

August 1-3, Foundation University, Dumaguete



PIISIITAA NGIIMIIAAAPAA

open data & software • free maps • community • talks • workshops



KAART



Mapillary UΔV4GEO

DRONE-SUPPORTED SURVEYING

UNMANNED AERIAL SYSTEM
FOR LAND SURVEYS IN THE
PHILIPPINES



OMIDYAR
NETWORK



The Asia Foundation

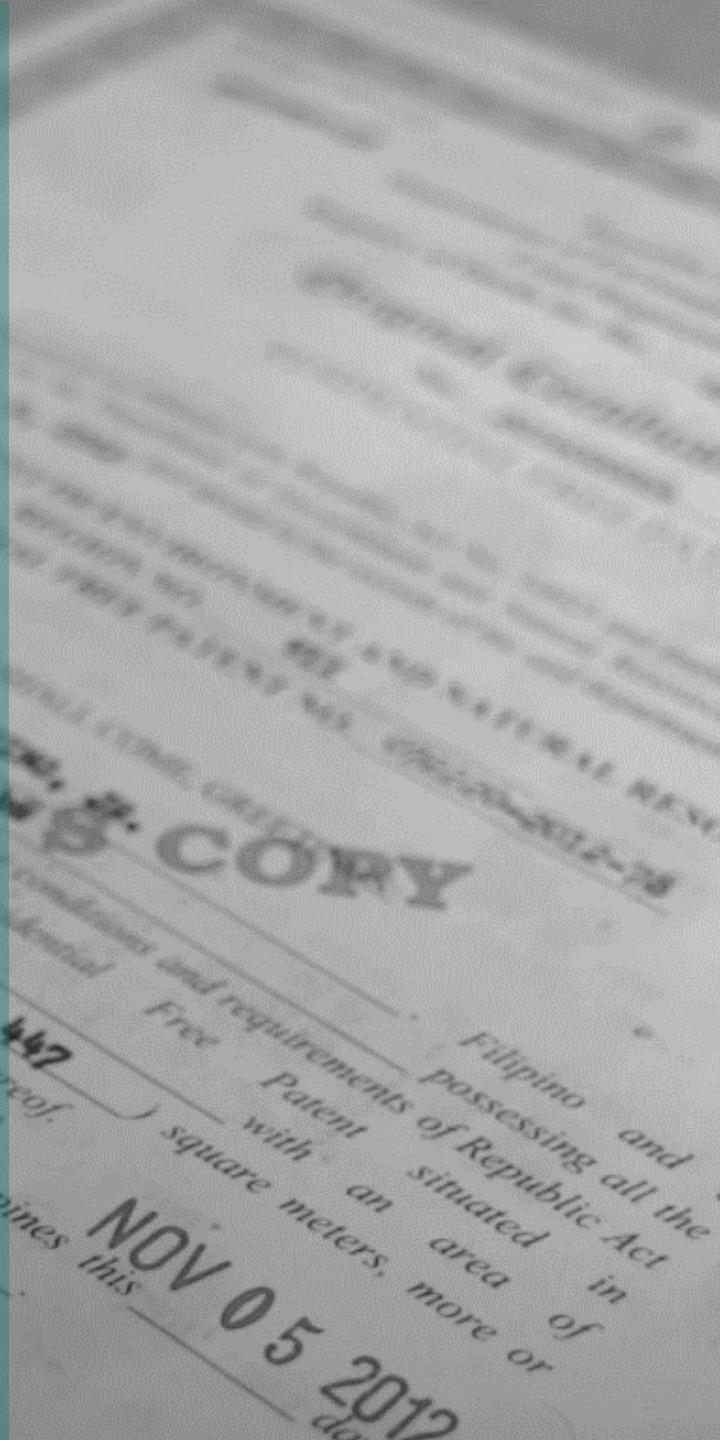


BACKGROUND

Approximately **6-8 million** untitled land parcels

Constricted land market hinders poverty reduction and economic development

Land tenure security is one of the major challenges in the Philippines



BENEFITS OF SECURED LAND TENURE

Increases social inclusion

Improves prospects of peace

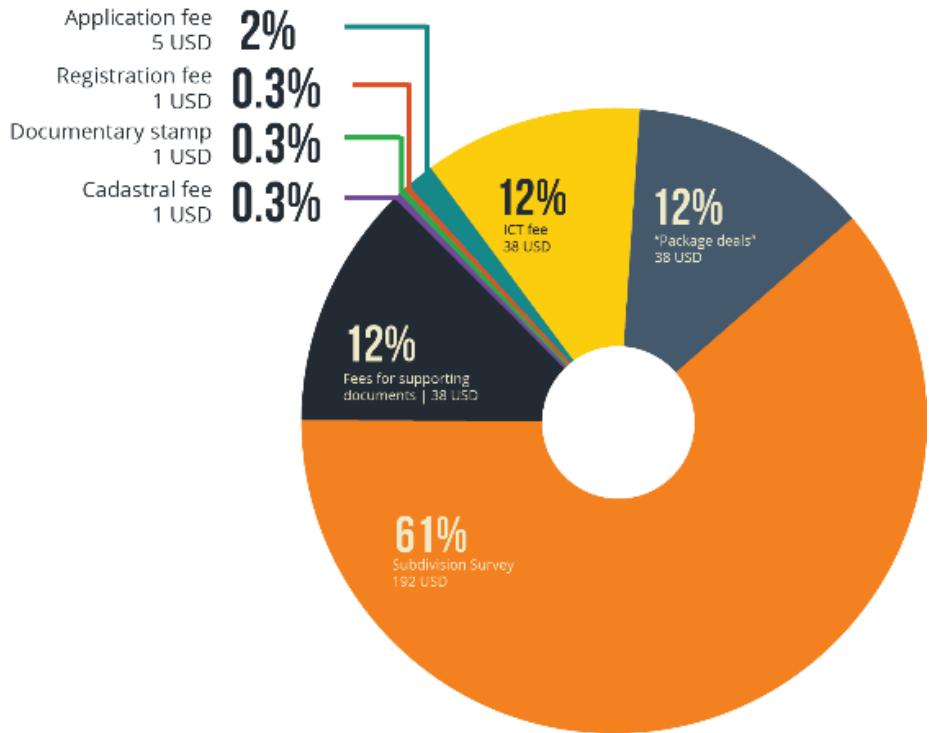
Increases economic opportunities

Improves governance

Promote environmental protection
and resilience

Total cost of land titling application In the Philippines: **314 USD**

Subdivision survey constitutes
61% of the total cost of
land titling application



It discourages land owners from
applying for titles

TECHNOLOGY FOR PROPERTY RIGHTS



The Asia Foundation



A project of the **Foundation for Economic Freedom**, supported by **The Asia Foundation** and **Omidyar Network**, which started in 2016, that promotes policies, partnerships and technologies to facilitate land titling.

Drone-supported Survey



Introduces drones as alternative surveying technique

Aims to show that surveys using UAVs can meet government accuracy standards and that it is cost effective and time-efficient

Philippines is one of the **pioneers in Asia** to use drone for land surveying and land titling.

