



The class will
start at 16h15

Also part of :



sia

Schweizerischer Ingenieur- und Architektenverein
Société suisse des ingénieurs et des architectes
Società svizzera degli ingegneri e degli architetti
Swiss society of engineers and architects

■ Dimitrios Terzis



Innovation for construction & the environment

Dr. Dimitrios Terzis

08/10/2024

Today's class

CIVIL-424 Innovation for construction and the Environment / Fall 2024

Tuesdays 16:15-18:00 pm
Tuesdays 18:00 - 19:00 pm
Office hours:

Lectures
Project discussions and continuous reporting
Tuesdays morning (upon email request and confirmation)

Room GCA331

Title

Week 1	10.Sep 45 mins 45 mins	Introduction to the course Disruptive, Incremental Innovation and Research, Projects from last year and takeaways
Week 2	17.Sep 45 mins 45 mins	Cement-free concrete Cement-free concrete
Week 3	24.Sep 45 mins 45 mins	Circular economy, Impact and Life Cycle Assessment Sustainalytics
Week 4	01.Oct 45 mins 45 mins	Data-driven structural health monitoring and damage detection for smart infrastructure and buildings Data-driven structural health monitoring and damage detection for smart infrastructure and buildings
Week 5	08.Oct 45 mins 45 mins	Monitoring and surveillance GIS and BIM for construction and risk management
Week 6	15.Oct 45 mins 45 mins	Project preparation / Paper reading Project preparation / Paper reading
Week 7	29.Oct 45 mins 45 mins	Industrial innovation from the perspective of a construction giant Industrial innovation from the perspective of a construction giant
Week 8	05.Nov 45 mins 45 mins	Sustainalytics Sustainalytics
Week 9	12.Nov 45 mins 45 mins	Traffic Operations, Unmanned Aerial Systems (UAS) and Data Science for smart mobility Traffic Operations, Unmanned Aerial Systems (UAS) and Data Science for smart mobility
Week 11	19.Nov 45 mins 45 mins	Harnessing renewables for buildings Harnessing geo-energy for buildings
Week 12	26.Nov 45 mins 45 mins	Nature-based innovations Nature-based innovations
Week 13	03.Dec 45 mins 45 mins	Parametric design Robotic construction
Week 14	10.Dec 45 mins 45 mins	Project presentations - schedule to be announced Project presentations - schedule to be announced
Week 15	17.Dec 45 mins 45 mins	Synthesis of Innovation project and takeaways Synthesis of Innovation project and takeaways

Today's class

1) How do we digitize reality

2) BIM / GIS and photogrammetry

3) Use cases with an example from the Swiss Innovation ecosystem (Pix4D)

Today's class

BIM: BIM is a digital representation of the physical and functional characteristics of a building. It uses 3D modeling to manage and visualize building information throughout its lifecycle. Photogrammetry can be used in BIM workflows to create accurate 3D models of existing structures or environments, especially for renovation projects or site analysis, by capturing spatial data from photos. The photogrammetric data can be integrated into BIM software as point clouds or 3D meshes to aid in creating detailed models.

GIS: GIS deals with spatial data and mapping at broader scales (like cities, infrastructure, or landscapes). Photogrammetry helps capture geographic data, especially for topographical mapping and 3D models of the terrain. It's commonly used for creating maps and visualizing geographical spaces. These photogrammetric data can be imported into GIS systems for analysis, planning, and decision-making.

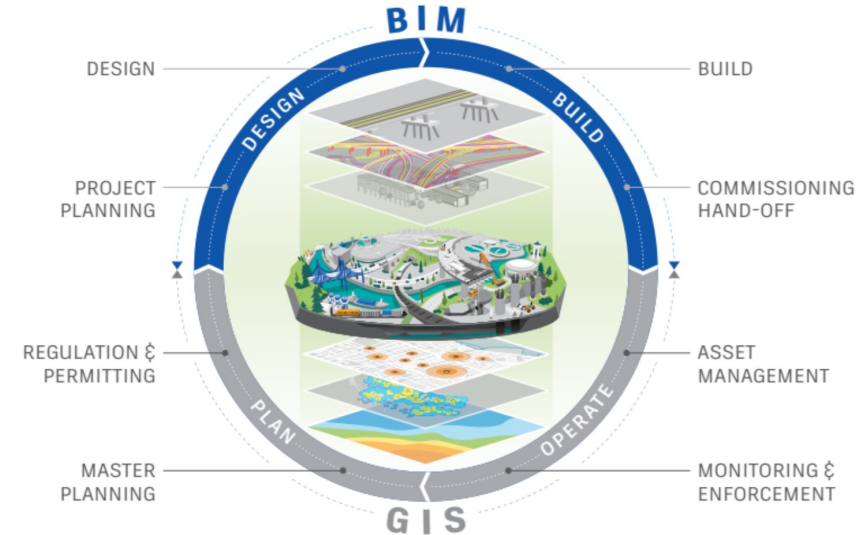


Image Source: <https://damassets.autodesk.net/>

What is photogrammetry?



Photogrammetry is the science and technology of obtaining reliable information about physical objects and the environment through the process of recording, measuring and interpreting photographic images and patterns of electromagnetic radiant imagery and other phenomena.

“Evolution favours eyes that perceive the world in 3D.”



Christoph Strecha, Founder and CEO of Pix4D

A follow-up on SHM:

**If you went to bed last night as an industrial company,
you're going to wake up today as a software and analytics
company.**

Jeffrey Immelt, former CEO of General Electric

A follow-up on SHM:

If you went to bed last night as an industrial company, you're going to wake up today as a software and analytics company.

Jeffrey Immelt, former CEO of General Electric

If you went to bed last night as general contractor, you're highly going to wake up today as a data and analytics company.

Today's class

Make computers understand the physical world to unlock the digitization potential and that of AI for the infrastructure industry (traffic; construction sites; etc.)

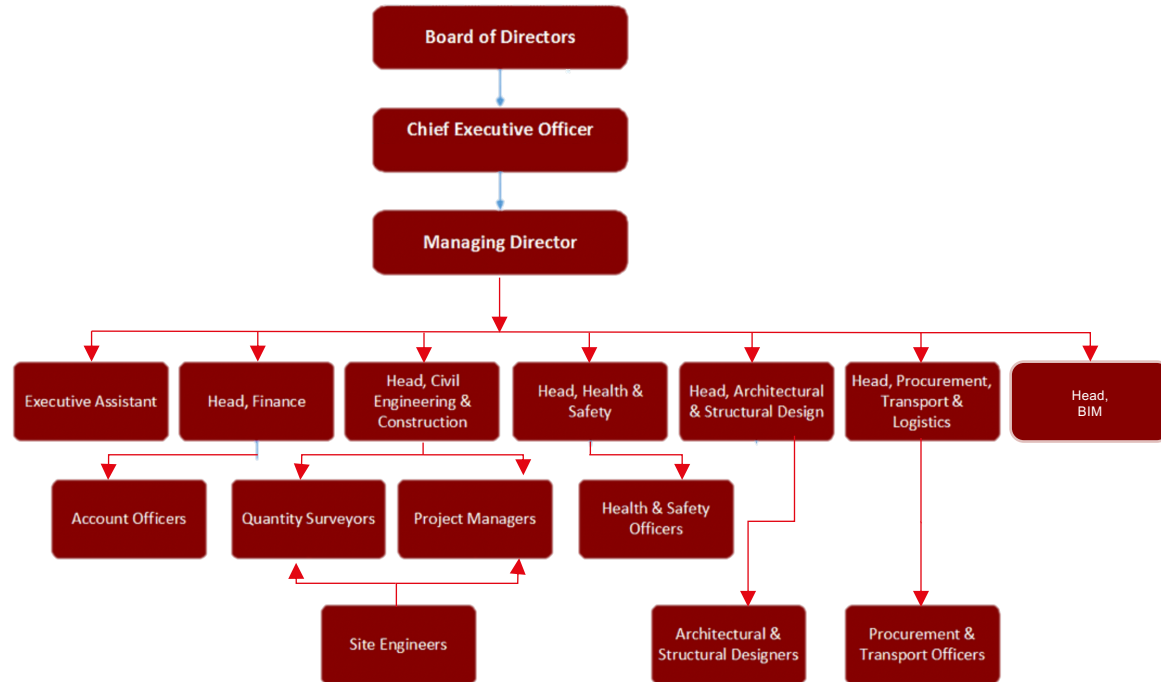
How do we digitize reality?

- **Select a sensor: LiDAR (laser) vs Photogrammetry (camera)**
- **Select a level of detail: Distance from the object (Level of detail vs Coverage)**

How to integrate innovation into "business as usual": The example of digitization



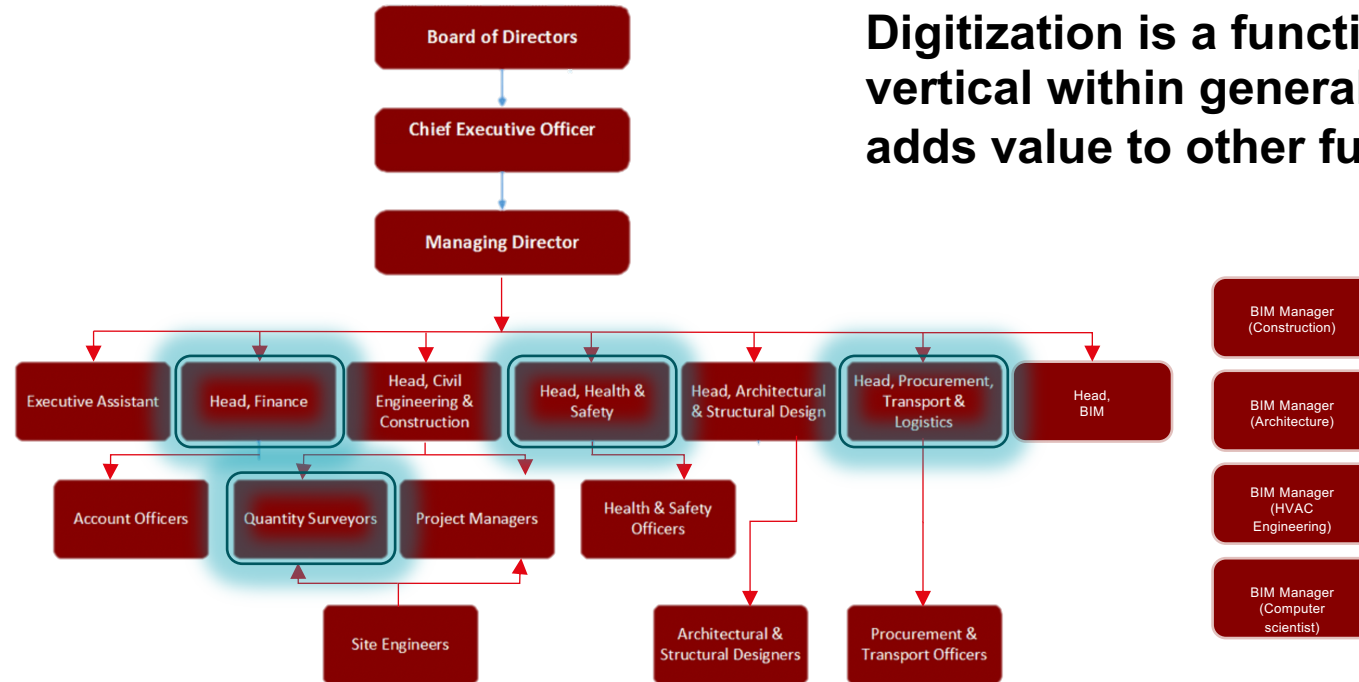
How to integrate innovation into "business as usual": The example of digitization



How to integrate innovation into "business as usual": The example of digitization



How to integrate innovation into "business as usual": The example of digitization



Today's class

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Jeffrey Immelt, former CEO of General Electric

If you went to bed last night as general contractor, you're highly going to wake up today as a data and analytics company.

How do we digitize reality?

