AEROKATS and ROVER Education Network (AREN)

Annual Progress Report - Program Year 2016

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

Solicitation: NNH15ZDA004C

Award Number NNX16AB95A

The Annual Progress Report uses the following template to include 1) Administrative data, 2) Accomplishments, 3) Status, 4) Dissemination, 5) Evaluation/collaboration, and 6) Future Plans. Please remove the highlighted text before submitting a report. If you have questions or comments, contact Mary.F.Sladek@nasa.gov.

I. Administrative

- Name and address of the recipient's institution & Cooperative Agreement Number:
  Wayne RESA, 33500 Van Born Rd., Wayne, MI 48184
  NNX16AB95A
- Name of the Principal Investigator: David Bydlowski
- Cooperative Agreement Title: *AEROKATS and ROVER Education Network (AREN)*
- Type of Report: Annual
- Period covered by the report: January 2016 through December 2016

II. Accomplishments

Review of the Project -- Major Goals and Objectives

The AEROKATS and ROVER Education Network (AREN) introduces NASA technologies and practices in authentic, experiential learning environments. Low-cost instrumented systems for in-situ and remotely sensed Earth observations include kite-based "AEROKATS", and remotely controlled aquatic and land-based "ROVERS".

AREN technologies and lesson development are NGSS aligned and provide necessary science literacy skills. Data capture and visualization tools, designed to integrate with the GLOBE Program, enable the expansion of GLOBE study sites with transects and vertical profiles. Engineering Design concepts are embedded in student development of platform and instrument systems. Training, safety practices, and STEM challenges are a focus of the AREN Team, concurrently advancing student research projects investigating Earth science related phenomena.

The Goal of *AEROKATS and ROVER Education Network* (AREN) is to train the next generation of scientists, engineers, and other professionals to observe and understand our planet Earth through experiential learning using NASA technology and data in real-world settings.

Towards this goal, the five-year AREN objective is to develop approaches, learning plans, and specific tools that can be affordably implemented nationwide (globally). The project will enable the delivery of NASA remote sensing and in-situ observation concepts, technology, and data into formal and informal educational settings for all ages and socioeconomic backgrounds, thereby integrating science and engineering into the curriculum. The AREN objectives are consistent with those of the NASA Science Mission Directorate (SMD).

The four-fold Objectives of the NASA SMD Science Education (SE) Award are:

1) Enable STEM Education,

2) Improve U.S. Scientific Literacy,

3) Advance National Education Goals, and

4) Leverage Efforts Through Partnerships

Overview of 2016 Accomplishments

Hardware and Technology Development and Deployment

- Aeropod construction, testing and deployment
    - *MonoCams*: 12 delivered, 10 in short term production,
    - *Profilers*: 12 delivered, 10 available, 20 in short term production, Anasonde *Profiler* v2 design underway
    - *ThermoPod* - in design and development phase
    - Alternative funds (Maryland Education) captured for additional Aeropods
- ROVER construction, testing and deployment
    - *ROVER X3:* Deployed at CBEC and GSFC with participation of Co-I Smith
    - *ROVER X4 and X4XL:* Completed and Tested,
    - *ROVER X4:* Deployment at CBEC scheduled for 12/1/2016
    - *ROVER X4XL*: Deployment scheduled for 12/1/2016
- Instrument calibration procedures: In development
- Calibration Buoys - Buoy No.1 system build and initiation is underway (Spring 2017 deployment)
- Data Management: ArcGIS Online database in development for mission/observation data retention and visualization. GLOBE integration of data in discussion.

Team Training and Capacity Building

- Weekly Team Teleconferences
- First full Team Meeting at UMES (June 6-9, 2016)
- Ongoing Team Field Practice Sessions

Program Reach 2016

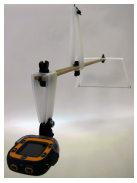
- CBEC - conducted preliminary sessions with
    - Wye River High School: (25) Students
    - Gunston High School: (10) Students
    - Girl Scout troop: (7) students
- UMES - Undergraduate Participation
    - AEROKATS Training (4 including 1 Morgan State exchange student)
    - ROVER Training and Operations (1 - College Park exchange student)
- USF - *Bulls-EYE Environment* Summer session completed with:
    - Student Mentors (10) and
    - Middle School Students (30)

Weather Stations Online Network
Three stations reporting to Wunderground
Example:
https://www.wunderground.com/cgi-bin/findweather/getForecast?query=pws:KMDGRASO7

AEROKATS users identified with license request submitted:
Team Titanium Wrecks Robotics, Worcester County MD
University of Mary Washington/Ron Mitsugo Zacharski
Associate Professor, Department of Computer Science

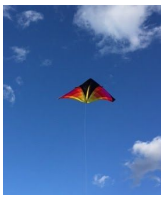
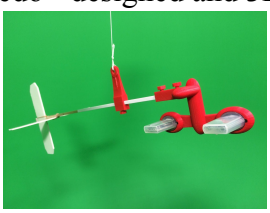
Course development has been completed - UMES Spring Airborne Science course:
Department of Engineering and Aviation Sciences
Spring Semester 2017
Course Title: AVSC 310 Aerial Operations in Remote Sensing
Section 0101, 3 credits
Course Description: This course covers the concepts and procedures needed to operate unmanned Remote Sensing (RS) platforms in support of various scientific endeavors. The processing and analysis of data using Geographic Information Systems (GIS) and other relevant software tools will also be covered. Prerequisite: AVSC 390 or MATH 210 or Permission of Instructor.

Alternative Aeropods have been built and tested.




Co-I Henry has created an Aeropod with nadir and zenith viewing light measuring data loggers to capture albedo. This system is being tested by End User Betsy Stefany (The SABENS Group, NH).

Betsy Stefany
Custom "FlyPod" for albedo - designed and 3D printed by Co-I Henry

Co-I Lippincott developed an alternative building method for Aeropods to reduce materials and fabrication costs.

