DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
REPUBLIC OF THE PHILIPPINES

REPUBLIC OF THE PHILIPPINES
FOLLOW-UP STUDY
ON PARAÑAQUE SPILLWAY PROJECT

FINAL REPORT

VOLUME 2: TOPOGRAPHIC SURVEY

OCTOBER 2020

JAPAN INTERNATIONAL COOPERATION AGENCY

CTI ENGINEERING INTERNATIONAL CO., LTD.

NIPPON KOEI CO., LTD.

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COMPOSITION OF FINAL REPORT

Volume 1：Main Report

Volume 2：Topographic Survey

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1 PHP = 2.130 JPY
January 2020

LOCATION MAP-1

LOCATION MAP-2

ABBREVIATIONS AND ACRONYMS

ADB	Asian Development Bank
ASEAN	Association of South – East Asian Nations
ASTI	Advanced Science and Technology
BOC	Bureau of Construction
BOD	Bureau of Design
BRS	Bureau of Research and Standards
CIDA	Canadian International Development Agency
CLB	Calamba-Los Baños
CLUP	Comprehensive Land Use Plan
CTIE	CTI Engineering Co., Ltd.
CTII	CTI Engineering International Co., Ltd.
DEM	Digital Elevation Model
DENR	Department of Environment and Natural Resources
DILG	Department of the Interior and Local Government
DOF	Department of Finance
DOST	Department of Science and Technology
DPWH	Department of Public Works and Highways
EFCOS	Effective Flood Control Operation System
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EMB	Environmental Management Bureau
ESSD	Environmental and Social Safeguards Division
FCMC	Flood Control Management Cluster
FCSEC	Flood Control and Sabo Engineering Center
FRIMP	Flood Risk Management Project
GIS	Geographic Information System
ICC	Investment Coordination Committee
ICHARM	International Centre for Water Hazard and Risk Management
IC/R	Inception Report
IPCC	Intergovernmental Panel on Climate Change
ISF	Informal Settler Families
ISO	International Organization for Standardization
JICA	Japan International Cooperation Agency
IT/R	Interim Report
JV	Joint Venture
LGU	Local Government Unit
LLDA	Laguna Lake Development Authority
LLEDP	Laguna Lakeshore Expressway Dike Project
LPPCHEA	Las Piñas-Parañaque Critical Habitat and Ecotourism Area
MCGS	Marikina Control Gate Structure
MMDA	Metro Manila Development Authority
MSL	Mean Sea Level
MWSS	Metropolitan Waterworks and Sewerage System
NAMRIA	National Mapping and Resources Information Authority
NBCP	National Building Code of the Philippines
NCR	National Capital Region
NDRRMC	National Disaster Risk Reduction Management Council
NEDA	National Economic Development Authority
NHA	National Housing Authority
NHCS	Napindan Hydraulic Control Structure
NK	Nippon Koei Co., Ltd.
NSCP	National Structural Code of the Philippines
NWRB	National Water Resource Board
ODA	Official Development Assistance
PAGASA	Philippines Atmospheric Geophysical & Astronomical Services Administration
PEISS	Philippines Environmental Impact Statement System

PPP	Public-Private-Partnership
PRBFFWC	Pampanga River Basin Flood Forecasting and Warning Center
PSA	Philippine Statistic Authority
SC	Steering Committee
STEP	Special Terms for Economic Partnership
TOR	Terms of Reference
TWG	Technical Working Group
UNDP	United Nations Development Program
UP	University of Philippines
UPMO	Unified Project Management Office
USAID	United States Agency for International Development
WB	World Bank

REPUBLIC OF THE PHILIPPINES
FOLLOW-UP STUDY
ON PARAÑAQUE SPILLWAY PROJECT

Final Report
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Chapter 1. Project Description

1.1 Background

The Philippines is one of the countries that are most vulnerable to natural disasters in the world. The Metropolitan Manila Area (also known as Metro Manila or the National Capital Region), which includes the City of Manila, the political, economic and cultural center of the Philippines, is located in a lakeshore lowland area susceptible to typhoons/storms and floods, so that the economic and social activities are seriously affected. The Philippine government has been continuously addressing this problem through the development and implementation of flood control projects for more than 50 years, but there is not yet enough capacity to respond to flood events in the region.

The Philippine government states in its Mid-Term Development Plan (2017-2022) that, to improve the coordination capacity for river management, needed are the continuous initiative to reduce flood risk, updating of design and maintenance standards for flood control facilities, the development of river information database and updating of baseline data for flood plain designation, and the updating and development of flood control and drainage plans for the 18 major river basins.

For over 40 years since the 1970’s, Japan has been providing and implementing wide-ranging support and technical assistance as well as ODA loan projects to the Philippines, including the preparation of flood control plans, targeting mainly Metro Manila and the major rivers. Regarding river floods, after the completion of the Manggahan Floodway in 1988, JICA implemented the “Study on Flood Control and Drainage Project in Metro Manila” from 1988 to 1991, and the “Pasig-Marikina River Channel Improvement Project” was selected as a highly urgent project for flood management of the Pasig-Marikina River. Through the feasibility study (F/S) and JICA’s Special Assistance for Project Formation (SAPROF), the project was decided to be implemented in four phases, namely; Phase I, Phase II, Phase III and Phase IV. Currently, additional works in Phase III (Supplemental Agreement No. 6) and the permanent works of Phase IV (L/A signed in 2018) are in progress.

Regarding measures against drainage and inland inundation, JICA has been supporting the implementation of river dredging and the construction/installation of pumping facilities, water-gates, drainage channels and others through various projects, including the ODA loan project called “Metro Manila Flood Control and Drainage Project” in 1973, the grant aid project named as “Project for Retrieval of Flood Prone Areas in Metro Manila (Phases I and II)” from 1989 to 1994, and the ODA loan project called “The KAMANAVA Area Flood Control and Drainage System Improvement Project” from 2000 to 2008.

In addition, as measures against floods causing inland inundation and lake water level rise in the western Manggahan District and the area surrounding the Laguna de Bay (Basin Area: 2,920 km^2; Lake Surface Area: 900 km^2), JICA had provided support on the detailed design work for the Eastern and Western Manggahan districts through the ODA loan project entitled “North Laguna Lakeshore Urgent Flood Control and Drainage Project (L/A signed in 1989)” and also supported the construction of lakeshore dikes, the construction of drainage facilities and the installation of drain-gates in the western Manggahan District through the ODA loan project known as "Metro Manila Flood Control Project – West of Manggahan Floodway (1997~2007)."

However, Typhoon Ondoy, in September 2009, had brought an unprecedented daily rainfall recorded at 453 mm which caused massive flood damage in areas along the Marikina River and the surrounding Laguna de Bay lakeshore areas in Metro Manila. The Laguna de Bay lakeshore area where low-lying areas without flood management measures are widespread had experienced inundation for more than one month. Flood control measures in the Laguna de Bay lakeshore areas had lagged behind those implemented in the center of Manila and hence flood management measures in the whole Metro Manila are urgent matters to be addressed.

Furthermore, as a countermeasure for flooding in the Laguna de Bay lakeshore areas, in addition to the construction of lakeshore dikes, drainage channels and pumping stations, the construction of a spillway (hereinafter referred to as the "Parañaque Spillway") for draining lake water from Laguna de Bay through Parañaque City to the Manila Bay to control the water level of Laguna de Bay is under consideration. Since it is difficult to acquire land in Parañaque City which is an urbanized area, underground channeling is being considered instead of the open-cut method.

In view of the necessity of flood countermeasures for the Laguna de Bay lakeshore areas, JICA conducted the "Data Collection Survey on Parañaque Spillway in Metro Manila (hereinafter referred to as Parañaque Survey 2018)" from 2017 to 2018. In this project, additional studies on the integrated flood control plan for the Pasig-Marikina River basin and the Laguna de Bay basin were conducted, including the effects of the Parañaque Spillway, based on the previous survey results, as well as the collection and confirmation of information to evaluate the feasibility of JICA's ODA loan projects and the direction of the Preparatory Survey.

1.2 Objective

The objectives of this project are to analyze the situation in the Laguna de Bay basin, including the Pasig-Marikina River basin, in a unified manner and in coordination with the existing flood control projects and plans, to prepare the comprehensive flood management plan of the entire Laguna de Bay Lakeshore Area, and to conduct collection and confirmation of information to examine the feasibility of JICA's ODA loan assistance project and the direction of the preparatory survey.

1.3 Project Description

1） Study Area

The Study Area involves the entire Laguna de Bay Lakeshore Area (Metro Manila Area and Surrounding Areas).

2） Related Government Offices and Authorities

・Department of Public Works and Highways (DPWH)

・Lake Laguna Development Authority (LLDA)

・Metro Manila Development Authority (MMDA)

3）JICA's Major Assistance related to theProject

① Development Study

- Study on Flood Control and Drainage Project in Metro Manila (1990)

② ODA Loan

- Metro Manila Flood Control and Drainage Project (1973~)
- Metro Manila Flood Control Project - West of Manggahan Floodway (1997 ~ 2007)
- Pasig-Marikina River Channel Improvement Project (Phase I) (1999 ~ 2000)
- Pasig-Marikina River Channel Improvement Project (Phase II) (2006 ~ 2013)
- Pasig-Marikina River Channel Improvement Project (Phase III) (2012 ~ 2018)
- Pasig-Marikina River Channel Improvement Project (Phase IV) (2019 ~)

③ Basic Information Collection and Confirmation Study

- Data Collection Survey on Drainage System in Metro Manila (2013)
- Data Collection Survey on Flood Management Plan in Metro Manila (2014)
- Data Collection Survey on Parañaque Spillway in Metro Manila (2018)

1.4 Schedule

To show the progress of the work, the following reports are to be prepared and submitted to the agencies concerned:

- Inception Report: November 2019
- Draft Final Report: April 2020
- Final Report: June 2020

The work plan is as shown in the following table.

Table 1.4.1 Work Plan for Follow-up Study on Parañaque Spillway Project

Work Items / Period	FY 2019			FY 2020									
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
【1】 Domestic Preparation Works and Consultation of IC/R with JICA													
【2】 Confirmation and arrangement of existing plans and studies on flood control, water utilization, land use, environmental management / basin conservation, climate change													
【3】 Confirmation of inflow from Manggahan floodway into Laguna Lake, resulting rise in Laguna Lake level, inundation area													
【4】 Consideration and proposal of a method for organizing and examining the coast of Laguna Lake and flood control in the Pasig-Marikina river basin as the flood control effect of the Paranaque spillway													
【5】 Collection of information on people using Laguna Lake													
【6】 Creating an interim report (IT / R)													
【7】 Confirmation of optimal facility scale combination by sensitivity analysis													
【8】 Reorganization of basic design plan and trial calculation of maintenance costs													
【9】 Examination of the components of the implementation procedure													
【10】 Reorganization of project economic effects (EIRR,B/C)													
【11】 Outline of climate change adaptation measures													
【12】 Rearrangement of non-structural measures													
【13】 Rearrangement of flood control plan in Laguna Lake basin													
【14】 Examination of operation rules for Paranaque spillway													
【15】 Organizing the position of the Paranaque floodrway development project on sustainable development and conservation of Laguna Lake													
【16】 Examination and proposal of the presentation method of the project effect of Paranaque spillway													
【17】 Creation, explanation and discussion of DF/R													
【18】 Pereparation, Submission of F/R													
【19】 Topographic Survey													
Discussion and Submission of the Report													
Report		Δ IC/R	Δ IT/R					Δ DF/R			Δ F/R (Main Report)		Δ F/R (Survey Report)

【Legend】 In the Philippines : ■ Domestic Works : □ Reporting: Δ

IC/R: Inception Report, IT/R: Interim Report, DF/R: Draft Final Report, F/R: Final Report

Chapter 2. LiDAR Topographic Survey of Parañaque Spillway Route 2-B

2.1 Survey Details

1) Purpose

LiDAR topographic survey was conducted on Route 2-B, which is the most likely route among the four routes of the Parañaque Spillway, and an orthophoto map and contour map were created. Based on the survey results, the feasibility of Route 2-B was examined.

2) Survey Area

The LiDAR topographic survey range (Route 2-B) is shown in the figure below. The total measured area is 120 ha. The survey results will be a 1: 200 scale topographic map showing contour lines at 1-meter intervals. Detailed topographic survey results are shown in Appendix 1.

Table 2.1.1 LiDAR Topographic Survey Range (Route 2-B)

Area No.	Length (m)	Width (m)	Area (ha)
Survey Area 1	1,100	500	55.0
Survey Area 2	5,100	50	25.5
Survey Area 3	3,200	100	32.0
Survey Area 4	250	300	7.5
Total	**9,650**	**-**	**120.0**

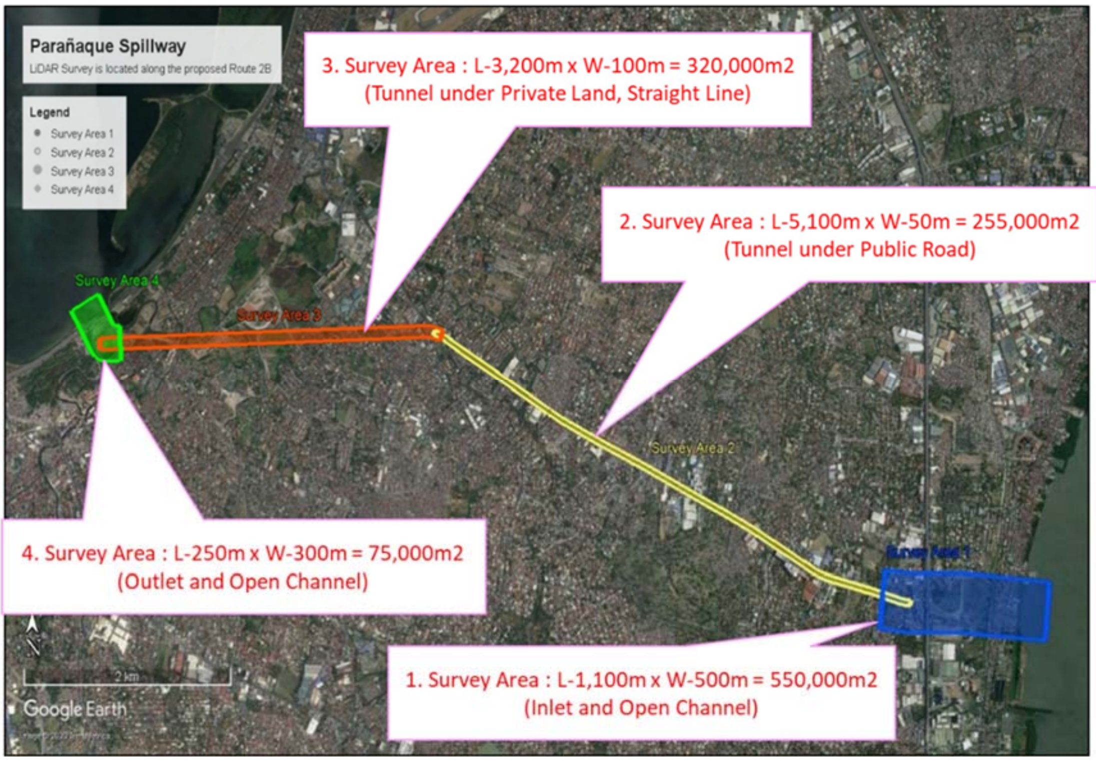

Figure 2.1.1 LiDAR Topographic Survey Area (Route 2-B)

2.2 Survey Result

1) Planar Topographic Map

Sample topographic maps and orthophoto maps for each Survey Area are shown below.

Figure 2.2.1 Survey Area 1：Topographic map and orthophoto map sample near inlet facility of Spillway

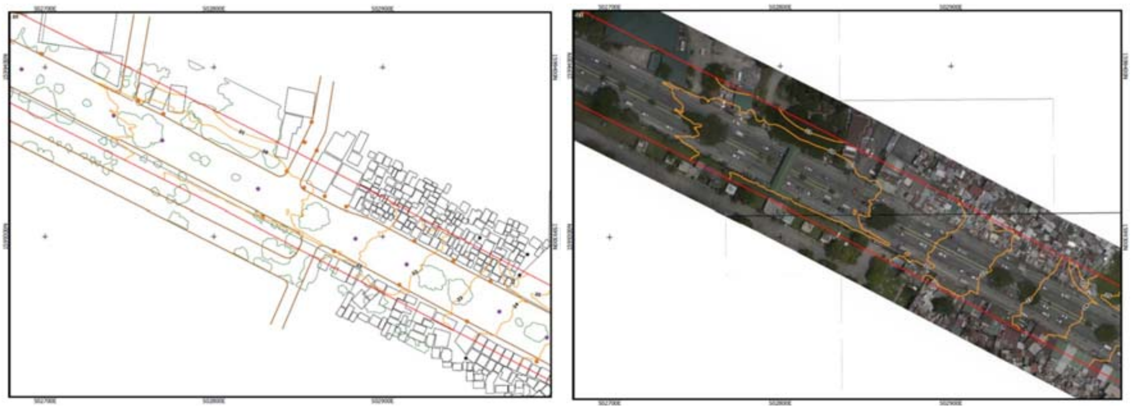

Figure 2.2.2 Survey Area 2：Topographic map and orthophoto map sample of Dr.A.Santos Avenue

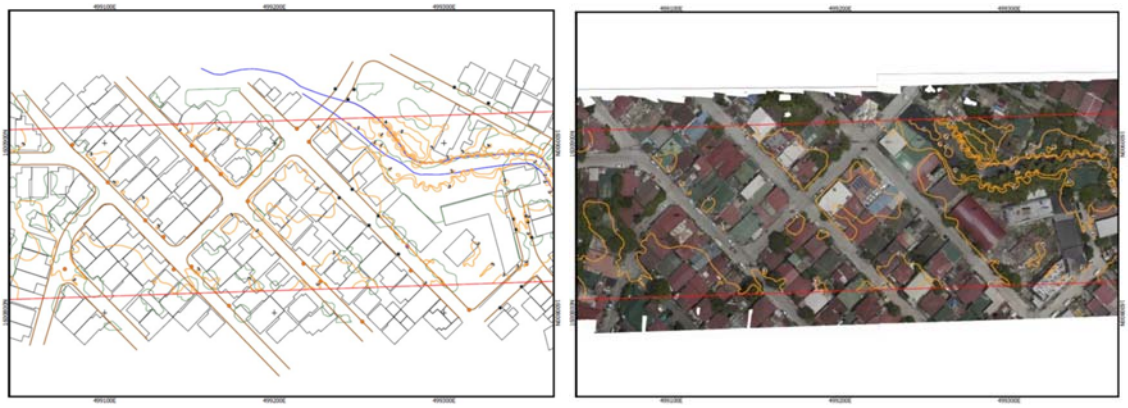

Figure 2.2.3 Survey Area 3：Topographic map and orthophoto map sample from Dr.A.Santos Avenue to Zapote River

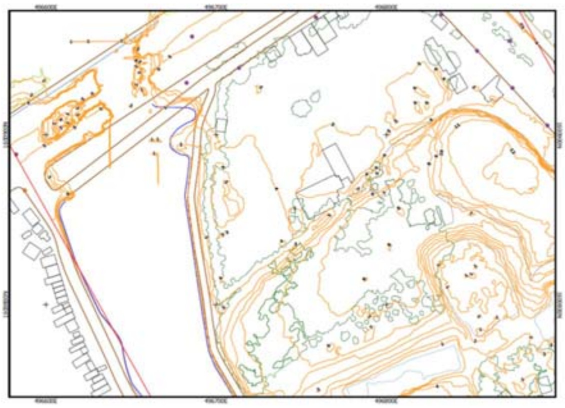

Figure 2.2.4 Survey Area 4：Topographic map and orthophoto map sample near outlet facility of Spillway

2）Longitudinal Topographic Map

From the topographic survey results, the vertical topographic map of Route 2-B is shown below.

