

Working toward an optimized PPK Workflow Solution for accurate Aerial Photogrammetry Surveys to support dynamic construction worksites



Raymond Bure
Strident7 Mapping

in collaboration with



Arman Larmer Surveys Ltd

INTRODUCTION

FORWARD

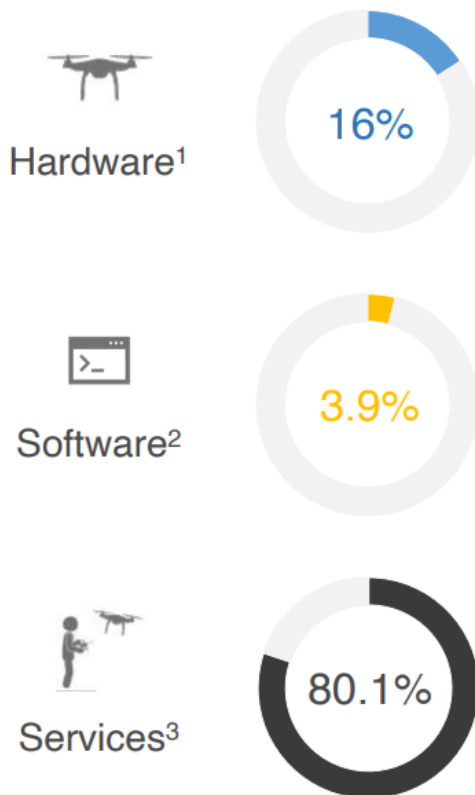
1. Objective
2. Project Area
3. Test case with Mission 3:
 - a) Mission Planning
 - b) RTK Photogrammetry Surveys
 - c) PPK Processing of RTK Data
 - d) Geoprocessing & Geomodeling
 - e) Data Analysis & Validation
4. Support dynamic construction projects

Forward – “Global Trend of the Drone Market”

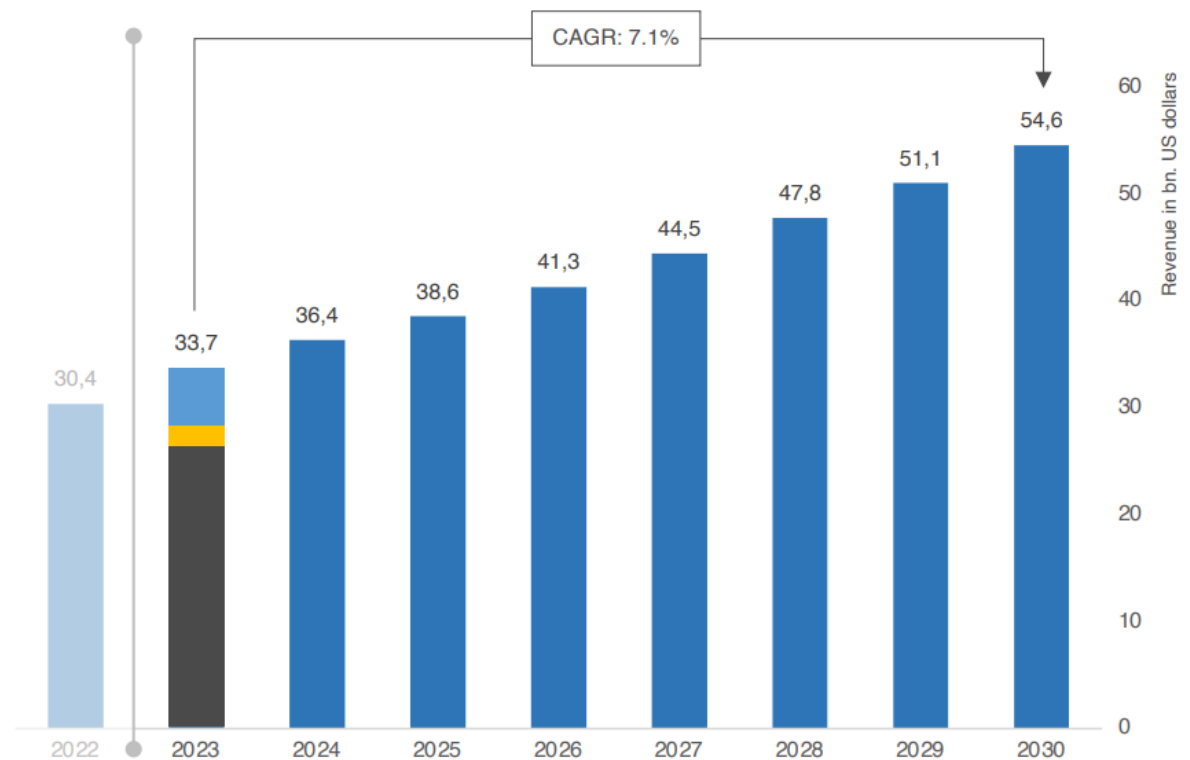
DRONE MARKET SIZE AND FORECAST 2023-2030

DRONE
INDUSTRY INSIGHTS

MARKET SHARE BY SEGMENT IN 2023



GLOBAL MARKET SIZE AND GROWTH



Forward - Global Trend of the Drone Surveying Market

Global Drone Surveying Market Forecast, 2023-2033

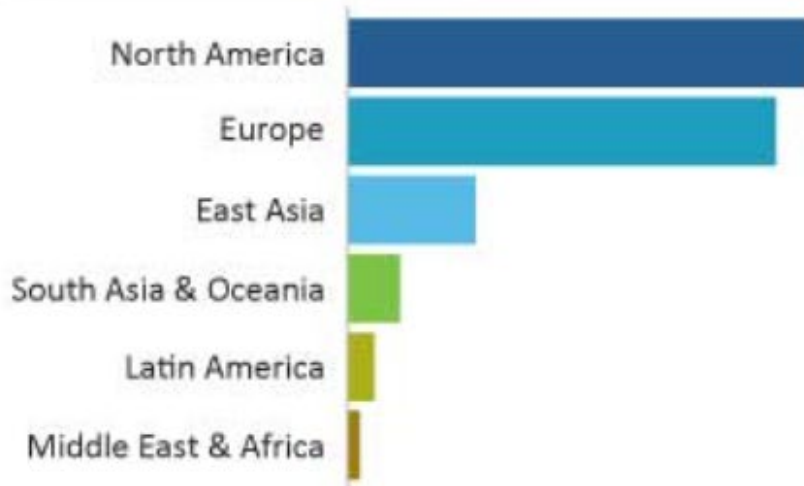
19.3%
Global Market Value CAGR
(2023 – 2033)