Preliminary kite flying with Aeropods with pilot groups:
Dan Borick/Portsmouth VA Public Schools
Betsy Stefany, STEM Project Manager and Researcher
Chief Dull Knife College (Doug Brugger)

Contributions from Co-Investigator Institutions

The following pages provide a summary of the contributions of the Co-Investigator team members and their Institutions:

- Anasphere, Inc. -- John Bognar
- Chesapeake Bay Environmental Center – Eileen Friedman, Hannah Spongberg, Alissa Quinton, Vicki Paulas, Judy Wink
- Montana State University – Suzi Taylor, Kim Obbink, Kelly Boyce
- NASA/GSFC– Geoff Bland, Sallie Smith, Patrick Coronado
- Public Lab – Mathew Lippincott, Becki Chall, Shannon Dosemagen
- University of Maryland Eastern Shore – Abhijit Nagchaudhuri, Chris Hartman, Willie Brown
- University of South Florida – Jonathan Gaines
- Washington College – Doug Levin, Jemima Clark
- Wayne RESA – David Bydlowski, Andy Henry

AREN Management Team

A management team was organized, composed of Geoff Bland, David Bydlowski and Andy Henry. The team's primary purpose is to make decisions that guide the project's operations. The management team meets weekly and coordinates weekly teleconferences with the co-investigators and their team members. Members of the management team participated in:

- Monthly Phone conferences with NASA Headquarters
- Attendance at annual meeting
- Coordination of Cross-Collaboration with other NASA CAN Awardees
- Writing of annual report and other required documentation
- Coordination of the full AREN team meeting at UMES
- Development of an AREN Project timeline
- Other issues impacting the AREN Project

Wayne RESA

PI David Bydlowski and Co-I Andy Henry attended the AREN program orientation meeting in June and have coordinated the AREN Project grant at Wayne RESA. One of their major tasks to is to be the liaison between finance and the educational services departments at Wayne RESA. Wayne RESA has taken a leadership role in project leadership, GLOBE coordination, AEROKATS development and production, NGSS alignment, and presenting AREN to the community.

Wayne RESA, the Wayne County Mathematics and Science Center at Wayne RESA has been a GLOBE partner for over 15 years and David Bydlowski has been a GLOBE trainer, since then,. This year, six GLOBE training sessions, both face to face and online were conducted adding 53 new educators to the GLOBE Program. Many of the GLOBE educators entered data into the GLOBE database. Many of the NASA CAN Awards are aligned to the GLOBE program. This has led to multiple meetings with Tony Murphy of GLOBE, who has assigned the AREN project a GLOBE liaison, Travis Anderson. Talks have taken place regarding the development of new GLOBE protocols, from AREN. The AREN project has also been a vehicle to inform educators about the 2017 GLOBE International Science Fair and the 2017 GLOBE Science Student Symposium.

Andy Henry of Wayne RESA has been involved in AREOKATS development and production. In particular, he has worked on monocam, profiler, and twincam development and production. He has also been actively involved in the coordination of a safety plan and safety management system. He has also worked on the AEROKAT dissemination process to reach end users.

Wayne RESA has taken the lead on aligning the AREN Project with the Next Generation of Science Standards (NGSS). It has aligned AREN to the atmosphere and hydrosphere performance expectations. It has also been exploring the need to make sure that AREN incorporates science education "best practices." A document, "NGSS Designed Lessons and Units, That Can Then Be Assessed by Using the EQuIP Rubric," has also been developed.

Wayne RESA has been very active in sharing the AREN Project at various venues in the form of a professional presentation. Presentations have taken place at the National Science Teachers Association, Michigan Science Teachers Association, Metropolitan Detroit Science Teachers Association and at national GLOBE meetings.

Goddard Space Flight Center (Wallops Flight Facility)

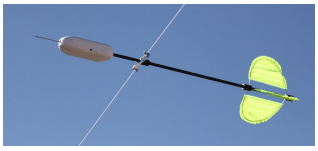
Co-I Geoff Bland, who attended the AREN program orientation meeting in June, and technician Ted Miles, created, tested, and fabricated several Aeropod systems, including a relatively standardized *MonoCam* (low cost training camera), a modernized *Profiler* (for atmospheric measurements), and a high performance *ProCam* (high resolution camera). Approximately 20 *MonoCams* and 15 *Profilers* are now in service with the AREN Team and pilot programs/partners. Co-I Bland participated in frequent discussions covering training aspects and use by learners of all ages to support the pilot programs.

The GSFC /WFF team also completed trials of the ROVER "*X4XL*", a lightweight variant of the "*X3*" which is currently in service at CBEC and will be used at Camp Schmidt in 2017 by Co-I Smith. The *X4XL* will be modified by Co-I Levin for a variety of new sensors and missions. Preliminary development of the follow-on ROVER "*X5"* system is underway.

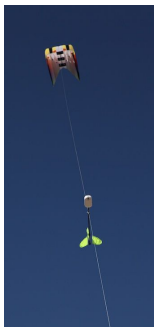


Co-I Bland lead AREN Team training activities at UMES and CBEC as well. Also, a 3D printer is up and running for fabrication of Aeropod kits. Additionally, Collaborator Brian Campbell (610W) provided valuable input regarding GLOBE and contributed significantly to the project.

Anasphere



Co-I John Bognar of Anasphere has focused on the design of a new logging *Profiler* for the AREN project. This work will culminate in a lower-cost *Profiler* as compared to the current *Kestrel*-based design, which will enable the project to distribute these atmospheric instruments to more schools and other users. Variants of Anasphere's new Profiler will cost between $153 and $296 per unit, with key features including analog sensor suites to enable students to probe sensor responses on their own and the option for voice telemetry so that students can receive and write down data for manual graphing activities during the flight.



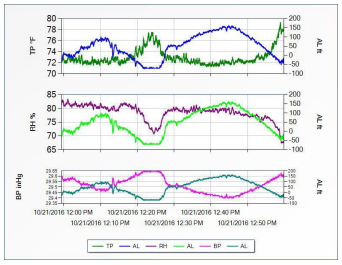
Other activities Anasphere has been engaged in include gathering preliminary information for the development of a relative humidity calibration procedure and developing a course description and content for a Montana State University course related to the use of AREN Profilers.

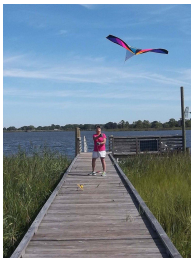
Chesapeake Bay Environmental Center (CBEC)

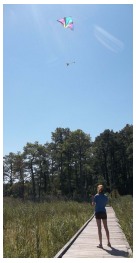
Co-I Judy Wink, attended the AREN program orientation meeting in June, has coordinated the AREN CBEC Team. The AREN team at the Chesapeake Bay Environmental Center, Grasonville, MD consists of four instructors: Judy Wink, Eileen Friedman, Hanna Spongberg and Alissa Quinton. The team has been working since August 2016 on developing curriculum and mastering use of equipment/technology with the intent of affording the opportunity to utilize the technology by students in an informal field setting.
The curriculum focuses on two main topics:
1) water quality and its relationship to pond biota (R. catesbeiana), and
2) mapping succession of invasives in a marsh habitat.

The educational components regarding these topics include:

- Use of the ROVER X-3 in collecting water quality data and underwater photography. Emphasize the technological process for data collection.
- Use of sensors in water testing.
- Use of test tabs in water testing. (3 methods for comparative data)
- Surveying tadpole development in 3 ponds and correlating with water quality.
- Use of AEROKATS for photographing/mapping invasives in a marsh.
- Use of AEROKATS for collecting atmospheric data (Profiler).