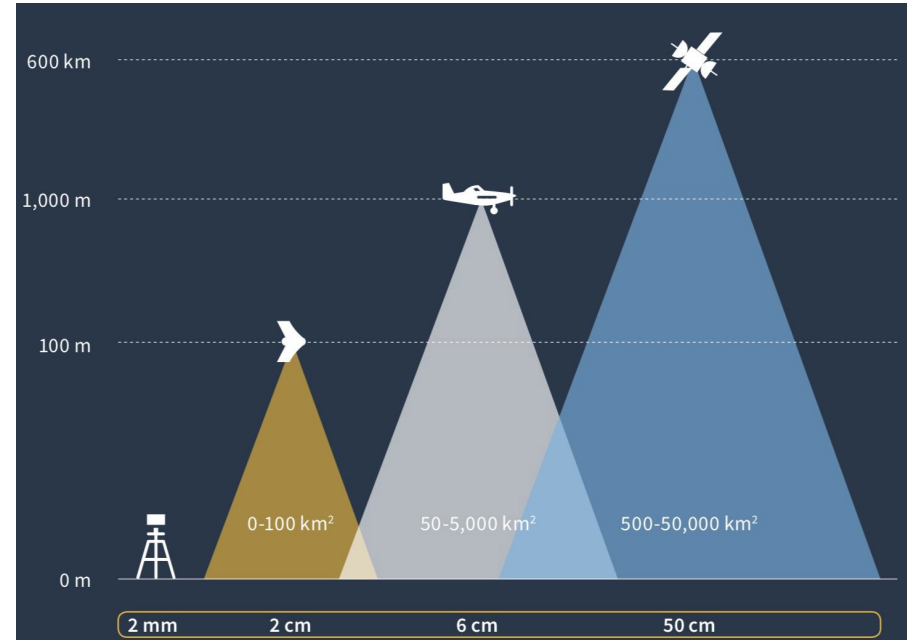
Ingredient 1 (What) - Sensor type:

- A. **Laser**
Active Sensor (touch)
- B. **Camera**
Passive Sensor (see)



Ingredient 2 (Where) - Distance from the object

- A. **Close range**
High Level of Detail (LOD)
Poor coverage
- B. **Long distance**
Decreased LOD
Higher coverage



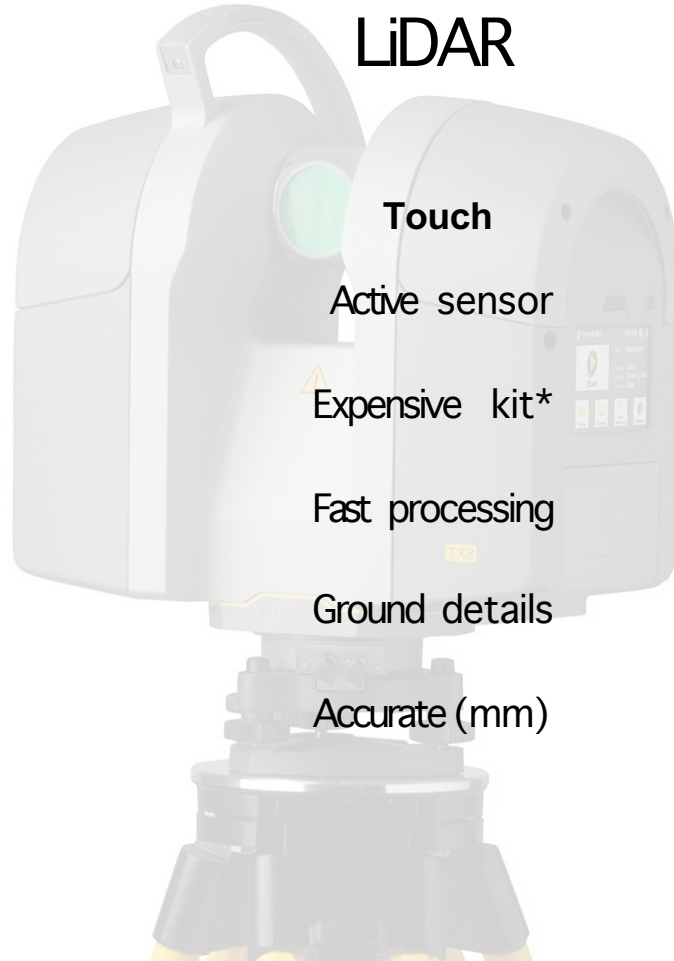
LiDAR

LiDAR (Light Detection And Ranging) is a surveying method that measures distance to a target by illuminating the target with laser light and measuring the reflected light with a sensor.

Photogrammetry

The extraction of three-dimensional measurements from two-dimensional data (i.e. images).

LiDAR



Touch

Active sensor

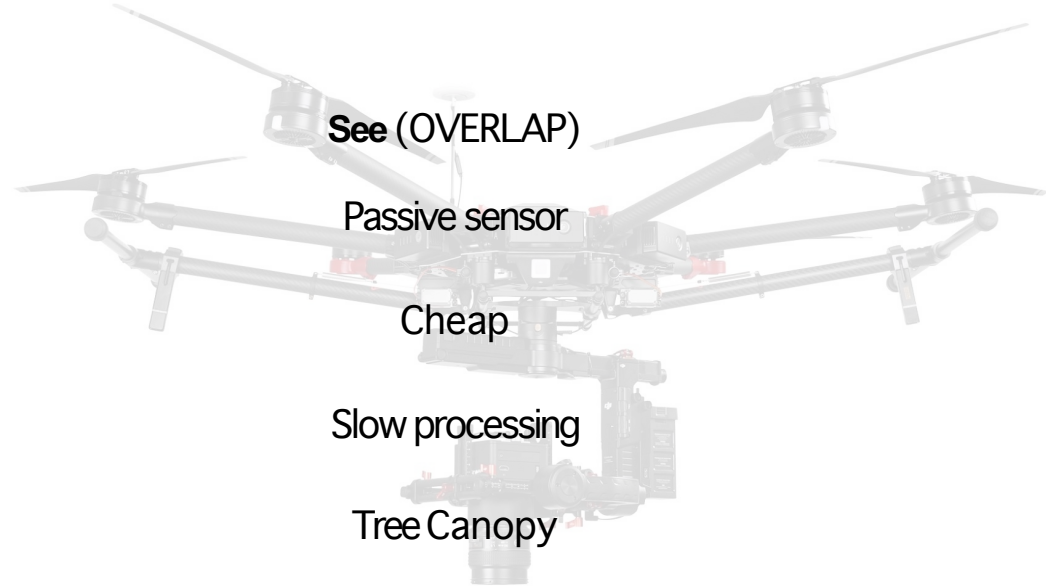
Expensive kit*

Fast processing

Ground details

Accurate (mm)

Photogrammetry



See (OVERLAP)

