

August 1-3, Foundation University, Dumaguete



PISTATA ING MAPA

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



KAART



mapbox



Mapillary UΔV4GEO

DRONE-SUPPORTED SURVEYING

UNMANNED AERIAL SYSTEM FOR LAND SURVEYS IN THE PHILIPPINES



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

The background of the slide features a blurred image of a document. The document contains various lines of text, including the word 'COPY' in large, bold letters. At the bottom of the document, there is a date stamp that reads 'NOV 05 2012'. The overall tone of the background is light and professional.

BENEFITS OF SECURED LAND TENURE

Increases social inclusion

Improves prospects of peace

Increases economic opportunities

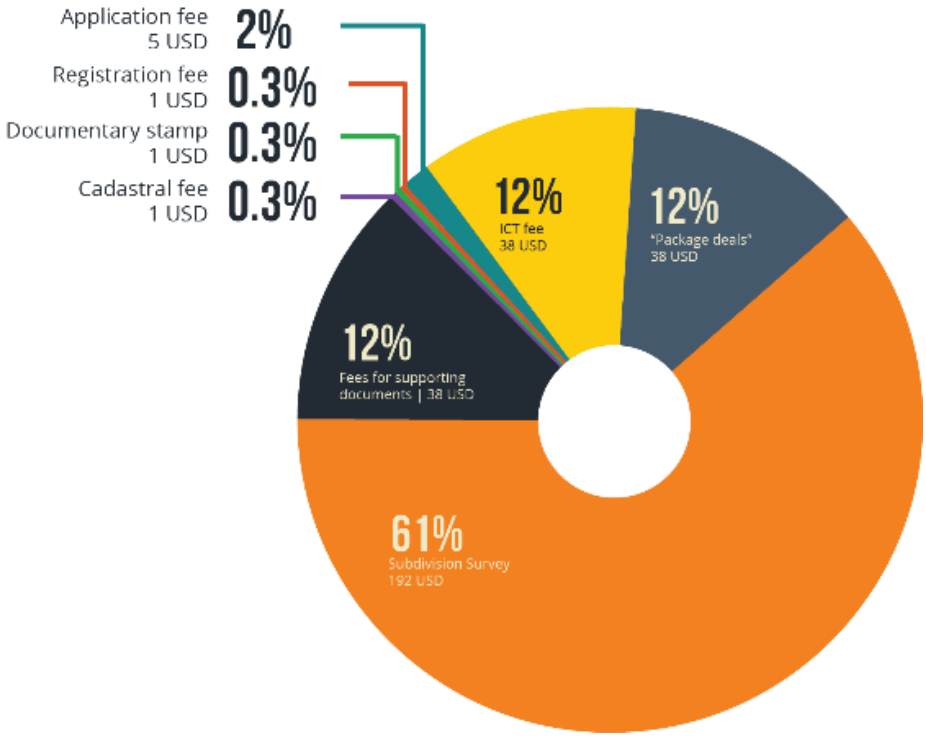
Improves governance

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

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



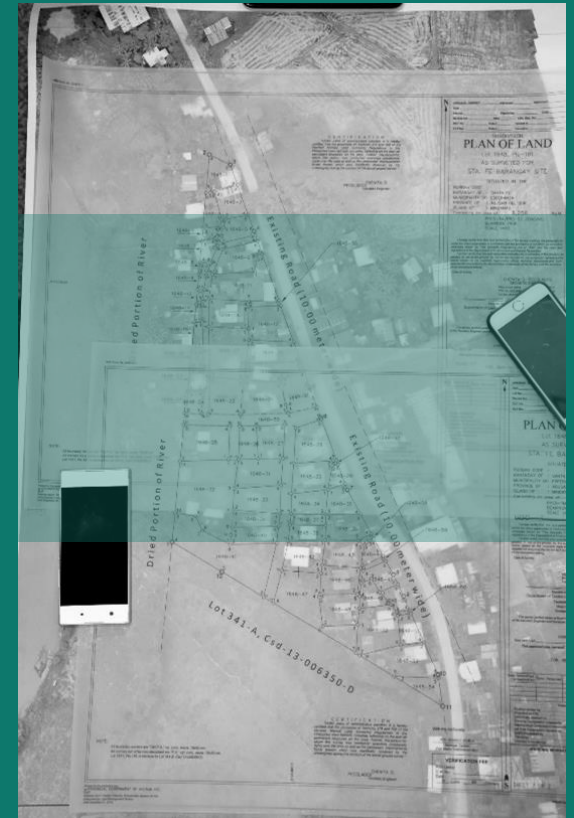
Pilot study

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



