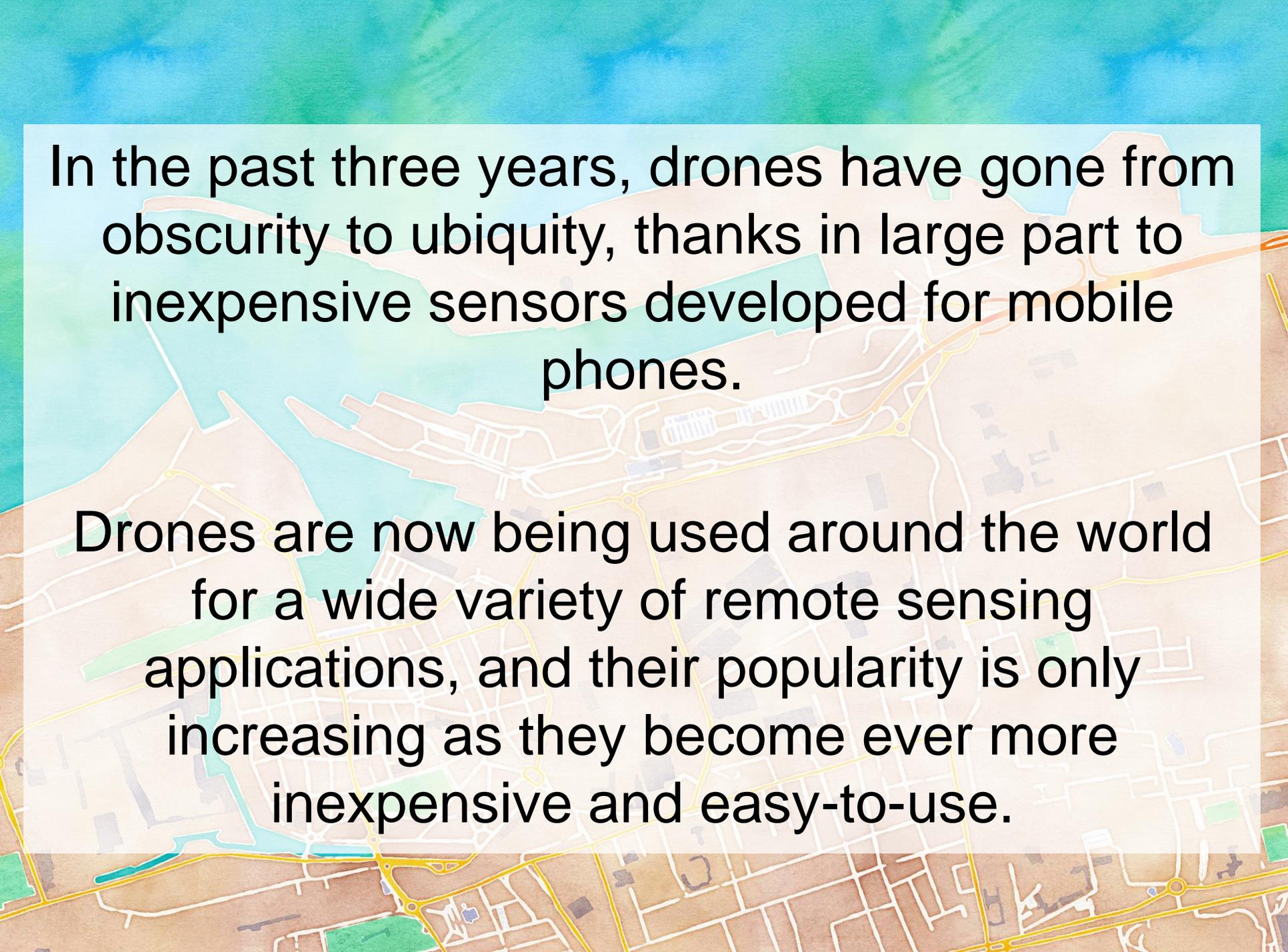


An aerial photograph of a baseball field and a river. The baseball field is on the left, with a dirt infield and a green outfield. A river flows along the right side of the image. A path runs through the center, and there are trees and a fence visible. The text is overlaid on the image.