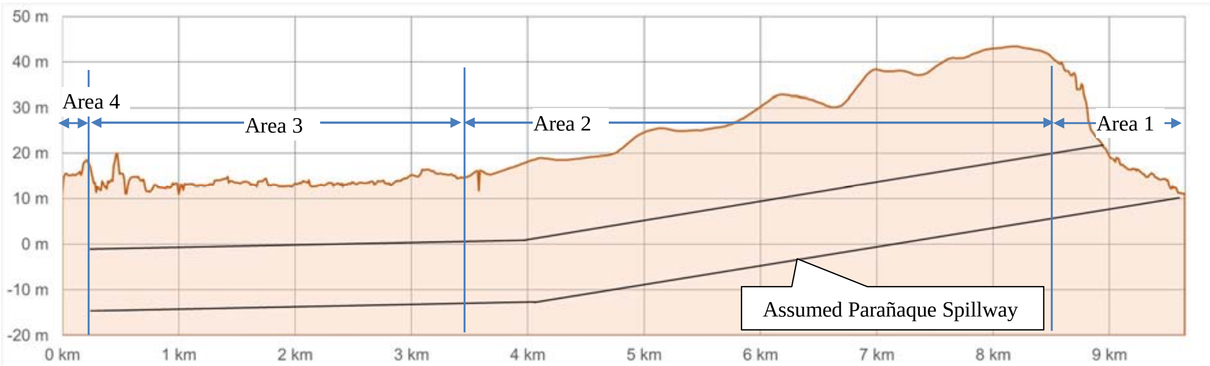

Figure 2.2.5 Longitudinal Topographic Map of Parañaque Spillway Route 2-B

2.3 The Feasibility of Route 2-B plan

The feasibility of Route 2-B based on the survey results is summarized below.

<u>Survey Area 1</u>

- It was confirmed that the underground tunnel, open channel, and tunnel entrance on the Lake Laguna side are densely populated areas with gentle slopes and unused land with relatively steep slopes, as initially expected.
- It is assumed that tunnel excavation can be started directly from the ground surface by using this steep slope, and the construction period can be significantly shortened by omitting the inlet vertical shaft.
- For densely populated areas, land expropriation and house relocation are required.
- See 4.10.2 (5) for estimated compensation costs. This compensation cost is an approximation, and it is necessary to examine it in detail in the next F / S survey based on the results of this survey and the facility layout plan.

<u>Survey Area 2</u>

- The width of Dr. Santos A. Avenue, which is a public road, is about 25 m, which is wide enough for the spillway channel (inner diameter 13 m).
- It was also confirmed that the road alignment is almost straight and it is easy to plan a spillway using the underground space of the public road.
- The road has a gentle descent of about 0.6%, and the tunnel can be designed with a downhill slope that matches the slope of the ground surface by securing a cover of 13 m (about the inner diameter of the tunnel) from the ground surface.

<u>Survey Area 3</u>

- It was confirmed that the part that turns from the public road toward the Zapote River is a flat residential area as initially expected.
- Since the terrain is flat, it is assumed that the tunnel will be covered from the ground surface to the inside diameter of the tunnel and will be designed with a very gentle downward slope for drainage.
- Since this part is less than 50m underground, it is necessary to compensate for the underground use right (Perpetual Easement). The compensation cost is 20% of the market price of private land on the ground according to the detailed implementation rules of THE IRR OF R.A. 10752 (Implementing Rules and Regulations of Republic ACT NO. 10752). See 4.10.2 (5) for estimated compensation costs.
- In this survey, permission for ground surveying of some sections was not obtained. In the next F / S survey, it is necessary to examine in detail based on the results of this survey and the final route plan.

<u>Survey Area 4</u>

- It was confirmed that the shaft and the outlet of the spillway on the Manila Bay side are flat land with almost no buildings as initially expected.
- It is envisioned that this flat land will be used to construct drainage shafts and outlet facilities, including gate facilities.

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Appendix　1

Topographic survey report by subcontractor

2020

PROJECT REPORT

The conduct LiDAR Topographic Survey and Mapping under Follow-up Study on Paranaque Spillway for CTI Engineering Co. Ltd.

AERO 360 Solutions, Inc.

Surveyed on 16 July – 04 August; 13 August – 10 September 2020

SOLUTIONS BEYOND DRONES

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1. LIDAR TOPOGRAPHIC SURVEY AND MAPPING

1.1. BACKGROUND

CTI Engineering International Co., Ltd. hereinafter referred to as Client, is an engineering consulting firm which was founded in April 1999 in Tokyo, Jap7an, as one of the companies affiliated with the CTI Group, aiming to increase the Group's share in the global market and further intensify its overseas business, especially, in developing countries receiving technological and financial assistance from international financing institutions. In September 2017, the CTI Philippine Branch was established with its principal office of business located in the City of Manila.

Aero 360 Solutions, Inc. hereinafter referred to as Contractor, is an integrated engineering solutions company registered in the Philippines and Singapore, and a Certified Drone Operator under Civil Aviation Authority of the Philippines. Aero 360 Solutions, Inc. is a pioneer in utilizing industrial-grade and survey-grade Unmanned Aerial Vehicles (UAVs), or drones to perform aerial, ground, and hydro surveys by leveraging on advanced technologies – Photogrammetry, LIDAR, multi-beam bathymetric sensors, Hi-Res Ground Penetrating Radar and exploration drilling.

The client requires the conduct of LiDAR Topographic Survey and Mapping utilizing unmanned airborne platforms to clarify the contours along the proposed Route 2B of the Paranaque Spillway and the alignment and ROW boundary of the Dr. Santos A. Avenue.

1.2. AREA OF INTEREST (AOI)

The target areas of the LiDAR Topographic Survey and Mapping are located along the proposed Route 2B of the Paranaque Spillway, as shown in Figure 1.
However, there were areas that was not able to survey by ground methods due to privacy reasons especially those areas that was owned by Adelfa Properties as shown in Figure 2. Areas not surveyed by ground methods

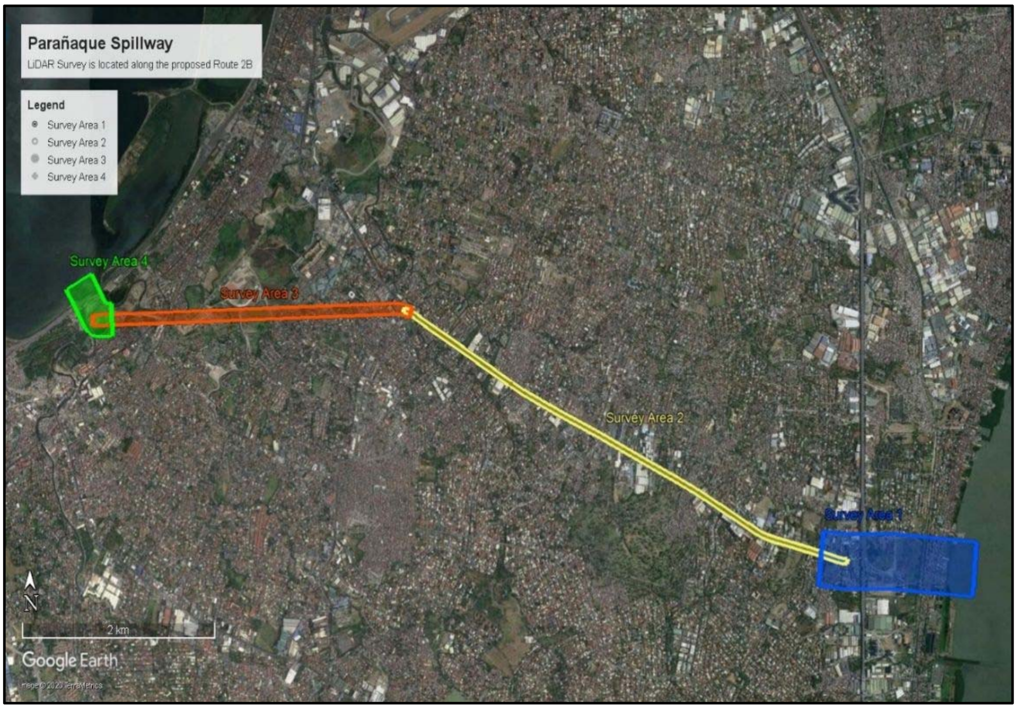


Figure 1. Area of Interest (AOI)

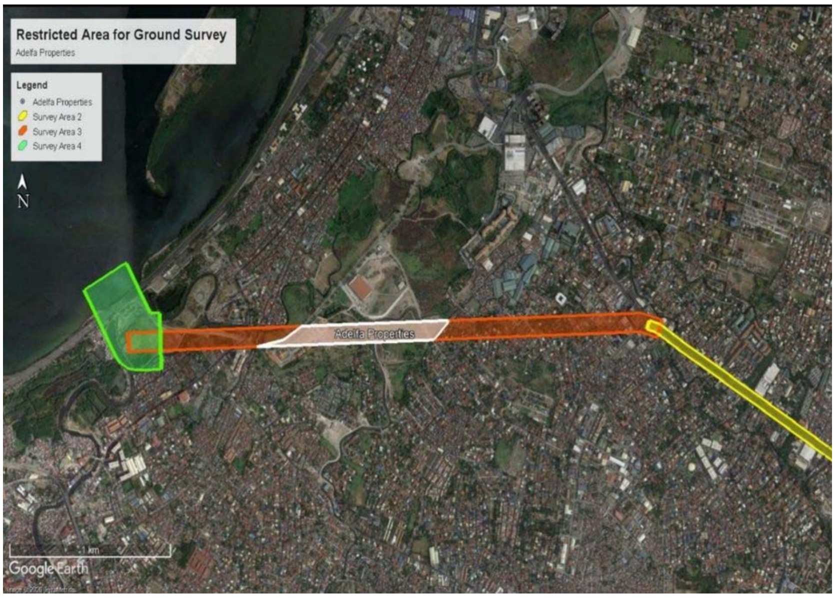


Figure 2. Areas not surveyed by ground methods

1.3. SCOPE OF WORKS

The Consultant will be responsible for executing the LiDAR Topographic Survey and Mapping for areas with a total of 120 hectares.

Details are shown as follows:

1. Survey Area: L-1,100m x W-500m = 550,000m2 (55 has.) to design the Inlet and Open Channel of the Paranaque Spillway, 1-meter contour, 1:1000 scale.
2. Survey Area: L-5,100m x W-50m = 255,000m2 (25.5 has.) to design the Paranaque Spillway (Underground Tunnel) under a public road (Doctor A. Santos Avenue), 1-meter contour, 1:1000 scale; necessary for clarifying the public area (ROW) to fix the alignment of underground tunnel.
3. Survey Area: L-3,200m x W-100m = 320,000m2 (32 has.) to design the Paranaque Spillway (Underground Tunnel) under private lands, straight line, 1-meter contour, 1:1000 scale; necessary for clarifying the private area and number of houses to fix the alignment (straight line) of underground tunnel.
4. Survey Area: L-250m x W-300m = 75,000m2 (7.5 has.) to design the Outlet and Open Channel, 1-meter contour, 1:1000 scale.

2. EQUIPMENT

2.1. AUTOMATIC LEVEL

A level is an optical instrument used to establish or verify points in the same horizontal plane in a process known as levelling, and is used in conjunction with a levelling staff to establish the relative heights levels of objects or marks. It is widely used in surveying and construction to measure height differences and to transfer, measure, and set heights of known objects or marks. It is also known as a Surveyors level, Builders level, Dumpy level, or the historic "Y" level. It operates on the principle of establishing a visual level relationship between two or more points, for which an inbuilt telescope and a highly accurate bubble level are used to achieve the necessary accuracy. Traditionally the instrument was completely adjusted manually to ensure a level line of sight, but modern automatic versions self-compensate for slight errors in the coarse levelling of the instrument and are thereby quicker to use.

The team utilized one (1) Topcon AT-B2 Automatic level for this project. Technical specifications of the equipment are shown in Table 1

Figure 3. Topcon AT-B4 Automatic level

Table 1. Technical specifications of Topcon AT-B4 Automatic Level

SPECIFICATIONS	Topcon AT-B4 AL
MAGNIFICATION	24X
FIELD OF VIEW	1°25’
MIN. FOCUS	0.3m. (1ft.)
IMAGE	Erect
STADIA	Yes (1:100)
ACUURACY (1km double run leveling)	2.0mm.
WEIGHT	1.7kg.

2.2. GNSS RECEIVERS

GNSS receivers determine the user position, velocity, and precise time (PVT) by processing the signals broadcasted by satellites. Because the satellites are always in motion, the receiver must continuously acquire and track the signals from the satellites in view, to compute an uninterrupted solution, as desired in most applications. Any navigation solution provided by a GNSS receiver is based on the computation of its distance to a set of satellites, by means of extracting the propagation time of the incoming signals travelling through space at the speed of light, according to the satellite and receiver local clocks. This time difference is transformed into a fake range, the "pseudorange", by multiplying it by the speed of the light in the vacuum. The pseudorange might be seen as a very rough estimate of the true range between satellite and user and has to be corrected to account for a number of phenomena before it can be interpreted as a precise measurement of the true distance.

The team utilized four (4) South Galaxy G1 (Figure 4) and Two (2) Hi-Target V30 (Figure 5) GNSS receivers for this project. Technical specifications of the equipment are shown in Table 2 and Table 3.

Figure 4. SOUTH Galaxy G1 GNSS Receiver

Table 2. Technical specifications of South Galaxy G1 GNSS

SPECIFICATIONS	SOUTH GALAXY G1
POSITIONING OUTPUT RATE	1 Hz ~ 50Hz
INITIALIZATION RELIABILITY	>99.99%
RTK ACCURACY (HORIZONTAL)	+/- 8mm + 1ppm
RTK ACCURACY (VERTICAL)	+/- 15mm + 1ppm
CODE DIFFERENTIAL ACCURACY (HORIZONTAL)	+/- 0.25m + 1ppm
CODE DIFFERENTIAL ACCURACY (VERTICAL)	+/- 0.50m + 1ppm
SATELLITE SIGNAL TRACKING	GPS, GLONASS, SBAS, BDS, GALLILEO, QZSS
WEIGHT	2.14 lbs.

Figure 5. Hi-Target V30 GNSS Receiver

Table 3. Technical specifications of Hi-Target V30 GNSS

SPECIFICATIONS	HI-TARGET V30
POSITIONING OUTPUT RATE	1 Hz ~ 20Hz
INITIALIZATION RELIABILITY	>99.99%
RTK ACCURACY (HORIZONTAL)	+/- 8mm + 1ppm
RTK ACCURACY (VERTICAL)	+/- 15mm + 1ppm
CODE DIFFERENTIAL ACCURACY (HORIZONTAL)	+/- 25cm + 1ppm
CODE DIFFERENTIAL ACCURACY (VERTICAL)	+/- 50cm + 1ppm
SATELLITE SIGNAL TRACKING	GPS, GLONASS, SBAS, BDS, GALLILEO, QZSS
WEIGHT	< 2.86 lbs.

2.3. TOTAL STATION

Total station (TS) is an electronic/optical instrument mostly used for surveying and construction. It is an electronic transit theodolite integrated with electronic distance measurement (EDM) to measure both vertical and horizontal angles and the slope distance from the instrument to a particular point, and an on-board computer to collect data and perform triangulation calculations. Team used the STS-750 R6LC Total Station (Figure 6) to acquire the coordinates of the targets around the tower which was placed vertically. This method will increase the accuracy of the output.

The team utilized one (1) SanDing STS-750 R6LC Total Station for this project. Technical specifications of the equipment are shown in Table 4.

Figure 6. SanDing STS-750 R6LC Total Station

Table 4. Technical specifications of SanDing STS-750 R6LC Total Station

SPECIFICATIONS	SanDing STS 750R6Lc
DISTANCE (RANGE) FOR SINGLE PRISM	5.0 KILOMETER (MAX)
DISTANCE (RANGE) FOR REFLECTOR-LESS	350 METERS (MAX)
ACCURACY (WITH REFLECTOR)	2mm+2ppm
ACCURACY (W/O REFLECTOR)	5mm+3ppm
EDM READING TIME (FINE)	1 second
EDM READING TIME (TRACKING)	0.5 second
ATMOSPHERIC REFRACTION	MANUAL INPUT; AUTOMATIC
EARTH CURVATURE	MANUAL INPUT; AUTOMATIC

2.4. ECHO SOUNDER

Single beam echo sounders (SBES), also known as depth sounders or fathometers determine water depth by measuring the travel time of a short sonar pulse, or "ping". The sonar ping is emitted from a transducer positioned just below the water surface, and the SBES listens for the return echo from the bottom.