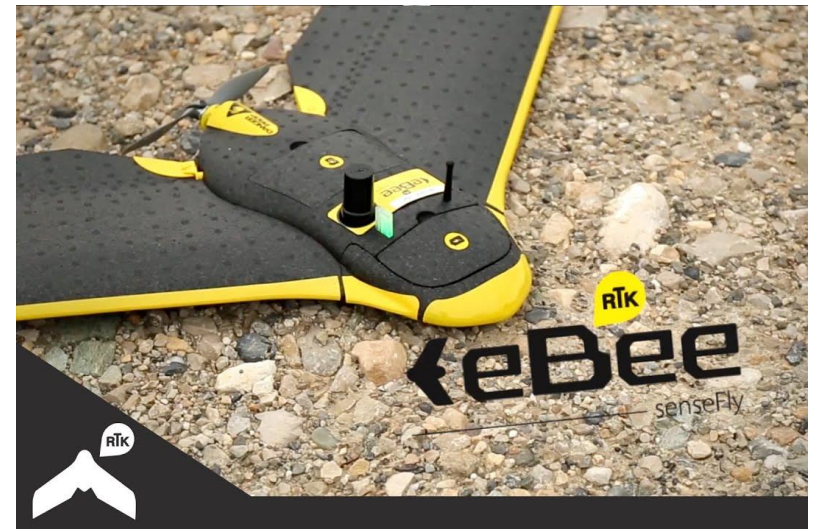
DJI Phantom 4 Pro



Trimble UX5HP



Parrot ANAFI Work UAV



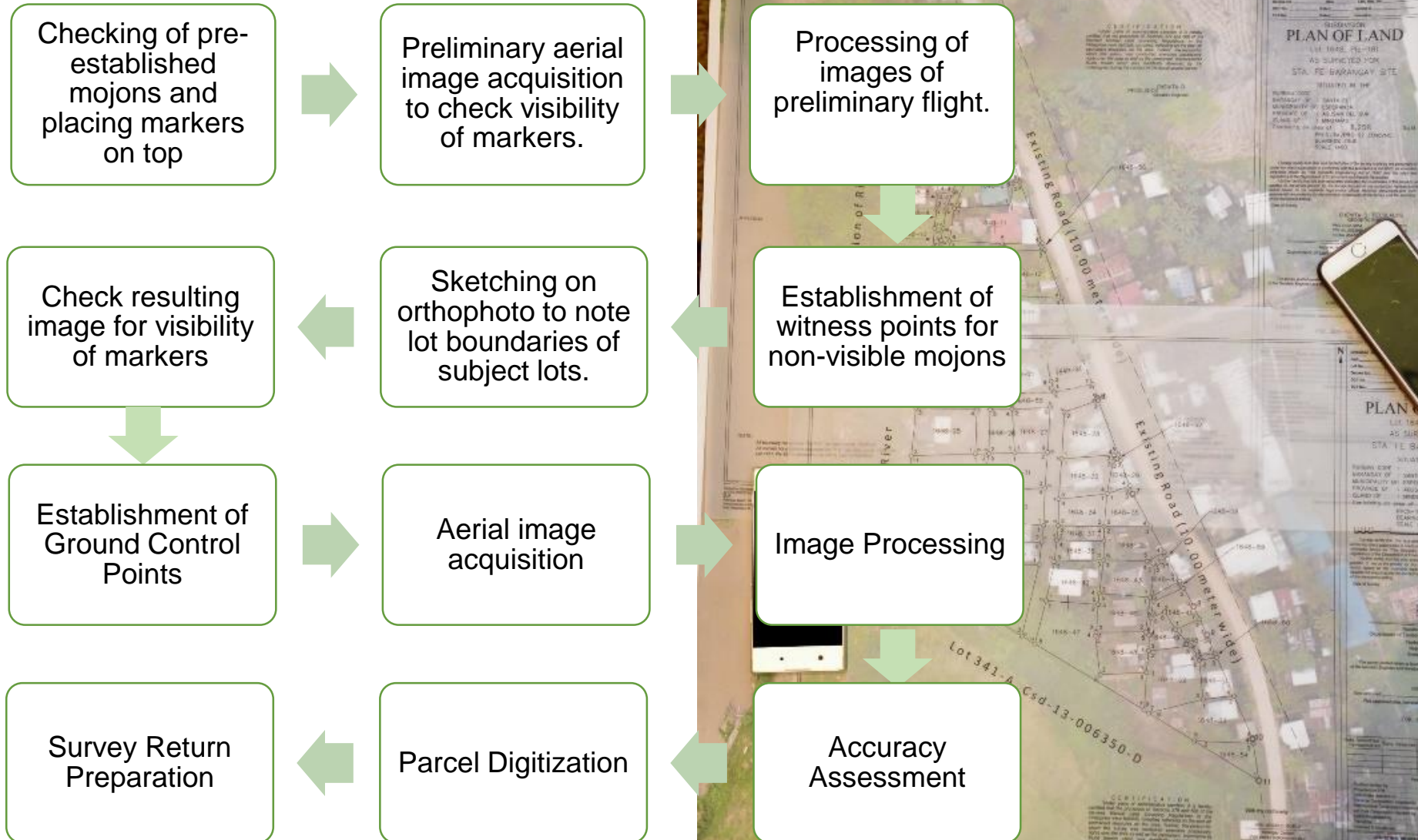
RANGE OF PRODUCTS

- 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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- 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



Validation points



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**

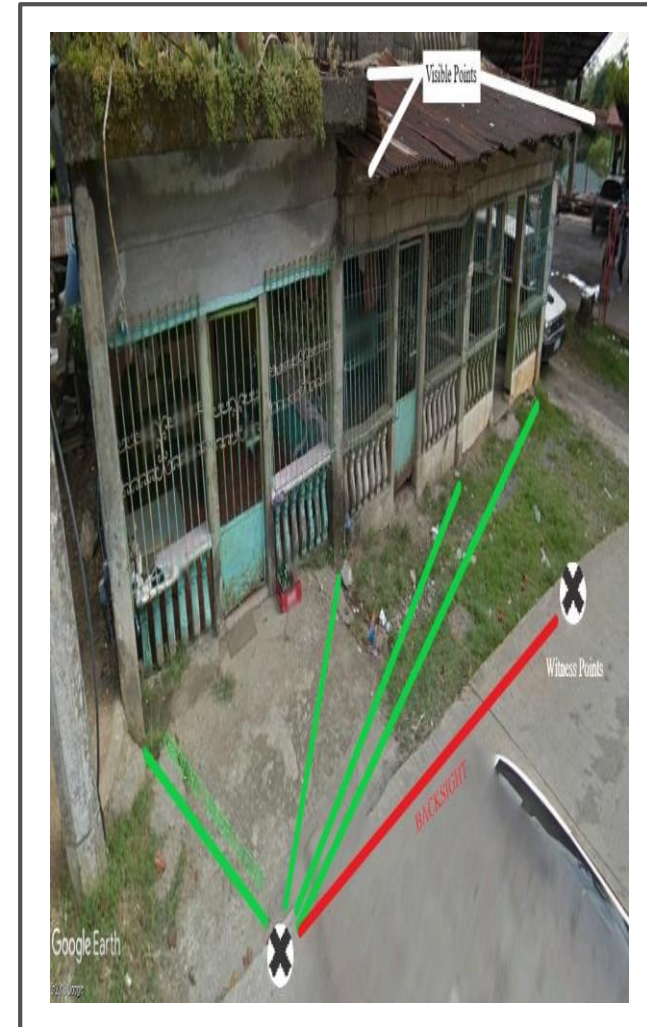
- Paint the top of the monument
- Clear vertical obstructions



