Aerial Photogrammetry on a budget

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About the speaker

Ben Bisares

Media & Entertainment and AEC specialist at Autodesk with over 10 years of experience in the fields of 3D Animation and Design, Visualization, Graphic Design, Web Design, and Photography.

In his spare time he is an active maker and participates in many DIY events involving 3D printing, multirotors, and single-board computers like the Arduino and Raspberry Pi

What is this class about?

What we will see today

HOW TO DO AERIAL PHOTOGRAMMETRY NOT LAND SURVEYING

Land surveying requires require expensive equipment to ensure high and repeatable accuracy which puts these types of projects out of scope for this class

WHAT’S THE MINIMUM NEEDED FOR AERIAL PHOTOGRAMMETRY

Due to the demand of aerial photogrammetry there is an abundance of hardware, software, and accessory options out there. This class will help you sort though all the clutter and help you make informed decisions

EXAMPLES, BEST PRACTICES, AND TIPS & TRICKS

Having the right hardware isn’t all you need, knowing how to use it is even more important! We will take a look at how to take photos for best results. Once we have a good project we will see some examples of what we can do with it.

Who is this class for?

Who can benefit from this

ARCHITECTURAL VISUALIZATION

- Relatively quick digital recreation of surrounding areas
- Help customers make better informed decisions both before and during your project

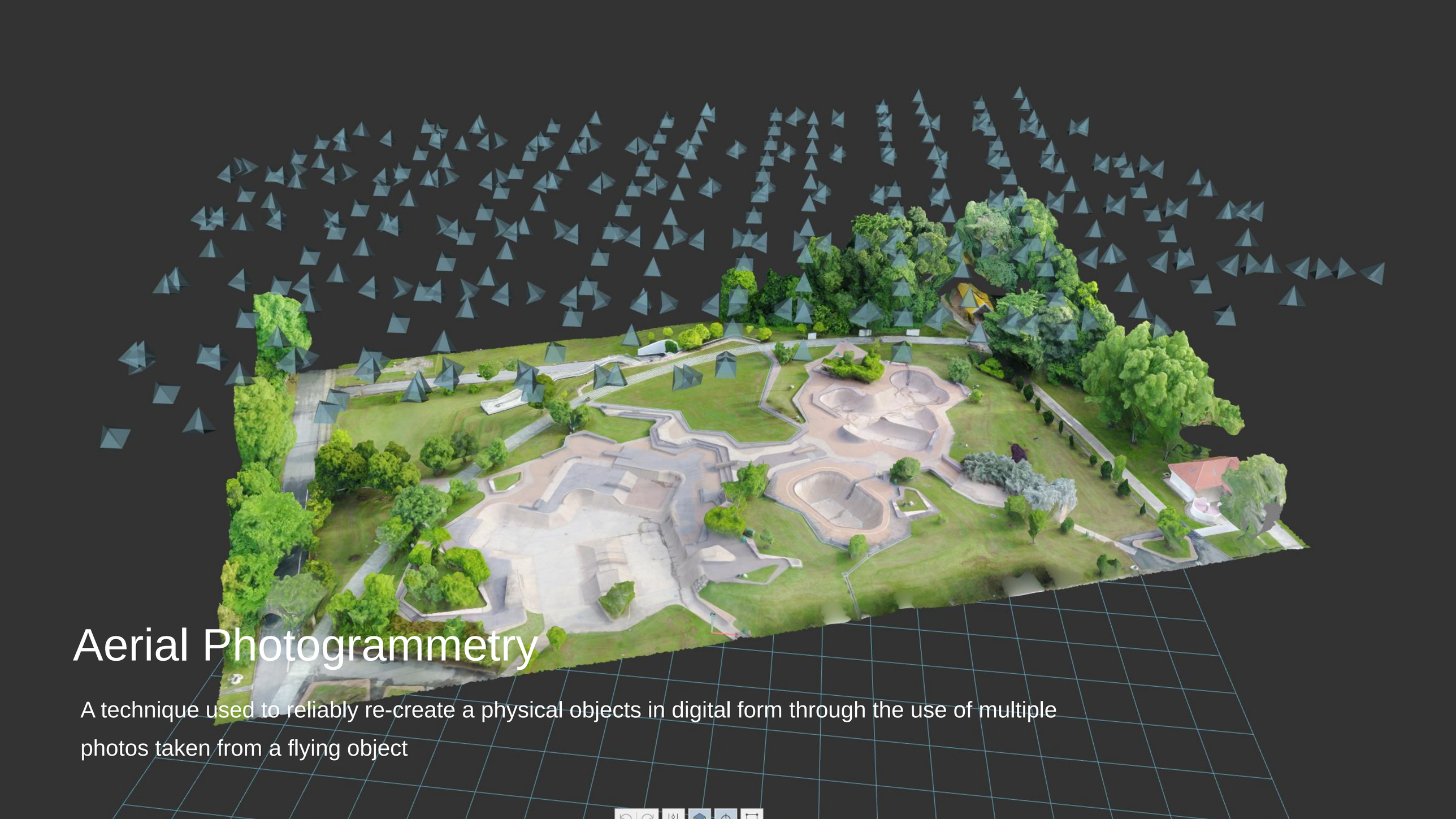
VR AND VIDEO GAME ASSET CREATION

- Use high density aerial photogrammetry data to efficiently create convincingly realistic low density assets that can be used in VR and video games

MULTIROTOR ENTHUSIASTS

- Those that already have equipment and skills needed and would like to try aerial photogrammetry

What is Aerial Photogrammetry



Aerial Photogrammetry

A technique used to reliably re-create a physical objects in digital form through the use of multiple photos taken from a flying object

