



AREN, GLOBE and NASA Resources

[http://www.globe.gov/web/
aren-project](http://www.globe.gov/web/aren-project)

NASA Science Mission Directorate Science Education
Cooperative Agreement Notice (CAN)

Solicitation: NNH15ZDA0044C

Award Number: NNX16AB95A

Principal Investigator: David Bydlowski, Wayne RESA, Wayne, MI

AREN Partners

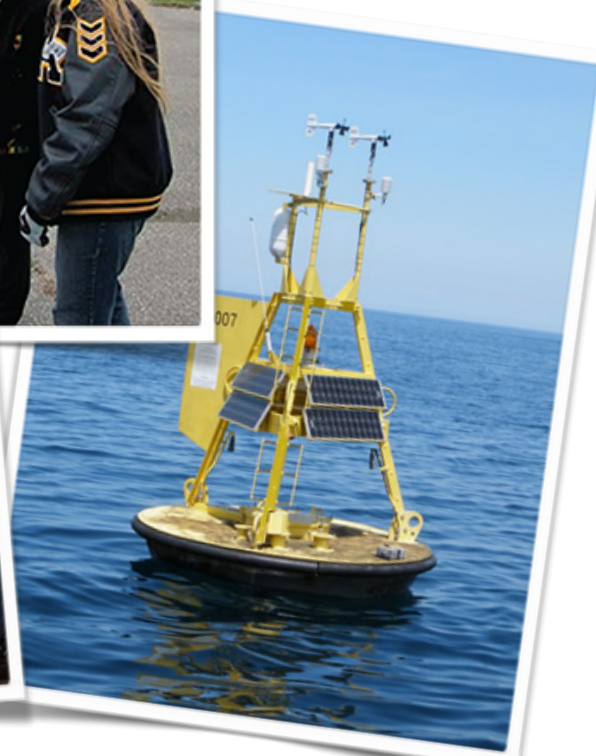
(Attendees at GLOBE Conference Listed)

- Anasphere, Inc.
- Chesapeake Bay Environmental Center
- Goddard Space Flight Center — *Geoff Bland, Brian Campbell and Sallie Smith*
- Montana State University — *Kelly Boyce*
- Public Lab — *Jeff Warren*
- University of Maryland Eastern Shore — *Willie Brown*
- University of South Florida
- Washington College
- Wayne RESA — *David Bydlowski and Andy Henry*
- Evaluation — *Anil Aranha*

HOW DO WE MAKE OBSERVATIONS?

In situ (on site) measurements

Observing or measuring phenomena in place, often with direct physical contact.



Remote sensing

Observing or measuring phenomena without direct physical contact, often from a distance.



LOCAL SCALE REMOTE SENSING: WHAT CAN WE OBSERVE FROM KITES?



A E R O K A T S

Advancing Earth Research Observations with Kites and Atmospheric/Terrestrial Sensors

Using NASA's kite based Aeropod systems to capture remotely sensed imagery and in-situ atmospheric data for use in the classroom



Geoff Bland - NASA Aero-Engineer



Geoff Bland and NASA Technician, Ted Miles



Geoff Bland

Kite based Aeropods allow students to:

- collect and process real data about their environment,
- learn image processing and data analysis skills,
- validate the remote sensing process.



ALIGNING WITH GLOBE DATA COLLECTION



THE GLOBE PROGRAM

CONNECTING THE NEXT GENERATION OF SCIENTISTS

Global Learning and Observations to Benefit the Environment

Protocols and Learning Activities

Site Definition Sheet

Name, time, location, type

Atmosphere – air temperature, barometric pressure, precipitation, relative humidity, wind

Surface temperature

Soil moisture and temperature

Site photos

Land cover sample site

Biosphere investigation instruments - MUC

Computer-Aided Land Cover Mapping

Discovery Area Post-Protocol

Do You Know Your MUC

Getting to Know Your Satellite Imagery and GLOBE Study Site

Land Cover Change Detection

Manual Land Cover Mapping

Odyssey of the Eyes (Beginning and Intermediate Levels)

Using GLOBE Data to Analyze Land Cover

Aeropods are the result of development efforts at NASA's Goddard Space Flight Center

- Monopods, aka Monocam: Single, low cost camera used for aerial imaging.
- Procam: High resolution single camera
- Twincam: Multiband/multicamera for image processing
- Thermocam or Thermopod: Thermal imaging system
- Profiler: Atmospheric (air-column) profiling

AERIAL IMAGING



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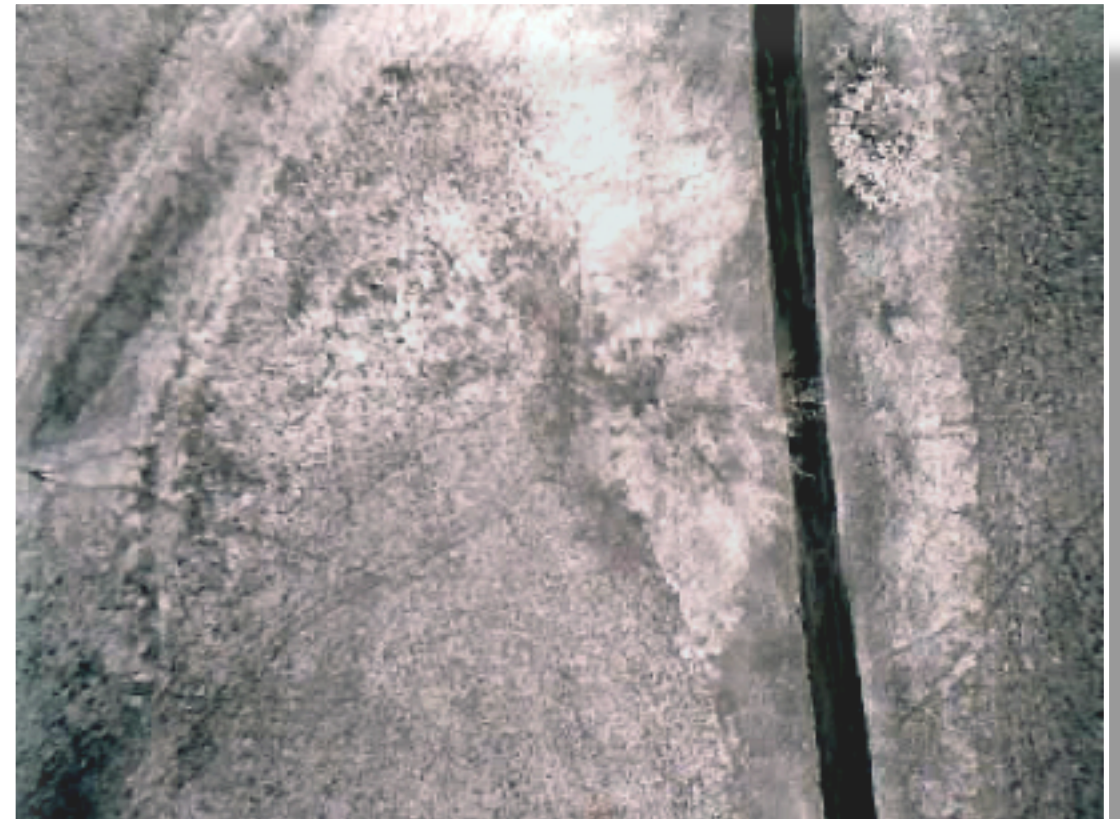
IMAGE PROCESSING