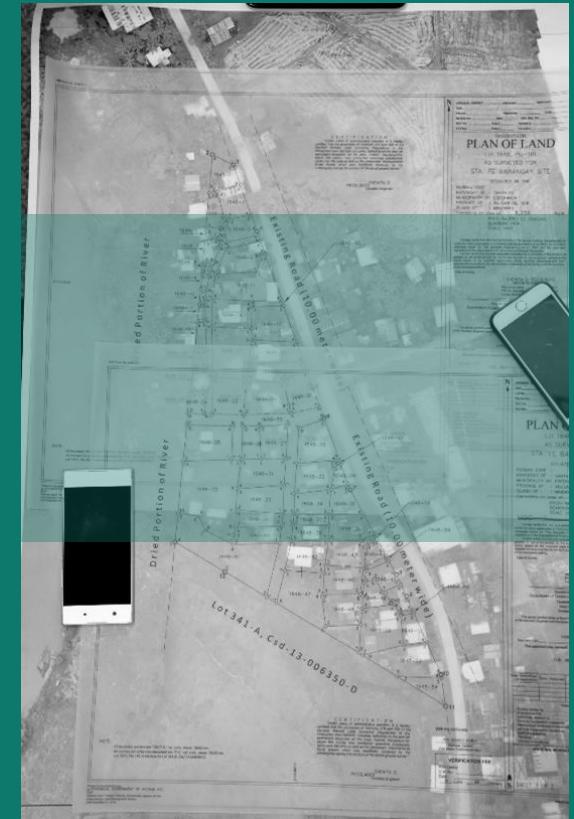
Study and Policy Development



Pilot study
2016 – Cordova Cebu



**Research study with
DENR-LMB and UPDGE**
2017 – Norzagaray, Bulacan



**Policy development
and discussions**
2017 after study was completed

Partners



Department of Environment and Natural Resources
– Land Management Bureau

University of the Philippines – Department of
Geodetic Engineering



Republic of the Philippines

Department of Environment and Natural Resources

LAND MANAGEMENT BUREAU

LMB Building, Plaza Cervantes, Binondo, Manila

LMB Memorandum Circular
No. 2017-003

27 DEC 2017

SUBJECT : ADOPTION ON THE ALTERNATIVE USE OF UNMANNED
AERIAL SYSTEMS (UAS) IN THE CONDUCT OF LAND
SURVEY

LMB TECHNICAL BULLETIN No. 2 Series of 2017

GUIDELINES ON THE USE OF UNMANNED
AERIAL SYSTEMS (UAS) IN SUPPORT OF
LAND SURVEY

Policy Issuance and Implementation

DENR-LMB issued **Land Management Circular No. 2017-003** and **Technical Bulletin No. 2 series of 2017** on December 2017.

It opened up opportunities for the Geodetic Engineering community to learn about the new drone technology and its application in supporting land surveys.

