Payloads

Which one(s) are right for your organization?

What is a payload anyway?

Not as simple as it may sound –
and critically important.

- *Integrated and fixed?*
- *Interchangeable?*
- *Field changeable?*
- *Impact on battery life?*
- *Designed to deliver or construct something?*

Payload

Technically:

- Refers to the amount of load, typically excluding the weight of the operational UAV, that can be carried.
- Included in the regulated weight of the UAS. sUAS is less than 55 lbs. including the weight of the aircraft, battery and payload (at any time).

Practically speaking:

- For a UAV, the payload typically refers to the 'thing' that you will be carrying. Be that a camera, a set of cameras, a rope, some water, etc.
- For UAV's which carry only built in integrated cameras, there is often no payload specification.
- Payloads can cost more than the UAV.

Caution – there is some lack of consistency in UAS specifications regarding what is included when a "payload" is specified. Sometimes, batteries are included, sometimes not. Sometimes "low range" batteries.

Imaging and non-Imaging Payloads

Imaging Payloads

- Digital Cameras
- Video Cameras
- Infrared Cameras
- Hyperspectral Sensors
- LIDAR (Light Distance and Ranging)
- Combinations

Non-Imaging Payloads

- People – yes people
- Ropes
- Supplies
- Radios
- RADAR
- "Dropping" devices
- Chemicals

Tethers

Munitions

Important Note: While I show pictures of real products here, I'm making no statements about quality or use of a particular product.

Imaging Payloads

Most common and simplest UAS payload is “just” a camera

- *Imaging is driving the commercial UAS Market*
- *GoPro or commercial camera*
- *Integrated – comes with the UAV*
- *Still/Video – usually both*
- *Stabilization methods – digital, optical, gimbal*
- *Navigation Cameras (obstacle avoidance)*

Yuneec CG04:

- *3x Optical Zoom*
- *16 MP*
- *4/3 CMOS Sensor*
- *4K Video*

This is a consumer/prosumer digital camera by Panasonic, packed for a UAS.

Digital Camera Specifications

Mega Pixels (MP):

The number of picture elements the camera can capture in still images.

The *least important* specification

- Higher MP does not give you resolution, it gives you digital zoom (cropping).
- Example – A very nice 8x10 photograph can come from 3.2MP.
- 4K TV's are 8.3 MP.

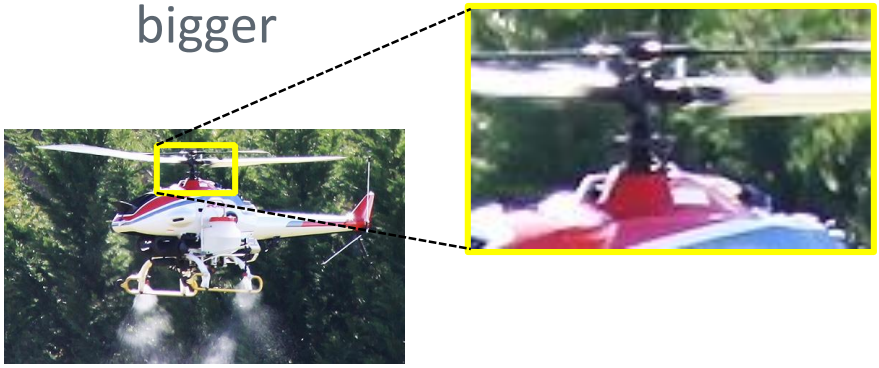
Zoom:

Optical Zoom:

- Traditional zoom lens, the entire sensor is used for the image.

Digital Zoom:

- Cropping. You take the center out of the image, and make it bigger



Wright R-3350 Duplex-Cyclone Turbo Compound Radial Engine from a P2V Aerial FF tanker (Neptune).

Stabilization – 3 forms

Optical Stabilization:

- Typically what is seen in consumer digital cameras.
- The sensor and/or an optical component is moved to compensate for camera shake.

Gimbal Stabilization

- The sensor is mounted in a Gimbal that is stabilized.

Both systems deliver full camera view and image size because the sensor or it's mount is moved.

Digital Stabilization:

- Really only effective in video.
- Can take out motion from frame to frame, but not motion IN a frame.
- You loose some "edge" pixels.
- Can be applied afterward.

Digital stabilization, like digital zoom, crops the image. In digital stabilization the 'crop' moves around the image to capture a stable portion.

Often, with digital stabilization, 4K video cannot be stabilized.

Colorimetry and Metamerism

The color of an object in an image depends on:

- The “spectral reflectance” of the object.
- The “spectral sensitivity” of the sensor.
- The light shining on the sensor.
- Image processing in the camera.
- “Unusual” light sources like fluorescent, mercury vapor, even LED can cause very different colors to be captured *and cannot be corrected for.*

Metamerism: Those socks matched when I put them on in the bedroom – but not outside in the sun.

In colorimetry, **metamerism** is a perceived matching of the colors that, based on differences in spectral power distribution, do not actually match. Colors that match this way are called metamers.

