

Lecture 9: UAVs: Sensors and Applications

GEOG413/613
Dr. Anthony Jjumba

1

UAVs

- History
- Sensors
- Applications
- Prospects for the future

2

UAVs

- Technology has been With US Army since WW I
 - Modern Phase took off in 1960s
 - Paused development in 1970s
 - Picked up again in the late 1980s
- Has been in university circles for decades
 - Engineering
 - Automation

3

UAVs

- UAV: Unmanned Aerial Vehicle
- UAS: Unmanned Aerial System
- RPV: Remotely Piloted Vehicle

- Micro or Miniature UAV
 - micro air vehicle
 - Could fit into your palm
- **Small UAV**
 - Man portable

4



Photo by Spc. Latoya Wiggins/Handout via U.S. Army (PBS.ORG)



Source: Geoawesomeness



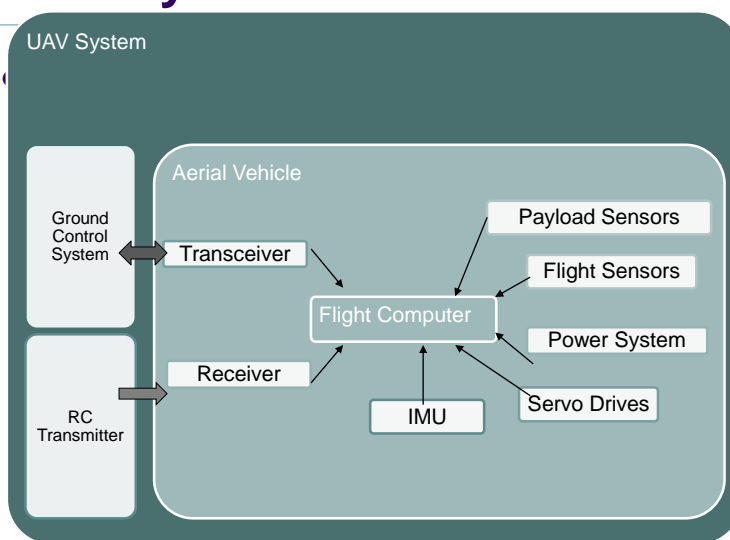
Source: CropLife



Credit: Proxdynamics (Discover Magazine)
<https://www.youtube.com/watch?v=4o7mRg74qcY>

7

UAV System Architecture



8

UAVs

- Aircraft Pre-Flight Preparations
- Launch
- In Flight Monitoring
 - Autopilot
 - Manual Override
- Landing
- Post-Landing
 - Data Processing
 - Review Images
 - Add Ground Control Points,
 - Processing

9

UAVs

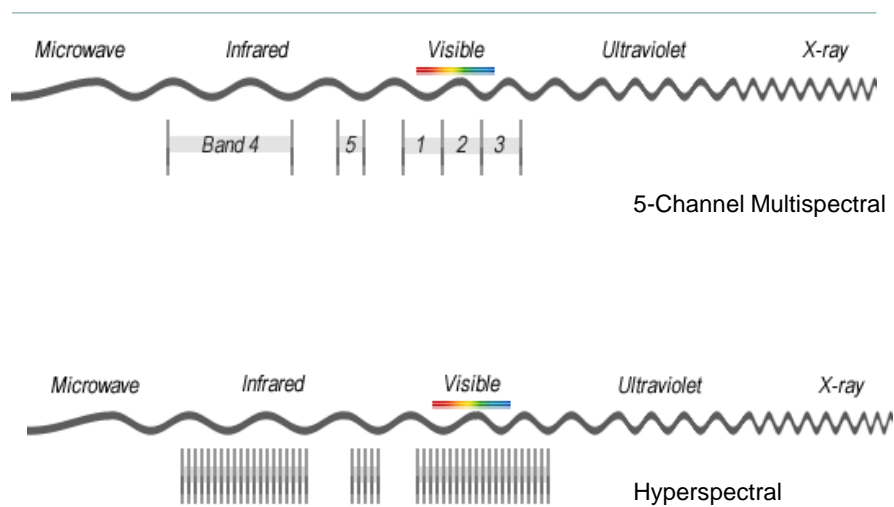
- Some UAV Flight Systems
 - Precision Hawk, SenseFly, Trimble, DJI
- Some UAV image processing platforms
 - Precision Hawk, ENVI, Pix4D, PCI Geomatica