Passive sensor

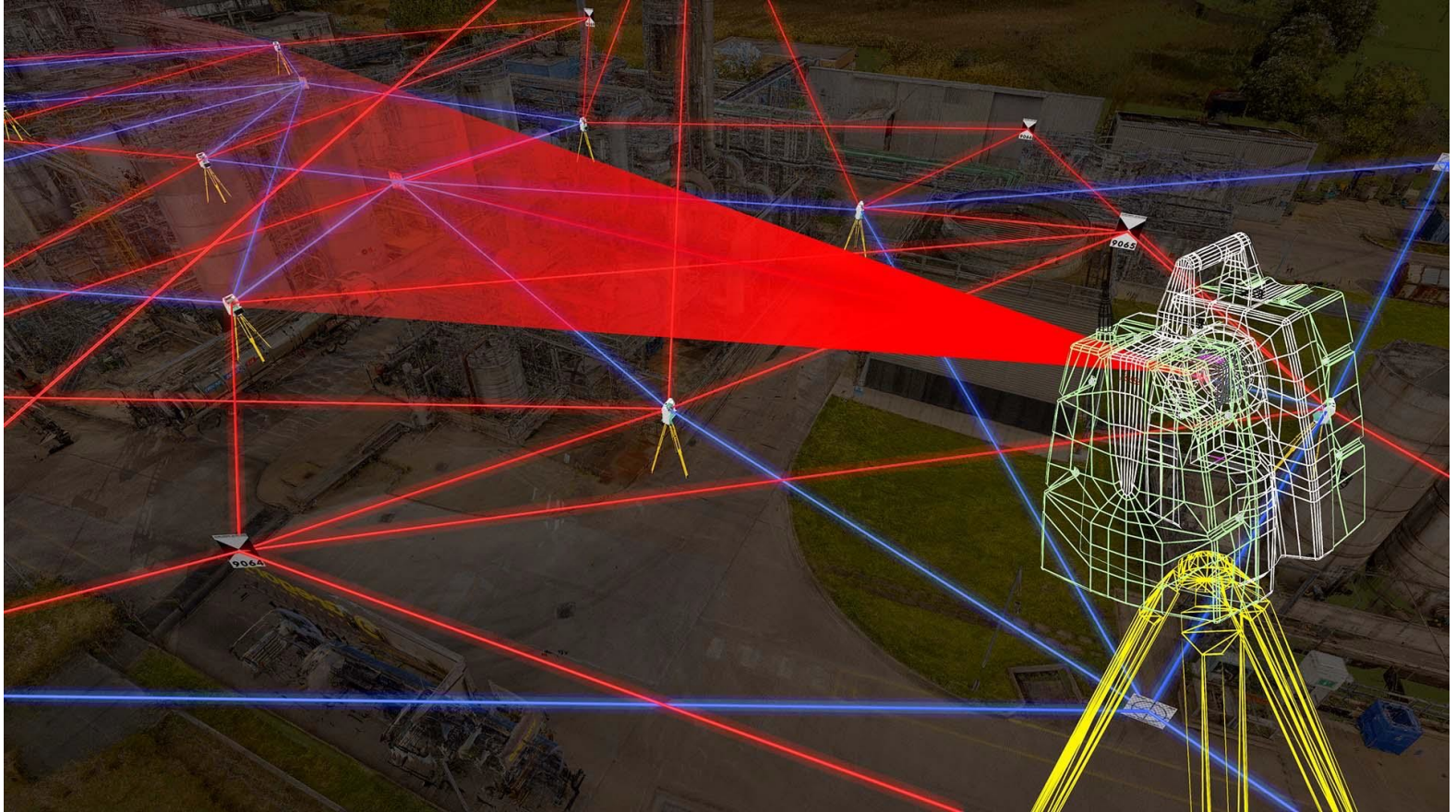
Cheap

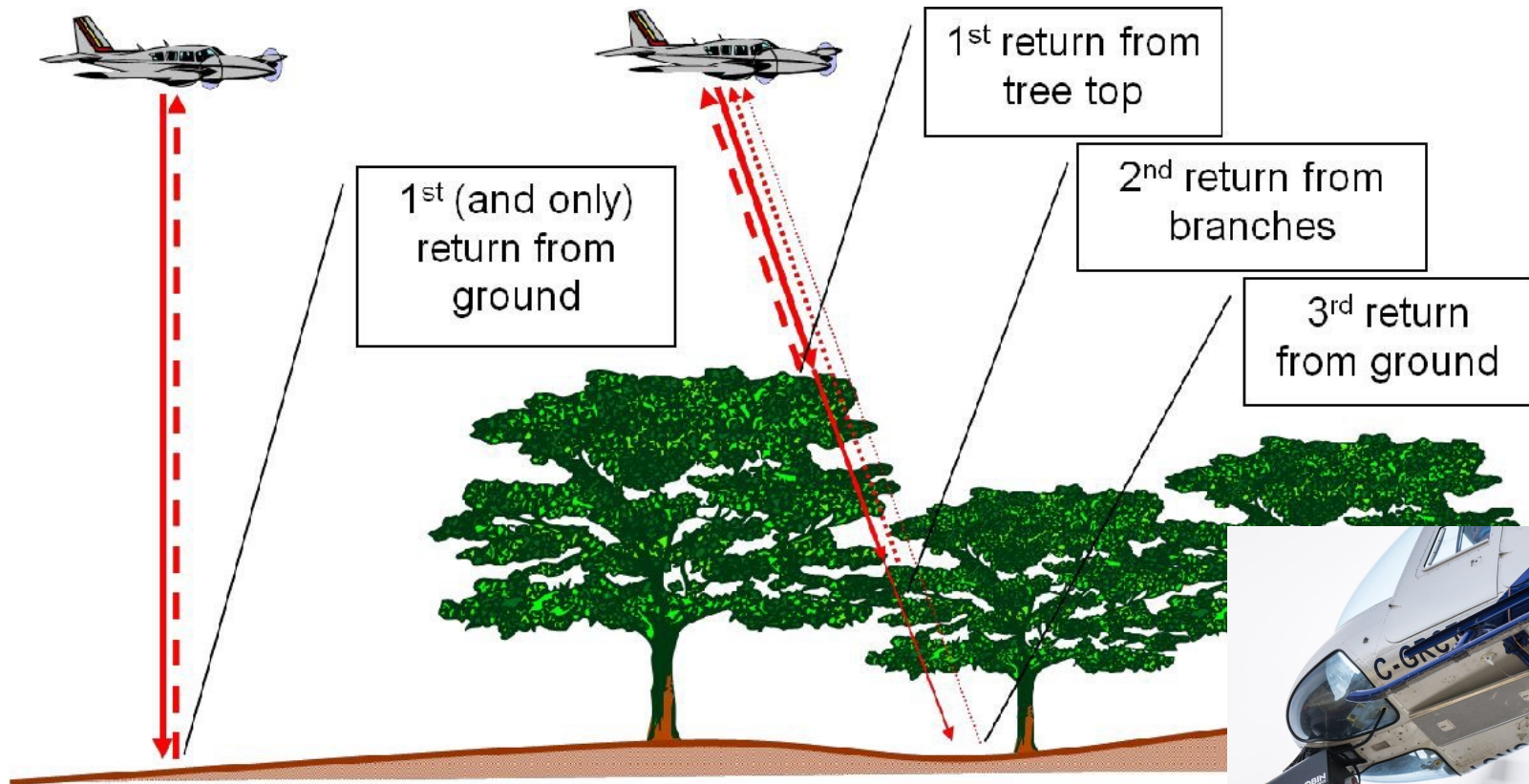
Slow processing

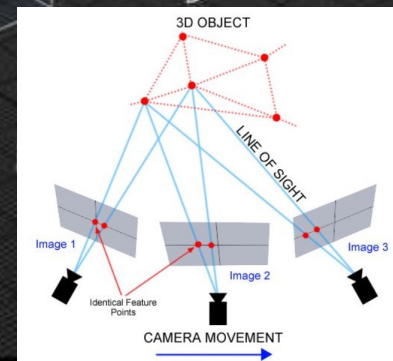
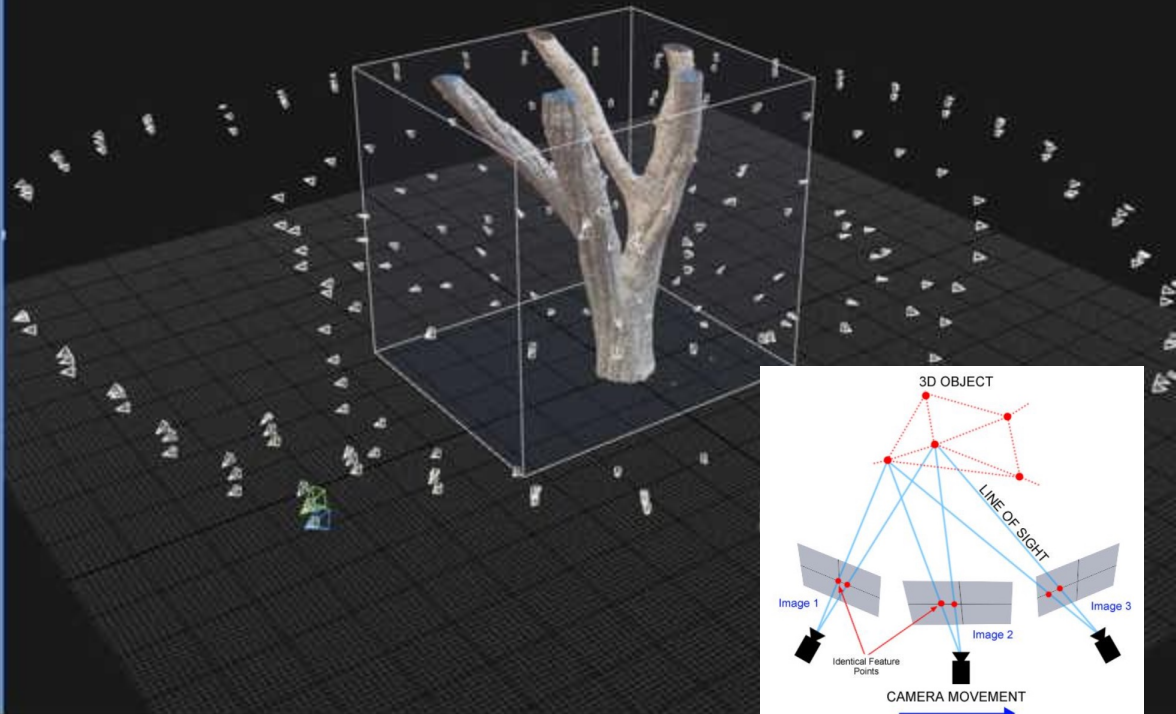
Tree Canopy

Accurate (cm)









How do we digitise reality?!

The Level of Detail (LOD) matters

600 km



Mixed data capture (Ground Sample Distance GSD)

Satellite:

- GSD: 50cm/px
- Resolution: 500MP
- Altitude: 700,000m (2,300,000ft)

Drones:

- GSD: 2.5cm/px
- Resolution: 20MP
- Altitude: 100m (350ft)



100 m



Planes:

- GSD: 10cm/px
- Resolution: 260MP
- Altitude: 3,000m (10,000ft)

Phones:

- GSD: >0.5cm/px
- Resolution: 12MP
- Altitude: Ground

0 m



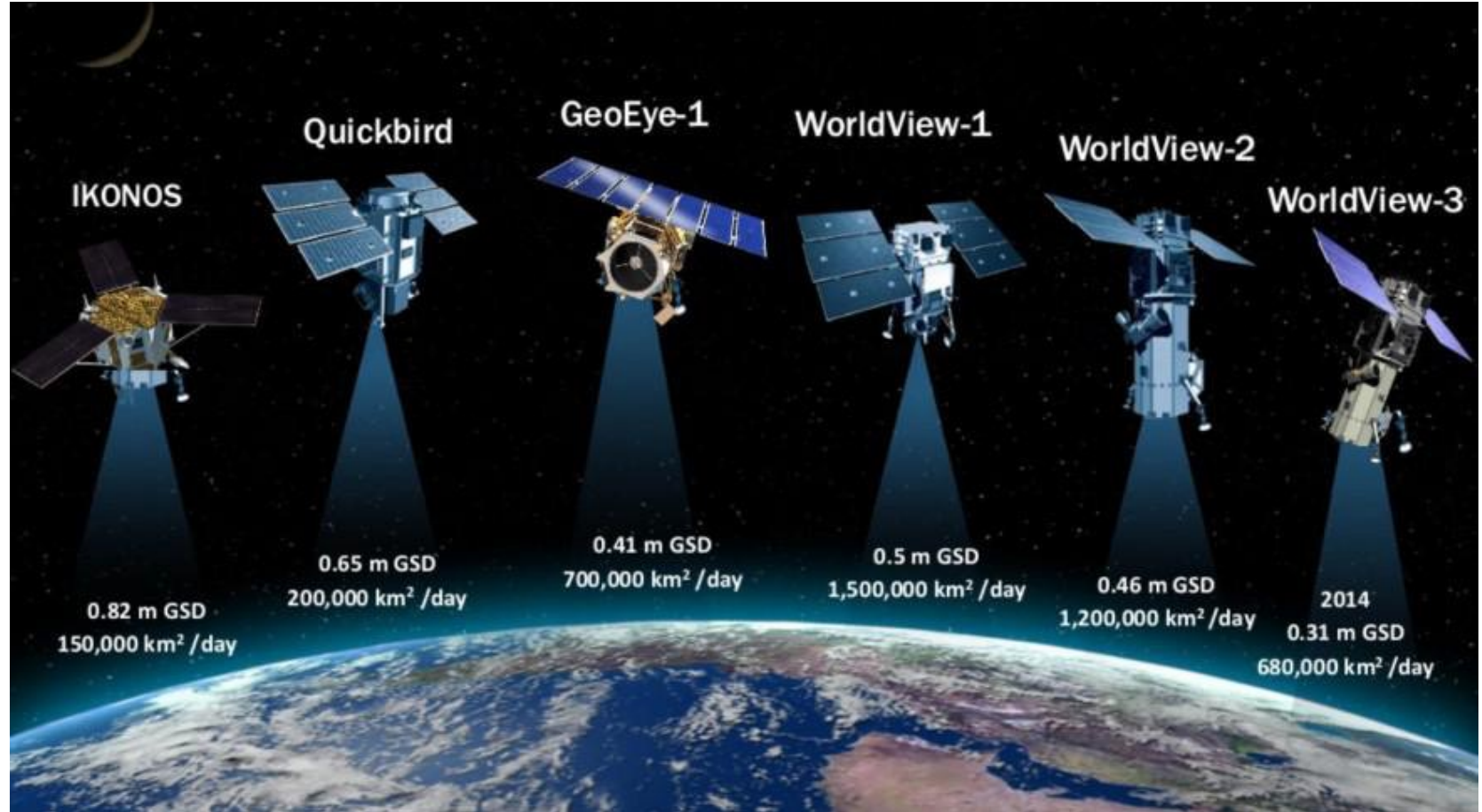
5-100 km²

10-5,000 km²

500-55,000 km²

Satellite

Hardware - Capture - Model



Satellite

Hardware - **Capture** - Model



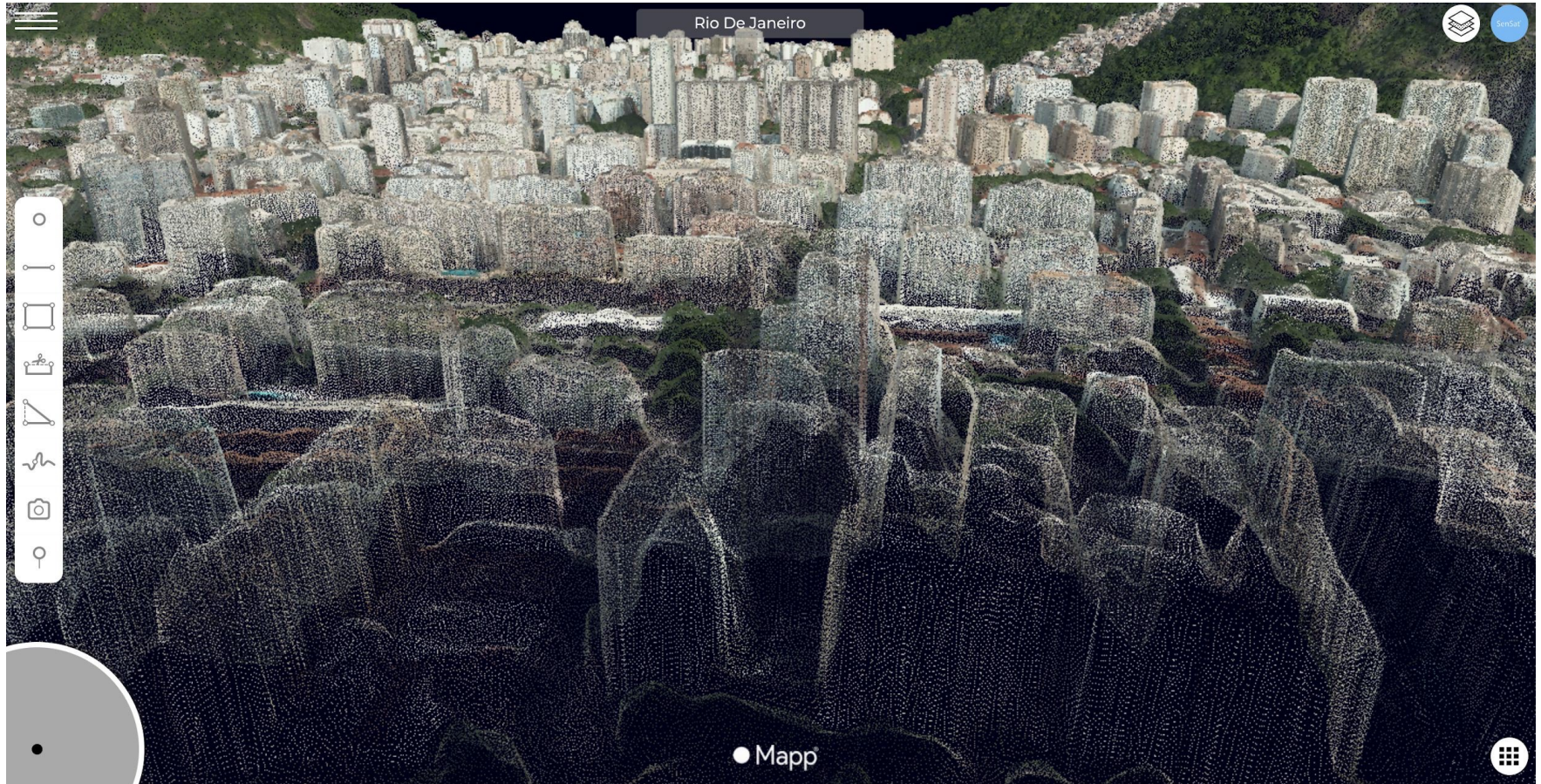
Satellite

Hardware - Capture - Model



Satellite

Hardware - Capture - **Model**



Plane

Hardware - Capture - Model



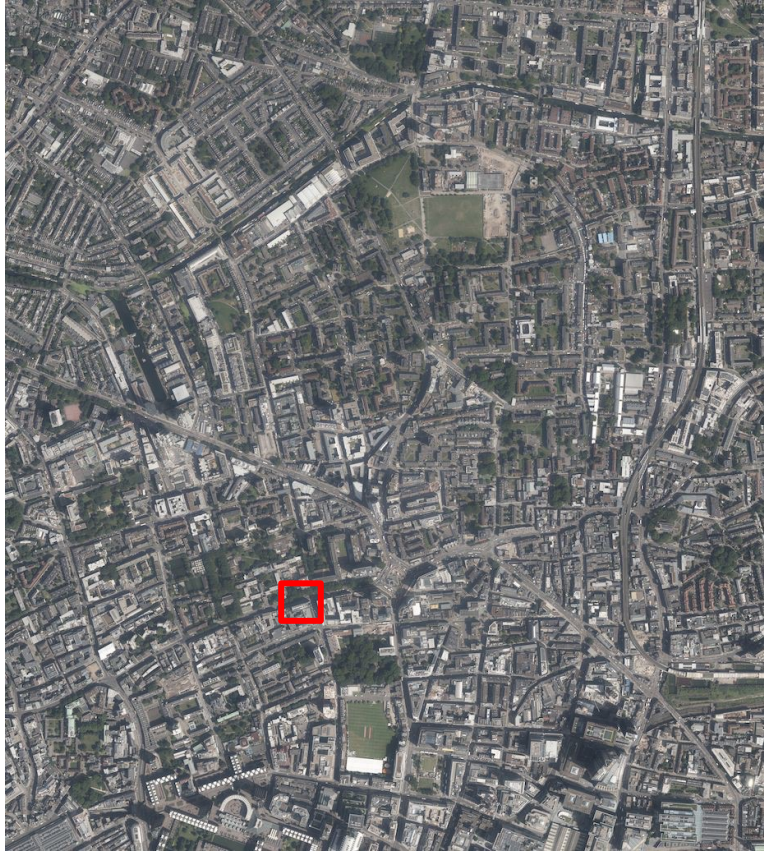
Plane

Hardware - Capture - Model



Plane

Hardware - **Capture** - Model



Plane

Hardware - Capture - Model



Plane

Hardware - Capture - Model



Plane

Hardware - Capture - **Model**



Drones

Hardware - Capture - Model



Drones

Hardware - **Capture** - Model



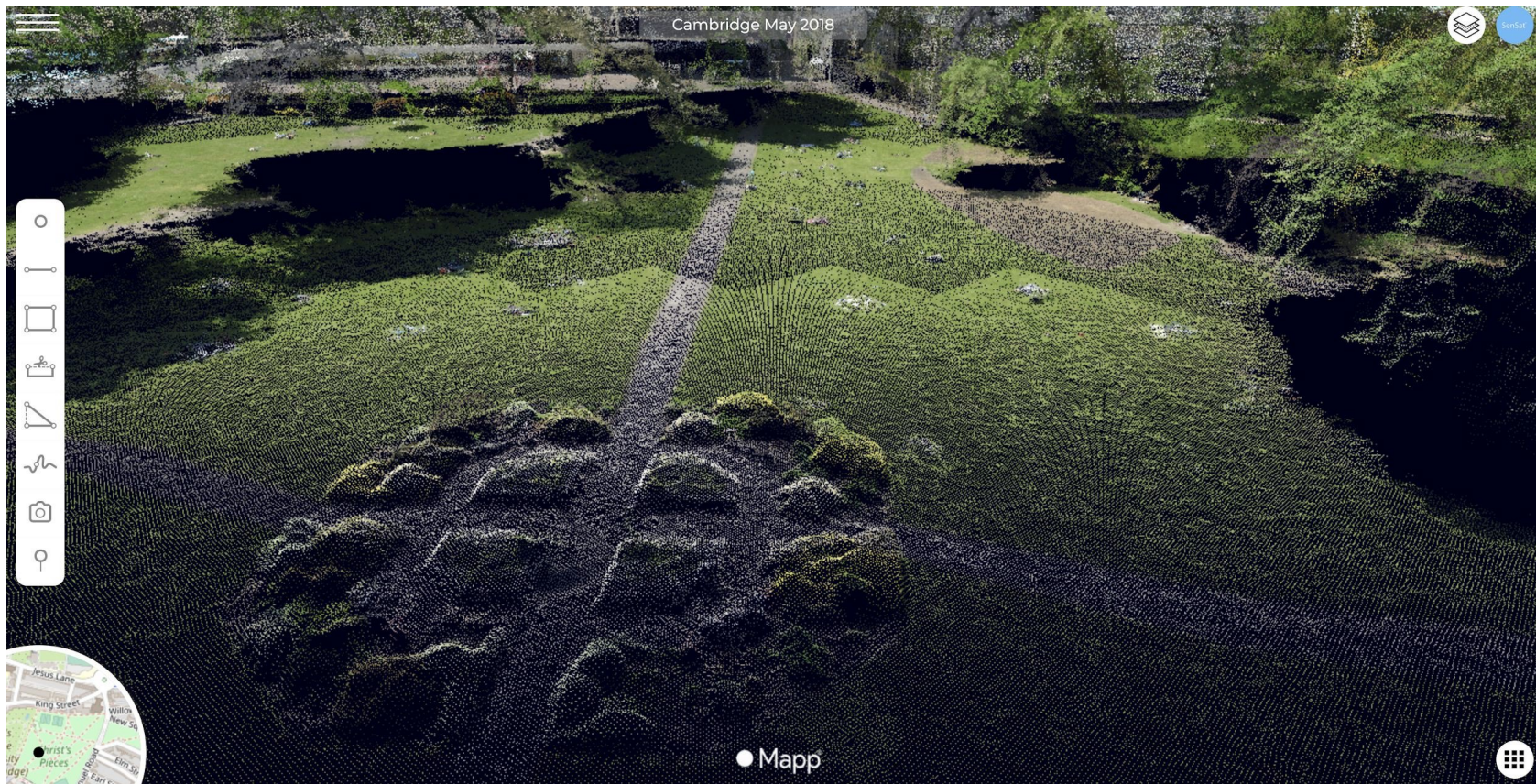
Drone

Hardware - Capture - Model



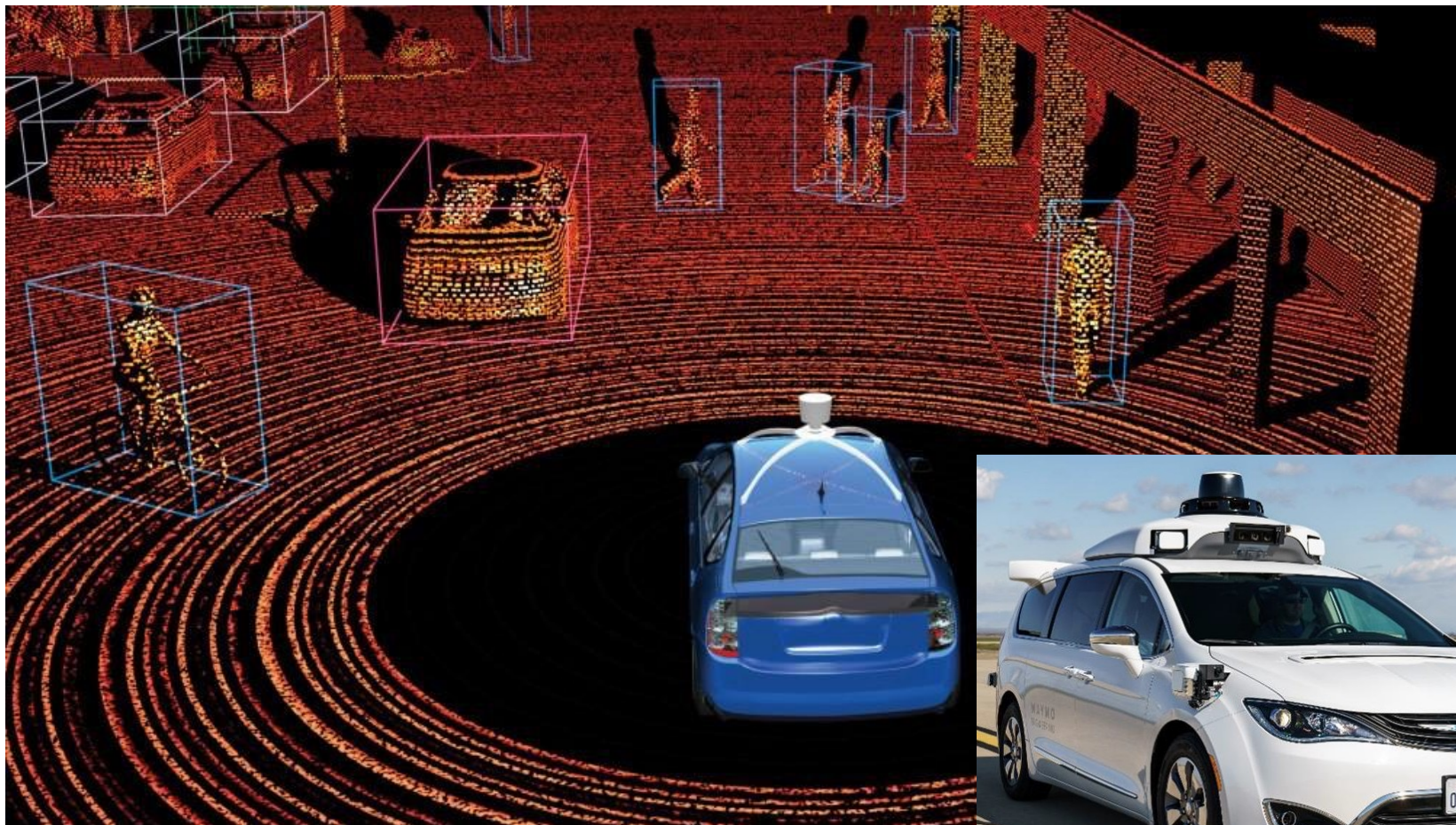
Drone

Hardware - Capture - Model



Driven LiDAR

Hardware - Capture - Model



Driven LiDAR

Hardware - Capture - Model



Terrestrial LiDAR

Hardware - Capture - Model





Mixed data capture (Ground Sample Distance GSD)

600 km
1,000 m
100 m
0 m

A. Satellite:

- GSD: 50cm/px
- Resolution: 500MP
- Altitude: 700,000m (2,300,000ft)

C. Drones:

- GSD: 2.5cm/px
- Resolution: 20MP
- Altitude: 100m (350ft)

B. Planes:

- GSD: 10cm/px
- Resolution: 260MP
- Altitude: 3,000m (10,000ft)

D. Phones:

- GSD: >0.5cm/px
- Resolution: 12MP
- Altitude: Ground

Limitations?