Notional field sessions with students will be concurrent with rotation to another station every 40 minutes. The learning multiplier effect will be cumulative from station to station.

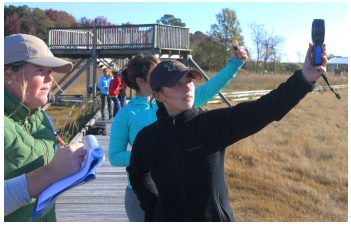
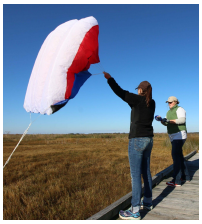
After the work with water quality monitoring is complete, the students will shift their experience to the Aerokats. The same procedure of 40 minute sessions and rotation will be employed. In this experience they will:

- Learn the techniques in flying the Aerokats
- Learn the technology used with camera, Kestrel; and attach payloads.
- Fly Aerokats, collect data, download and interpret the data.
- Discuss the problem of invasive vegetation vs. native vegetation; possible solutions.

Preliminary lesson plans, equipment and supplemental materials were available for the pilot class from Wye River Upper School which visited CBEC October 19th for a trial run of the activities. The classes met for 40 minutes at each of four stations where the the plans were to experience:

- A mission with the ROVER X-3
- Data collection with Vernier Sensors
- Data collection with Manual water testing
- Investigation of Tadpole Development in comparison to water data analysis at 3 ponds.

Two more groups, from Gunston High School and the Girl Scouts participated in similar activities November 4. Valuable feedback has been shared with the AREN Team.


Goddard Space Flight Center (Greenbelt)

Co-I's Sallie Smith, attended the AREN program orientation meeting in June, and Patrick Coronado have been actively working on various resources and instructional models.

To date, the GSFC (Greenbelt) AREN Team has:

· Assisted AREN Network partner institution leaders' team meeting presenting NASA resources for infusion into local AREN network trainings and course development.
· Became GLOBE certified for "Atmosphere, Temperature and Clouds" protocols.
· Developed protocols for AREN participants to access Direct Readout Laboratory NASA Earth Observing Satellite Resources.
· Assisted with AREN Program Mission Science Development at the Chesapeake Bay Environmental Center and Camp Schmidt Environmental Center.
· Provided AREN ROVER Platform Training to CBEC AREN staff.
· Field Tested AEROKAT and ROVER Remote Sensing Platforms and payloads, providing feedback and best practices recommendations.
· Assisted with AEROKAT and ROVER Science Mission Development.
· Assisted AREN CBEC AEROKAT Training Day.
· Participated in weekly AREN Team Conference Calls.
· Participated in UMES Alpine Mono-pod Camera Field Testing, analyzed imagery and provided feedback.
· Assisted with identification of AREN safety and best practice Field Procedures.
· Created an AREN Participant photo release form.

Montana State University - National Teacher Enhancement Network

Co-I Suzi Taylor, attended the AREN program orientation meeting in June, has actively learned about the kites and instruments, and has contributed ideas about organizing and using the equipment.

Also, she has shared the AREN project with several different groups.
-Montana Technology Student Association
-Montana Girls STEM Collaborative
-Montana Afterschool Alliance
-Science Horizons
-Montana Apprenticeship Program (American Indian Research Opportunities (AIRO) at MSU)
-Montana Education Association
-Chief Dull Knife College
-Montana 21st Century Learning Centers
-Montana Environmental Education Association

She has also initiated talks with a local GLOBE teacher, Lynne Powers.

Her team is working on developing a graduate-level online course via the National Teachers Enhancement Network (NTEN). NTEN is a worldwide network of online courses for science teachers based at Montana State University. The network has reached 20,000 teachers in its 23-year history and features instructors from Montana State University, NASA, USGS and many other institutions.

The Public Laboratory for Open Technology and Science

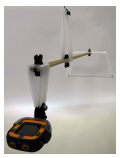
Co-I Becki Chall and PublicLab staff member Mathew Lippincott, attended the AREN program orientation meeting in June, prepared for and attended the project kickoff meeting in Maryland June 6-9 where they engaged with the team in person and introduced the group to Public Lab's work and methods. Mathew has begun documenting and sharing various approaches to aerial data collection that could be appropriate for students, teachers, and informal participants, and the Public Lab team is working to better understand GLOBE and potential interconnections. Additionally, Becki Chall has coordinated with Wayne RESA to set up all logistical and administrative needs as outlined in the agreement.

Public Lab's contributions over the first year of AREN have focused on collecting and documenting kit needs, planning kit releases and production schedules, and resources for using kites in classroom-oriented design and engineering challenges. Kites are more than just an inexpensive way to lift sensor payloads into the air, they are also aerodynamic systems naturally suited to hands-on physics education. Over the first year of the AREN project, Public Lab has collected three types of resources to support the use of kites in the classroom: resources for analyzing kites as aerodynamic systems, materials for planning kite flights and safely flying kites, and kite and payload design and construction resources appropriate for classroom assembly.

Kite Aerodynamics Resources have been identified, including https://publiclab.org/wiki/kite-anemometers.
They will release a replica of the TALA, a commercial kite anemometer now in the public domain, in the first quarter of 2017. Currently Public Lab users Chris Fastie and Ecta64 are using the design, and they hope to engage a total of 5 volunteer developers with the system, as well as 20 other users.

Public Lab has made important progress toward the goals outlined in the Year 1 Description of Work.
September 2016:

- Strategic planning around AREN's kit needs and Lending Library
- Testing of AEROKATS tools and field learning
- Development of new reduced cost Aeropods
- Sharing of Public Lab aerial photography kits and design patterns relevant to future profiler designs with AREN partners.
- Documenting kite anemometry and lessons around kite aerodynamics, as well as replicating kite anemometers for testing by AREN partners and Public Lab volunteers.
- Initiating talks about local Public Lab groups with Chesapeake Bay AREN partners.



University of Maryland Eastern Shore

Co-I's Chris Hartman and Abhijit Nagchaudhuri, and faculty members Willie Brown and Xavier Henry, of The University of Maryland Eastern Shore, Department of Engineering and Aviation Science, attended the AREN program orientation meeting in June, have committed to providing aviation and engineering concepts as an integral part of all activities related to the AREN Project. Their team at the University of Maryland Eastern Shore has taken the initiative in creating a safety management system (SMS) for monitoring activities in order to ensure best safety practices are incorporated within the AREN Project. The department has identified the following core values that will support the AREN's initiative through engineering and aviation practices based on continual commitment to safety, performance evaluation systems, AREN's expectations, conditions of the operating areas, and an open communication system. The Department of Engineering and Aviation Sciences next steps will be to develop a SMS tool that is meaningful to AREN's activities using concepts to train, build and maintain a safety culture for specific environmental practices. AREN Project has identified in the matrix below main features in a SMS tool to ensure safe assurance with regard to a gap analysis comparison that involves the following: FAA's SMS (only for 121 Operators); Annex 19 – ICAO (SMS); ISO 9001; and NASA Safety and Hazard Reporting.

