TerraDrone

Work Report – Drone Lidar Topographic Survey for Development of Regional Disaster Risk Resilience Plan in Central Sulawesi

TERRA DRONE INDONESIA

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Table of Contents

Preface

Background and Purpose

Aerial phography is one form of Remote Sensing which often used for observing actual condition of a certain area or object quickly. Aerial photography also become one of the core of data acquisition works for various purpose, e.g aerial mapping and photogrammetry, aerial surveillance, as well as asset inspection from air. Aerial mapping using manned aerial vehicle has been well known in community, as well as aerial inspection and aerial assets inspection. However, along with development of technology, there has been new alternative for data acquisition using unmanned aerial vehicle (UAV) or usually known as drone.

The utilization of the drone itself is now quite extensive and has been used almost throughout the industry in accordance with the needs. For example, airborne drone surveys are generally used for land planning, land management, land use evaluation, environmental impact monitoring, monitoring of work progress, as well as to audit the number of objects within a particular area. Meanwhile, for aerial supervision and inspection of assets purpose, drone are generally used for inspection of assets which classified as dangerous works, pipeline supervision, powerline supervision, inspection of construction equipment, or identification of phenomena in an object or area. Drones become an attractive alternative for these applications because of drones are created to make it easier for humans to do 3D (dull, dangerous, dirty) work. In addition, there are many advantages possessed by drones rather than other technologies such as satellite images and manned aircraft in terms of data quality, economic terms, to the aspect of efficiency.

For that reason, Yachiyo Engineering has asked Terra Drone Indonesia to conduct drone lidar topographic survey for development of regional disaster risk resilience plan in Central Sulawesi. Through this report, team intends to provide an overview of the method, technical specifications of the equipment used, data acquisition process, data processing, and results.

Survey Location

Aerial survey is conducted on Palu City. Survey is conducted to obtain topographical model of AOI for Yachiyo Engineering. Survey is conducted on rural area with the total area of interest is ± 750 Ha. Below is images of Area of interest (AOI) overlaid on google images and world topo map. It can be seen that the some part of the AOI is in hilly area, and rest is relatively flat area.

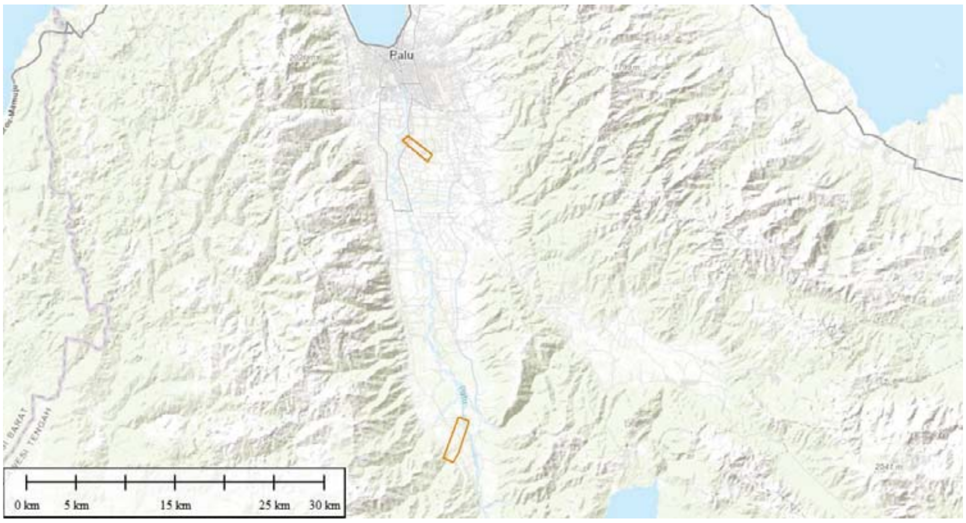


Figure 1. AOI location

(a)

(b)

Figure 2. AOI location (a) Area 1 (b) Area 2

Basic Principal

Unmanned Aerial Vehicle or Drone

Drone, or Unmanned Aerial Vehicle, is basically a flying vehicle equipped with certain technology so that it can be flown without the need for an onboard crew drone is a term for the vehicle, as well as other term for the vehicle, as well as other terms such as the aircraft (PUNA), unmanned aerial vehicle (UAV), or Remotely Piloted Aircraft System (RPAS).

Figure 3. Drone type Multirotor (left), and Fixed Wing (right)

Drones commonly used today are divided into two types which its utilization are depends on the type of mission or desired output. The two types are:

1. Multirotor, is a drone that has a propulsion system in the form of electric motors mounted.
2. Fixed wing, is an airplane-shaped drone, and generally have 1 unit of propulsion system in the form of electric motor or fuel motor.

Fundamentally, the difference between Multirotor and Fixed Wing can be seen in the following table.

Table 1. The difference between Multirotor and Fixed Wing

Parameter	Multirotor	Fixed Wing
Stationer Flying	Yes	No
Vertical Take Off & Landing	Yes	No
Flying Duration	15 – 90 minute	1 – 4 hour
Flying Distance	10 – 20 km	50 – 200 km
Communication range	Up-to 5 km	Up-to 25 km
Propultion system	Electrical motor	Electrical motor Fuel motor
Utilization	Documentation Cinematography Inspection 3D Remodeling	Mapping Surveillance Patrol

Drone has 3 advantaged over other technologies, that is:

1. Image quality and resolution. The quality of images produced by using drones will be much better than satellite imagery, or images from manned aircraft. For mapping purpose, the resulting map resolution can be up to 5 cm/pixel, or equivalent to a 1: 500 scale map; while for inspection, the image resolution obtained can reach up to 1 mm / pixel, sufficient to capture the visual crack phenomenon.

2. High productivity and low cost. In a day, our drones can map an area of up to ± 4,000 hectares appropriately. In addition, the compact shape allows our drones to be operated anywhere and in a variety of terrains like lowland, beaches, hills, as well as mountains.
3. Human risk free and easy operation. Drone technology is basically designed to complete tasks that belong to 3D (Dull, Dangerous, and Dirty) so it is suitable for use in industries that have a high accident risk due to repetitive work or hazardous environments. In addition, the operation was relatively easy compared to other technologies on the market.

GPS Measurement Method

Static radial mode measurement and RTK measurements are two commonly used positioning methods. Static radial mode measurement is a method of positioning with GPS. Measurements of this method require that a measured point to be tied to a national reference point of a higher order, eg the 1st order point of the National Geodetic Control Network (BIG) managed by the Geospatial Information Agency (BIG). The results of this static measurement cannot be used directly, because it needs to be processed first to get the coordinates of the point measured.

Meanwhile, RTK-Based measurement can directly obtain coordinates without performing coordinate processing because the rover simultaneously obtain correction from base station. The advantages of static radial mode over RTK is the resulted coordinates is more accurate, but it takes a longer measurement time to get the coordinates. Meanwhile, RTK can not be used if the connection between base and rover is blocked and the tipical baseline between base and rover is significantly close compared to static radial

Other method is PPK, which combines the short time advantage of RTK but increasing the baseline capability between base and rover better. This method require post processing as in static radial. *This method along with RTK is then often adapted in UAV directly to significantly reduce the time to do GCP in ground, especially where GCP installation is considered unsafe*.

Table 2. Static Mode and RTK CORS Comparison

	Static Radial	RTK	PPK
Time	Longer period (~ 30 minute)	Very Brief period (~ <1 minute)	Very Brief period (~ <1 minute)
Accuracy	Higher (~ 5 mm)	Lower (~ 1 cm)	Lower (~ 1 cm)
Processing	Require post-processing	Doesn't require post-processing	Require post-processing
Baseline	>20 km	<2-3 km	2-10 km

Lidar

LIDAR, which stands for Light Detection and Ranging, is a remote sensing method that uses light in the form of a pulsed laser to measure ranges (variable distances) to the Earth. These light pulses—combined with other data recorded by the airborne system— generate precise, three-dimensional information about the shape of the Earth and its surface characteristics.

A LIDAR instrument principally consists of a laser, a scanner, and a specialized GPS receiver. Airplanes and helicopters are the most commonly used platforms for acquiring LIDAR data over broad areas. Two types of LIDAR are topographic and bathymetric. Topographic LIDAR typically uses a near-infrared laser to map the land, while bathymetric lidar uses water-penetrating green light to also measure seafloor and riverbed elevations.

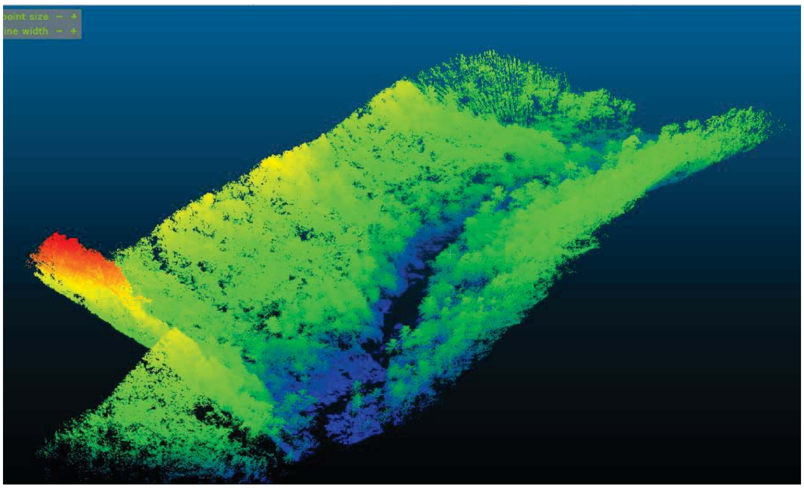


Figure 4. Example of LiDAR Point Cloud

The LiDAR instrument fires rapid pulses of laser light at a surface, some at up to 300,000 pulses per second. A sensor on the instrument measures the amount of time it takes for each pulse to bounce back. Light moves at a constant and known speed so the LiDAR instrument can calculate the distance between itself and the target with high accuracy. By repeating this in quick succession the insturment builds up a complex 'map' of the surface it is measuring. With airborne LiDAR other data must be collected to ensure accuracy. As the sensor is moving height, location and orientation of the instrument must be included to determine the position of the laser pulse at the time of sending and the time of return. This extra information is crucial to the data's integrity.