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



PROJECT DESIGN

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GCP SURVEY

**AERIAL IMAGE
ACQUISITION**

IMAGE PROCESSING

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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

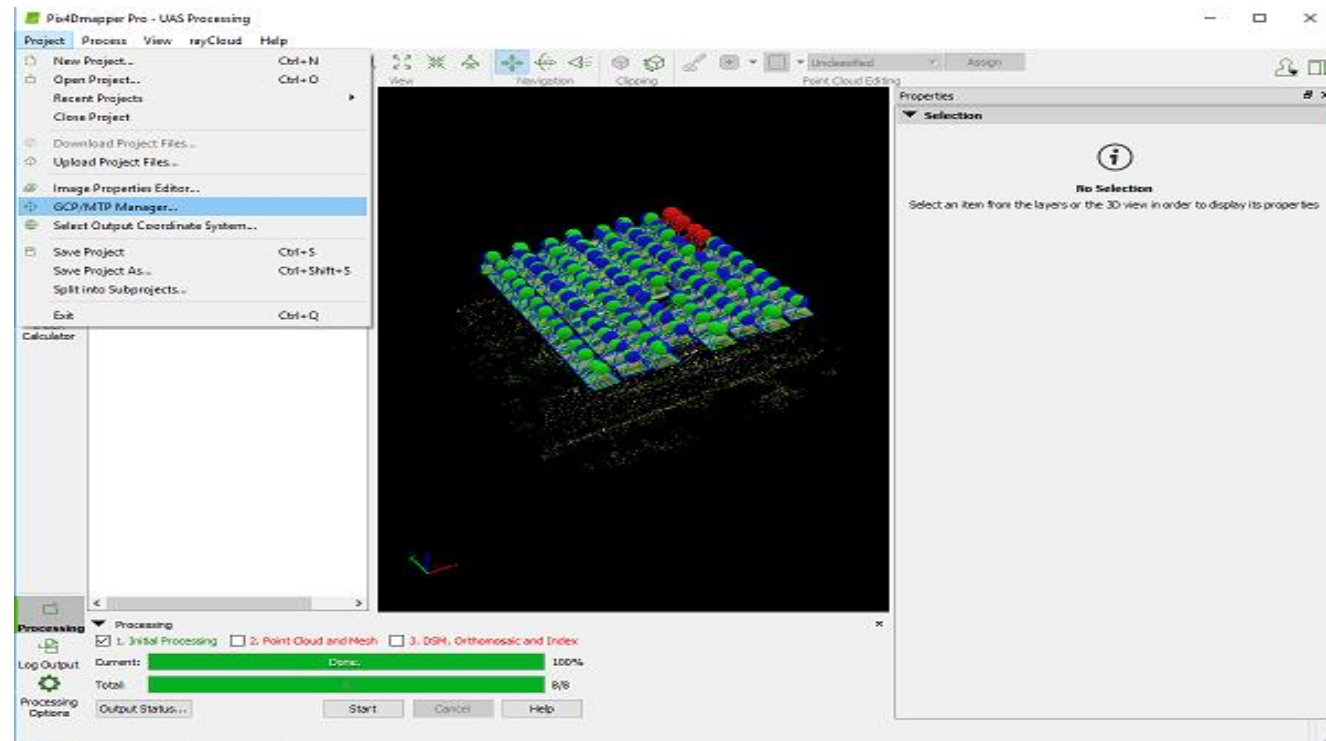
ACCURACY
ASSESSMENT

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.