US\$ 1380.4 Million
Global Addressable Market
Value, 2023 E

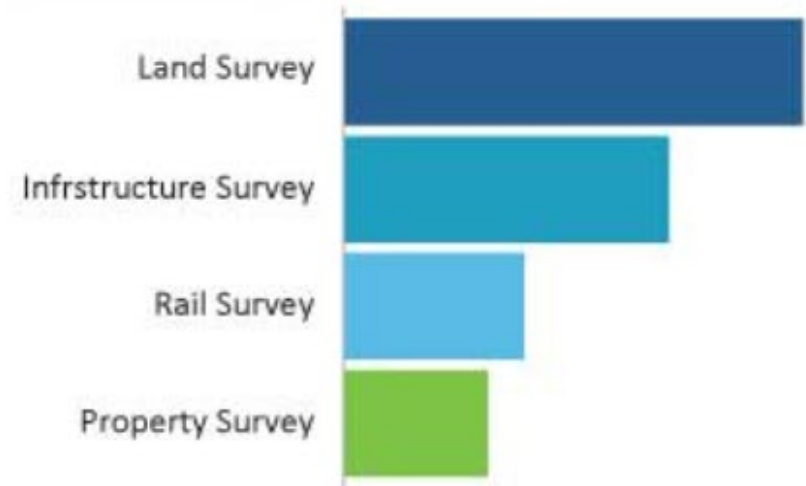
10.7%
Historical Market Value
CAGR (2018 – 2022)

53%
Land Surveying Value
Share, 2023 E

Market Split by Region, 2023 E



Market Split by Service Type, 2023 E



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1. Objective

Making the case of migrating toward an optimized **PPK Workflow Solution** as applied in PNG conditions

- PPK Aerial Photogrammetry Survey
- PPK Post-Processing
- Photogrammetry Geoprocessing
- GIS Geomodeling & Mapping
- GIS – BIM Integration for AEC

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2. Project Area



Bunu Water Supply Project

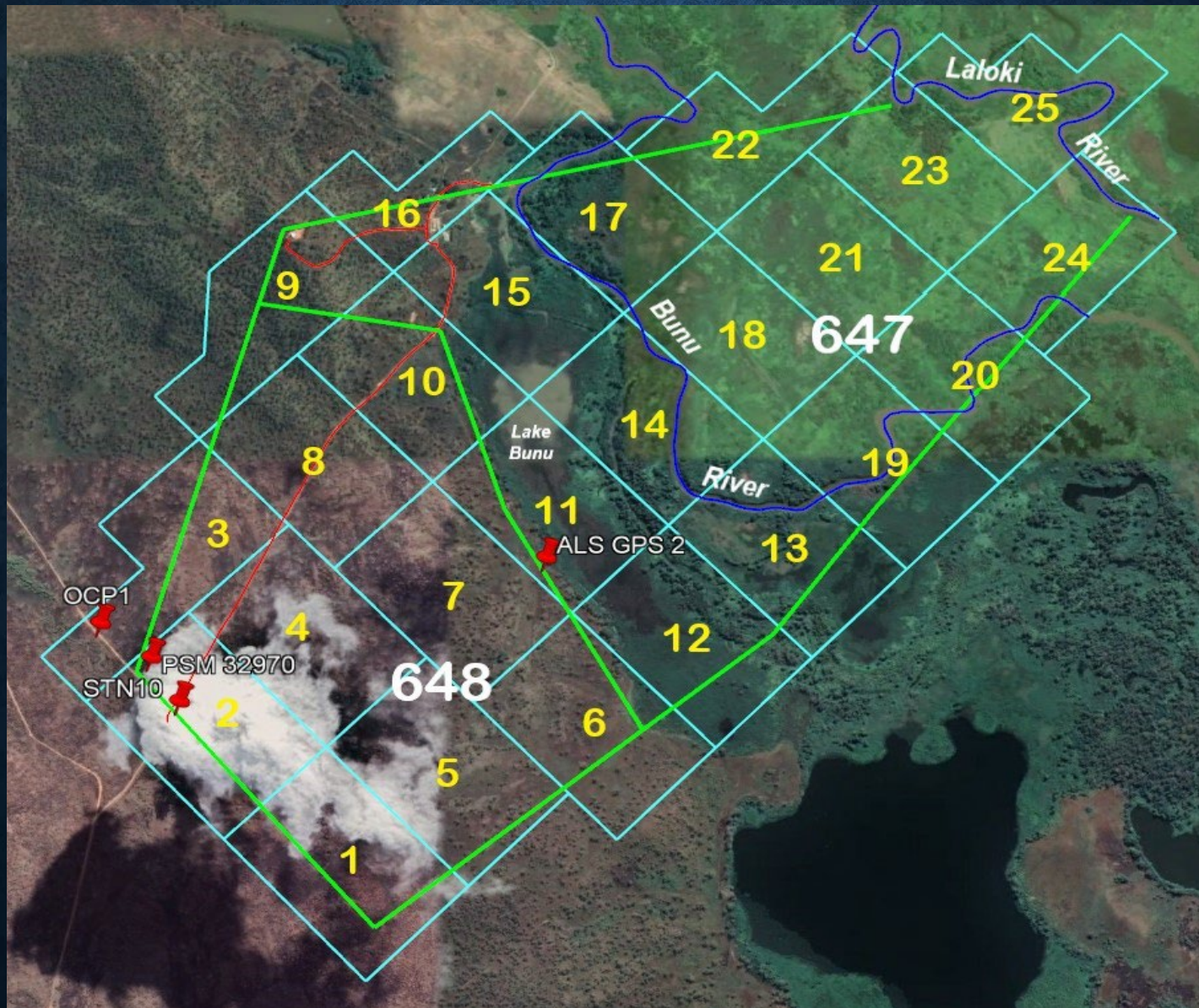
- Portions 647 & 648 (353 ha.)
- Laloki & Bunu Rivers, Lake Bunu
- Water treatment plant, water tank, pipeline



INTRODUCTION

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2. Project Area
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3(a). Mission Planning



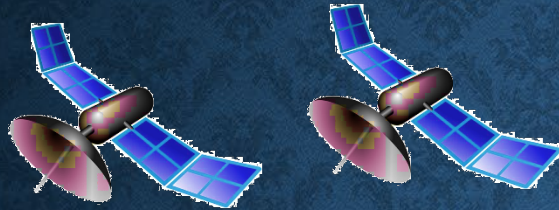
DJI Phantom 4 RTK survey drone



INTRODUCTION

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2. Project Area
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3(b). RTK Photogrammetry Surveys