Hyperspectral and Infrared

Both hyperspectral and infrared refer to sensors that 'see' outside the range of the human vision system.

Hyperspectral can also refer to capturing more "colors" but always includes non-visible light.

Infrared Cameras can be:

- *Radiometric: Essentially Calibrated. They tell you the absolute temperature of things in the scene.*
- *Non-radiometric: Non-calibrated. They tell you the relative temperature of things in the scene.*

Hyperspectral cameras "see" lots of wavelengths and can provide very interesting results by "seeing the world" in a way we don't.

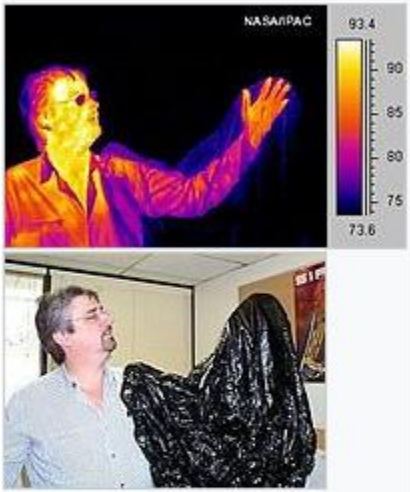
Infrared Cameras

Near Infrared (NIR .75-1.4µm):

- Used in visual augmentation systems (night vision).
- Not that sensitive to ‘heat’.

Long wave infrared (LWIR 8-15µm):

- Thermal Imaging.
- The “color” in a thermal image is not real, it is put there by the camera to make it easy to interpret what you see.



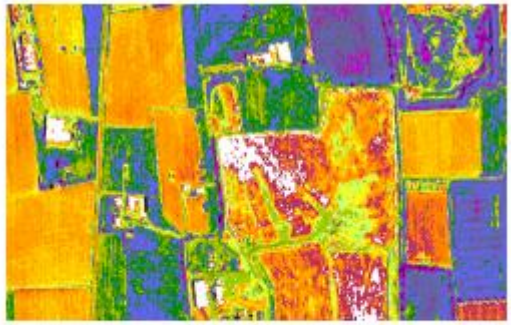
A comparison of a thermal image (top) and an ordinary photograph (bottom) shows that a trash bag is transparent but glass (the man's spectacles) is opaque in long-wavelength infrared.

Hyperspectral Cameras

Most common use today is in crop, forest health or chemistry.

- Healthy versus unhealthy plants radiate in different ‘colors’ and the amount of moisture impacts how they reflect different frequency bands.
- Chemicals, particularly spills, can be very obvious in Hyperspectral images.

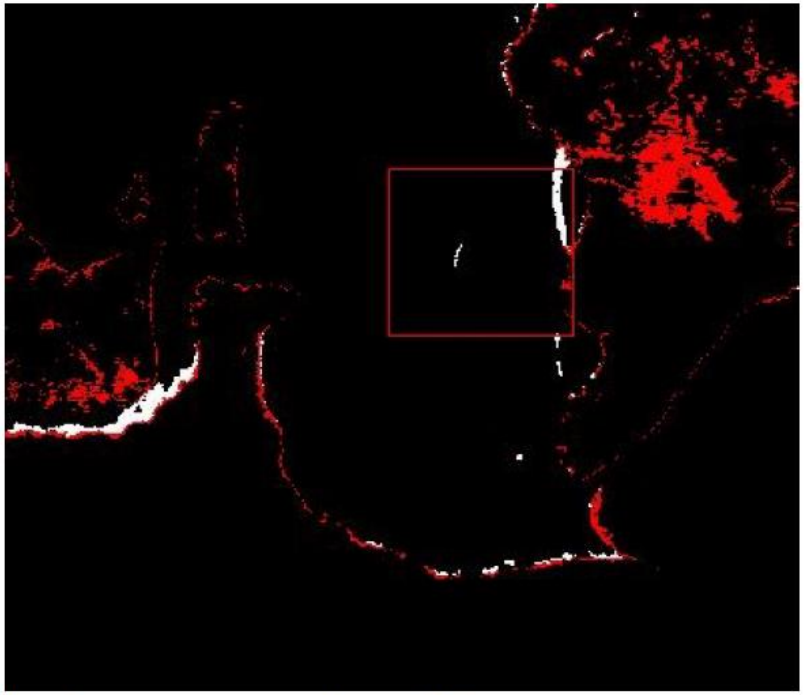
Identification soil use and cultivations with a multi-spectral camera



Detection of unauthorized waste areas with a multi-spectral camera

Identification of asbestos ith a multi-spectral camera

Oil/Chemical Detection Example



Class Image Figure (8)

Figure (9)

Figure (8) shows two classes, white indicted heavy oil slicks on water, it appear close to the shore outline, and red color represents oil spills on land and on the river edges due to the pipeline break.

