
- The total number of vertical survey marks is 5747 points, of which 4860 points have both vertical coordinate and gravity value, and 524 points only have vertical coordinate.



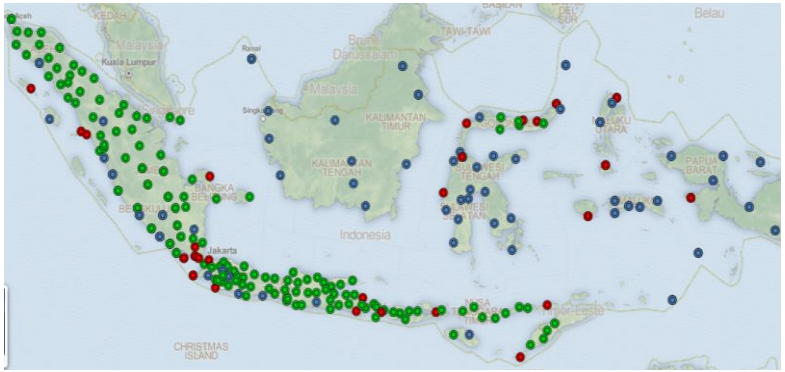
InaGeoid – Indonesia National Geoid Model

Island	Number of Verification Points	Min (cm)	Mean (cm)	Max (cm)	Deviation Standard (cm)
Jawa	186	-12.8	0.03	30.4	5.1
Bali	184	-38.3	-0.3	31.1	10.3
Sumatera	26	-8.38	21.4	51.3	17.3
Sulawesi	53	-60.1	-10.5	41.3	22.4
Kalimantan	35	-35.7	23.3	69.5	24.7

- The Indonesian Geoid Model 2020 (**InaGeoid**) is generated using gravity data, global geoid models, and digital elevation models (DEM).
- Centimeter – few decimeter accuracy

Existing Vertical Ground Survey Marks & Indonesia National Geoid Model

Positioning Infrastructures



InaCORS BIG

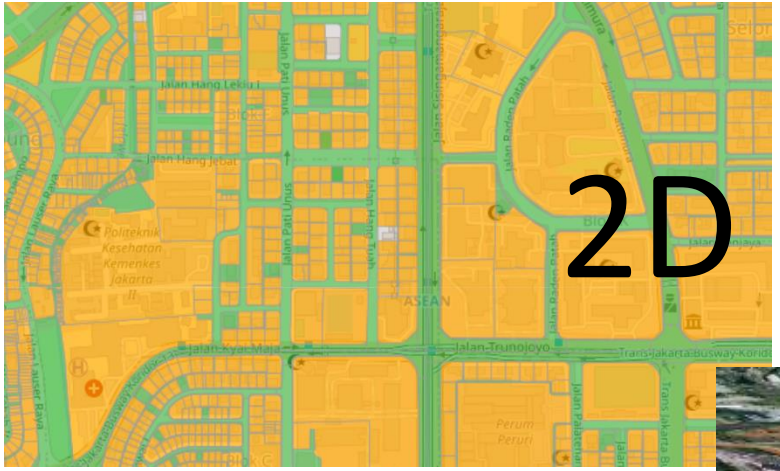
- InaCORS was established by Geospatial Information Agency (BIG) to support establishing the Indonesian Geospatial Reference System (SRGI), monitoring tectonic activity and making Indonesian deformation models.
- As part of the SRGI 2013, the coordinates of InaCORS has been referred to the ITRF 2008 2012.0.
- Total 295 stations in 2020, will be 345 by the end 2021

BPN CORS – JRSP (Jaring Referensi Satelit Pertanahan)

- CORS managed by BPN is known as the Land Satellite Reference Network (JRSP) - approximately 120 stations.
- It was developed to support cadastral mapping for land registration.
- Development was prioritized for Land Offices with high volumes of land transactions and with complex land issues.
- The coordinate of JRSP still referred to DGN95. Currently, JRSP is being unified and integrated with InaCORS and will be managed by BIG.