10

UAVs Sensors

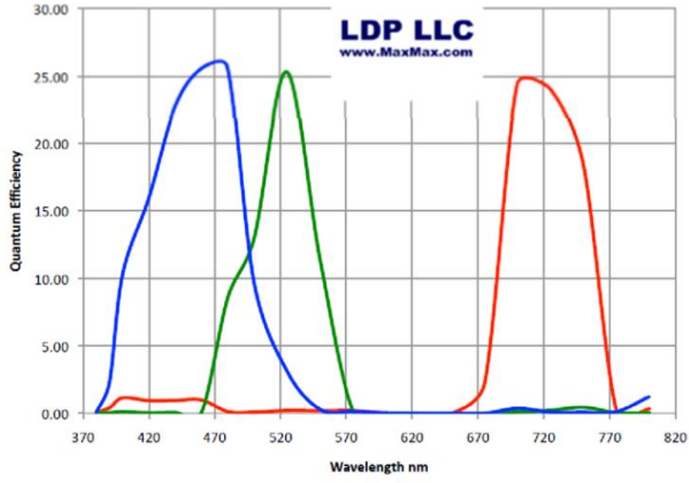
Type	Sensor
Frame Based	RGB
	BGNIR
	Thermal
	5-Channel Multispectral
Line Scanning	Hyperspectral
LiDAR	LiDAR

11



Source: GIS Geography

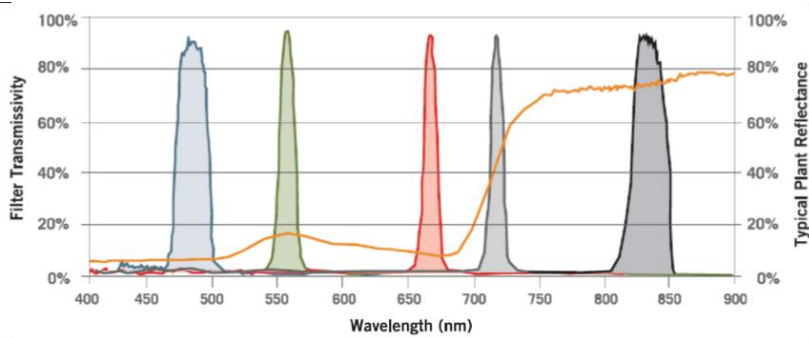
12



BGNIR (Blue, Green, NIR) [480, 520, 700]

13

UAVs



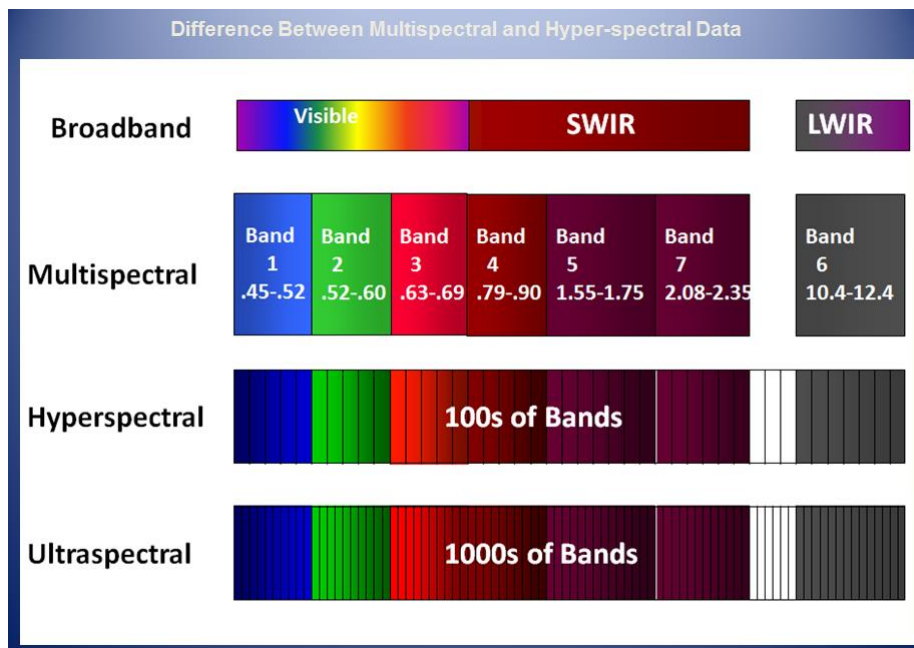
5 Ch. MULTISPECTRAL (Blue, Green, Red, NIR, Red Edge) [470, 560, 670, 720, 840]