Figure (9) shows picture was taken on the same time of oil spill event is used as ground truth for comparing results

HYPERSPECTRAL IMAGE ANALYSIS FOR OIL SPILL DETECTION

Foudan Salem,1 Menas Kafatos,1 Tarek El-Ghazawi,2 Richard Gomez,1 and Ruixin Yang1

1Center for Earth Observing and Space Research

George Mason University, Fairfax, VA USA.

LIDAR (and Photogrametry)

LIght Distance And Ranging:

- Send out a sweeping laser beam
- Measure the reflected light using time-of-flight to measure distance
- Move the beam a little bit.
- Rinse – Repeat

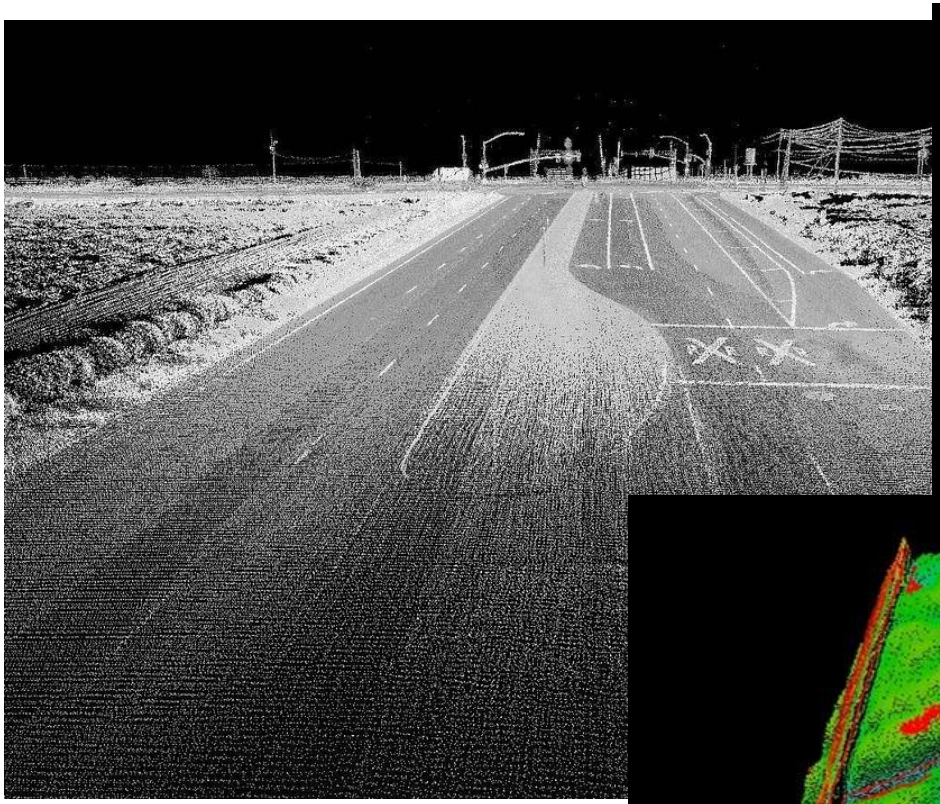
LIDAR

- Expensive but decreasing
- Precise
- Growing dramatically (autonomous vehicles, collision avoidance, etc.)
  - *Self Driving Cars*

Precise documentation of physical structures:

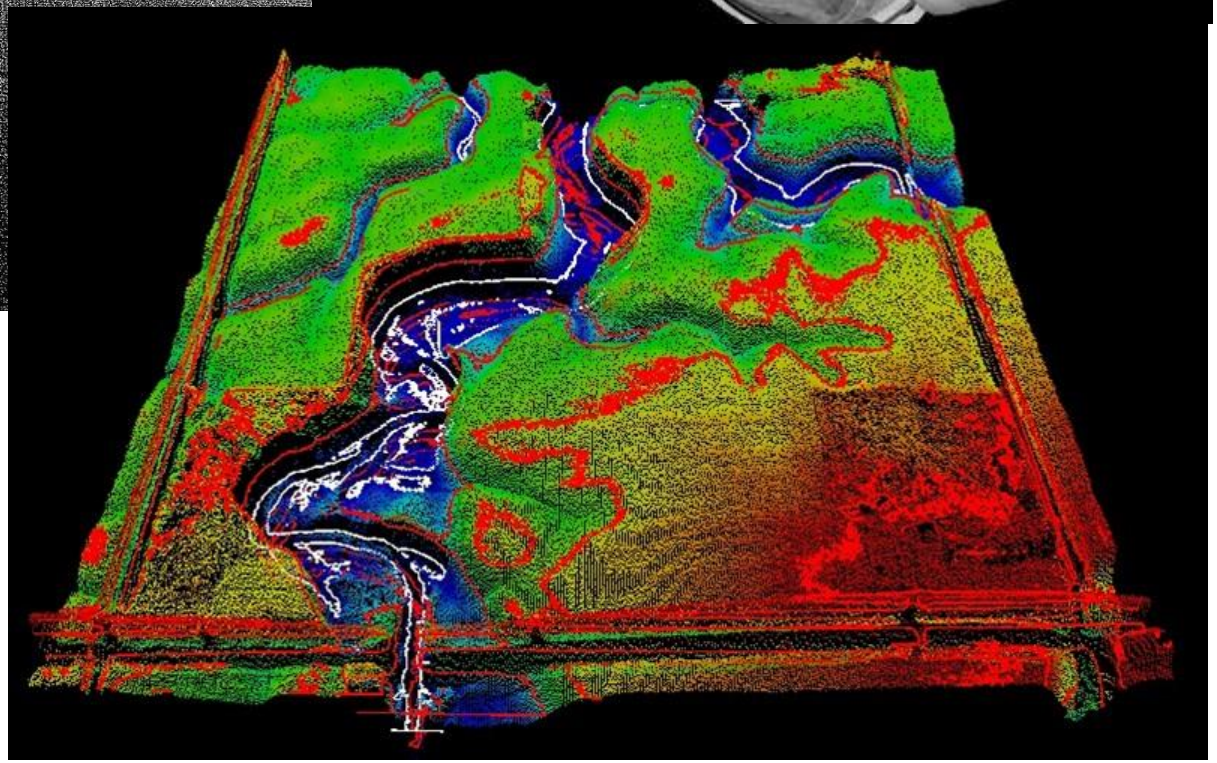
- Buildings, accident scenes, structure, trees, etc.