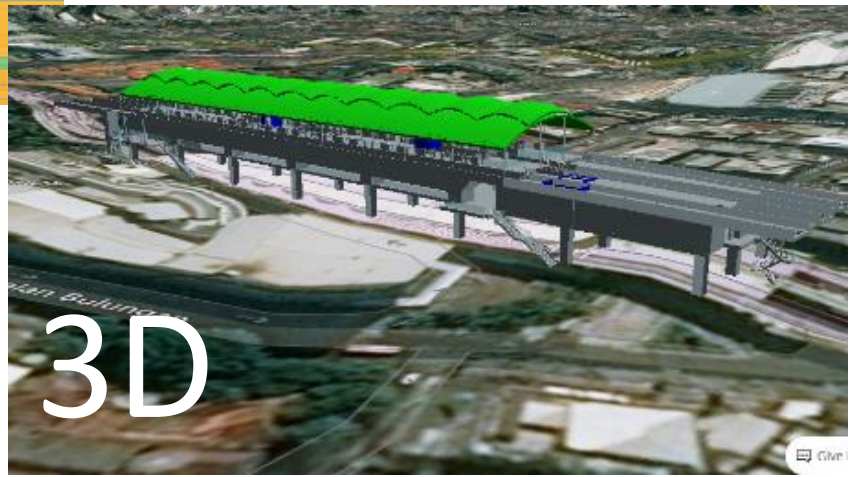
Existing Continuously Operating Reference Stations (CORS) in Indonesia

2D & 3D Cadastral Mapping Surveys

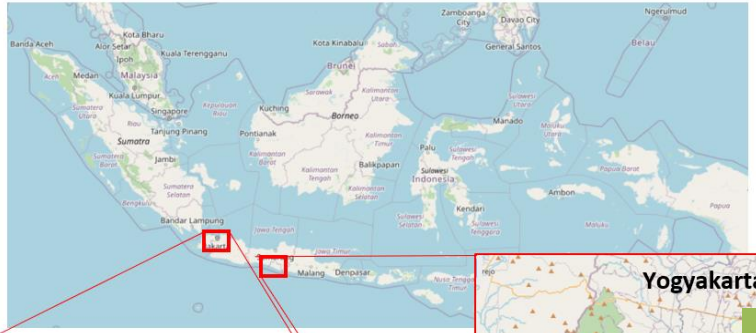


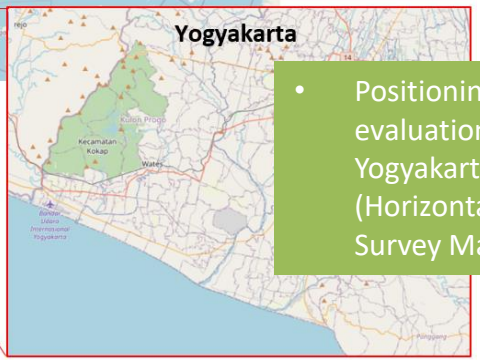
- In the past, 2D cadastral mapping in Indonesia was mostly done without referring to control points that lead to ungeoreferenced land parcels.
- In the last decade, the Indonesian government are implementing complete systematic land registration (PTSL) activities and improving the quality of land parcel maps.
- Awareness of the use of control points is increasing.

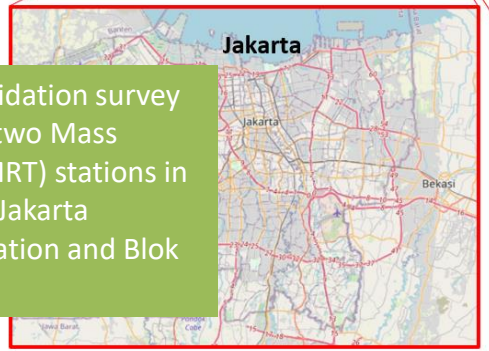
- Strata titles – started from 2011. Measurements using a distance meter/distometer or measuring tape are sufficient to validate the distance and area based on the data on the separation deed.
- According to Government Regulation no. 18/2021, a 3D cadastral mapping survey is required to verify the geometry of legal spaces and the 3D position of each 3D cadastral object