The team utilized one (1) South SDE-28S SBES for this project. Technical specifications of the equipment are shown in Table 4.

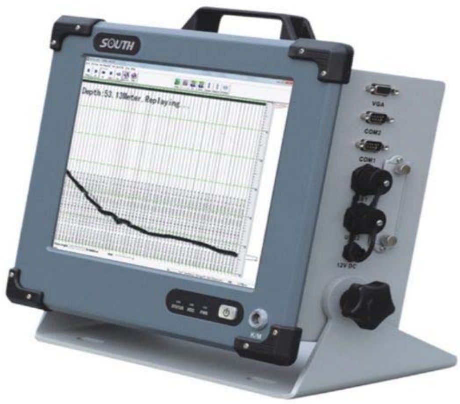


Figure 7. South SDE-28S Echo-Sounder

Table 4. Technical specifications of South SDE-28S Echo Sounder

SPECIFICATIONS	SOUTH SDE-28S ECHO SOUNDER
FREQUENCY RANGE	200 kHz
BEAM ANGLE	7!
DEPTH RESOLUTION	0.1 ft / 0.01 m.
PING RATE	14 Hz – 30 Hz
OUTPUT DATA FORMAT	SOUTH, SDH-13D, DES025, INN455, ODOM
POWER SUPPLY	9-15V DC, less than 25 w
DIMENSION	35 cm. x 29 cm. x 14 cm.
WEIGHT	7.5 Kg.

2.5. LiDAR SENSOR

For Aerial surveys of transmission lines or conductors, the team utilized the Phoenix Scout Ultra (Figure 8), a compact integrated LiDAR system that includes an Inertial Measurement Unit (IMU), GPS receiver, Laser scanner, and a Micro-computer.

Technical specifications of the Riegl VUX1-LR LiDAR system are shown in *Table 5.*

Figure 8. Riegl VUX1-LR LiDAR system

Table 5. Technical specifications of Riegl VUX1-LR LiDAR system

SPECIFICATION	RIEGL VUX1-LR LIDAR SYSTEM
ABSOLUTE ACCURACY (MM, RMSE@50M)	25-35
WEIGHT(KG)	5.3
LASER RANGE (M, @60% REFLECTIVITY)	1350
LASER CLASS	CLASS 1 (1550NM)
NUMBER OF RETURNS	MULTIPLE

2.6. PLATFORMS

A Robinson R44 helicopter (Figure 9. R44 Heli) was used for the integrated LiDAR and Photogrammetry fights. Sony A7R (Figure 10. SONY A7R) was integrated with the LiDAR sensor.

Technical specifications of the platform are shown in Table 6.

Figure 9. R44 Heli

Figure 10. SONY A7R

Table 6. Technical specifications SONY A7R

Specification	SONY A7R
Sensor Resolution	36.4 Megapixel
Optical Sensor Type	Exmor CMOS
Total Pixels	36800000 pixels
Effective Sensor Resolution	36400000 pixels
Optical Sensor Size	Full Frame (24 x 35.9 mm)
Max Shutter Speed	1/8000 sec
Min Shutter Speed	30 sec
Exposure Compensation	±5 EV range, in 1/2 or 1/3 EV steps
Continuous Shooting Speed	1.5 frames per second, 4 frames per second

3. REFERENCE DATUM

3.1. HORIZONTAL DATUM

In accordance with Executive order No. 45, series of 1993, as amended by EO 321 and EO 280, series of 2000 and 2004, respectively, the Philippine Reference System of 1992 (PRS92) shall be the standard reference system for all surveys and mapping in the Philippines. The PRS92 was the geodetic datum established during the implementation of the Australian Government-funded Natural Resources and Management and Development Project (NRMDP) in 1989-1992 using global navigation satellite system (GNSS)-based positioning technology, specifically the Global Positioning System.

The client requires PPCS-PRS92 for horizontal reference datum.

3.2. VERTICAL DATUM

Project elevations shall be referred to the mean sea level as established by the Coast and Geodetic Survey Department (formerly the Bureau of Coast and Geodetic Survey) of the National Mapping and Resource Information Authority (NAMRIA). A nationwide network of benchmarks, generally located at about 1km intervals along national, provincial, and municipal roads, serve as reference stations for the mean sea level vertical datum.

The client requires mean sea level (msl) for vertical reference datum.

4. DATA ACQUISITION

4.1. RECONNAISANCE SURVEY

The reconnaissance survey is an extensive study of an entire area that might be used before the actual deployment. Its purpose is to collect information that could be useful prior to the conduct of actual survey. This could be useful in the process of Identifying terrain type, access roads, lot boundaries, existing controls etc.

4.2. GEODETIC CONTROL SURVEY

4.2.1. STATIC OBSERVATION

Static observations were done to establish project control network within the AOI. This step is vital to ensure that the survey made was in accordance and in conformity to the Philippine surveying and mapping standards.

All the controls were observed for a minimum of one (1) hour using dual frequency GPS Receivers. Horizontal and vertical coordinates were computed and generated using Trimble® Business Center (TBC), a GPS processing software. Long static observations were done to minimize the errors especially in long baselines. Generated coordinates from TBC are shown in *Table 6*.

Table 6. List of GCP generated in PRS92 coordinates system

GCP NAME	EASTING	NORTHING	ELEV (MSL)	ESTABLISH
MMA-3	504195.049	1607527.693	25.410	NAMRIA
GM-39M	504022.342	1598729.564	32.550	NAMRIA
MMA-3555	500435.872	1600609.206	7.344	NAMRIA
MMA-3958	497122.391	1601263.136	3.691	NAMRIA
AERO-01A	496614.933	1600864.654	5.093	AERO 360
AERO-01B	496860.236	1600986.249	4.752	AERO 360
AERO-01C	497164.554	1600835.411	4.792	AERO 360
AERO-02A	497750.328	1600785.397	2.652	AERO 360
AERO-02B	498133.598	1601135.424	2.941	AERO 360
AERO-03A	498576.514	1600889.756	4.055	AERO 360
AERO-03B	499224.034	1600917.529	3.434	AERO 360
AERO-04A	499880.598	1600994.572	3.956	AERO 360
AERO-04B	500267.406	1600711.532	5.557	AERO 360
AERO-05A	500691.489	1600450.457	8.206	AERO 360
AERO-05B	501118.760	1600184.253	10.218	AERO 360
AERO-06A	501783.368	1599848.315	14.731	AERO 360
AERO-06B	502179.975	1599665.312	18.741	AERO 360
AERO-07A	502618.524	1599431.688	21.456	AERO 360
AERO-07B	503030.514	1599221.483	26.204	AERO 360
AERO-08A	503555.401	1598917.815	28.397	AERO 360
AERO-08B	504265.734	1598674.864	32.837	AERO 360
AERO-09A	504916.541	1598506.155	19.245	AERO 360
AERO-09B	505292.486	1598399.065	6.172	AERO 360
AERO-10A	505703.589	1598747.437	3.604	AERO 360
AERO-10B	505781.272	1598829.916	3.057	AERO 360

PRS92 coordinate system was utilized in this project. However, all the above listed coordinates are transformable to any projection if desired.

Aside from being used as project control, the established GCP were also used as LiDAR base stations and ground validation survey check points.

4.2.2. LEVELING SURVEY

Levelling is a process of determining the height of one level relative to another. It is used in surveying to establish the elevation of a point relative to a datum, or to establish a point at a given elevation relative to a datum.

The team used a close-loop level traverse in determining msl heights starting from a known NAMRIA benchmark named “GM-39M”.

4.3. BATHYMETRIC SURVEY

Bathymetric survey is the study of the bed (floor) of a waterbody, involving mapping of features on charts to provide information on water depth. Bathymetric charts and plans are typically produced to aid navigation, inform dredging activities, support feasibility studies etc.

Bathymetric survey traditionally uses an echosounder attached to a survey boat. As the boat drives across the survey area, the echosounder generates electrical signals that are then converted to sound waves by a transducer under water. The sound waves bounce off the underwater features and this echo is picked up by the echosounder which then calculates the distance to the feature. The system uses high accuracy GNSS (GPS) system to then link each distance measurement to a specific depth on a map.

4.4. LiDAR SURVEY

Light Detection and Ranging (LiDAR) is a remote sensing method that uses light in the form of a pulsed laser to measure ranges (variable distances) above ground level. These light pulses – combined with GPS observations and data recorded by the Inertial Measurement Unit (IMU) – generate precise, three-dimensional information about the Earth’s surface characteristics. LiDAR technology was employed for this project to acquire topographic data over the specified area of interest.

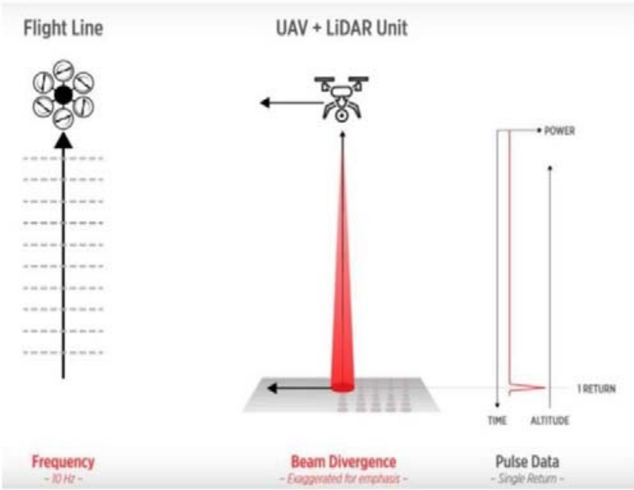


Figure 11. LiDAR Scan Frequency, Beam Divergence and Laser Pulse Data (Phoenix Lidar, 2017)

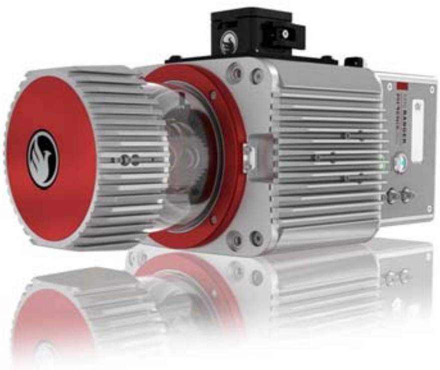


Figure 12. LiDAR system set-up

Figure 13. Actual LiDAR system set-up

4.4.1. FLIGHT MISSIONS

Team conducted a total of four (4) flight missions to cover the required AOI. Flight plans were prepared in accordance to the project's requirements, topography, area geometry, platform configuration, and wind patterns using various UAV-based software. Parameters used are tabulated in Table 7.

Team made an excessive buffer to the AOI for around 50-100 meters. The purpose of this is to gain access adjacent to roads for the ground validation. Due to its flat surface and gradual slopes, roads are the most ideal place for ground validation surveys.

Table 7. LiDAR survey flight parameters

FLIGHT PARAMETERS	PHOENIX RANGER - LR
FLYING HEIGHT (AGL – Above Ground Level) (m)	150-250
MIN. SIDE OVERLAP (%)	50
MAX. FIELD OF VIEW (θ) (max)	60
PLATFORM SPEED (m/s)	25
PULSE REPETITION FREQUENCY (kHz)	400 to 820
MINIMUM POINT DENSITY (p/m²)	10

Flight missions were all conducted using manual mode. This methodology occurs when the aircraft needs to be operated on critical areas such as high vegetation, the pilot has a less visual line of sight (VLOS) of the aircraft and mostly, for better terrain following to produce a more detailed and dense point cloud. The number of flight lines for each site is shown in Table 8.

Table 8. Number of flight missions per site

AREA OF INTEREST (AOI)	NO. OF FLIGHT MISSIONS
Along Transmission Tower 84	**2**
Along Transmission Tower 86	**2**
Total	**4**

4.5. CHECKPOINT SURVEY

Checkpoint survey is a method of assessing the accuracy of the survey works. Checkpoints may be installed using nails, paints, or any similar markers to facilitate identification. These checkpoints should be clearly recognizable in the aerial photographs (both raw and processed), must be placed in secured locations to guarantee recovery, and must be well-distributed throughout the target area. Their coordinates may be determined using RTK receivers, with the necessary adjustments on the vertical datum properly implemented.

However, checkpoints shall not, in any way, utilize the points during the processing of the LiDAR data and the aerial photographs to calibrate and improve the accuracies.

The team established more than 30 checkpoints within the project site.

5. DATA PROCESSING

5.1. GNSS DATA PROCESSING

5.1.1. GNSS DATA CONVERSION

Raw static observation data from GNSS receivers were downloaded and then converted into a Receiver Independent Exchange Format (RINEX) file using dedicated software for a specific model of the GNSS receiver.

5.1.2. TRIMBLE BUSINESS CENTER

Converted RINEX file is now loaded into Trimble Business Center (TBC). TBC is a GNSS processing software that has a range of tools for processing control, running traverse adjustments, and combining all your data sources including GNSS, level and total station measurements. TBC uses robust calculations including least squares adjustments within the processing engine so your network is as accurate as it can be.

The GPS baselines were processed simultaneously in TBC by observing that all baselines have fixed solutions with horizontal and vertical precisions within +/- 10 cm or better, requirement. Masking is done by removing portions of these baseline data using the same processing software. It is repeatedly processed until all baseline requirements are met. If the reiteration yields out of the required accuracy, resurvey is initiated.

All the baselines have fixed solutions and passed the required ±5 cm or better requirement for both horizontal and vertical precisions.

5.1.3. LiDAR DATA PROCESSING

The flight trajectory exhibiting the path of the platform, a UAV, for the LiDAR system during data acquisition first go through georeferencing. Georeferencing is a process of assigning correct position to each laser returns associated with the flight trajectory. This process is utilized to rectify the acquired LiDAR point cloud data. The geo-rectified point clouds then are quality checked to ensure that the required accuracies are attained. The processing workflow and the quality checks employed for this project are shown in Figure 14 and Table 9, respectively.

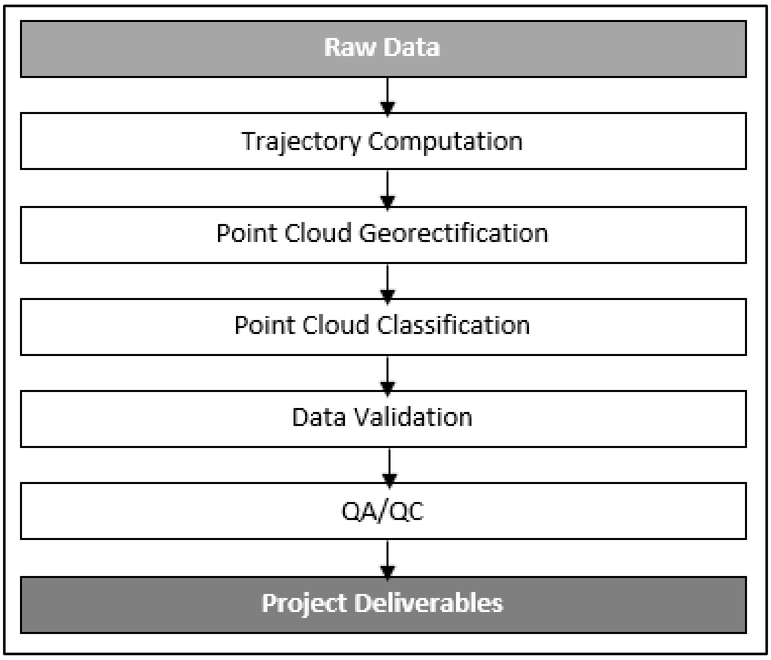


Figure 14. LiDAR data processing workflow

Table 9. Summary table for Quality assessment (QA)

PARAMETER	OPTIMAL VALUES
HORIZONTAL ACCURACY (M)	-0.10 TO +0.10
VERTICAL ACCURACY (M)	-0.10 TO +0.10

The classification of geo-rectified point clouds is categorized into three (3) main classes namely, Ground, Buildings, and Vegetation. Images acquired simultaneously with the LiDAR data were orthorectified by means of the corrected LiDAR point clouds. Quality assurance and quality control measures are employed prior to the creation of the final project deliverable.

5.1.4. TRAJECTORY COMPUTATION

The flight path of the LiDAR platform (UAV) is logged by the system's Global Positioning System (GPS) receivers and Inertial Measurement Unit (IMU) - a mechanism that accounts the platform's position and orientation during LiDAR acquisition survey (Figure 15). Simultaneous with the LiDAR survey, GPS observation is performed on a ground control for the purpose of generating a georeferenced trajectory data.

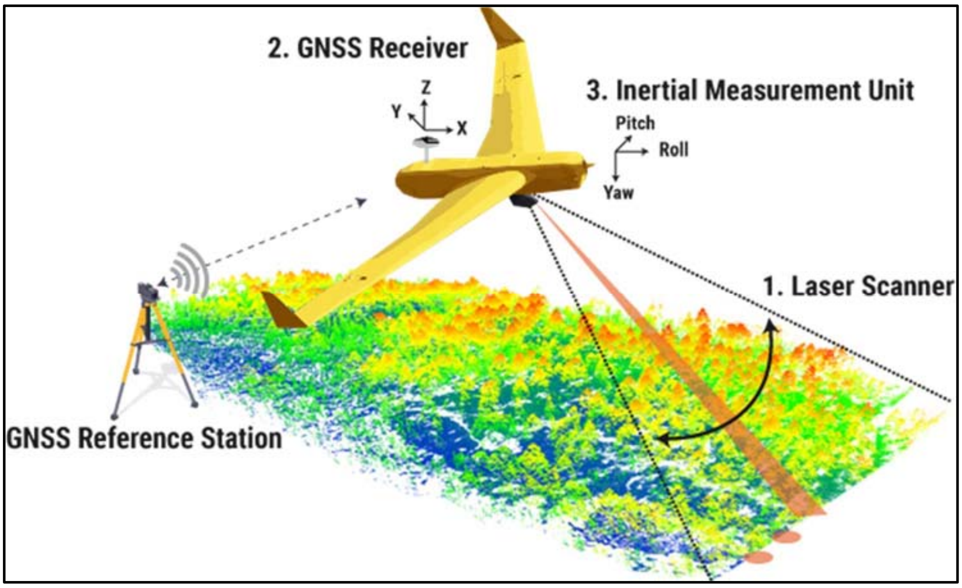


Figure 15. The IMU and the components of LiDAR data acquisition (Yellowscan, 2017)

The acquired IMU and GPS data were processed in Inertial Explorer v8.70 to produce the Smoothed Best Estimated Trajectory (SBET). This SBET file determines the position and orientation of the LiDAR point clouds.