Trivia question: How long does it take for light to travel 1 inch?



https://www.viatechnik.com/blog/5-lidar-technology-applications/

http://www.faro.com/measurement-solutions/applications/accident-reconstruction



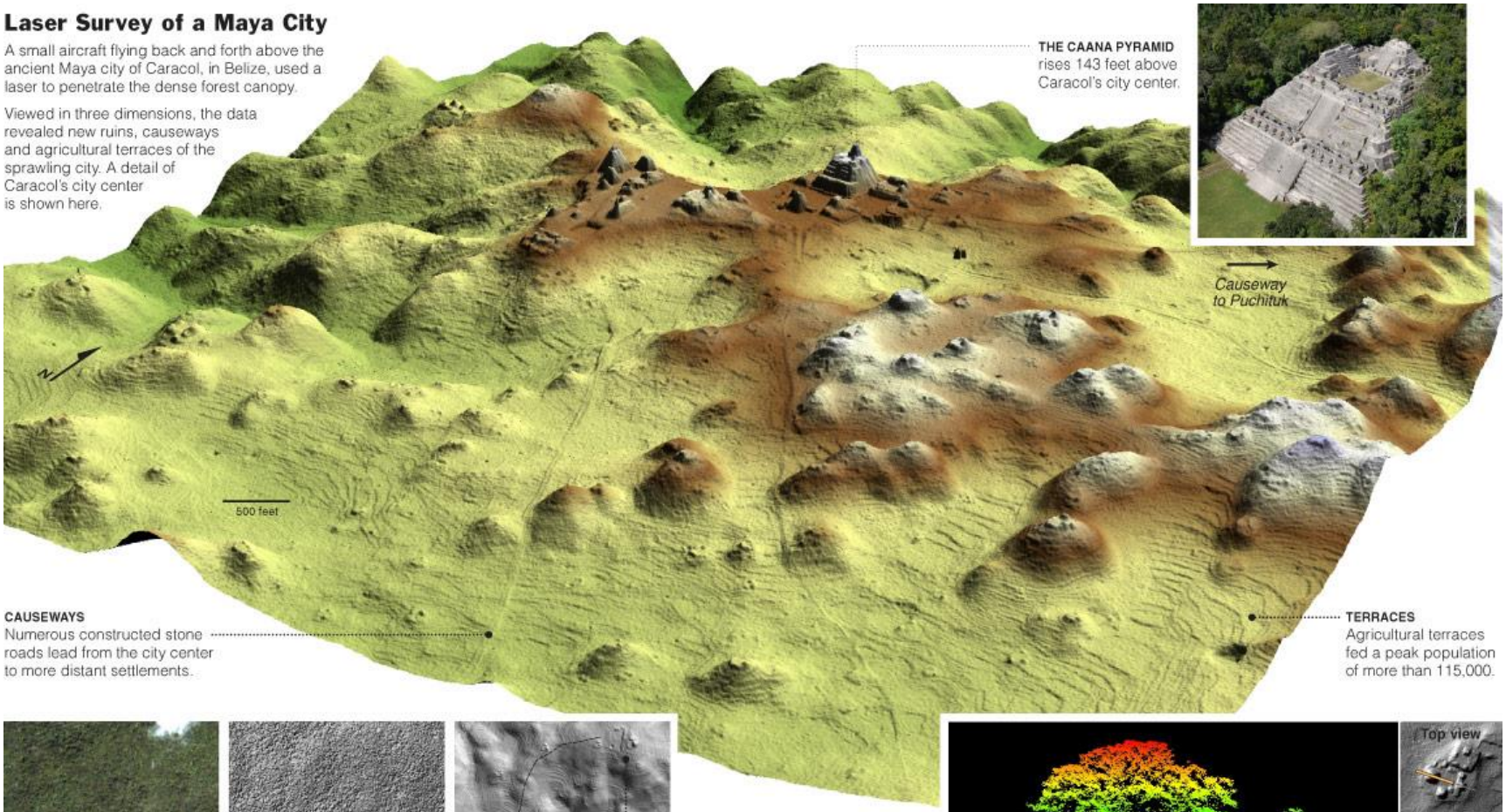
http://talk.newagtalk.com/Classifieds/Classified.aspx?id=58324