ACCURACY ASSESSMENT

PROJECT DESIGN

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FLIGHT PLANNING

GCP SURVEY

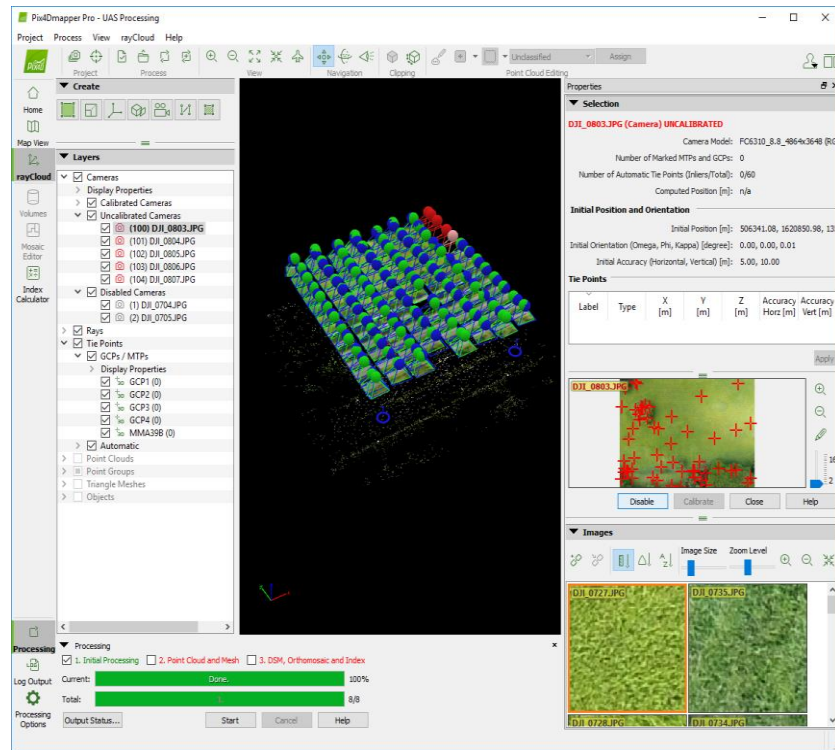
AERIAL IMAGE
ACQUISITION

IMAGE PROCESSING

**ACCURACY
ASSESSMENT**

PARCEL DIGITIZATION

SURVEY RETURN
PREPARATION



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

Accuracy Assessment using the Root Mean Square Error (RMSE)