WORKING WITH TWINCAM IMAGE DATA

Example using TwinCam visible and near infrared imagery

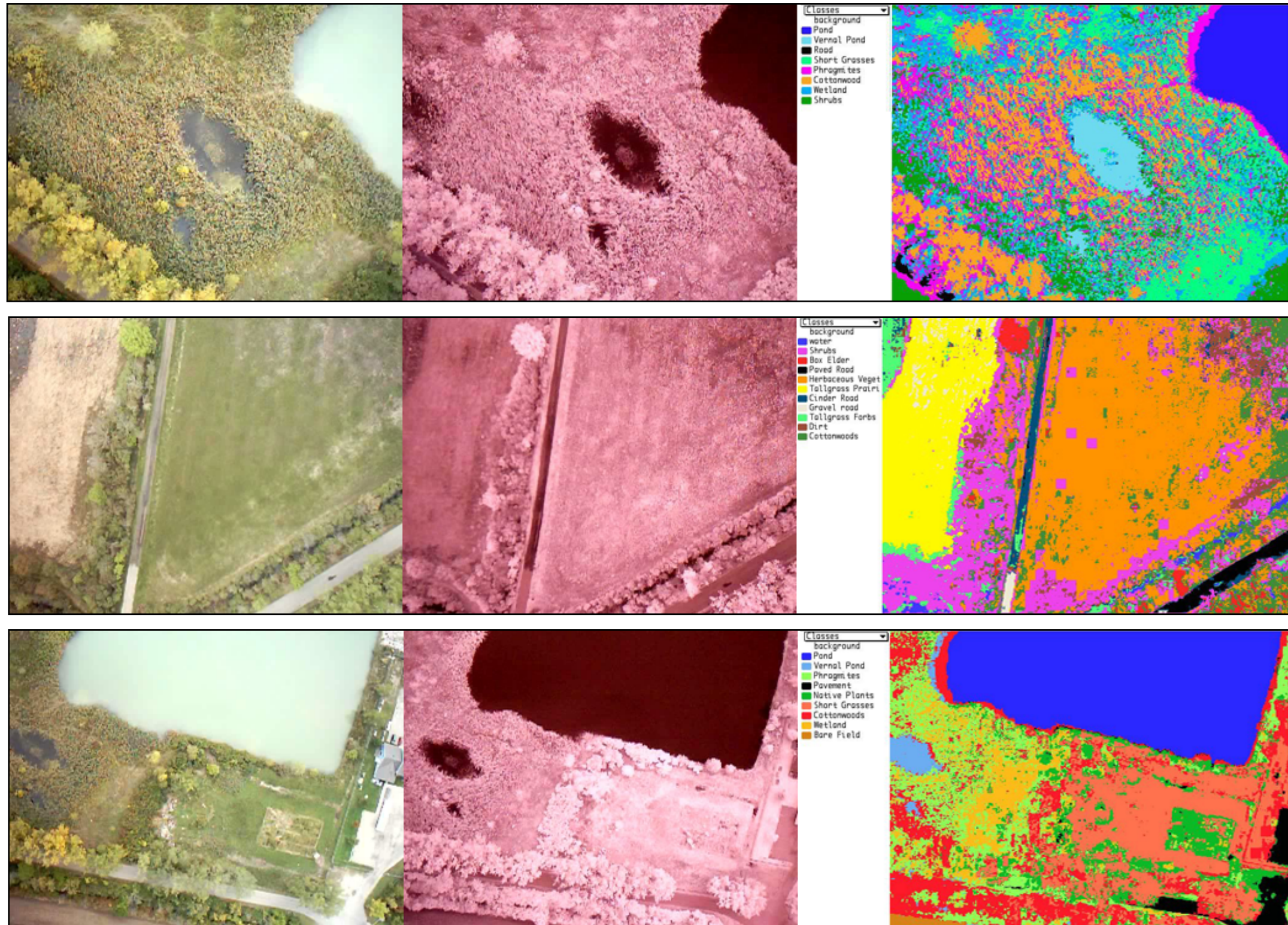


TwinCam - Visible Light Image

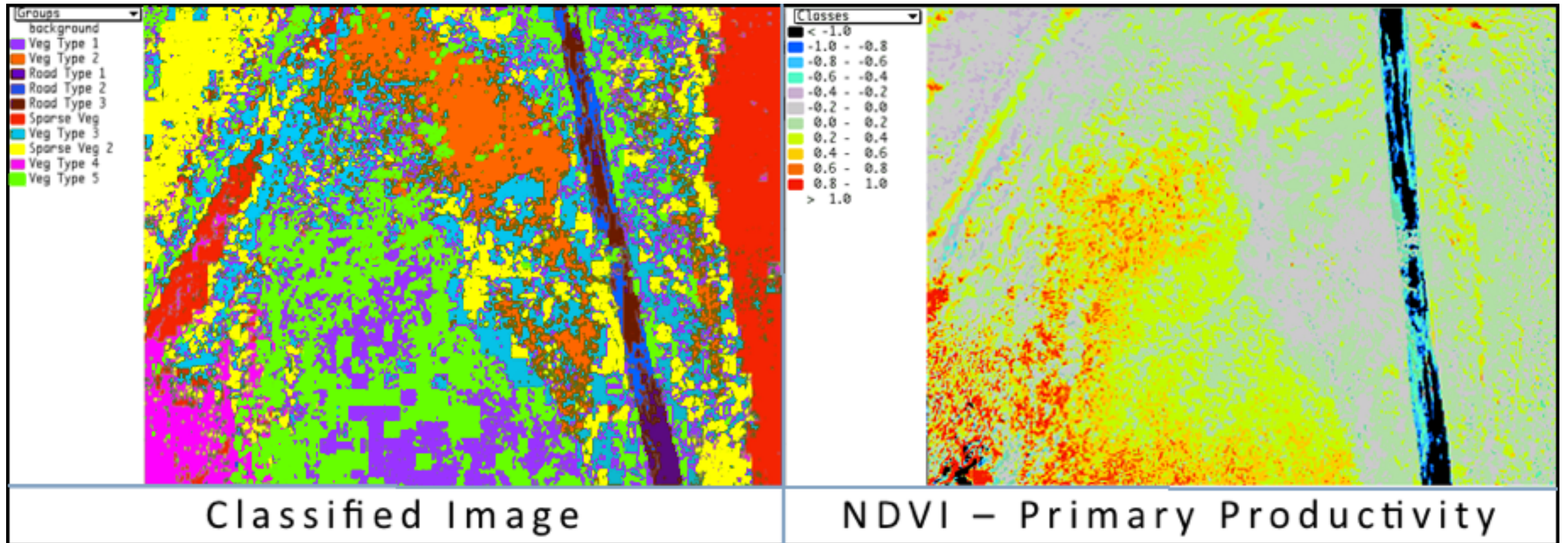


TwinCam - Near-Infrared Image

TwinCam Examples - Knabusch Center for Science and Mathematics



Use MultiSpec to produce classified image and vegetation indices



The numbers behind the imagery - quantifying the data



Classes
background
Grass(Lawn)Green
Roof
Grass(Lawn) Gree
Drain (Water)
Green Plot
Grass Lawn (Mixe
Tree (bare)
Tree Greening
Conifer
Mixed Shrubs
Bare Soil
Soil-veg_rows
Shaded Soil and
Shrubs bare
Tall grasses (mi
GrassLawn(Mixed)



TRAINING CLASS PERFORMANCE (Re-substitution Method)

OVERALL CLASS PERFORMANCE (10940 / 16080) = 68.0%
Kappa Statistic (X100) = 64.5%. Kappa Variance = 0.000016.

+ (100 - percent omission error); also called producer's accuracy.
* (100 - percent commission error); also called user's accuracy.

CLASS DISTRIBUTION FOR SELECTED AREA

	Class	Number Samples	Percent
1	Grass(Lawn)Green	5,300	1.8
2	Roof	3,479	1.2
3	Grass(Lawn) G Shdw	8,360	2.8
4	Drain (Water)	6,310	2.1
5	Green Plot	4,241	1.4
6	Grass Lawn (Mixed)	36,889	12.4
7	Tree (bare)	26,951	9.1
8	Tree Greening	19,617	6.6
9	Conifer	21,020	7.1
10	Mixed Shrubs	29,286	9.8
11	Bare Soil	14,946	5.0
12	Soil-veg_rows	16,959	5.7
13	ShdSoil and Grasses	23,493	7.9
14	Shrubs bare	27,718	9.3
15	Tall grasses (Mixed)	12,176	4.1
16	GrassLawn(Mix)Shd	40,903	13.7
	Total	297,648	100.0

Average likelihood probability is 46.7%.
Maximum likelihood classification