14

UAVs

- Compare 5-Channel to Landsat 8 multispectral sensor produces 11 images with the following bands:
 - Band 1: Coastal aerosol (0.43-0.45 μm)
 - Band 2: Blue (0.45-0.51 μm)
 - Band 3: Green (0.53-0.59 μm)
 - Band 4: Red (0.64-0.67 μm)
 - Band 5: Near infrared NIR (0.85-0.88 μm)
 - Band 6: Short-wave Infrared SWIR 1 (1.57-1.65 μm)
 - Band 7: Short-wave Infrared SWIR 2 (2.11-2.29 μm)
 - Band 8: Panchromatic (0.50-0.68 μm)
 - Band 9: Cirrus (1.36-1.38 μm)
 - Band 10: Thermal Infrared TIRS 1 (10.60-11.19 μm)
 - Band 11: Thermal Infrared TIRS 2 (11.50-12.51 μm)

15



Source: Mark Elowitz

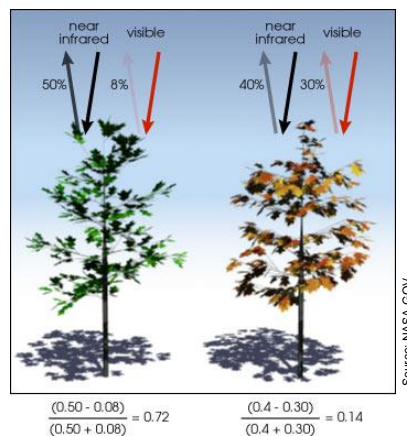
Normalized Difference Vegetation Index (NDVI)

- Used to assess greenness of vegetation
 - When sunlight strikes a green leaf, the chlorophyll strongly absorbs visible light (from 0.4 to 0.7 μm) for use in photosynthesis
 - It also strongly reflects near-infrared light (from 0.7 to 1.1 μm)
- $\text{NDVI} = (\text{NIR} - \text{VIS}) / (\text{NIR} + \text{VIS})$

17

Normalized Difference Vegetation Index (NDVI)

- $\text{NDVI} = (\text{NIR} - \text{VIS}) / (\text{NIR} + \text{VIS})$



18

Normalized Difference Vegetation Index (NDVI)

- NDVI for a given pixel ranges from minus one (-1) to plus one (+1)
- A zero means no vegetation
- Close to +1 (0.8 - 0.9) indicates a high density of green leaves

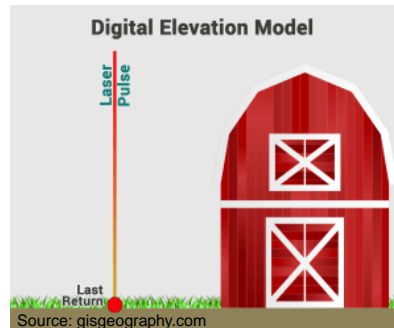
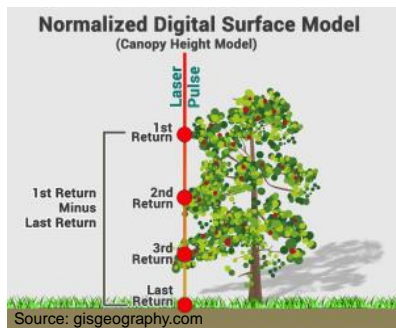
19

UAVs

- LiDAR (Light Detection and Ranging)
 - Distance measurement technology
 - Active light energy (**pulse**) to the ground
 - Reflected light is known as a **return**
 - UAV LiDAR can send 300,000 pulses per second (Velodyne puck)
- How LiDAR works?
 - <https://www.youtube.com/watch?v=EYbhNSUnIdU&feature=youtu.be>