Sample Drones Covered by the Policy Issuance



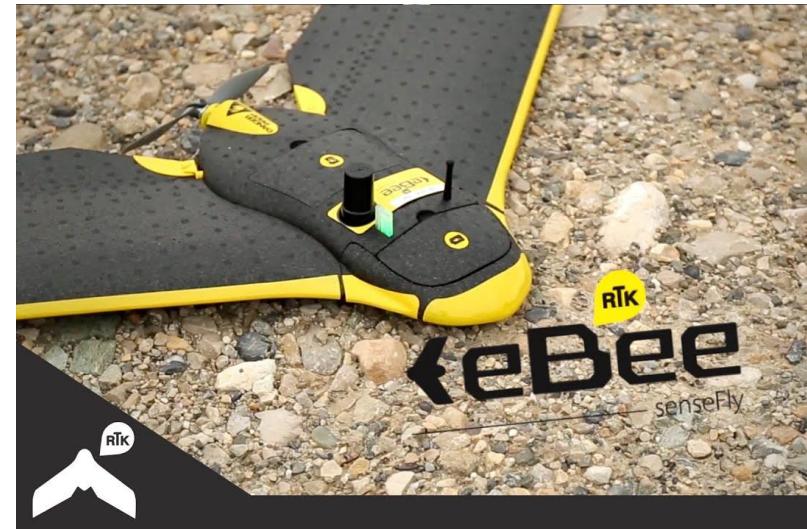
DJI Phantom 4 Pro



Trimble UX5HP



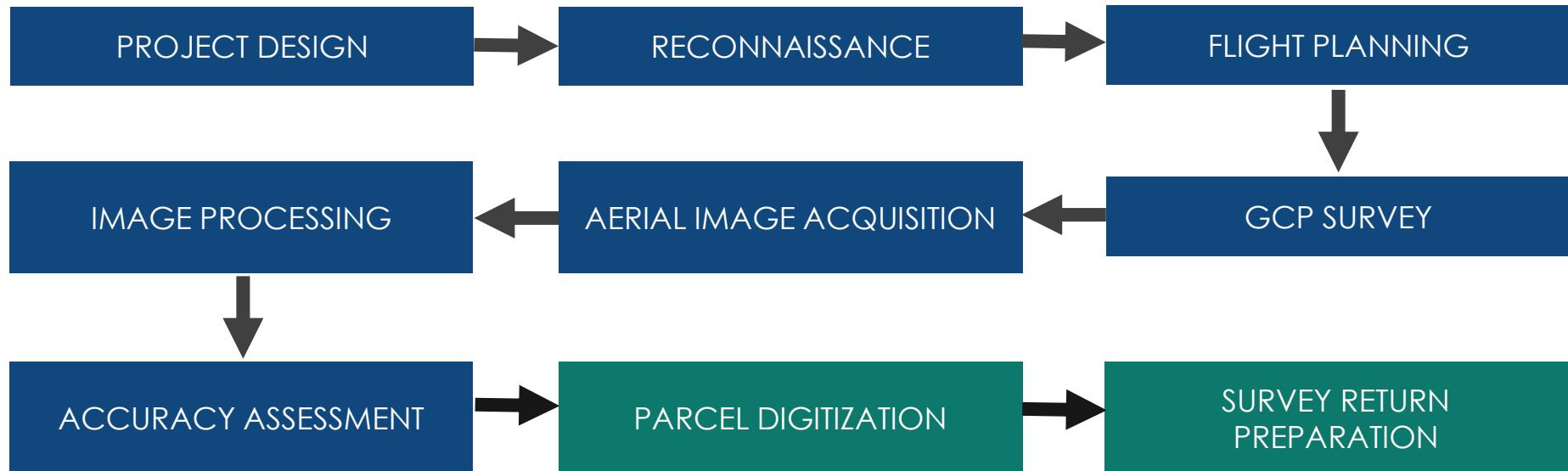
Parrot ANAFI Work UAV



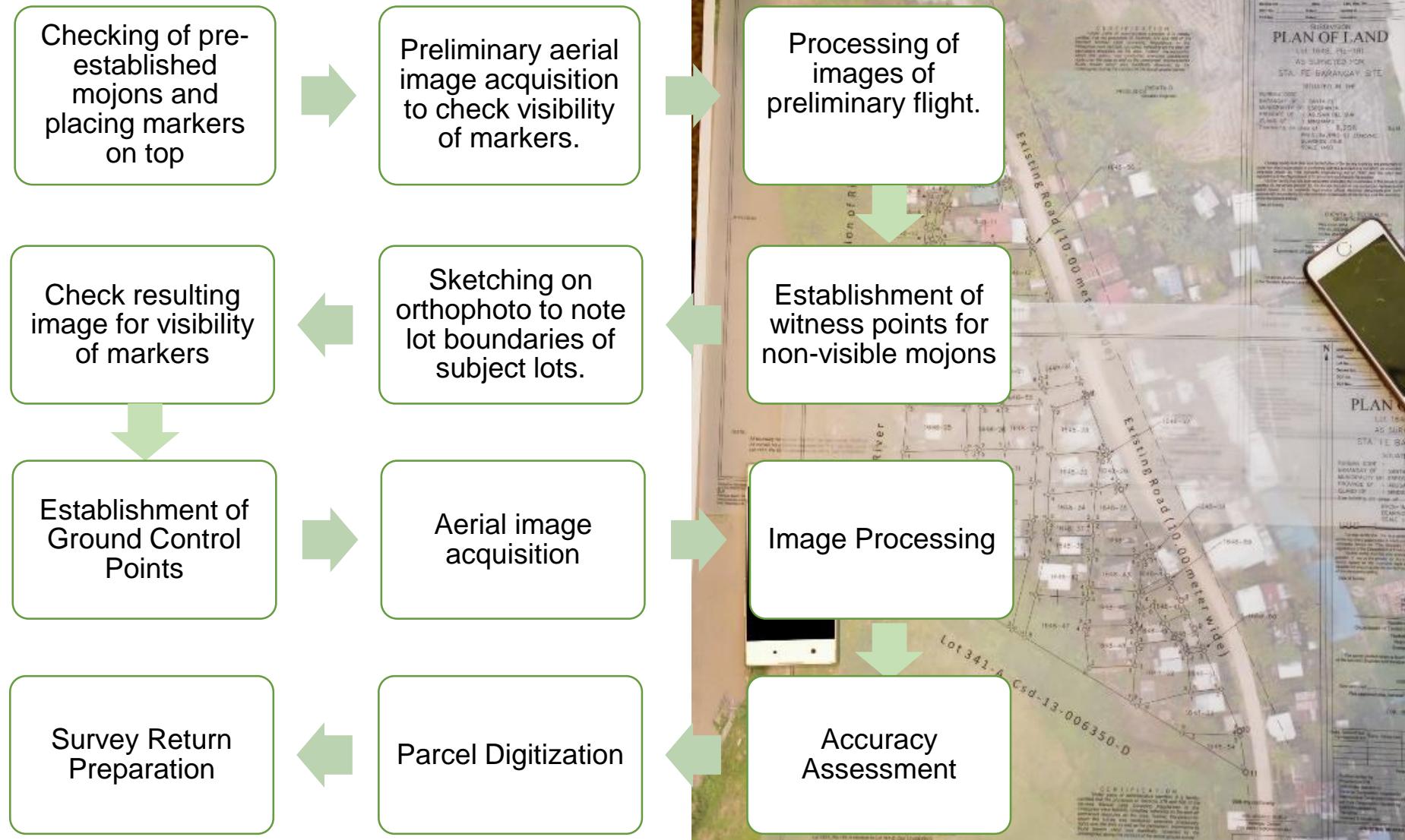
RANGE OF PRODUCTS

- DEM / DTM / DSM (surface models)
- Orthophoto's (geospatially corrected aerial images)
- 3D Building Models
- Contour Maps
- Planimetric features (road edges, heights, signs, building footprints, etc)
- Volumetric Surveys

TYPICAL UAS MAPPING WORKFLOW



Actual Methodology



PROJECT DESIGN

RECONNAISSANCE

FLIGHT PLANNING

GCP SURVEY

AERIAL IMAGE
ACQUISITION

IMAGE PROCESSING

ACCURACY
ASSESSMENT

PARCEL DIGITIZATION

SURVEY RETURN
PREPARATION

PROJECT DESIGN

All technical and logistical needs are considered, so that UAS data acquisition will be successful.