There are 4 main components of LiDAR:

Lasers	Lasers are categorised by their wavelength. 600-1000nm lasers are more commonly used for non-scientific purposes but, as they can be focused and easily absorbed by the eye, the maximum power has to be limited to make them 'eye-safe'. Lasers with a wavelength of 1550nm are a common alternative as they are not focused by the eye and are 'eye-safe' at much higher power levels. These wavelengths are used for longer range and lower accuracy purposes. Another advantage of 1550nm wavelengths is that they do not show under night-vision goggles and are therefore well suited to military applications.
Scanners and Optics	The speed at which images can be developed is affected by the speed at which it can be scanned into the system. A variety of scanning methods are available for different purposes such as azimuth and elevation, dual oscillating plane mirrors, dual axis scanner and polygonal mirrors. They type of optic determines the resolution and range that can be detected by a system.
Photodetector and receiver electronics	The photodetector is the device that reads and records the signal being returned to the system. There are two main types of photodetector technologies, solid state detectors, such as silicon avalanche photodiodes and photomultipliers.
Navigation and positioning systems	When a LiDAR sensor is mounted on a mobile platform such as satellites, airplanes or automobiles, it is necessary to determine the absolute position and the orientation of the sensor to retain useable data. Global Positioning Systems provide accurate geographical information regarding the position of the sensor and an Inertia Measurement Unit (IMU) records the precise orientation of the sensor at that location. These two devices provide the

	method for translating sensor data into static points for use in a variety of systems.

Different from photogrammetry which require post processing to generate topographic map, LiDAR practically doesn't require a post processing because the three dimensional point cloud has been generated directly. However, the original point cloud data from the sensor does not contain the GPS and IMU data. Thus, the GPS and IMU has to be injected into point cloud data to correct the data. Not only injected, the coordinate from GPS also corrected to the base station data on a known point (benchmark), to generate highly accurate point cloud that refers to defined coordinate system.

Compared to photogrammetry, LiDAR has several advantages. Laser beams as an active sensor technology can penetrate vegetation. LiDAR is able to get through gaps in the canopy and reach the terrain and objects below, so it can be useful for generating Digital Terrain Models. LiDAR is also particularly useful for modeling narrow objects such as power lines or telecom towers as photogrammetry might not recognize narrow and poorly visible objects. Besides, LiDAR can work in poor lighting conditions and even at night. However, LiDAR point cloud is colorless. Thus, LiDAR and photogrammetric method can be combined to generate colored point cloud.

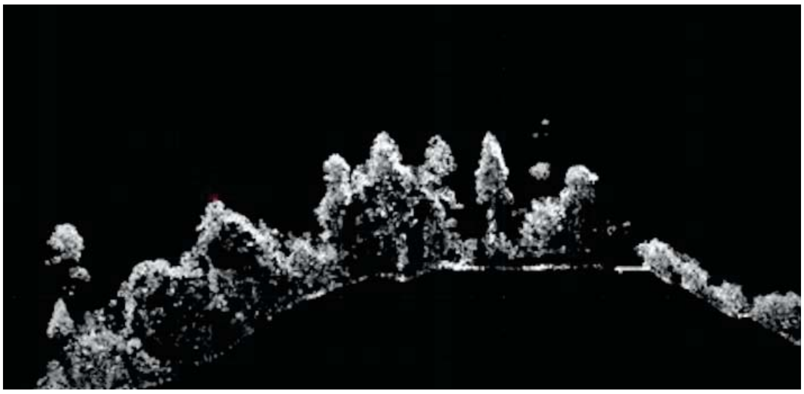


Figure 5. LiDAR Result in Dense Vegetation area

Work Plan

General Workflow

In accomplishing unmanned aerial survey, there is a work flow to be referred. This work flow can be described as below:

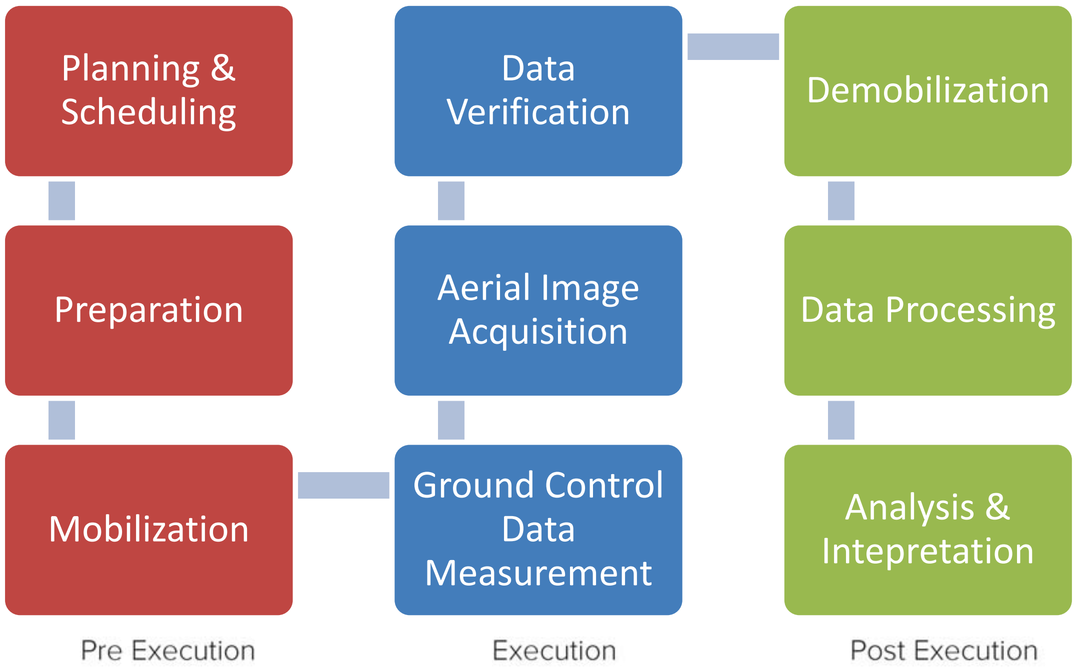


Figure 6. Unmanned Aerial Survey Work Flow

There are three main parts in the process which are:

1. Pre-Execution, which includes any activities that requires planning, scheduling, staffing, and preparation, which contains task such as tools and equipment calibration, flight test, permit request, work planning, etc. The output will be operation permit letter, work breakdown structure, and work execution plan based on scope of work given.
2. Execution, which is the main part of the work. It includes activities related to data acquisition, which involves ground control data measurement, aerial image acquisition, and initial data processing for data verification. The output will be all record documentation regarding survey activities, raw images, daily reports, and preview of outputs.
3. Post-Execution, which will produce all of the expected outputs. The processes that are involved are data management, backup, processing, and interpretation, as well as reporting and delivery. The output will be all of expected deliverables and final report.

Permit Request

At the moment, drone operation has been regulated by Ministry of Transportation through Transportation Minister Decree Number 163 Year 2015, Number 180 Year 2015, and Number 47 Year 2017, where each decree regulates particular issues as described below:

1. PM No 163 Tahun 2015, which contains appendix as Civil Aviation Safety Regulation (CASR) Part 107 that discusses about Small Unmanned Aircraft Systems. This particular part of CASR regulates technical limitations upon drone operations such as restriction to fly at night, restriction to operate drone from moving vehicle unless it is a vessel, restriction to operate multiple simultaneously, etc. Besides, this decree also regulates about operator certification and aircraft registration and identification. However, until now, Ministry of Transportation has not published the guideline for those two processes, and has not authorized any institution to conduct them. Therefore, in the meantime, to be able to comply to current effective regulations, all of PT Aero Terra Indonesia's operators have been certified internally by following standards and regulations that have been published, and all the trainings conducted have been adjusted to conform Ministry's requirements.
2. PM No 180 Tahun 2015, which had been refined by PM No 47 Tahun 2016, which regulates drone operations inside controlled airspace in Indonesia, which is regulated by either Perum LPPNPI (Airnav) and/or Indonesia Air Force. In the regulation, it is stated that basically to operate drone in Indonesia, operators have to request for permit to Ministry of Transportation, and intensively coordinate their activities with air traffic management services in the location. The process of requesting permit can be described below:
   a. Request for recommendation letter from local air traffic management services. If the AOI is located inside controlled airspace for civil aviation, or located outside controlled airspace but the mission altitude is more than 150 feet above ground level. Then, the required recommendation is from Airnav. If the AOI is located inside restricted or prohibited airspace, then the required recommendation is from local Indonesia Air Force.
   b. After the recommendation letter is received, the recommendation letter then shall be attached to receive operation permit letter from Directorate General of Civil Aviation, Ministry of Transportation. This operation permit letter is the proof that the operation is legally accepted and can be proceed.
   c. Next, operators have to send NOTAM (Notice to Airmen) request to local air traffic management service to that NOTAM can be published before the operation is conducted.
   d. Lastly, during the operation, operators have to intensively communicate with local air traffic management service by requesting flight dispatch before conducting take off and reporting mission status after landing successfully.

   Besides, in the PM No 47 Tahun 2016, it is also has been stated about sanctions if the operators disobey the regulations that apply. Sanctions could be administrative, legal, or penalty up to IDR 300,000,000.

Planning

Before executing a project, a well-prepared plan must be considered to create its success parameter. Every activity and that progress have to be discussed to prevent unwanted and unnecessary incident. Technical issues such as any equipment and tools, personnel allocation, and work methods have to be prepared for the project. To collect all information, Work Breakdown Structure (WBS) is prepared, which contains:

1. **Area of Interest**: Areas are already determined used for planning must be studied first. The results will be considered whether to take a project or not based on equipment availability and personnel skills.
2. **Scheduling**: Departure time, estimated time work and demobilization has been planned well. Plans were made has already buffered to anticipate contingency from problems that can potentially occur. Length of work is also became a consideration for making flight permit on a certain location.
3. **Personnel**: The personnel that involved in the project can be listed as below:

Table 3. Personnel involved and its job description

Project Manager	Responsible for all the activities related to the project, from the making of work plan until the final result presentation.
Team Leader	Responsible for all activities and progress on the field, collaborate with project manager to always update and inform all the issues happen in the field
UAV Operator	Responsible for preparing and operating the drone
UAV Mechanic	Responsible for all the repair of drone in the field
UAV Engineer	Responsible for any troubleshooting in the field
GCS Operator	Responsible for preparing flight mission and also checking photo data quality
GIS Officer	Responsible for processing all the data, the output, and also preparing map layout to complete the final result presentation

4. **Permit**: a permit to do a flight processed after a project has already approved to be done. The departure time for a team determined after permit issued. The contain of a permit clearly stated the recommendation for flight in certain area, the altitude of a flight, and important contacts to make sure that the traffic has clear to do a flight. All flight that have a trajectory to cross that area has already been informed in the beginning.
5. **Equipment Preparation**: A project that has a certain necessity required a different equipment to be prepared. After a schedule and work needs have been determined, amount of equipment will be prepared, whether the UAV to do a test flight and also GPS equipment required.
6. **Accommodation**: Trip from office in Bandung needs a vehicle to bring several devices, equipment, and all personnel.