GNSS Satellites

Aerial Photogrammetry

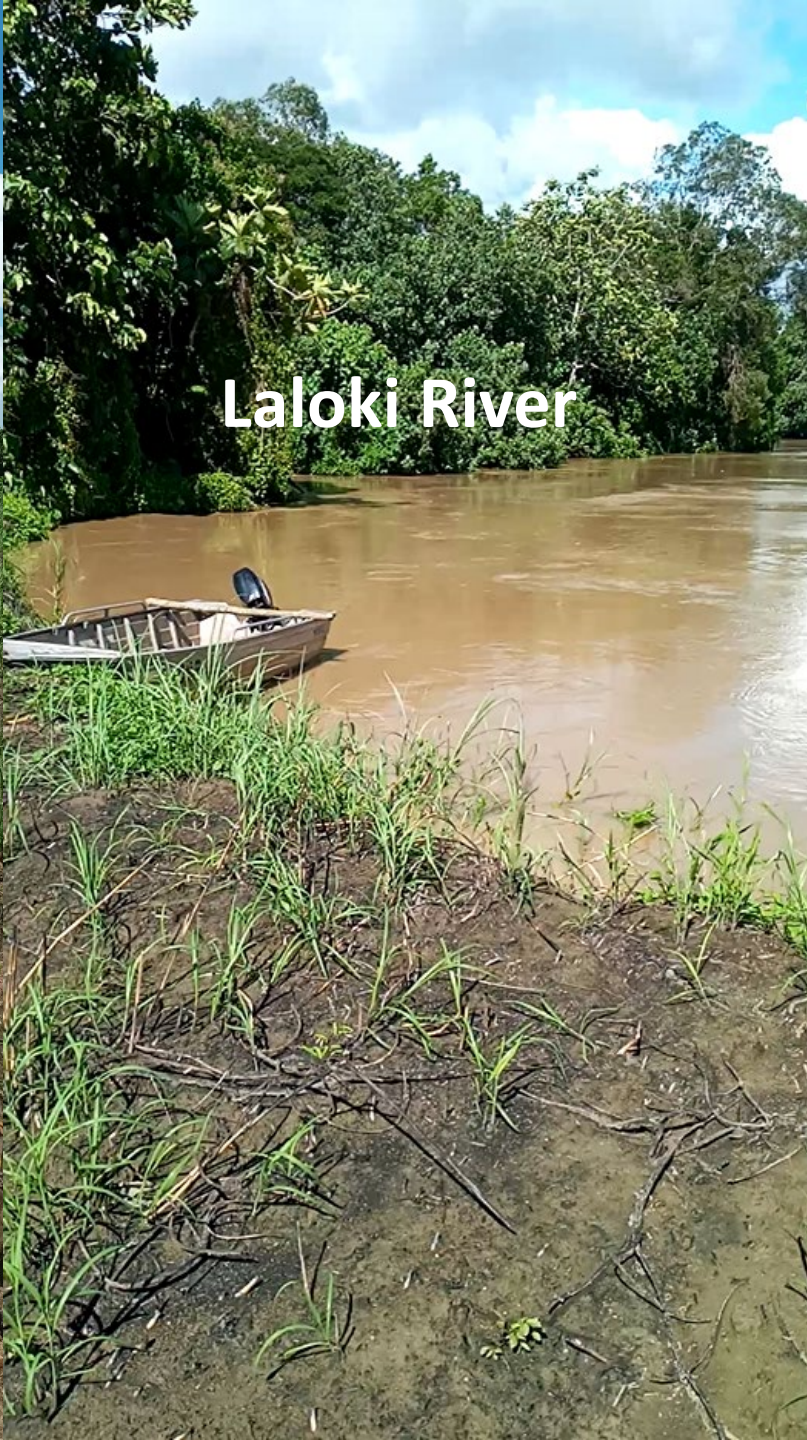


Mobile Base for RTK





**Mobile Base
for RTK**



Laloki River



**Aerial
Photogrammetry**



**Flight
Planning**

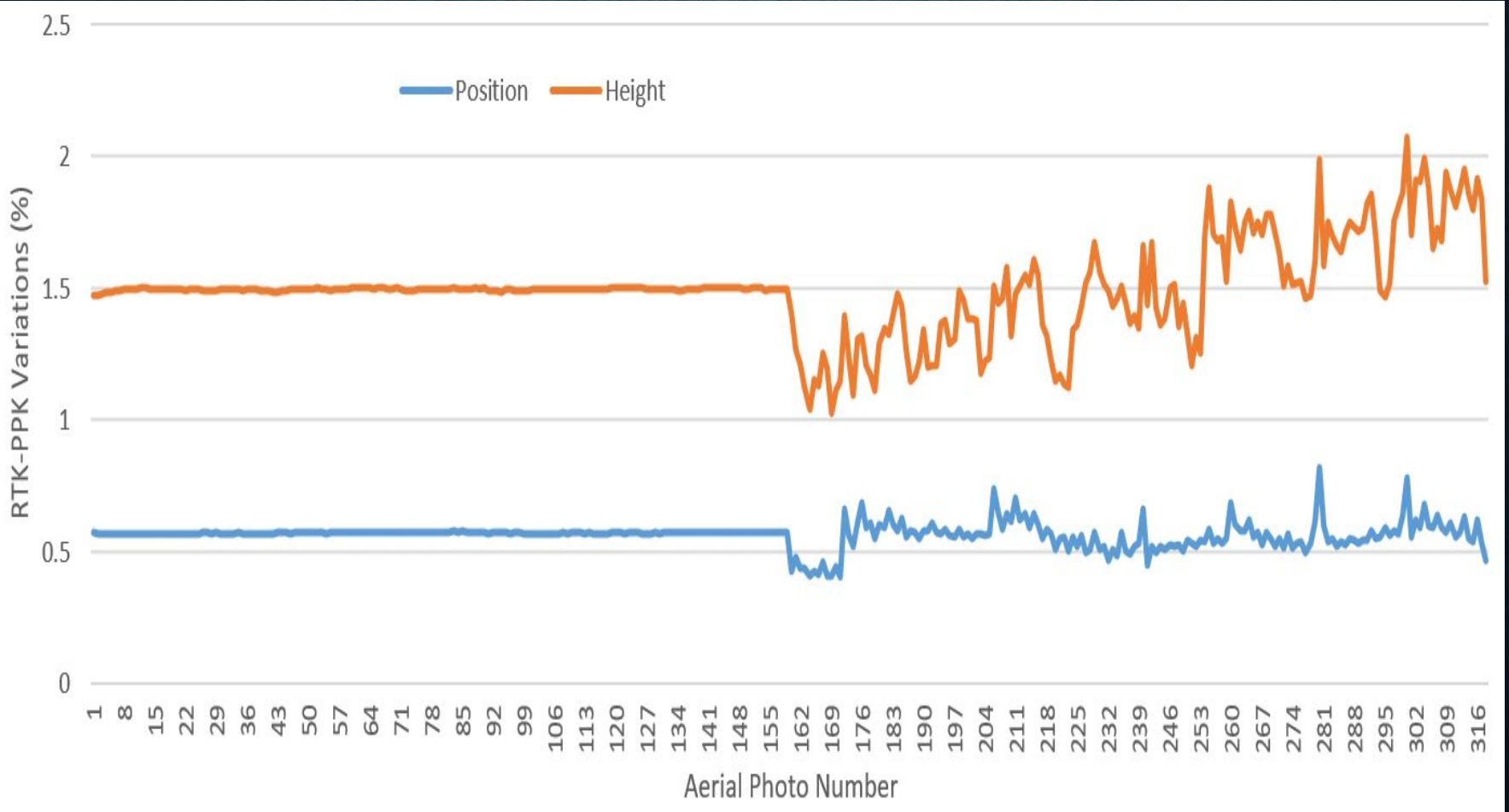


**Bunu River
Crossing**



**Monitoring
Flight
Operations**

RTK Drone Trajectory

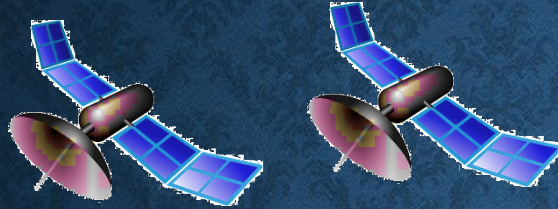


INTRODUCTION

1. Objective
2. Project Area
3. Test case with Mission 3:
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3(c). Optimized PPK Workflow Solution

Satellites



Drone



Static
Base for
PPK

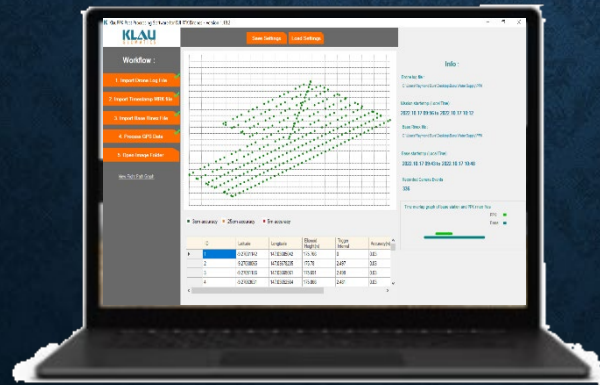


X, Y, Z, T

X, Y, Z, T

Rinex file

Rinex file and
Timestamp file



PPK processing
Photogrammetry processing
GIS modelling & mapping

PPK post-processing with KLAUPPK GEOMATICS

- Import Drone Log file (Rinex OBS) and Timestamp (MRK) files
- Import Base Rinex file
- Process GNSS data, sorting photos & applying IMU trajectory
- Geotag photos by writing new coordinates to the EXIF file

PPK post-processing of RTK data

KlauPPK Post Processing Software for DJI RTK Drones - Version 1.18.2



Workflow :

1. Import Drone Log File ✓

2. Import Timestamp MRK file ✓

3. Import Base Rinex File ✓

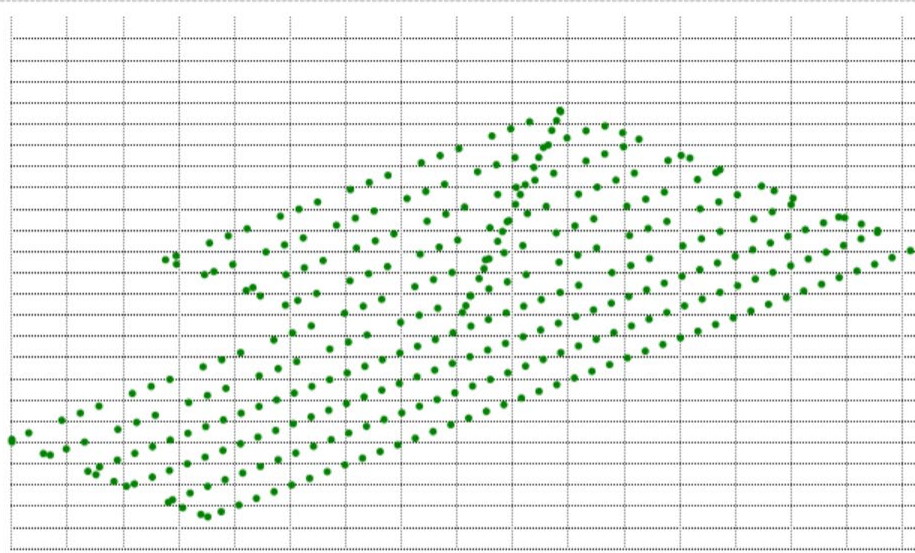
4. Process GPS Data ✓

5. Open Image Folder

[View Flight Path Graph](#)

Save Settings

Load Settings



■ 3cm accuracy ■ 25cm accuracy ■ 5m accuracy

	ID	Latitude	Longitude	Ellipsoid Height(m)	Trigger Interval	Accuracy(m)
▶	1	-9.2703115	147.03685073	175.79	0	0.03
	2	-9.27038072	147.03678266	175.805	2.497	0.03
	3	-9.27051193	147.03665093	175.711	2.498	0.03
	4	-9.27063635	147.03652596	175.877	2.481	0.03

Info :

Drone log file :

C:\Users\Raymond Bure\Desktop\Bunu Water

Mission start/stop (Local Time):

2022.10.17 09:56 to 2022.10.17 10:12