- Area to be mapped
- UAV type, sensor specifications
- Accuracy requirement
- Number of ground based equipment such as GNSS
- Selection of the appropriate reference control point
- number of control points (at least 3, located at periphery)
- Coordinate Reference System Tied to Philippine Reference System of 1992

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RECONNAISSANCE

- Ocular inspection of the area, to gather additional inputs for planning and implementation
- Coordination with the respective local government units
- Recover old and existing control points
- Check for possible obstruction of UAS flight or ground survey
- Locations of ground markers and the material of marker

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FLIGHT PLANNING

- Pertains to the flight lines that the drone will follow to accomplish its mission
- Recommended forward overlap: 60%
- Recommended side overlap: 70%

TAKE INTO ACCOUNT THE FOLLOWING:

DRONE SPECIFICATIONS (wind speed, altitude, work radius limit, camera sensor, launching and landing, flight time)

TERRAIN AND FLIGHT HEIGHT

- ✓ Flight limits (400 feet or 121 meters)

Photogrammetry requires each point to be captured from at least three positions. This will capture each point many times, so that if the drone fails to trigger a photo exactly on time or goes slightly off course, you will still capture every feature at least three times.

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GROUND CONTROL SURVEY

Corner marker



Figure 3.2 -1 Ground Control Survey using a survey grade GNSS



INCLUDES THE FOLLOWING ACTIVITIES

1. Establishment of ground control points
2. GNSS GCP Control Survey
3. Establishment of lot corner markers
4. Generation of validation points

ESTABLISHMENT OF GROUND CONTROL POINT MARKERS

- Flat surface
- Visible on the orthoimage
- Suitable for GNSS observations
- Semi-permanent in nature



GNSS GCP CONTROL SURVEY

- Survey grade equipment
- Baseline < 5km: 30mins – 1hr GNSS observation
- Session documentation
- GNSS data is post-processed
- Reference options
- Same tie point
- Common point method



ESTABLISHMENT OF LOT CORNER MARKERS

Lot corner monuments must be visible on the orthoimage

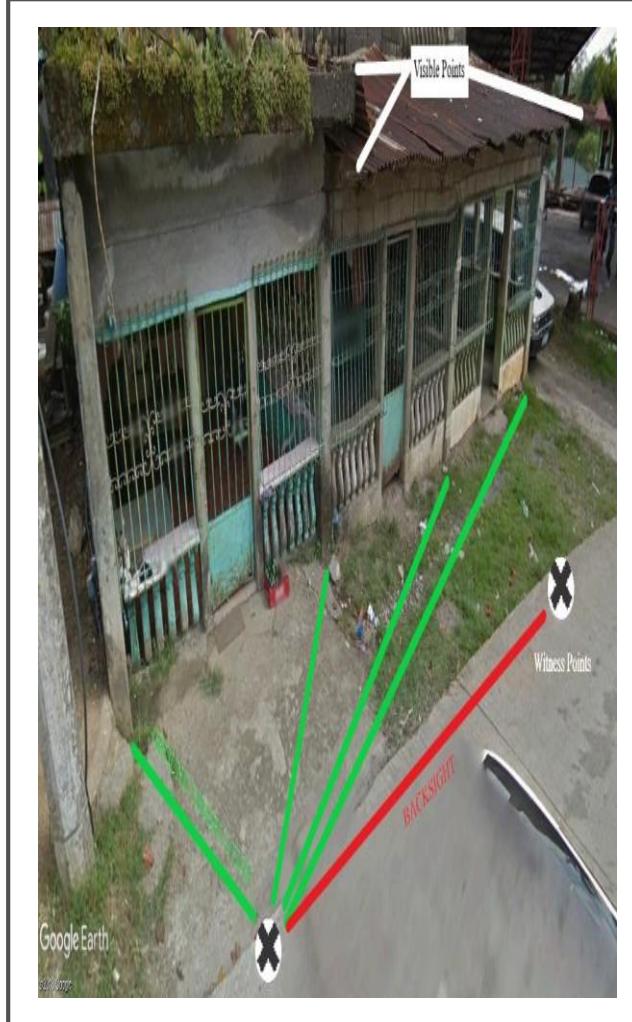
- Paint the top of the monument
- Clear vertical obstructions



ESTABLISHMENT OF LOT CORNER MARKERS

Witness points

- Not lot corner
- Visible on the orthoimage
- May be used as reference for baseline



GROUND MARKER



LOT CORNER MONUMENT



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AERIAL IMAGE ACQUISITION

- Different UAS fly in different ways (e.g., banking for some fixed-wing UAS)
- Last-minute pre-flight preparations and revisions
 - weather
 - current situation on the take-off/landing sites
 - disturbances that may have happened to the ground markers.
- Rapid post-processing of the images: needed to ensure completeness and quality of data acquired before leaving the site.
- GE must be present throughout the data acquisition process to provide guidance, and ensure that SOP's and plans are followed.