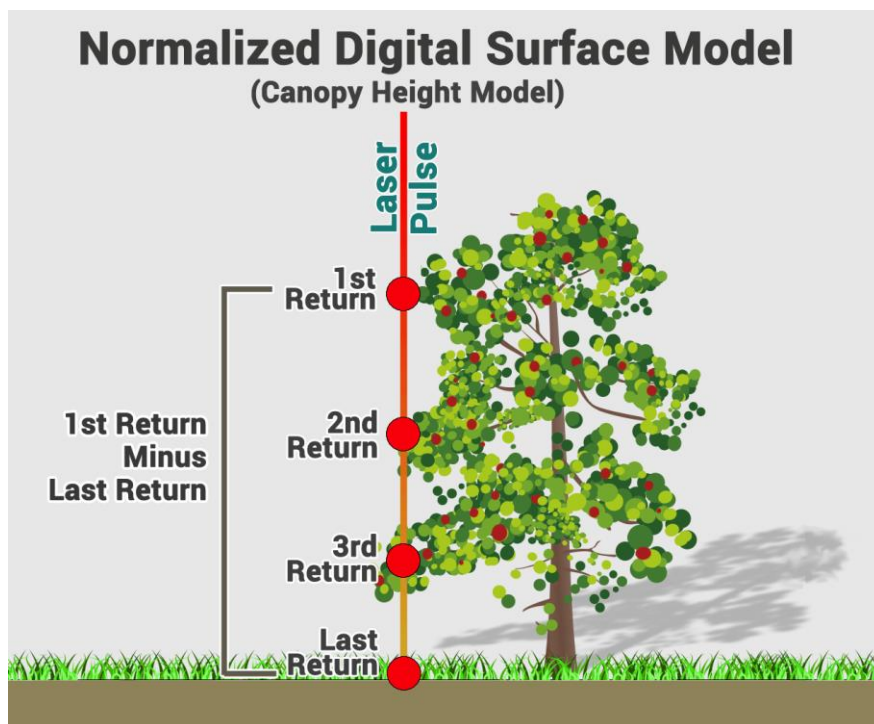
20

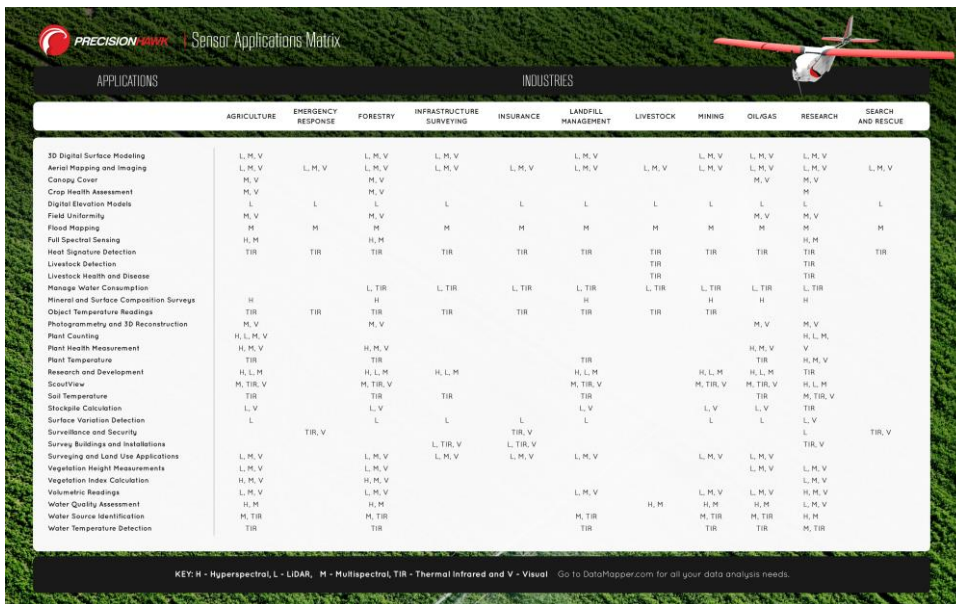
UAVs



- LiDAR Intensity refers to the strength of the returns. Varies with the composition of the reflecting surface, range, incident angle, beam, receiver.
- Point Classification: LiDAR data are classified using standardized codes