Preparation & Calibration

All equipment will be taken and prepared due to needs of the project. To list all of it, there will be a checklist form and must be filled right before and after departure for preparation in the field. It is really mandatory because all tools consists of many small parts to be assembled into one big UAV, so it should be listed to prevent lost item.

Calibration must be done right before doing a test flight UAV and another device works properly. It compulsory to do after item replacement enacted. The item that must be calibrated is:

Table 4. Calibration activities

Device	Calibrate
Battery	For equating voltage and current of battery to be monitored in software
Radio Transmitter	For checking every switch and stick functionality in radio transmitter
Level 3-axis	To calibrate sensor IMU accelerometer
Level 1-axis	To calibrate sensor IMU gyro

After calibration, test flight must be done to see UAV performance. Testing conducted by pilots who will be dispatched to the field to see and memorize the characteristics of the UAV. if there is still contain an error when operate it, then trim is enough to adjust it on air.

After all equipment taken out off the plane from a flight, re-calibration must be done to anticipate error. For UAV, the calibration is done just to fix sensor IMU gyro (level 1-axis calibration). While the camera has to be re-adjusted white balance and focus on field.

Mobilization & Pre-survey

Mobilization for personnel and for equipment is differentiated. The team of operators will be mobilized after the operation permit is released, and all of the preparation and calibration activities have been conducted, and the equipment that will be used are in good condition and fit to work. The mobilization and the accommodation for the operators to get to the site determined by PHM will be company's responsibility.

Before performing the flight, there is a place to be surveyed beforehand since it will affect subsequent activity, namely:

1. Checking physical feasibility of BIG's N point BM if there is a need for geodetic GPS measurements.
2. Surveying areas of take-off and landing in accordance with the conditions UAV operator entry requirements. Determination of the area take-off and landing into the pilot's decision under field conditions. The most ideal conditions for making the flight:
   a. Area without a high tree to help the vision of pilots when operating in the air.
   b. Area without base stations or other electrical building so there is no interference to aircraft
   c. Large areas around like a football field so that the position of the take-off and landing can be arranged from any direction based on the direction of the wind.

Besides, before doing the data acquisition, on field calibration will be conducted, and on field pre-work briefing and risk assessment will be done. The data acquisition will be started after the work permit is released from the site's officials.

Data Acquisition

Data retrieval is executed when field condition proposed for take-off and landing is quite conducive and when the weather condition at the limited hours. Before flight, checklist form was prepared and completed by the team leader to anticipate shortages installation procedures. Pilot always had to check configuration and aircraft structures before placed above the launcher. Wind conditions examined condition for making the flight, if not yet possible then flight had to delay until wind is stable.

Previously, Ground Control Station (GCS) has been set up the mission to be uploaded to the UAV and has already calculating the area to be acquired. Dangerous or prohibited area has become a benchmark for GCS to be avoided in the base of missions flown. The aircraft's altitude is set by the resolution to be obtained and is already considering its contour using elevation data like Shuttle Radar Topography Mission (SRTM).

Data Verification

Any data obtained after the plane finished acquiring data should be checked beforehand to make sure whether the image data obtained in accordance with the requirement for processing. Exposure of a photo can be taken into consideration in making quality results. Even issues such as the camera does not trigger to take a photo can happen and checks can only be done when the aircraft landing.

Weather conditions can be very different in the area of aviation. For example, during take-off weather was sunny, but when looking at areas that will be acquired it produce a dark image because of the clouds. Therefore, before take-off must be ascertained from wind direction that mission area is not a problem, whether it is checked through a website that displays the weather status or simply have to be seen with the vision from afar.

Normal result is the image data that have sufficient brightness levels as well as the parameters of weather problems that can be tolerated. things into consideration whether the image should be repeated or not is when the image contains clouds, dark because of the clouds, fog, smoke, shadow, covered by fuselage, blur, corrupted data photo, etc.

After data acquisition finished in one day of work, all output at field shall be collected and will be given to the client. Starting from raw data of photo and video, data log, until the mission which has been discussed must be checked for initial data processing. If data does not meet requirement because of its quality or deficiency, data will be retaken on the other day.

Temporary output shall be produced on field to be checked by user requirement based on its quality and desired output for orthophoto, Digital Surface Model, and video. Orthophoto has a clear interpretation objects and good texture. Digital Surface Model presents elevation data for all Area of Interest. Video already records all desired scene of places or object. Decision when to modify data or maybe to repeat data acquisition can be determined in all quality form checking from client e.g. raw quality check form for raw photo checklist.

Data Management, Processing, and Interpretation

Data Management is required to store all the data obtained with a predetermined format. Operator in charge of storing the data acquisition (which is usually done by GCS) should adjust the naming and image storage with Standard Operating Procedures that can be understood by anyone, including those who process the image data. This uniformity is also used to geotagging photo, and after that will be given to the user.

Once all the data has been recapitulated with the appropriate naming, all data photos then will be processed using software. Start the process of alignment of the entire photo, optimization point cloud, and mesh-making between point clouds, build its orthomosaic, lastly export orthophoto and DSM with the format of .tiff. At first, export orthophoto have to be set to low resolution (e.g. 1 meter resolution) to earlier checking, after the problem was not detected then export with maximum resolution. if there is a problem, then it must be reprocessed from phase of optimization, alignment, or even doing a re-flight of mission. For DSM, if resolution lack from requirements, dense clouding process shall be executed for a better output.

When creating a mission of flight, Area of Interest has buffered 150 m beforehand to prevent any loss data information and error. Lastly the output shall be cropped based on original Area of Interest to be delivered. This makes the job so much longer but much safer in most cases like:

- Final output still lack coverage from original Area of Interest target
- Final output contains distortion in edge of orthophoto and DSM
- Final output contains error bundle adjustment at the edge of orthophoto and DSM from software processing.

Interpretation can be executed right after the existing output has been generated. The purpose of this interpretation is to provide clearer information and georeferenced for a specific object. To be able to highlight information is usually done by giving vector information point for many and small objects such as palm trees, line for information such as highway corridors, and areas for large buildings such as the factory area. All interpretation output will be used as a single map to finalize it.

Reporting & Output Delivery

After exporting output to preparing the map, report will be created to inform the quality as well as an explanation of parameters - parameters contained in the data. Contents starting from error reports generated on an output of up to revision. This reporting purposes as well as to inform the user about all the activities related to work activities until the end.

Output delivery will be sent with requested format, whether in from of a map or can be sent its raw data such as .tiff for orthophoto and DSM or .shp. for data vector. Packaging can be using recording media such as hardisk external and can be sent through a courier service or delivered directly to user office as well as presenting the output.

For main contract and additional job, our company will deliver:

Table 5. List of deliverables based on scope of work determined

Deliverables	Point Cloud
	Digital Surface Model (DSM)
	Digital Terrain Model (DTM)
	Contour with interval 1 m
	All daily work form
	Final Report

Equipment Technical Specification

Geodetic GPS

Trimble R8 Series

For GCP Measurement purpose, GPS Geodetic is used for cm-level measurement. Below is the specification of Geodetic GPS used in the survey:

Figure 7. Trimble R8s

Multirotor UAV

DJI Phantom 4

DJI Phantom 4 is a consumer grade drone that can be used also for industrial application, but limited to only several cases such as documentation and monitoring. The DJI Phantom 4 will be used for any application that needs simple solution. The technical specification of DJI Phantom 4 is listed below:

Figure 8. Picture of DJI Phantom 4

Table 6. DJI Phantom 4 technical specification

Parameter	Value
Type of UAV	Multirotor – Quadcopter
Manufacture	Dà-Jiāng Innovations Science and Technology Co., Ltd. (DJI)
Year of manufacture	2016
Total flight time of Airframe	10 hours
Number of flying hourse before next major replacement: (if aplicable)	40 hours
Registarsion marks and serial number	AGS-P401
Ownership and nationality	PT. Aero Terra Indonesia
Diagonal Size (cm)	35 cm
Maximum Weight (kg)	1,380 kg
Maximum Speed (m/s)	20 m/s
Ceiling Altitude (meter)	6000 m

Maximum Flight Endurance (minutes)	28 minutes
Maximum Trajectory (km)	15 km
Frequency (MHz/GHz)	2.4GHz ISM
Payload Platform	Integrated Camera
Material Type	Plastic
Telemetry Range (km)	5 km
Battery Type	Li-Po 4S
Battery Capacity (mAh)	5350 mAh
Controller Type	Remote Control
Data Link Type	Digital RF Modem
Streaming Video Link Type	Digital RF Modem

DJI Matrice 600 + Yellowscan Surveyor

Figure 9. Picture of DJI Matrice 600

This multirotor is perfect to carry heavy payload such as LiDAR. Its redundancy system also allow this drone to be operated in various situations including high altitude locations. This system has been proofed to have high accuracy as other lidar in the market.

Table 7. UAV Specification

Type of UAV	Multirotor	Take Off Method	Vertical Take Off
Maximum Weight	9.1 kilograms	Landing Method	Vertical Landing
Maximum Speed	18 m/s (no wind)	Maximum Trajectory	5 km
Maximum Speed of Ascent	5 m/s	Frequency	900 MHz Telemetry 2.4 GHz Remote
Maximum Speed of Descent	3 m/s		
Maximum Pitch Angle	25°		
Payload Platform	Yellowscan Surveyor	Coverage	45 ha/ flight

Figure 10. Yellowscan mounted on DJI Matrice 600

With a robust and fully integrated system designed to meet the needs of most demanding survey and terrain professionals, YellowScan Surveyor is quick and easily adapted to any drone, generating data when and where you need it.