PIX4D RAPID PROCESSING OUTPUT



**PIX4D RAPID
PROCESSING OUTPUT**



GROUND MARKER



**PIX4D RAPID
PROCESSING OUTPUT**

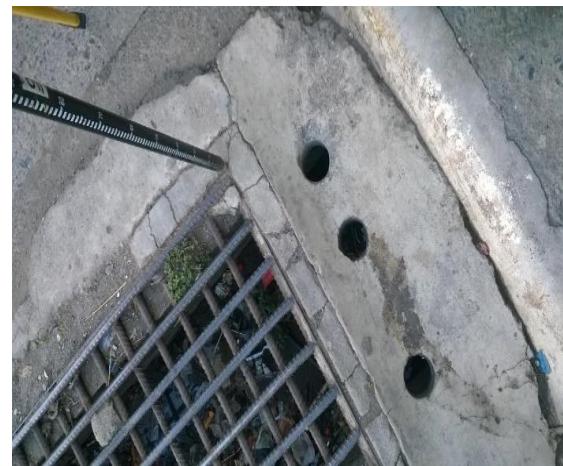


**LOT CORNER
MONUMENT**



GENERATION OF VALIDATION POINTS

- **Visible features readily observed on the processed orthoimage**
 - Additional GCPs
 - Lot corners
 - Witness points
 - Corners of structures
 - Road intersection
- **Same coordinate system**