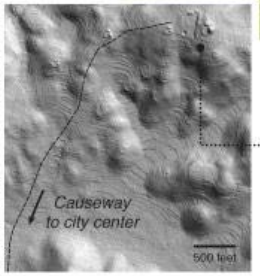
85ps *(pico seconds)*

Laser Survey of a Maya City

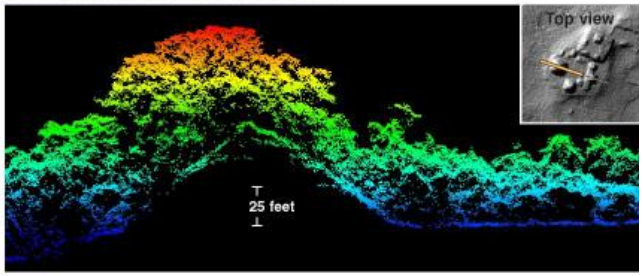
A small aircraft flying back and forth above the ancient Maya city of Caracol, in Belize, used a laser to penetrate the dense forest canopy.

Viewed in three dimensions, the data revealed new ruins, causeways and agricultural terraces of the sprawling city. A detail of Caracol's city center is shown here.





PUCHITUK
Once surrounded by hundreds of open terraces, the hilltop settlement of Puchituk is now obscured by the forest.



SATELLITE IMAGERY from the Ikonos satellite is unable to penetrate heavy foliage.

LIDAR Using a laser instrument called lidar, for light detection and ranging, to scan the upper canopy shows little detail (left). But some of the laser pulses penetrate the foliage and reflect off of the ground, revealing ruins and extensive terracing (right).

PEERING THROUGH THE FOREST A lidar scan along a straight track (orange line, inset) shows reflections off of the ground and different layers of foliage, revealing the cross-section of a pyramid-shaped structure. In this image the measured points are colored according to height, and are accurate to about six inches.

Source: Arlen F. Chase, Diane Z. Chase and John F. Weishampel, University of Central Florida

THE NEW YORK TIMES; IMAGES COURTESY OF CARACOL ARCHAEOLOGICAL PROJECT

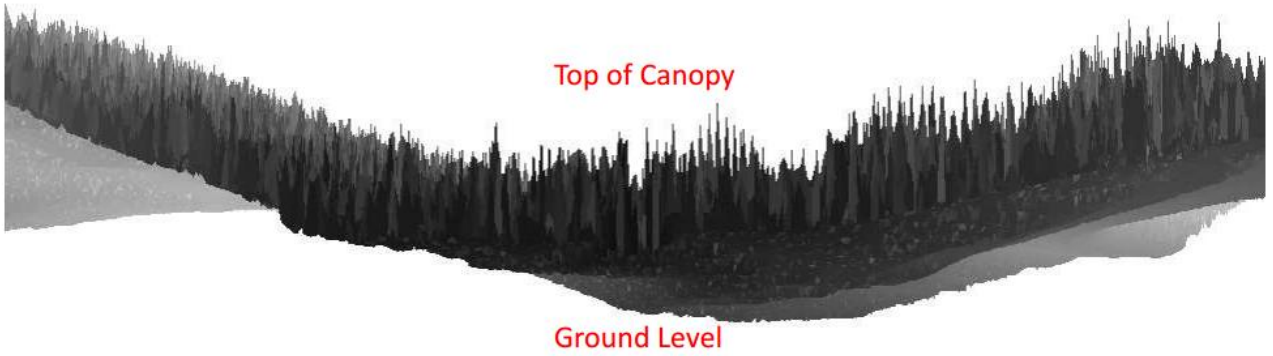
Photogrammetry (Structure from Motion or SFM)