Main Features in a SMS tool	**AREN's SMS**	**FAA's SMS (Only for 121 Operators)**	**Annex 19 - ICAO SMS**	**ISO 9001**	**NASA Safety and Hazard Reporting**
Hazard Reporting	√	√	√	√	√
Risk Management	√	√	√	√	√
Corrective Action Tracking	√	√	√	√	√
In-depth Investigations	√	√ (NTSB)	√		√
Policies & Procedures	√	√	√	√	√
Hazard Analysis	√	√	√	√	√
Communication Board	√	√	√		√
Public issue reporting	√	√	√		√
Independent SMS Audit	?	Pending in some cases	Pending in some cases		√

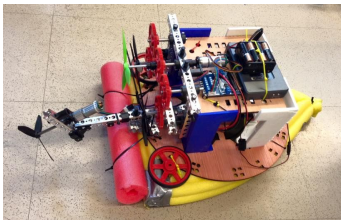
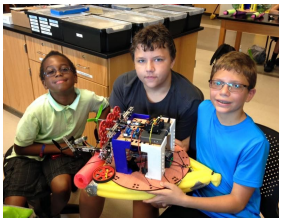
The development of these features identified will allow the AREN initiative to promote preventive measures that will be comprised of a systematic approach to manage safety risk and assure the effectiveness necessary to the project (e.g., procedures, practices, and policies for safety risk control). According to the industry's experts, the pros and cons of a SMS tool is presented below and has been considered in the decision making process within the AREN Project. From the consideration and the discussions lead by the University of Maryland Eastern Shore, the AREN team agreed to move forward with the SMS tool based on the items listed.

Pros	**Cons**
Help to Quantify the Risk	It's Difficult
Builds Barriers to Entry – Gap analysis	Involves a different thought process and mindset
Performance Indicators	Could change the way in practice
Longer Term Payoff	Additional task
Align project strategy with safety strategy	Identifying the appropriate system
Foster Innovation through concerns	Mistakes will be made
Operate Above compliance	Disagreements in the practices
Identify Safety Policies	
Risk Assessment Tool	
Manage Operation	
Promote Safety Activities	
Hazard Reporting	
Training & Qualification Management	
Preventive Tool and Program	

The main purpose of the SMS tool is to report and will act as a risk control for accident and incident prevention. The SMS tool will not serve as an attribution of blame, but will cultivate and foster a procreant safety culture featured in the AREN Project. This tool is a non-punitive reporting system and the policies will encourage members to bring safety concerns to the attention of the AREN team. The safety concern of all participants will be the University of Maryland Eastern Shore's strategic issue in the AREN Project.

The Department of Engineering and Aviation Sciences at the University of Maryland Eastern Shore has approved the course (*AVSC 310 – Aerial Operations in Remote Sensing*) to address AREN's related requirements and the course objectives will be aligned with the training of future students in the field of practice. The AVSC 310 – Aerial Operations in Remote Sensing course covers the operation of aerial platforms as it relates to remote sensing in support of various scientific endeavors. The discussion will address the operation of AREN tools and the collection of data using aerial platforms. The Aerial Operations in Remote Sensing course will focus on data analysis using Geographic Information Systems (GIS) and other relevant software tools. Students will engage in a research project, data collection and analyzing data in accordance with AREN's objectives. Furthermore, the instructors that were assigned to teach the course; currently, these instructors are involved with the AREN Project and team. The AVSC 310 – Aerial Operations in Remote Sensing course will be held in Spring 2017 and the meeting days are on Tuesdays and Thursdays from 2:00 pm to 3:15 pm.

University of South Florida

Co-I Jonathan Gaines, attended the AREN program orientation meeting in June, lead the summer Bulls-EYE Environment program incorporating a novel mentoring arrangement. Undergraduate students were engaged to mentor middle school students during an immersive 2 week program exploring robotic platforms for environmental observations.

GLOBE was an integral part of the design projects for Bulls-EYE Environment's Earth Science focus because students used GPS and temperature GLOBE protocols. Groups learned about robotic hardware and designed teleoperated robots for a search and rescue mission. They learned about UART for serial communication and NMEA protocol for GPS measurements and outfitted their robots with a data acquisition system based around National Instruments myRIO hardware and Vernier temperature sensors. Students had to remember to do a communications, hardware, and safety check before taking their robot out into the field.

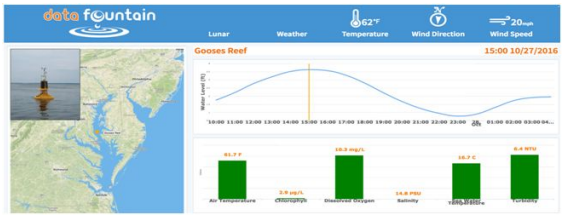
Two primary rapid prototyping tools were used for ROVER platforms as shown above - 3D printers and a laser cutter. The ROVER projects allows teams to design two sub-systems: the propulsion where they had to increase the rotational speed of propellers using gear trains and the floatation where they had to use recyclables and learn about buoyancy. Both sub-system design activities can be a basis for a future GLOBE protocol. Each ROVER was equipped with GPS and temperature sensors. Design teams ran out of time before they could collect data using the GPS and temperature GLOBE protocols. Some simple changes to the project were determined to streamline the development of ROVERs, allowing for more time for data acquisition in the future.

Washington College

Co-I Doug Levin attended the AREN program orientation meeting in June. At that time he met the program participants and learned what each partner was to contribute to the program. Kite flying demonstrations with Aeropods was a major component of the meeting.

The development of TerraROVERs for land-based observations has been initialized.
Land based mapping is being added to the ARENs tool kit portfolio using remote sensing and mapping devices. An inexpensive, off the shelf mapping system is being developed at Washington College's CES.
Using NGSS Phenomenon system of discovery, students will be challenged to create a hypothetical temperature distribution map for a portion of their school yard.

The materials to build a buoy that monitors water temperature, salinity, turbidity, dissolved oxygen and pH have been purchased. The system will be built and readied for launch in the Spring of 2017. The buoy assembly is being managed by Kenny Evans, Technician, CES, Washington College. The buoys are designed as endpoints, deployed in the Chester River, between which, the ROVER, will transit and collect water quality measurements. These ROVER measurements will be calibrated against the professional grade systems being deployed at the buoys, which will be "end points" of the transect.