PROJECT DESIGN

RECONNAISSANCE

FLIGHT PLANNING

GCP SURVEY

AERIAL IMAGE
ACQUISITION

IMAGE PROCESSING

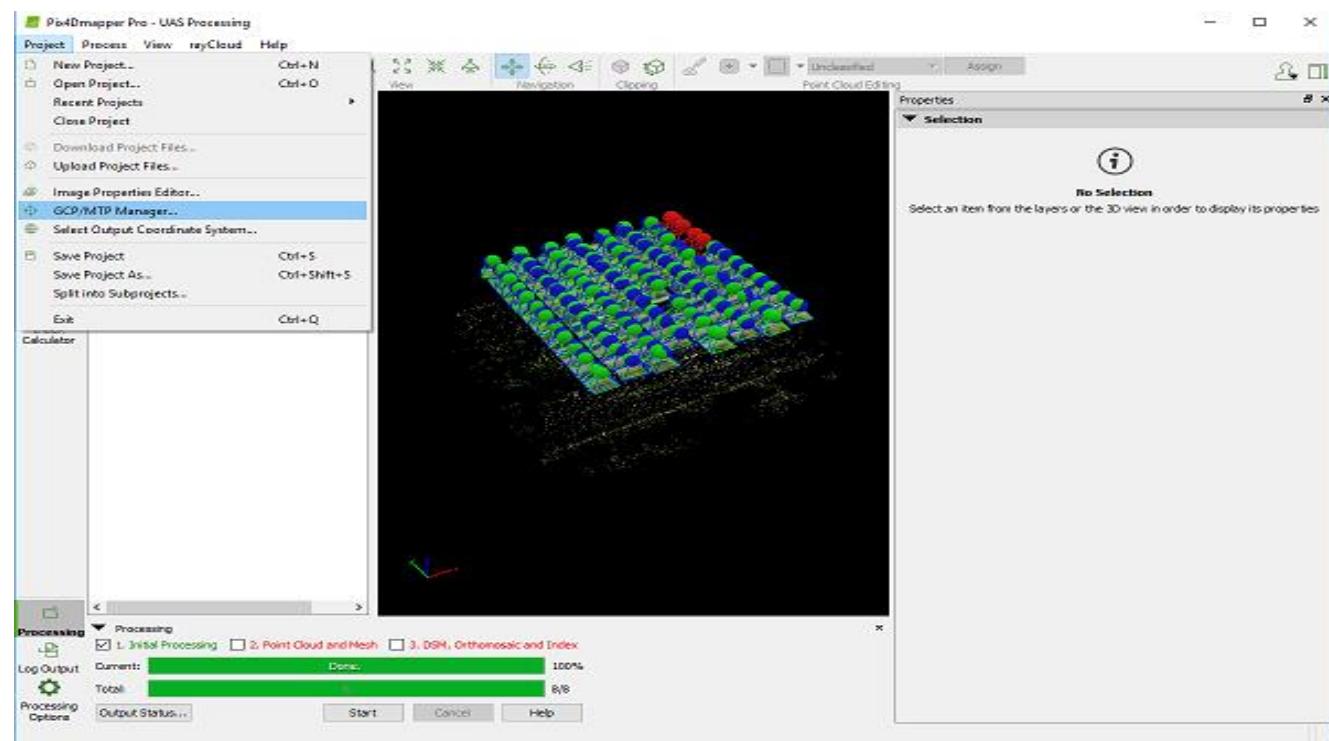
ACCURACY
ASSESSMENT

PARCEL DIGITIZATION

SURVEY RETURN
PREPARATION

IMAGE PROCESSING

- Uses the UAV captured images as input
- Integrates the GCPs with coordinates and drone's GPS flight log
- Images are analyzed by the processing software to identify matching points
- Matching points are used to "stitch" the individual photos into a single orthomosaic.



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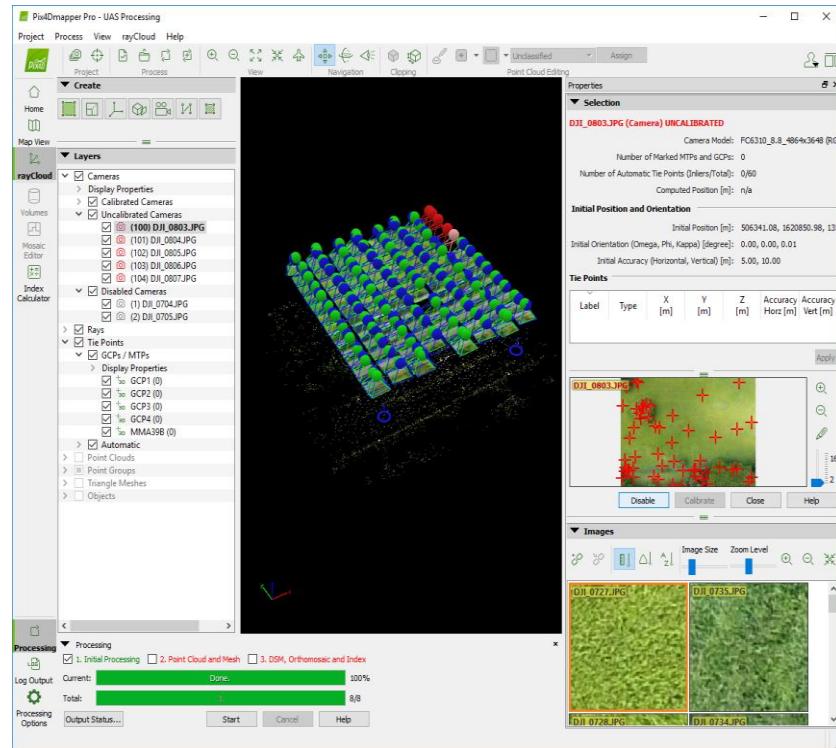
IMAGE PROCESSING

ACCURACY ASSESSMENT

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ACCURACY ASSESSMENT



Accuracy Assessment using the Root Mean Square Error (RMSE)

Accuracy Assessment from Vectorization or Digitization

Label:	GCP1
Type:	3D GCP
X [m]:	506244.465
Y [m]:	1620856.733
Z [m]:	97.806
Horizontal Accuracy [m]:	0.020
Vertical Accuracy [m]:	0.020
Number of Marked Images:	6
S_0^2 [pixel]:	0.2124
Theoretical Error $S(X,Y,Z)$ [m]:	0.003, 0.004, 0.016
Maximal Orthogonal Ray Distance $D(X,Y,Z)$ [m]:	-0.004, 0.013, 0.001
Error to GCP Initial Position [m]:	1.038, -6.382, 27.580
Initial Position [m]:	506244.465, 1620856.733, 97
Computed Position [m]:	506243.427, 1620863.115, 70

Automatic Marking Apply Cancel Help

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PARCEL DIGITIZATION

Generating parcel information by digitizing the pre-marked lot corners visible on the image.

- It must be guided by a sketch showing the relationship of each point that make up a line and the relationship of each line that make up a polygon.



Snapshots of the orthoimage indicating the location of corners

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**SURVEY RETURN
PREPARATION**

SURVEY RETURN PREPARATION

Survey returns are required to make the survey official through DENR and LRA.