DRONE MAPPING ON THE CHEAR

Faine Greenwood

Signal Program, Harvard Humanitarian
Initiative

An aerial map of a coastal area with a large body of water on the left and a city grid on the right. The text is overlaid on a semi-transparent white box.

In the past three years, drones have gone from obscurity to ubiquity, thanks in large part to inexpensive sensors developed for mobile phones.

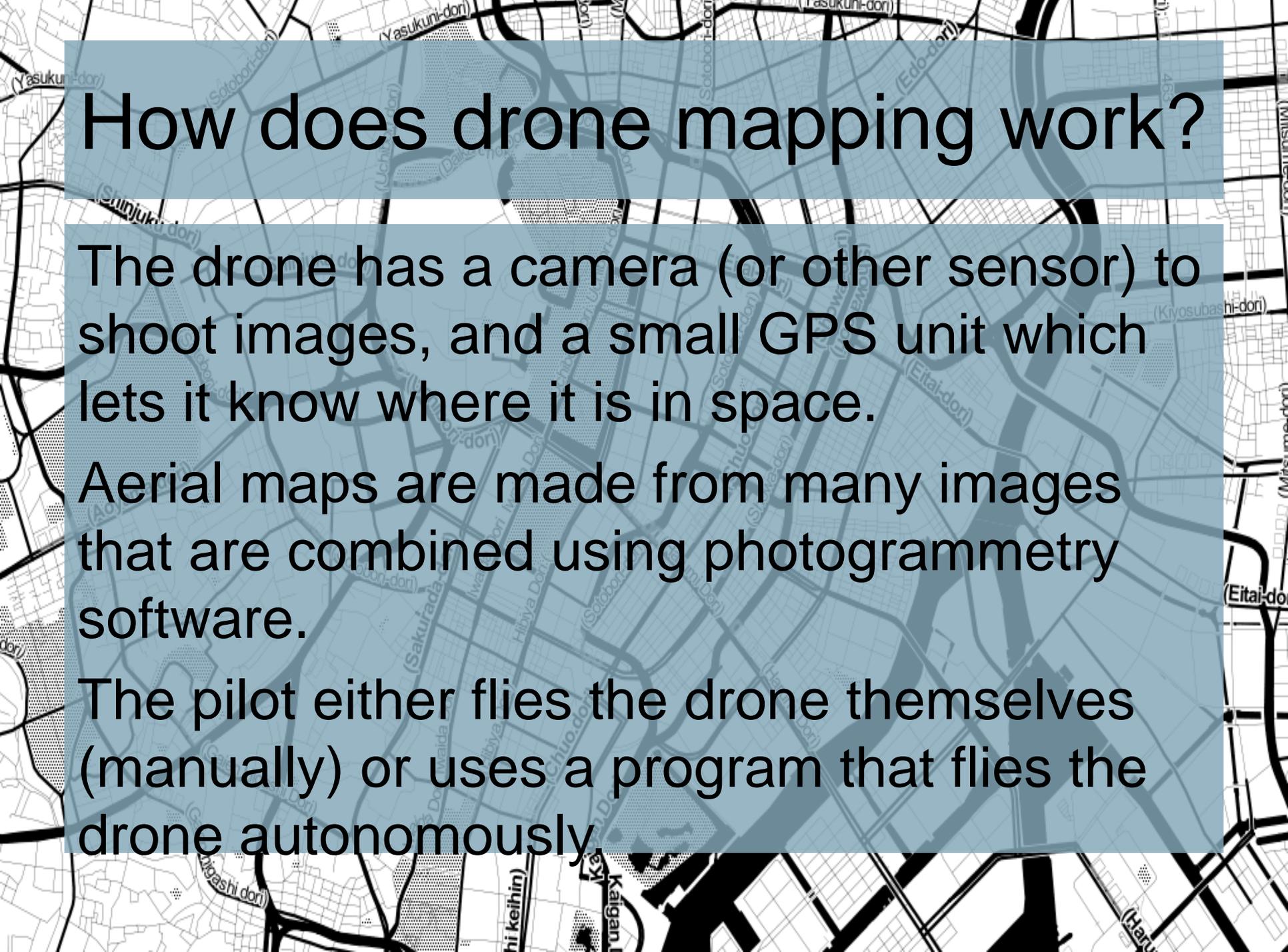
Drones are now being used around the world for a wide variety of remote sensing applications, and their popularity is only increasing as they become ever more inexpensive and easy-to-use.