Coverage / Access
Weather (cloud)

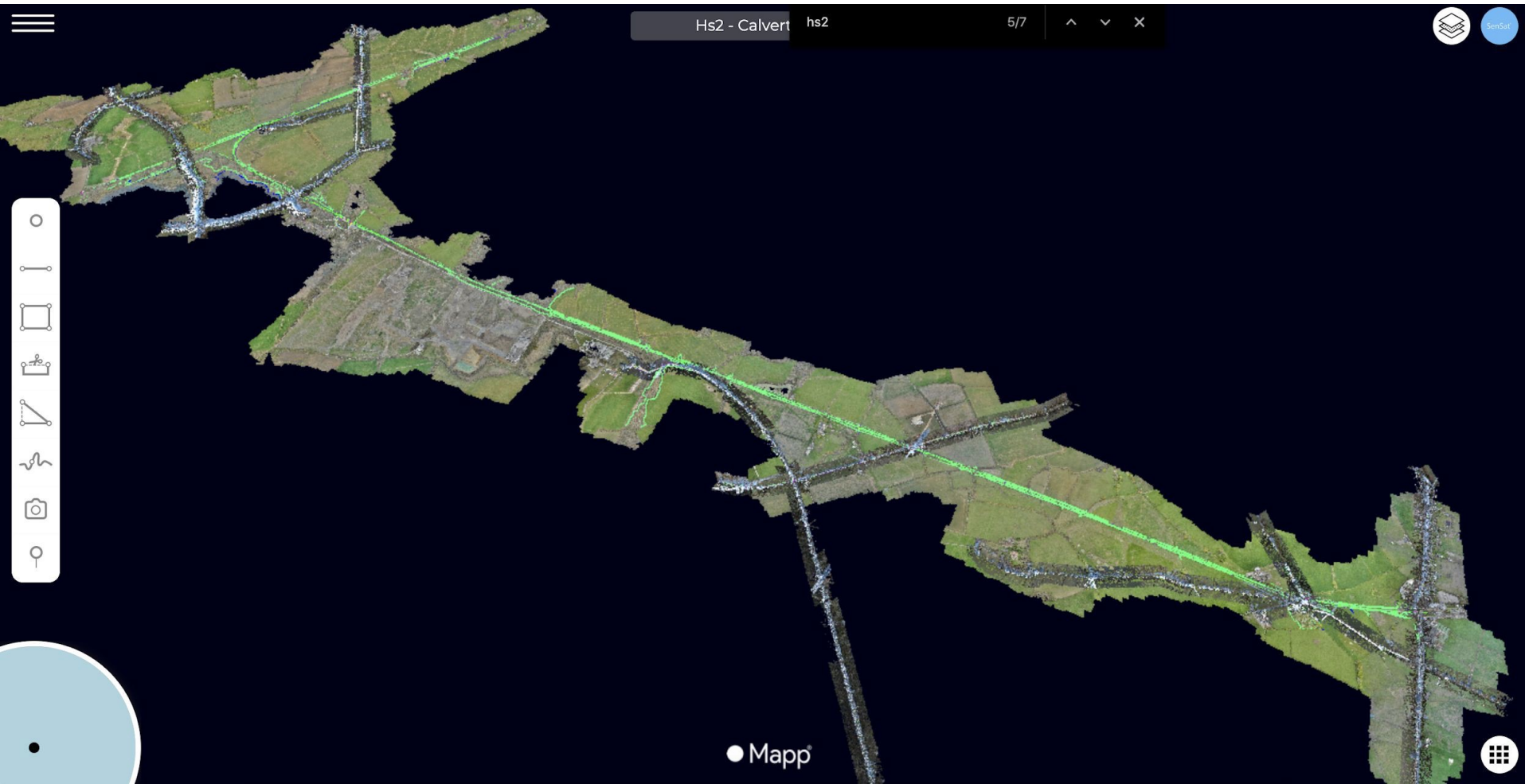
0-100 km²

50-5,000 km²

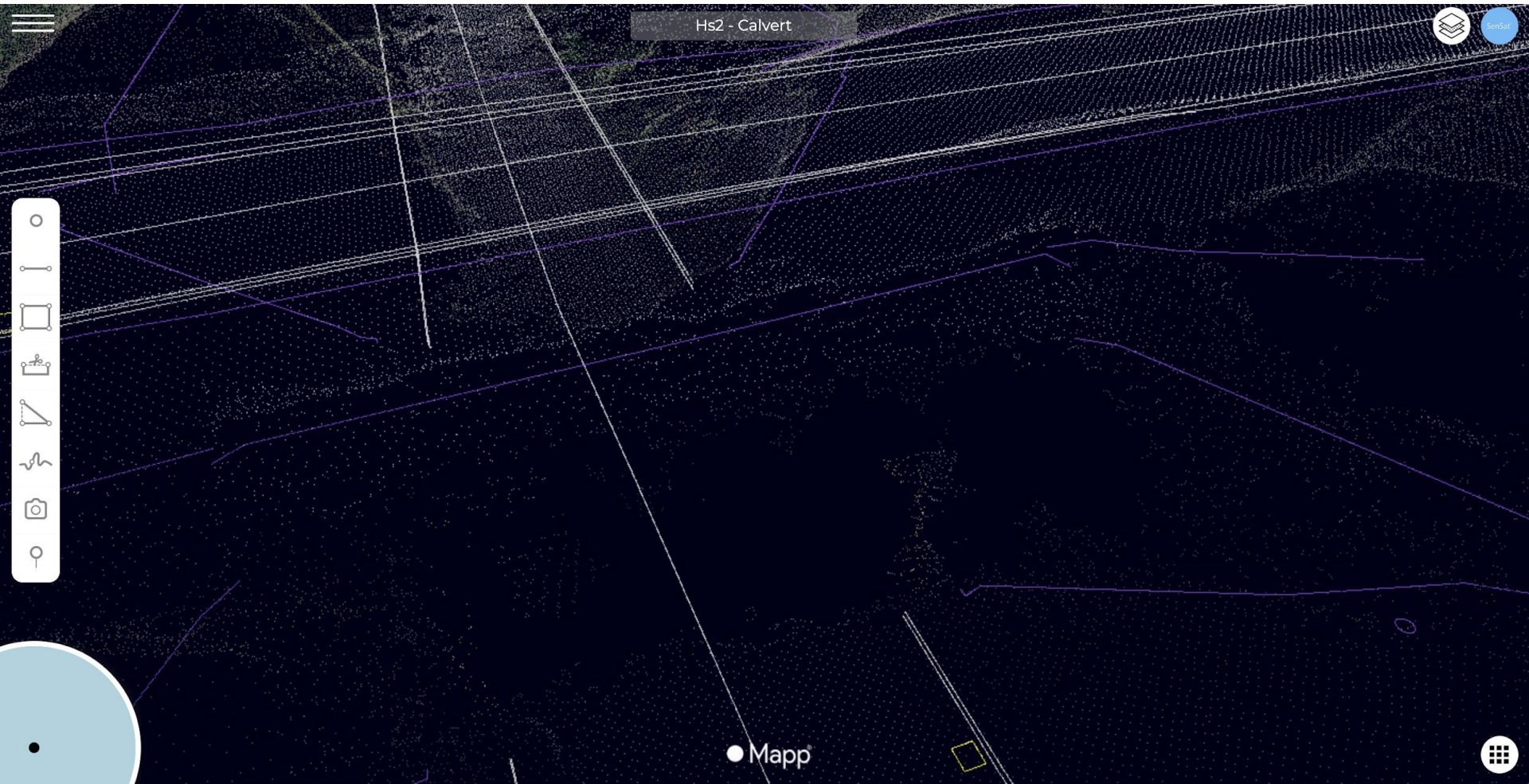
500-50,000 km²



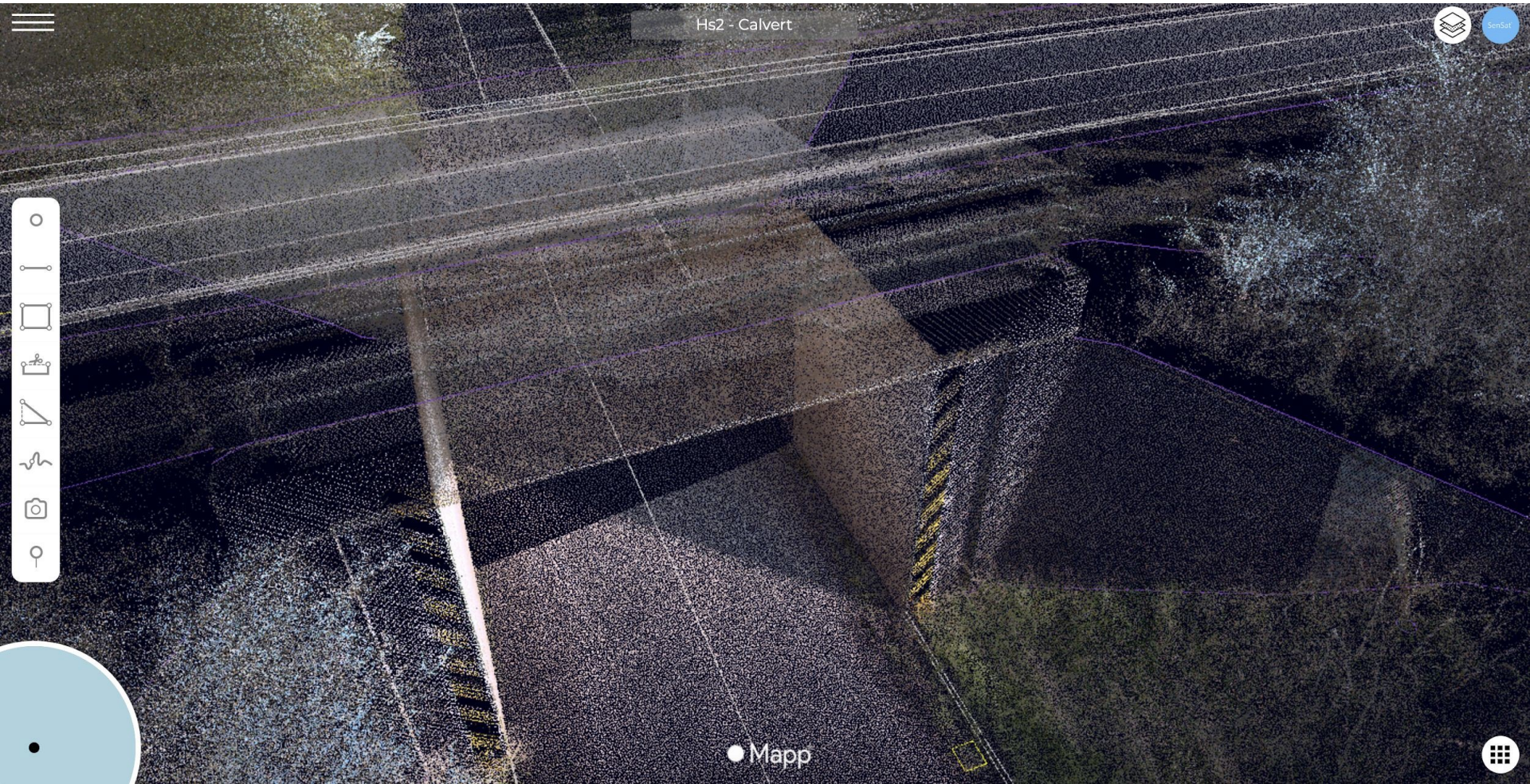
Mixed data capture



Mixed data capture



Mixed data capture





Founded at the Swiss EPFL in 2011



Market leader in geospatial B2B desktop, mobile and cloud applications



60'000+ clients around the world



180+ employees, 26 languages, 7 offices, 25 nationalities



Manufacturer-agnostic software solutions



More than 570'000 km² (140 million acres) in 2020 mapped



Offices in Switzerland, USA, China, Germany, Spain, Japan. Authorised resellers worldwide