As a precursor to GLOBE protocol development a unique data ingestion and analysis tool is under development.

The buoy data will be posted on the Data Fountain (http://data-fountain.rpsasa.com/). Showing water quality changes every 20 minutes. Constituents of the ARENS program will be able to have their ROVERS Calibrated against the Buoy system. Washington College will use their ROVER system to provide training to partners using the ROVERs and also to our own students and educators in how to use this tool to measure and evaluate water quality data.
g field (complete with ditches, fields, and patchy habitat of grasses, dirt, and other). Terry (All Terrain Robot) will be deployed by the students to test their hypothetical map. In this way, the students will learn the variance in temperature regimes at different habitat and develop the ability to discern accurate data that they will be adding to the GLOBE data portal.

Using funds from the Math Science Partnership program of the Maryland State Department of Education (independent of the NASA AREN Project) – 20 kite systems are being assembled that will support the AREN Lending Library. These systems will represent a shared resource that can be shipped nationwide for AREN partner use in Kites in Technology Education (KITE) programs.

- 10 - 7’ kites for young (down to elementary) flying demonstrations.
- 10 - 10’ kites for advanced flying and data acquisition.
- 20 - VTech recording aerial video
- 10 - Kestrel 5500 bluetooth atmospheric profilers
- 10 - Strike Alerts (Lightning Alerts)
- 4 - Scanse LIDAR systems
- 4 - FLIR Thermal Imagers/longwave infrared imagery
- Shipping systems for national sharing of the shared resources.

III. Status/Changes/ Issues

During 2016, there was a shift in funding levels between Wayne RESA and GSFC. Incompatibilities became apparent in the contractual language required by three university partners and Wayne RESA with regard to compliance with their respective state laws. This resulted in those institutions applying for individual Cooperative Agreements with NASA SMD. To cover the cost of this, the necessary funding for the contracts and costs for managing these contracts was de-obligated from Wayne RESA and obligated to GSFC. This amounted to a funding transfer of approximately $600,000 over the course of the program. The three Co-I institutions, Montana State University (MSU), the University of Maryland Eastern Shore (UMES), and the University of South Florida (USF) are now funded through cooperative agreements with NASA GSFC (Co-I Bland is the Technical Monitor).

IV. Dissemination Activities

AREN team members have been active in disseminating the AREN Project throughout the community since March, 2016. The following dissemination activities have taken place:

David Bydlowski and Andy Henry -- Michigan Science Teachers Association Conference (MSTA) -- Workshop Sessions: "Atmospheric and Earth Observations with Kite-Borne Sensors"; and "NASA's Soil Moisture Measurement Mission," Lansing, MI, March 4, 2016.

David Bydlowski -- GLOBE North American Partners Meeting -- Presentation on the AREN Project, Nashville, TN, March 30, 2016

David Bydlowski and Andy Henry -- National Science Teachers Association Conference (NST) -- Workshop Sessions: "Acquiring and Sharing Airborne and Ground-Based Earth Observations and Data Using NASA AEROKATS" and "Students and Teachers Investigating Climate Change and Remote Sensing," Nashville, TN, March 31 and April 2, 2016.

David Bydlowski -- GLOBE Midwest Student Science Fair -- Presentation to student participants on using kites with GLOBE, Toledo, OH, May 14, 2016.

David Bydlowski -- GLOBE Annual Meeting -- Video Presentation on the AREN Project, Boulder, CO, July 20, 2016

David Bydlowski -- Metropolitan Detroit Science Teachers Association Conference -- Workshop Sessions: "AREN: Doing Team-Based Field Investigations with a GLOBE Earth Science Partner" and "GLOBE in the Middle School Classroom," Warren, MI, November 5, 2016.

Geoff Bland -- AGU - Poster for Education Session: "String Theory - Using Kites for Introducing Remote Sensing and In-Situ Measurement Concepts", San Francisco CA, December 15, 2016

Mathew Lippincott -- AGU - Poster: "Acquiring Data by Mining the Past: Pairing Communities with Environmental Monitoring Methods through Open Online Collaborative Replication", San Francisco CA, December 16, 2016

V. Evaluation, Collaborators and Cross-Collaboration Agreements Activities

The evaluator for the AREN Project is:
Anil Aranaha, PhD
anfaranha@yahoo.com
406-388-4177

The evaluation section is composed of two parts. First the evaluation from the team meeting in June, 2016, then a summary of the evaluation plan that will be used with teachers and students in 2017.

Evaluation Report of AREN Project Team Meeting (June 7-8, 2016)

Background: The *AEROKATS and ROVER Education Network* (AREN) Project is a 5-year project funded on January 4, 2016 by NASA to train the next generation of scientists, engineers, and other professionals to observe and understand our planet Earth through experiential learning using NASA technology and data in real-world settings. This is the first of a series of annual on-site meetings of AREN Project Team members.

Objective: To evaluate perceptions, understand expectations and assess outcomes of the AREN project team meeting, of attendees from AREN partner institutions, held on June 7-8, 2016 in Salisbury, Maryland.

Methods: 13 meeting attendees, representing 8 AREN partner institutions, completed at the conclusion of the two day meeting (June 8, 2016), a 16-item survey evaluation designed to measure perceptions, expectations and outcomes on a 5-point Likert Scale (Strongly Disagree à Strongly Agree or Poor à Excellent). The results are reported as Mean (M) ± Standard Deviation (SD) or number (n) and percentage (%).

Results: Among the attendees (Table 1), a majority were of the opinion that their meeting objectives were met (3.7 ± 1.0) and that the meeting was well organized (3.5 ± 1.1). There was also a general feeling among the attendees that the AREN project was made clear (3.7 ± 0.9) and that the AREN team meeting was a success (4.2 ± 0.6).

A clear outcome of the AREN team meeting was the enhancement of attendees knowledge of the availability and use of NASA resources (4.5 ± 0.7); especially Remote Sensing, Earth Observing Science and AREN Technologies, that could be used at individual AREN partner teaching and training sites. In addition, the meeting provided an opportunity for the attendees to explore and familiarize themselves with the use of GLOBE Atmospheric Protocols (4.2 ± 1.0) to collect Atmospheric Temperature and Cloud Data. However, attendees were unable to satisfactorily use AEROKATS Remote Sensing Technologies to collect Atmospheric Field Data (2.3 ± 1.2). Furthermore, the meeting did not enhance the confidence of the attendees in their ability to Formulate and Draft the AREN Implementation Plan for their AREN partner site (2.2 ± 1.1).