Drone Mapping

Drones have proven useful for mapping, as a complement (or substitute) for aerial mapping and satellite imagery.

Strengths include:

- Inexpensive (less than \$1000 to buy some useful mapping platforms)
- Ability to gather both still photos and video
 - Ability to operate under cloud-cover
 - Modular – can use multiple sensors
 - (And more)



How does drone mapping work?

The drone has a camera (or other sensor) to shoot images, and a small GPS unit which lets it know where it is in space.

Aerial maps are made from many images that are combined using photogrammetry software.

The pilot either flies the drone themselves (manually) or uses a program that flies the drone autonomously.



Multicopter Drones

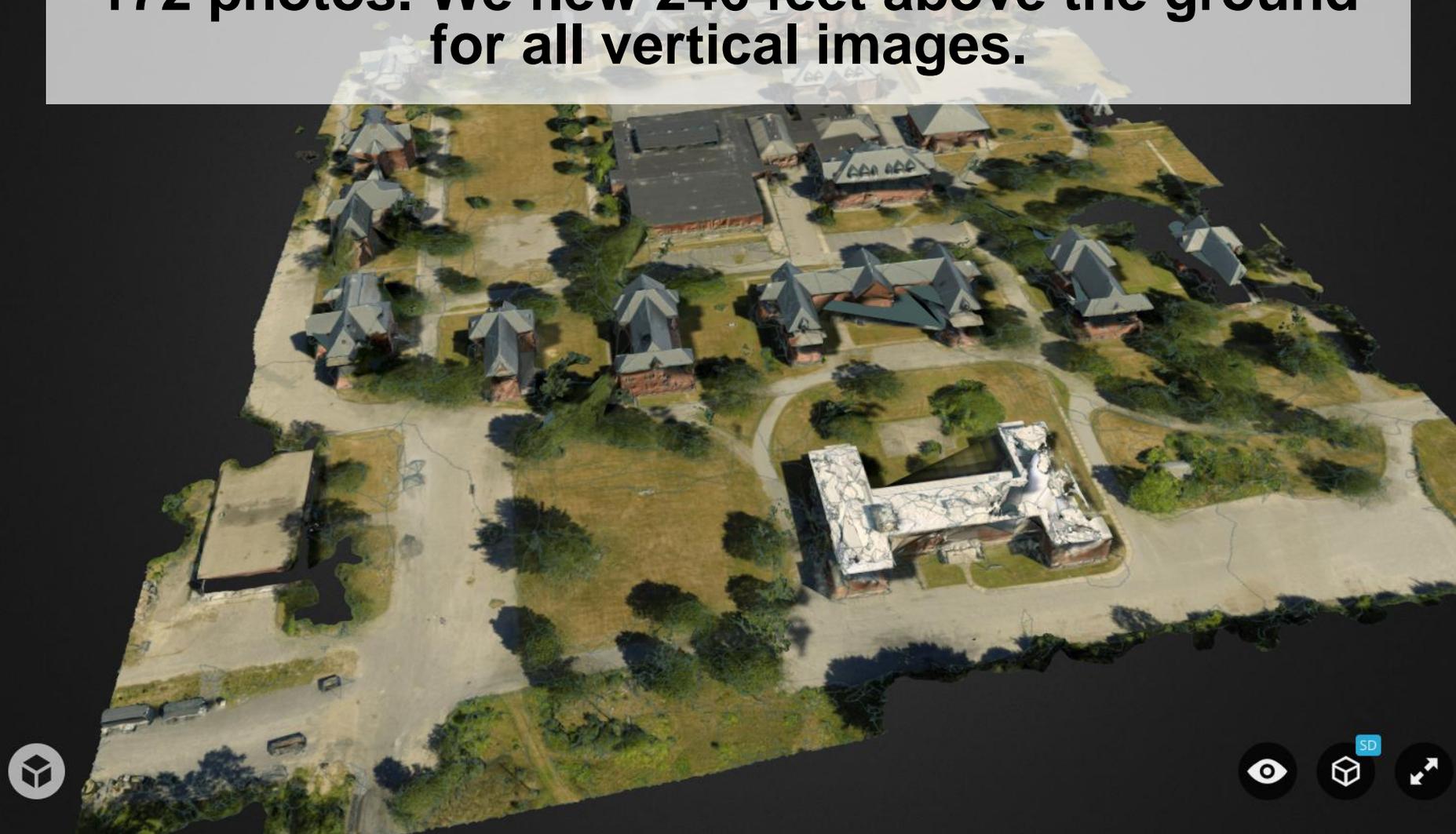
Small multicopter drones like the DJI Phantom 3 Professional can be piloted autonomously and are easy to learn to use. They look less threatening than larger drones, and can be purchased or built inexpensively. Newer models geotag each photograph they take.