Base Rinex file :

C:\Users\Raymond Bure\Desktop\Bunu Water Supply\PPK

Base start/stop (Local Time):

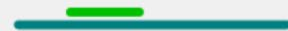
2022.10.17 09:43 to 2022.10.17 10:48

Recorded Camera Events :

336

Time overlap graph of base station and PPK rinex files

PPK: ■
Base: ■



Sorting Photos and Applying IMU...



Geotagging photo centres

Geotag Photos

<< Back to Processing

Image Coordinates Table

Coordinate System : WGS84 Latitude/Longitude
Height Reference: Ellipsoid

Change Projection Re-project coordinates, change the geoid model

Export Ground Target Coordinates Export selected ground target coordinates

Export Photo Coordinates Export camera coordinates to a comma seperated file

Geotag Photos Write coordinates to the image headers

	Image Name	Latitude	Longitude	Height	Accuracy	Ground Targets (Check Points)
▶	100_0001_0001....	-9.2703115	147.03685073	175.79	0.03	<input type="checkbox"/>
	100_0001_0002....	-9.27038072	147.03678266	175.805	0.03	<input type="checkbox"/>
	100_0001_0003....	-9.27051193	147.03665093	175.711	0.03	<input type="checkbox"/>
	100_0001_0004....	-9.27063635	147.03652596	175.877	0.03	<input type="checkbox"/>
	100_0001_0005....	-9.27076246	147.0363983	175.939	0.03	<input type="checkbox"/>
	100_0001_0006....	-9.2708879	147.0362713	175.877	0.03	<input type="checkbox"/>
	100_0001_0007....	-9.27101418	147.03614441	175.797	0.03	<input type="checkbox"/>
	100_0001_0008....	-9.27114032	147.03601668	175.817	0.03	<input type="checkbox"/>
	100_0001_0009....	-9.2712655	147.03589089	175.822	0.03	<input type="checkbox"/>
	100_0001_0010....	-9.27139114	147.03576345	175.817	0.03	<input type="checkbox"/>
	100_0001_0011....	-9.27151726	147.03563647	175.813	0.03	<input type="checkbox"/>

Progress bar: 10 steps, 10th step is active.