Industry-specific software solutions



USD 25 million global revenue in 2020



Part of the Parrot Group since 2012



60% R&D focussed
Data driven



Training and technical support in 11 languages

Photogrammetry



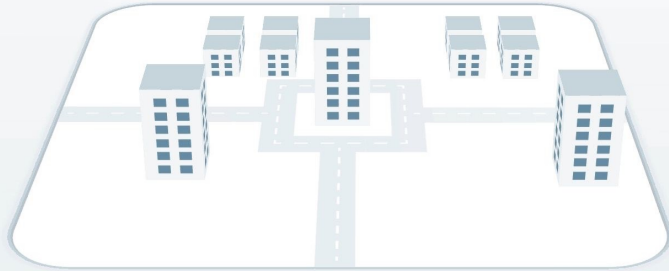
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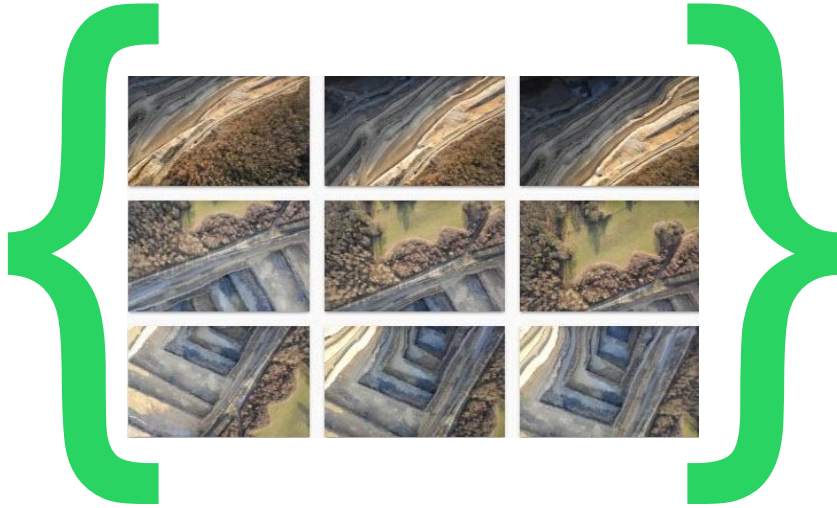
Photogrammetry



Extracting **3D information from photographs**

Photogrammetry is the science and technology of obtaining reliable information about physical objects and the environment through the process of recording, measuring and interpreting photographic images and patterns of electromagnetic radiant imagery and other phenomena.

Photogrammetry



Hardware

Pix4D software and hardware solutions

Software applications (desktop and cloud)



PIX4D**mapper**



PIX4D**matic**



PIX4D**survey**



PIX4D**engine**



PIX4D**fields**



PIX4D**inspect**



PIX4D**cloud**



PIX4D**react**

Mobile applications



PIX4D**scan**



PIX4D**catch**



PIX4D**capture**



Crane**Camera**

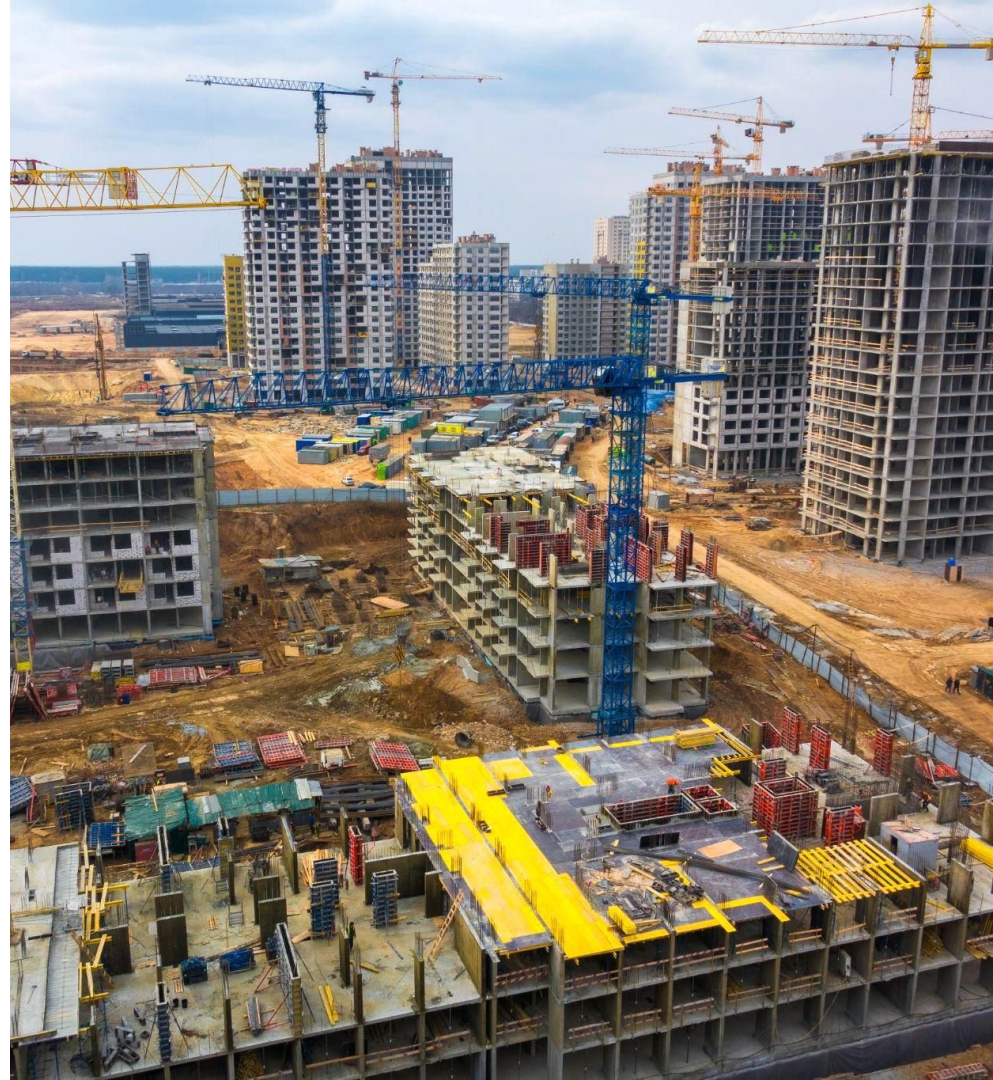
viDoc[®]

Photogrammetry in Construction

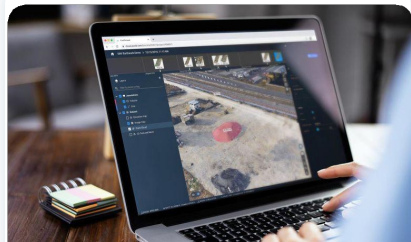
Construction challenges

- Project complexity
- Lack of communication
- Data not available or not accurate
- Build errors and costly reworks
- Open disputes and schedule delays

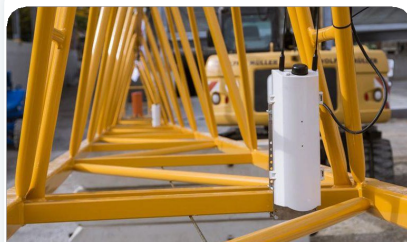
“15% of the cost of a typical construction project is allocated for mistakes”



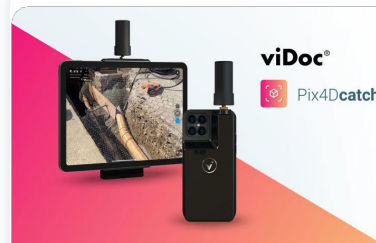
Pix4D's solutions for construction



Online platform for 2D & 3D mapping, progress tracking, and site documentation.



Automated and daily 2D and 3D as-built updates of construction sites.



Elevate 3D scanning with the power of RTK and photogrammetry



Turn your mobile device or tablet into a professional 3D scanner.



2D and 3D as-built data
delivered every day
automatically with no site
intervention