Fixed-Wing

Fixed wing drones resemble conventional airplanes, and are often used for large mapping jobs. Some people build their own (for as little as \$500), while others buy off-the-shelf models (at many price points).



We made [this model at the Medfield Mental Hospital outside Boston](#), using the DJI Phantom 3 Professional drone and Drone Deploy software. The map and 3D model spans 22 acres and used 172 photos. We flew 246 feet above the ground for all vertical images.



These 3D models can be manipulated and “flown” through, like a video game map.



We can use the same geo-referenced photographs to make an orthorectified and georeferenced 2D map, using photogrammetry software. We achieved a GSD (detail level per pixel) of 3.2 CM, flying 246 feet above the ground.



Drone Mapping Steps: Flight Planning



Flight Paths/Resolution

- **UAV flight paths need enough forward and lateral photographic overlap, allowing post-processing software to identify common points in each image. (Software does this for you now). 60% overlap is a good minimum figure.**
- Resolution in aerial photography is measured as ground sampling distance (GSD)—the length on the ground corresponding to the side of one pixel in the image, or the distance between pixel centers measured on the ground (these are equivalent) – or, the level of detail in each pixel. (This is also calculated

GSD Equation

- $GSD = (\text{pixel size} \times \text{height above ground level}) / \text{focal length}$.

A Canon S100 lens, zoomed out, has a focal length of 5.2 mm (26 mm zoomed in).

So if we wanted, say, to be able to resolve 1 cm-sized features on the ground using a zoomed-out S100, we would have to fly at:

$1 \text{ cm} \times 5.2 \text{ mm} / 0.0019 \text{ mm} = 27.3 \text{ m} = 89.7 \text{ feet}$