Project Class Name	Reference Class Number	Accuracy+ (%)	Number of Samples in Class Number Samples	1 GrsLn(G)	2 Roof	3 GrsLn(GS)	4 Water	5 GrnPlot	6 GrsLn(M)	7 Tree(B)	8 Tree(G)	9 Conifer	10 MixShrbs	11 BareSoil	12 Soil-VgRw	13 ShdSoil	14 Shrbs(B)	15 TallGrS	16 GrsLn(M)
Grass(Lawn)Green	1	96.3	652	628	0	0	0	0	23	0	0	0	0	0	1	0	0	0	0
Roof	2	98.7	159	0	157	0	0	0	0	0	1	0	0	0	1	0	0	0	0
Grass(Lawn) Green Shadow	3	100.0	422	0	0	422	0	0	0	0	0	0	0	0	0	0	0	0	0
Drain (Water)	4	98.6	276	0	0	0	272	0	0	0	0	0	0	0	0	4	0	0	0
Green Plot	5	98.3	233	0	0	0	0	229	3	0	1	0	0	0	0	0	0	0	0
Grass Lawn (Mixed)	6	81.9	3348	171	0	0	0	230	2742	0	127	0	0	0	13	0	0	0	65
Tree (bare)	7	64.3	1205	0	47	0	0	0	33	775	38	16	92	16	67	7	18	57	39
Tree Greening	8	26.8	1799	0	2	0	0	0	466	218	482	1	32	16	118	0	15	47	402
Conifer	9	93.0	812	0	4	0	0	0	0	8	0	755	20	0	0	4	0	0	21
Mixed Shrubs	10	46.3	1887	0	0	0	0	0	0	124	25	117	874	11	2	122	268	271	73
Bare Soil	11	81.8	782	0	0	0	0	0	5	66	8	0	0	640	6	0	57	0	0
Soil-veg_rows	12	21.4	327	0	1	0	0	2	28	53	29	1	21	12	70	1	74	21	14
Shaded Soil and Grasses	13	89.1	976	0	0	0	64	0	0	0	0	7	19	0	7	870	4	5	0
Shrubs bare	14	61.3	711	0	2	0	0	0	0	32	0	0	54	83	14	5	436	84	1
Tall grasses (mixed)	15	21.8	596	0	0	0	0	0	0	63	12	17	168	0	37	19	143	130	7
GrassLawn(Mixed)Shadow	16	76.9	1895	0	0	0	0	7	15	15	217	64	35	0	52	0	0	32	1458
TOTAL			16080	799	213	422	336	468	3315	1354	940	978	1315	778	388	1032	1015	647	2080
Reliability Accuracy (%)				78.6	73.7	100.0	81.0	48.9	82.7	57.2	51.3	77.2	66.5	82.3	18.0	84.3	43.0	20.1	70.1

DIRECT (IN-SITU) OBSERVATIONS FROM KITE-BORNE SENSORS

Air Column Profiler (Why is this in-situ?)