The AREN partner meeting, overall, recorded a positive evaluation from three-fourths (76.9%) of the attendees (3.9 ± 0.9). The attendees were also quite positive with the meeting location (4.5 ± 1.0), meeting dates (4.5 ± 0.5), meeting pace (3.8 ± 0.9), and meeting length (3.5 ± 1.0). However, whereas the meeting site was generally appreciated, the remoteness was a concern in the context of increased travel time. Another sentiment expressed by a segment of the attendees, to facilitate more interaction between team members and improved outcomes with weather constraints, was to increase the duration of future meetings from 2 days to 3 or 4 days.

Summarized below are the Highlights, Challenges, Concerns, Comments and Suggestions generated by the evaluation of the AREN team meeting.

*Highlights***:** 1) Opportunity to meet and get to know all AREN team members. 2) Interactive discussion of the scope of the AREN project and the partner institutions involved. 3) A great appreciation for the Power Point Presentation describing all Remote Sensing assets used to Map the Globe. 4) Ability to participate in AEROKATS set-up and live demonstration of the operation and protocols to be followed.

*Challenges and Concerns***:** 1) Clarity of the role of AREN partners and partner institutions in the whole project. 2) Inability to facilitate development of an evaluation plan without the AREN partner role clarity. 3) What is the equipment being provided to each site and for whose use (site coordinator, teacher or other)? 4) Establishing timelines for Curriculum or Lesson Plan development. 5) Who will be writing lesson plans and who will be piloting? 6) How will educational materials be communicated to educators and by whom? 7) How to involve engineering in formal and informal applications. 8) How to focus the AREN data collection into a Globe field campaign? 9) Clarity on future steps including how to move forward with partnerships and maintain momentum. 10) How to use AEROKATS and ROVER system platforms? 11) What support to other AREN participants should be planned for? 12) What are the technology development goals?

Comments and Suggestions: 1) The time spent on food provided an opportunity for interaction between team members, but it reduced the time available for other planned activities. 2) Need to better define roles and start establishing deadlines. 3) A worthwhile project and a good crew! 4) Interesting to follow aeronautical jargon e.g., sterile cockpit. 5) The team is outstanding, with great synergy, ending with an excellent result. 6) Reducing time spent on food by having food provided on site. 7) Would have benefited by hearing from each team partner their role in the project. 8) The agenda timing was not followed resulting in delayed lunch times.

Conclusion: The team meeting of AREN partner institutions held on June 7-8, 2016 in Salisbury, Maryland was successful in accomplishing the modest stated intentions of the organizing team. Nevertheless, the role of nature in the successful implementation of this weather-related project at all partner sites and the team meeting cannot be overlooked, making advance planning all the more challenging.

Table 1: Descriptive Statistics of the AREN Meeting Evaluation (N=13).

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Obj Met	13	2	5	3.69	.95
Well Org	13	2	5	3.46	1.05
Made Clear	13	2	5	3.69	.85
Meet Success	13	3	5	4.23	.60
Aware NASA Res	13	3	5	4.46	.66
Use GLOBE	13	2	5	4.15	.99
Use AEROKATS	13	1	5	2.31	1.18
Draft AREN Plan	13	1	5	2.15	1.07
Overall Meeting Eval	13	2	5	3.92	.86
Meeting Loc	13	2	5	4.54	.97
Meeting Dates	13	4	5	4.46	.52
Meeting Pace	13	2	5	3.77	.93
Meeting Length	13	2	5	3.54	.97
Valid N (listwise)	13				

Evaluation Plan for the AREN Project

For the purpose of the AREN project, using a modified definition of the Joint Committee on Standards for Educational Evaluations. Evaluation for this project is defined as a systematic investigation of the merit, worth or effectiveness of the project or curriculum material on teachers, students and their communities. Evaluation focuses on two main themes:

- Level of satisfaction of the participants
- Impact of the project on the targeted audience

The AREN project is being implemented at nine partner sites whose needs, method of education delivery as well as target groups are different.

The AREN Project will train teachers in and introduce students to the discipline of Earth Science with a view to impart knowledge and technology in a formal and informal manner to middle and high school students across multiple locations in the US and eventually nationwide. The project will be continually monitored and evaluated with formative and summative assessments to determine the impact of the project on teachers, students and their communities.

During the first year of the project, no data was collected on students or targets because no formal training was taking place. Students and teachers were observed at CBEC and USF and those observations will be used to develop assessment tools in 2017. Primarily, the following identified outcomes of the AREN project will be evaluated:

1. Did the Students and Teachers learn how remotely sensed data can be used to study Earth systems, and were they able to acquire remotely sensed data and produce meaningful information (including vegetation index, biomass and Land Use and Land Cover change over time) from that data?

2. Did the Students and Teachers learn how to collect and process remotely sensed imagery using AEROKATS kite-borne instrumentation?

3. Did the Students and Teachers learn how to collect and process in-situ atmospheric data using AEROKATS kite-borne instrumentation?

4. Did the Students and Teachers learn how to collect and process in-situ hydrologic data using ROVER aquatic vehicles?

5. Were the Students and Teachers able to utilize appropriate analysis and mapping tools to process and share their observation data via mapping tools (GIS), as well as contribute data where appropriate to the GLOBE database?

6. Were the Students able to participate in GLOBE field measurement campaigns and contribute observation data?

7. Were the Teachers able to become familiar with NGSS practices, disciplinary core ideas and cross-cutting concepts in the disciplines of Earth science, biology, physics and chemistry?

8. Were the Teachers able to understand the fundamental concepts of Project Based Learning (PBL) and were they also able to implement an instructional unit using a PBL methodology grounded in inquiry and Student led investigations?

9. Did the Students and Teachers have access to technology through affordable hardware and software solutions and did they receive Benefits of augmentation of STEM engagement for traditionally underrepresented populations?

10. Was AREN able to establish a sustainable nationwide network to provide affordable Earth science data collection instruments and experiences, with ongoing professional development opportunities and project support?

Secondarily, the evaluation questions to be addressed will include:

1. Did teachers improve their understanding of the project and were there any perceived difficulties in project implementation?

2. How successful were the teachers in generating an interest among students and in implementation of the project in the school?

3. What were the factors (e.g. course materials availability and costs, administrative support, time and weather) that impacted implementation of the project by the teachers?

4. What was the impact of the project activities on student development and interest in earth science?

5. Did the student participation in the project and the field experiments enhance the knowledge of Earth science and the potential impact of human behavior on Earth's conditions?

6. What is the long-term perceived impact of the project on the teacher, student and society?

7. What was the impact of the project on Technology Utilization and GLOBE participation rate?

8. How successful is the program management team in achieving the stated goals of the project and what weaknesses and/or strengths were observed?