5.1.4.1. POINT CLOUD GEORECTIFICATION

The smoothed best estimated trajectory file fused with the raw laser files yield the georectified LiDAR point cloud data.

5.1.4.2. POINT DENSITY

Acquired LiDAR point cloud data covering the entire AOI is used to calculate the overall pulse per square meter. The calculation is computed for each LiDAR mission surveyed at system specifications. The calculated point density for the entire AOI is **96** points/sqm.

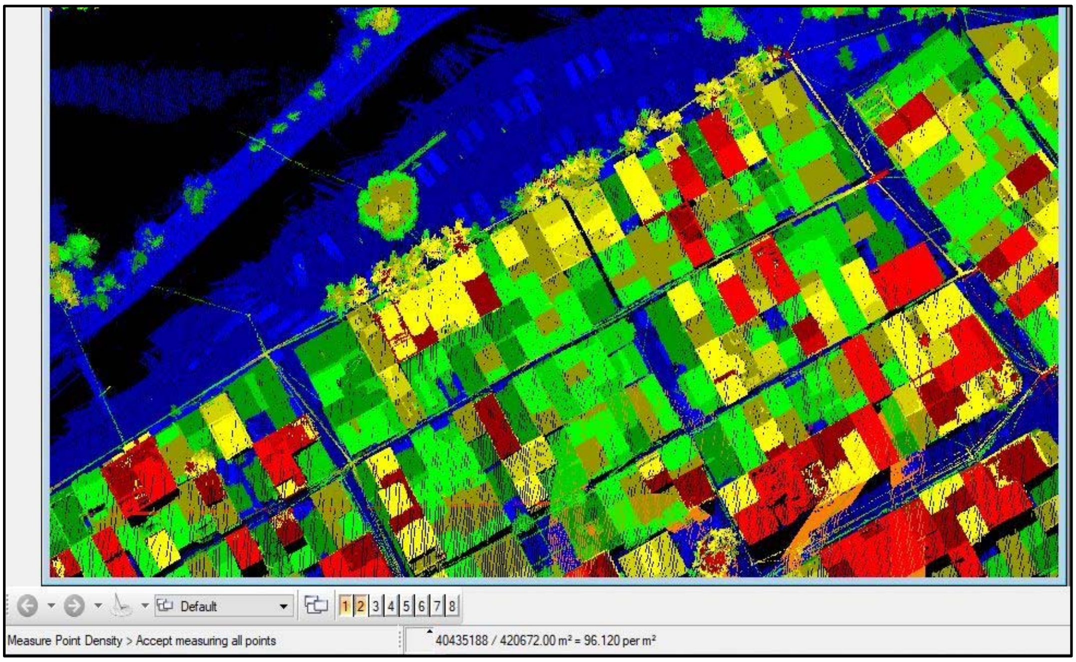


Figure 16 LiDAR pointcloud density per m²

5.1.4.3. LiDAR POINTCLOUD DATA VALIDATION

The statistical measures of the compared elevation values between the check points and the LiDAR data are computed and outlined in Table 10. Kindly refer to Annex 7.2.2 for the Vertical Accuracy Table.

Table 10. LiDAR data validation's statistical measures

STATISTICAL MEASURES (M)	VALUE
RMSE	0.033
STANDARD DEVIATION	0.032

5.1.3.5 HORIZONTAL ACCURACY

Horizontal Accuracy was measured by comparing coordinates from the ground survey (GPS) and the coordinates of points visible on the resulting ortho-imagery. Thirty points identified for this purpose and is part of Annex 7.2.3.

Table 11. Horizontal accuracy statistical measure

STATISTICAL MEASURES (M)	dX	dY
RMSE	0.031618	0.033058
STANDARD DEVIATION	0.031697	0.033174

6. OUTPUTS

The following shall be submitted by the Consultant at the end of the survey works:

- 2 printed copies of the Survey Report, which shall include but is not limited to the following:
    - Photos, location map, control point network diagram
    - General information (purpose, area, period, limits, etc.)
    - Mapping information (origin coordinates, projection, scale factor, etc.)
    - Results (coordinates table, accuracy table, calculation sheets, etc.)
    - Code legend for topographic survey and layer legend for the digital map
    - Instrument calibration certificates for the GNSS, total stations, leveling instruments, etc.
    - CAAP certificates/licenses (i.e., Operator, Controller, Aircraft Unit)
    - NAMRIA control point certificates
    - Copies of permits to conduct the survey as secured from CAAP, DND, LGUs and other related agencies
    - Descriptions of newly established control points, with 3 photos: Distant range and middle range photos shall be taken with conspicuous and remarkable landmarks, topographic features such as houses, structures, big trees, hills, creaks, etc. as a background; while short range photos shall be clear enough such that the conditions and inscriptions of the points must be seen.
    - 3D topographic map (scale 1:1000) showing the planimetric features and contour lines at 1-meter interval
- 2 digital copies of the following:
    - Survey Report (Microsoft Word format)

- 3D topographic map (1:1000 scale) showing the planimetric features and contour lines at 1-meter interval (DWG and SHP formats)
- Processed/classified Point Cloud data (LAS format)
- DTM / DSM (TIFF format)
- Digital Orthophotos (ECW format)
- Raw/unprocessed images used to produce the Digital Orthophotos
- Raw/unprocessed Point Cloud data (LAS format)
- Raw data of ground surveys (e.g., data downloaded from instruments, scanned fieldsheets, etc.)

7. ANNEXES

7.1. EQUIPMENT LIST

QUANTITY	NAME	MODEL
1	TOTAL STATION	SANDING STS-750 R6LC
2	SURVEY-GRADE GPS	HI-TARGET V30
4	SURVEY-GRADE GPS	SOUTH GALAXY G1
1	TLS	LEICA SCANSTATION P20
1	UAV-LiDAR SENSOR	PHOENIX SCOUT ULTRA
1	UAV	DJI MAVIC PRO 2 HASSELBLAD
1	UAV	DJI MATRICE 600
1	PANORAMIC CAMERA	CANON EOS REBEL T7i
4	TARGETS	MAGNETIC
50	TARGETS	LAMINATED PAPER
1	GIMBAL	NODAL NINJA
6	TRIPOD	GENERIC
6	TRIBRACH	GENERIC
2	RANGE POLE	GENERIC
2	BIPOD	GENERIC

7.2. PROCESSING REPORTS

7.2.1. HORIZONTAL ACCURACY TABLE

	Coordinates from GPS Survey		Coordinates from Imagery		Variance	
Name	Easting	Northing	Easting	Northing	dX	dY
AERO-08A	503555.4001	1598917.816	503555.398	1598917.758	-0.00215	-0.058
CP-01	496835.0273	1600995.983	496835.0383	1600995.984	0.011017	0.00118
CP-02	497053.0829	1600840.831	497053.0893	1600840.864	0.00632	0.0328
CP-03	497325.2253	1600817.041	497325.2305	1600817.072	0.00512	0.03108
CP-04	497500.5911	1600785.495	497500.6019	1600785.52	0.01074	0.02436
CP-09	498914.9562	1600840.461	498914.9464	1600840.472	-0.00981	0.0107
CP-10	499177.925	1600866.096	499177.9351	1600866.13	0.010127	0.03426
CP-11	499214.2644	1600902.406	499214.2696	1600902.44	0.005157	0.0339
CP-12	499630.3171	1600860.791	499630.3228	1600860.823	0.005723	0.03175
CP-13	499658.5892	1600833.41	499658.6079	1600833.438	0.018672	0.0282
CP-22	501352.0506	1600039.427	501352.0628	1600039.496	0.012287	0.06868
CP-23	501366.4684	1600051.123	501366.4917	1600051.159	0.02328	0.0361
CP-24	501604.9862	1599934.011	501604.982	1599933.982	-0.00414	-0.02869
CP-26	501980.4736	1599751.984	501980.5288	1599751.977	0.055145	-0.00728
CP-27	501994.051	1599775.137	501994.0886	1599775.108	0.037525	-0.02857
CP-29	502343.474	1599572.45	502343.4726	1599572.444	-0.00139	-0.00588
CP-30	502359.8907	1599598.051	502359.9127	1599598.004	0.021962	-0.04742
CP-31	502588.2345	1599424.876	502588.2363	1599424.834	0.001751	-0.04185
CP-32	502596.7819	1599441.358	502596.7857	1599441.322	0.003882	-0.03525
CP-33	502842.1069	1599321.466	502842.0694	1599321.457	-0.03744	-0.00887
CP-34	502849.7968	1599339.965	502849.7788	1599339.955	-0.01805	-0.00985
CP-35	503024.1718	1599203.363	503024.188	1599203.353	0.016135	-0.0099
CP-36	503038.1794	1599211.896	503038.1932	1599211.87	0.013829	-0.02644
CP-37	503280.5359	1599054.194	503280.5454	1599054.131	0.009483	-0.06333
CP-39	503291.3207	1599072.316	503291.3382	1599072.238	0.017529	-0.07748
CP-45	504226.2137	1598685.432	504226.2262	1598685.398	0.012462	-0.03328
CP-46	504248.9038	1598679.257	504248.909	1598679.234	0.005172	-0.0222
CP-48	504673.7545	1598553.764	504673.8471	1598553.768	0.092638	0.00322
CP-51	505054.8776	1598449.23	505054.8918	1598449.237	0.014248	0.00745
CP-52	505056.4483	1598462.133	505056.465	1598462.129	0.01674	-0.00411
CP-53	505072.5335	1598811.58	505072.5248	1598811.606	-0.00877	0.02572
CP-54	505126.6221	1598810.456	505126.6216	1598810.458	-0.00057	0.002
CP-55	505510.6406	1598654.047	505510.5523	1598654.024	-0.08827	-0.02235
CP-56	505517.3971	1598652.495	505517.3092	1598652.485	-0.08788	-0.00948

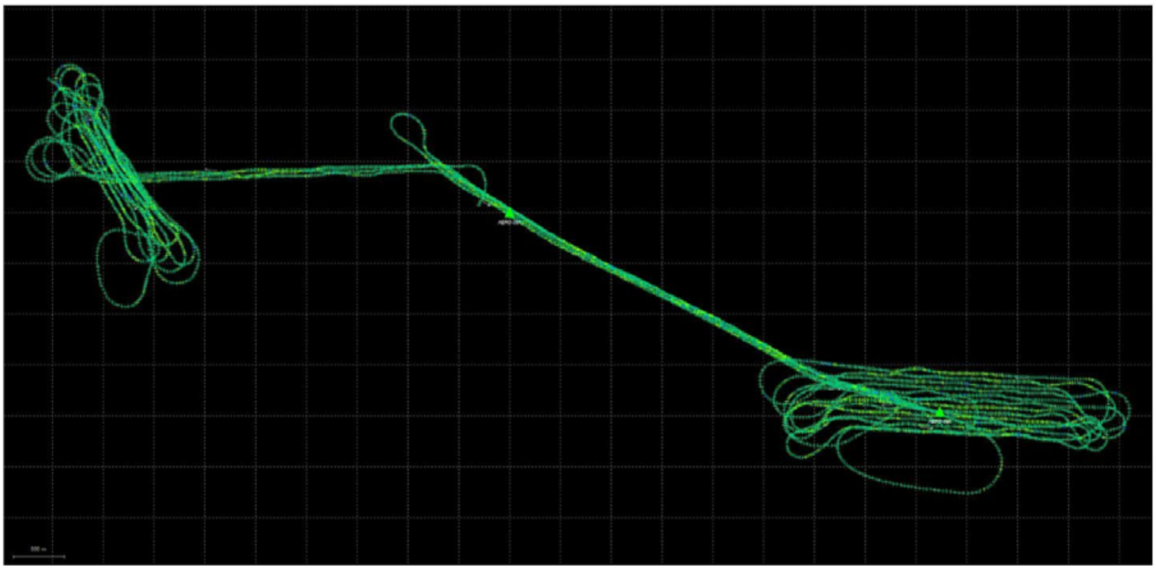
7.2.2. VERTICAL ACCURACY TABLE

Number	Easting	Northing	Elev	LIDAR Elev	dZ
1	505292.4756	1598399.063	6.128	6.193	0.065
2	505292.4826	1598399.061	6.136	6.193	0.057
3	502359.8907	1599598.051	20.544	20.594	0.05
4	505517.3971	1598652.495	3.842	3.888	0.046
5	505510.6406	1598654.047	3.813	3.855	0.042
6	502343.474	1599572.45	21.894	21.935	0.041
7	503695.9452	1598863.111	29.877	29.914	0.037
8	500973.7867	1600274.556	8.847	8.884	0.037
9	503693.0249	1598840.07	30.4	30.431	0.031
10	498914.9562	1600840.461	2.8	2.831	0.031
11	499965.7085	1600889.919	3.872	3.898	0.026
12	503835.453	1598768.991	30.874	30.898	0.024
13	505054.8776	1598449.23	11.245	11.268	0.023
14	500969.8863	1600276.17	8.828	8.849	0.021
15	504768.7914	1598832.102	30.756	30.775	0.019
16	504671.1076	1598574.632	27.403	27.417	0.014
17	504673.7545	1598553.764	27.672	27.685	0.013
18	497325.2253	1600817.041	2.811	2.82	0.009
19	500691.4734	1600450.489	8.148	8.156	0.008
20	501618.082	1599953.444	13.905	13.912	0.007
21	497500.5911	1600785.495	2.357	2.36	0.003
22	502596.7819	1599441.358	21.671	21.673	0.002
23	496835.0273	1600995.983	4.876	4.878	0.002
24	499232.3529	1600925.643	3.754	3.753	-0.001
25	501994.051	1599775.137	14.956	14.954	-0.002
26	505056.4482	1598462.133	11.03	11.028	-0.002
27	501604.9862	1599934.011	14.478	14.473	-0.005
28	504812.7441	1598811.801	23.159	23.154	-0.005
29	499177.925	1600866.096	2.931	2.925	-0.006
30	502588.2345	1599424.876	21.145	21.138	-0.007
31	500261.0822	1600713.817	5.442	5.435	-0.007
32	500691.4825	1600450.482	8.163	8.156	-0.007
33	499978.7604	1600900.807	3.995	3.986	-0.009
34	497556.2793	1600750.237	3.257	3.248	-0.009
35	501366.4684	1600051.123	14.478	14.469	-0.009
36	505292.4766	1598399.061	6.203	6.193	-0.01
37	504265.7243	1598674.875	32.839	32.826	-0.013
38	505292.4866	1598399.063	6.206	6.193	-0.013
39	505072.5335	1598811.58	8.364	8.349	-0.015
40	504248.9038	1598679.257	32.885	32.87	-0.015

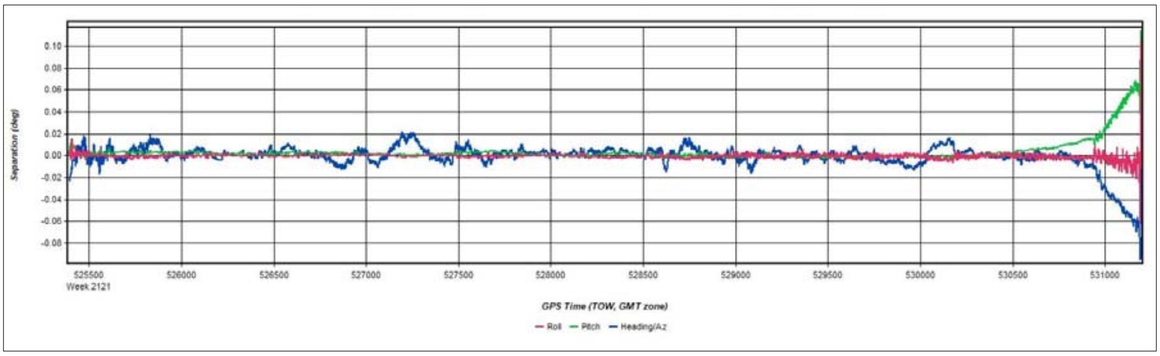
Number	Easting	Northing	Elev	LIDAR Elev	dZ
41	501352.0506	1600039.427	14.4	14.383	-0.017
42	499214.2644	1600902.406	2.694	2.675	-0.019
43	503291.3207	1599072.316	27.682	27.662	-0.02
44	500262.4396	1600716.164	5.37	5.349	-0.021
45	503693.3412	1598841.293	30.464	30.441	-0.023
46	505703.5884	1598747.437	3.604	3.581	-0.023
47	505126.6221	1598810.456	7.465	7.441	-0.024
48	503555.4001	1598917.816	28.397	28.372	-0.025
49	503280.5359	1599054.194	27.263	27.237	-0.026
50	502618.5233	1599431.688	21.456	21.429	-0.027
51	501980.4736	1599751.984	15.943	15.916	-0.027
52	500267.405	1600711.533	5.557	5.53	-0.027
53	497053.0829	1600840.831	4.165	4.137	-0.028
54	503290.7132	1599071.345	27.683	27.654	-0.029
55	499224.03	1600917.53	3.455	3.425	-0.03
56	502842.1069	1599321.466	19.945	19.915	-0.03
57	499224.031	1600917.535	3.457	3.425	-0.032
58	500691.5066	1600450.468	8.187	8.155	-0.032
59	502849.7968	1599339.965	20.159	20.127	-0.032
60	504226.2137	1598685.432	33.038	33.004	-0.034
61	503024.1718	1599203.363	26.584	26.545	-0.039
62	501783.3672	1599848.316	14.731	14.688	-0.043
63	503038.1794	1599211.896	26.649	26.603	-0.046
64	504265.7093	1598674.872	32.878	32.826	-0.052
65	500700.4875	1600443.749	8.133	8.075	-0.058
66	503845.2282	1598791.459	31.231	31.171	-0.06
67	500705.9478	1600439.812	8.12	8.058	-0.062
68	500691.5075	1600450.475	8.218	8.155	-0.063
69	497750.3273	1600785.398	2.652	2.585	-0.067
70	499630.3171	1600860.791	4.468	4.396	-0.072
71	499658.5892	1600833.41	4.649	4.572	-0.077