Figure 11. Yellowscan LiDAR

Table 8. Specification of LiDAR VLP-16

Type of Sensor	Time of Flight Distance with Calibrated Reflectivities	Angular Resolution (Vert.)	2.0°
Channel	16 Channels	FoV (Horizontal)	360°
Meas. Range	Up to 100 m	Angular Resolution (Vert.)	0.1°-0.4°
Signal Return	Dual (Strongest, Last)	Rotation Rate	5 Hz – 20 Hz
FoV (Vertical)	30.0° (+15.0° to -15.0°)		

Data Acquisition Process

Daily Activity Details

Time Table

Table 9. Time Table

Day No. #	Date	Status	Description	Total Flight	Acquired (±ha/km)	Base Installed	ICP Installed
1	23-Mar-19	Work	Installation of Base and ICP: 6 Points	-	-	4	2
2	24-Mar-19	Work	Installation of Base and ICP: 6 Points	-	-	2	4
3	25-Mar-19	Work	Flight Mission: 4 Flight	4	50 Ha	-	-
4	26-Mar-19	Work	Flight Mission: 6 Flight	6	75 Ha	-	-
5	27-Mar-19	Work	Flight Mission: 6 Flight Installation of Base and ICP: 3 Points	6	75 Ha	2	1
6	28-Mar-19	Work	Flight Mission: 6 Flight Installation of Base and ICP: 5 Points	4	50 Ha	2	3
7	29-Mar-19	Work	Flight Mission: 3 Flight Installation of Base and ICP: 2 Points	3	50 Ha	1	1
8	30-Mar-19	Work	Flight Mission: 6 Flight	6	75 Ha	-	-
9	31-Mar-19	Work	Flight Mission: 6 Flight	6	75 Ha	-	-
10	01-Apr-19	Work	Flight Mission: 6 Flight	6	75 Ha	-	-
11	02-Apr-19	Work	Flight Mission: 6 Flight	4	50 Ha	-	-
12	03-Apr-19	Work	Flight Mission: 6 Flight	6	75 Ha	-	-
13	04-Apr-19	Idle	Data quality check	-	-	-	-
14	05-Apr-19	Idle	Data quality check	-	-	-	-
15	06-Apr-19	Idle	Demobilization	-	-	-	-
			Total	**55**	**750 Ha**	**11**	**10**

Ground Control Data Measurement

The GCP data acquisition process was carried out in ± 21 measurements. The coordinate data acquisition technique used is a radial acquisition system. Base coordinate measurements are performed after the pegs and premarks are installed. This coordinate measurement uses Geodetic type GPS. There are total 2 GPS used in this coordinate measurement process, with 1 base and 1 rover systems. To perform georeferencing, measurements are tied to the BIG point, which is the CORS PALP point.

Figure 12. Sample of Base Measurement and ICP Installment

GCP data acquisition is conducted in five days work. Each measurement conducted between 45-60 minutes each except for the base.

<u>LiDAR Data Acquisition</u>

LiDAR data methodology divided into 3 major parts:

1. LiDAR flight mission planning
2. LiDAR data acquisition
3. LiDAR data processing

- ***LiDAR Mission Planning***

Using follow terrain method

Purpose: To make LiDAR have consistent amount of point cloud in each area
In order to maintain the altitude, we need appropriate DSM data. Digital Surface Model (DSM) is a digital (numerical) representation of the surface of the earth.

The Digital Surface model has a process similar to orthomosaic, which consists of a process of determining the position and orientation of a photo, a 3-dimensional point cloud reconstruction, but not through a mosaicking process but an interpolation process. DSM can be obtained through processing aerial photo data. This DSM result is used as a reference for making the Lidar mission.

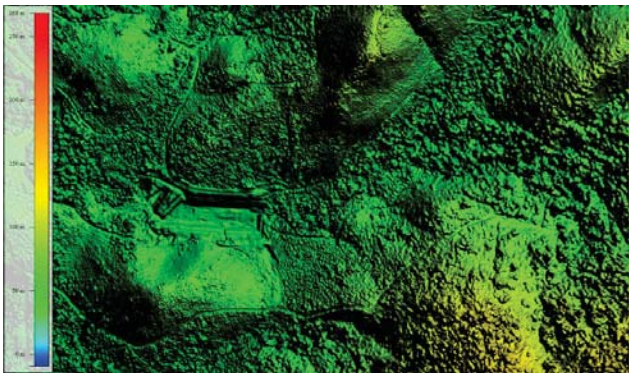


Figure 13. An Example of Digital Surface Model

Sidelap or separation between line

Since LiDAR have limited capabilities with coverage areas, we need to divide mission planning into each segment, It called "line". Each line represent some amount of data point cloud by cover some area. In the other words, to cover all area by LiDAR, repeat each Line until it covers all area.

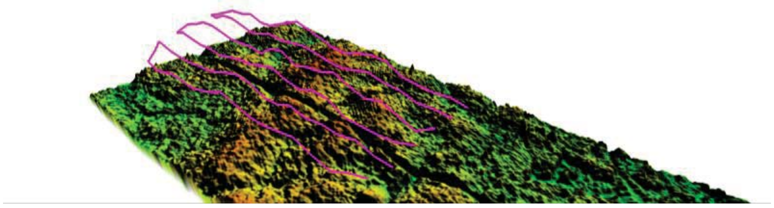


Figure 14. Line Separation

- ***LiDAR Data Acquisition***

Automatic Mission Following

The acquisition of LiDAR will follow different rules such as in terms of mission height, overlap, and buffer which already decided at mission planning section

BASE PPK

Using GPS type Geodetic, as BASE, while gps attached in LiDAR as rover

Figure 15. Base Station

GCP/ICP

GCP will be installed at each takeoff location because LiDAR will use the PPK module. GCP used is different from GCP aerial photography, GCP is used in the form of a box that has a height of approximately 1 m

Figure 16. ICP Figure

Groundspeed and Altitude

Less groundspeed and Altitude means more pointcloud LiDAR data. For the optimum result, Groundspeed = 4 m/s, Altitude = 50 m from surface

- ***LiDAR Data Processing***

To make georeferenced pointcloud from LiDAR result:

1. Correction position from UAV, result: precise poisition from UAV flypath
2. Correction position from each pointcloud, corrected based on each UAV position every 0.1 second, result: precise position from each pointcloud (local coordinate)

3. Inject fixed position based on BASE data with WGS84 projection, result: georeferenced pointcloud

Further processing:

1. There will be no processing but only point cloud and mesh classifications are available to produce DSM and DTM.
2. LiDAR will produce a colorless point cloud.

Data Acquisition Result

GCP Acquisition

Based on the results of the baseline processing, it can be seen that the accuracy obtained for all GCP baselines has met the accuracy standards of Geodetic GPS surveys for mapping. Coordinates from the processing of GPS data is resulted in a geographical coordinate system, which is a standard result produced in a survey with GPS.

For several practical use, coordinate resulted should be transformed to the UTM Projection System. The results of transformation of the coordinates can be seen in the following table:

Table 10. Base and ICP coordinates of Area 1

Poin ID	Easting UTM	Northing UTM	Geoid EGM 96	Geoid EGM2008	Latitude	Longitude	Ellipsoid
BM01	820231.663	9892604.306	16.359	16.4855	S0°58'13.47195"	E119°52'37.32203"	77.553
BM02	821034.817	9892734.427	20.385	20.552	S0°58'09.21703"	E119°53'03.27298"	81.607
BM03	821275.906	9891721.659	26.376	26.5567	S0°58'42.15431"	E119°53'11.09195"	87.661
BM04	822211.702	9891847.47	29.109	29.3262	S0°58'38.03563"	E119°53'41.32917"	90.428
BM05	822254.735	9890989.395	37.087	37.3085	S0°59'05.94622"	E119°53'42.74382"	98.451
BM06	823015.738	9891128.545	40.387	40.6308	S0°59'01.39836"	E119°54'07.33200"	101.777
ICP01	820319.436	9892626.147	15.55	15.6807	S0°58'12.75908"	E119°52'40.15788"	76.746
ICP02	820707.525	9892977.016	17.542	17.6927	S0°58'01.33497"	E119°52'52.68964"	78.737
ICP03	821648.718	9891875.463	29.203	29.3991	S0°58'37.14083"	E119°53'23.13529"	90.496
ICP04	822592.476	9890588.018	42.286	42.5194	S0°59'18.99277"	E119°53'53.66937"	103.684
ICP06	822925.797	9891136.55	39.374	39.6148	S0°59'01.14052"	E119°54'04.42531"	100.759
palp	823416.883	9898646.222	77.493	77.5923	S0°54'56.85138"	E119°54'20.09068"	138.468

Table 11. Base and ICP coordinates of Area 2

Poin ID	Easting	Northing	Geoid (EGM 96)	Geoid (EGM 2008)	Latitude	Longitude	elipsoid
BM01	826039.944	9864757.265	92.015	92.009	S1°13'19.10055"	E119°55'45.89813"	154.332
BM02	826491.177	9863740.319	100.210	100.185	S1°13'52.16294"	E119°56'00.51666"	162.562
BM03	826042.602	9862714.440	114.336	114.274	S1°14'25.54811"	E119°55'46.05663"	176.672
BM04	825254.908	9862233.194	150.498	150.400	S1°14'41.23019"	E119°55'20.61764"	212.795
BM05	825263.461	9861550.286	138.435	138.313	S1°15'03.44320"	E119°55'20.91859"	200.736
ICP01	825752.592	9864765.338	92.427	92.416	S1°13'18.84815"	E119°55'36.61146"	154.728
ICP02	826511.082	9864253.108	96.099	96.087	S1°13'35.48263"	E119°56'01.14172"	158.446
ICP03	825252.657	9863449.463	102.595	102.535	S1°14'01.66805"	E119°55'20.50151"	164.882
ICP04	825986.666	9862222.089	120.209	120.132	S1°14'41.56499"	E119°55'44.26657"	182.547

ICP05	825333.206	9861552.773	138.533	138.415	S1°15'03.35979"	E119°55'23.17250"	200.839
palp	823416.883	9898646.222	77.493	77.592	S0°54'56.85138"	E119°54'20.09068"	138.468

Lidar Acquisition

Acquired data are stored in point cloud formats. Below is the example of point cloud data.

