# Using drones for 2D/3D Modeling

**AHORN 2015 - Wildhaus**
**Alexis ROZE – Application Engineer**

# senseFly Today

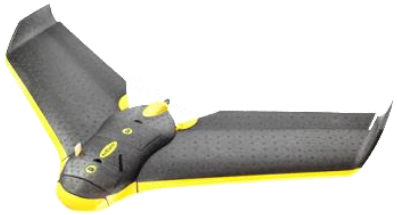
- Incorporated in 2009, EPFL spin-off
- Member of the **Parrot group** since June 2012
- A team of around 100 passionate people
- ~100 units/month
- Finalist Swiss Economic Award 2014 & TOP 100 - Best Swiss Startups
- #1 in fixed-wing mapping drones in terms of unit sold worldwide

# People and Environmental friendly

- Inspired by nature
- Ultra lightweight
- Inherently safer design with minimal impact to people
- implement fail-safe behaviors

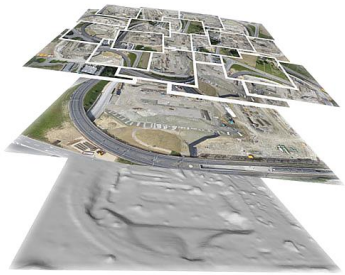
# The solution

- **Ultra-light** UAV
- **Fully automated and autonomous flight**
- **No launching system** (launched by hand for fixed-wing drone)
- **Easy processing of the data** (with Postflight Terra 3D)



**UAV**
eBee / eBee RTK / eXom

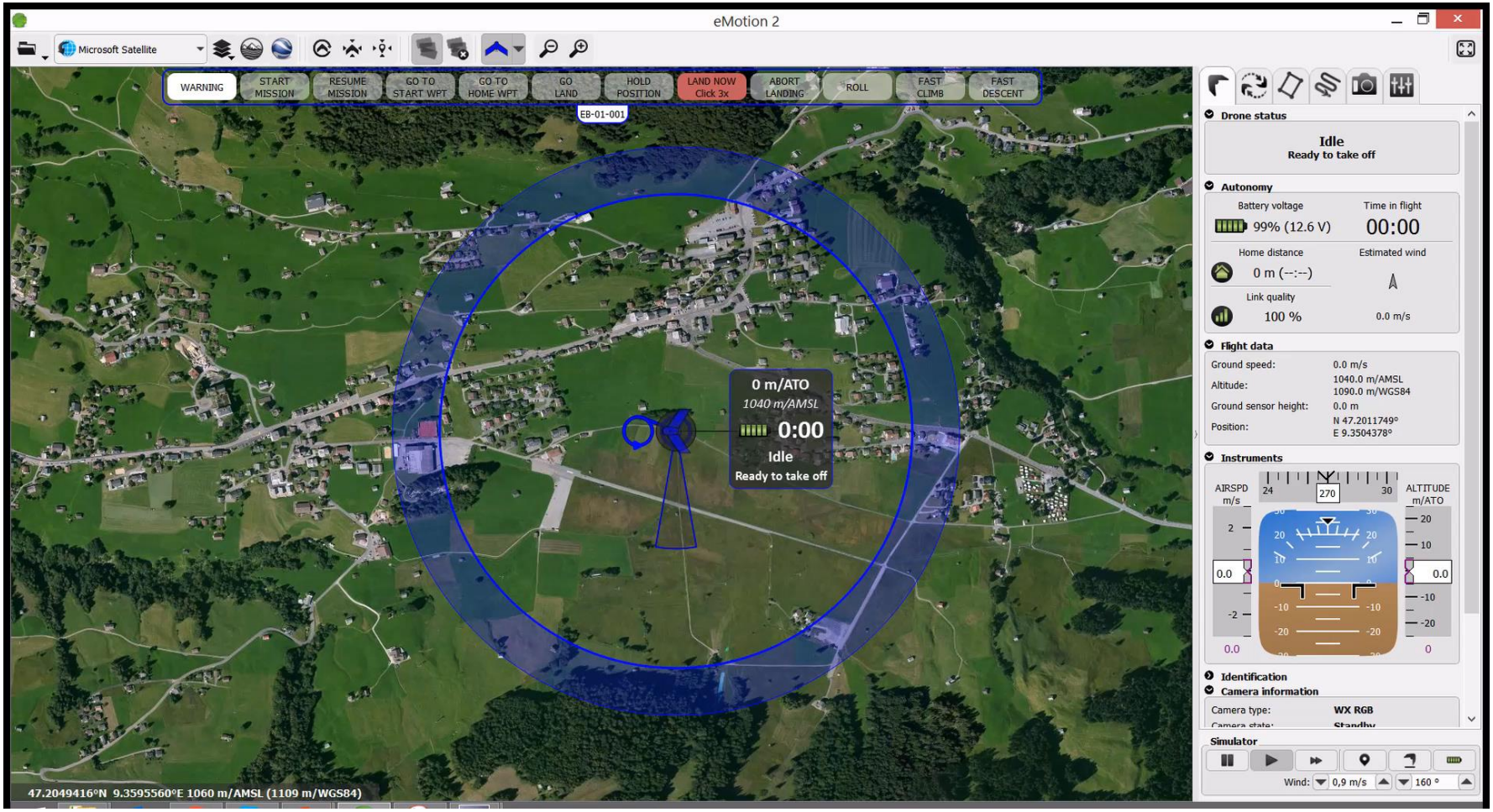

**eMotion2 and eMotionX**
Flight planning & control software



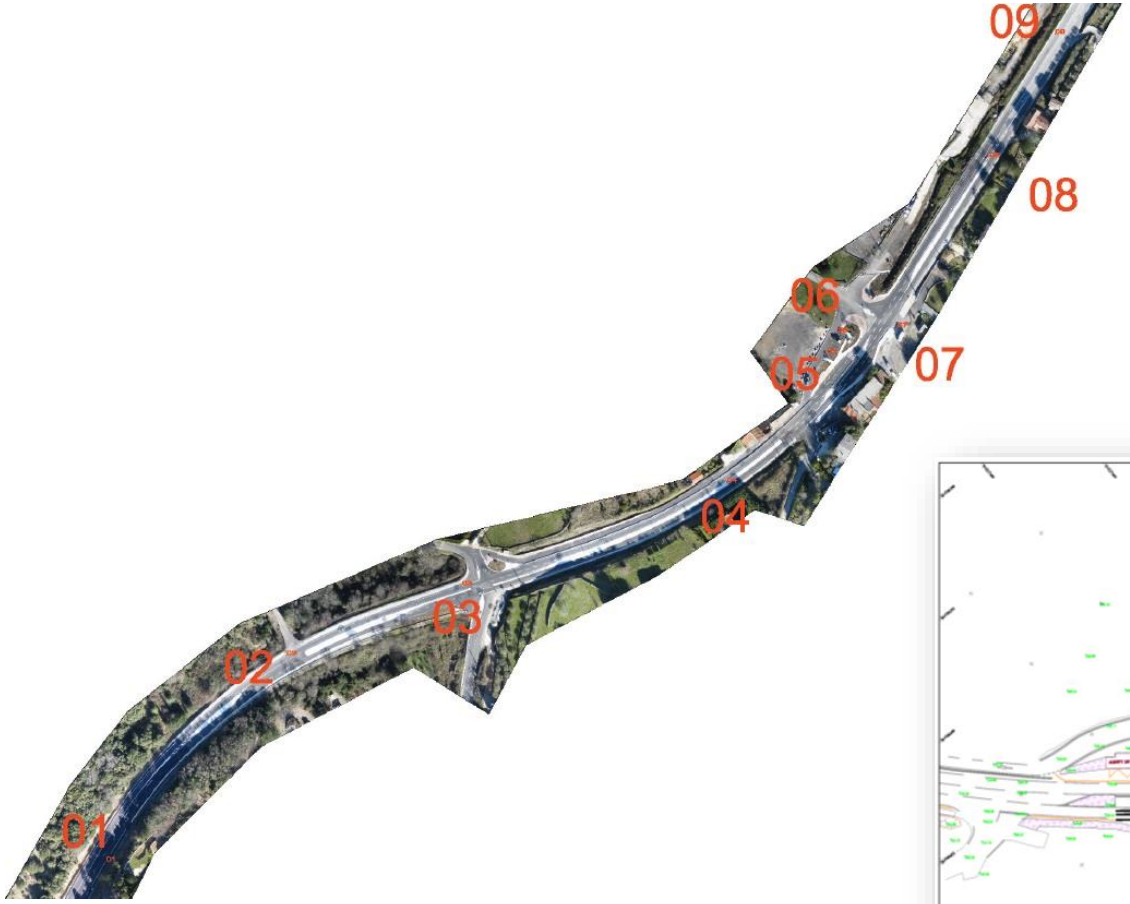
**Postflight Terra 3D**
Professional photogrammetry software (Powered by Pix4d)