2D & 3D Cadastral Mapping Surveys in Indonesia



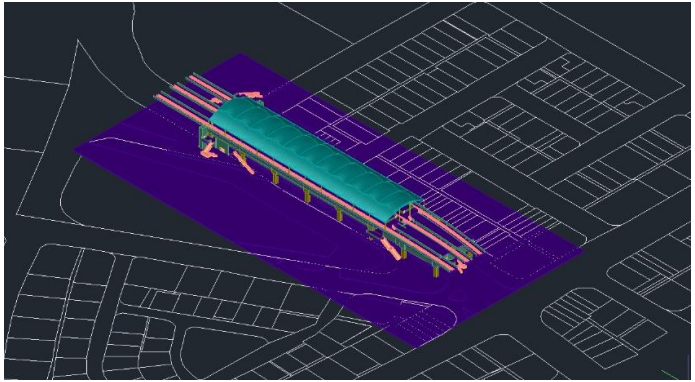




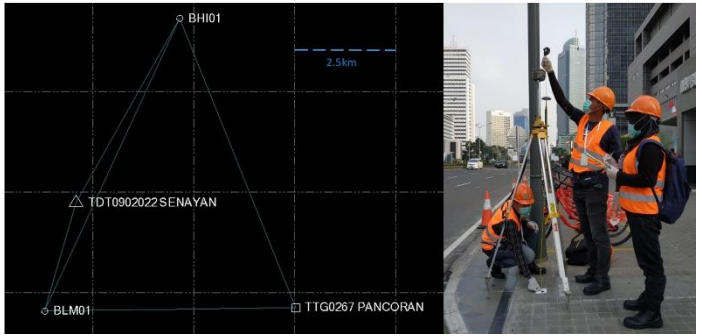
- 3D cadastral validation survey results done in two Mass Rapid Transit (MRT) stations in the Capital City Jakarta (Bundaran HI station and Blok M station)

- Positioning infrastructure evaluation in Special Region Yogyakarta Province (Horizontal & Vertical Ground Survey Marks, InaGeoid)

Locations of case study in Indonesia

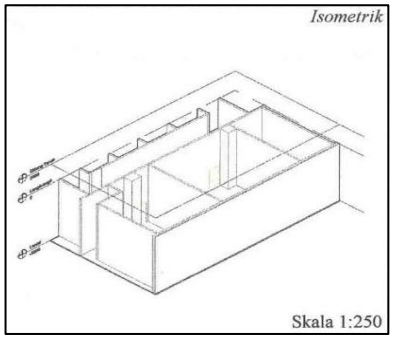


Creating a work plan map



Measuring control points at ground level

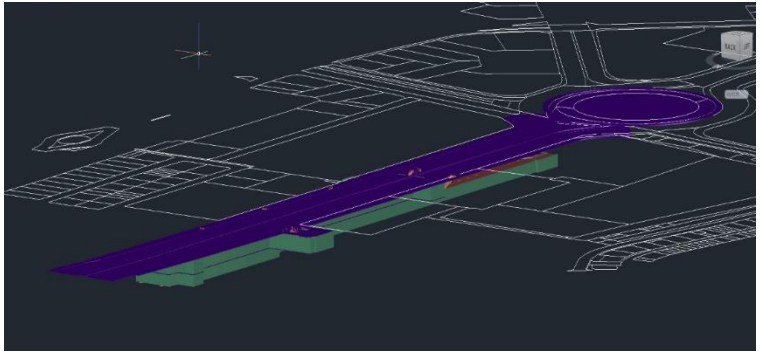
Validation survey of 3D cadastral object

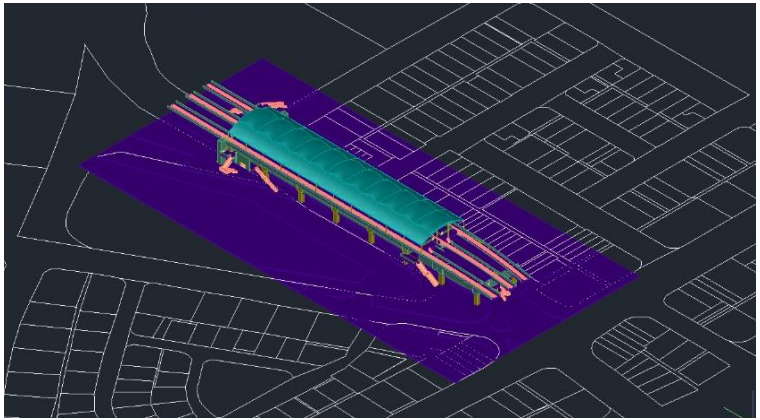


Making validation results document.