Taking multiple photographs creating a 3-d model

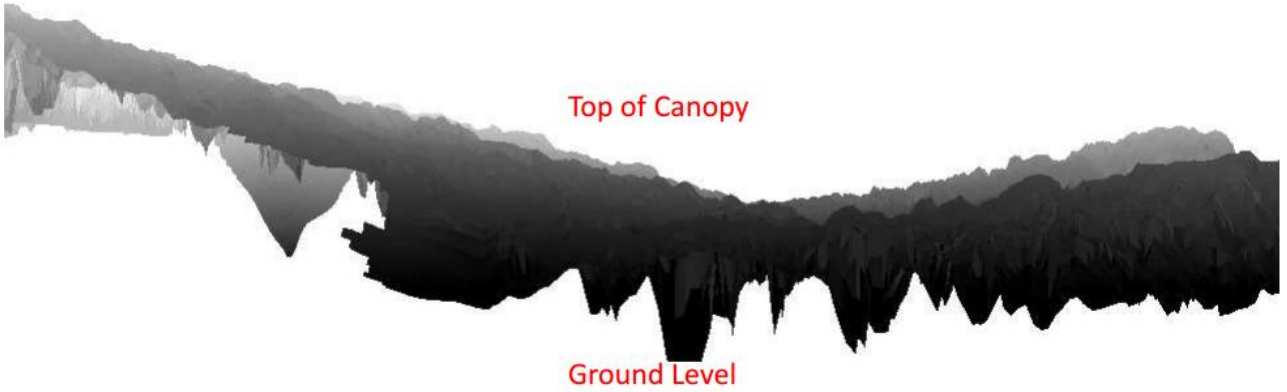
- Uses off the shelf sensors, so lower cost than LIDAR.
- Not as precise.
- Does not penetrate canopy/objects.
- More realistic.

Combination of LIDAR and Photogrammetry is very powerful.