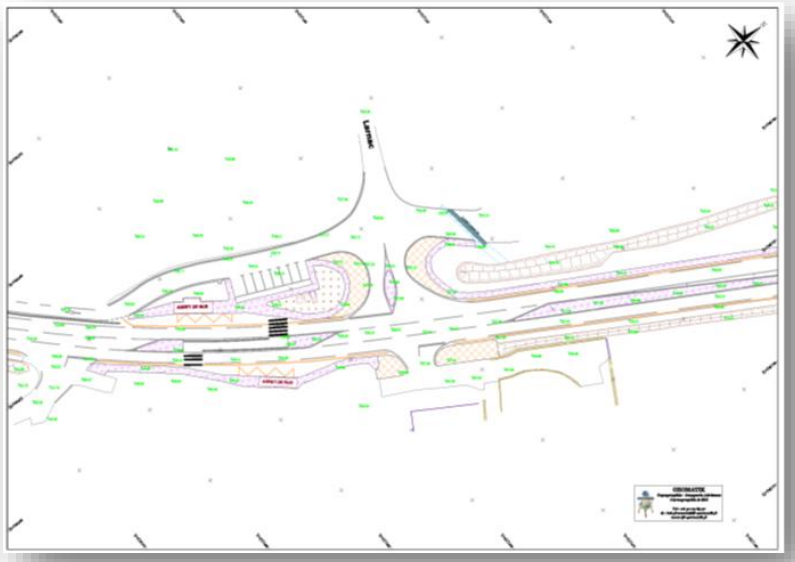
If needed, integration of the output into 3rd party software such as GIS software, CAD…

# eMotion flight planning



# eBee mapping - High absolute accuracy



Credits : Geomatik-Loic François

# Bringing RTK to UAVs

- **Main reason : No need of Ground Control Points**
  - As accurate as a standard eBee survey (when using a good GCPs coverage)
  - Faster
  - Safer

- Compatible with all the main GNSS receivers brands and NTRIP services

- Optimized for Postflight Terra 3D software
  - High precision of the geotags
  - Possibility to work with known coordinate systems or local coordinate systems

# How does it work?

RTK correction data from an online source or a local base station is streamed to the eBee RTK via the data link

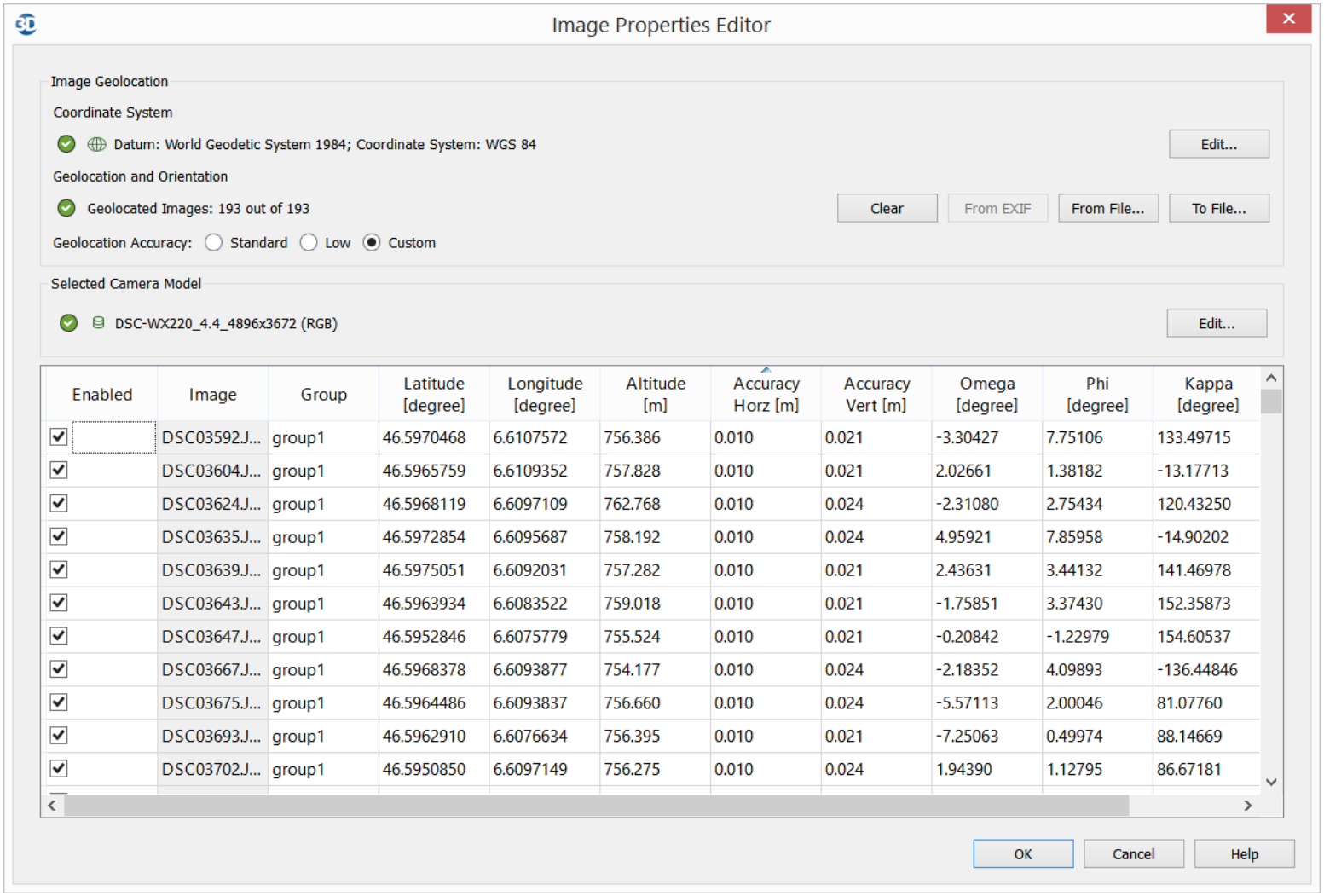
Link protocol : RTCM-2.x or RTCM-3.x

The eBee RTK uses this correction information to compute precise navigation and image metadata

# 3 operating modes

- Local base station with precisely known position
- Local base station with unknown position
- Online correction data : Connection to a Ntrip service required on-site
- Standalone mode (no RTK corrections).