21





PRECISIONMAPPER Sensor Applications Matrix

APPLICATIONS	INDUSTRIES										
	AGRICULTURE	EMERGENCY RESPONSE	FORESTRY	INFRASTRUCTURE SURVEYING	INSURANCE	LANDFILL MANAGEMENT	LIVESTOCK	MINING	OIL/GAS	RESEARCH	SEARCH AND RESCUE
3D Digital Surface Modeling	L, M, V		L, M, V	L, M, V		L, M, V		L, M, V	L, M, V	L, M, V	L, M, V
Aerial Mapping and Imaging	L, M, V	L, M, V	L, M, V	L, M, V	L, M, V	L, M, V	L, M, V	L, M, V	L, M, V	L, M, V	L, M, V
Canopy Cover	M, V		M, V						M, V	M, V	
Crop Health Assessment	M, V		M, V						M	M	
Digital Elevation Models	L	L	L	L	L	L	L	L	L	L	L
Field Uniformity	M, V		M, V						M, V	M, V	
Flood Mapping	M	M	M	M	M	M	M	M	M	M	M
Full Spectral Sensing	H, M		H, M						H, M	H, M	
Heat Signature Detection	TIR	TIR	TIR	TIR	TIR	TIR	TIR	TIR	TIR	TIR	TIR
Livestock Detection									TIR	TIR	
Livestock Health and Disease									TIR	TIR	
Manage Water Consumption			L, TIR	L, TIR	L, TIR	L, TIR	L, TIR	L, TIR	L, TIR	L, TIR	L, TIR
Mineral and Surface Composition Surveys	H		H						H	H	
Object Temperature Readings	TIR	TIR	TIR	TIR	TIR	TIR	TIR	TIR	TIR	TIR	TIR
Photogrammetry and 3D Reconstruction	M, V		M, V						M, V	M, V	
Plant Counting	H, L, M, V									H, L, M, V	
Plant Health Measurement	H, M, V		H, M, V						H, M, V	V	
Plant Temperature	TIR		TIR				TIR		TIR	H, M, V	
Research and Development	H, L, M		H, L, M	H, L, M			H, L, M		H, L, M	H, L, M	TIR
ScoutView	M, TIR, V		M, TIR, V				M, TIR, V		M, TIR, V	M, TIR, V	H, L, M
Soil Temperature	TIR		TIR	TIR			TIR		TIR	M, TIR, V	
Stockpile Calculation	L, V		L, V				L, V		L, V	L, V	TIR
Surface Variations Detection	L		L	L	L	L	L	L	L	L, V	
Surveillance and Security		TIR, V			TIR, V					L	TIR, V
Survey Buildings and Installations				L, TIR, V	L, TIR, V					TIR, V	
Surveying and Land Use Applications	L, M, V		L, M, V	L, M, V	L, M, V	L, M, V			L, M, V	L, M, V	L, M, V
Vegetation Height Measurements	L, M, V		L, M, V						L, M, V	L, M, V	L, M, V
Vegetation Index Calculation	H, M, V		H, M, V								L, M, V
Volumetric Readings	L, M, V		L, M, V				L, M, V		L, M, V	L, M, V	H, M, V
Water Quality Assessment	H, M		H, M					H, M	H, M	L, M, V	
Water Source Identification	M, TIR		M, TIR				M, TIR		M, TIR	M, TIR	H, M
Water Temperature Detection	TIR		TIR				TIR		TIR	TIR	M, TIR

KEY: H - Hyperspectral, L - LIDAR, M - MultiSpectral, TIR - Thermal Infrared and V - Visual. Go to DataMapper.com for all your data analysis needs.

Downloadfile here:

<https://www.dropbox.com/s/ce4bwxg2b0mu4zd/application%20matrix.png?dl=0> ²³

Other UAV Applications

- Herding Cattle

- <http://vancouver.sun.com/news/local-news/b-c-ranchers-use-drones-to-ensure-their-cows-come-home>
- <https://www.youtube.com/watch?v=6ouXhsAEb5U>

- Videography

- Sport

- <https://www.youtube.com/watch?v=BuRf6r0Lul8>

- Medical Supplies Delivery

Other UAV Applications



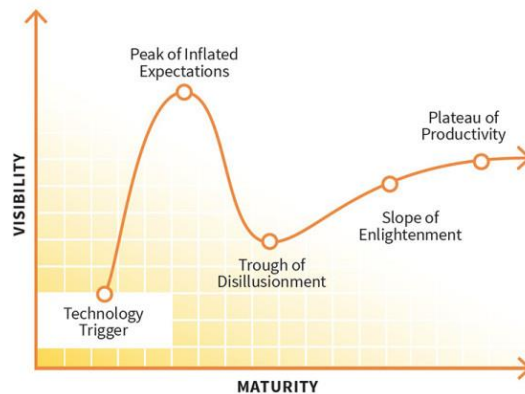
- <http://www.bbc.com/news/technology-37646474>

25

UAV Prospects

Are we in the trough of disillusionment?

GARTNER'S FIVE-STEP HYPE CYCLE



26

UAV Prospects

- Skeptical Side: Still a narrow segment
 - High Accuracy
 - Smaller Areas
 - However,
 - Regulations
 - Visual line of sight
 - Training
 - Hardware deployment
 - 40 minutes/ 200 acres
 - Take off and landing maneuverability
 - Ideal weather conditions

27

UAV Prospects

- Still a narrow segment
 - Processing Software
 - Cost
 - Processing Time
 - Results interpretation
 - Solution:
 - Fully autonomous systems?
 - Navigation and Image processing
 - Anti collision sensors, vertical take off
 - High accuracy DEM?
 - Regulations?

28

UAV Prospects

- Enthusiastic side: More is coming
 - Data collection in difficult places
 - Lower Costs (e.g. vs land surveying)
 - Precision Agriculture (high value crops)
 - Fields too large for manual scouting
 - Precise measurement of crop health (e.g. wineries)
 - Citizen scientists
- A systematic study is needed either way
 - Innovation needed either way

29