	ID	Latitude	Longitude	Ellipsoid Height(m)	Image Interval	Accuracy(m)
▶	1	-9.2703115	147.03685073	175.79	0	0.03
	2	-9.27038072	147.03678266	175.805	2.497	0.03
	3	-9.27051193	147.03665093	175.711	2.498	0.03
	4	-9.27063635	147.03652596	175.877	2.481	0.03

INTRODUCTION

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3(e). Geoprocessing & Deliverables

Agisoft Metashape:

- Import photos, GCPs & align to create a sparse point cloud
- Filter & optimize to create a dense point cloud
- Generate output (point clouds, contours, DSM/DEM & orthomosaics)

Geoprocessing PPK data (align photos to create point clouds)

Bunu3_dense1000.psx* — Agisoft Metashape Professional

File Edit View Workflow Model Photo Qrtho Tools Help



Reference

Cameras	Easting (m)	Northing (m)	Altitude (m)	Accuracy (m)	Error (m)
✓ 100_00...	503709.678888	8975493.676235	99.036518	0.030000	0.010352
✓ 100_00...	503724.473548	8975508.447703	98.809163	0.030000	0.007253
✓ 100_00...	503739.352788	8975523.210312	98.672802	0.030000	0.011924
✓ 100_00...	503763.335787	8975547.045605	99.272993	0.030000	0.003082
Total Error					0.016194

Markers	Easting (m)	Northing (m)	Altitude (m)	Accuracy (m)	Error (m)
✓ OCP1	503513.124000	8974930.466000	6.016000	0.005000	
✓ PSM 32...	503651.152000	8974833.518000	4.860000	0.005000	0.002850
Total Error					0.002850



Scale Bars	Distance (m)	Accuracy (m)	Error (m)
Total Error			
Control scale ...			
Check scale b...			



Ready

Wednesday, 9 August 2023

Generating Output (point cloud, orthomosaic, contours, DEM/DSM)

Bunu3_classified10.psx* — Agisoft Metashape Professional

File Edit View Workflow Model Photo Ortho Tools Help

Reference

Cameras	Easting (m)	Northing (m)	Altitude (m)	Accuracy (m)	Error (m)
<input checked="" type="checkbox"/> 100_0001_0316	503724.473548	8975508.447703	98.809163	0.030000	0.007253
<input checked="" type="checkbox"/> 100_0001_0317	503739.352788	8975523.210312	98.672802	0.030000	0.011924
<input checked="" type="checkbox"/> 100_0001_0318	503763.335787	8975547.045605	99.272993	0.030000	0.003082
Total Error					0.016194

Markers


Markers	Easting (m)	Northing (m)	Altitude (m)	Accuracy (m)	Error (m)
<input type="checkbox"/> OCP1	503513.124000	8974930.466000	6.016000	0.005000	0.002850
<input checked="" type="checkbox"/> PSM 32970	503651.152000	8974833.518000	4.860000	0.005000	0.002850
Total Error					0.002850
Control points					0.002850
Check points					

Scale Bars


Scale Bars	Distance (m)	Accuracy (m)	Error (m)
Total Error			
Control scale ...			
Check scale b...			

Model

Perspective 30°

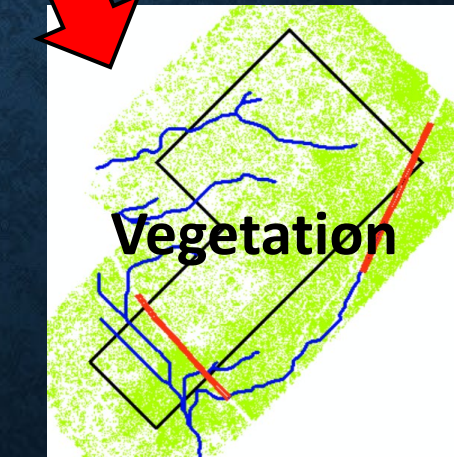
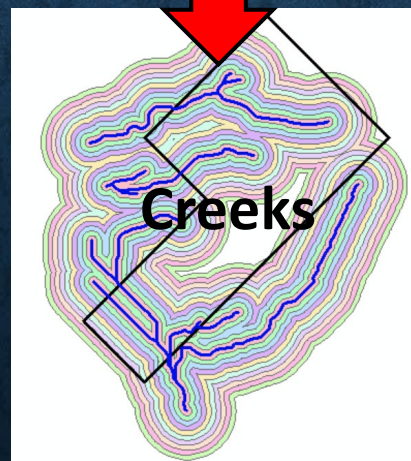
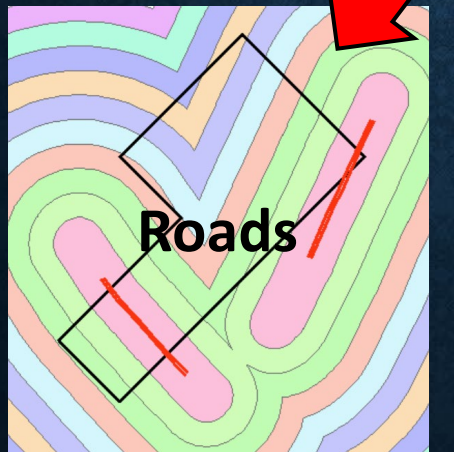
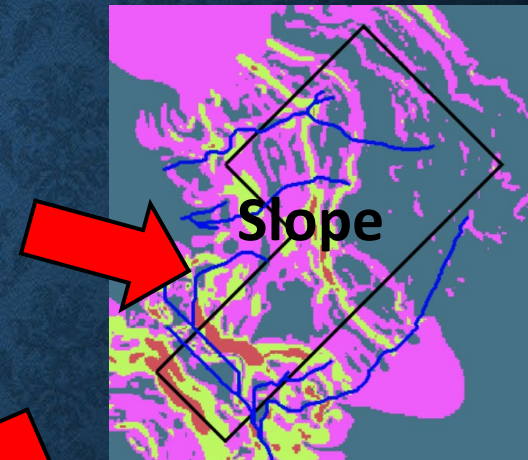
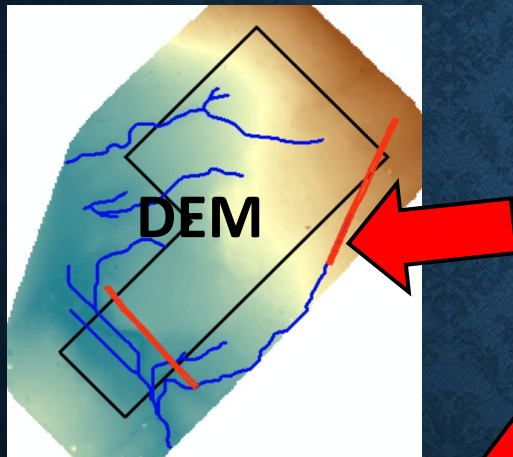