Validation Survey of MRT in Jakarta

Work Plan Map for Validation Survey

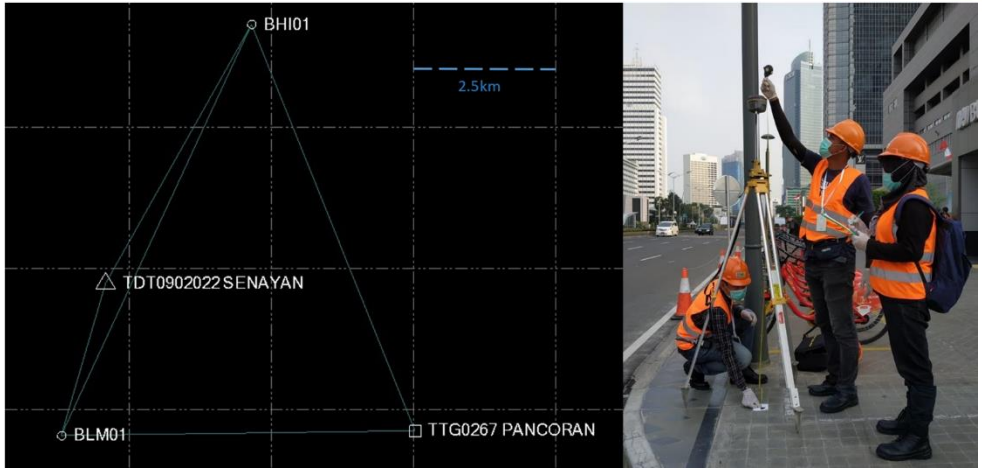




- Coordinate shifts and inconsistencies between the 3D models and the land parcel maps at the two stations were identified.
- The land parcel map uses the Transverse Mercator 3° projection system (TM3) and refers to the DGN95 datum
- The as-built drawing uses the Universal Transverse Mercator (UTM) projection system and no information about the datum used in the document.
- The absence of metadata of the datum used in the as-built drawing causes difficulties in creating the work plan map.
- This problem was overcome by switching the projection to TM 3 using DGN95 and SRGI2013 alternately as the reference system of the as-built drawing.
- This process was then followed by checking several features (common points) that can be recognized on the land parcel map and on the as-built drawings.
- Further verification was done by field measurement on several common points. From these processes, it can be concluded that the as-built drawings tend to refer to SRGI 2013.

Validation Survey of MRT in Jakarta

Measurement of Control Points for Validation Survey



Control Point	TM3 Easting (m)	TM3 Northing (m)	GNSS Heighting (m)	InaGeoid Height (m)
BHI01 (Bundaran HI)	235720.086	815452.031	2.139	2.027
BHI02 (Bundaran HI)	235715.697	815436.155	2.341	2.229
BLM01 (Blok M)	233048.109	809638.426	20.509	19.940
BLM02 (Blok M)	233063.734	809623.166	20.110	20.008

- Measurements were carried out using geodetic GNSS receiver referring to horizontal ground survey marks (TDT0902022) and vertical ground survey marks (TTG0267)
- The height of the control points was defined by two methods, i.e GNSS heighting by referring to the orthometric size of the vertical control point (TTG0267) and online processing by using InaGeoid service.
- The height difference in each control point is approximately 10cm between GNSS heighting and InaGeoid. In this case, both methods show results with a fairly good level of conformity.
- These results look promising but further research on different cases in Indonesia needs to be conducted to see the applicability of such system in national scale.