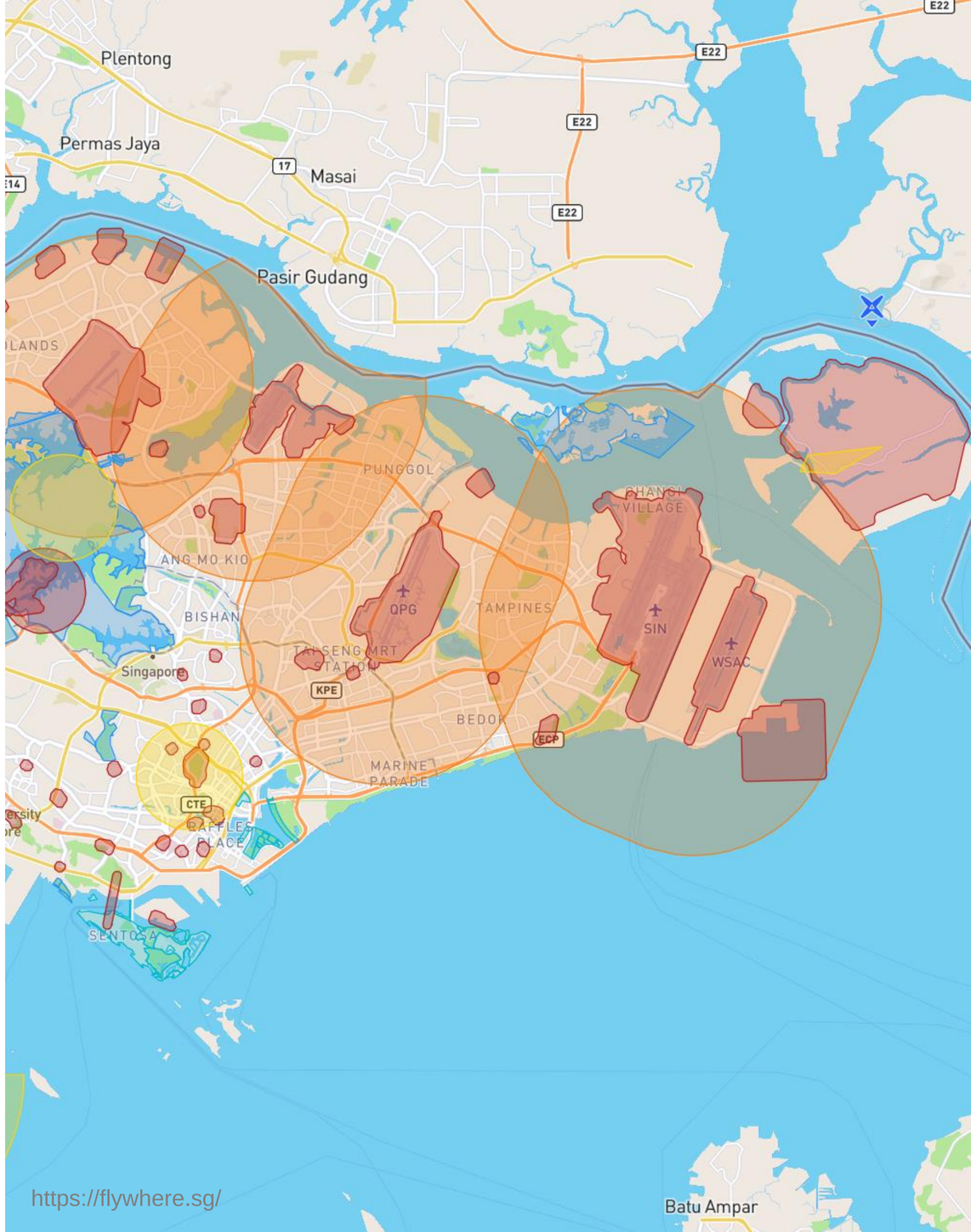
Equipment

- Can be done with any aerial vehicle (Manned/Unmanned)
- Generally multirotors are used to take the photos
  - Quadcopters (4 motors) / Hexacopter (6 motors)
- Drone must have a GPS system
  - RTK (Real Time Kinematic) systems can provide centimeter level accuracy
  - Consumer grade GPS (phone, drone) ~5m radius horizontal accuracy)
- Lack of RTK systems will still provide good **relative** but not **global** accuracy