Accuracy Assessment from Vectorization or Digitization

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PARCEL DIGITIZATION

SURVEY RETURN
PREPARATION

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

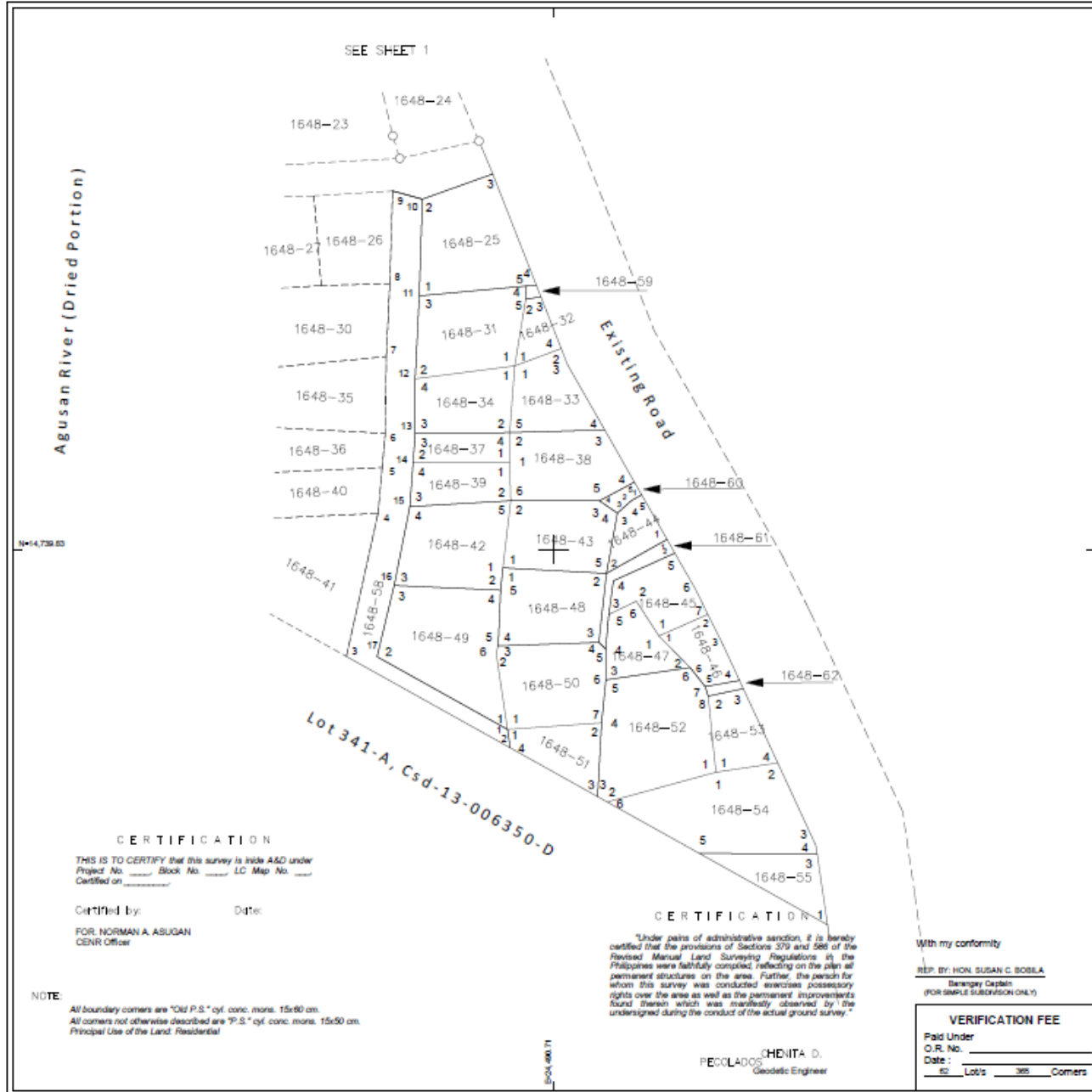
Survey returns are required to make the survey official through DENR and LRA.

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 this survey is made ASO under
 Project No. _____ Block No. _____ LC Map No. _____
 Certified on _____

Certified by: _____ Date: _____

FOR NORMAN A. ASUGAN
 CNR Officer

NOTE:
 All boundary corners are "Old P.S." cyl. conc. mons. 15x60 cm.
 All corners not otherwise described are "P.S." cyl. conc. mons. 15x50 cm.
 Principal Use of the Land: Residential

CERTIFICATION

Under pains of administrative sanction, it is hereby certified that the provisions of Sections 379 and 388 of the Revised Manual Land Surveying Regulations in the Philippines were faithfully complied, reflecting on the plan all permanent structures on the area. Further, the person for whom this survey was conducted exercises possessory rights over the area as well as the permanent improvements found therein which was manifestly observed by the undersigned during the conduct of the actual ground survey.

CHEDITA D. PECOLADOS
 Geodetic Engineer

With my conformity

REP. BY: HON. SUSAN C. BOSLA
 Barangay Captain
 (FOR SIMPLE SUBDIVISION ONLY)

VERIFICATION FEE

Paid Under
 O.R. No. _____
 Date: _____
 52 Lots 38 Corners

ORIGINAL SURVEY Surveyed: September 24-25, 2012 Approved: _____
 Cad: _____ Patent No. _____ Date: _____
 Decree No. _____ Date: _____ LRC Rec. No. _____
 OCT No. _____ Dated: _____ Issued to: _____
 TCT No. _____ Dated: _____ Issued to: _____

**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 1:400



I hereby certify that this is a correct plan of the survey made by me personally or under my direct supervision in conformity with the provisions of RA 8536, as amended, otherwise known as "The Geodetic Engineering Act of 1997" and the rules and regulations of the Department of Environment and Natural Resources.
 I further certify that this plan accurately indicates the boundaries of the property as pointed to me on the ground by the survey claimant or his authorized representative and/or based on the available legal and/or official technical documents and that I assume full responsibility for the technical correctness of the survey and the accuracy of the monument setting.