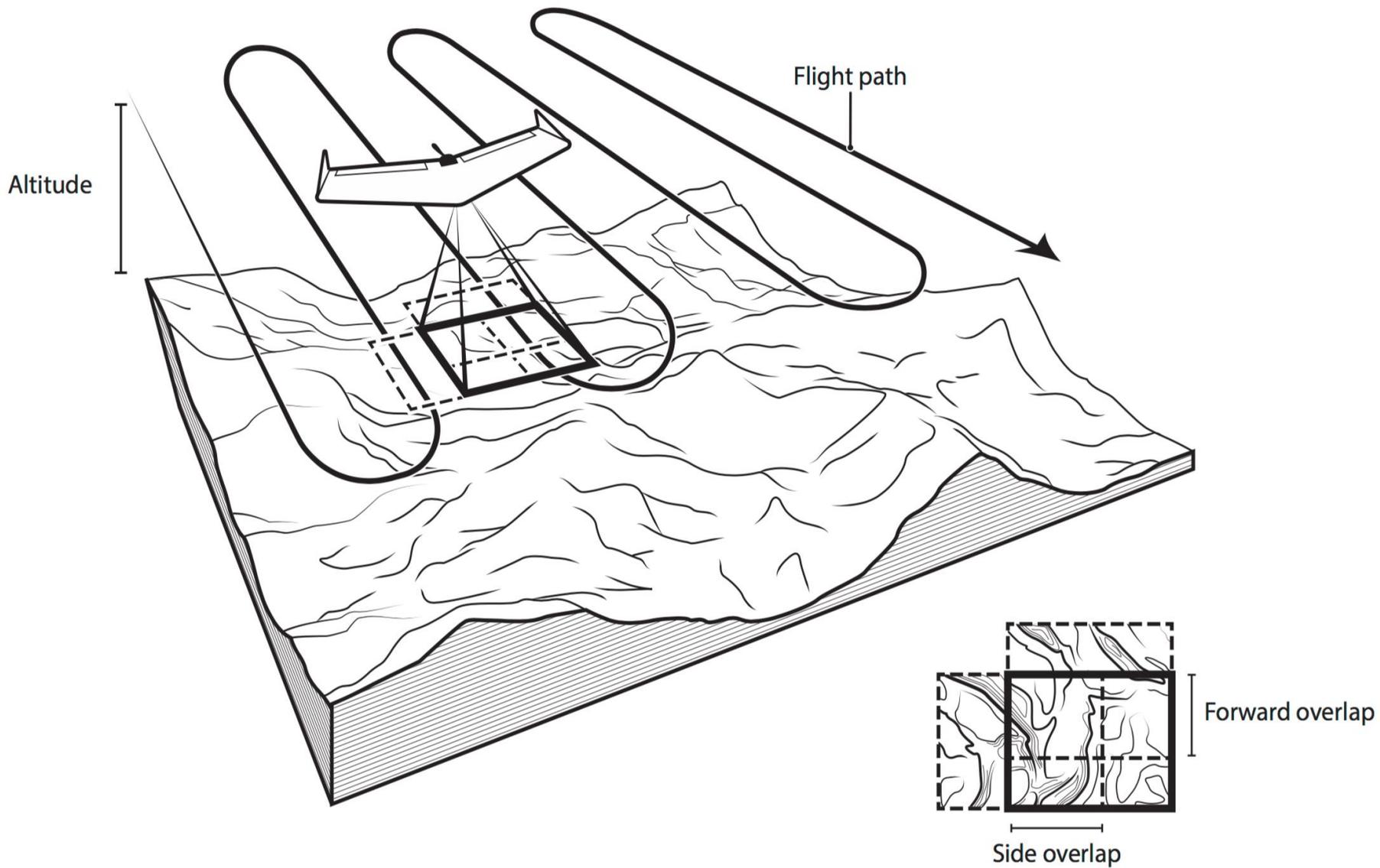


Illustration ©Valerie Altounian

UAV Image Outputs for Mapping

- Two-Dimensional : Orthorectified, georeferenced maps, generated from many still vertical (nadir) aerial photographs.
- Three-Dimensional – Digital Surface (DSM/3D models, viewable in Autodesk, generated by photogrammetry software from many vertical and oblique images. (And volume measurements).

Some Common Processing Software



- Desktop:
- Agisoft Photoscan
 - Pix4D



- Cloudbased:
- DroneDeploy



- Open-Source:
- VisualSFM

Ground Control Points/RTK

Surveyors use high-accuracy ground control points (often measured with a surveyor grade dual frequency RTK GNSS receiver) to align drone-generated maps with real world measurements. 10 GCPs are often enough, an improvement over the 1000+ points required w/ traditional surveying.