Creating projects using ReCap Photo

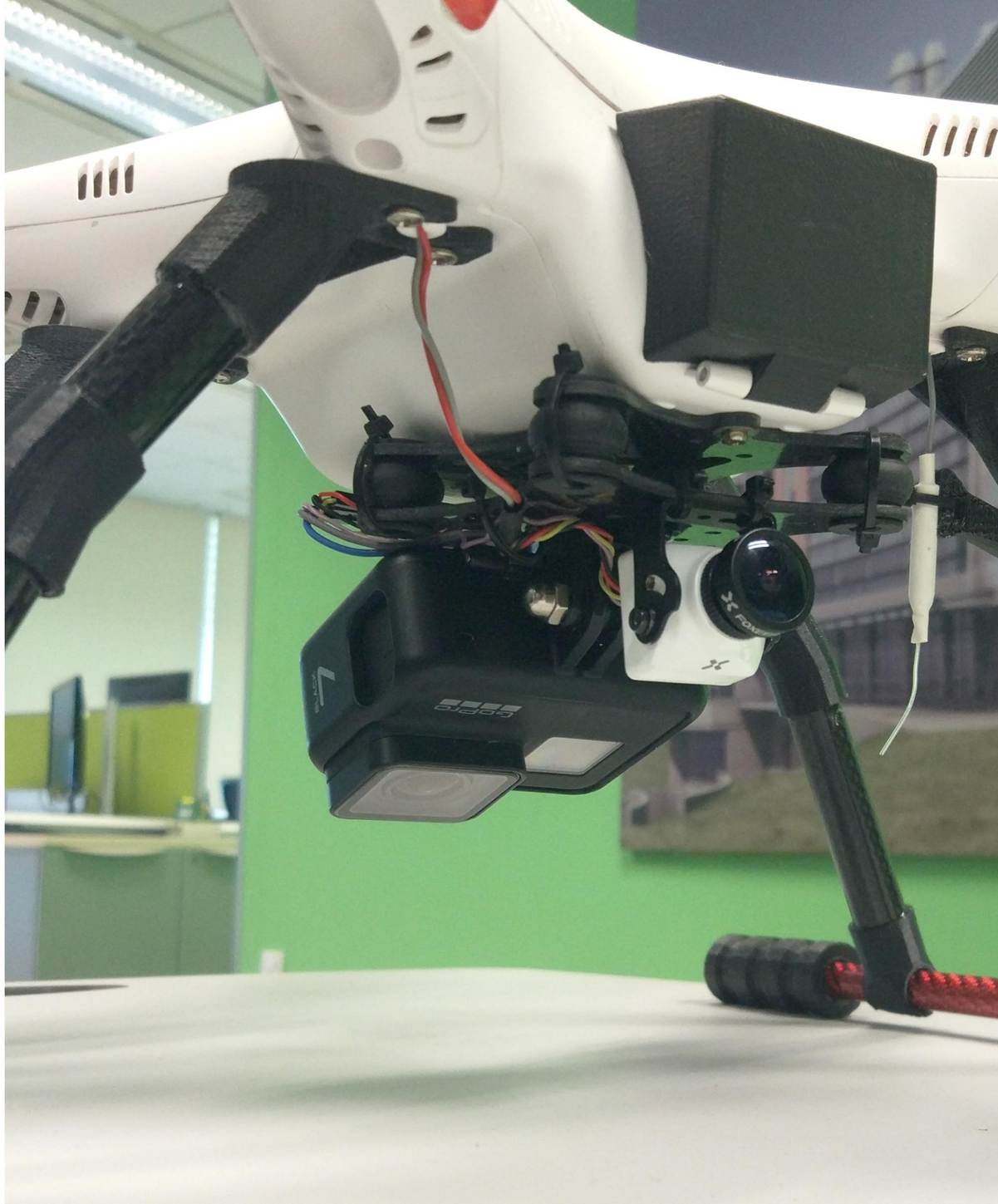
Before you go

- Be aware of drone rules and regulations
  - No-fly zones such as airports, shipping ports, government buildings, etc.
  - Drones over a certain weight may require registration and pilot certificate
  - Permit application may be needed if flight is for commercial purposes
  - VLOS (Visual line-of-sight) / BVLOS (Beyond visual line-of-site) rules



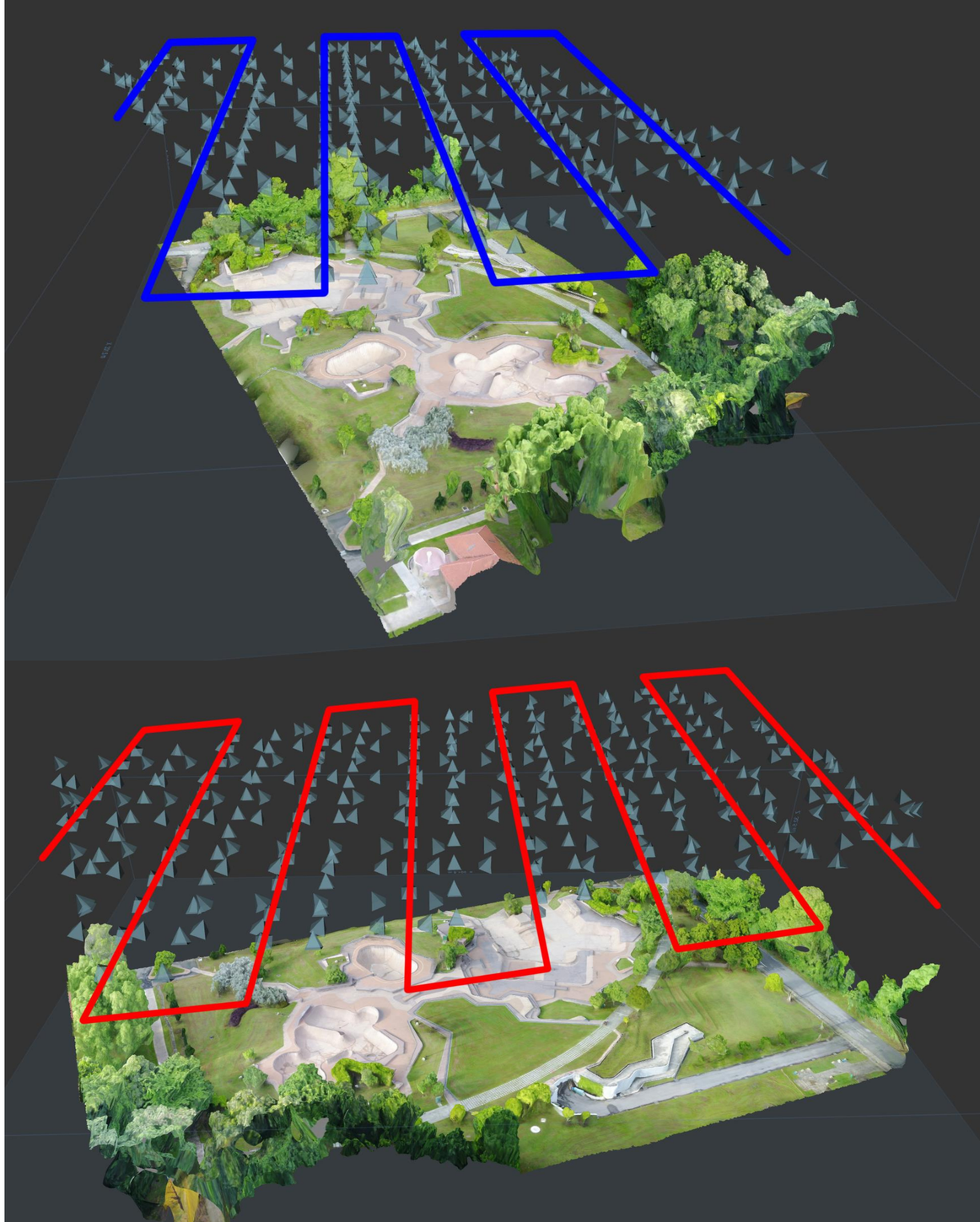
Taking photos

- Camera perpendicular to the subject
  - Downwards for flat terrain
  - Angled slightly forward if there are vertical elements (Trees, buildings, etc.)
- Can be combined with terrestrial photos when more data is needed
- If you can change camera settings
  - Set the white balance
  - Low ISO for less noise in the photos
  - Center weighted metering
  - Save as RAW files for post processing