# Images accuracy




| Enabled | Image | Group | Latitude [degree] | Longitude [degree] | Altitude [m] | Accuracy Horz [m] | Accuracy Vert [m] | Omega [degree] | Phi [degree] | Kappa [degree] |
|---|---|---|---|---|---|---|---|---|---|---|
| ☑ | DSC03592.J... | group1 | 46.5970468 | 6.6107572 | 756.386 | 0.010 | 0.021 | -3.30427 | 7.75106 | 133.49715 |
| ☑ | DSC03604.J... | group1 | 46.5965759 | 6.6109352 | 757.828 | 0.010 | 0.021 | 2.02661 | 1.38182 | -13.17713 |
| ☑ | DSC03624.J... | group1 | 46.5968119 | 6.6097109 | 762.768 | 0.010 | 0.024 | -2.31080 | 2.75434 | 120.43250 |
| ☑ | DSC03635.J... | group1 | 46.5972854 | 6.6095687 | 758.192 | 0.010 | 0.024 | 4.95921 | 7.85958 | -14.90202 |
| ☑ | DSC03639.J... | group1 | 46.5975051 | 6.6092031 | 757.282 | 0.010 | 0.021 | 2.43631 | 3.44132 | 141.46978 |
| ☑ | DSC03643.J... | group1 | 46.5963934 | 6.6083522 | 759.018 | 0.010 | 0.021 | -1.75851 | 3.37430 | 152.35873 |
| ☑ | DSC03647.J... | group1 | 46.5952846 | 6.6075779 | 755.524 | 0.010 | 0.021 | -0.20842 | -1.22979 | 154.60537 |
| ☑ | DSC03667.J... | group1 | 46.5968378 | 6.6093877 | 754.177 | 0.010 | 0.024 | -2.18352 | 4.09893 | -136.44846 |
| ☑ | DSC03675.J... | group1 | 46.5964486 | 6.6093837 | 756.660 | 0.010 | 0.024 | -5.57113 | 2.00046 | 81.07760 |
| ☑ | DSC03693.J... | group1 | 46.5962910 | 6.6076634 | 756.395 | 0.010 | 0.021 | -7.25063 | 0.49974 | 88.14669 |
| ☑ | DSC03702.J... | group1 | 46.5950850 | 6.6097149 | 756.275 | 0.010 | 0.024 | 1.94390 | 1.12795 | 86.67181 |

# Final accuracy

**The expected accuracy is within the same range of a standard eBee with good GCPs coverage and good overlap :**

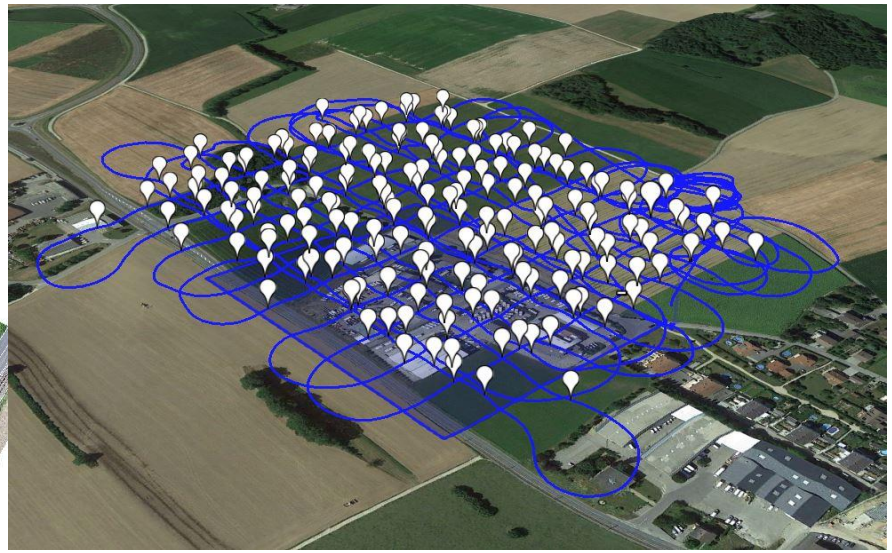
- Down to 3cm in XY
- Down to 5cm in Z (can even be better in some cases)

- Expectation in most cases :
  **1 to 3 times** the Ground Sampling Distance (GSD)

**The accuracy also depends on external factors :**

- Local base, known position : Accuracy of the known point
- Local base, unknown position : Occupation time, Baseline length
- Virtual Reference Station : Accuracy of the base station network

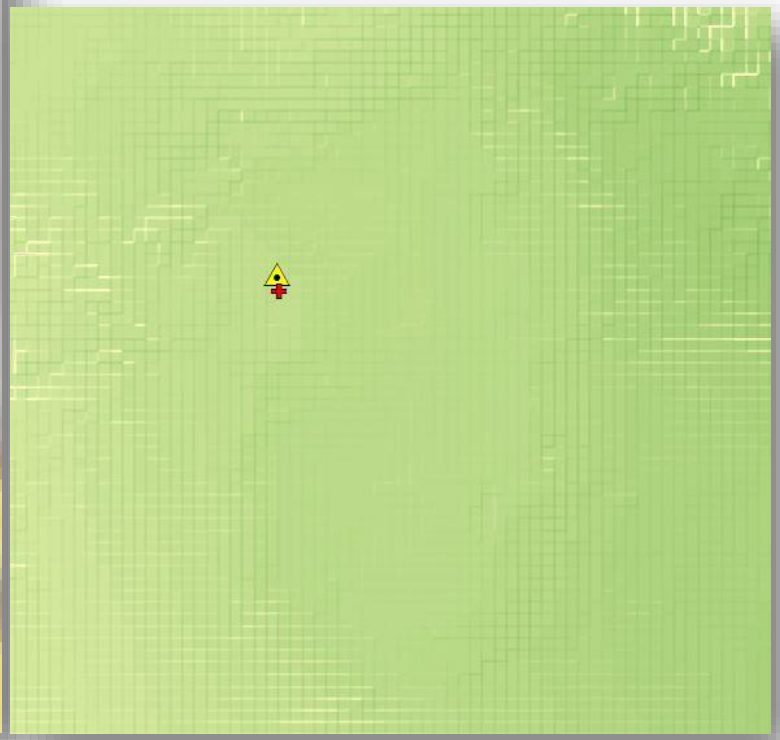
# Accuracy assessment : Test field



- 19 check points on the ground (road marks)
- DSM and orthomosaic accuracy assessment