Some drone manufacturers, like Trimble and Sensefly, sell RTK-GPS enabled drones that streamline this process – potentially enabling absolute accuracy down to 3 CM.

An aerial photograph of a construction site. In the center-left, there is a large, white, dome-shaped structure under construction. To its right, there are several smaller buildings with grey roofs. The ground is a mix of dirt, gravel, and green grass. The background shows more trees and a clear sky.

Drone Mapping Uses: There's Lots!

Drones are being used for mapping work around the world and in a variety of different professions.

Archeologists

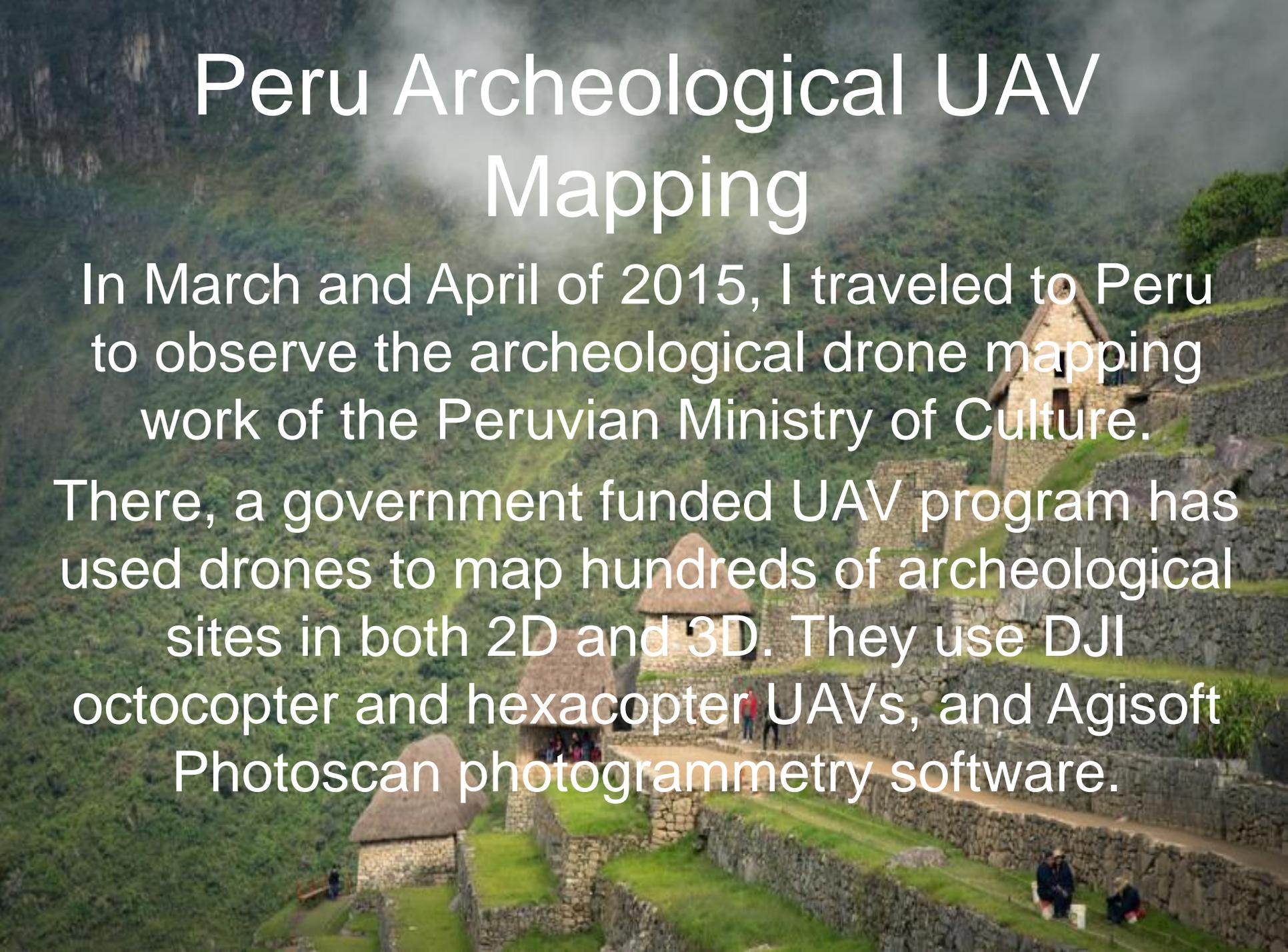
- Miners
- Farmers
- Architects
- Construction Planners
- Wildlife Researchers
-and many more.