Flight Paths

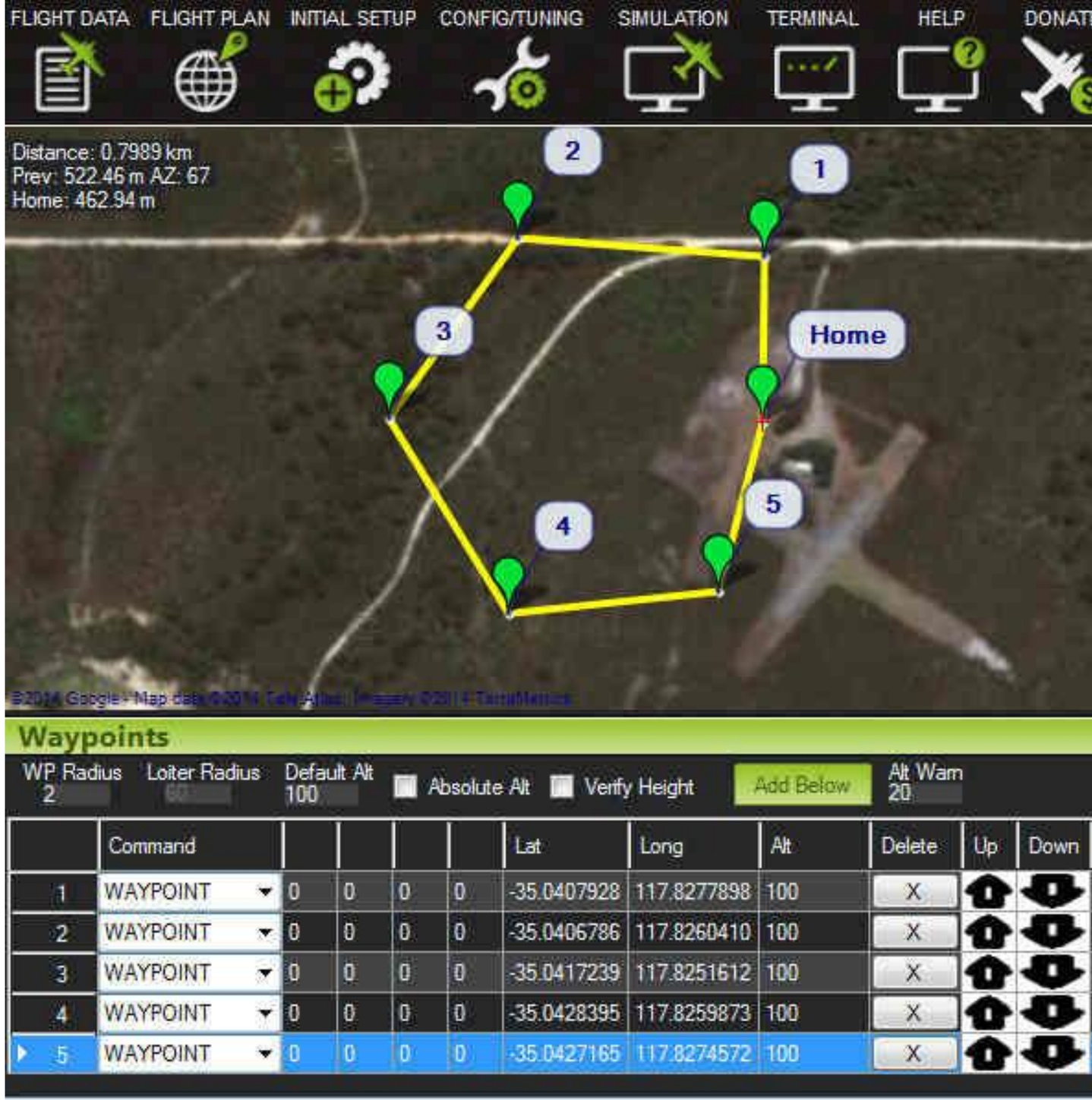
- More photos, more better
- Grid pattern, both horizontally and vertically
  - In addition flying in the opposite direction
- Always capture a wider area than desired as photos on edges will not be used due to lack of overlap
- If vertical elements are critical, take additional photos with camera facing more forward