Photos



100_0001_0001 100_0001_0002 100_0001_0003 100_0001_0004 100_0001_0005 100_0001_0006

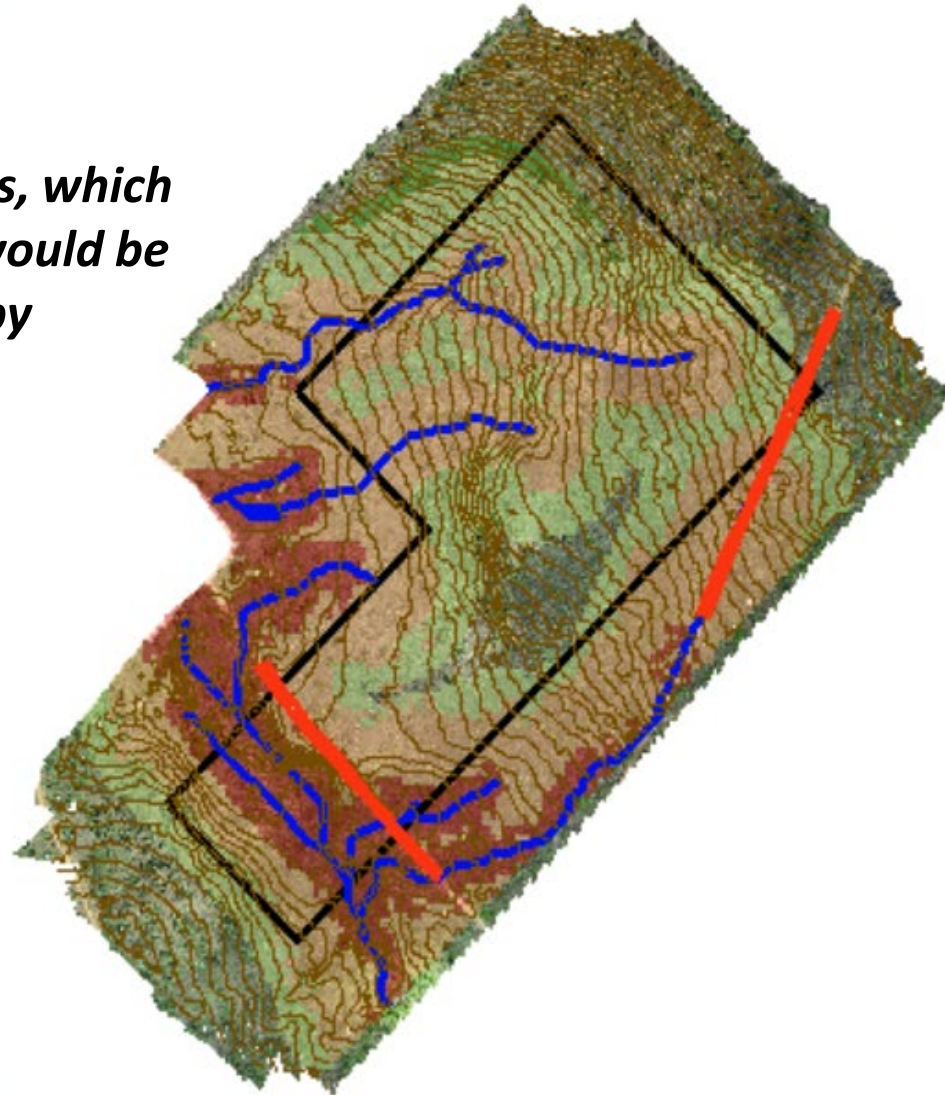
Geomodeling with ESRI ArcGIS



Value-Added Reality Capture – Map of Potential Flood Risk Zones

WHAT-IF SCENARIO:

“In the event of heavy rains, which areas (around the roads) would be most-likely to be affected by flash flooding?”



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ANALYSIS & VALIDATION OF PPK AERIAL PHOTOGRAMMETRY

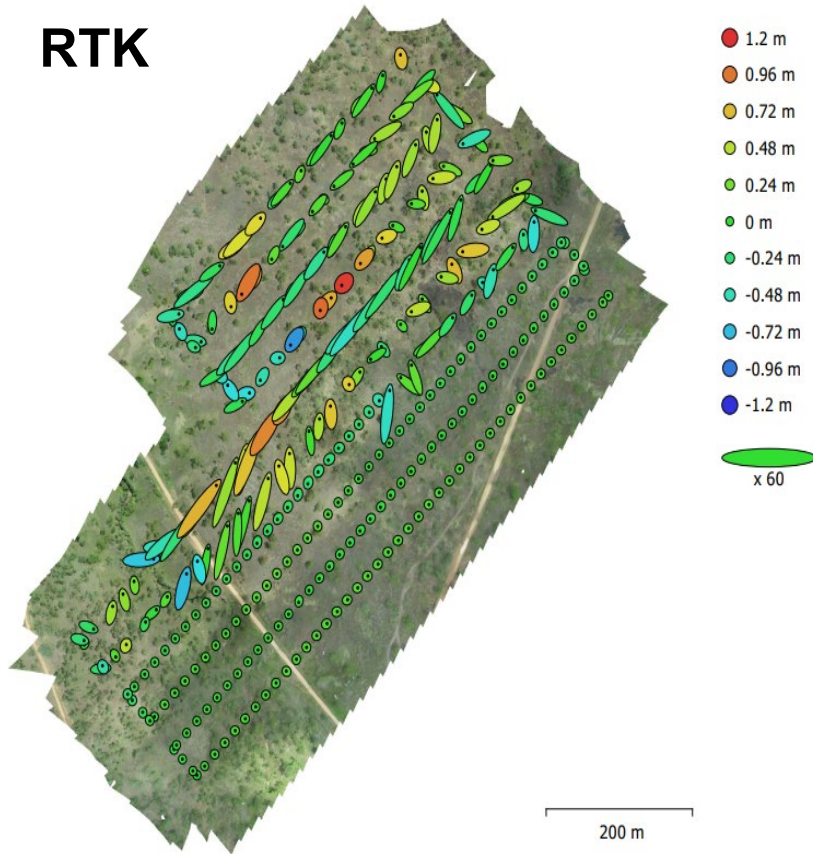
- Control Point RMSE for Base GCP
(PSM 32970)