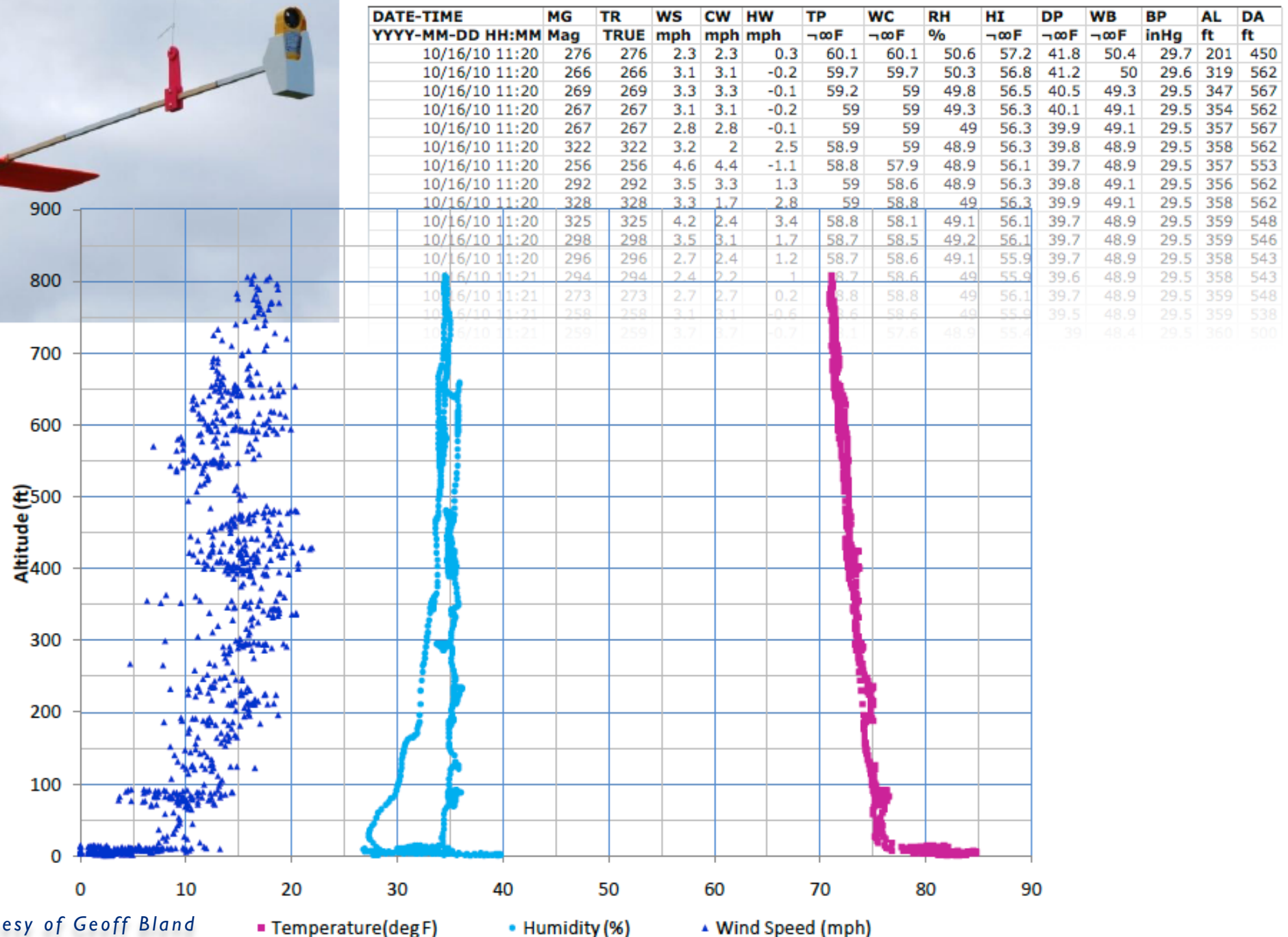
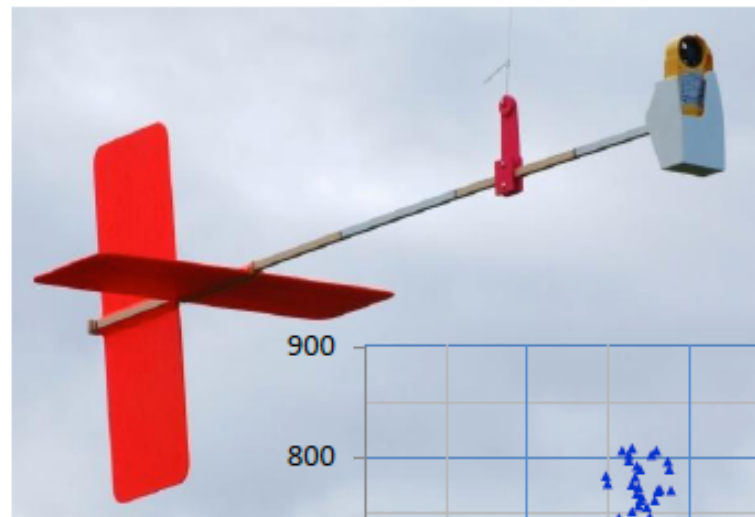