7.2.3. TRAJECTORY PLOTS

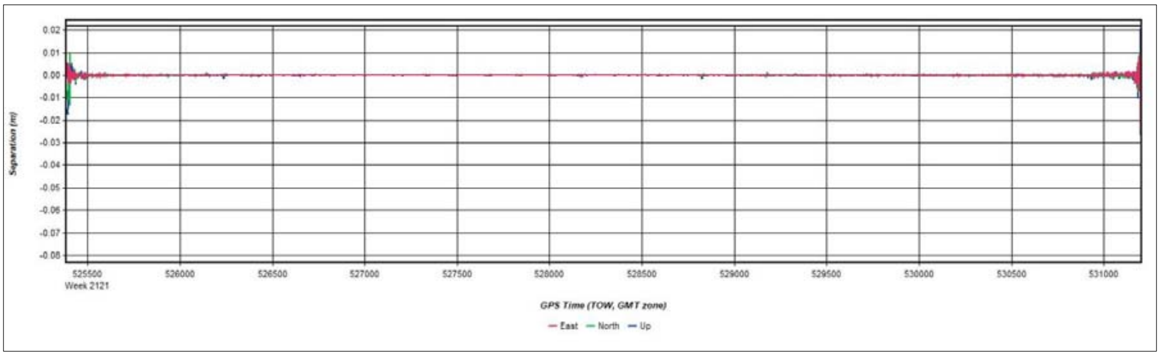
7.2.3.1. Trajectory Map



7.2.3.2. Attitude Separation Plot



7.2.3.3. Combined Separation Plot



7.2.4. LEVELING ACCURACIES

Leveling Survey Accuracies				
Level Run	Controls	Error of Closure (mm)	Allowable EOC (mm)	Loop Length
1	GM-39M - CALD1 - GM-39M	-0.001	0.010	717.200
2	CALD1 - MMA-3405 - MMA-3406 - UNI - CALD1	-0.009	0.013	1219.000
3	UNI - MM188A - UNI	0.003	0.012	990.900
4	MMA-138A - AERO-07A - MM-138A	0.001	0.009	569.400
5	AERO-07A - AERO-06B - AERO-07A	-0.001	0.012	1076.800
6	AERO-06B - AERO-06A - AERO-06B	0.001	0.011	853.500
7	AERO-06A - MMA-3553 - GM-36M - AERO-05B - AERO-06A	-0.008	0.015	1608.100
8	AERO-05B - AERO-05A - AERO-05B	-0.001	0.012	1030.600
9	AERO-05A - MMA-3555 - AERO-04B - AERO-05A	0.000	0.013	1104.100
10	AERO-04B - S6-A - GM-35M - AERO-04A - AERO-04B	0.003	0.012	1083.000
11	AERO-04A - MM-139A - AERO-04A	0.000	0.011	916.200
12	AERO-04A - AERO-03B - S5-A -S5-B -AERO-4A	0.010	0.017	1929.400
13	AERO-03B - AERO-03A - AERO-03B	0.000	0.018	2165.500
14	AERO-03A - AERO-02A - AERO-03A	-0.001	0.019	2556.800
15	AERO-02A - PV -AERO-02A	0.005	0.009	616.700
16	PV - AERO-01C - PV	0.000	0.009	606.300
17	AERO-01C - AERO-01B - AERO-01C	-0.002	0.010	729.100
18	AERO-01B - AL - AERO-01B	0.004	0.009	542.000
19	AL - AERO-01A - AL	0.000	0.004	94.000
20	GM-39M - MM117 - GM-39M	0.014	0.018	2231.800
21	MMA-117 - AERO-09A - MM-117	0.009	0.010	761.600
22	AERO-09A - AERO-09B - AERO-09A	0.006	0.011	803.100
23	AERO-09B - AERO-10A - AERO-09B	-0.009	0.020	2880.200
24	GM-39M - AERO-08B - GM-39M	0.003	0.008	499.300
25	MM-138A - AERO-07B - MM-138A	-0.003	0.008	419.600
26	CPB - AERO-10A -CPB	0.001	0.004	132.900
27	CPB - AERO-10B - CPB	0.003	0.006	282.900
28	GM-39M - AERO-08A - GM-39M	-0.007	0.012	1019.920
29	AERO-02A - S3-A - AERO-02A	0.000	0.012	1063.350
30	AERO-01B - MMA-3958 - AERO-01B	-0.007	0.012	1005.000

See Attached XLS (PRNQ_LEVELING.XLS) for raw Leveling Calculations.

SOLUTIONS BEYOND DRONES

7.2.4 GNSS BASELINE PROCESSING

Aero 360 International
#8 F. Pasco Ave.
National Capital Region
Pasig City 1610
Philippines

Phone: (+632) 370-3920
Fax: (+632) 370-3920
www.aero360intl.com

Project file data		Coordinate System	
Name:	C:\Users\Aero 360 Engineering\Desktop \USER\AERO\PROJECTS\JICA\Static \Process\TBC \JICA_ControlNetwork_PGM_20200820.vce	Name:	World wide/UTM
		Datum:	WGS 1984
		Zone:	51 North
Size:	3 MB	Geoid:	PGM
Modified:	8/21/2020 1:59:35 PM (UTC:8)	Vertical datum:	
Time zone:	Malay Peninsula Standard Time		
Reference number:			
Description:			

Baseline Processing Report

Processing Summary

Observation	From	To	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	ΔHeight (Meter)
MMA-3555 --- MMA-3 (B7)	MMA-3555	MMA-3	Fixed	0.010	0.054	28°31'02"	7874.176	18.325
MMA-3555 --- MMA-3958 (B8)	MMA-3555	MMA-3958	Fixed	0.007	0.054	281°09'49"	3377.551	-3.883
MMA-3 --- MMA-3958 (B9)	MMA-3	MMA-3958	Fixed	0.012	0.065	228°28'32"	9448.579	-22.235
GM-39B --- MMA-3958 (B10)	MMA-3958	GM-39B	Fixed	0.007	0.036	110°09'16"	7350.743	29.416
MMA-3555 --- GM-39B (B11)	MMA-3555	GM-39B	Fixed	0.009	0.056	117°39'30"	4049.365	25.536
MMA-3 --- GM-39B (B12)	MMA-3	GM-39B	Fixed	0.010	0.062	181°07'58"	8800.242	7.192
MMA-3555 --- AERO-06A (B13)	MMA-3555	AERO-06A	Fixed	0.009	0.018	119°27'03"	1547.524	7.500
MMA-3555 --- AERO-07A (B14)	MMA-3555	AERO-07A	Fixed	0.009	0.052	118°20'45"	2480.142	14.245
MMA-3555 --- AERO-03B (B15)	MMA-3555	AERO-03B	Fixed	0.005	0.014	284°16'27"	1250.504	-4.042
MMA-3555 --- AERO-01C (B16)	MMA-3555	AERO-01C	Fixed	0.007	0.052	273°57'19"	3279.283	-2.854
AERO-01C --- AERO-03B (B17)	AERO-01C	AERO-03B	Fixed	0.005	0.013	87°42'31"	2061.215	-1.200
MMA-3555 --- AERO-05B (B18)	MMA-3555	AERO-05B	Fixed	0.012	0.020	121°53'35"	804.352	2.942
MMA-3555 --- AERO-06B (B19)	MMA-3555	AERO-06B	Fixed	0.008	0.014	118°25'17"	1983.226	11.497
AERO-06B --- AERO-03A (B20)	AERO-06B	AERO-03A	Fixed	0.007	0.024	288°46'16"	3805.992	-14.961

1

MMA-3555 --- AERO-03A (B21)	MMA-3555	AERO-03A	Fixed	0.007	0.011	278°34'48"	1880.493	-3.452
AERO-03A --- AERO-04A (B22)	AERO-03A	AERO-04A	Fixed	0.004	0.007	85°24'00"	1308.352	-0.001
AERO-06B --- AERO-04A (B23)	AERO-06B	AERO-04A	Fixed	0.008	0.040	300°02'08"	2656.078	-14.940
MMA-3555 --- AERO-04A (B24)	MMA-3555	AERO-04A	Fixed	0.006	0.009	304°45'38"	675.924	-3.458
MMA-3555 --- AERO-02B (B27)	MMA-3555	AERO-02B	Fixed	0.006	0.050	278°41'29"	2312.205	-3.675
AERO-04B --- AERO-02B (B28)	AERO-04B	AERO-02B	Fixed	0.018	0.069	276°39'21"	2131.550	-1.918
MMA-3555 --- AERO-04B (B30)	MMA-3555	AERO-04B	Fixed	0.005	0.013	301°16'27"	197.116	-1.785
AERO-05A --- AERO-02B (B31)	AERO-05A	AERO-02B	Fixed	0.011	0.022	281°18'31"	2591.593	-4.602
MMA-3555 --- AERO-05A (B33)	MMA-3555	AERO-05A	Fixed	0.004	0.008	121°50'29"	300.916	0.900
MMA-3555 --- AERO-10A (B34)	MMA-3555	AERO-10A	Fixed	0.005	0.029	109°27'52"	5587.307	-3.291
MMA-3555 --- AERO-01A (B35)	MMA-3555	AERO-01A	Fixed	0.005	0.026	273°49'28"	3829.648	-2.620
AERO-01A --- AERO-01B (B36)	AERO-01A	AERO-01B	Fixed	0.002	0.003	63°37'25"	273.798	-0.322
MMA-3555 --- AERO-01B (B37)	MMA-3555	AERO-01B	Fixed	0.006	0.028	276°01'09"	3595.630	-2.935
AERO-10A --- AERO-09A (B38)	AERO-10A	AERO-09A	Fixed	0.002	0.005	252°58'05"	823.241	15.591
MMA-3555 --- AERO-09A (B39)	MMA-3555	AERO-09A	Fixed	0.006	0.035	115°08'35"	4949.901	12.349
AERO-09A --- AERO-09B (B40)	AERO-09A	AERO-09B	Fixed	0.003	0.005	105°54'35"	390.919	-13.038
AERO-10A --- AERO-09B (B41)	AERO-10A	AERO-09B	Fixed	0.002	0.004	229°44'01"	538.886	2.553
MMA-3555 --- AERO-09B (B42)	MMA-3555	AERO-09B	Fixed	0.006	0.034	114°28'08"	5336.115	-0.739
AERO-05A --- AERO-02A (B43)	AERO-05A	AERO-02A	Fixed	0.015	0.018	276°29'49"	2960.311	-5.814
MMA-3555 --- AERO-02A (B44)	MMA-3555	AERO-02A	Fixed	0.012	0.039	273°45'12"	2691.441	-4.947
MMA-3555 --- S5A (B46)	MMA-3555	S5A	Fixed	0.007	0.010	284°43'51"	1244.480	-3.696
MMA-3555 --- S6A (B47)	MMA-3555	S6A	Fixed	0.004	0.008	301°23'56"	324.948	-1.982
AERO-08A --- AERO-08B (B48)	AERO-08A	AERO-08B	Fixed	0.012	0.018	108°53'20"	750.755	4.539
MMA-3555 --- AERO-08B (B49)	MMA-3555	AERO-08B	Fixed	0.011	0.059	116°47'47"	4290.844	25.852
MMA-3555 --- AERO-08A (B50)	MMA-3555	AERO-08A	Fixed	0.008	0.046	118°27'57"	3548.720	21.271
MMA-3555 --- AERO-07B (B51)	MMA-3555	AERO-07B	Fixed	0.007	0.049	118°08'21"	2942.578	19.106
MMA-3555 --- AERO-10B (B52)	MMA-3555	AERO-10B	Fixed	0.006	0.034	108°24'37"	5634.021	-3.824
AERO-10B --- S3-A (B53)	AERO-10B	S3-A	Fixed	0.007	0.035	286°47'17"	7988.010	-0.805

MMA-3555 --- S3-A (B54)	MMA-3555	S3-A	Fixed	0.009	0.059	282°52'27"	2361.758	-4.689

Acceptance Summary

Processed	Passed	Flag	Fail
43	43	0	0

MMA-3555 - MMA-3 (12:47:44 PM-3:26:49 PM) (S7)

Baseline observation:	MMA-3555 --- MMA-3 (B7)
Processed:	8/21/2020 1:29:05 PM
Solution type:	Fixed
Frequency used:	Dual Frequency (L1, L2)
Horizontal precision:	0.010 m
Vertical precision:	0.054 m
RMS:	0.158 m
Maximum PDOP:	3.086
Ephemeris used:	Broadcast
Antenna model:	NGS Absolute
Processing start time:	7/18/2020 12:47:44 PM (Local: UTC+8hr)
Processing stop time:	7/18/2020 3:26:49 PM (Local: UTC+8hr)
Processing duration:	02:39:05
Processing interval:	1 second

7.2.5 NETWORK ADJUSTMENT

Network Adjustment Report

Adjustment Settings

Set-Up Errors
GNSS
Error in Height of Antenna: 0.000 m
Centering Error: 0.000 m

Covariance Display
Horizontal:
Propagated Linear Error [E]: U.S.
Constant Term [C]: 0.000 m
Scale on Linear Error [S]: 1.960
Three-Dimensional
Propagated Linear Error [E]: U.S.
Constant Term [C]: 0.000 m
Scale on Linear Error [S]: 1.960

Adjustment Statistics

Number of Iterations for Successful Adjustment: 3
Network Reference Factor: 1.00
Chi Square Test (95%): Passed
Precision Confidence Level: 95%
Degrees of Freedom: 48

Post Processed Vector Statistics
Reference Factor: 1.00
Redundancy Number: 48.00
A Priori Scalar: 1.15

Control Coordinate Comparisons

Values shown are control coordinates minus adjusted coordinates.

Point ID	ΔEasting (Meter)	ΔNorthing (Meter)	ΔElevation (Meter)	ΔHeight (Meter)
MMA-3	?	?	-0.128	?
MMA-3555	0.025	-0.072	?	0.510

Control Point Constraints

Point ID	Type	East σ (Meter)	North σ (Meter)	Height σ (Meter)	Elevation σ (Meter)
GM-39B	Grid				Fixed
MMA-3	Global	Fixed	Fixed	Fixed	
MMA-3958	Global	Fixed	Fixed	Fixed	
Fixed = 0.000001(Meter)					

Adjusted Grid Coordinates

Point ID	Easting (Meter)	Easting Error (Meter)	Northing (Meter)	Northing Error (Meter)	Elevation (Meter)	Elevation Error (Meter)	Constraint
AERO-01A	281191.867	0.006	1601206.160	0.006	5.179	0.049	
AERO-01B	281438.276	0.006	1601325.644	0.006	4.840	0.049	
AERO-01C	281741.340	0.006	1601172.129	0.007	4.904	0.048	
AERO-02A	282326.792	0.010	1601117.009	0.008	2.772	0.046	
AERO-02B	282728.375	0.006	1601286.774	0.006	3.968	0.046	
AERO-03A	283154.041	0.006	1601214.198	0.006	4.167	0.041	
AERO-03B	283801.922	0.006	1601236.342	0.006	3.519	0.042	
AERO-04A	284459.275	0.006	1601307.686	0.006	4.045	0.039	
AERO-04B	284843.689	0.006	1601021.230	0.006	5.670	0.041	
AERO-05A	285265.575	0.006	1600756.420	0.006	8.306	0.039	
AERO-06B	286747.487	0.007	1599958.196	0.006	18.729	0.042	
AERO-08A	288116.640	0.009	1599198.621	0.007	28.370	0.059	
AERO-08B	288824.974	0.009	1598949.459	0.010	32.833	0.061	
AERO-09A	289474.415	0.007	1598775.070	0.007	19.245	0.049	
AERO-09B	289849.486	0.007	1598664.697	0.007	6.167	0.050	
AERO-10A	290263.678	0.007	1599009.549	0.007	3.579	0.050	
AERO-10B	290342.089	0.008	1599091.366	0.007	3.015	0.057	
GM-39B	288582.019	0.006	1599006.283	0.006	32.550	?	e
MMA-3	288831.410	?	1607804.280	?	25.533	?	LLh
MMA-3555	285011.294	0.005	1600917.420	0.005	7.435	0.038	
MMA-3958	281702.892	?	1601600.304	?	3.873	?	LLh
S3-A	282713.180	0.007	1601463.767	0.007	3.016	0.059	

Adjusted Grid Coordinates

Point ID	Easting (Meter)	Easting Error (Meter)	Northing (Meter)	Northing Error (Meter)	Elevation (Meter)	Elevation Error (Meter)	Constraint
AERO-01A	281191.867	0.006	1601206.160	0.006	5.179	0.049	
AERO-01B	281438.276	0.006	1601325.644	0.006	4.840	0.049	
AERO-01C	281741.340	0.006	1601172.129	0.007	4.904	0.048	
AERO-02A	282326.792	0.010	1601117.009	0.008	2.772	0.046	
AERO-02B	282728.375	0.006	1601286.774	0.006	3.968	0.046	
AERO-03A	283154.041	0.006	1601214.198	0.006	4.167	0.041	
AERO-03B	283801.922	0.006	1601236.342	0.006	3.519	0.042	
AERO-04A	284459.275	0.006	1601307.686	0.006	4.045	0.039	
AERO-04B	284843.689	0.006	1601021.230	0.006	5.670	0.041	
AERO-05A	285265.575	0.006	1600756.420	0.006	8.306	0.039	
AERO-06B	286747.487	0.007	1599958.196	0.006	18.729	0.042	
AERO-08A	288116.640	0.009	1599198.621	0.007	28.370	0.059	
AERO-08B	288824.974	0.009	1598949.459	0.010	32.833	0.061	
AERO-09A	289474.415	0.007	1598775.070	0.007	19.245	0.049	
AERO-09B	289849.486	0.007	1598664.697	0.007	6.167	0.050	
AERO-10A	290263.678	0.007	1599009.549	0.007	3.579	0.050	
AERO-10B	290342.089	0.008	1599091.366	0.007	3.015	0.057	
GM-39B	288582.019	0.006	1599006.283	0.006	32.550	?	e
MMA-3	288831.410	?	1607804.280	?	25.533	?	LLh
MMA-3555	285011.294	0.005	1600917.420	0.005	7.435	0.038	
MMA-3958	281702.892	?	1601600.304	?	3.873	?	LLh
S3-A	282713.180	0.007	1601463.767	0.007	3.016	0.059	