[A database is available at \[drones.newamerica.org\]\(http://drones.newamerica.org\).](http://drones.newamerica.org)

Peru Archeological UAV Mapping

In March and April of 2015, I traveled to Peru to observe the archeological drone mapping work of the Peruvian Ministry of Culture.

There, a government funded UAV program has used drones to map hundreds of archeological sites in both 2D and 3D. They use DJI octocopter and hexacopter UAVs, and Agisoft Photoscan photogrammetry software.







Área de
Fotogrametría
'Arqueometría
Ministerio de Cultura

Disaster Mapping in Vermont

Jarlath O'Neil-Dunne of the University of Vermont's Spatial Analysis Lab has used a Sensefly eBee fixed wing drone to do small-scale disaster mapping.

He believes drones will be particularly useful tools for small communities that lack the budget to afford manned aircraft or satellite imagery.

Great, But is it *Ethical*?

Ethical standards in the use of drones are still being developed. Some of the most common concerns include

- Privacy
- Data Security
- Safety
- Community Involvement
- And more!





Privacy

- How do we protect the privacy of people being photographed from a drone?
- Can we identify individuals from the drone imagery? How does our drone imagery compare to imagery taken from Google Maps and other public services?
- How do we convey what we are doing to people who we may be photographing?
- How can we use social media to tell people what we are doing?



Data Security

- Who do we share the data we collect with?
- What should we do about drone data that might be used to harm innocent parties?
- How do we make sure we collaborate with people who share our values?
- What do we do if our drone inadvertently detects illegal activity or other unintended data?



Safety

- How do we ensure we fly as safely as is possible?
- How do we mandate that pilots are competent and well-trained?
- What do we do if a drone crashes? What do we do if it harms somebody?
- What kind of insurance should drone operators carry?



Community Involvement

- How do we inform communities of what we are doing? How to involve them in the process?
- How do we convey what we're doing to people in different cultures and in different languages?
- How do we work with communities to ensure we're gathering data that they can use, and that they are comfortable with?
- Are we flying the drone because we want to, or because communities can use and benefit from the data we gather?

New America Drone Primer

NEW
AMERICA

In July 2015, New America released a primer to civilian drones, co-authored by Konstantin Kakaes and myself.

You can read it for free at drones.newamericainstitute.org.