Image Courtesy of Geoff Bland

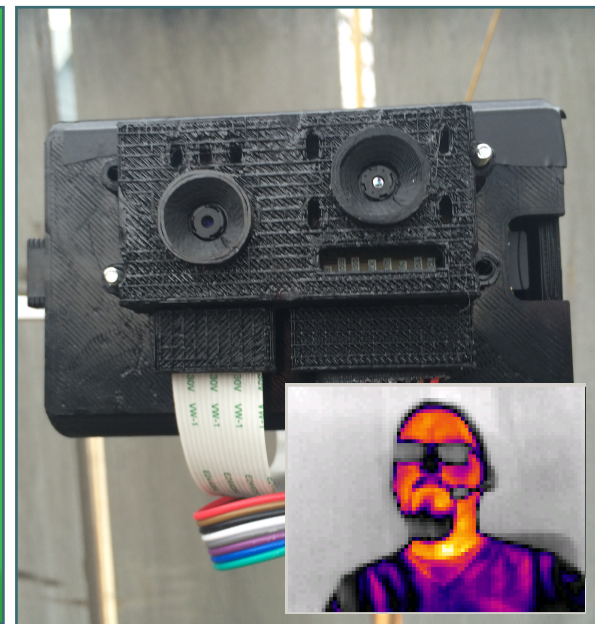
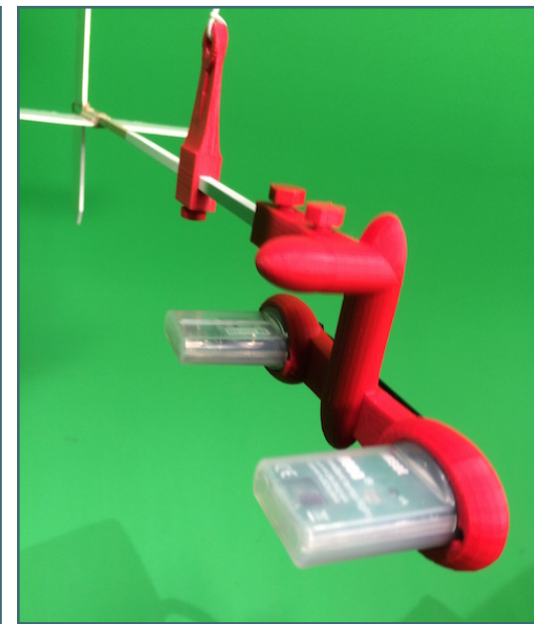
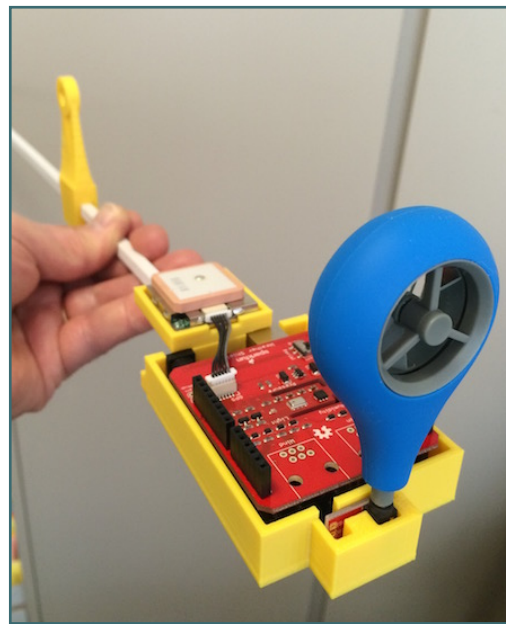
Engineering focus: Prototyping New Systems and Re-designing Existing Systems

Engineering is a **systematic and often iterative** approach to designing objects, processes, and systems to meet human needs and wants.



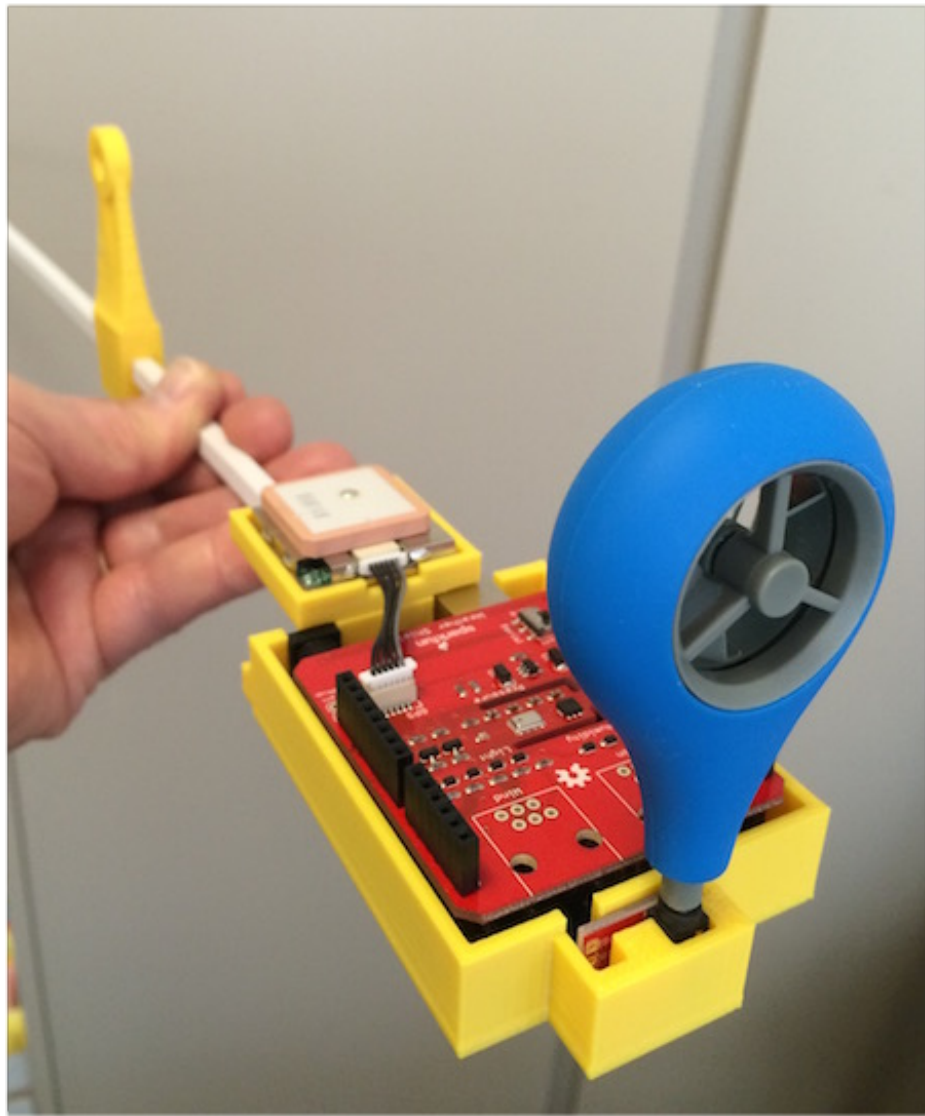
Engineering focus: New Aeropods

- MonoCam HD and TwinCam HD
- New Air-Column Profiler (w/ Kestrel)
- New Arduino based Air-Column Profiler
- HoboPod - Using Hobo Data Loggers
- ThermoPod-TC
- Aerosol Sampler