Autopilot

Multirotors can have some form of autopilot

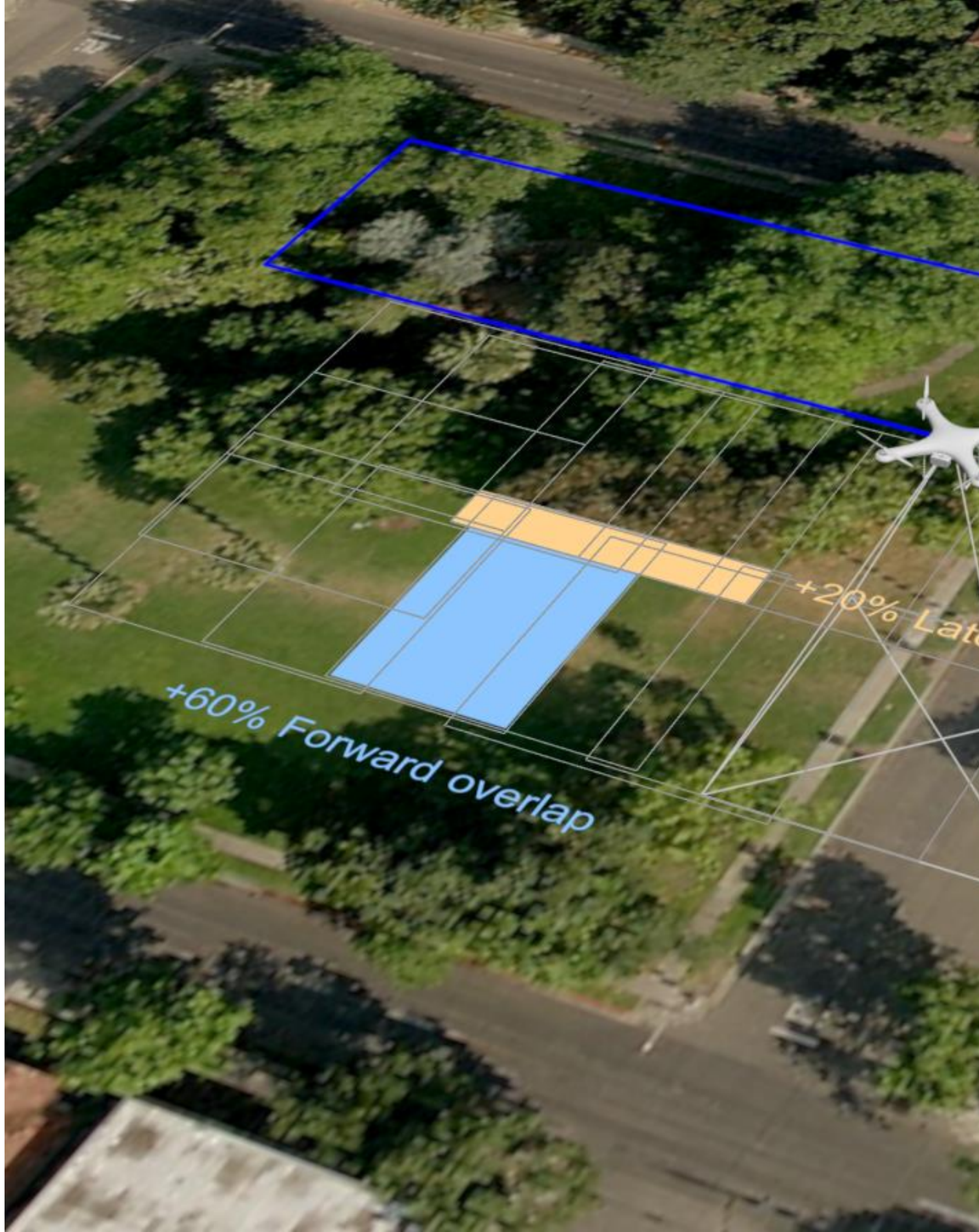
- Usually done through a Ground Station
- Map overview
- Set waypoints
  - Altitude/Aircraft orientation
- Automatically set speed based on photo overlap
- NOT a requirement for aerial photogrammetry

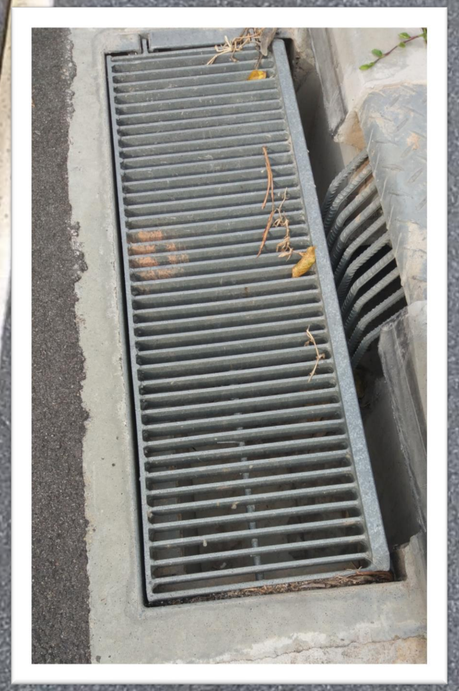


http://ardupilot.org/copter/docs/common-choosing-a-ground-station.html

How fast, how high?

- Photo overlap is key
  - 60% or more with photo taken before
  - 20% or more with photos taken in the last leg
- Altitude
  - As low as possible but…
  - Fly higher than the tallest object you want to capture
  - Adhere to rules pertaining to maximum altitude
- So isn’t higher always better?
  - No, pixel determine measurement precision