# Accuracy assessment :

- **Orhomosaic and DSM**



# Accuracy assessment : Results

## Orthomosaic and DSM

| | Error X (m) | Error Y (m) | Error Z (m) |
|---|---|---|---|
| Check point 1 | 0,002 | 0,023 | -0,022 |
| Check point 2 | 0,033 | 0,014 | -0,026 |
| Check point 3 | -0,019 | 0,021 | -0,060 |
| Check point 4 | -0,033 | -0,038 | -0,064 |
| Check point 5 | -0,017 | 0,000 | -0,030 |
| Check point 6 | -0,003 | 0,000 | -0,012 |
| Check point 7 | 0,053 | -0,019 | -0,029 |
| Check point 8 | 0,007 | 0,017 | 0,016 |
| Check point 9 | -0,009 | 0,018 | 0,017 |
| Check point 10 | 0,015 | 0,013 | -0,020 |
| Check point 11 | 0,031 | 0,010 | -0,017 |
| Check point 12 | 0,003 | -0,035 | -0,047 |
| Check point 13 | 0,002 | -0,034 | -0,045 |
| Check point 14 | 0,008 | 0,020 | 0,024 |
| Check point 15 | 0,010 | -0,013 | -0,028 |
| Check point 16 | 0,019 | -0,028 | -0,028 |
| Check point 17 | -0,038 | -0,052 | -0,056 |
| Check point 18 | -0,025 | 0,000 | -0,030 |
| Check point 19 | 0,008 | -0,013 | 0,024 |
| | | | |
| Mean error | 0,002 | -0,005 | -0,023 |
| Standard deviation | 0,022 | 0,023 | 0,026 |
| RMSE | 0,023 | 0,023 | **0,035** |
| RMSE XY | **0,033** | | |

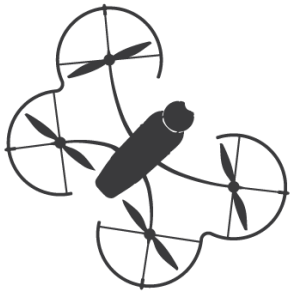
# Accuracy assessment : Results

**10 % of the geotags randomly shifted :**

| | X (m) | Y (m) | Z (m) |
|---|---|---|---|
| Mean error | 0,015 | -0,001 | -0,046 |
| Standard deviation | 0,028 | 0,025 | 0,016 |
| RMSE | 0,033 | 0,025 | **0,048** |
| RMSE XY | **0,038** | | |

# Large-scale corridor mapping Australia

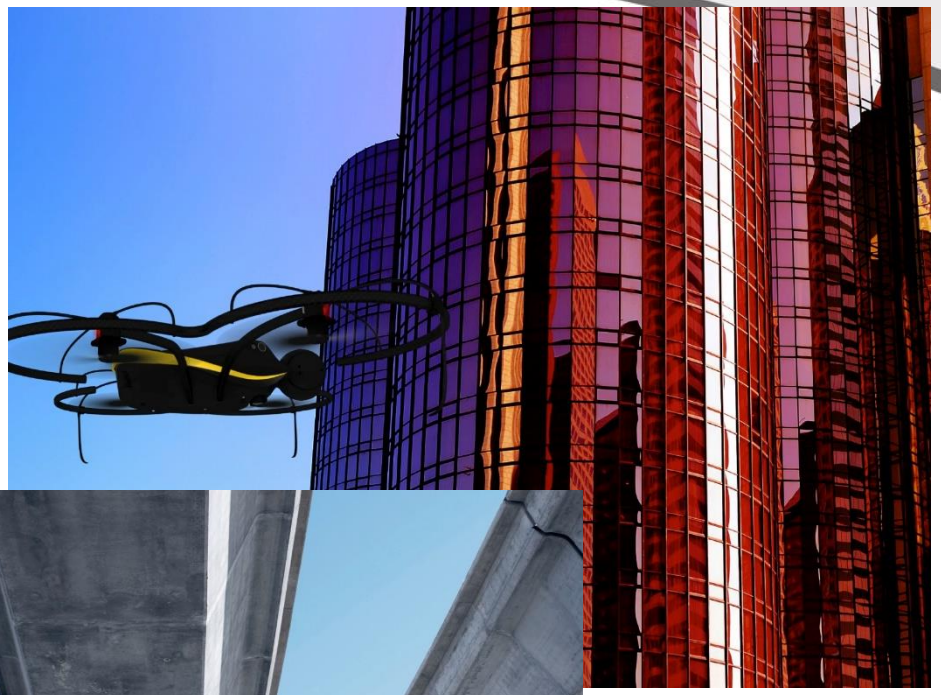

# Fixed-wing vs rotorcraft



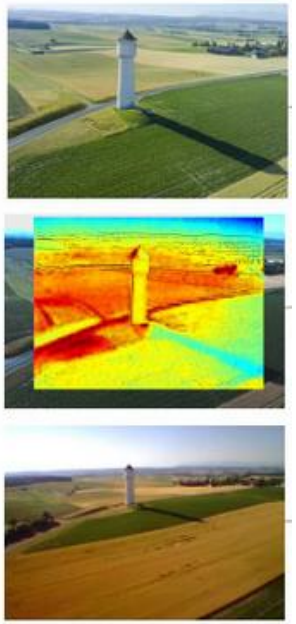
| | | |
|---|---|---|
| coverage | large areas | small areas |
| takeoff & landing | sectors | spot |
| object resolution | cm/px | mm/px |
| oblique imagery | 0° to -50° | +90° to -90° |
| 3D mapping of infrastructure | difficult | much easier |
| Close-up inspection | not adapted | well adapted |