LiDAR



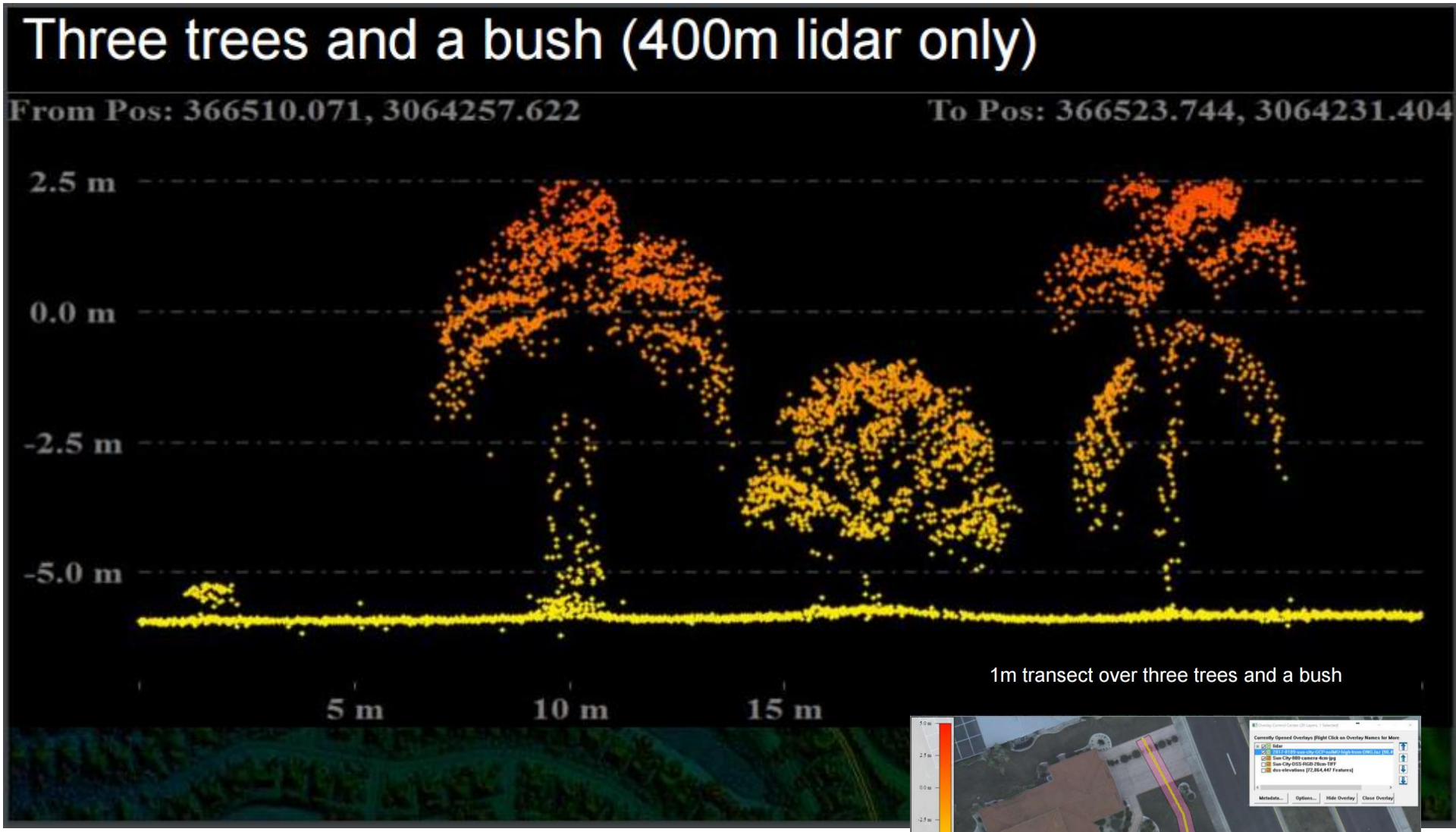
Structure from Motion



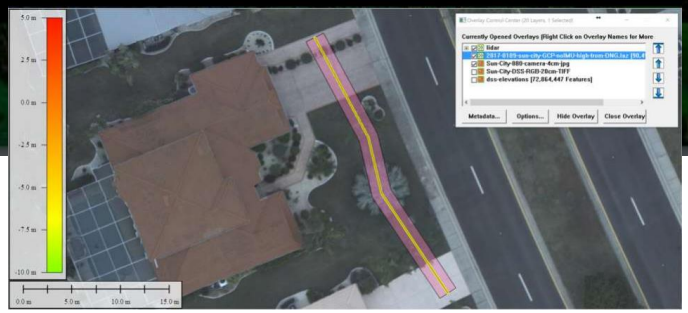
West Virginia University

http://www.lidarmap.org/wp-content/uploads/2017/02/Strager-Michael-021417.pdf

Three trees and a bush (400m lidar only)