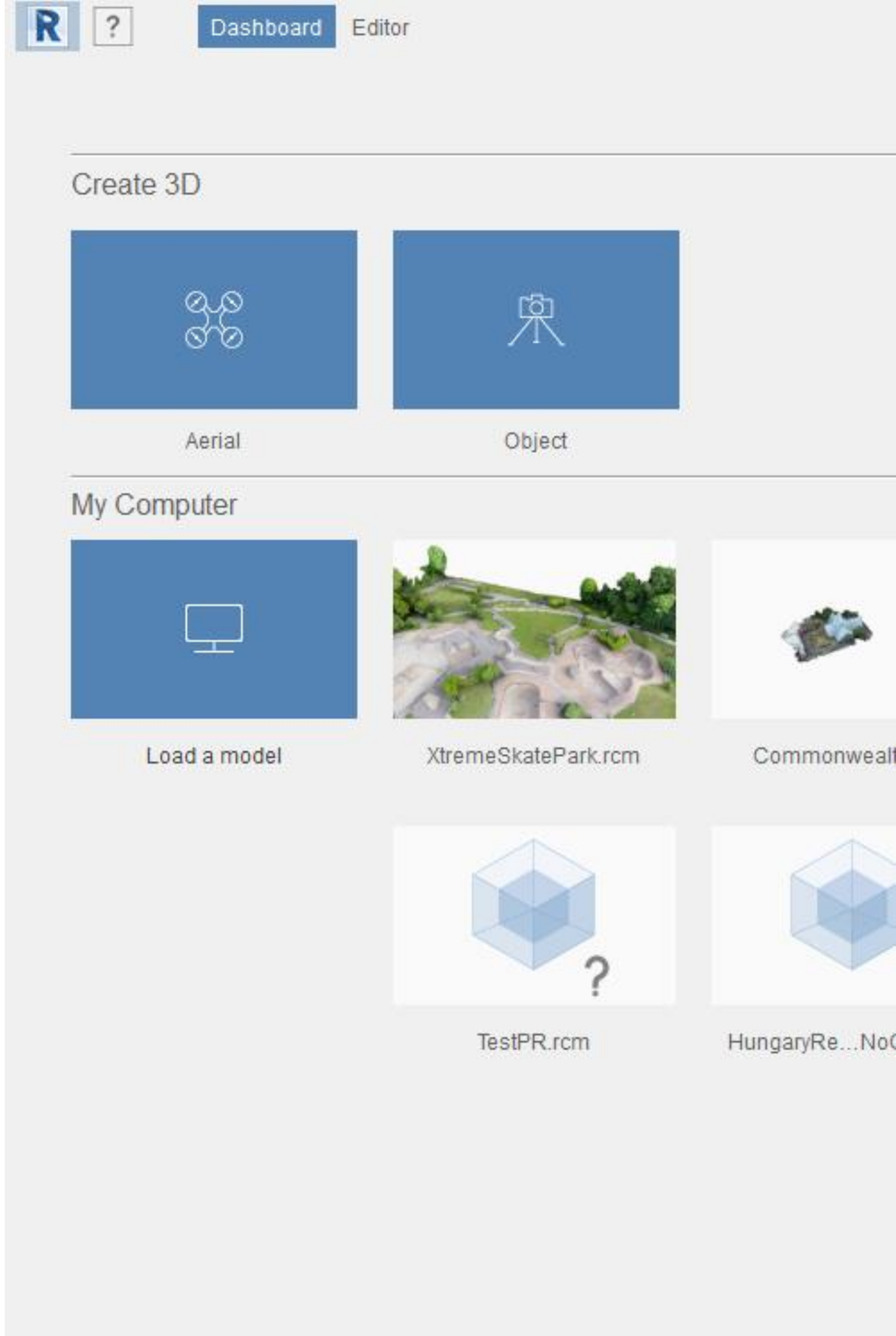


Pixel accuracy

Accuracy can only be as good as the smallest unit of the photo (pixel).

ReCap Photo

- Create an Aerial project
  - Uses GPS coordinates to determine physical dimensions and photo location
- Algorithm will reconstruct the data taken from the photos into a 3D object
- Blurry photos and changes such as moving cars, passing clouds can lead to poor results. Remove those photos from the project

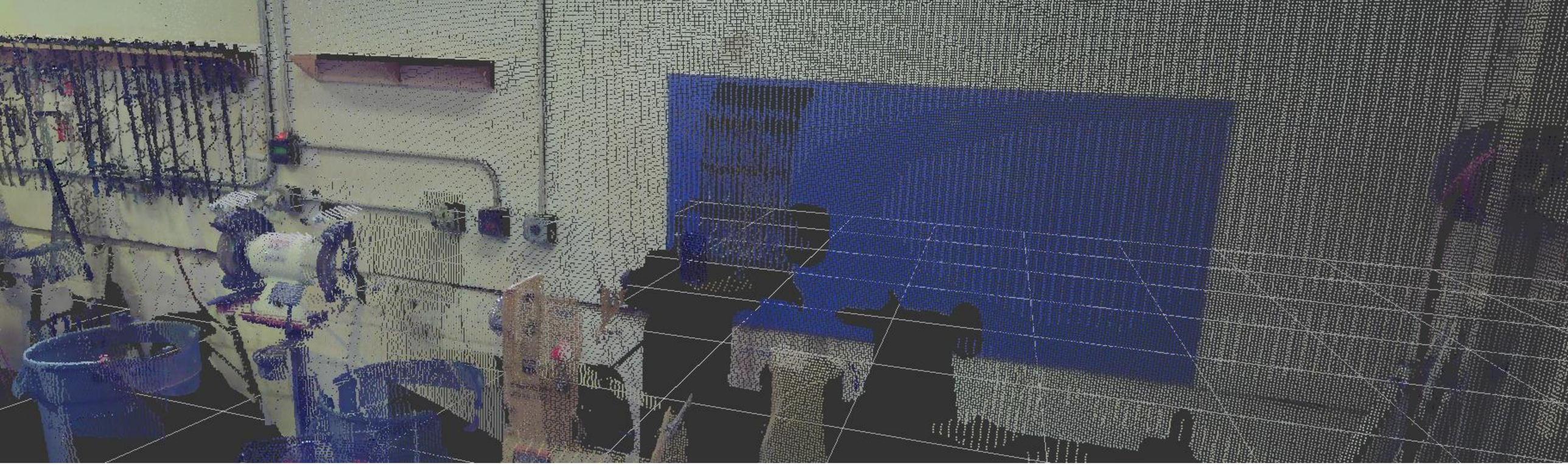


How Aerial Photogrammetry can be used

3D Maps

The most straightforward use of aerial photogrammetry is in the creation of 3D maps.

Can be used in software like Map 3D, Navisworks, and Revit when you need to have a 3d representation of the surrounding terrain.



Supplement Point Cloud data

Industry standard for capturing indoor or small outdoor areas is to use laser scanners