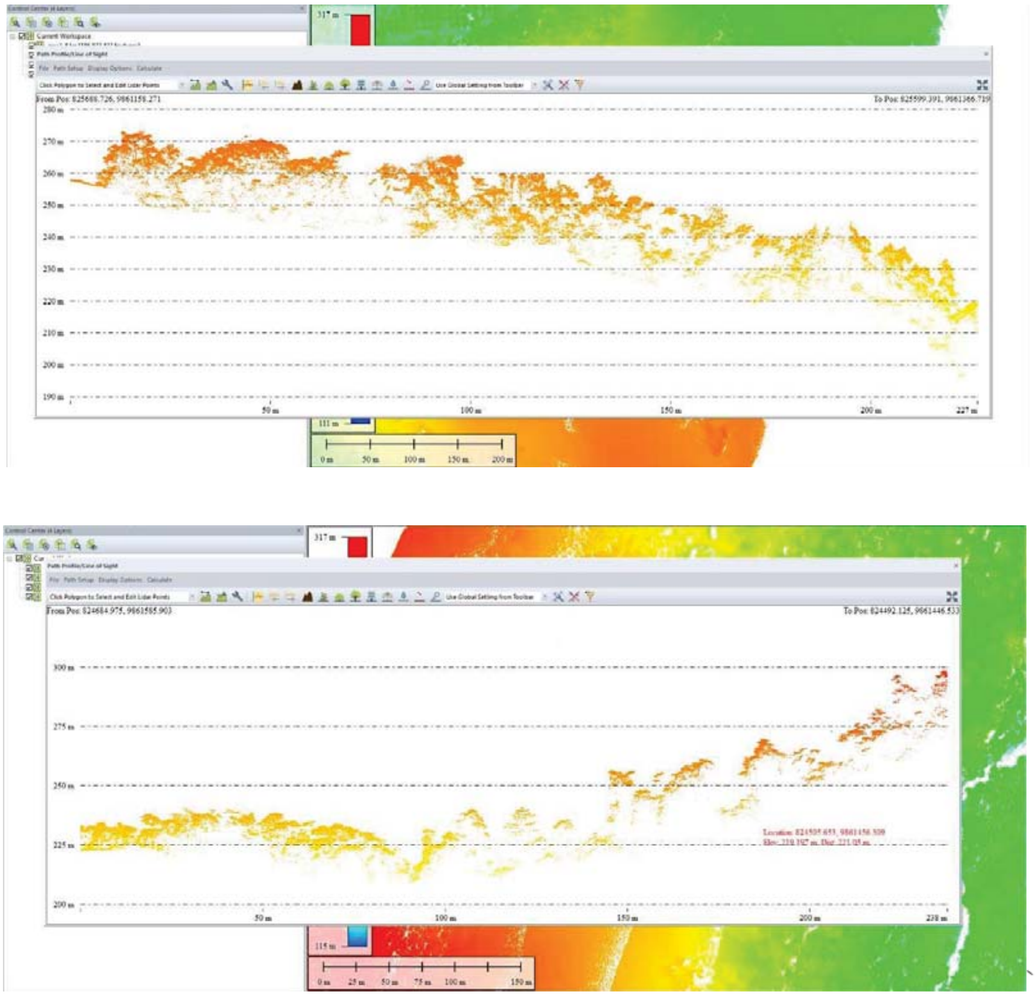


Figure 17. Sample of LiDAR data acquired on survey area

Output Data

Point Cloud

Point cloud is a basic product of LiDAR survey using drone. Each dot is representing position of certain object in x,y,z of known coordinates. Resulted point cloud already corrected in coordinates through PPK system using base station. This information can be assessed on GIS software and can shows cross section of topography in certain area. Point density is around 100-200 points/m^2.

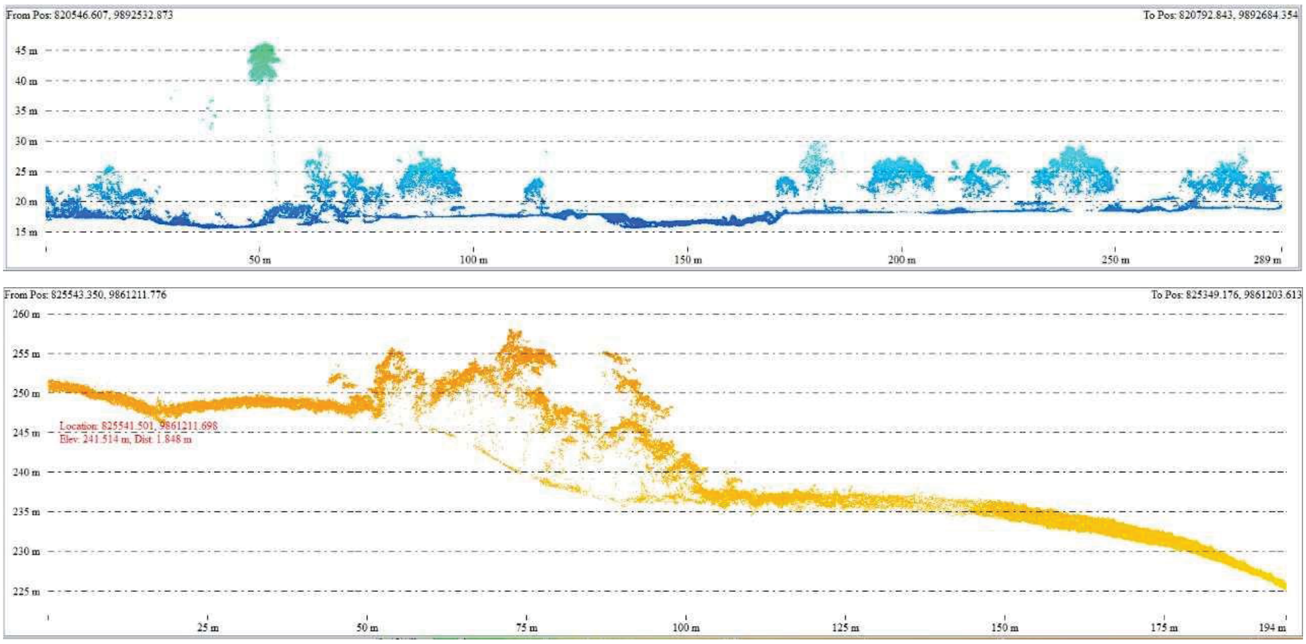
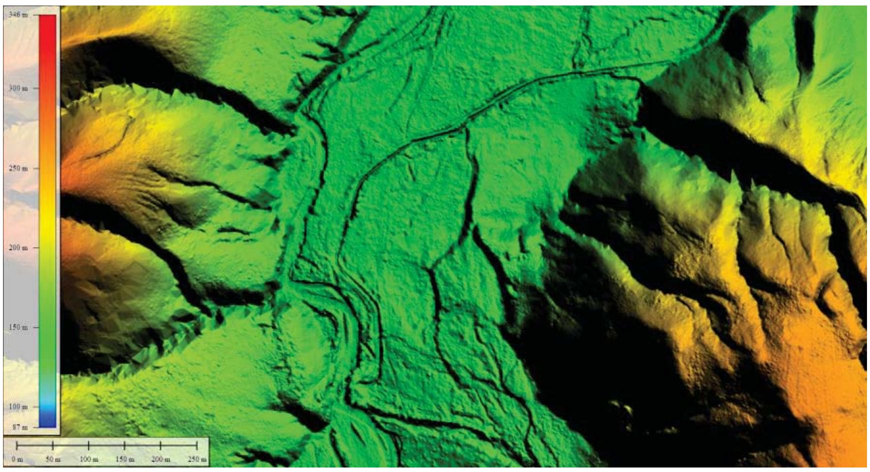


Figure 18. Point cloud sample

Digital Terrain Model

DTM is a numerical representation of the relief of earth surface without objects or features on it (topography). DTM is obtained by filtering DSM data, either automatically using software filtering algorithm or manually using stereo-vector method. In this case, the stereo-vector method is used to produce DTM with high accuracy.



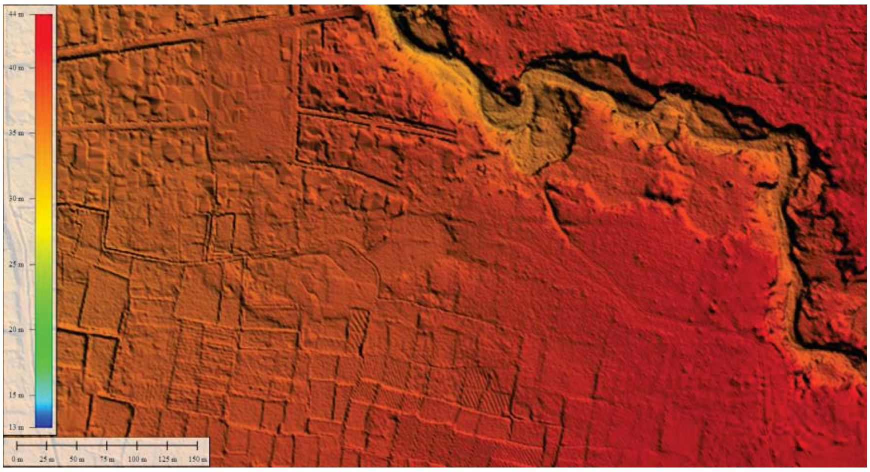


Figure 19. Digital Terrain Model Sample

DTM results are then checked to see the deviation between GCP vertical value as reference point. Accuracy assessment result can be seen in Appendix A.

Contour

Contour is an imaginary line that describes all the points with same height, either above or below an average data set on sea level. Created contours have 1 meter intervals.

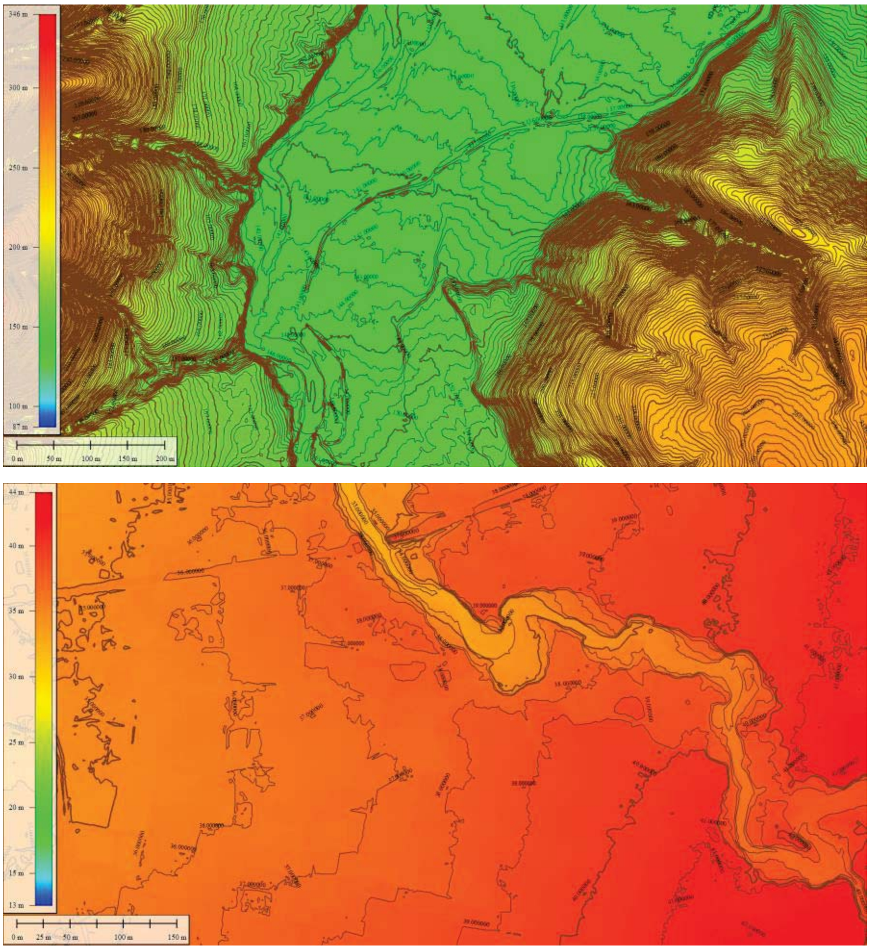


Figure 20. Contour Sample

Closing

Remarks

1. Data acquisition of Drone Topography Survey for a Drone Topographic Survey for Development of Regional Disaster Risk Resilience Plan in Palu for Yachiyo Engineering is performed well and without any casuality.
2. Mobilization and demobilization by Terra Drone Indonesia was conducted smoothly and structured.
3. Aerial mapping acquisition was mostly conducted with Matrice 600 equiped with Yellowscan Surveyor and Phantom 4 Pro to check the mission, with total flight mission is 35 flights within ten day.
4. Total Base Station and ICP installed and used is 21 points.
5. All conducted flights provide 100% score of safety for Personnel for take-off and landing process.