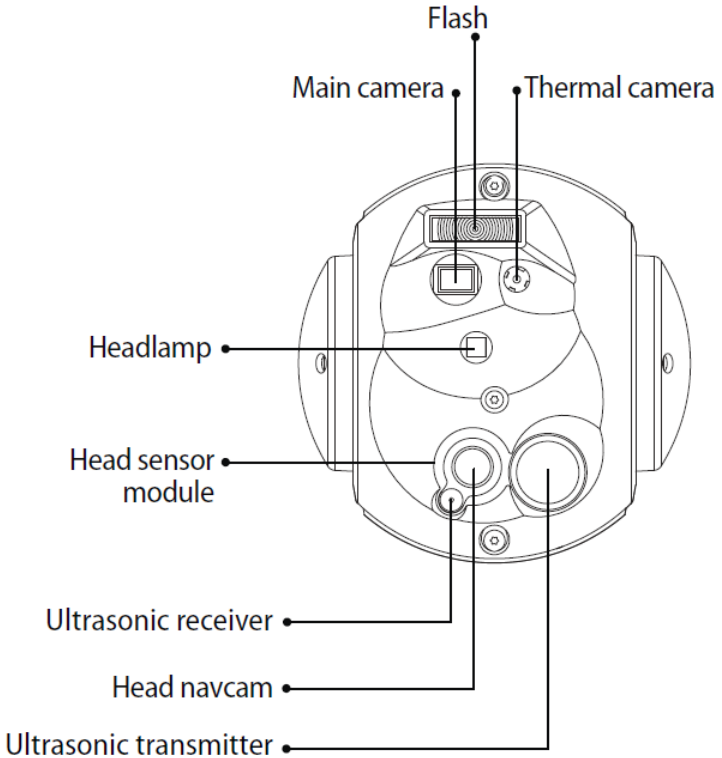
senseFly
a Parrot company

# 3 main applications



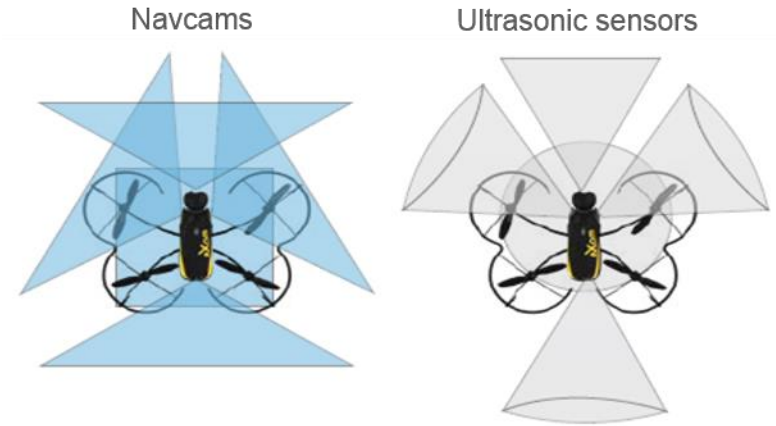
# Triple View Head





# Obstacle Avoidance

## Multi-directional sensor intelligence



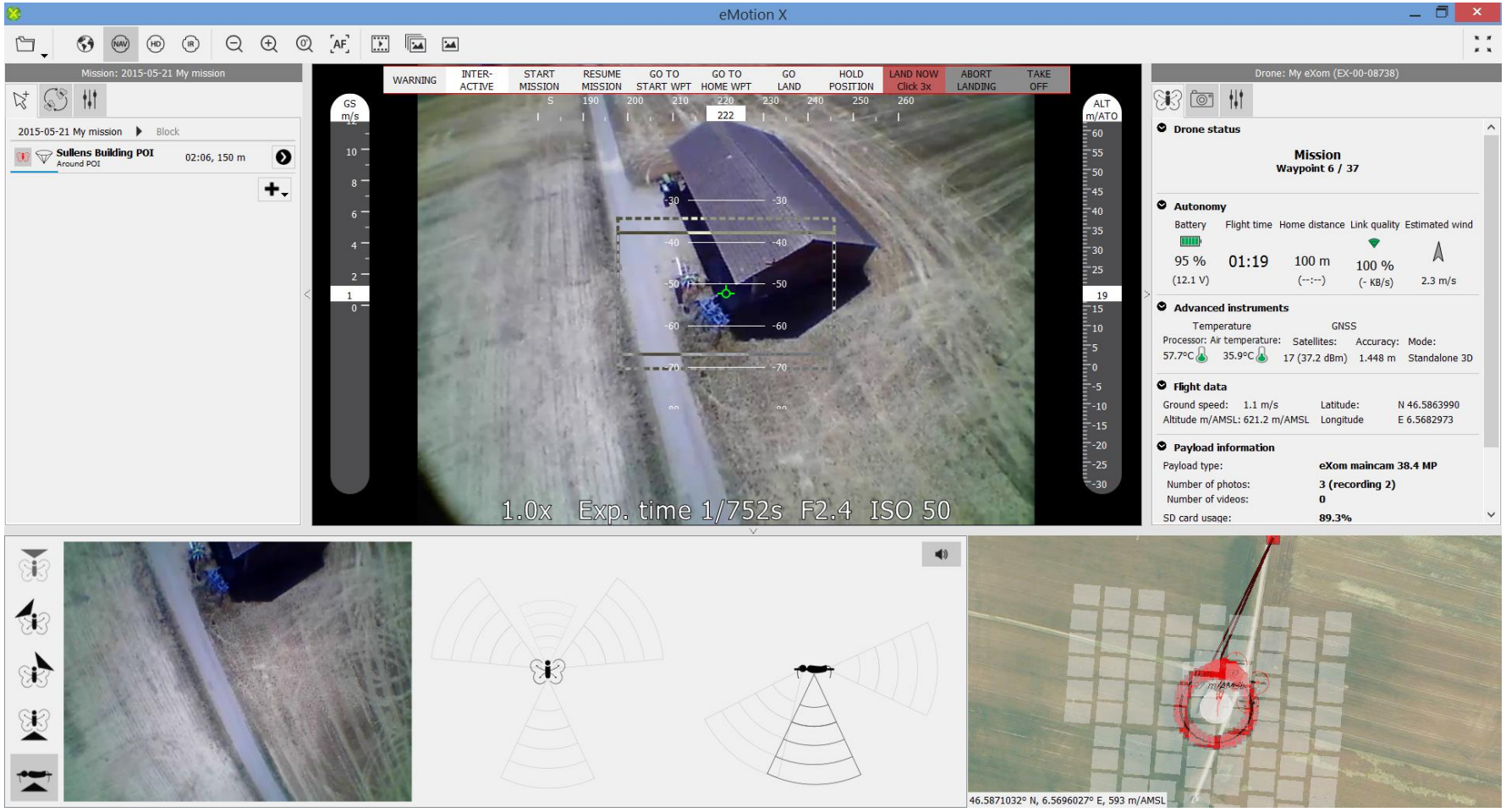

5 ultrasonic sensors + 5 navcams (visual sensors)

- Advanced situational awareness
- Obstacle avoidance
- Flight stabilisation

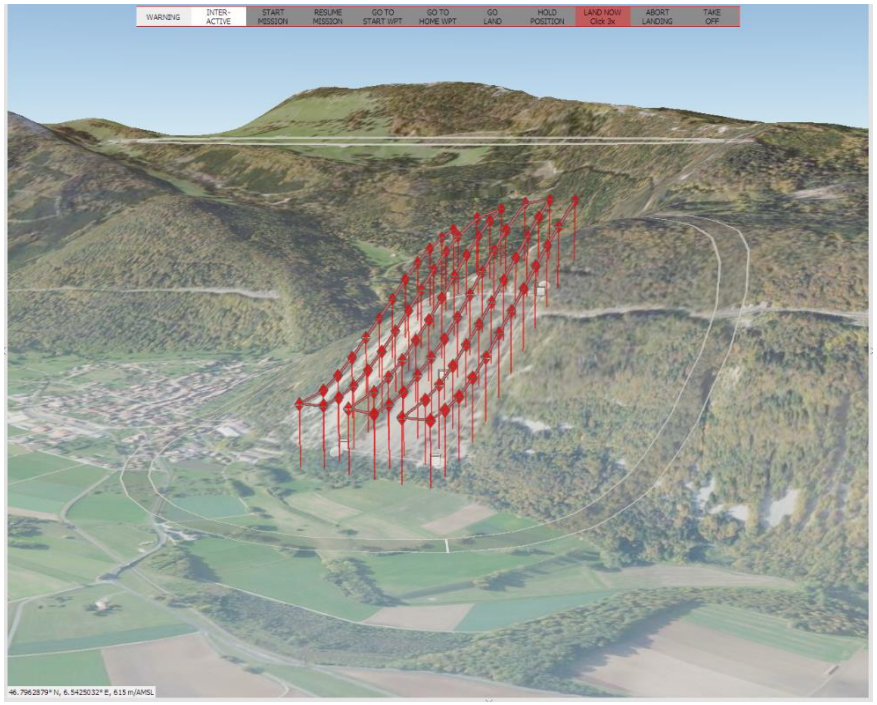
# Safety & Security

- One of the lightest rotary UAVs
- Carbon fiber shrouding
- Signalization lights
- Ground proximity detection
- Flight assistance features (Interactive mode):
  - Cruise control: Maintains (low) constant speed in a given direction
  - Distance lock: Keeps distance to frontal objects (10 to 16 feet)
  - Obstacle avoidance
- Safety procedures:
  - Automated failsafe behaviors: Geofencing, return home, emergency stop, emergency landing
- Autopilot fallback:
  - In case of major failure of the main autopilot, a lower level auto-pilot will auto-land the drone
  - Independent RC controller (take manual control at any time)