- Laser scanners are more accurate than photogrammetry
- Maximum distance can be ~49yd/45m
- Optimum range is usually around 1 - 3 meters
- Increasing distances result in lower density
- Poor quality with reflective/transparent surfaces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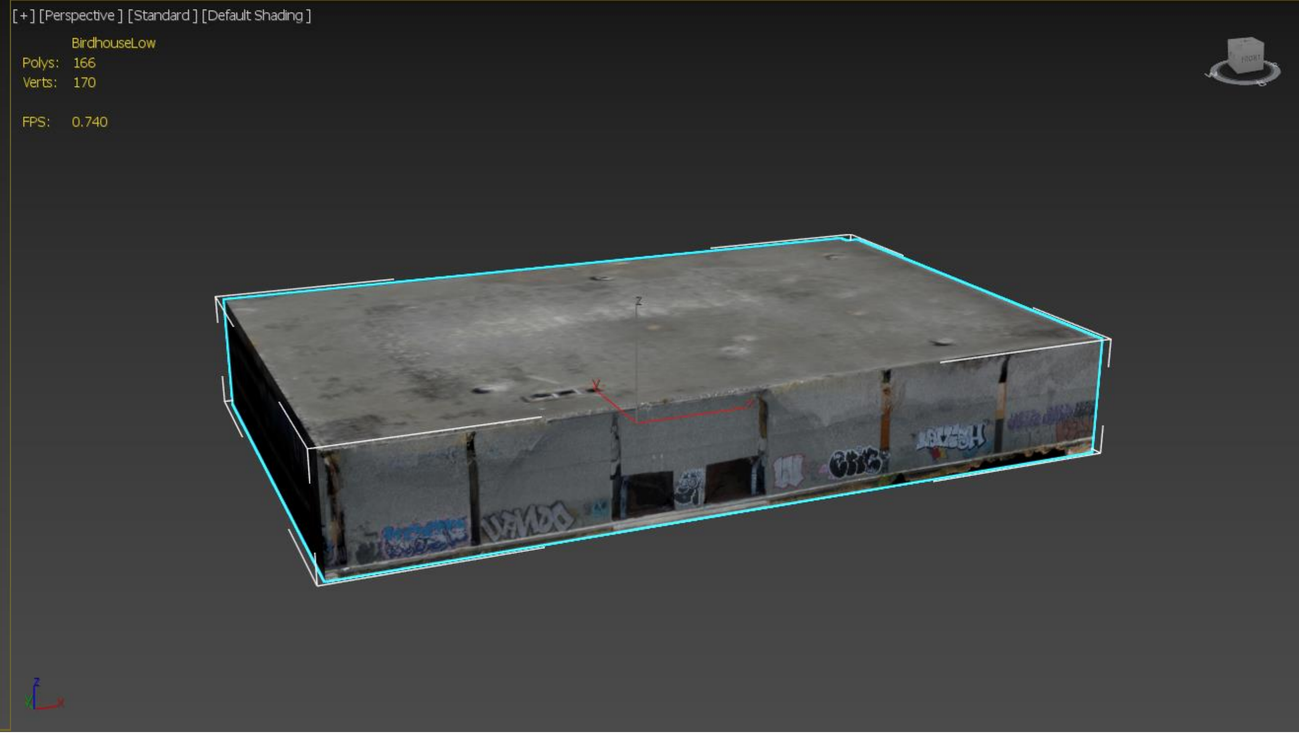
Use aerial photogrammetry to capture areas not suitable for laser scanning

- Capture area using multirotor
- Convert photos to point clouds with ReCap Photo
- Combine with existing laser scans in ReCap Pro



Projection source in 3ds Max

When creating content for video games, VR, and mobile the 3d assets must consist of simple objects due to hardware limitations.

Photogrammetry can be used to create content that will be used as sources for textures that will be used on those simple objects to give the illusion of something more complex

What is commonly used in the industry

DJI series (1,500$ – 21,000$ USD)

- First company to come out with multirotors that were relatively easy to use
  - Ready-to-Fly (RTF). Everything needed came in the box
  - Position hold due to on board GPS and barometer
  - Easy to change flight characteristics though the included software
- Current models offer advanced features like autopilot and obstacle avoidance

What is the bare minimum needed

Bare minimum – what does that mean?

The minimum amount of hardware and features needed to successfully complete an aerial photogrammetry project

Multirotor with GPS and a barometer

- Position/Altitude hold when not providing input on the transmitter/controller
- Barometer needed for precise altitude (vertical) measurement not possible with just GPS

Lightweight camera with GPS

- No means to sync multirotor GPS with photos. Camera GPS must be used
- Time lapse feature (i.e. take photos at set intervals)

Enough thrust for takeoff weight

- Weight of camera and mount

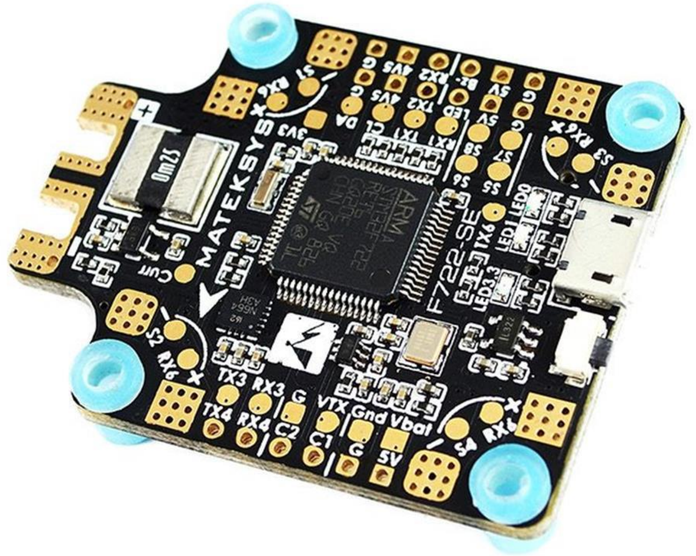
~15 minute flight time

- Bring additional batteries, land, switch battery

DIY

Frame

- Provisions to mount camera underneath
- Sufficiently large for motors and propellers that are suitable for the weight of the craft and payload
    - Usually measured in mm, center of motor mount, diagonally
- Quadcopter (4 motors) / Hexacopter (6 motors)