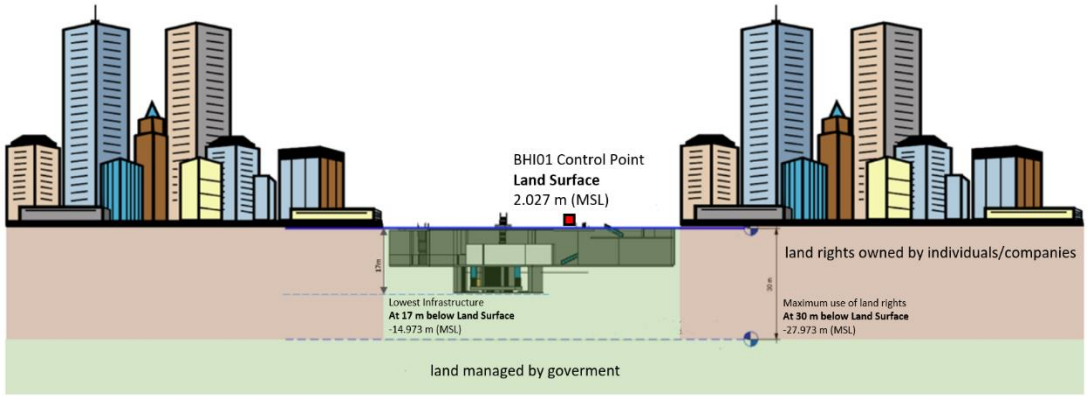
Validation Survey of MRT in Jakarta

- Measurement is done by trigonometric levelling referring to control points BHI01 and BHI02, which are located near the station entrance at ground level.
- Validation survey was then followed by measuring distances, areas and volumes of several 3D cadastral objects

- Validation survey at each station includes validation of position, length, area and volume of 3D cadastral objects
- Position validation at the Bundaran HI station is carried out by using Total Station. Measurements are carried out to determine the height value and the maximum depth of the underground facility at the Bundaran HI station.

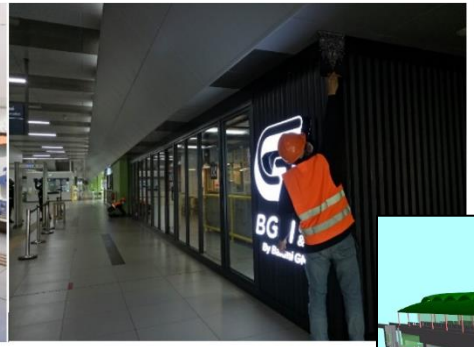
Validation Survey of MRT in Jakarta

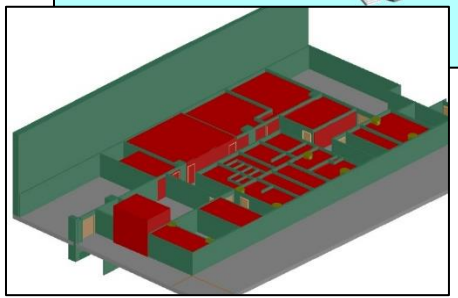
Case Studies



- Results of the measurements shows that the underground facility at the Bundaran HI station is located from the 0-17 meters below land surface.
- The height of the lowest infrastructure is at 14.973 meters below MSL.
- Because the Bundaran HI station is located under a public road, the station which is located from ground level to a depth of 17 meters is in accordance with existing legal provisions
- In cases MRT infrastructure is located below land rights which are owned by individuals/companies, it is necessary to ensure that the infrastructure is located below 30 meters or in accordance with the depth limits determined by the siteplan.