9. Is the AREN Partnership approach effective?

10. Is the Team approach for teachers and students helpful in addressing safety and operations elements?

The evaluation process, towards meeting the objectives of the program, will use an adaptation of the Kilpatrick and Kilpatrick (2006) four-level evaluation methodology which includes:

1. *Reaction* - How well did the learners (students) like the learning process?
2. *Learning* - To what extent did the learners (students) gain knowledge and skills?
3. *Behavior* - How did acquired knowledge and skills impact the behavior of the students and what was the consequential impact on science, society and the planet earth?
4. *Results* - What are the overall tangible impacts of the program in terms of the student knowledge and skills, development of student interest in earth science, changes in student perception or behavior, and projected long-term impact on society and the planet earth?

Based on the above evaluation methodology, Evaluation Instruments will be developed to measure outcomes in knowledge, attitudes, skills, behavior and practice and to answer the questions that stem from the project objectives.

Survey responses will be measured on a 5-point Likert Scale with a few 'Yes-No' and 'True-False' response questions. The evaluation instrument will incorporate Questions on Earth Science and will also measure the sociodemographics of the training Site and Sample. This will permit evaluation of the participation rate and the impact of the AREN project on the different segments of society. The variation in the project partner sites will necessitate unique evaluation instruments to be designed for every evaluation at each site.

A pre-post test study design will be mainly used for evaluation of this study. However, a few post-test only surveys will be conducted as part of the evaluation process to elucidate participants opinion and enable a quick feedback on project implementation.

A Cluster sampling will be used in this evaluation study, since only teachers and students agreeing to participate in the AREN project across multiple (nine) partner sites in the US will be included in the sample. The pre-post test survey design used in this evaluation will enable control of sampling biases. The base knowledge of the teachers and students will be evaluated prior to delivery of the educational/training program. In order to protect the identity of all human participants, results will only be reported as a group or sociodemographics and no individual data will be reported.

The data obtained will be coded and analyzed using SPSS for Windows version 22.0 (IBM SPSS Inc., Chicago, IL). Descriptive statistics on all study variables will be generated. Continuous data (e.g., age) of two groups will be analyzed using *t* test, and categorical data (e.g., gender) associations will be evaluated using χ^2 test. Pearson correlation coefficients will be used for analysis of associations between continuous data. The pre-post impact of the training program on the target population (e.g., teachers) will be studied using a paired *t* test. Results will be presented as Mean (M) ± Standard Deviation (SD) or as number (n) and percentage (%). Statistical significance will be established at $P < .05$.

Project Evaluation Activity Plan

Phase 1: Baseline Data Collection - Design, Development, Testing and Administration of Evaluation Instruments. The Evaluation Instruments will consist of sociodemographic variables and incorporate all variables necessary to address the stated research questions.

Phase 2: Project Monitoring and Mid-Year-1 Report - Monitor the teacher acquisition of knowledge and skills. Administer pre and post evaluation of teachers using the Evaluation Instruments. Monitor the student acquisition of knowledge and skills. Administer pre and post evaluation of students using the Evaluation Instruments. Monitor project implementation using teacher self-report. Prepare Mid-Year evaluation status report and incorporate project changes, as needed.

Phase 3: End of Project Year-1 Data Collection - Collect teacher and student survey data.

Phase 4: Annual Year-1 Report - Summarization of pre-post performance evaluation and surveys, analysis and interpretation of findings in relation to project objectives; generation of report.

The AREN evaluation is being designed and conducted by Anil Aranha, PhD, an independent Evaluation Consultant, contracted by Wayne RESA for the AREN Project. The evaluation will be conducted in conjunction with and assistance of the nine Partner sites located across the US.

The AREN project is being implemented at nine Partner sites located across the US. Participation in the project is absolutely voluntary. Also, in order to protect the identity of all human participants, the results will only be reported as a group or sociodemographics and no individual data will be reported. Currently, there is no intention to obtain an Institutional Review Board (IRB) approval, since the Risks associated with participation in the project (e.g., falls on the field or playground while flying kites or the psychological impact of answering evaluation/survey questions) to Human Participants (teachers and students) is minimal and/or normally associated with other outdoor activity. However, to safeguard the participants, institutions and stakeholders from any associated risks, in lieu of an Informed Consent, a Project Information Sheet detailing the Project and the Risks and Benefits generally associated with participation in the AREN project will be provided to all the participants. Furthermore, for participants below 18 years of age, a Parental approval shall be obtained prior to enrolling in the project.

References

Donald L. Kirkpatrick, James D. Kirkpatrick. Evaluating Training Programs: The Four Levels (3rd Edition). San Francisco, CA: Berrett-Koehler Publishers Inc, 2006.

Cross - Collaborations

The AREN Project collaborating with many of the NASA CAN Awardees. To date, AREN has signed agreements with the following:

GLOBE -- We need to collaborate with GLOBE on two projects, University of Toledo and the University of Alaska, Fairbanks. New GLOBE protocols will be developed along with a media plan for upcoming AREN workshops. AREN needs to determine if there are any costs that will be incurred. AREN will also work with GLOBE on partnering with future measurement campaigns. AREN will also work with the University of Alaska to do aerial imaging of sea ice.

- University of Alaska, Fairbanks: Impacts and Feedbacks of a Warming Arctic: Engaging Learners in STEM Using NASA and GLOBE Assets
- University of Toledo: Mission Earth: Fusing GLOBE with NASA Assets to Build Systemic Innovation in STEM Education
- Southwestern Community College: Eclipse 2017
- Gulf of Maine Research Institute: Online Earth Science Course
- University of Colorado, Boulder: Eclipse 2017, Videos of ARE
- National Solar Observatory/Association of Universities for Research in Astronomy: Eclipse 2017
- University of Washington: Winglee/Camera Technology/Operations
- Goddard Space Flight Center: Outreach/Education
- American Museum of Natural History: OpenSpace/Data Sets

VI. Future Plans for 2017

AEROKATS and ROVERs

Maturation and Commercial Production of *Aeropods*. *MonoCams* and *Profilers* are relatively mature; *TwinCams* and *ThermoCams* require significant development.

3D printers are on-line at Wayne Resa, GSFC/WFF, UMES, and Public Lab. These are being used to prototype and produce increasing numbers of parts for Aeropods (camera mounts, pylons, fin attachment hardware). Use of these machines will significantly reduce fabrication labor per system. We also intend on having parts needed for AEROKATS and ROVER activities printed by schools using their own printers - the goal is to be able to share part files with schools and Maker Spaces. This will also aid in distribution. We will continue to develop our distribution methodology to enable cost effective access to hardware regardless of economic conditions at participating schools, clubs, and civic organizations.