July 2015

**DRONES AND AERIAL OBSERVATION:
NEW TECHNOLOGIES FOR PROPERTY RIGHTS,
HUMAN RIGHTS, AND GLOBAL DEVELOPMENT**

PRIMER

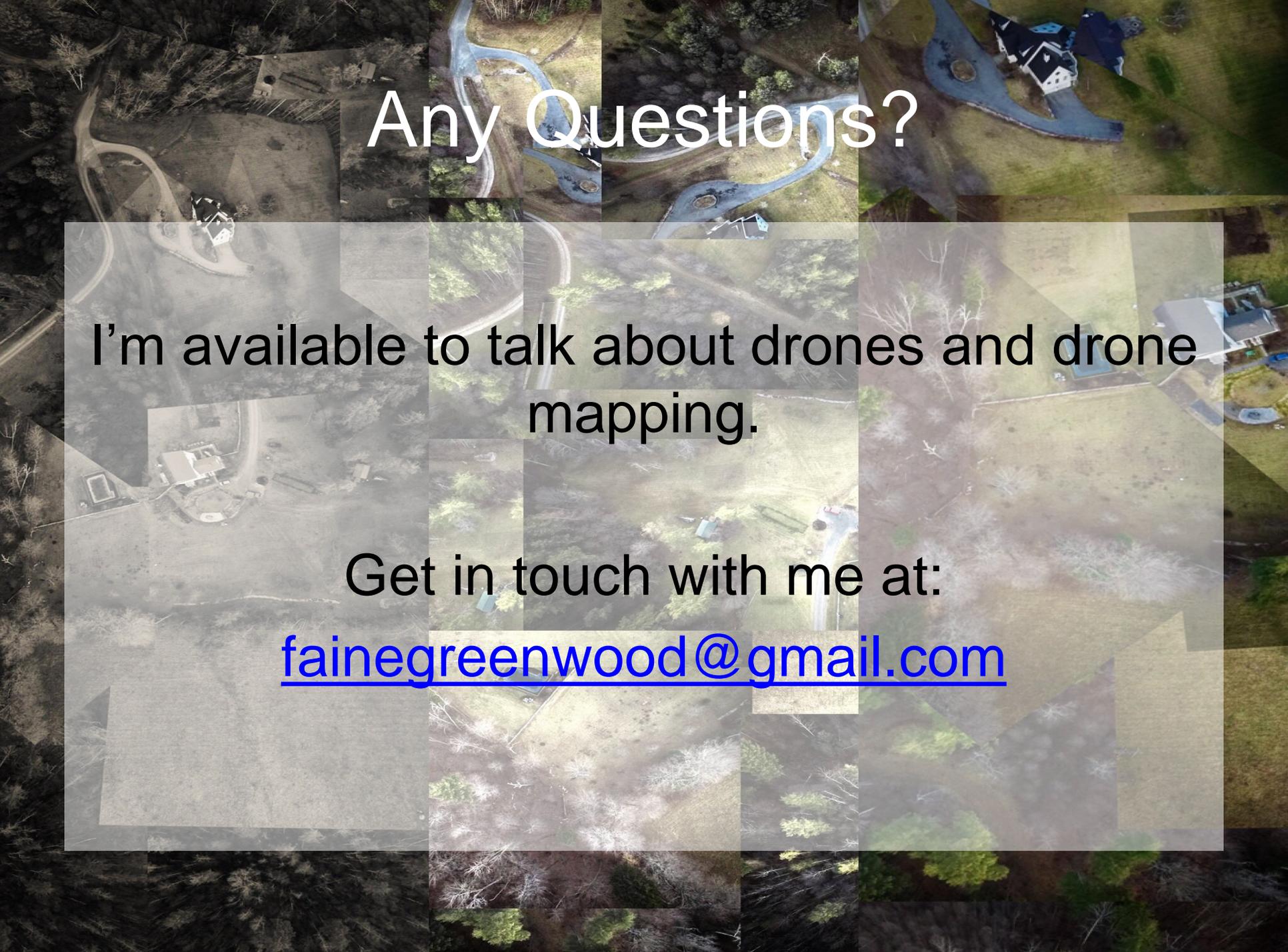
Signal Program at HHI

The Signal Program will be incorporating drone technology into its existing humanitarian-focused work with satellites. We plan to release new research on drones for humanitarian purposes in many areas, including ethics, practical applications, tool-to-task match guidance, and more.

We also will be holding a remote sensing workshop at Harvard in June.



**HARVARD
HUMANITARIAN
INITIATIVE**

The background of the slide is a collage of various aerial drone photographs. The images show different landscapes: a winding blue river through a green forest, a large white house with a dark roof on a grassy hill, a dirt road curving through a wooded area, a large open field with some structures, and a dense forest of trees. The photos are arranged in a grid-like pattern with some overlapping, creating a textured, multi-faceted visual.

Any Questions?

I'm available to talk about drones and drone mapping.

Get in touch with me at:

fainegreenwood@gmail.com