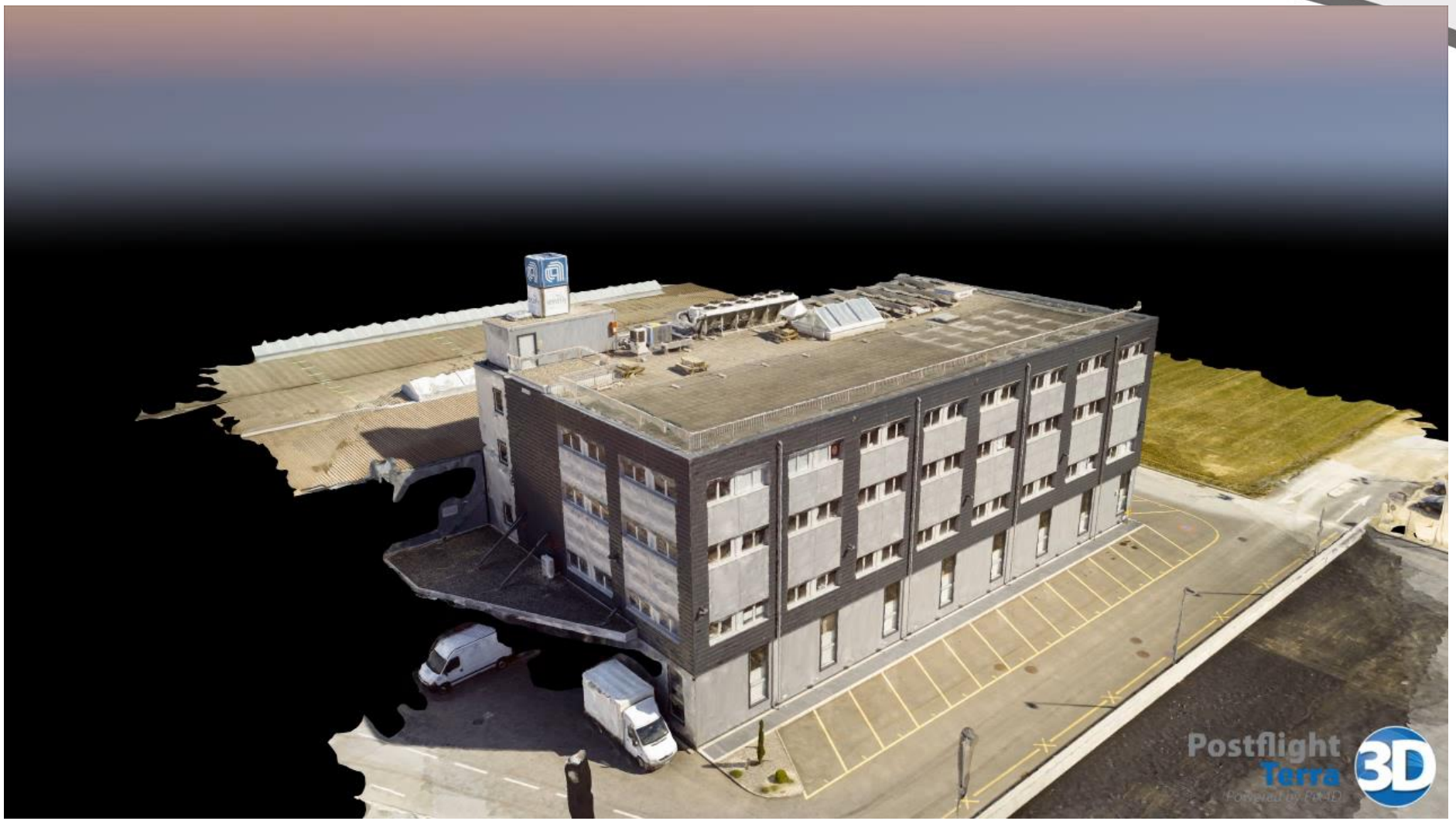
# eMotion X


eMotion X
Mission: 2015-05-21 My mission
2015-05-21 My mission
Block
Sullens Building POI
Around POI
02:06, 150 m
WARNING
INTER-ACTIVE
START MISSION
RESUME MISSION
GO TO START WPT
GO TO HOME WPT
GO LAND
HOLD POSITION
LAND NOW Click 3x
ABORT LANDING
TAKE OFF
GS m/s
ALT m/ATO
1.0x Exp. time 1/752s F2.4 ISO 50
Drone: My eXom (EX-00-08738)
Drone status
Mission
Waypoint 6 / 37
Autonomy
Battery
Flight time
Home distance
Link quality
Estimated wind
95 %
(12.1 V)
01:19
100 m
100 %
(- KB/s)
2.3 m/s
Advanced instruments
Temperature
GNSS
Processor:
Air temperature:
Satellites:
Accuracy:
Mode:
57.7°C
35.9°C
17 (37.2 dBm)
1.448 m
Standalone 3D
Flight data
Ground speed: 1.1 m/s
Altitude m/AMSL: 621.2 m/AMSL
Latitude: N 46.5863990
Longitude E 6.5682973
Payload information
Payload type: eXom maincam 38.4 MP
Number of photos: 3 (recording 2)
Number of videos: 0
SD card usage: 89.3%
46.5871032° N, 6.5696027° E, 593 m/AMSL