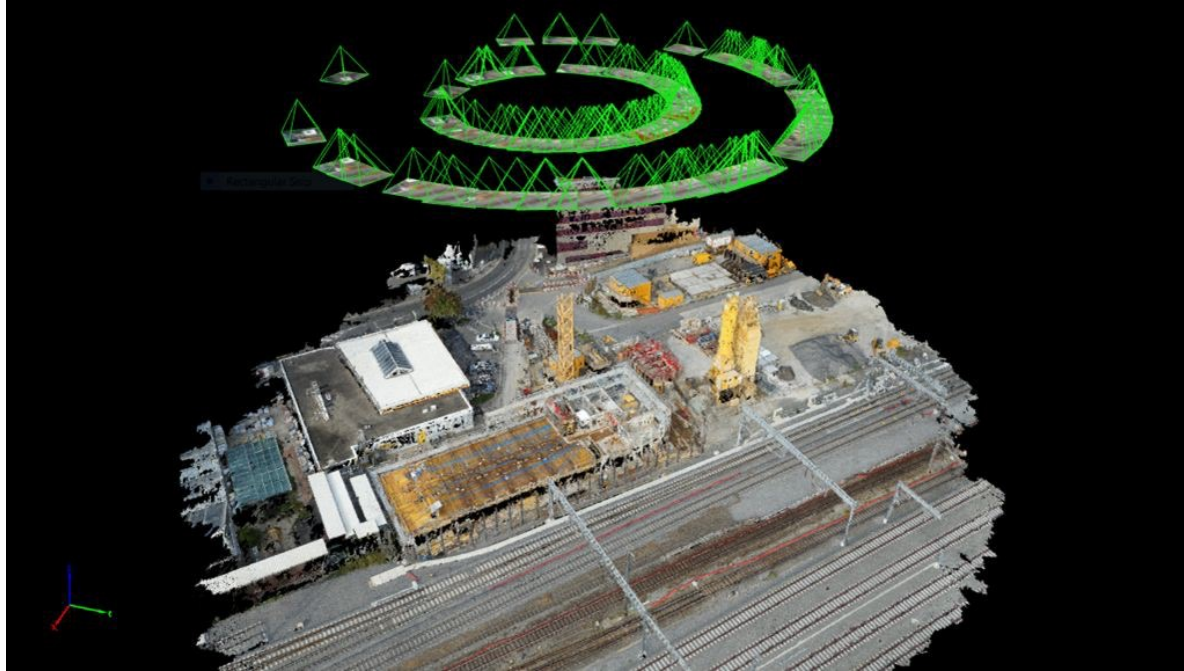
The hardware



The hardware



The hardware



The solution



PIX4D**cloud**
Advanced

Image processing

Projects available
online for analysis

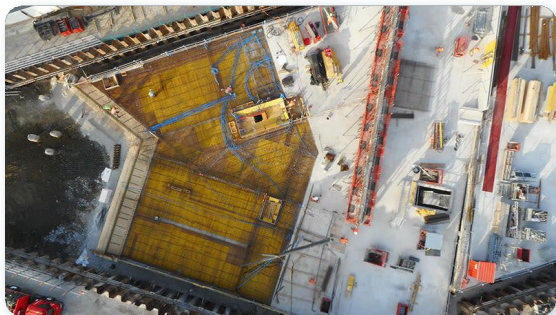


Crane**Camera**

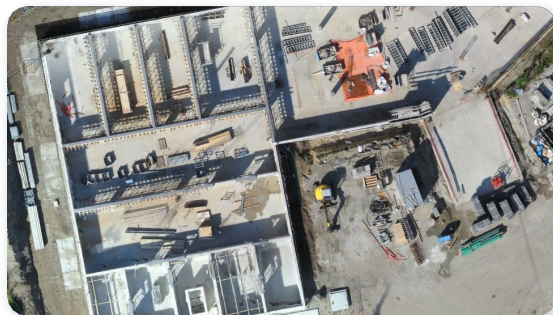
Data capture devices
from cranes

User platform for fleet
management

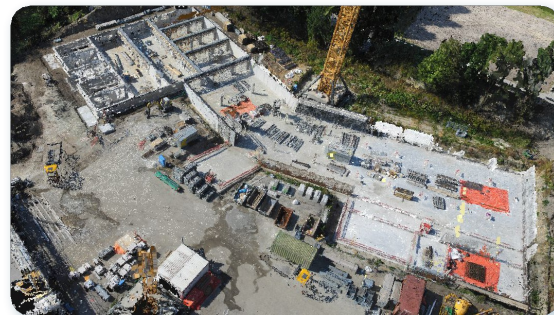
Daily results



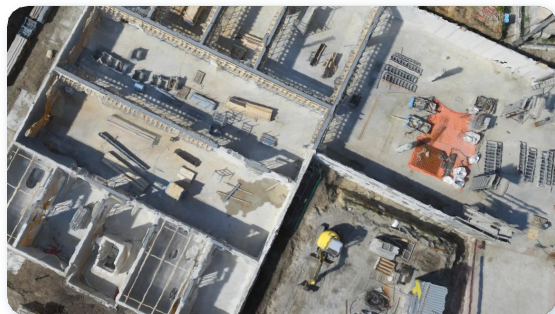
Original high-res images



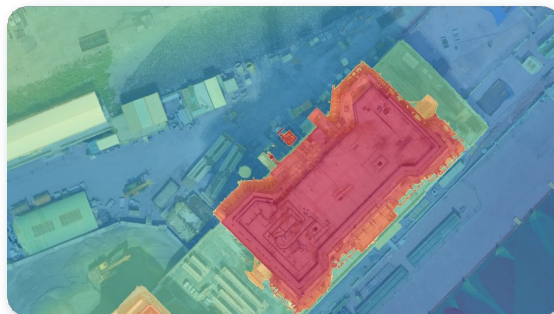
2D orthomosaic



3D point cloud



3D textured mesh



DSM

A large graphic on the left side of the slide, consisting of a yellow triangle pointing downwards and an orange triangle pointing upwards, meeting at a diagonal line.

Use cases

How to avoid construction errors and costly rework



Maximizing space in a constricted area





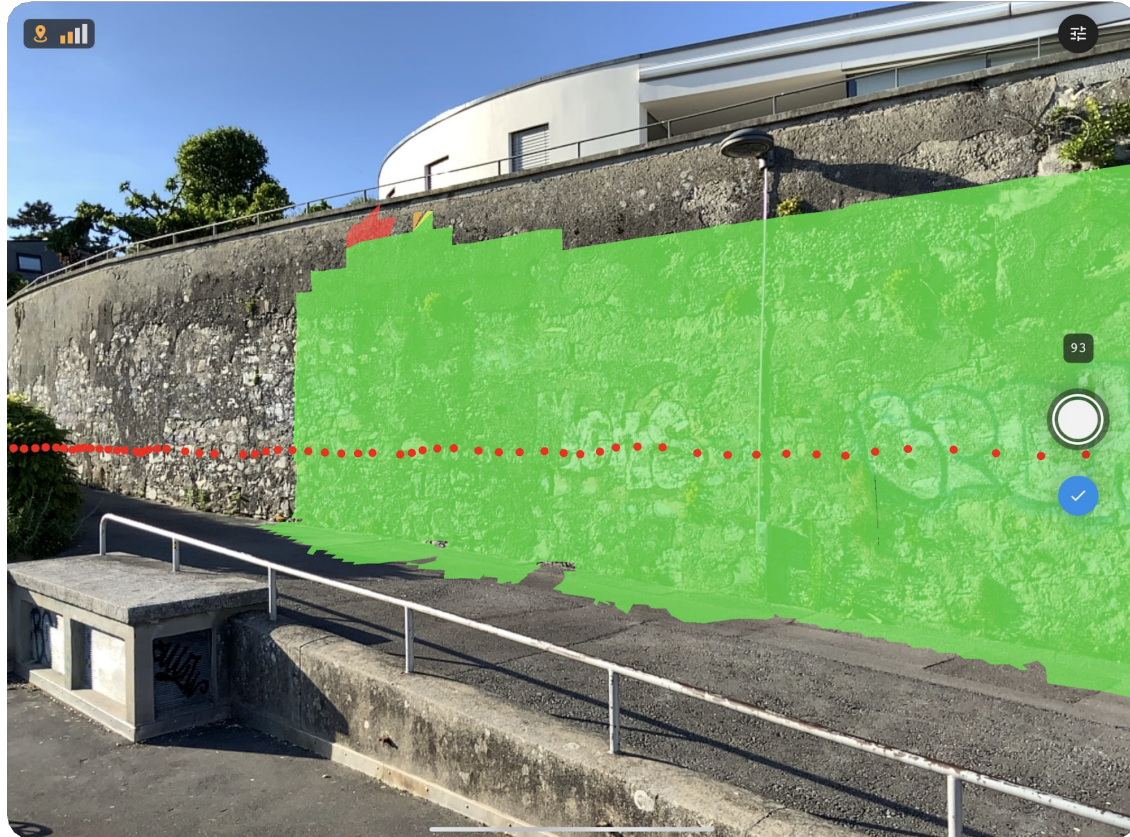
PIX4D**catch**

Handheld terrestrial scanner and rover

Powered by photogrammetry and
LiDAR



Our mobile devices are becoming a surveying tool



Ground data collection: challenges

- Capturing of ground data is mainly dependant on laser scanners, handheld rovers, or drones.
- Laser scanners although highly accurate, are expensive and not portable
- Handheld rovers deliver sparse TIN meshes
- Drones require permissions and are difficult to fly in some areas, e.g central locations
- Laser scanners, handheld rovers and drones require strong expertise

Combined hardware within hand's reach



Camera



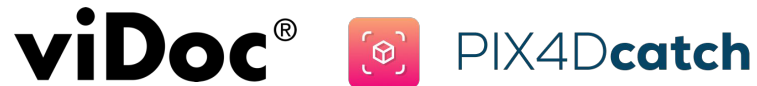
LiDAR / ToF
sensor

PIX4Dcatch leverages the camera and LiDAR/(time of flight:ToF) sensor technologies to create 3D models, thereby being the ideal replacement for cumbersome, time-consuming and expensive workflows for ground data collection

*real-time kinematic (RTK) positioning technology, which provides centimeter-level accuracy

viDoc RTK Rover

Elevate 3D scanning with the power of RTK and photogrammetry on a mobile device



For iPad and iPhone



Insufficient accuracy - Fixed



PIX4D**catch**

The positional accuracy of
geolocated images



± 4-5 m accuracy



PIX4D**catch**

+

viDoc[®]

The positional accuracy of
geolocated images

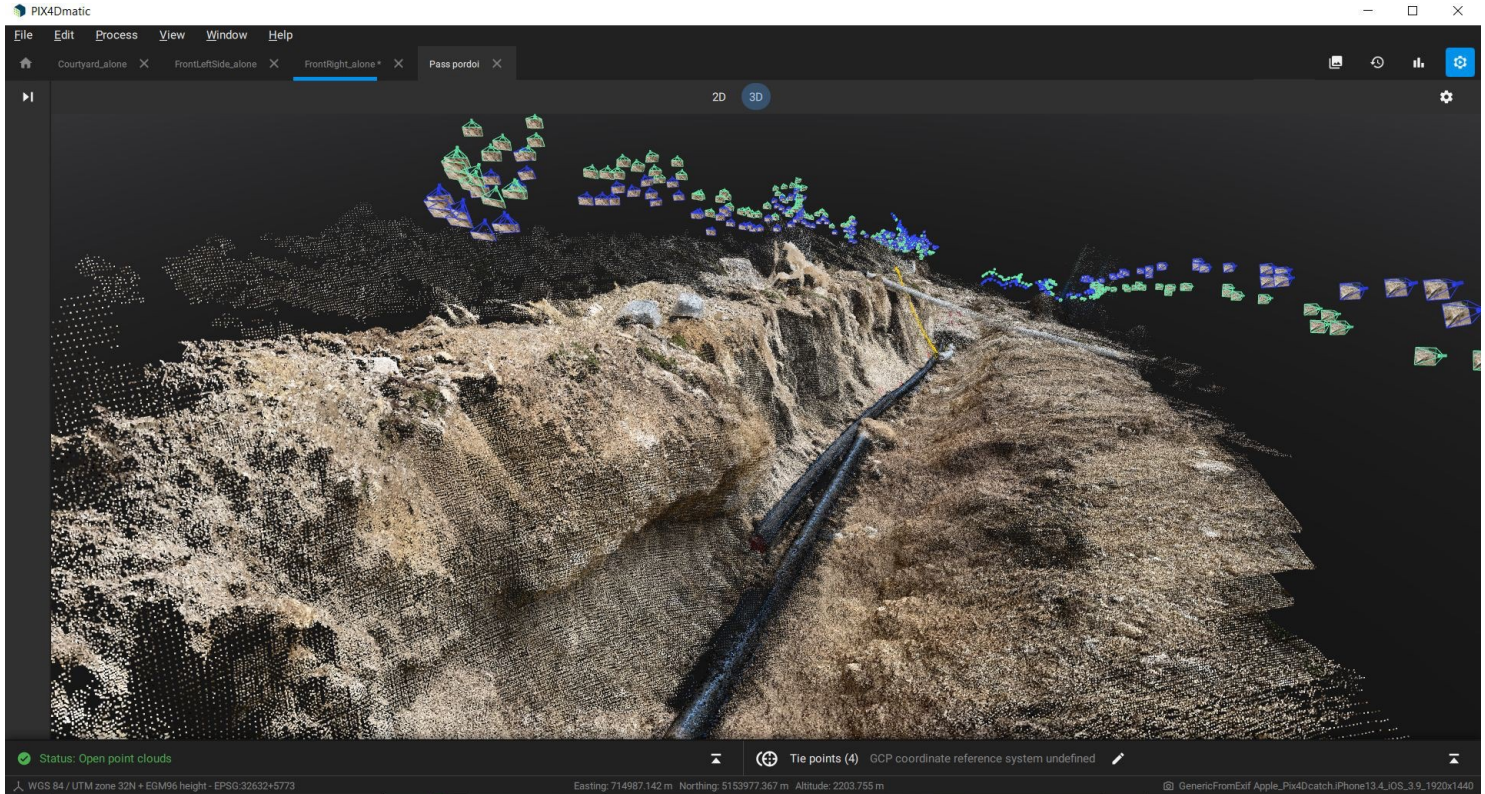
< 5 cm accuracy

RTK accuracy from an iPhone or iPad

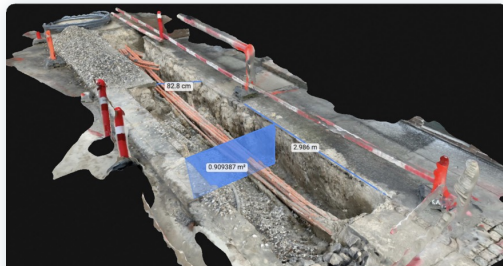
- **viDoc RTK rover with Pix4Dcatch:**
German / Swiss collaboration
- Adjustable iOS device case, compatible with:
- NTRIP network connectivity