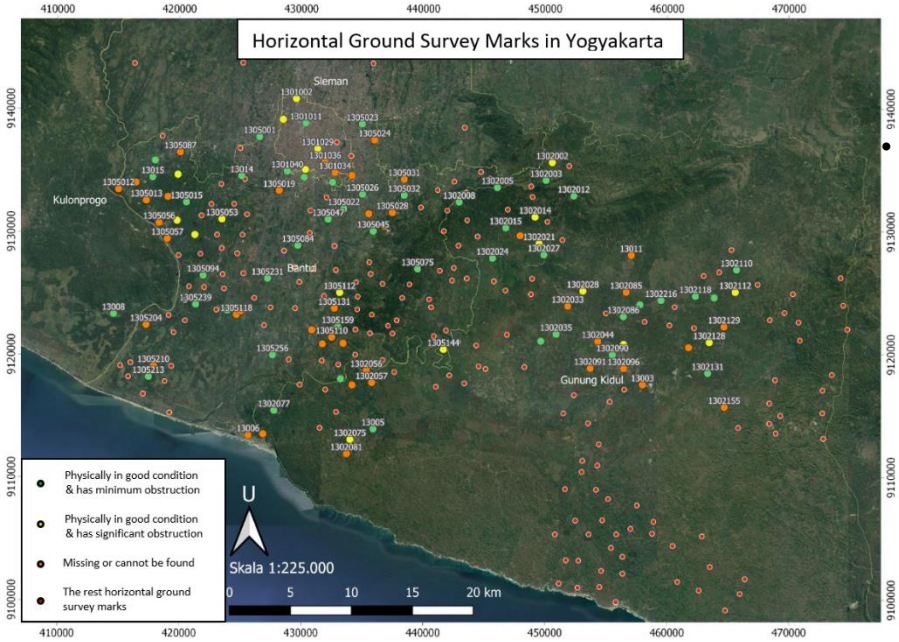
Validation Survey of MRT in Jakarta





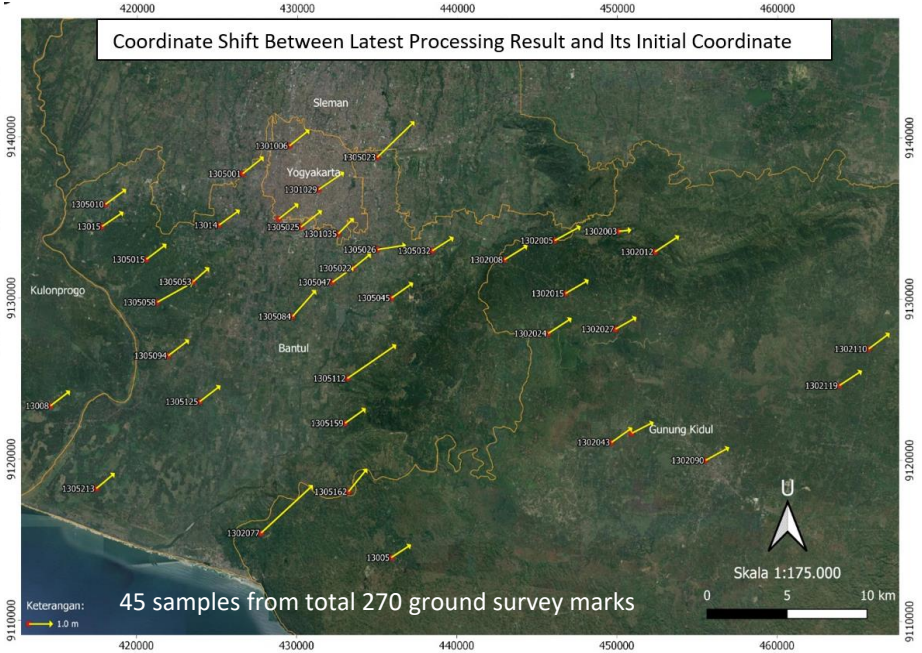
- Position validation at Blok M Station is simpler because this 3D cadastral object is located above a public road. From the Total Station measurements, it is known that the maximum height of the building is in accordance with the provisions.
- The results of the validation of distance, area and volume at both stations showed promising results. The results from measuring length with the Total Station and diameter with data from the 3D model differ only in millimetres to 1 -2 centimetres. The difference in areas and volumes of validation results with 3D models is mostly less than 2%.