APPENDIX A – ACCURACY ASSESSMENT

調整用基準点調査表

地区名	palu				作業者	松本　鉱明				
					点検者	庄野　航				
		調整用基準点			Lidar			較差		
番号	点名	x	y	z	x	y	z	x	y	z
1	ICP01	820319.40	9892626.15	15.66	820319.80	9892626.07	15.54	0.400	0.077	0.116
2	ICP02	820707.53	9892977.02	17.67	820707.58	9892977.07	17.81	0.055	0.054	0.135
3	ICP03	821648.72	9891875.46	29.40	821648.63	9891875.58	29.32	0.088	0.117	0.082
4	ICP04	822592.48	9890588.02	42.52	822592.40	9890588.14	42.60	0.076	0.122	0.076
5	ICP06	822925.80	9891136.55	39.62	822925.79	9891136.59	39.76	0.007	0.040	0.138
6										
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26										
27										

	データ数	平均値（m）	最大値（m）	最小値（m）	最大値ー最小値	標準偏差
計測範囲全域の水準との差	5	0.110	0.138	0.076	0.062	0.029

調整用基準点調査表

地区名	palu	作業者	松本　鉱明
		点検者	庄野　航

		調整用基準点			Lidar			較差		
番号	点名	x	y	z	x	y	z	x	y	z
1	ICP01	825752.6	9864765.3	92.4	825752.6	9864765.5	92.3	0.012	0.192	0.069
2	ICP02	826511.1	9864253.1	96.1	826511.1	9864253.2	96.1	0.002	0.122	0.033
3	ICP03	825252.7	9863449.5	102.5	825252.8	9863449.5	102.4	0.093	0.057	0.113
4	ICP04	825986.7	9862222.1	120.1	825986.7	9862222.0	120.2	0.006	0.129	0.055
5	ICP05	825333.2	9861552.8	138.4	825333.2	9861552.7	138.5	0.046	0.123	0.041
6										
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	データ数	平均値（m）	最大値（m）	最小値（m）	最大値ー最小値	標準偏差
計測範囲全域の水準との差	5	0.062	0.113	0.033	0.080	0.032

APPENDIX B – DAILY PROGRESS REPORT

DAILY PROGRESS REPORT

TerraDrone

Contractor's Representative Phone:	**E-mail:**

Project	JICA-PAL-02	**Contract Number**	
Location	Palu	**Work Type**	Aerial Mapping (Lidar)
Date	23 March 2019	**Work Order**	

To: Terra Drone Indonesia	Attention: Adi Poetra Pratama	E-mail: adi@terra-drone.co.id
To: JICA	Attention: Junichi Fukushima	E-mail:

A. SURVEY LOCATION

1.	-	Coordinate: -

B. DIARY OF EVENTS

From	To	Activities	Remarks
12.00	13.30	Mobilization to survey Area	
14.00	19.00	Installation and Measurement of 6 Point (4 Base Points, 2 ICPs)	
19.00	20.30	Return to hotel	

C. DAILY WORK SUMMARY – AERIAL IMAGE ACQUISITION

Flight	Duration	Total Area	Progress	Remarks
-	-	-	0%	

D. DAILY WORK SUMMARY – GCP ACQUISITION

GCP Type	Installed	Measured	Progress	Remarks
Temporer	6	6	25%	

E. PERSONNEL AND MAN-HOURS

Personnel	Today Man-Hours	Overall Man-Hours	Remarks
2	11	11	APP, OS

F. SAFETY EVENTS

Activity	Remarks
-	

G. PLAN FOR NEXT DAY

- Measurement of 6 Point in Jono Oge area (2 Base Points, 4 ICPs)

H. COMMENTS

TDID:
-
JICA:
-

I. SIGNATURES

Team Leader	Project Control
Oki Setiawan	**Ray Ozma**

J. PICTURES

Picking materials used for ICP


GPS measurement


Base Point installation


GPS measurement

DAILY PROGRESS REPORT

TerraDrone

Contractor's Representative Phone:	**E-mail:**

Project	JICA-PAL-02	**Contract Number**	
Location	Palu	**Work Type**	Aerial Mapping (Lidar)
Date	24 March 2019	**Work Order**	

To: Terra Drone Indonesia	Attention: Adi Poetra Pratama	E-mail: adi@terra-drone.co.id
To: JICA	Attention: Junichi Fukushima	E-mail:

A. SURVEY LOCATION

1.	-	Coordinate: -

B. DIARY OF EVENTS

From	To	Activities	Remarks
08.30	09.30	Mobilization to survey Area	
09.30	17.00	Installation and Measurement of 6 Point (2 Base Points, 4 ICPs)	
17.00	18.00	Demobilization and afternoon lunch	

C. DAILY WORK SUMMARY – AERIAL IMAGE ACQUISITION

Flight	Duration	Total Area	Progress	Remarks
-	-	-	0%	

D. DAILY WORK SUMMARY – GCP ACQUISITION

Point Type	Installed	Measured	Progress	Remarks
Base Point	6	6	50%	All base point in Jono Oge is measured. Tying to National Point will wait for National Agency reply for CORS
ICP	5	5	50%	All ICPs in Jono Oge is measured.

E. PERSONNEL AND MAN-HOURS

Personnel	Today Man-Hours	Overall Man-Hours	Remarks
2	11	22	APP, OS

F. SAFETY EVENTS

Activity	Remarks
- Using helmet for survey	

G. PLAN FOR NEXT DAY

- Measurement of 5-6 Points in Walatana area
- Making sure all equipment ready
- Picking up the Pilot

H. COMMENTS

TDID:

-

JICA:

-

I. SIGNATURES

Team Leader	Project Control
Oki Setiawan	Ray Ozma

J. PICTURES

GPS measurement on Survey Area

Reaching to the survey area

Reaching to the survey area

GPS measurement on Survey Area

DAILY PROGRESS REPORT

TerraDrone

Contractor's Representative Phone:	**E-mail:**

Project	JICA-PAL-02	**Contract Number**	
Location	Palu	**Work Type**	Aerial Mapping (Lidar)
Date	25 March 2019	**Work Order**	

To: Terra Drone Indonesia	Attention: Adi Poetra Pratama	E-mail: adi@terra-drone.co.id
To: JICA	Attention: Junichi Fukushima	E-mail:

A. SURVEY LOCATION

1.	-	Coordinate: -

B. DIARY OF EVENTS

From	To	Activities	Remarks
08.30	09.00	Picking up Matsumoto	
10.30	11.30	Mobilization to Base Point 1	
12.00	16.00	2 Phantom Flight, 4 Lidar flight	Phantom flight used for checking flight path used for Lidar (via video)
16.00	17.30	Demobilization to Hotel	

C. DAILY WORK SUMMARY – AERIAL IMAGE ACQUISITION

UAV	Flight	Duration	Total Area	Progress	Remarks
Matrice	4	80	50 Ha	6%	
Phantom	2	40	-	6%	

D. DAILY WORK SUMMARY – GCP ACQUISITION

Point Type	Installed	Measured	Progress	Remarks
Base Point	6	6	50%	
ICP	5	5	50%	

E. PERSONNEL AND MAN-HOURS

Personnel	Today Man-Hours	Overall Man-Hours	Remarks
2	11	33	APP, OS

F. SAFETY EVENTS

Activity	Remarks
-	

G. PLAN FOR NEXT DAY

- 6 Matrice Flight

H. COMMENTS

TDID:
-
JICA:
-

I. SIGNATURES

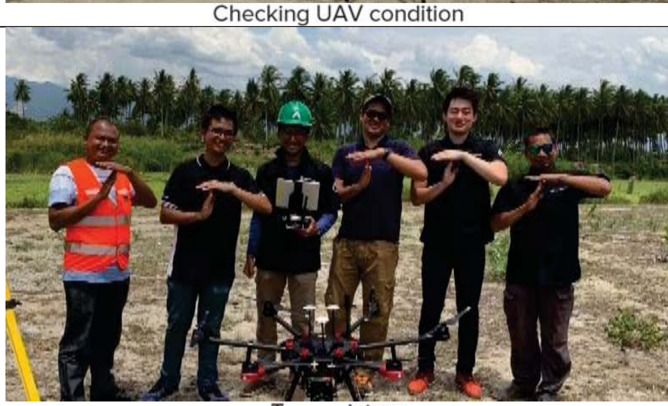
Team Leader	Project Control
Oki Setiawan	**Ray Ozma**

J. PICTURES


Installation of ICP box


Checking UAV condition


Phantom flight of lidar route


Team picture

DAILY PROGRESS REPORT

jica | TerraDrone

Contractor's Representative Phone:	**E-mail:**

Project	JICA-PAL-02	**Contract Number**	
Location	Palu	**Work Type**	Aerial Mapping (Lidar)
Date	26 March 2019	**Work Order**	

To: Terra Drone Indonesia	Attention: Adi Poetra Pratama	E-mail: adi@terra-drone.co.id
To: JICA	Attention: Junichi Fukushima	E-mail:

A. SURVEY LOCATION

1.	-	Coordinate: -

B. DIARY OF EVENTS

From	To	Activities	Remarks
08.00	09.00	Mobilization to site area	
09.30	16.30	2 Phantom Flight, 6 Lidar flight	
16.30	17.30	Demobilization to Hotel	

C. DAILY WORK SUMMARY – AERIAL IMAGE ACQUISITION

UAV	Flight	Duration	Total Area	Progress	Remarks
Matrice	6	120	126 Ha	17%	
Phantom	2	40	-	17%	