Method	X Error (cm)	Y Error (cm)	Z Error (cm)	XY Error (cm)	Total Error (cm)
RTK	79.98	152.38	313.34	172.10	357.49
PPK	0.21	0.15	0.12	0.26	0.29

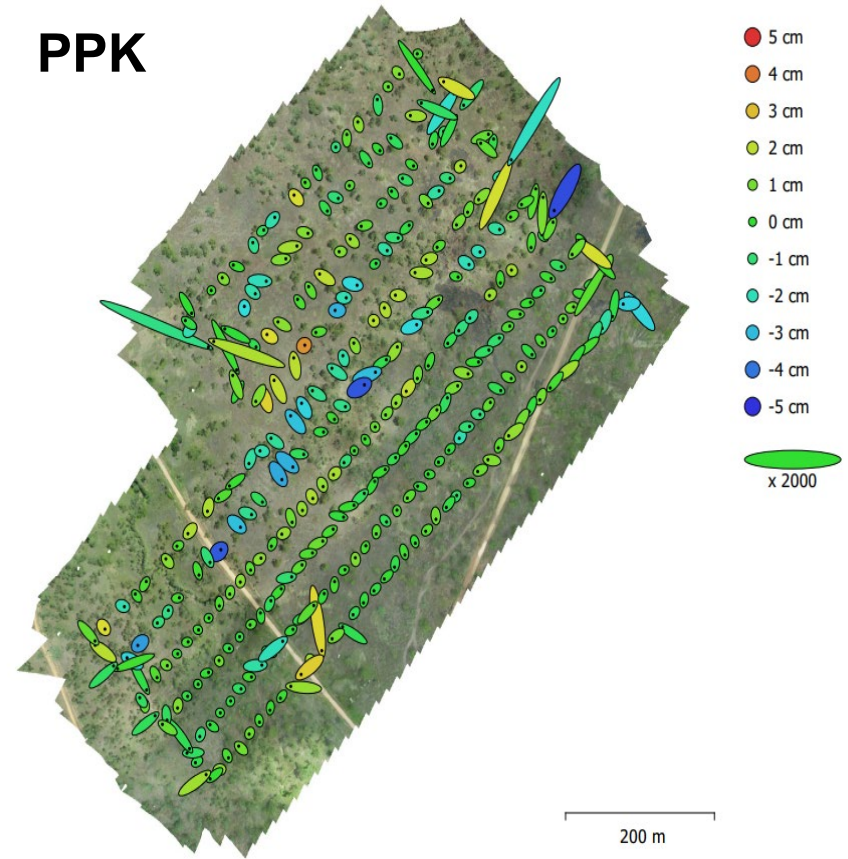
ANALYSIS & VALIDATION OF PPK AERIAL PHOTOGRAMMETRY

- Ave. camera locations (318 photos)

RTK



PPK



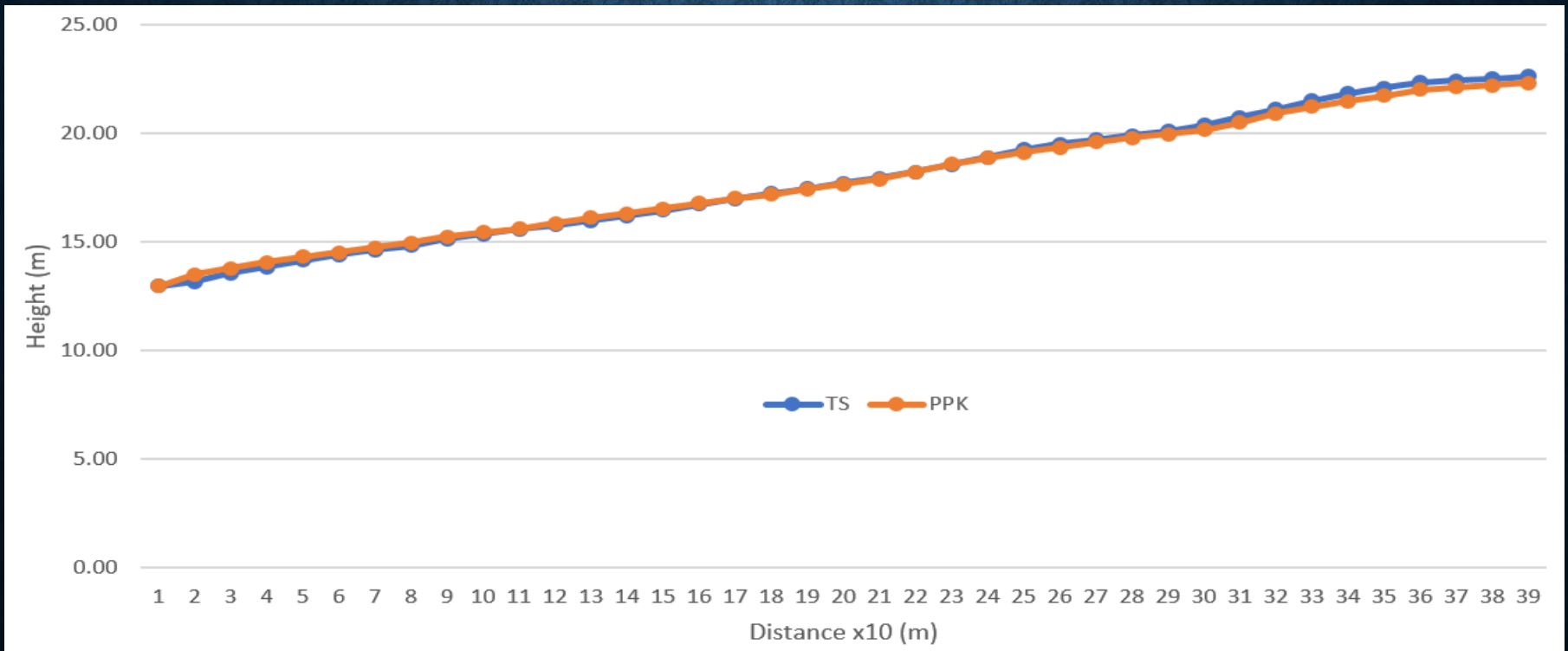
ANALYSIS & VALIDATION OF PPK AERIAL PHOTOGRAMMETRY

- Average camera locations & their error estimates (318 photos)