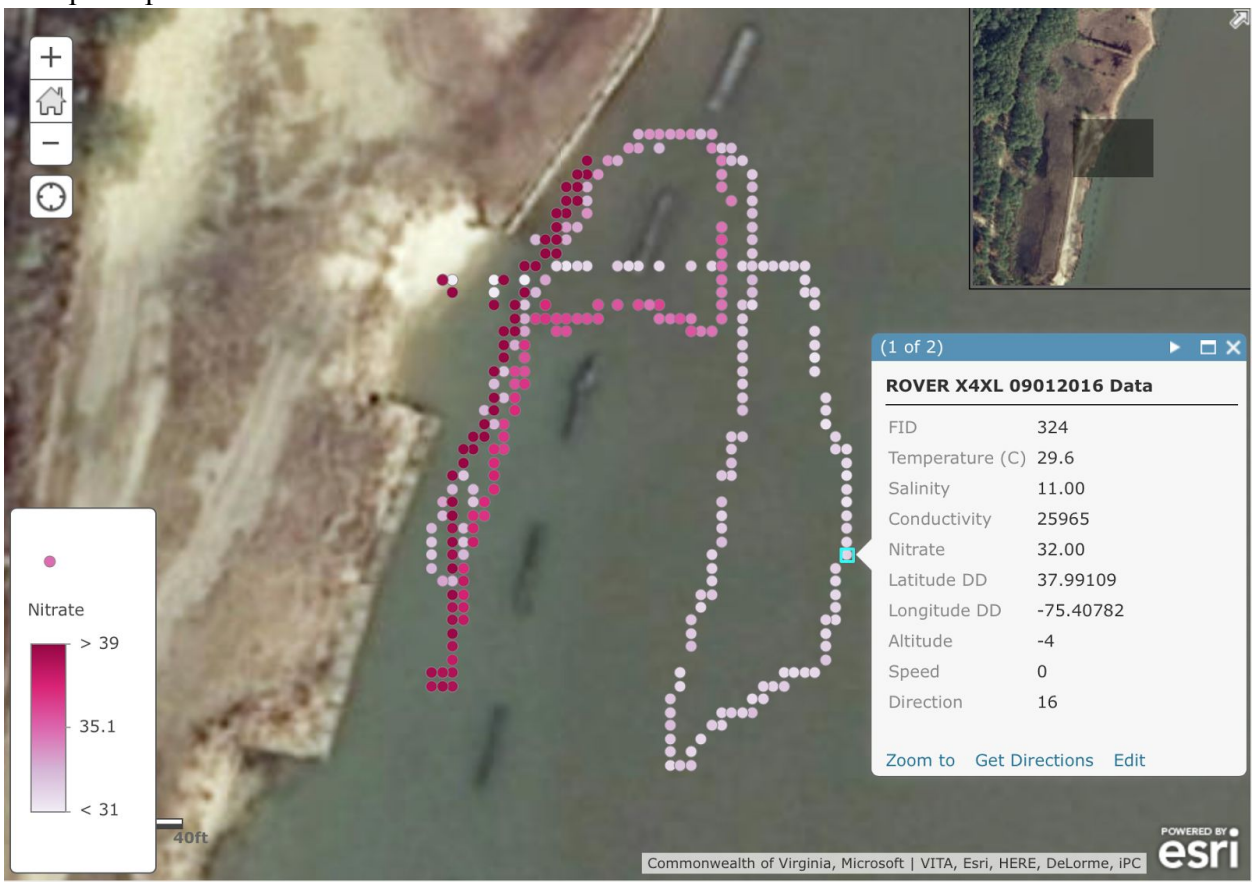
Following a solid start with “MonoCam” and “Profiler” Aeropods, the next step is the development of standardized “TwinCam” (Color and Near-Infrared) and “ThermoCam” (Thermal Imaging) Systems. An advanced “Profiler” will also be developed by Anasphere to drive the cost down. A high resolution “ProCam”color imager has been developed and tested by GSFC/WFF, and will be available to the team and end users where image quality is critical for the science missions. New materials have been explored and tested by Public Lab, and dissemination of new versions of all Aeropods is planned via web-based distribution tools.

ROVER development will continue with the upcoming "X5" which will combine the most desirable features of the series to date: multiple sensors, submersible cameras, lightweight, and easy to operate. Several detail enhancements will be incorporated as a result of this year’s testing, particularly in the battery charging and connector areas. Material and hardware selection will be continue to be evaluated, as will sensor systems. A 2017 goal is deployment of ROVERs in the Rouge River by Wayne RESA and area partners.

Lending Library development is underway - continued work will aim to create inventory and processing of requests.

GLOBE

Initiate development of AEROKATS GLOBE Protocol and Learning Activities. Begin the development to use an ARC GIS - based tool which will enable development of data formatting and a visualization approach. ArcGIS tools will be used to development of data capture and analysis processes that can be incorporated in the GLOBE Program when appropriate. A photo example is provided below:



Learning Resource Development

K-12 Formal Classroom Environment Learning Resource(s):

- NGSS Instructional Implementation
- Hands on STEM Learning Activities
  Lead Institution: Wayne RESA - PI Bydlowski, Co-I Henry

K-12 Formal/Informal Blend - Environmental Ed Learning Resource(s):

- Project Based/Hands on STEM Learning Activities
- Engineering Challenges
  Lead Institution: GSFC (Co-I's Bland, Coronado, Smith)

- On Site Day Activity (AREN Lesson Plans w/ pre/post in-class work)
  Lead Institution: Chesapeake Bay Environmental Center (Co-I Wink)

- On Site Day Activity (AREN Lesson Plans w/ pre/post in-class work) Rouge Education Project Water Monitoring Program
  Lead Institution: Wayne RESA (PI Bydlowski, Co-I Henry)

- Chester River Watershed Monitoring Program
  Lead Institution: Washington College (Co-I Levin)

Undergraduate/K-12 Hybrid Summer Program

- Bulls-EYE Summer Mentoring Program
  Lead Institution: University of South Florida (Co-I Gaines)

Undergraduate Education

- Chief Dull Knife Tribal College - Undergraduate Course (Environmental Education)
  Lead Institution: MSU/NTEN (Co-I Obbink, Co-I Taylor)

- Student Workshop for Aviation, Science, Technology, and Education departments
  Lead Institution: University of Maryland Eastern Shore (Co-I Nagchaudhuri, Co-I Hartman, Co-I Brown)

- AVSC 310 – Aerial Operations in Remote Sensing Course (3 credit)
  Lead Institution: University of Maryland Eastern Shore (Co-I Nagchaudhuri, Co-I Hartman, Co-I Brown)

Graduate Education

- Online Earth Science Course for Educators
  Lead Institution: MSU/NTEN (Co-I Obbink, Co-I Taylor)

Public Engagement/Citizen Science

- Public Workshops and DIY Educational kits
  Lead Institution: The Public Laboratory for Open Technology and Science (Co-I Chall, Co-I Lippincott)