Create 3D models



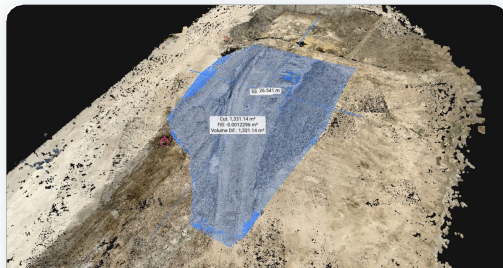
Measure and analyze sites



Utility mapping



Excavations



Stockpiles

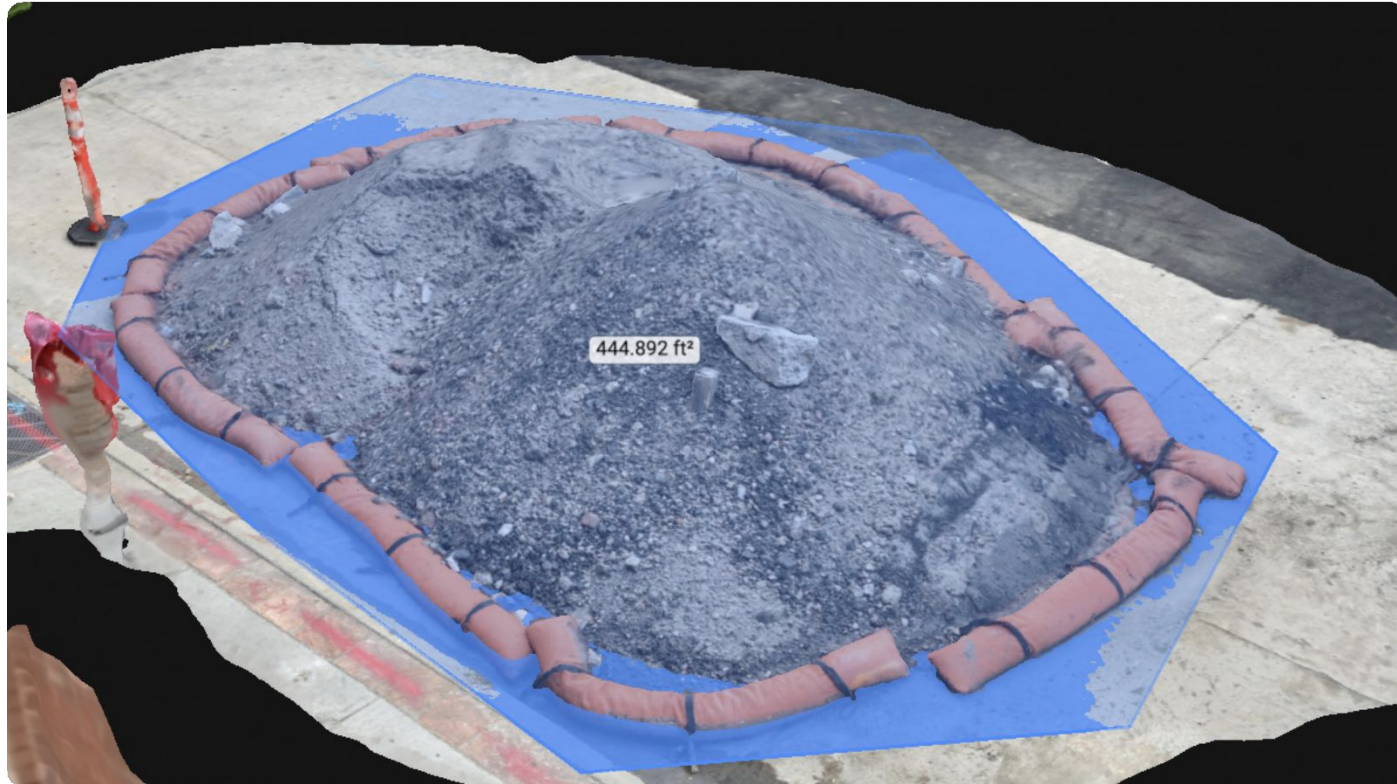


Road infrastructure

Public works - Underground utility mapping



Construction - stockpiles



Constructions - Footings / foundations



Explore 3D spaces captured with an iPad

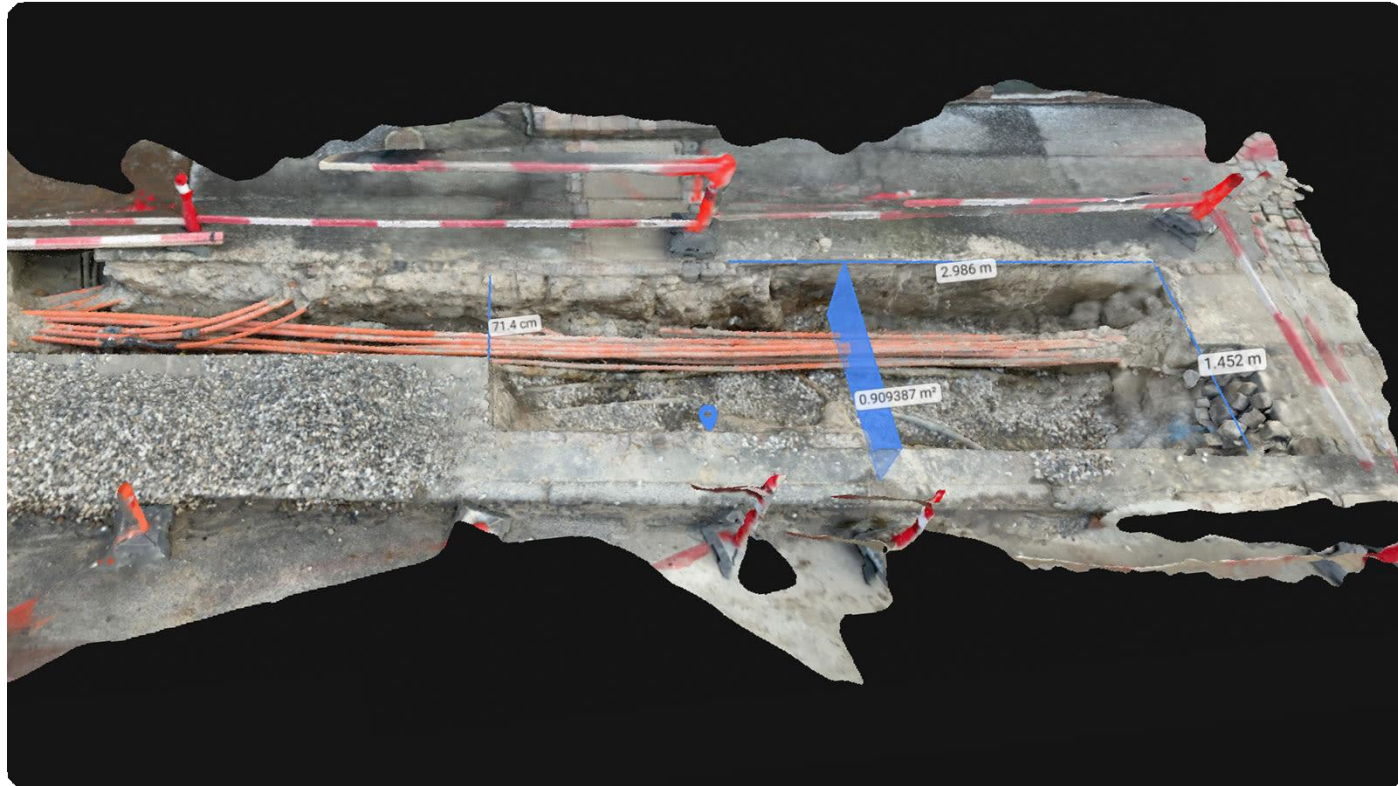




PIX4D**catch**

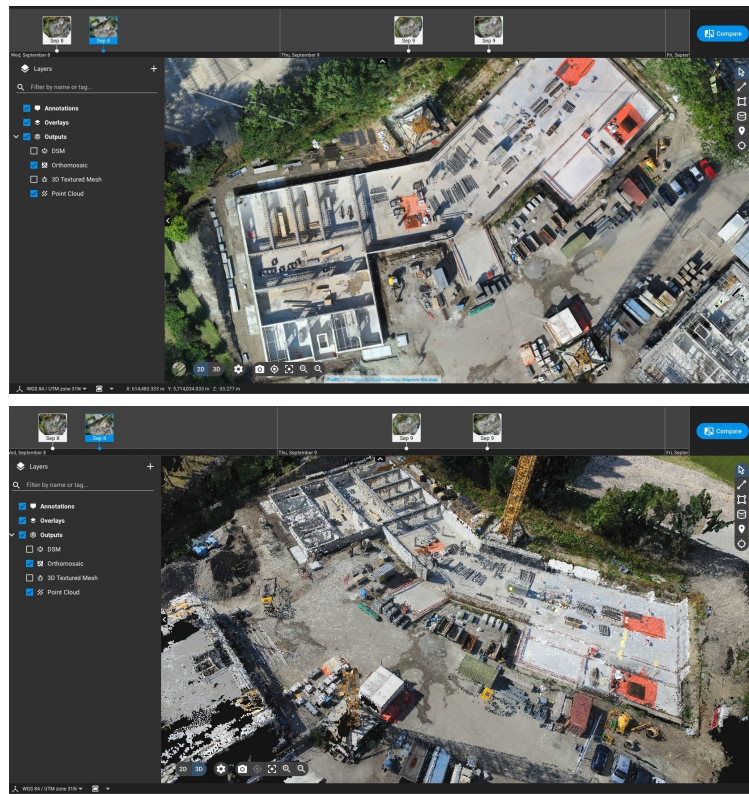
Use cases

Using mobile 3D scanning to cut visits to excavation sites



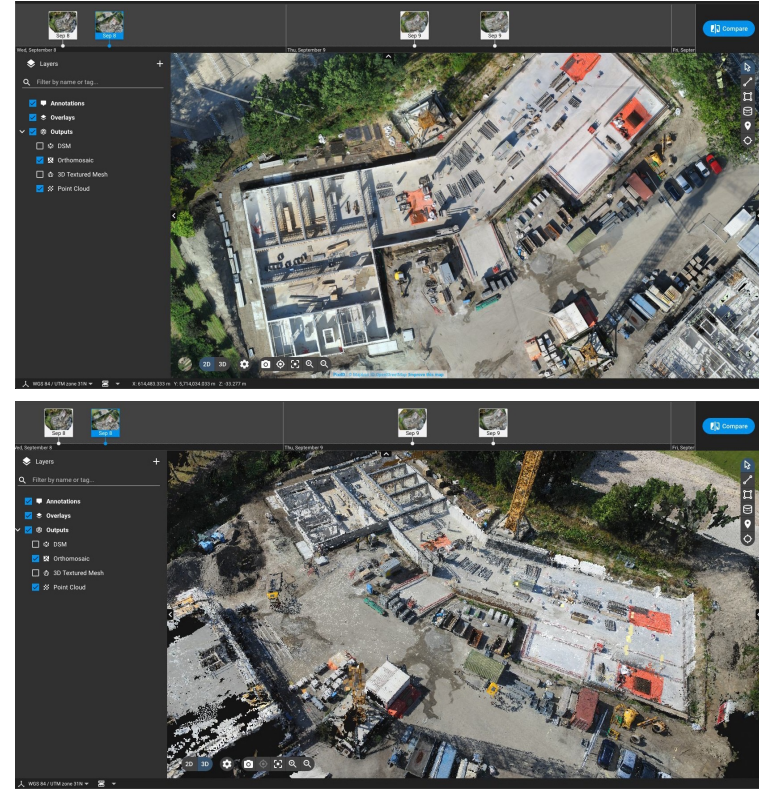
Integrations

- Improved algorithms to maximize efficiency
- **Interoperability** between platforms
- Further synergies among capturing tools and outputs
- More AI plug-ins for **auto-detection of features**



A new Crane Camera

- Improved connectivity
- Simplification of the installation
- Improvement of results accuracy and alignment
- Self-governance of the systems:
self-service installation & fleet
management via a dedicated user
platform (web-based)



Real-time data

A web-based platform with simple dashboards to control the data capture on your multiple sites and monitor your fleet of cameras

- “Self-service” installation
- Camera status monitoring
- Capture configuration and monitoring
- Warning notifications and SMS alerts
- Accessible from desktop, mobiles and tablets