7.3. EQUIPMENT'S TECHNICAL SPECIFICATIONS

SOUTH GALAXY G1 GNSS RECEIVER

SPECIFICATIONS

Satellite Signals Tracked Simultaneously	
Signal tracking	220 channels (standard),692 channels (optional), 555 channels (optional)[1]
	BeiDou (B1, B2, B3)
	GPS (L1C/A, L1C, L2E, L2C, L5),
	Galileo (E1, E5a, E5b, Alt-BOC, E6)
	Glonass (L1C/A, L1P, L2C/A, L2P, L3)
	SBAS (WAAS, EGNOS, MSAS, GAGAN), L-band, QZSS (L1 C/A, L1C, L2C, L5, LEX)
GNSS features	Positioning output rate:1Hz~50Hz
	Initialization time:<10s
	Initialization reliability:>99.99%
Positioning precision	
Code differential DGPS/RTCM Typically	Horizontal: 25cm+1ppm Vertical: 50cm+1ppm
SBAS positioning accuracy	Typically < 5m 3DRMS
Fast Static GNSS surveying	H:3mm+0.5ppm V:5mm+0.5ppm
High Precision Static Survey	H:3mm+0.1ppm V: 3.5mm+0.4ppm
Real-time Kinematic surveying	Horizontal: 8mm+1ppm Vertical: 15mm+1ppm
Network RTK	Horizontal: 8mm+0.5ppm Vertical: 15mm+0.5ppm
RTK initialization time	2~8s
User interaction	
Operaing system	Linux
Buttons	Single button operation
Indicators	Three indicate lights
Web UI	Freely to configure and monitor the receiver by accessing to the web server via Wi-Fi and USB
Voice guide	iVoice intelligent voice technology provides status and voice guide
	Supporting Chinese, English, Korean, Russian, Portuguese, Spanish, Turkish and user define
Hardware performance	
Dimension	129mm(Diameter)x112mm(Height)
Weight	1kg(battery included)
Material	Magnesium aluminum alloy shell
Operating	-45°C~+65°C
Storag	-55°C~+85°C
Humidity	100% Non-condensing
Waterproof/Dustproof	IP68 standard, protected from long time immersion to depth of 3m
	IP68 standard, fully protected against blowing dust
Vibration Standard:	Vibration MIL-STD-810G, 514.6
Shock and vibration	Withstand 3 meters pole drop onto the cement ground naturally
Power Supply	9-25V DC, overvoltage protection
Battery	Rechargeable, removable Lithium-ion battery, 7.4V; standard four batteries power
Communications	package(optional)
I/O port	5PIN LEMO external power port + RS232, 7PIN external USB(OTG)+Ethernet
	1 TNC radio antenna interface, SIM card slot
UHF modem	Built-in radio, 1W/2W/3W switchable, typically work range can be 8KM
	Radio and internet repeater switchable
Frequency Range	410-470MHz
Communication Protocol	TrimTalk450s, TrimMark3, PCC EOT, SOUTH, SOUTHx
Cellular Mobile Network	WCDMA/CDMA2000/TDD-LTE/FDD-LTE 4G network modem, downward compatible with 3G GPRS/EDGE
Double Module Bluetooth	BLEBluetooth 4.0 standard, support for android, ios cellphone connection
	Bluetooth 2.1 + EDR standard
NFC Communication	Realizing close range (shorter than 10cm) automatic pair between receiver and controller
	(controller equipped NFC wireless communication module needed)
WIFI	
Standard	802.11 b/g standard
WIFI Hotspot	The WIFI hotspot allows any mobile terminal to connect and access to the internal webserver for the control
	and moditor receiver
WIFI data link	To work as the datalink that receiver is able to broadcast and receive differential data via WIFI
Data storage/ Transmission	
Data Storage	8GB SSD internal storage
	Support external USB storage and automatical cycle storage
	Changeable record interval, up to 50Hz raw data collection
Data Transmission	USB data transmission, supporting FTP/HTTP data download
Data Format	Differential data format: CMR+, CMRx, RTCM 2.1, RTCM 2.3, RTCM 3.0, RTCM 3.1, RTCM 3.2
	GPS output data format: NMEA 0183, PJK plane coordinates, Binary code, Trimble GSOF
	Network model support: VRS, FKP, MAC, fully support NTRIP protocol
Inertial sensing system	
Tilt survey (optional)[2]	Built-in tilt compensator, correcting coordinates automatically according to the tilt direction and angle
	of the centering rod
Electronic bubble (optional)[3]	Controller software display electronic bubble, checking leveling status of the centering rod real time
Thermometer	Built-in thermomter sensors, adopting intelligent temperature control technology which can mornitor and
	adjust the temperature of receiver in real time

[1] The OEM board with 555 channels reserves the function of tracking L-Band from TerraStar, it requires a subscription to TerraStar data service.
[2] Tilt sensor is not the standard configuration on new Galaxy G1.
[3] Bonding with tilt sensor, electronic bubble also is an option for new Galaxy G1.

HI-TARGET V30 GNSS RECEIVER

PERFORMANCE SPECIFICATIONS

MEASUREMENTS

- 220 Channels
- Advanced Pacific Crest Maxwell 6 Custom Survey GNSS Technology
- High precision multiple correlator for GNSS pseudo range measurements
- Unfiltered, unsmoothed pseudo range measurements data for low noise, low multipath error, low time domain correlation and high dynamic response
- Very low noise GNSS carrier phase measurements with <1 mm precision in a 1 Hz bandwidth
- Signal-to-Noise ratios reported in dB-Hz
- Proven Pacific Crest low elevation tracking technology

Satellite signals tracked simultaneously

GPS .... Simultaneous L1C/A, L2C, L2E, L5
GLONASS .... Simultaneous L1C/A, L1P, L2C/A (GLONASS M only), L2P
SBAS .... Simultaneous L1 C/A, L5
BDS........ B1, B2
QZSS .... L1 C/A, L1 SAIF, L2C, L5

POSITIONING PERFORMANCE[1]

High-Precision Static

Horizontal .... 2.5 mm + 0.1 ppm RMS
Vertical .... 3.5 mm + 0.4 ppm RMS

Static and Fast Static

Horizontal........ 2.5 mm + 0.5 ppm RMS
Vertical........ 5 mm + 0.5 ppm RMS

Post Processing Kinematic (PPK / Stop & Go) GNSS surveying

Horizontal........ 8mm+1ppm RMS
Vertical .... 15mm+1ppm RMS
Initialization time .... Typically 10 minutes for base while 5 minutes for rover
Initialization reliability .... Typically > 99.9%

Realtime Kinematic(RTK) surveying

Horizontal .... 8mm+1ppm RMS
Vertical .... 15mm+1ppm RMS
Initialization time .... Typically 2-10s
Initialization reliability .... Typically > 99.9%

Code Differential GNSS positioning

Horizontal .... 25cm+1ppm RMS
Vertical .... 50cm+1ppm RMS
SBAS[2] .... 0.50m Horizontal, 0.85m Vertical

HARDWARE

Physical

Dimensions (W x H) .... 19.50cm x 10.40cm (7.68 in x 4.09 in)
Weight .... 1.3kg (2.86lb) with internal battery, internal radio, standard UHF antenna
Operating temperature .... -45°C to +65°C (-49°F to +149°F)
Storage temperature .... -55°C to +85°C (-67°F to +185°F)
Humidity .... 100%, condensing
Water/dustproof .... IP67 dustproof, protected from temporary immersion to depth of 1m (3.28ft).
Shock and Vibration .... Designed to survive a 3m(9.84ft) nature fall onto concrete.

Electrical

Power 6V to 28V DC external power input
Power consumption 2.5W
Automatic Switching between internal power and external power
Rechargeable, removable 7.4V, 5000mAh Lithium-Ion battery in internal battery compartment

Internal battery life

Static 13 - 15 hours
RTK Rover (UHF/GPRS/3G) 10 - 12 hours
RTK Base 8 - 10 hours

I/O interface

1 x Bluetooth
1 x standard USB2.0 port
2 x RS232 serial port
2 x DC power input (8-pin & 5-pin)

COMMUNICATION AND DATA STORAGE

GPRS/GSM or 3G

Fully integrated, fully sealed internal GPRS/GSM or 3G
Network RTK (via CORS) range 20-50km

HI-TARGET internal UHF radio

Frequency .... 457-467 MHz with 116 channels
Transmitting power .... 0.5W, 1W, 2W adjustable
Transmitting Speed .... Up to 19.2Kbps
Working range .... 3~5Km typical, 8~10km optimal

Pacific Crest ADL Foundation internal UHF radio(Optional)

Frequency........ 403~473 MHz
Transmitting power........ 0.5W, 1.0W, 2.0W adjustable
Transmitting Speed .... Up to 19.2Kbps
Support most of radio communication protocol
Working range .... 3~5km typical, 8~10 optimal

HI-TARGET External UHF radio

Frequency .... 460 MHz with 116 channels
Transmitting power .... 5W, 10W, 20W, 30W adjustable
Transmitting Speed .... Up to 19.2Kbps
Working Range .... 8~10Km typical, 15~20km optimal

Pacific Crest ADL Vantage Pro External UHF radio(Optional)

Frequency .... 390~430 MHz or 430~470 MHz
Transmitting Power .... 4W to 35W adjustable
Transmitting Speed .... Up to 19.2Kbps
Support most of radio communication protocol
Working Range .... 8~10Km typical, 15~20km optimal

Support other external communication device

For example, external GSM modem.

Data storage

64MB internal memory

Data formats

(1Hz positioning output, up to 50 Hz - depends on installed option)
CMR: sCMRx,CMR,CMR+input and output
RTCM: RTCM 2.1, 2.2, 2.3, 3.0, 3.1,3.2 input and output
Navigation outputs ASCII: NMEA-0183 GSV, AVR, RMC, HDT, VGK, VHD, ROT, GGK, GGA, GSA, ZDA, VTG, GST, PJT, PJK, BPQ, GLL, GRS, GBS
Navigation outputs Binary: GSOF
1 Pulse Per Second Output

[1] Precision and reliability may be subject to anomalies due to multipath, obstructions, satellite geometry, and atmospheric conditions. The specifications stated recommend the use of stable mounts in an open sky view, EMI and multipath clean environment, optimal GNSS constellation configurations, along with the use of survey practices that are generally accepted for performing the highest-order surveys for the applicable application including occupation times appropriate for baseline length. Baselines longer than 30 km require precise ephemeris and occupations up to 24 hours may be required to achieve the high precision static specification.
[2] GPS only and depends on SBAS system performance. FAA WAAS accuracy specifications are <5 m 3DRMS.

Descriptions and Specifications are subject to change without notice

7.4. EQUIPMENT'S CALIBRATION CERTIFICATES

Republic of the Philippines
Department of Environment and Natural Resources
NATIONAL MAPPING AND RESOURCE INFORMATION AUTHORITY
www.namria.gov.ph

February 11, 2019

CERTIFICATE OF REGISTRATION AND CALIBRATION

TO WHOM IT MAY CONCERN:

This is to certify that six (6) units Dual Frequency GPS Receivers described herein as:

SOUTH, Model Galaxy G1 with serial number as follows:

SN. = S8256C117197227WHS
SN. = S82568117187497WHN
SN. = S82568117188421WHS
SN. = S82568117188424WHS
SN. = S82582117249763WHS
SN. = S82582117249806WHS

of **AERO 360 SOLUTIONS , INC.** with address at 008 F. Pasco Avenue, Brgy. Santolan, Pasig City 1610 was calibrated and now duly registered with this office.

The GPS Receivers was found to meet the accuracy standard set by the International Geodetic Authorities for first order geodetic control positioning and in accordance with the specifications prescribed in the Revised Manual of Land Surveying Regulations in the Philippines (DAO 98-12).

RUEL DM. BELEN, MNSA
Director, Mapping and Geodesy Branch

Registration No. :015-2019
O.R. No. : 8515921 Q

NAMRIA OFFICES:
Main : Lawton Ave., Ft. Bonifacio, 1634 Taguig City, Philippines Tel. No. (632) 810-4831 to 41
Branch: 421 Barraca St. San Nicolas, 1010 Manila., Philippines, Tel. No. (632) 241-3494 to 98

ISO 9001 : 2015 CERTIFIED FOR MAPPING AND GEOSPATIAL INFORMATION MANAGEMENT

INVESTORS IN PEOPLE | Accredited Until 2020

Republic of the Philippines
Department of Environment and Natural Resources
NATIONAL MAPPING AND RESOURCE INFORMATION AUTHORITY
www.namria.gov.ph

February 11, 2019

CERTIFICATE OF REGISTRATION AND CALIBRATION

TO WHOM IT MAY CONCERN:

This is to certify that two (2) units Dual Frequency GPS Receivers described herein as:

Hi-Target, Model V30 with serial number as follows:

SN. = 10221020
SN. = 10220219

of **AERO 360 SOLUTIONS , INC.** with address at 008 F. Pasco Avenue, Brgy. Santolan, Pasig City 1610 was calibrated and now duly registered with this office.

The GPS Receivers was found to meet the accuracy standard set by the International Geodetic Authorities for first order geodetic control positioning and in accordance with the specifications prescribed in the Revised Manual of Land Surveying Regulations in the Philippines (DAO 98-12).

RUEL DM. BELEN, MNSA
Director, Mapping and Geodesy Branch

Registration No. : 016-2019
O.R. No. : 8515921 Q

NAMRIA OFFICES:
Main : Lawton Ave., Ft. Bonifacio, 1634 Taguig City, Philippines Tel. No. (632) 810-4831 to 41
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7.5. DESCRIPTION OF REFERECE CONTROL POINTS

Republic of the Philippines
Department of Environment and Natural Resources
NATIONAL MAPPING AND RESOURCE INFORMATION AUTHORITY
www.namria.gov.ph

July 16, 2020

CERTIFICATION

To whom it may concern:

This is to certify that according to the records on file in this office, the requested survey information is as follows:

Province: **NCR - FOURTH DISTRICT**		
Station Name: **MMA-3 TAGUIG**		
Order: **2nd**	Accuracy Class:	Elevation:
Island: **LUZON**	Barangay: **FORT BONIFACIO**	Municipality: **TAGUIG CITY**
PRS92 Coordinates		
Latitude: **14° 32' 11.45534"**	Longitude: **121° 2' 20.12714"**	Ellipsoidal Hgt. **27.75802 m**
PTM / PRS92		
Northing: **1607527.695**	Easting: **504195.044**	Zone: **3**
UTM / PRS92		
Northing: **1607872.6360**	Easting: **288683.3400**	Zone: **51**
WGS84 Coordinates		
Latitude: **14° 32' 6.05556"**	Longitude: **121° 2' 25.02637"**	Ellipsoidal Hgt: **71.57400 m ±**
	Error Ellipse:	
UTM / WGS84		
Northing: **1607804.27983**	Easting: **288831.40225**	Zone: **51**

The accuracy standards reported herein (FGDC-STD-007-1998) supercedes and replace the previous accuracy standards found in FDCC 1984. Classified control points are certified as being consistent with all other points in the network, not merely those within that particular survey.

MMA-3
From the south super highway/E. de los Santos interchange, travel northeast for 1 kilometer towards Nichols/Fort Bonifacio gate, (Gate 3). Then turn left to enter the gate of Fort Bonifacio. Continue travelling on northwest direction for 2 kilometers up to the National Mapping and Resource Information Authority building; (NAMRIA). Station is located at the sidewalk about 10 meters north of the western gate and approximately 10 meters from the guard house. Station mark is 0.15 m. x 0.01 m. in diameter brass rod centered in a 0.25 m. x 0.25 m. x 0.65 m concrete block, flush level with the ground surface with inscription "MMA-3 1989 NAMRIA"

Requesting Party: **Aero 360 Solutions**
Purpose: **Reference**
OR No. **7336056**
Transaction No. **JCP2020-2145**

RUEL DM. BELEN, MNSA
Director, Mapping and Geodesy

NAMRIA OFFICES:
Main : Lawton Ave., Ft. Bonifacio, 1634 Taguig City, Philippines
Tel. Nos.: (632) 810-4831 to 41
Branch : 421 Barraca St. San Nicolas, 1010 Manila, Philippines

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Republic of the Philippines
Department of Environment and Natural Resources
NATIONAL MAPPING AND RESOURCE INFORMATION AUTHORITY
www.namria.gov.ph

July 16, 2020

CERTIFICATION

To whom it may concern:

This is to certify that according to the records on file in this office, the requested survey information is as follows:

Province: **NCR - FOURTH DISTRICT**		
Station Name: **MMA-3958**		
Order: **3rd**	Accuracy Class:	Elevation:
Island: **LUZON**	Barangay:**ELIAS ALDANA**	Municipality: **CITY OF LAS PIÑAS**
PRS92 Coordinates		
Latitude: **14° 28' 47.61121"**	Longitude: **120° 58' 23.90348"**	Ellipsoidal Hgt: **5.49000 m**
PTM / PRS92		
Northing: **1601263.138**	Easting: **497122.388**	Zone: **3**
UTM / PRS92		
Northing: **1601668.8190**	Easting: **281554.5750**	Zone: **51**
WGS84 Coordinates		
Latitude: **14° 28' 42.21931"**	Longitude: **120° 58' 28.80786"**	Ellipsoidal Hgt: **49.30700 m ±**
	Error Ellipse:	
UTM / WGS84		
Northing: **1601600.30405**	Easting: **281702.88485**	Zone: **51**

The accuracy standards reported herein (FGDC-STD-007-1998) supercedes and replace the previous accuracy standards found in FGCC 1984. Classified control points are certified as being consistent with all other points in the network, not merely those within that particular survey.

MMA-3958

The station is located on a concrete sidewalk infront of Meralco Sub-Station along coastal road about 3 meters SW of Steel post of Merlaco Transmission Line and 10 meters SW of MMDA Ecological Processing Center.

Station mark is the head of 8mm. stainless bolt flushed in a 20cm. x 20cm. cement putty with inscription "MMA-3958; 2011; LMS-NCR, FLS."