This refers to the lot data computation and the survey plan itself. Other requirements include a soft copy of the orthophoto map, RINEX data, field notes cover, among others.

They go through Inspection, Verification, Approval of Survey (IVAS) process.



Orthophoto with Parcels Overlaid at Brgy. Sta Fe, Esperanza,
Agusan del Sur

CERTIFICATION
THIS IS TO CERTIFY THAT the survey was made AND under
Project No. _____ Block No. _____ Lot No. _____
Certified on _____

Certified by: _____
FOR NORMAN A. ASUGAN
CENH Officer

NOTE:
All boundary corners are "Old P.R." type, more 15x17 cm.
All corners not otherwise described are "P.S." cut, conc. more 25x50 cm.

CERTIFICATION
I hereby certify that the above survey is correct, it is hereby
submitted in accordance with Sections 278 and 280 of the
Revised Act of 1987 on Surveying. Regulations in the
Philippines were faithfully complied reflecting on the plan all
pertinent findings on the area. Further, the person for
whom this plan is made has been advised of the survey results
and the areas as well as the permanent improvements
and other items which were reasonably observed by the
undersigned during the conduct of the actual ground survey.

CHENITA D. PECOLADOS
Surveyor/Engineer

CHENITA D. PECOLADOS
Surveyor/Engineer

**SUBDIVISION
PLAN OF LAND**
Lot 1648, Pls-181
AS SURVEYED FOR
STA. FE BARANGAY SITE
SITUATED IN THE

RURBAN CODE :
BARANGAY OF : SANTA FE
MUNICIPALITY OF: ESPERANZA
PROVINCE OF : AGUSAN DEL SUR
ISLAND OF : MINDANAO
Containing an area of 8,528 Sq.M.
PPCS-TM/PRS-92 ZONE/VNO:
BEARINGS TRUE
SCALE 1:500

I hereby certify that this is a certified plan of the survey made by me personally or
under my direct supervision in conformity with the provisions of R.A. 8030 as amended,
otherwise known as "The Geodetic Engineering Act of 1987" and the rules and
regulations issued thereunder and the corresponding National Standards.

I further certify that this plan accurately indicates the boundaries of the property as
plotted to scale on the ground by the survey engineer or his authorized representative
and/or based on the available legal and/or official recording documents and that I
assume full responsibility for the technical correctness of the survey and the accuracy
of the monumenting.

Date of Survey: _____

CHENITA D. PECOLADOS
GEODETIC ENGINEER
PRC ID No. 9094 Date 01-12-2013
PTB No. EGS398 Date 01-12-2018
TB No. 454-005-72

TO:
Republic of the Philippines
Department of Environment and Natural Resources
Technical Services
Regional Office II
Antipolo, Rizal City

The survey plotted herein is found to be in order as per submitted survey return
of the Geodetic Engineer and therefore recommended for approval.

ARTHUR S. GERMAN
Chair, SURVEYS AND MAPPING DIVISION
Date Approved: _____
This approved plan, however, shall not be construed as title to the land.

FOR BEN-ALI B. DECAMPO, AL-HADJ
O/C, ASST. REGIONAL
DIRECTOR FOR TECHNICAL

Date Submitted	Date Returned	Remarks	Documents Received by:

Printed Name & Signature _____ Date _____

Position verified by: _____
Project on P.R. _____ # sq.m. _____
Field Notes checked by: _____
Traverse Computer checked by: _____
Area Computed checked by: _____
Lot Data Computer checked by: _____
CADD/Plotter checked by: _____
Traced by: _____
Checked & Verified by: _____

ADDITIONAL INFORMATION AFTER DATE OF APPROVAL

Nikon SurveyPro Software 2017 (v7.0) created by Samson S. Alonto

Capacity-building & Training

To provide comprehensive training material to numerous government professionals, academic institutions, various organizations, and private practitioners who can fully increase awareness and understanding of the value of drone-assisted surveying.





Participants during the Test Run training on Drone-Supported Surveying last Feb. 26-Mar. 1, 2019



Participants during the Visayas-wide rollout on Drone-Supported Surveying last May 7-10, 2019



Participants during the Luzon-wide training on Drone-Supported Surveying last May 28-31, 2019



Participants during the Mindanao-wide training on Drone-Supported Surveying last July 26-28, 2019

Takeaways

- Low-cost commercial drones with appropriate specifications can also achieve accuracy set by survey standards
- For such drones, establishment of GCPs is important to increase accuracy of the measurement and to conform to a geodetic coordinate system

MARAMING SALAMAT! SAUO