Date of Survey: _____
 CHEDITA D. PECOLADOS
 GEODETIC ENGINEER
 PRC ID No. 9064 Date 09-12-2013
 PTR No. 8032858 Date 01-12-2019
 TIN No. 454-989-722

Republic of the Philippines
 Department of Environment and Natural Resources
 Technical Services
 Regional Office XIII
 Ambago, Butuan City

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

ARTHUR S. GERMAN
 CHIEF, 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-HAJI
 CGO, ASST. REGIONAL DIRECTOR FOR TECHNICAL

Re Submitted (S/M)	Date Returned	Remarks	Documents Received (S)

Printed name & Signature _____ Date _____
 Position verified by: _____ N _____ E by: _____
 Field notes checked by: _____
 Traverse Computation checked by: _____
 Astronomical Computation checked by: _____
 Lot Data Computation checked by: _____
 CAD/Processed by: _____
 Traced by: _____
 Checked & Verified by: _____

ADDITIONAL INFORMATION AFTER DATE OF APPROVAL

SHEET 2 OF 2 SHEETS



CERIFICATION
 I, the undersigned, being a duly licensed and registered Professional Engineer, do hereby certify that the foregoing is a true and correct copy of the original survey plan as shown to me by the owner of the land surveyed, and that the same is in accordance with the provisions of the laws, rules and regulations of the Department of Environment and Natural Resources. I further certify that this plan accurately indicates the boundaries of the property as shown to me on the ground by the survey claimant or his authorized representative and/or based on the available legal and/or official technical documents and that I assume full responsibility for the technical correctness of the survey and the accuracy of the monument setting.

CHENITA D. PECOLADOS
 Civil Engineer

CERTIFICATION
 THIS IS TO CERTIFY that the survey of block AND shown
 Titled No. _____ Block No. _____ LG. Dist. No. _____
 Certified on _____ Date: _____
 FOR: NORMAN A. ASUGAN
 CENR Officer

NOTE:
 All boundary corners are 'Old F.S.' by corner, 15x15cm.
 All corners not otherwise described are 'I.P.S.' by corner, 100x100x150 cm.

ORIGINAL SURVEY Surveyed September 24 2012 Approved: _____
 Cas. _____
 Lot No. _____ Patent No. _____ Date _____
 Deed No. _____ Date _____ LRC Ref. No. _____
 OCT No. _____ Dated _____ Issued to _____
 TCT No. _____ Dated _____ Issued to _____

**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 : MINDANAG
 Containing an area of 8,528 Sq. M.
 PPCS-TM/PRS-92 70NEVNO:
 BEARINGS TRUE
 SCALE 1:500

I hereby certify that this is a correct plan of the survey made by me personally or under my direct supervision in conformity with the provisions of RA 5528, as amended, otherwise known as "The Geometric Engineering Act of 1926" and the rules and regulations of the Department of Environment and Natural Resources.
 I further certify that this plan accurately indicates the boundaries of the property as shown to me on the ground by the survey claimant or his authorized representative and/or based on the available legal and/or official technical documents and that I assume full responsibility for the technical correctness of the survey and the accuracy of the monument setting.

Date of Survey: _____

CHENITA D. PECOLADOS
 GEOMETRIC ENGINEER
 PRC ID No. 50584 Date 09-17-2011
 PTR No. 852395 Date 01-12-2019
 TR. No. 404-055-722

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

No survey plan or notes shall be in order as per submitted survey returns of the Geometric Engineer and therefore recommended for approval.

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

FOR: BEN-ALI B. DECAMPO, AL-HAJU
 O.C. ASST. REGIONAL
 DIRECTOR FOR TEG-M-CAL

Date Submitted	Date Returned	Remarks	Documents Received by

Printed name & Signature: _____ Date: _____

Position verified by: _____
 Prepared by P.E. _____
 Field Notes checked by: _____
 Traverse Computation checked by: _____
 Astronomical Computation checked by: _____
 or Data Computation checked by: _____
 CADD/Processed by: _____
 Traced by: _____
 Checked & Verified by: _____

ADDITIONAL INFORMATION AFTER DATE OF APPROVAL

VERIFICATION FEE

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