D. DAILY WORK SUMMARY – GCP ACQUISITION

Point Type	Installed	Measured	Progress	Remarks
Base Point	6	6	50%	
ICP	5	5	50%	

E. PERSONNEL AND MAN-HOURS

Personnel	Today Man-Hours	Overall Man-Hours	Remarks
2	11	44	APP, OS

F. SAFETY EVENTS

Activity	Remarks
-	

G. PLAN FOR NEXT DAY

- 6 Matrice Flight
- Base point measurement in Walatana

H. COMMENTS

TDID:
-
JICA:
-

I. SIGNATURES

Team Leader	Project Control
Oki Setiawan	Ray Ozma

J. PICTURES

Installation of ICP box

Phantom flight of lidar route

Observing UAV condition by visual

Team picture with JICA representative

DAILY PROGRESS REPORT

TerraDrone

Contractor's Representative Phone:	E-mail:

Project	JICA-PAL-02	**Contract Number**	
Location	Palu	**Work Type**	Aerial Mapping (Lidar)
Date	27 March 2019	**Work Order**	

To: Terra Drone Indonesia	Attention: Adi Poetra Pratama	E-mail: adi@terra-drone.co.id
To: JICA	Attention: Junichi Fukushima	E-mail:

A. SURVEY LOCATION

1.	-	Coordinate: -

B. DIARY OF EVENTS

From	To	Activities	Remarks
08.00	09.00	Mobilization to site area	
09.30	16.30	2 Phantom Flight, 6 Lidar flight	
17.00	19.00	Demobilization to Hotel Ibenk: Mobilization to Walatana	
19.00	24.00	Ibenk: Survey 3 points in Walatana (2 base, 1 ICP)	
24.00	02.00	Ibenk: Demobilization to hotel	

C. DAILY WORK SUMMARY – AERIAL IMAGE ACQUISITION

UAV	Flight	Duration	Total Area	Progress	Remarks
Matrice	6	120	201 Ha	28%	
Phantom	2	40	-	28%	

D. DAILY WORK SUMMARY – GCP ACQUISITION

Point Type	Installed	Measured	Progress	Remarks
Base Point	8	8	73%	
ICP	6	6	60%	

E. PERSONNEL AND MAN-HOURS

Personnel	Today Man-Hours	Overall Man-Hours	Remarks
2	11	55	APP, OS

F. SAFETY EVENTS

Activity	Remarks
-	

G. PLAN FOR NEXT DAY

- 4 Matrice Flight
- Base point and ICP measurements in Walatana

H. COMMENTS

TDID:
-
JICA:
-

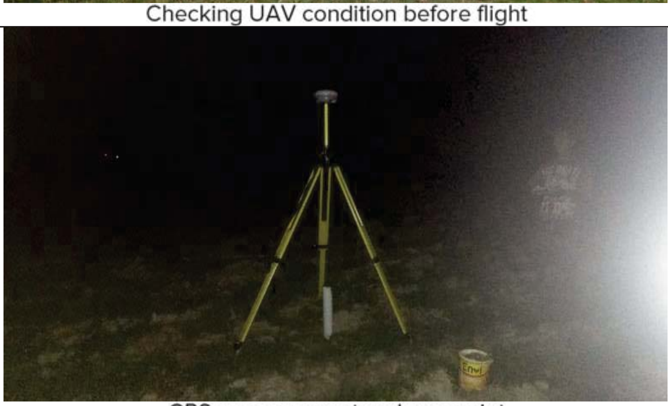
I. SIGNATURES

Team Leader	Project Control
Oki Setiawan	**Ray Ozma**

J. PICTURES


Checking UAV condition before flight


Flight mission of lidar


GPS measurement on base point


Battery charging

DAILY PROGRESS REPORT

JICA | TerraDrone

Contractor's Representative Phone:	E-mail:

Project	JICA-PAL-02	**Contract Number**	
Location	Palu	**Work Type**	Aerial Mapping (Lidar)
Date	28 March 2019	**Work Order**	

To: Terra Drone Indonesia	Attention: Adi Poetra Pratama	E-mail: adi@terra-drone.co.id
To: JICA	Attention: Junichi Fukushima	E-mail:

A. SURVEY LOCATION

1.	-	Coordinate: -

B. DIARY OF EVENTS

From	To	Activities	Remarks
08.00	09.00	Mobilization to site area	
09.30	13.00	2 Phantom Flight, 4 Lidar flight	
13.00	15.00	Demobilization to Hotel Ibenk: Mobilization to Walatana	
16.00	21.00	Ibenk: Survey 5 points in Walatana (2 base, 3 ICP)	
21.00	23.00	Ibenk: Demobilization to hotel	

C. DAILY WORK SUMMARY – AERIAL IMAGE ACQUISITION

UAV	Flight	Duration	Total Area	Progress	Remarks
Matrice	4	80	253 Ha	33%	
Phantom	2	40	-	33%	

D. DAILY WORK SUMMARY – GCP ACQUISITION

Point Type	Installed	Measured	Progress	Remarks
Base Point	10	10	91%	
ICP	9	9	90%	

E. PERSONNEL AND MAN-HOURS

Personnel	Today Man-Hours	Overall Man-Hours	Remarks
2	11	66	APP, OS

F. SAFETY EVENTS

Activity	Remarks
-	

G. PLAN FOR NEXT DAY

- Mobilization to area 2 (Walatana)
- 6 Matrice Flight
- Base point and ICP measurements in Walatana

H. COMMENTS

TDID:
-
JICA:
-

I. SIGNATURES

Team Leader	Project Control
[signature] **Oki Setiawan**	**Ray Ozma**

J. PICTURES

 Checking UAV condition	 Phantom flight of lidar route
2  Flight mission	 GPS observation on night

DAILY PROGRESS REPORT

TerraDrone

Contractor's Representative Phone:	**E-mail:**

Project	JICA-PAL-02	**Contract Number**	
Location	Palu	**Work Type**	Aerial Mapping (Lidar)
Date	29 March 2019	**Work Order**	

To: Terra Drone Indonesia	Attention: Adi Poetra Pratama	E-mail: adi@terra-drone.co.id
To: JICA	Attention: Junichi Fukushima	E-mail:

A. SURVEY LOCATION

1.	-	Coordinate: -

B. DIARY OF EVENTS

From	To	Activities	Remarks
07.30	09.30	Mobilization to site area	
10.00	13.00	2 Phantom Flight, 3 Lidar flight Ibenk: Survey 2 points in Walatana (1 base, 1 ICP)	Rain occurs after 13.00
14.30	17.00	Demobilization to Hotel	

C. DAILY WORK SUMMARY – AERIAL IMAGE ACQUISITION

UAV	Flight	Duration	Total Area	Progress	Remarks
Matrice	3	60	303 Ha	40%	
Phantom	2	40	-	40%	

D. DAILY WORK SUMMARY – GCP ACQUISITION

Point Type	Installed	Measured	Progress	Remarks
Base Point	11	11	100%	
ICP	10	10	100%	

E. PERSONNEL AND MAN-HOURS

Personnel	Today Man-Hours	Overall Man-Hours	Remarks
3	11	77	APP, OS, SY

F. SAFETY EVENTS

Activity	Remarks
-	

G. PLAN FOR NEXT DAY

- 6 Matrice Flight

H. COMMENTS

TDID:
-
JICA:
-

I. SIGNATURES

Team Leader	Project Control
Oki Setiawan	Ray Ozma

J. PICTURES

 Local enthusiasm in UAV related events	 Walking across the river to install ICP box
2  GPS station on base point	 Last check before flight

DAILY PROGRESS REPORT

Contractor's Representative Phone:	**E-mail:**

Project	JICA-PAL-02	**Contract Number**	
Location	Palu	**Work Type**	Aerial Mapping (Lidar)
Date	30 March 2019	**Work Order**	

To: Terra Drone Indonesia	Attention: Adi Poetra Pratama	E-mail: adi@terra-drone.co.id
To: JICA	Attention: Junichi Fukushima	E-mail:

A. SURVEY LOCATION

1.	-	Coordinate: -

B. DIARY OF EVENTS

From	To	Activities	Remarks
07.30	09.30	Mobilization to site area	
10.00	16.00	4 Phantom Flight, 6 Lidar flight	
16.00	18.00	Checking home point	
18.00	20.00	Demobilization to hotel	

C. DAILY WORK SUMMARY – AERIAL IMAGE ACQUISITION

UAV	Flight	Duration	Total Area	Progress	Remarks
Matrice	6	120	~405 Ha	52%	
Phantom	2	40	-	52%	

D. DAILY WORK SUMMARY – GCP ACQUISITION

Point Type	Installed	Measured	Progress	Remarks
Base Point	11	11	100%	
ICP	10	10	100%	

E. PERSONNEL AND MAN-HOURS

Personnel	Today Man-Hours	Overall Man-Hours	Remarks
3	11	88	APP, OS, SY

F. SAFETY EVENTS

Activity	Remarks
-	

G. PLAN FOR NEXT DAY

- 6 Matrice Flight

H. COMMENTS

TDID:
-
JICA:
-

I. SIGNATURES

Team Leader	Project Control
Oki Setiawan	**Ray Ozma**

J. PICTURES


Walking across river to get to the base point


Flight mission


GPS station on base point


Phantom flight

DAILY PROGRESS REPORT

TerraDrone

Contractor's Representative Phone:	**E-mail:**

Project	JICA-PAL-02	**Contract Number**	
Location	Palu	**Work Type**	Aerial Mapping (Lidar)
Date	31 March 2019	**Work Order**	

To: Terra Drone Indonesia	Attention: Adi Poetra Pratama	E-mail: adi@terra-drone.co.id
To: JICA	Attention: Junichi Fukushima	E-mail:

A. SURVEY LOCATION

1.	-	Coordinate: -

B. DIARY OF EVENTS

From	To	Activities	Remarks
07.30	09.30	Mobilization to site area	
10.00	13.30	Waiting for the wind and rain	
13.30	17.00	4 Phantom Flight, 6 Lidar flight	
17.00	17.30	Checking home point	
17.30	19.30	Demobilization to hotel	

C. DAILY WORK SUMMARY – AERIAL IMAGE ACQUISITION

UAV	Flight	Duration	Total Area	Progress	Remarks
Matrice	6	120	~507 Ha	66%	
Phantom	2	40	-	66%	

D. DAILY WORK SUMMARY – GCP ACQUISITION

Point Type	Installed	Measured	Progress	Remarks
Base Point	11	11	100%	
ICP	10	10	100%	

E. PERSONNEL AND MAN-HOURS

Personnel	Today Man-Hours	Overall Man-Hours	Remarks
2	11	99	APP, OS

F. SAFETY EVENTS

Activity	Remarks
-	

G. PLAN FOR NEXT DAY

- 6-7 Matrice Flight

H. COMMENTS

TDID:
-
JICA:
-

I. SIGNATURES

Team Leader	Project Control
Oki Setiawan	Ray Ozma

J. PICTURES

Installation of ICP box

UAV check before flight

2

UAV check before flight

Flight mission

DAILY PROGRESS REPORT

TerraDrone

Contractor's Representative Phone:	**E-mail:**

Project	JICA-PAL-02	**Contract Number**	
Location	Palu	**Work Type**	Aerial Mapping (Lidar)
Date	1 Apri 2019	**Work Order**	