# Flight modes – Automatic flight plan

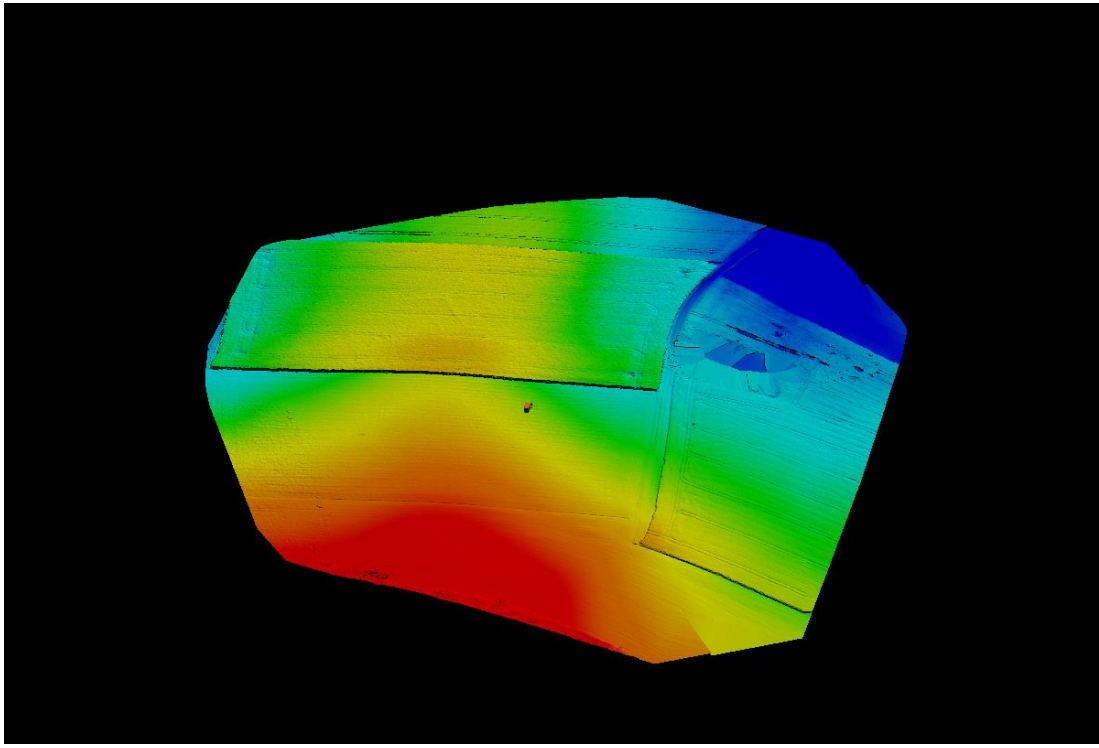



# 3D Building Mapping (senseFly HQ)

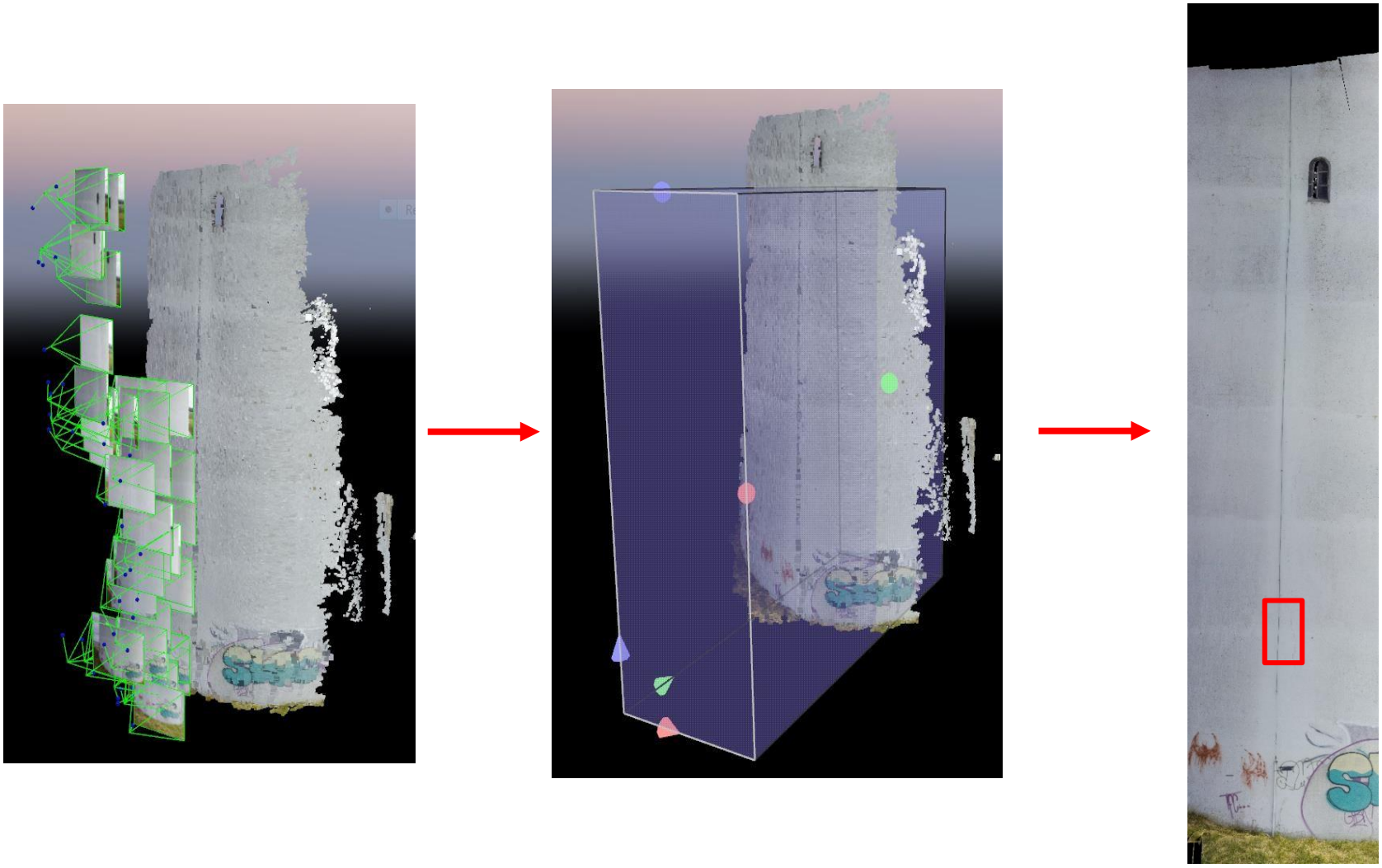

Postflight
Terra
3D

# 2D mapping

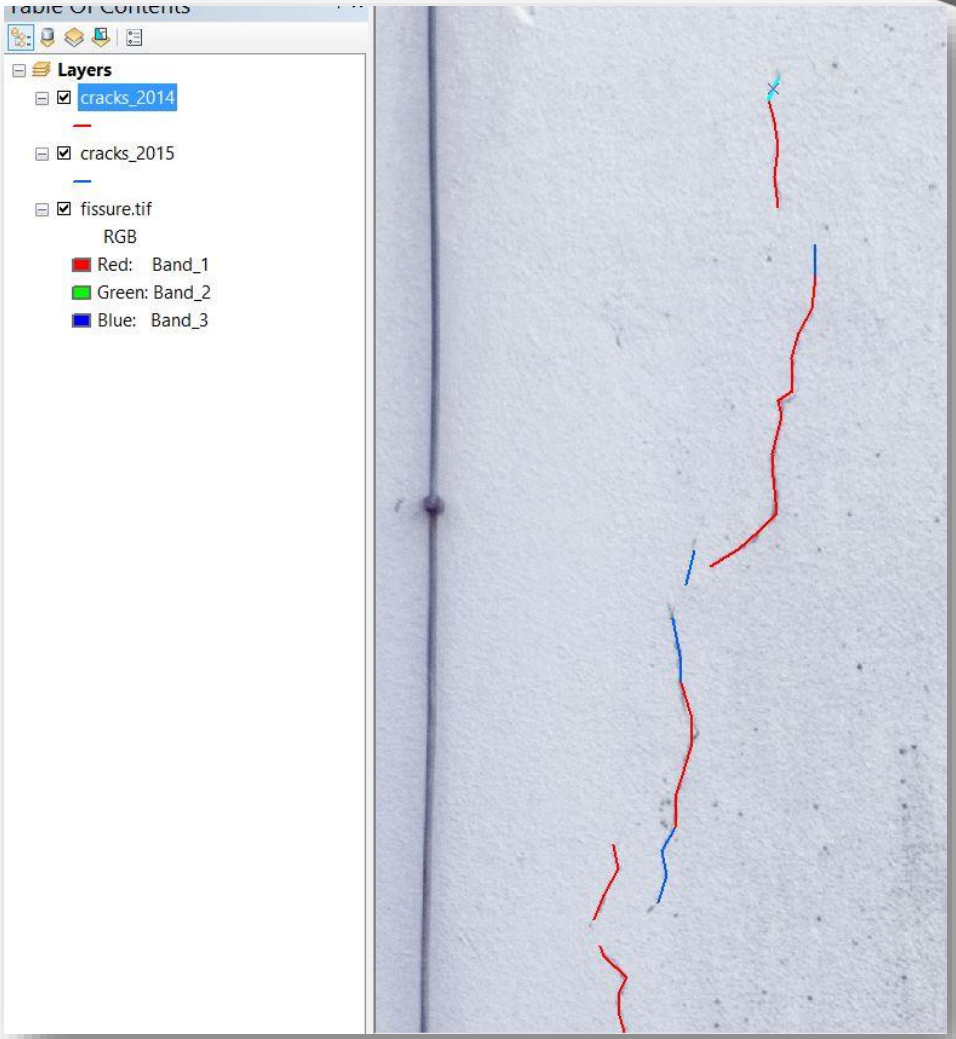
- GSD: 1.82 cm (0.71 in) / pixel
- Images: 35
- Altitude: 300 ft
- Coverage: 12.5 ac (5 ha)