Validation Survey of MRT in Jakarta

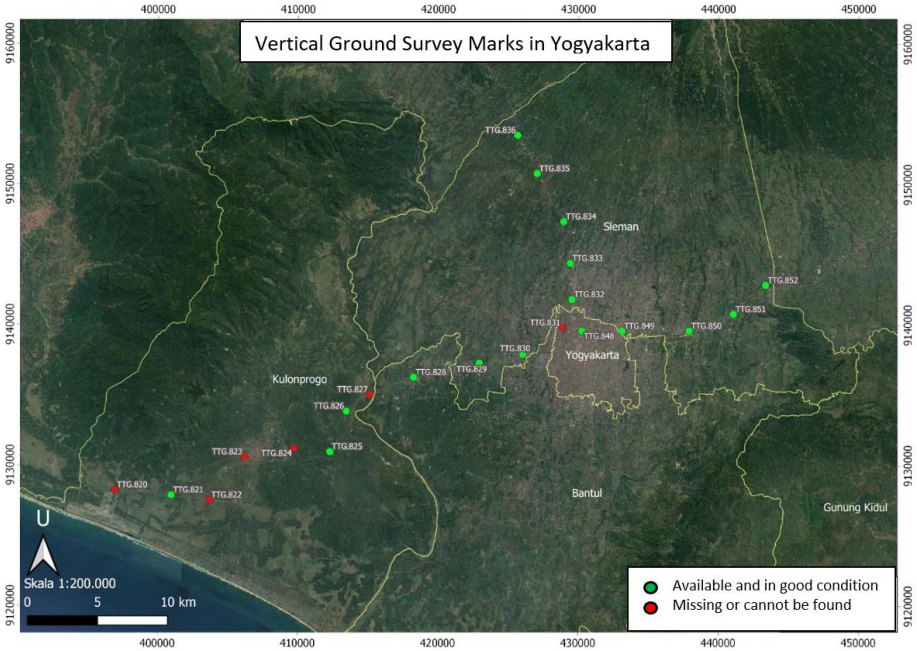


- A preliminary survey of 109 ground survey marks sample was carried out. 65 control points (60% from total points) are still in good condition, 8 control points are physically damaged, and 36 points are missing or cannot be found
- Number of horizontal ground survey marks with minimum obstruction is 45 points.

The coordinate shift between the latest processing result (SRGI 2013) and its initial coordinate from the site log (DGN95) range from 0.8-1.5 meters (systematic shift direction)

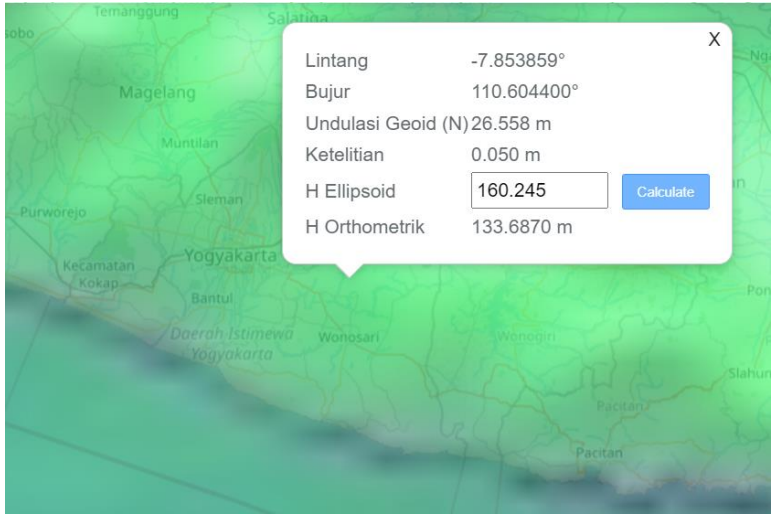


Positioning Infrastructure Evaluation in Yogyakarta



- A preliminary survey shows that from 22 vertical ground survey marks sample in Yogyakarta, 16 points are physically still in good condition and the rest of the control points are missing or cannot be found (about 70% can still be used as height reference for validation survey of 3D cadastral object in Yogyakarta.

- As claimed by the InaGeoid online service, the accuracy of the height referencing by using InaGeoid in Yogyakarta is about 5 centimeters
- Further investigation needs to be done to verify the consistency of height referencing between vertical ground survey marks and InaGeoid



Positioning Infrastructure Evaluation in Yogyakarta

Positioning infrastructure plays a vital role in validating the position of 3D cadastral objects below and above ground level. Positioning infrastructure in Jakarta can be used to validate the position, distances, areas, and volumes of 3D units with good results. The use of GNSS heighting refers to ground survey marks, and the determination of height using the InaGeoid online service is different at the decimeter level. However, the availability and reliability of positioning infrastructure in other regions or cities in Indonesia need to be further investigated.

From the evaluation of positioning infrastructure in Yogyakarta, it is identified that the availability of the horizontal ground survey marks is at 60% of its total number and 70% for vertical ground survey marks. Meanwhile, about 30-40% of the ground survey marks are missing or cannot be found on the field. The reduced number of ground survey marks in the field may hinder the implementation of 3D cadastral. Therefore, the Indonesian government needs to increase the number of ground survey marks or increase the number of CORS stations.

The result of the latest processing of horizontal ground survey marks shows that the coordinate shift between the latest processing result (SRGI 2013) and its initial coordinate from the site log (DGN95) range from 0.8-1.5 meters with a systematic shift direction. As claimed by the online service, the accuracy of InaGeoid online height referencing in Yogyakarta is about 5 centimeters. Further investigation needs to be done to verify the consistency of height referencing between vertical ground survey marks and InaGeoid.

THANK YOU

TERIMA KASIH

Mengakar Kuat
Menjulang Tinggi