Engineering focus: New Aeropods

Air-Column Profiler Arduino



- Arduino Uno rev3
- Sparkfun weather shield
- GPS chip
- WeatherFlow Anemometer

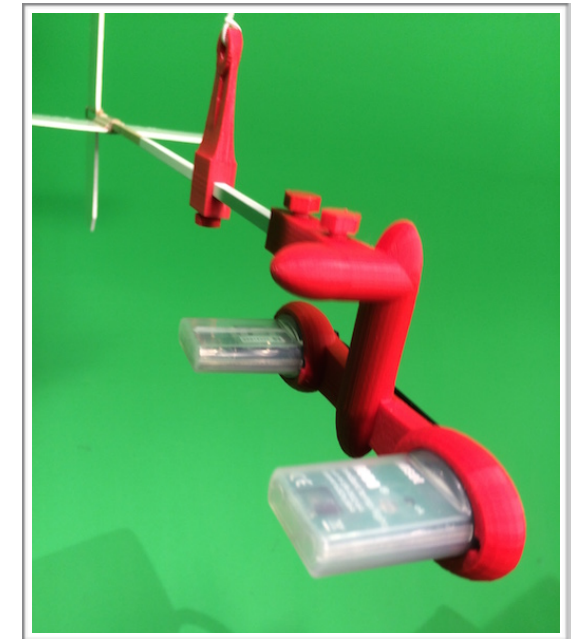
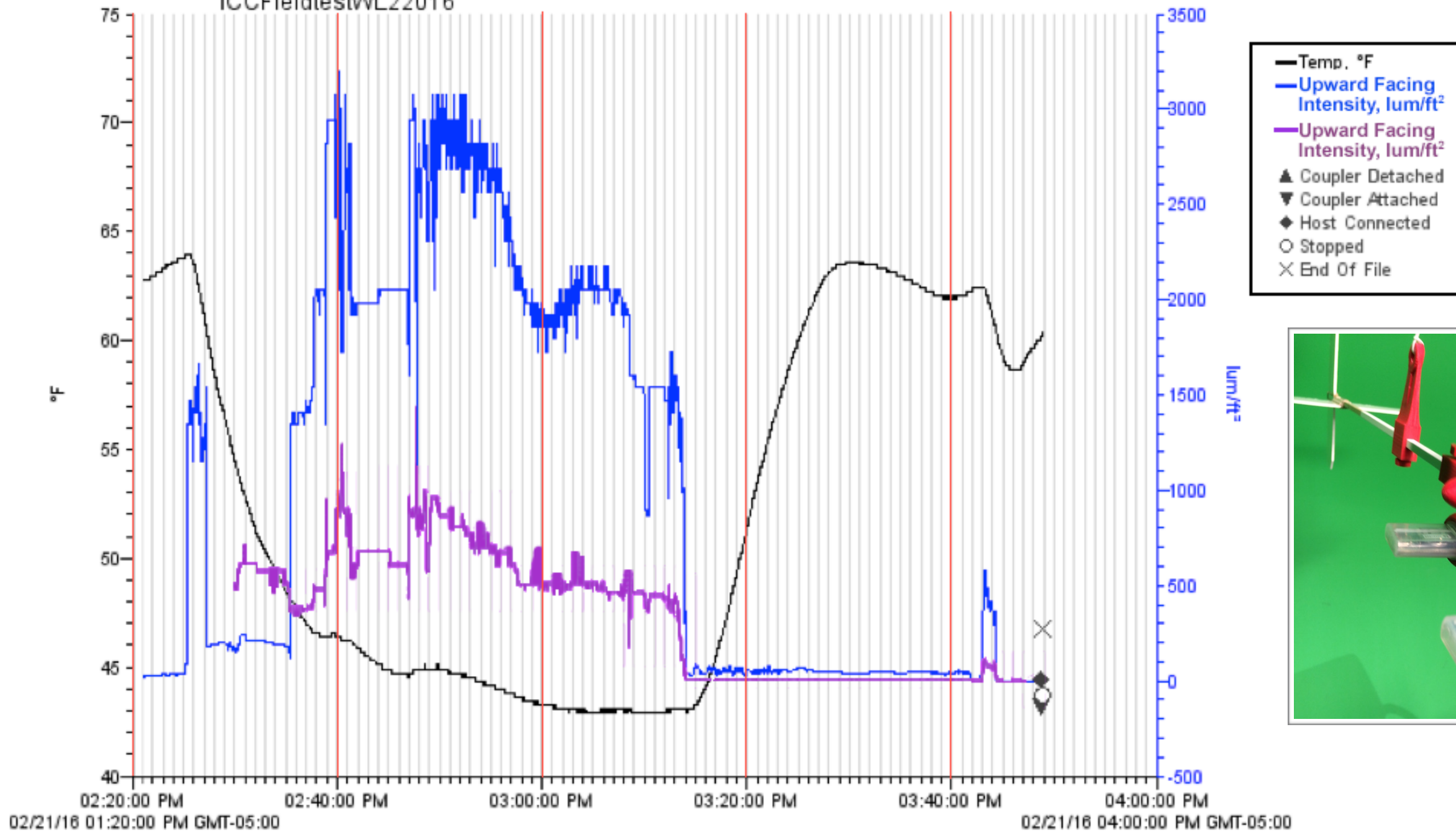
Records:

- Wind speed
- Temperature
- Humidity
- Barometric Pressure
- Light sensor
- Position (Longitude/Latitude)