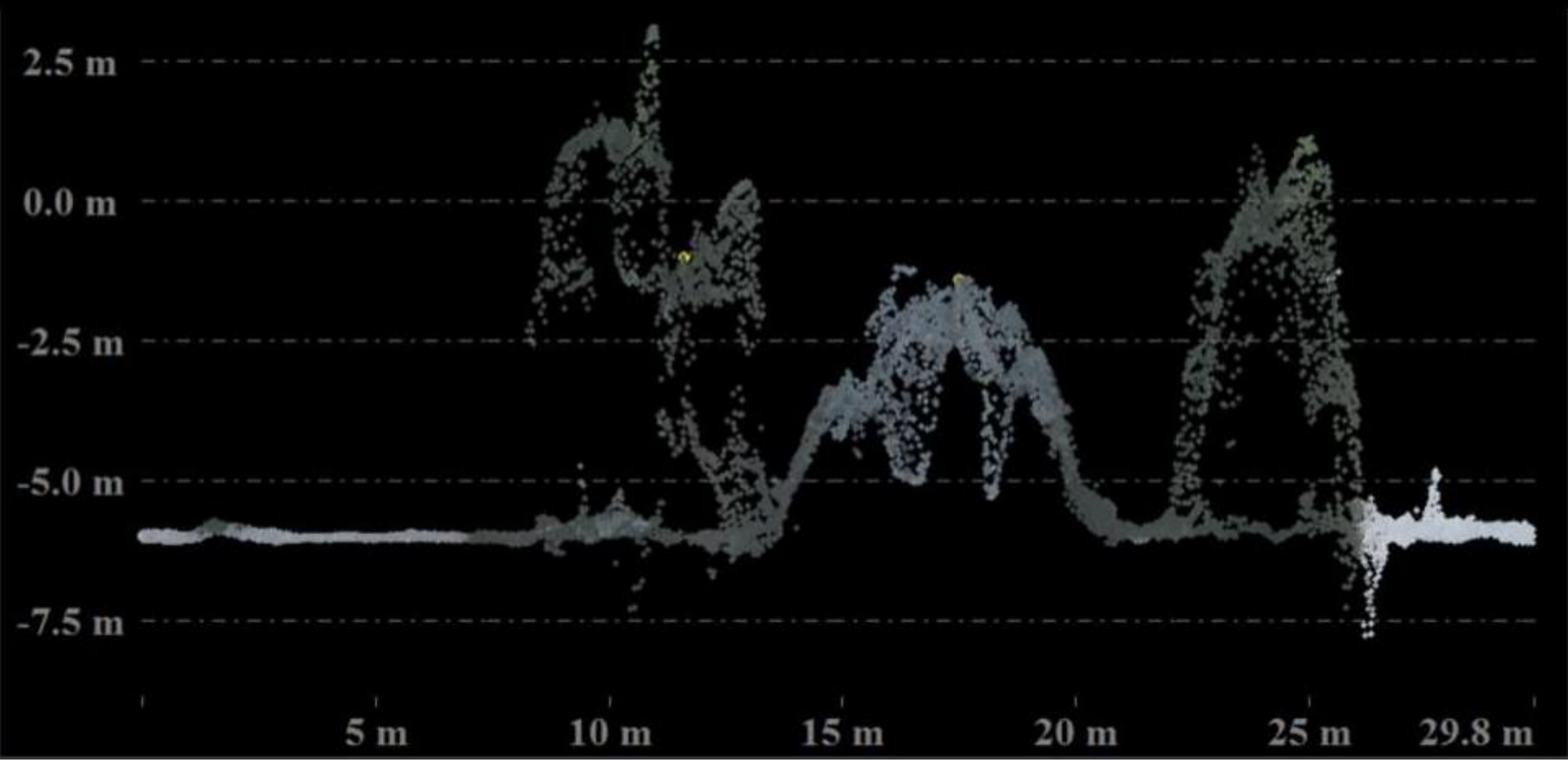


1m transect over three trees and a bush

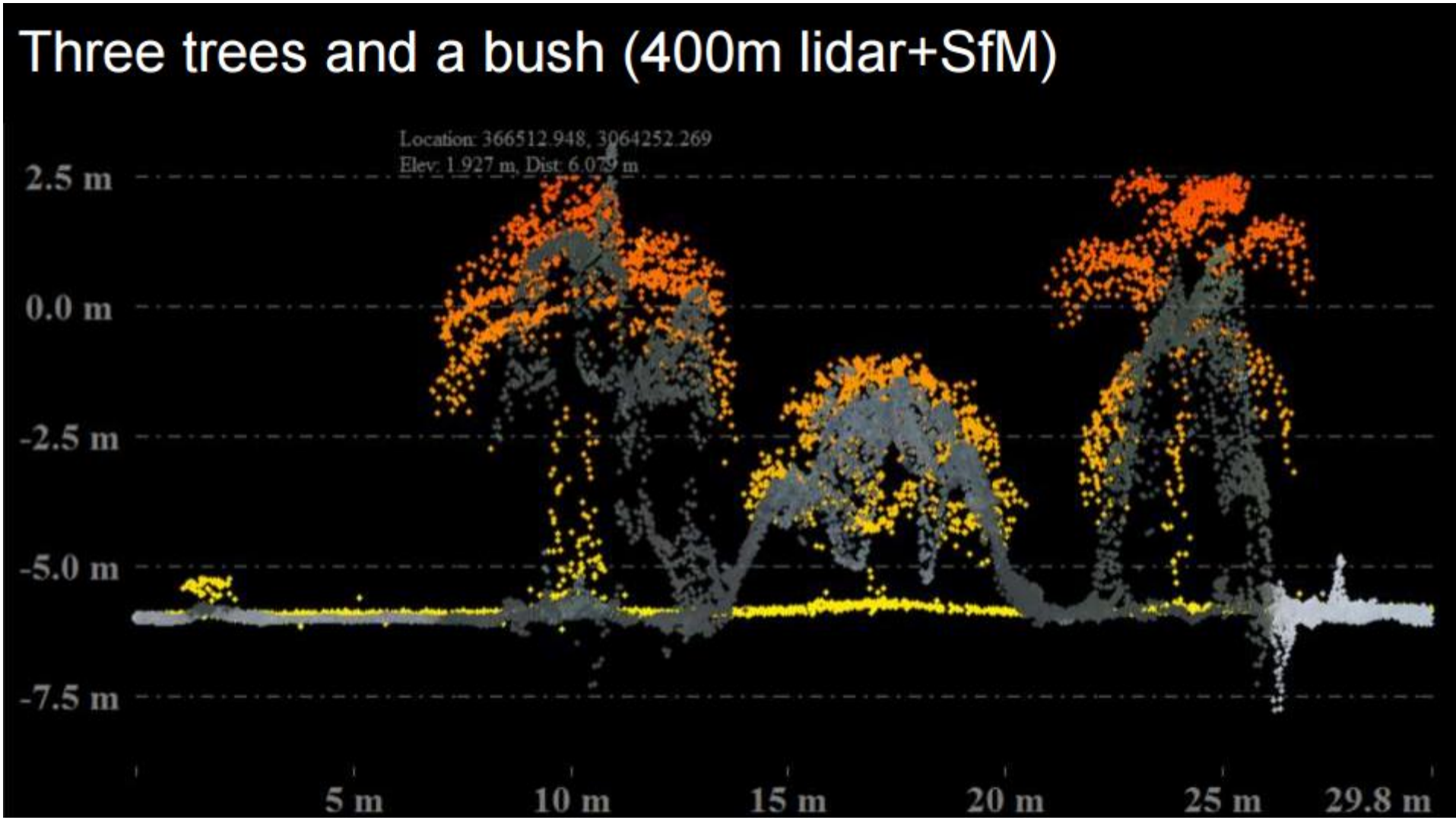


http://www.lidarmap.org/wp-content/uploads/2017/02/Wright-Wayne-021417.pdf

Three trees and a bush (400m SfM only)



Three trees and a bush (400m lidar+SfM)



Non-imaging Payloads

Carrying ‘things’ to people.

- Ropes and rigging.
- Medicine, food, water.
- Radios, phones, batteries.

Carrying ‘chemicals’.

- Fire Suppressant or Retardant? (not really sUAS)
- Fertilizer, pesticide, etc.

Radios.

- Providing communications or relay.
- Auto-locating coverage site and creating a repeater.

A word about “LTE” and “Firstnet”

There is some uncertainty if a device like this can be used as an LTE ‘tower’. Having an aerial device connect to the cell network is much different than having it act as a tower. Unclear the later will happen anytime soon.

Tethers

The idea of a tethered UAV is compelling from a couple of standpoints:

- Power can be supplied through the tether.
- More bandwidth between the UAV and the ground (fiber optic connection).
- Less ‘operator’ interaction.

On the other hand:

- Impact of weather and wind on a tethered UAV is ‘interesting’.
- The weight of the tether is part of the payload.
- The tether is an additional aerial hazard.