Requesting Party: **Aero 360 Solutions**
Purpose: **Reference**
OR No. **7336056**
Transaction No. **JCP2020-2147**

RUEL DM. BELEN, MNSA
Director, Mapping and Geodesy

NAMRIA OFFICES:
Main : Lawton Ave., Ft. Bonifacio, 1634 Taguig City, Philippines
Tel. Nos.: [illegible]
Branch : 421 Barraca St. San Nicolas, 1010 Manila, Philippines

[illegible] CERTIFICATION
ISO 9001 : 2015
CERTIFIED FOR MAPPING AND GEOSPATIAL INFORMATION MANAGEMENT
INVESTORS IN PEOPLE | Accredited

Republic of the Philippines
Department of Environment and Natural Resources
NATIONAL MAPPING AND RESOURCE INFORMATION AUTHORITY
www.namria.gov.ph

July 16, 2020

CERTIFICATION

To whom it may concern:

This is to certify that according to the records on file in this office, the requested survey information is as follows:

Station Name: **GM-39M**	
Island: **LUZON**	Province: **NCR - MANILA, FIRST DISTRICT**
Municipality: **PARANAQUE**	Barangay: **LOYOLA MEMORIAL PARK**
Elevation: **32.5499 m +/- 0.033625 m**	Accuracy Class: **3 cm**
Latitude:	Longitude:
Datum: **Mean Sea Level**	

The accuracy standards reported herein (FGDC-STD-007-1998) supercedes and replace the previous accuracy standards found in FGCC 1984. Classified control points are certified as being consistent with all other points in the network, not merely those within that particular survey

BM GM-39M
is located along the sidewalk, SW of Dr. A Santos Rd. (Sucat Rd.), Paranaque. It is 30 NW from the Main Entrance gate of Loyola Memorial Park. The station is 60cm E of a fire hydrant and about 50cm from the perimeter fence of the cemetery. Station mark is a 3in. copper nail, centered and embedded on a 15cm x 15cm concrete putty with inscription GM-39M 2001 NAMRIA.

Requesting Party: **Aero 360 Solutions**
Purpose: **Reference**
O.R. No.: **7336056**
Transaction No.: **JCP2020-2144**

RUEL DM. BELEN, MNSA
Director, Mapping and Geodesy

NAMRIA OFFICES:
Main : Lawton Ave., Ft. Bonifacio, 1634 Taguig City, Philippines
Tel. No.: (632) 810-4831 to 41
Branch : 421 Barraca St. San Nicolas, 1010 Manila, Philippines

ISO 9001 : 2015
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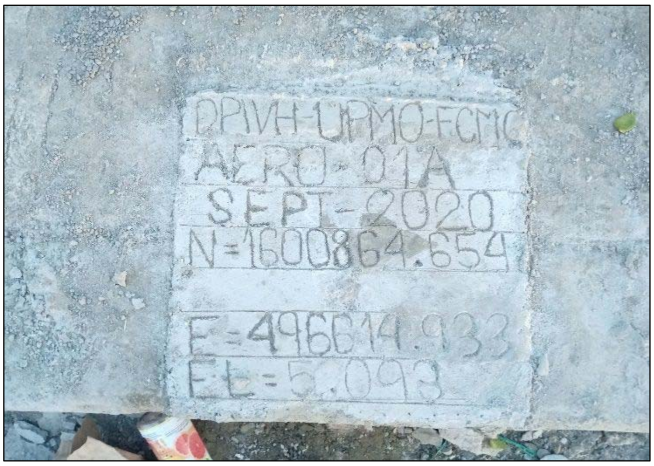
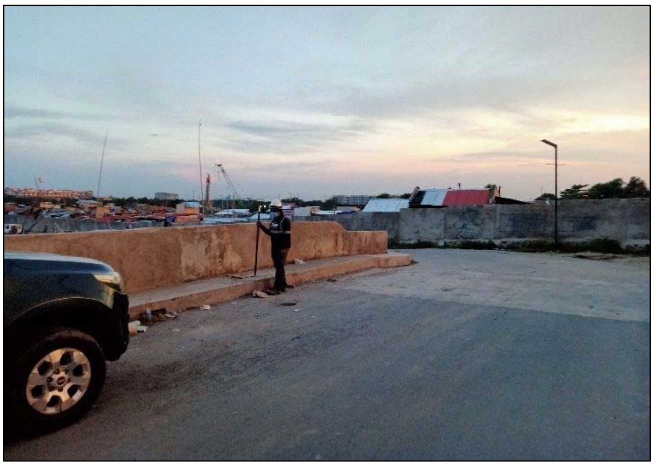
7.6. DESCRIPTION OF PROJECT CONTROL POINTS

LOCATION DESCRIPTION OF CONTROL POINT				
STATION	DESCRIPTION / REMARKS			DATE
AERO-01A	The control point is in the Province of Metro Manila, City of Las Piñas, Brgy. Pulang Lupa Uno. The station is located on the edge of an on-going bridge construction over Zapote River, around 30 meters northwest of Radial Road 1. Mark is the head of a 5 mm. concrete nail set flush on a 30 x 30 cm. cement putty with inscriptions "DPWH-UPMO-FCMC, AERO-01A, SEPT-2020".			SEPT 2020
Island:	Luzon	**Barangay:**	Pulang Lupa Uno	
Province:	Metro Manila	**City / Municipality:**	Las Piñas	
Latitude:	**Longitude:**	**Spheroid Height:**	**Spheroid:**	
--	--	--	WGS–84	
--	--	--	PRS–92	
Easting	**Northing**	**Elevation (Msl)**	**Projection**	**Zone**
496614.933	1600864.654	5.093	PPCS-PRS-92	3

Vicinity Map

Photograph of Monument





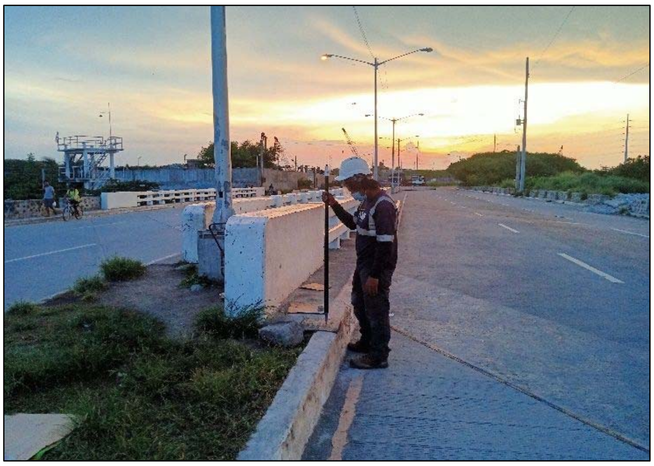
LOCATION DESCRIPTION OF CONTROL POINT

STATION	DESCRIPTION / REMARKS	DATE
AERO-01C	The control point is in the Province of Metro Manila, City of Las Piñas, Brgy. Pulang Lupa Uno. The station is located on the edge of Munting Ilog bridge over Munting Ilog River, less than 1-meter west of Carlos P. Garcia Ave. Ext south bound. Mark is the head of a 5 mm. concrete nail set flush on a 30 x 30 cm. cement putty with inscriptions "DPWH-UPMO-FCMC, AERO-01C, SEPT-2020".	SEPT 2020

Island:	Luzon	**Barangay:**	Pulang Lupa Uno	
Province:	Metro Manila	**City / Municipality:**	Las Piñas	
Latitude:	**Longitude:**	**Spheroid Height:**	**Spheroid:**	
--	--	--	WGS–84	
--	--	--	PRS–92	
Easting	**Northing**	**Elevation (Msl)**	**Projection**	**Zone**
497164.554	1600835.411	4.792	PPCS-PRS-92	3

Vicinity Map

Photograph of Monument



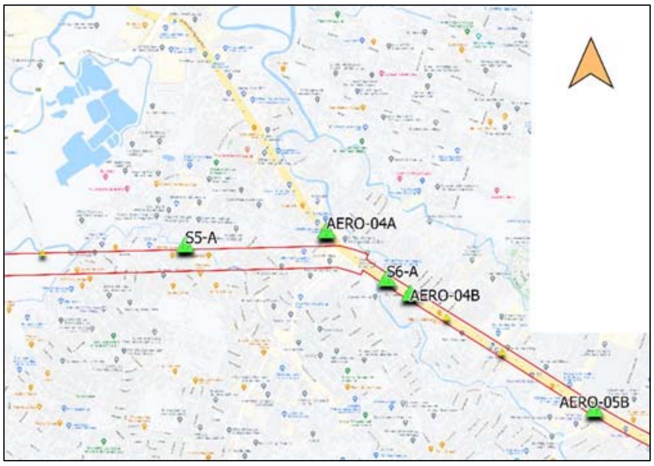
LOCATION DESCRIPTION OF CONTROL POINT

STATION	DESCRIPTION / REMARKS	DATE
AERO-04A	The control point is in the Province of Metro Manila, City of Parañaque, Brgy. Sucat, along Dr. Arcadio Santos Ave. The station is located 3 meters from the end of the center island, approximately 25 meters northwest of the footbridge and about 20 meters northeast of McDonalds. Mark is the head of a 5 mm. concrete nail set flush on a 30 x 30 cm. cement putty with inscriptions "DPWH-UPMO-FCMC, AERO-04A, SEPT-2020".	SEPT 2020

Island:	Luzon	**Barangay:**	Sucat
Province:	Metro Manila	**City / Municipality:**	Parañaque
Latitude:	**Longitude:**	**Spheroid Height:**	**Spheroid:**
--	--	--	WGS–84
--	--	--	PRS–92

Easting	Northing	Elevation (Msl)	Projection	Zone
499880.598	1600994.572	3.956	PPCS-PRS-92	3

Vicinity Map

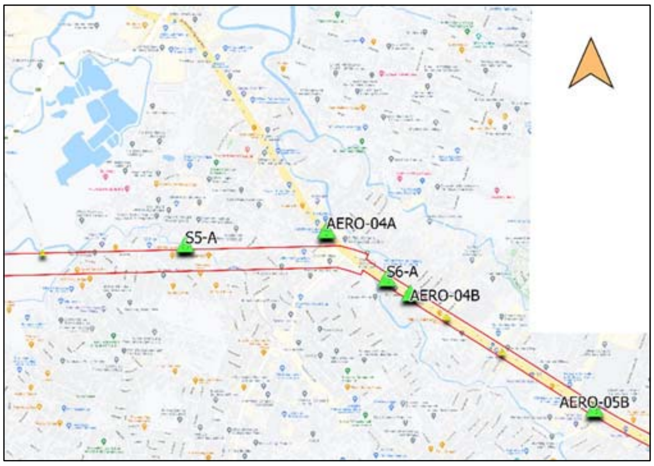


Photograph of Monument

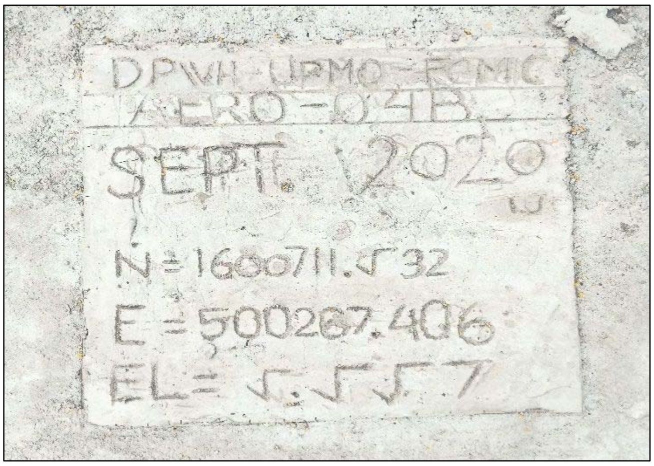
LOCATION DESCRIPTION OF CONTROL POINT		
STATION	**DESCRIPTION / REMARKS**	**DATE**
AERO-04B	The control point is in the Province of Metro Manila, City of Parañaque, Brgy. Sucat, along Dr. Arcadio Santos Ave. The station is located at the end of the center island, approximately 25 meters southwest of the Clarmen Village and about 15 meters northeast of Eastwest bank. Mark is the head of a 5 mm. concrete nail set flush on a 30 x 30 cm. cement putty with inscriptions "DPWH-UPMO-FCMC, AERO-04B, SEPT-2020".	SEPT 2020

Island:	Luzon	**Barangay:**	Sucat	
Province:	Metro Manila	**City / Municipality:**	Parañaque	
Latitude:	**Longitude:**	**Spheroid Height:**	**Spheroid:**	
--	--	--	WGS–84	
--	--	--	PRS–92	
Easting	**Northing**	**Elevation (Msl)**	**Projection**	**Zone**
500267.406	1600711.532	5.557	PPCS-PRS-92	3

Vicinity Map

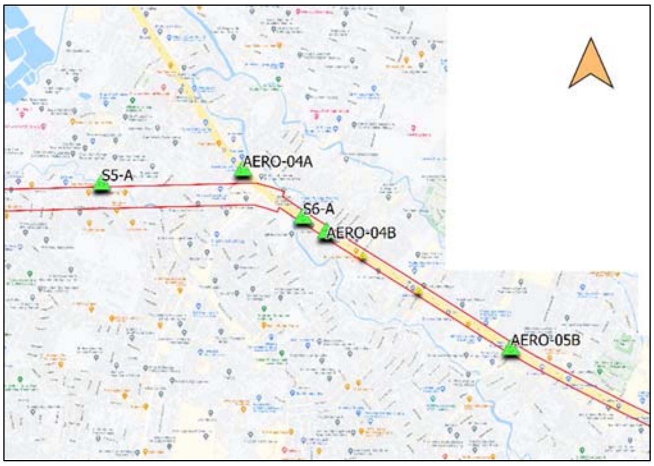


Photograph of Monument



LOCATION DESCRIPTION OF CONTROL POINT				
STATION	**DESCRIPTION / REMARKS**			**DATE**
AERO-05B	The control point is in the Province of Metro Manila, City of Parañaque, Brgy. Sucat, along Dr. Arcadio Santos Ave. The station is located at the end of the center island, approximately 15 meters northwest of the intersection of Dr. A Santos Ave and San Pedro Road. Mark is the head of a 5 mm. concrete nail set flush on a 30 x 30 cm. cement putty with inscriptions "DPWH-UPMO-FCMC, AERO-05B, SEPT-2020".			SEPT 2020
Island:	Luzon	**Barangay:**	Sucat	
Province:	Metro Manila	**City / Municipality:**	Parañaque	
Latitude:	**Longitude:**	**Spheroid Height:**	**Spheroid:**	
--	--	--	WGS–84	
--	--	--	PRS–92	
Easting	**Northing**	**Elevation (Msl)**	**Projection**	**Zone**
501118.760	1600184.253	10.218	PPCS-PRS-92	3

Vicinity Map



Photograph of Monument

LOCATION DESCRIPTION OF CONTROL POINT

STATION	DESCRIPTION / REMARKS	DATE
AERO-07A	The control point is in the Province of Metro Manila, City of Parañaque, Brgy. Sucat, along Dr. Arcadio Santos Ave. The station is located at the end of the center island, approximately 15 meters southeast of the intersection of Dr. A Santos Ave and Sampaguita Ave and about 30 meters in front of Manila Memorial Park Cemetery. Mark is the head of a 5 mm. metal nail set flush on a 15 x 15 cm. cement putty with inscriptions “SS2U, BM-4”.	SEPT 2020

Island:	Luzon	**Barangay:**	Sucat	
Province:	Metro Manila	**City / Municipality:**	Parañaque	
Latitude:	**Longitude:**	**Spheroid Height:**	**Spheroid:**	
--	--	--	WGS–84	
--	--	--	PRS–92	
Easting	**Northing**	**Elevation (Msl)**	**Projection**	**Zone**
502618.524	1599431.688	21.456	PPCS-PRS-92	3

Vicinity Map

Photograph of Monument

LOCATION DESCRIPTION OF CONTROL POINT				
STATION	**DESCRIPTION / REMARKS**			**DATE**
AERO-07B	The control point is in the Province of Metro Manila, City of Parañaque, Brgy. Sucat, along Dr. Arcadio Santos Ave. The station is located at the end of the center island, approximately 25 meters southwest of San Antonio High School. Mark is the head of a 5 mm. concrete nail set flush on a 30 x 30 cm. cement putty with inscriptions “DPWH-UPMO-FCMC, AERO-07B, SEPT-2020”.			SEPT 2020
Island:	Luzon	**Barangay:**	Sucat	
Province:	Metro Manila	**City / Municipality:**	Parañaque	
Latitude:	**Longitude:**	**Spheroid Height:**	**Spheroid:**	
--	--	--	WGS–84	
--	--	--	PRS–92	
Easting	**Northing**	**Elevation (Msl)**	**Projection**	**Zone**
503030.514	1599221.483	26.204	PPCS-PRS-92	3

Vicinity Map

Photograph of Monument

LOCATION DESCRIPTION OF CONTROL POINT				
STATION	**DESCRIPTION / REMARKS**			**DATE**
AERO-09A	The control point is in the Province of Metro Manila, City of Muntinlupa, Brgy. Sucat, along Meralco Road. The station is located at the top of a wall, approximately 5 meters northwest of Meralco road northbound. Mark is the head of a 5 mm. concrete nail set flush on a 30 x 30 cm. cement putty with inscriptions "DPWH-UPMO-FCMC, AERO-09A, SEPT-2020".			SEPT 2020
Island:	Luzon	**Barangay:**	Sucat	
Province:	Metro Manila	**City / Municipality:**	Muntinlupa	
Latitude:	**Longitude:**	**Spheroid Height:**	**Spheroid:**	
--	--	--	WGS–84	
--	--	--	PRS–92	
Easting	**Northing**	**Elevation (Msl)**	**Projection**	**Zone**
504916.541	1598506.155	19.245	PPCS-PRS-92	3