Engineering focus: New Aeropods

HoboPod - Using Hobo Data Loggers

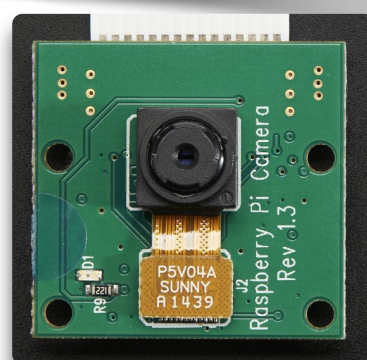
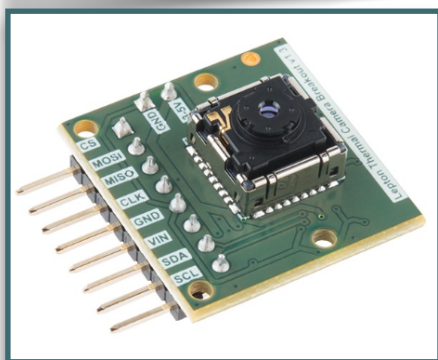
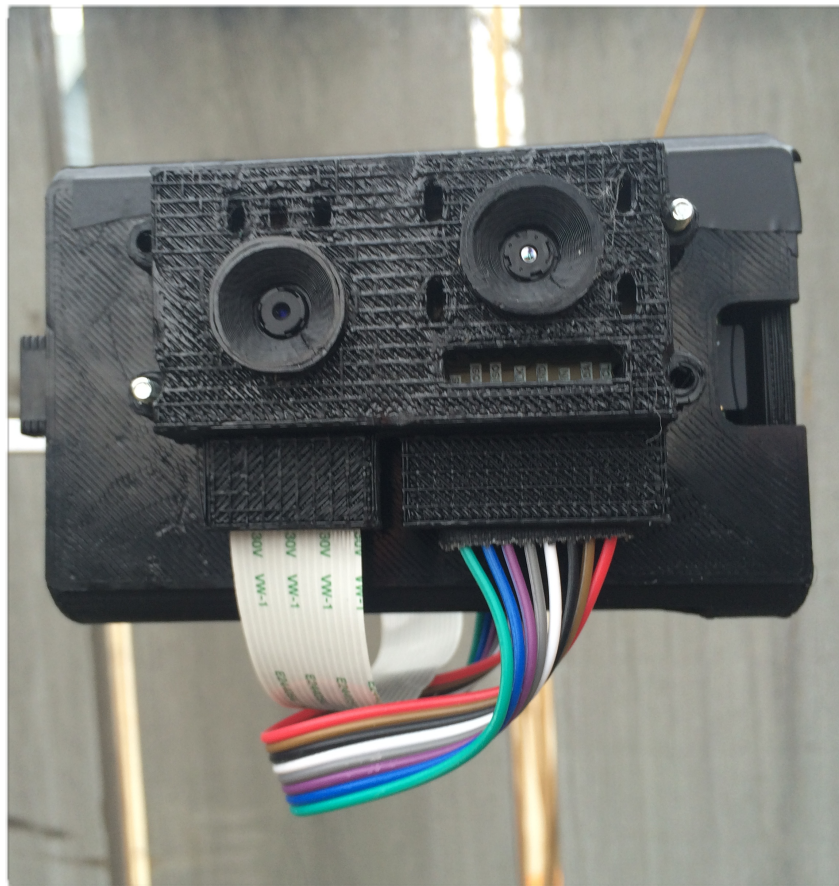
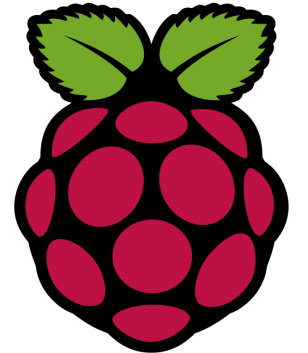
ICCFfieldtestWL22016