# Concrete tower – Cracks mapping



# Cracks detection and monitoring

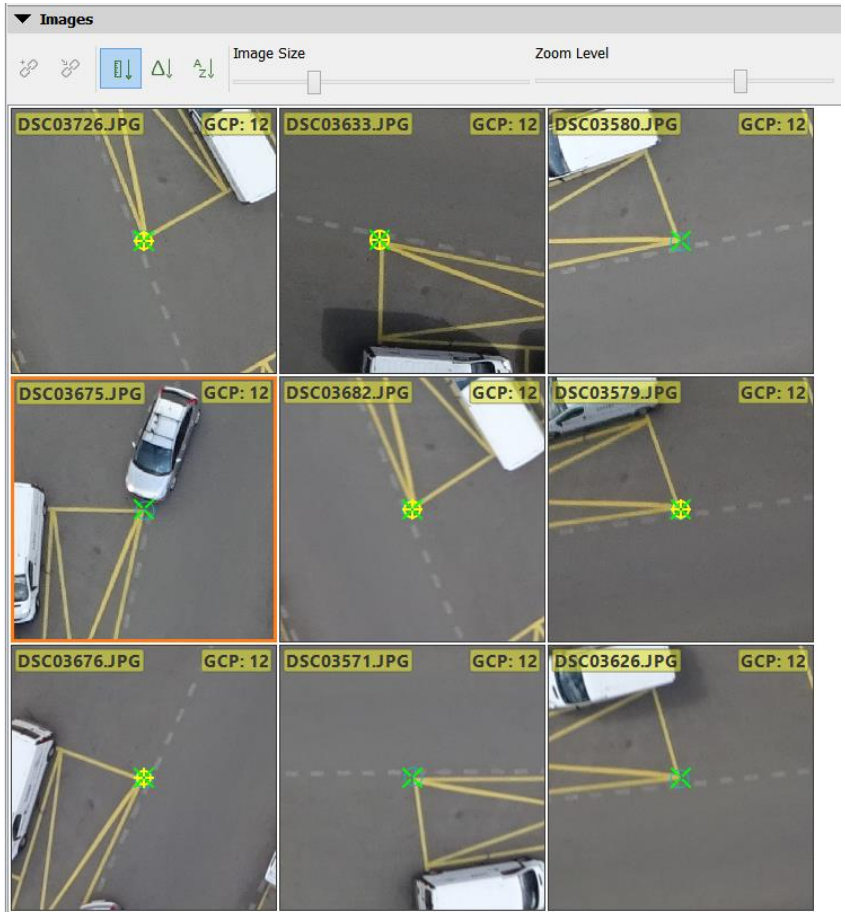


# Cliff face inspection

- 15 minutes flight
- 11 m (36 ft) distance from cliff
- 0.3 cm (0,11 inch) / pixel
- Cracks & potential rockfalls clearly visible (useful for volume / mass estimation & reinforcement planning)

# How to get high precision with eXom?

- **Ground control points or manual scaling and orientation**

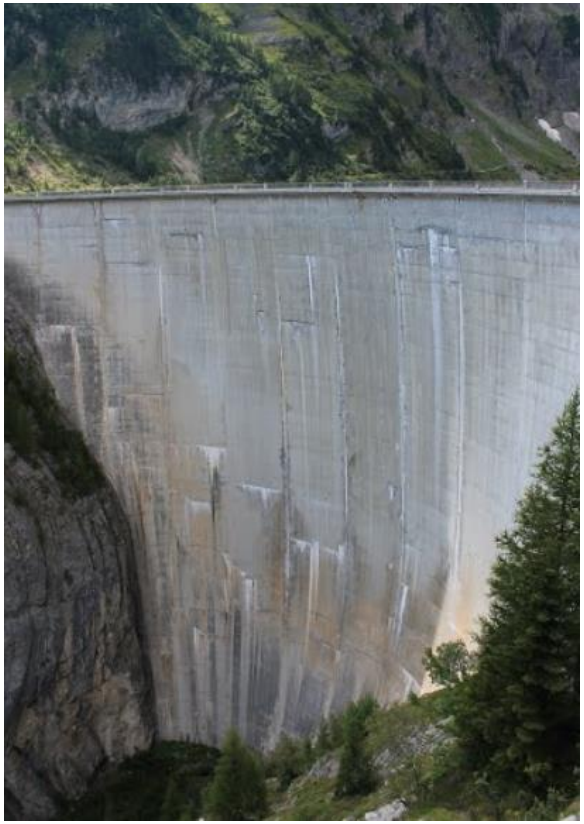


# High accuracy

| Check point | Error | | | Projection Error (pixel) |
|---|---|---|---|---|
| | X (m) | Y (m) | Z (m) | |
| 700 | 0.0003 | 0.0002 | -0.0061 | 0.1962 |
| 800 | 0.0003 | -0.0003 | -0.0048 | 0.2103 |
| 900 | 0.0011 | 0.0003 | 0.0013 | 0.1765 |
| 1000 | -0.0011 | -0.0010 | -0.0053 | 0.2704 |
| 1100 | -0.0010 | -0.0004 | -0.0003 | 0.3256 |
| Mean (m) | -0.000072 | -0.000334 | -0.003023 | |
| Sigma (m) | 0.000818 | 0.000415 | 0.002945 | |
| RMS (m) | 0.000821 | 0.000533 | 0.004220 | |

# What's next in close range automatic mapping?

- Flightline direction: up/down or left/right?
- Maintaining the Connection
- Poor GNSS signal
- Start & Landing
- Power (Batteries, Laptops/Tablets)
- Data Storage




# Thank you!