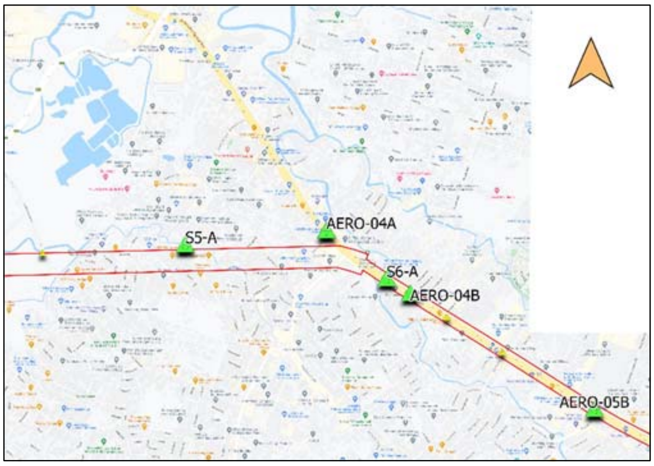
Vicinity Map

Photograph of Monument

LOCATION DESCRIPTION OF CONTROL POINT		
STATION	**DESCRIPTION / REMARKS**	**DATE**
S5-A	The control point is in the Province of Metro Manila, City of Las Piñas, Brgy. Kilyawan, Gatchalian Village. The station is located along edge of the gutter of Sto. Niño Bridge, approximately 6 meters southwest of the subdivision's guard house. Mark is the head of a 5 mm. concrete nail set flush on 30 x 30 cm. cement putty with inscriptions "DPWH-UPMO-FCMC, S5-A, SEPT-2020".	SEPT 2020

Island:	Luzon	**Barangay:**	Sucat	
Province:	Metro Manila	**City / Municipality:**	Muntinlupa	
Latitude:	**Longitude:**	**Spheroid Height:**	**Spheroid:**	
--	--	--	WGS–84	
--	--	--	PRS–92	
Easting	**Northing**	**Elevation (Msl)**	**Projection**	**Zone**
499232.354	1600925.642	3.754	PPCS-PRS-92	3

Vicinity Map



Photograph of Monument

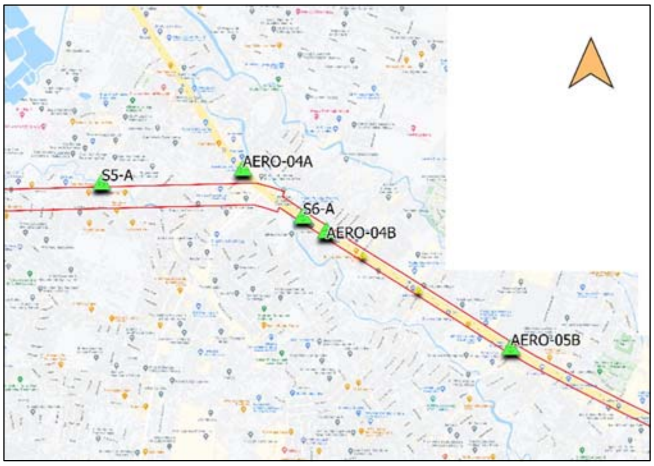
LOCATION DESCRIPTION OF CONTROL POINT

STATION	DESCRIPTION / REMARKS	DATE
S6-A	The control point is in the Province of Metro Manila, City of Parañaque, Brgy. Sucat, along Dr. Arcadio Santos Ave. The station is located at the middle of the center island, approximately 24 meters north of Salvador estate. Mark is the head of a 5 mm. concrete nail set flush on a 30 x 30 cm. cement putty with inscriptions “DPWH-UPMO-FCMC, S6-A, SEPT-2020”.	SEPT 2020

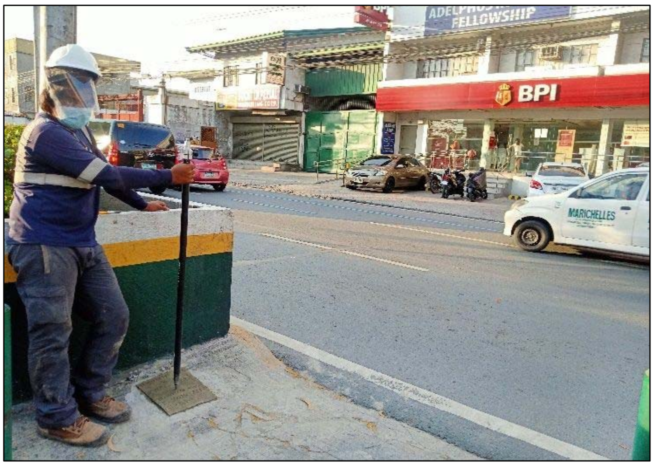
Island:	Luzon	**Barangay:**	Sucat
Province:	Metro Manila	**City / Municipality:**	Muntinlupa
Latitude:	**Longitude:**	**Spheroid Height:**	**Spheroid:**
--	--	--	WGS–84
--	--	--	PRS–92

Easting	Northing	Elevation (Msl)	Projection	Zone
500158.523	1600778.496	5.399	PPCS-PRS-92	3

Vicinity Map



Photograph of Monument

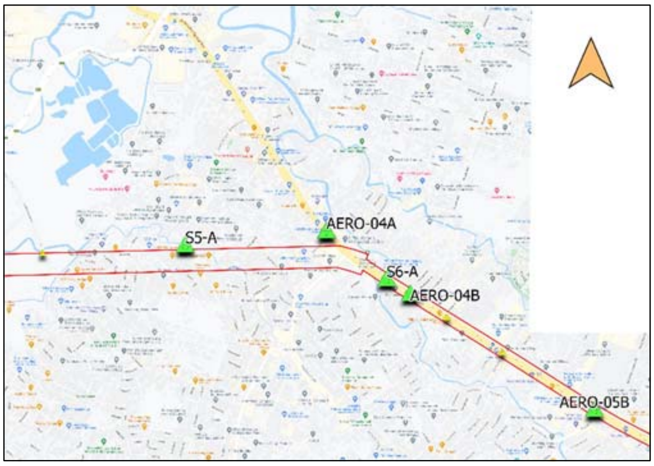


LOCATION DESCRIPTION OF CONTROL POINT

STATION	DESCRIPTION / REMARKS	DATE
AERO-06A	The control point is in the Province of Metro Manila, City of Parañaque, Brgy. Sucat, along Dr. Arcadio Santos Ave. The station is located at the end of the center island, approximately 12 meters from the intersection of Dr. A. Santos Ave. and Filipinas Ave. Mark is the head of a 5 mm. brass nail set flush on a 15 x 15 cm. cement putty with inscriptions “MMA-3554, 2011, LMS-NCR, ABSD”.	SEPT 2020

Island:	Luzon	**Barangay:**	Sucat	
Province:	Metro Manila	**City / Municipality:**	Muntinlupa	
Latitude:	**Longitude:**	**Spheroid Height:**	**Spheroid:**	
--	--	--	WGS–84	
--	--	--	PRS–92	
Easting	**Northing**	**Elevation (Msl)**	**Projection**	**Zone**
501783.368	1599848.315	14.731	PPCS-PRS-92	3

Vicinity Map **Photograph of Monument**



7.7. CAAP AND J2 PERMITS

Republic of the Philippines
CIVIL AVIATION AUTHORITY OF THE PHILIPPINES

3SP2020-023
19 August 2020

MR. ROWELL P. ANGELES
Flight Operations Officer
Flight Operations Department
LIONAIR INCORPORATED
PADC Hangar V, General Aviation Area
Domestic Airport, Pasay City

Dear Mr. Angeles:

We refer to your letter dated 17 August 2020, requesting to conduct Aerial Light and Ranging (LIDAR) survey of the segment of Parañaque Spillway Project and in the area of Bulacan utilizing Robinson R44/ Raven II with Registration No. RP-C3985 from 24-28 August 2020.

Please be informed that your request is hereby **APPROVED,** subject to the following conditions:

1. Must be subject to Air Traffic Control.
2. Must be conducted during day VMC only.
3. Must be conducted on from **24-28 August 2020** only.
4. Must be conducted at a maximum altitude of **300ft AGL in Parañaque are and 500ft AGL in Bulacan area**.
5. Must confine activity within the following coordinates: (PLEASE SEE ATTACHED DISPOSITION)
6. Must be transponder equipped and must squawk on assigned transponder code as appropriate.
7. Must maintain continuous communication with Manila Control Tower.
8. Must advise Manila Control Tower of the start and termination of the said activity.
9. Must file appropriate flight plan as per normal procedure.
10. Delay of the said activity must be anticipated in consideration and prioritization of regular air traffic.
11. Must secure J-2 clearance prior to the conduct of the said activity.
12. Aircrew must update themselves with the current NOTAMs for other aerial activities.
13. Activity may be suspended or deferred by the shift supervisor on duty at Davao Tower facility if in his/her opinion flight safety will be jeopardized.

Very truly yours,

CAPTAIN DONALDO A. MENDOZA
DDG-O / OIC-FSIS

Old MIA Road corner Ninoy Aquino Avenue, Pasay City, Metro Manila, Philippines, 1300
Tel: (+632) 944 2030-2031 / www.caap.gov.ph

Republic of the Philippines
CIVIL AVIATION AUTHORITY OF THE PHILIPPINES

3SP2020-031
21 September 2020

MR. MARK VINCENT B. VILLAFLOR
CEO/President
AERO 360 SOLUTIONS, INC.
008 F. Pasco Ave., Brgy. Santolan
Pasig City, M.M.

Dear Mr. Villaflor:

We refer to your letter dated 15 September 2020, requesting to conduct Pothogrammetry and LIDAR Survey of Parañaque Spillway Project utilizing Remotely Plioted Aircraft System (RPAS) from 22 September – 22 October 2020.

Please be informed that your request is hereby **APPR[illegible]V[illegible]**, subject to the following conditions:

- Must be conducted during VMC only.
- Must be conducted from **22 September – 22 October 2020 between 8:00AM-5:00PM**.
- Must be conducted at a maximum altitude of **100ft. AGL** only.
- Must confine activity within the following coordinates:

  (Parañaque City)
  A. 14 28 33.78N 120 58 14.40E
  B. 14 27 14.00N 121 03 13.47E

- Must secure permit/approval from the local government of Parañaque City.
- **Aerial Photo/ Video cov.**
- Must advise Manila Control Tower (Tel No. 02-7944-2167) of the start and termination of said activity.
- **CAAP shall not be held liable for any untoward incident or accident that may occur during the said operation.**

Very truly yours,

CAPTAIN DONALDO A. MENDOZA
DDG-O / OIC-FSIS

Old MIA Road corner Ninoy Aquino Avenue, Pasay City, Metro Manila, Philippines, 1300
Tel: (+632) 944 2030-2031 / www.caap.gov.ph

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REPUBLIC OF THE PHILIPPINES
DEPARTMENT OF NATIONAL DEFENSE
GENERAL HEADQUARTERS, ARMED FORCES OF THE PHILIPPINES
OFFICE OF THE DEPUTY CHIEF OF STAFF FOR INTELLIGENCE, J2
Camp General Emilio Aguinaldo, Quezon City

D2/20/0348

JUL 29 2020

MR. MARK VINCENT B. VILLAFLOR
CEO/President
Aero 360 Solutions, Inc.
008 F. Pasco Ave., Brgy. Santolan
Pasig City

Dear Mr. Villaflor:

This has reference to your letter dated July 14, 2020 requesting for clearance to conduct aerial operations in Parañaque.

Please be informed that the personnel listed in the attached clearance have been cleared to conduct aerial photogrammetry and Light Detection and Ranging (LiDAR) survey effective this date until 30 September 2020 for the follow-up study of the Parañaque Spillway which will be used for the comprehensive flood control management plan for the entire Laguna de Bay Lakeshore area. Kindly ensure that all the necessary coordination and permits from the concerned local governments have been secured to ensure the smooth conduct of the survey operations.

Further, please be advised to acknowledge in writing the receipt of the clearance, indicating that they understood and will abide by the special instructions therein. Upon expiration of their permit or completion of the activity, their special attention is requested on the provision regarding the proper disposition of the external hard drive used for storing the data gathered from the aerial survey operations. Likewise, please be reminded that requests for extension of OJ2 clearance together with the supporting documents/requirements should reach this Office **at least two (2) weeks** before the expiration of the current clearance. Kindly designate a contact person for the activity to include his contact details for efficient coordination.

In this regard, kindly contact the Office of the Assistant Chief of Air Staff for Intelligence, A2, Philippine Air Force (PAF) at Colonel Jesus Villamor Air Base, Pasay City with telephone numbers 851-1252 and/or 854-6701 local 6220 and the 300th Air Intelligence and Security Wing (AISW), PAF mobile number 0927-821-8315 or AISW, PAF NCOIC SSg Richard Tedd B. Montilla PAF at mobile number 0926-610-8016 for further coordination prior to the conduct of your project and for the availability of a PAF representative to supervise your activities.

Truly yours,

FOR THE DEPUTY CHIEF OF STAFF FOR INTELLIGENCE, J2:

CHARLTON SEAN M GAERLAN
Brigadier General PN(M)
ADCS for Intelligence, J2

AFP Core Values: Honor, Service, Patriotism

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REPUBLIC OF THE PHILIPPINES
DEPARTMENT OF NATIONAL DEFENSE
GENERAL HEADQUARTERS, ARMED FORCES OF THE PHILIPPINES
OFFICE OF THE DEPUTY CHIEF OF STAFF FOR INTELLIGENCE, J2
Camp General Emilio Aguinaldo, Quezon City

JUL 29 2020

AERIAL PHOTOGRAPHY CLEARANCE

This is to certify that the following personnel of Aero 360 Solutions, Inc. have been cleared in accordance with Presidential Decree 1588 to conduct aerial photogrammetry and Light Detection and Ranging (LiDAR) survey in Parañaque effective this date until 30 September 2020 for the follow-up study of the Parañaque Spillway which will be used for the comprehensive flood control management plan for the entire Laguna de Bay Lakeshore area:

1. RPAS Controllers (Controller Number)	a. Mr. Michael G. de Leon (RPA-135290) b. Mr. Christian M. Magnaye (RPA-137224) c. Mr. Paul Silas B. Balona (RPA-010529) d. Mr. Jefferson A. Tan (RPA-010528)
2. Project Staff/Flight Team	a. Mr. Vergel Cabanes b. Mr. James Danganan c. Mr. Noelito Valerio d. Mr. Regiemer Agao e. Mr. Ronnie Fuentes f. Mr. Renier Pautan g. Mr. Darius Ronquillo
3. UAV (Registration Number)	a. DJI M600 Hexacopter (RP-U322A) b. Gryphon Hexa 1 (RP-U176A)

It is understood that the materials to be used shall:

1. Be handled by the above-named persons only and used only for the purpose stated in the request;
2. Not to be reproduced, not issued to a third party, nor shipped out of the Philippines;
3. Be stored and safeguarded from unauthorized access or pilferage when not in use;
4. Be subject to inspection by the Deputy Chief of Staff for Intelligence, J2 or his designated representative; and
5. Be turned over to the Office of the Assistant Chief of Air Staff for Intelligence, A2, Philippine Air Force (Attn: 300th AISW, PAF) if defaced, torn, or rendered unusable or upon expiration of this clearance.

This clearance may be withdrawn or cancelled and subsequent request for clearance may be denied for violation of the foregoing provisions.

FOR THE DEPUTY CHIEF OF STAFF FOR INTELLIGENCE, J2:

CHARLTON SEAN M GAERLAN
Brigadier General PN(M)
ADCS for Intelligence, J2

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		REC'D	REL'D			REC'D	REL'D

7.8. CAAP-RELATED CREDENTIALS

CAA PHILIPPINES

REMOTELY PILOTED AIRCRAFT SYSTEM OPERATOR CERTIFICATE

MIA Rd. corner Ninoy Aquino Ave, Pasay City Metro Manila, Philippines 1300	**REPUBLIC OF THE PHILIPPINES** ISSUING AUTHORITY: **CIVIL AVIATION AUTHORITY OF THE PHILIPPINES**	Tel : +632-89442172 Email : fod@caap.gov.ph
ROC#: 2016005 Expiry Date: **14 NOVEMBER 2022**	OPERATOR NAME: **AERO 360 SOLUTIONS, INC.** **Operator Address:** 008, F. Pasco Ave., Santolan, Pasig City Telephone no.: (+632)532-1159	**Mr. Mark Vincent B. Villaflor** CEO & President Email: aero360solutions@gmail.com

This certifies that **AERO 360 SOLUTIONS, INC.** is authorized to perform remotely piloted aircraft system in commercial air operations in accordance with the Philippine Civil Aviation Regulations Part 11, series of 2008.

Date of Issue: **15 NOVEMBER 2019**	CAPTAIN JIM C. SYDIONGCO Director General

7.9. THE SURVEY TEAM

PROJECT DESIGNATION	NAME
PROJECT MANAGER	SORVIGENALEON ILDEFONSO
GEODETIC ENGINEER , DEPUTY PROJECT MANAGER	MARK RAYMOND SEBASTIAN
SURVEY TECHNICIAN	CLARK ADONIS NUNAG
SURVEY TECHNICIAN	GAMALLER BUGNA
SURVEY TECHNICIAN	MARK JOSEPH SEBSATIAN
SURVEY TECHNICIAN	JOHN MICHAEL GUILLEN
SURVEY TECHNICIAN	EDUARDO SAL, JR.
UAV LEAD PILOT	PAUL SILAS BALONA
UAV TECHNICIAN	RONNIE FUERTES
LIDAR OPERATOR	IRO NIEL ROXAS
DATA LEAD ANALYST	CHELOU PRADO
DATA ANALYST	PAULINE JOANNE ARCEO
DRIVER	MARK GLENN SAMPAGA
DRIVER	GERALD SANTOS

The conduct LiDAR Topographic Survey and Mapping under Follow-up Study on Paranaque Spillway for CTI Engineering Co. Ltd.

AERO 360 Solutions, Inc.

Surveyed last 16 July – 04 August; 13 August – 10 September 2020

This project was performed under contract between CTI Engineering Co. Ltd. and Aero 360 International. This report is part of its project deliverable.

For queries regarding this report, you may contact:

Engr. Sorvigenaleon Ildefonso
Project Manager
Aero 360 Solutions, Inc.
sr.ildefonso@aero360intl.com

Engr. Mark Raymond B. Sebastian
Geodetic Engineer
Aero 360 Solutions, Inc.
mrsebastian@aero360intl.com

Engr. Chelou P. Prado
Lead Data Analyst
Aero 360 Solutions, Inc.
cpprado@aero360intl.com