Method	X Error (cm)	Y Error (cm)	Z Error (cm)	XY Error (cm)	Total Error (cm)
RTK	22.84	28.74	29.66	36.71	47.20
PPK	0.75	0.67	1.27	1.01	1.62

ANALYSIS & VALIDATION OF PPK AERIAL PHOTOGRAMMETRY

- Validated against data captured by Total Station (ave. ht diff ~ 5 cm)



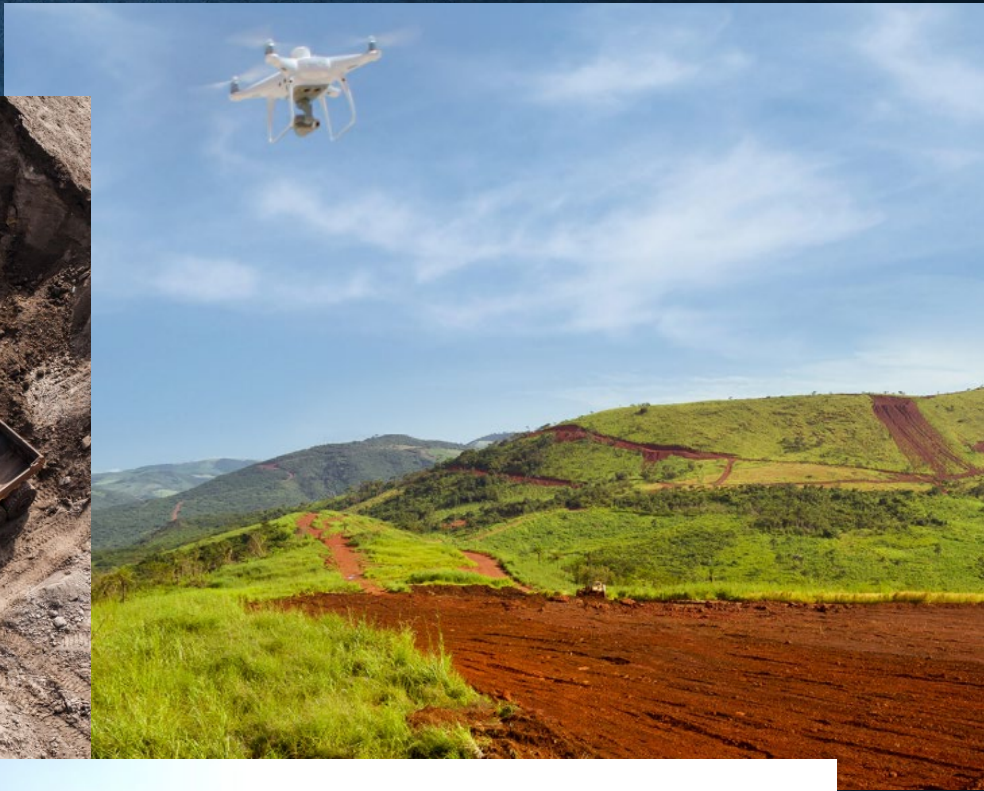
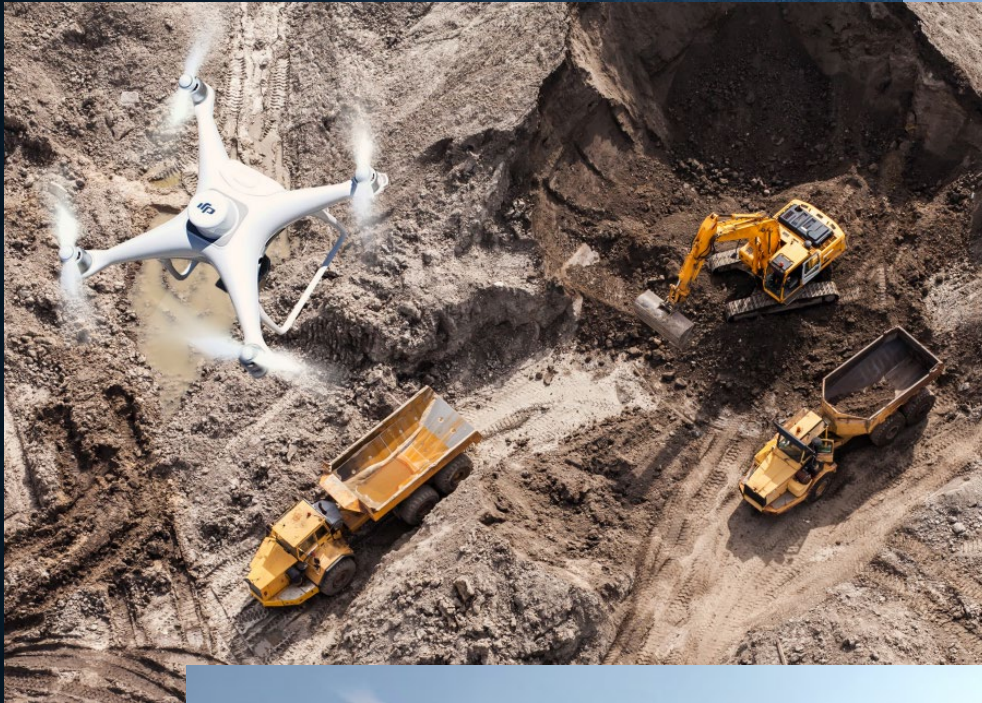
INTRODUCTION

1. Objective
2. Project Area
3. Test case with Mission 3:
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4. Support dynamic Construction Projects

PPK Aerial Photogrammetry:

- Medium-sized project areas (1-5 km² / 100-500 ha.)
- Frequency of surveys with quicker turnaround times
- Hazardous terrain or inaccessible areas including busy worksites



GIS-BIM integration

- **GIS (e.g. ESRI ArcGIS GeoBIM):**
 - Reality capture – GIS provides info about assets in the context of the built & natural environment
- **BIM (e.g. Autodesk BIM 360):**
 - Engineering design – BIM provides detailed info about built assets

GIS-BIM collaboration to build a Digital Twin



CONCLUSION

- **The PPK Aerial Photogrammetry:**
 - Rapid & accurate survey of medium-sized construction project areas
- **Geomodeling Approach:**
 - A value-added data-driven solution
- **GIS – BIM Integration:**
 - Optimize performance of real world assets

CONCLUSION

Ultimately, the **PPK Workflow Solution** supports a Business Model based on:

- quality performance, and
- cost efficiency.

ACKNOWLEDGEMENT

1. Arman Larmer Surveys Limited:

- Masang Bangindo
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- Gairo Waigeno

2. Quickclose Pty Limited

- Dr. Richard Stanaway, PhD



Lake Bunu

“Thank You”