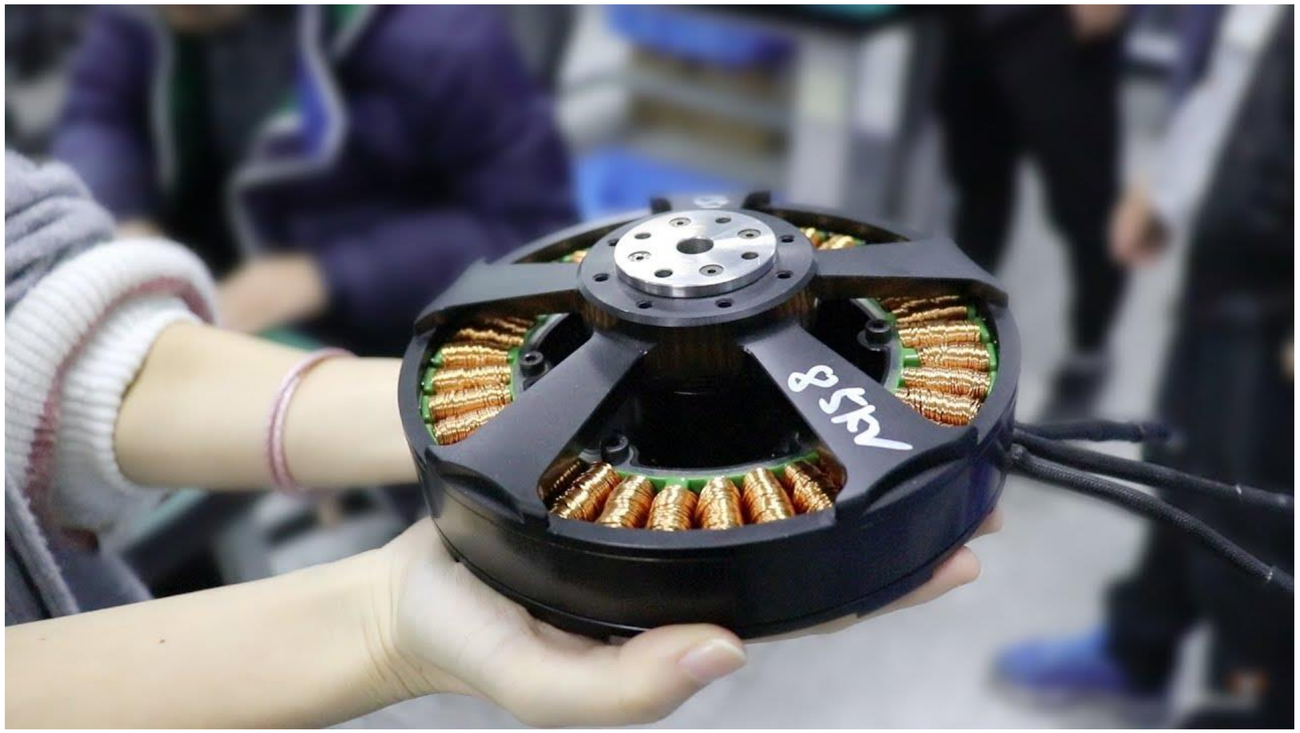


Flight Controller (FC)

- Brain of the craft
- Processing power denoted by “F” number (F3, F4, F7, etc.)
- More powerful flight controllers usually have / can add more features (GPS, Compass, Autopilot, etc.)

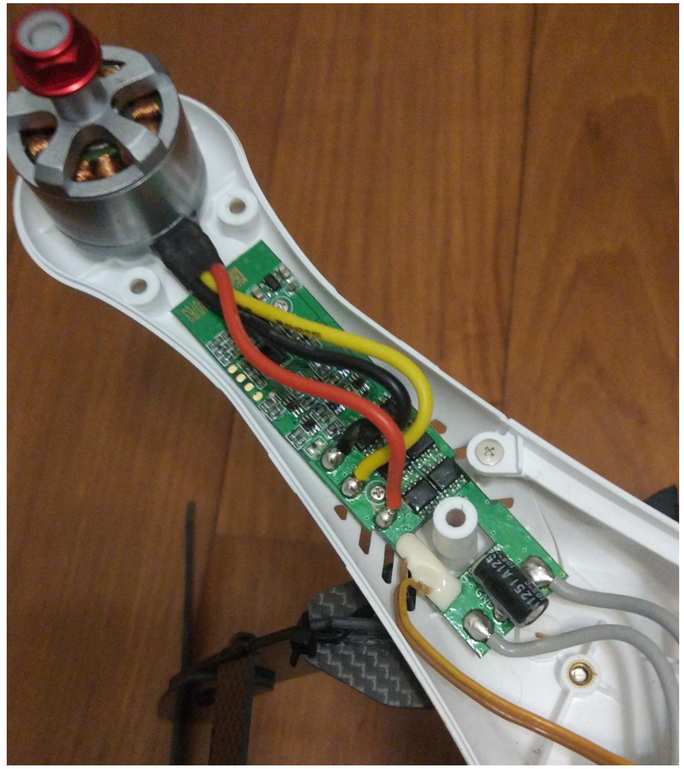
Propellers

- Denoted by Size / Pitch / # of blades (9x4.3x2, 10x5x3, etc.)
- Generally get the largest size your frame can handle
- Come in 2 / 3 / 4 blade variants
- Pitch value: Theoretical distance the propeller would travel in 1 turn



Motors

- Denoted by size and KV
- Motor diameter and height (mm)
- KV is # revolutions per minute with 1V applied
- Takeoff weight and prop size will determine what motor to use (50% power should give enough thrust to hover the craft)



ESCs

- Electronic Speed Controller
- Denoted by the amount of power it can provide (amps)
- Provides the power to the motors and controls how fast it turns
- Each motor requires an ESC

Battery

- Denoted by voltage, capacity, how many amps it can provide
- Voltage: expressed directly or in # of cells (2s, 3s…6s)
    - 1s = 3.7v, 2s = 7.4v…
- Capacity is in milliamp hours (mAh)
- Choice is determined by motor and propeller choice, physical space

RC Transmitter and receiver

- Transmitter sends commands which are received by the transmitter on the craft
- Both transmitter and receiver need to use the same protocol (PWM, CPPM, SBUS, etc.)
- One transmitter can connect to multiple receivers (not at the same time)
- Some transmitters are compatible with many protocols
- Many transmitters can be used on computers for drone simulators

Camera

- Compact and light camera (Action camera)
- Built-in GPS is required

Buy or DIY

Buy or DIY?

BUY PROS

- Contains everything you need
- No need to fiddle with setup

DIY PROS

- Usually more cost-effective on a feature to feature basis
- Replacement parts can be easier to find, easier to repair
- Components can be reused for future projects
- Contains only what you need

BUY CONS

- Pricey
- Components may be non-standard
- Hard or impossible to upgrade

DIY CONS

- Components less integrated. Heavier and/or bulkier
- Time needed for setup and tuning
- Can be more cumbersome to operate

Cost Analysis

Components	Cost (USD)
Frame	15.00
Flight Controller	150.00
Propellers (1 set)	20.00
Motors (x4)	30.00
ESC (x4)	65.00
Battery	25.00
Transmitter	180.00
Receiver	25.00
Camera (GoPro Hero)	250.00
Total	$760.00 USD

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