Engineering focus: New Aeropods

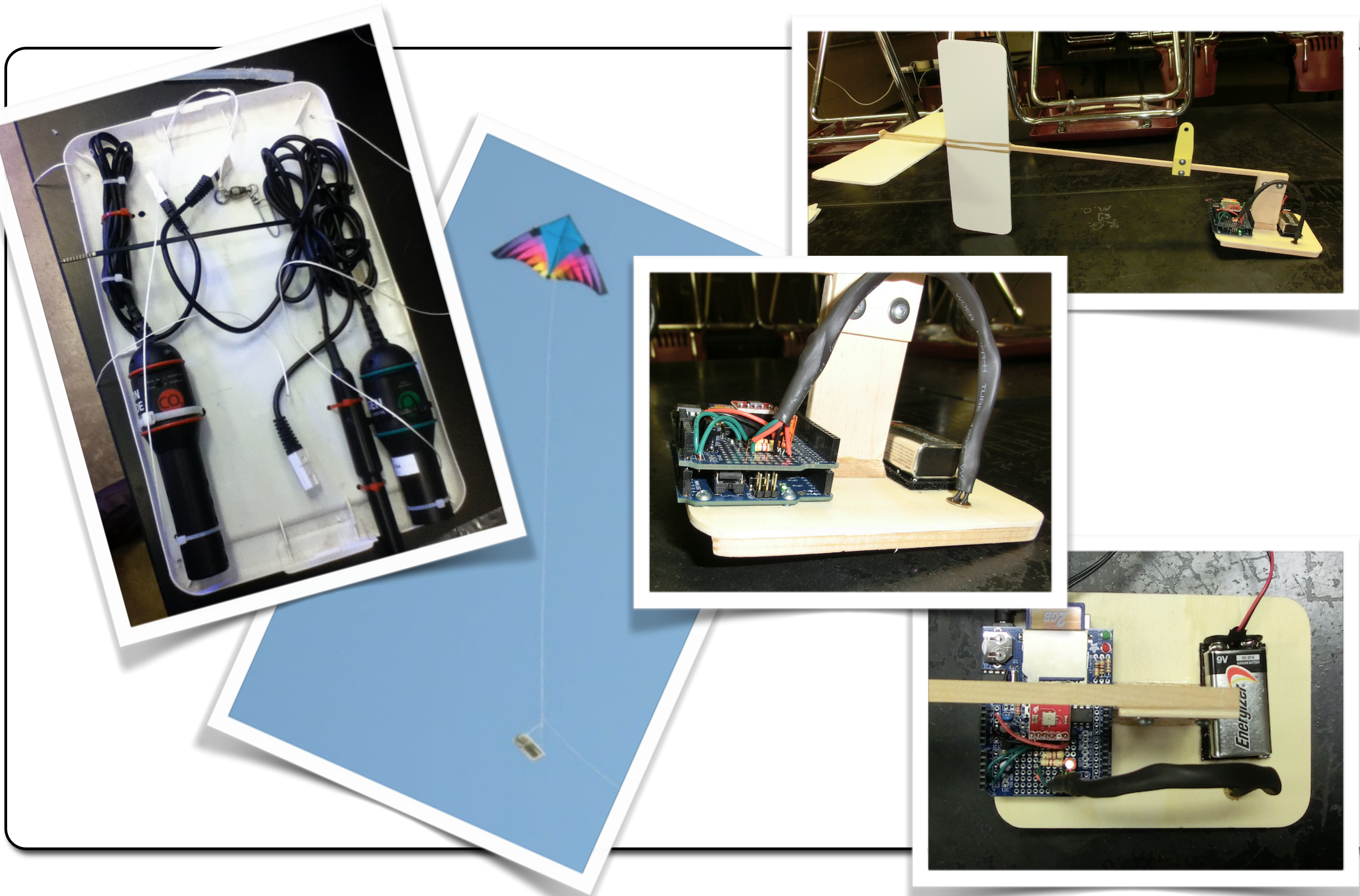
TwinCam ThermalPod

- Raspberry Pi based
- Includes Raspberry Pi Camera (5mp)
- Flir Lepton thermal imager
- and other stuff to make it work...



(Thermal-guy)

Engineering focus: Student Designed Systems



THE AREN PROJECT

AEROKATS AND ROVER EDUCATION NETWORK

GLOBE.GOV/WEB/AREN-PROJECT

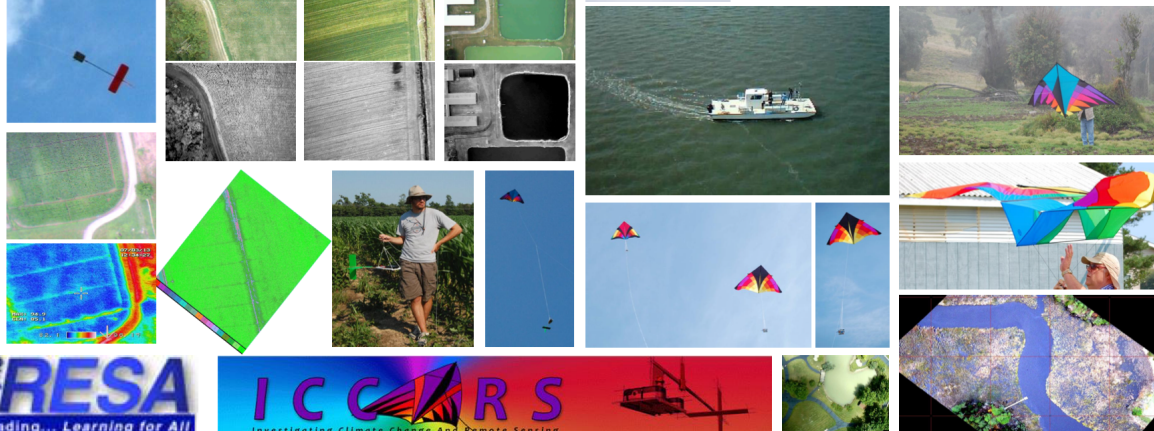
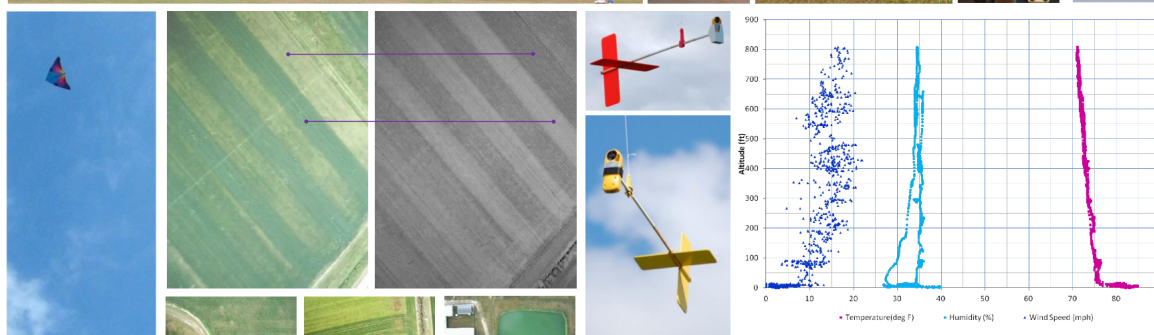


NASA's Global View from Space

NASA's Airborne Science Missions



We will begin the *AEROKATS* and *ROVER* Education Network (AREN) Project in 2016, with a combination of activities that will compliment and augment NASA's established *Global Learning and Observations to Benefit the Environment (GLOBE)* program



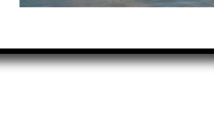
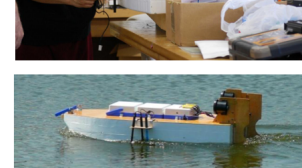
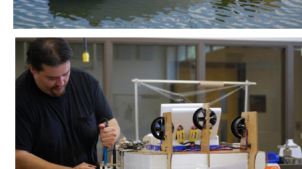
Applicable GLOBE Protocols

AEROKATS

Green Up - Green Down
Land Cover Classification
Fire Fuel Classification
Phenological Gardens
Barometric Pressure
Albedo
Air Temperature
Surface Temperature
Air Temperature
Relative Humidity
Clouds
Water Vapor
Soil Moisture - SMAP
Block Pattern
Soil Moisture -Gravimetric
Soil Moisture Sensors
Soil Temperature

ROVER

Conductivity
Dissolved Oxygen
Nitrates
Salinity
Water Temperature
Water Transparency
pH
GPS



Typical NASA Mission Model



AREN Model



ADDITIONAL RESOURCES:

Please visit:

<http://www.globe.gov/web/aren-project>

The AEROKATS program was developed by Geoff Bland at the NASA/GSFC Wallops Flight Facility. Aeropods and the Aeropod concept are the Intellectual Property of NASA and are considered competition sensitive. Aeropods or other aerodynamically stabilized tethered remote sensing systems based on the Aeropod concept may not be produced without the express consent of NASA through a formalized Space Act Agreement. Please contact Andy Henry at Wayne RESA henry@resa.net with questions.