To: Terra Drone Indonesia	Attention: Adi Poetra Pratama	E-mail: adi@terra-drone.co.id
To: JICA	Attention: Junichi Fukushima	E-mail:

A. SURVEY LOCATION

1.	-	Coordinate: -

B. DIARY OF EVENTS

From	To	Activities	Remarks
07.30	09.30	Mobilization to site area	
11.00	15.00	4 Phantom Flight, 6 Lidar flight	
16.00	18.00	Demobilization to hotel	

C. DAILY WORK SUMMARY – AERIAL IMAGE ACQUISITION

UAV	Flight	Duration	Total Area	Progress	Remarks
Matrice	6	120	~607 Ha	80%	
Phantom	4	60	-	80%	

D. DAILY WORK SUMMARY – GCP ACQUISITION

Point Type	Installed	Measured	Progress	Remarks
Base Point	11	11	100%	
ICP	10	10	100%	

E. PERSONNEL AND MAN-HOURS

Personnel	Today Man-Hours	Overall Man-Hours	Remarks
2	11	110	APP, OS

F. SAFETY EVENTS

Activity	Remarks
-	

G. PLAN FOR NEXT DAY

- 6-7 Matrice Flight

H. COMMENTS

TDID:
-
JICA:
-

I. SIGNATURES

Team Leader	Project Control
Oki Setiawan	**Ray Ozma**

J. PICTURES

 Phantom Flight	 UAV check before flight
 Take Off	 Flight mission

	DAILY PROGRESS REPORT	TerraDrone

Contractor's Representative Phone:	**E-mail:**

Project	JICA-PAL-02	**Contract Number**	
Location	Palu	**Work Type**	Aerial Mapping (Lidar)
Date	2 April 2019	**Work Order**	

To: Terra Drone Indonesia	Attention: Adi Poetra Pratama	E-mail: adi@terra-drone.co.id
To: JICA	Attention: Junichi Fukushima	E-mail:

A. SURVEY LOCATION

1.	-	Coordinate: -

B. DIARY OF EVENTS

From	To	Activities	Remarks
07.30	09.30	Mobilization to site area	
11.00	15.00	2 Phantom Flight, 4 Lidar flight	
16.00	18.00	Demobilization to hotel	

C. DAILY WORK SUMMARY – AERIAL IMAGE ACQUISITION

UAV	Flight	Duration	Total Area	Progress	Remarks
Matrice	4	80	~660 Ha	86%	
Phantom	2	30	-	86%	

D. DAILY WORK SUMMARY – GCP ACQUISITION

Point Type	Installed	Measured	Progress	Remarks
Base Point	11	11	100%	
ICP	10	10	100%	

E. PERSONNEL AND MAN-HOURS

Personnel	Today Man-Hours	Overall Man-Hours	Remarks
2	11	110	APP, OS

F. SAFETY EVENTS

Activity	Remarks
-	

G. PLAN FOR NEXT DAY

- 6-7 Matrice Flight

H. COMMENTS

TDID:
-
JICA:
-

I. SIGNATURES

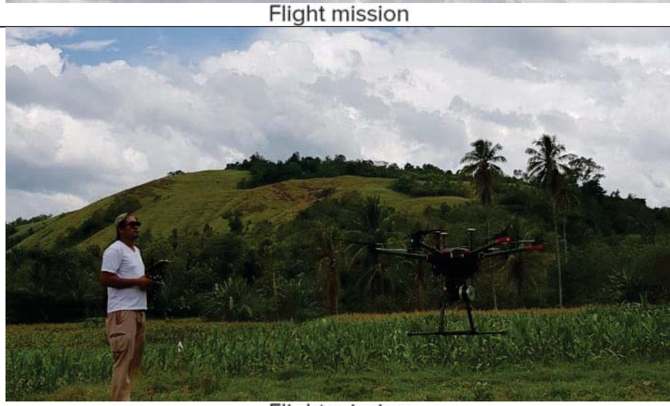
Team Leader	Project Control
Oki Setiawan	**Ray Ozma**

J. PICTURES


ICP Check


Flight mission


Base Station


Flight mission

DAILY PROGRESS REPORT

TerraDrone

Contractor's Representative Phone:	**E-mail:**

Project	JICA-PAL-02	**Contract Number**	
Location	Palu	**Work Type**	Aerial Mapping (Lidar)
Date	3 April 2019	**Work Order**	

To: Terra Drone Indonesia	Attention: Adi Poetra Pratama	E-mail: adi@terra-drone.co.id
To: JICA	Attention: Junichi Fukushima	E-mail:

A. SURVEY LOCATION

1.	-	Coordinate: -

B. DIARY OF EVENTS

From	To	Activities	Remarks
07.30	09.30	Mobilization to site area	
11.00	15.00	4 Phantom Flight, 6 Lidar flight	
16.00	18.00	Demobilization to hotel	

C. DAILY WORK SUMMARY – AERIAL IMAGE ACQUISITION

UAV	Flight	Duration	Total Area	Progress	Remarks
Matrice	6	120	~750 Ha	100%	
Phantom	4	60	-	100%	

D. DAILY WORK SUMMARY – GCP ACQUISITION

Point Type	Installed	Measured	Progress	Remarks
Base Point	11	11	100%	
ICP	10	10	100%	

E. PERSONNEL AND MAN-HOURS

Personnel	Today Man-Hours	Overall Man-Hours	Remarks
2	11	110	APP, OS

F. SAFETY EVENTS

Activity	Remarks
-	

G. PLAN FOR NEXT DAY

- Waiting for data confirmation

H. COMMENTS

TDID:
-
JICA:
-

I. SIGNATURES

Team Leader	Project Control
Oki Setiawan	**Ray Ozma**

J. PICTURES

Phantom Flight

Flight mission

2

Flight mission

Team Photo

DAILY PROGRESS REPORT

TerraDrone

Contractor's Representative Phone:	E-mail:

Project	JICA-PAL-02	**Contract Number**	
Location	Palu	**Work Type**	Aerial Mapping (Lidar)
Date	4 April 2019	**Work Order**	

To: Terra Drone Indonesia	Attention: Adi Poetra Pratama	E-mail: adi@terra-drone.co.id
To: JICA	Attention: Junichi Fukushima	E-mail:

A. SURVEY LOCATION

1.	-	Coordinate: -

B. DIARY OF EVENTS

From	To	Activities	Remarks
07.30	18.00	Waiting for data confirmation	

C. DAILY WORK SUMMARY – AERIAL IMAGE ACQUISITION

UAV	Flight	Duration	Total Area	Progress	Remarks
Matrice	0	0	~750 Ha	100%	
Phantom	0	0	-	100%	

D. DAILY WORK SUMMARY – GCP ACQUISITION

Point Type	Installed	Measured	Progress	Remarks
Base Point	11	11	100%	
ICP	10	10	100%	

E. PERSONNEL AND MAN-HOURS

Personnel	Today Man-Hours	Overall Man-Hours	Remarks
2	11	110	APP, OS

F. SAFETY EVENTS

Activity	Remarks
-	

G. PLAN FOR NEXT DAY

- Waiting for data confirmation
- Plan for Demobilization

H. COMMENTS

TDID:

-

JICA:

-

I. SIGNATURES

Team Leader	Project Control
Oki Setiawan	**Ray Ozma**

J. PICTURES

DAILY PROGRESS REPORT

TerraDrone

Contractor's Representative Phone:	E-mail:

Project	JICA-PAL-02	**Contract Number**	
Location	Palu	**Work Type**	Aerial Mapping (Lidar)
Date	5 April 2019	**Work Order**	

To: Terra Drone Indonesia	Attention: Adi Poetra Pratama	E-mail: adi@terra-drone.co.id
To: JICA	Attention: Junichi Fukushima	E-mail:

A. SURVEY LOCATION

1.	-	Coordinate: -

B. DIARY OF EVENTS

From	To	Activities	Remarks
07.30	18.00	Waiting for data confirmation and plan for demobilization	

C. DAILY WORK SUMMARY – AERIAL IMAGE ACQUISITION

UAV	Flight	Duration	Total Area	Progress	Remarks
Matrice	0	0	~750 Ha	100%	
Phantom	0	0	-	100%	

D. DAILY WORK SUMMARY – GCP ACQUISITION

Point Type	Installed	Measured	Progress	Remarks
Base Point	11	11	100%	
ICP	10	10	100%	

E. PERSONNEL AND MAN-HOURS

Personnel	Today Man-Hours	Overall Man-Hours	Remarks
2	11	110	APP, OS

F. SAFETY EVENTS

Activity	Remarks
-	

G. PLAN FOR NEXT DAY

- Demobilization

H. COMMENTS

TDID:
-
JICA:
-

I. SIGNATURES

Team Leader	Project Control
 **Oki Setiawan**	**Ray Ozma**

J. PICTURES

DAILY PROGRESS REPORT

TerraDrone

Contractor's Representative Phone:	**E-mail:**

Project	JICA-PAL-02	**Contract Number**	
Location	Palu	**Work Type**	Aerial Mapping (Lidar)
Date	6 April 2019	**Work Order**	

To: Terra Drone Indonesia	Attention: Adi Poetra Pratama	E-mail: adi@terra-drone.co.id
To: JICA	Attention: Junichi Fukushima	E-mail:

A. SURVEY LOCATION

1.	-	Coordinate: -

B. DIARY OF EVENTS

From	To	Activities	Remarks
07.00	09.30	Demobilization	

C. DAILY WORK SUMMARY – AERIAL IMAGE ACQUISITION

UAV	Flight	Duration	Total Area	Progress	Remarks
Matrice	0	0	~750 Ha	100%	
Phantom	0	0	-	100%	

D. DAILY WORK SUMMARY – GCP ACQUISITION

Point Type	Installed	Measured	Progress	Remarks
Base Point	11	11	100%	
ICP	10	10	100%	

E. PERSONNEL AND MAN-HOURS

Personnel	Today Man-Hours	Overall Man-Hours	Remarks
2	11	110	APP, OS

F. SAFETY EVENTS

Activity	Remarks
-	

G. PLAN FOR NEXT DAY

H. COMMENTS

TDID:
-
JICA:
-

I. SIGNATURES

Team Leader	Project Control
Oki Setiawan	**Ray Ozma**

J. PICTURES