

Annual Progress Report Template-2017
NASA Science Mission Directorate Science Education
Cooperative Agreement Notice (CAN)
Solicitation: NNH15ZDA004C

I. Administrative

- **Name and address of the recipient's institution & Cooperative Agreement Number:**
Wayne RESA -- Cooperative Agreement Number: NNX16AB95A
- **II. Name of the Principal Investigator:** David Bydlowski
- **III. Cooperative Agreement Title:** *AEROKATS and ROVER Education Network (AREN)*
- **IV. Type of Report:** Annual
- **V. Period covered by the report:** January, 2017 - December, 2017

II. Accomplishments

In AREN, we.....

Strive to understand our changing Earth in order to make informed decisions.

NASA helps us do that globally; AREN helps us do that locally.

In AREN, we.....

Follow protocols and procedures that help answer a science mission question, including collecting baseline data

In AREN we...

- Plan and prepare for a mission
- Review roles and safety procedures
- Launch kites
- Attach payloads
- Collect data
- Conduct post-mission debrief
- Analyze and share our data

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).

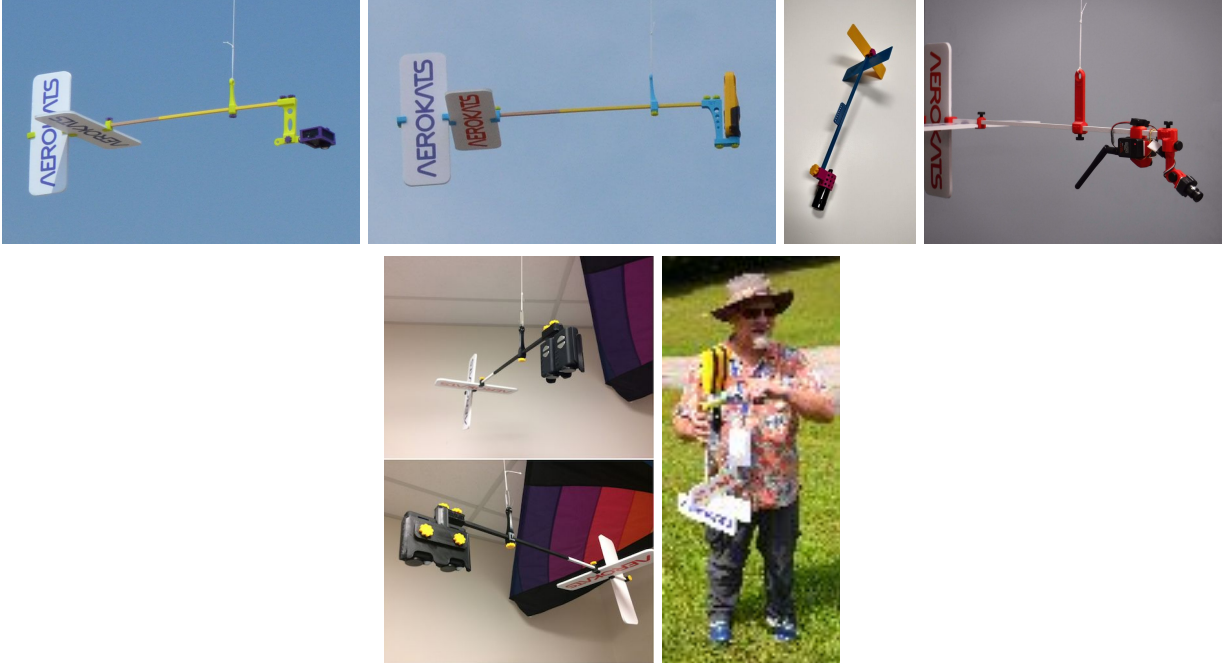
The four-fold Objectives of the NASA SMD Science Education (SE) Award are:

- 1) Enable STEM Education,
- 2) Improve U.S. Scientific Literacy,
- 3) Advance National Education Goals, and
- 4) Leverage Efforts Through Partnerships

Overview of 2017 Accomplishments:

Hardware and Technology Development and Deployment

Collaborative 3D Printing design and production is in full swing for multiple Aeropods -- baseline designs and files (.stl) are now available: MonoCam, ProCam, Profiler, TwinCam, AlbedoPod, MicroPod, VideoPod (ThermoCam, AnasondeProfiler are still in prototype form)



New low cost, instrument carrying kites are also under development.



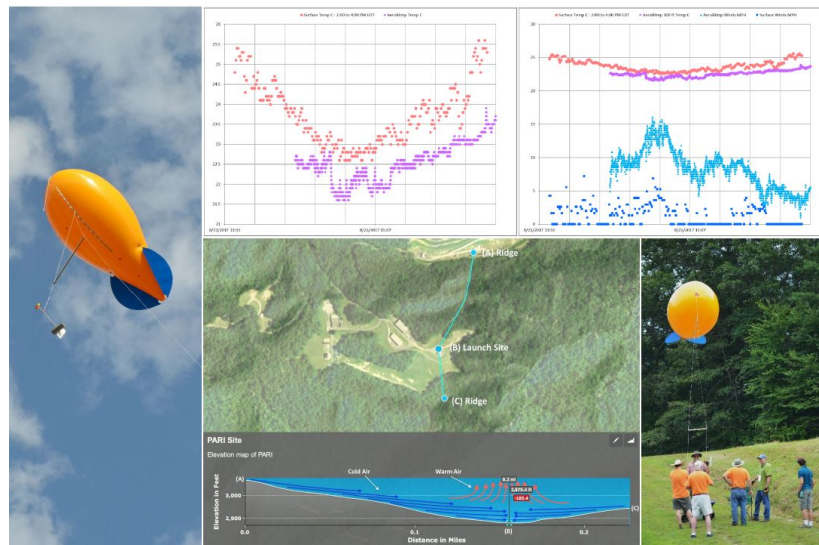
Team Training and Capacity Building

- Weekly Team Meeting Teleconferences -- Each Wednesday from 3:30 pm to 5:00 ET
- AREN team attended and participated in the GLOBE Annual Meeting in New Haven, CT from July 31 - August 4, 2017
- Ongoing Team Field Practice Sessions

Program Reach 2017

Eclipse 2017 Outreach

- 13 Individual Events - 3000 Learners
- AREN at PARI -- 100+ participants
- Comparison of surface based temperature (GLOBE App) to airborne Profiler Aeropod data (on tethered blimp provided by The Blimp Works)



University of Maryland Eastern Shore

- Aviation AVSC 310 course with 20 students
- TerraKites Productions summer activity with 5 students
- Engineering ENGE 150 course with 20 students
- Flight Crew for Vanilla Aircraft 5 day flight of unmanned aircraft

Wayne RESA

- AREN Presentations (13 presentations, 500 participants)
- Water Quality Testing of Rouge River (10 schools, 300 students, 15 teachers)
- Midwest GLOBE Science Symposia (20 students, 5 teachers, 2 parents)
- Odyssey of the Mind Event (45 students, 30 adults)
- Online GLOBE Training (15 pre-service educators)

Goddard Space Flight Center

- Kite Building/Flying - "*Reach for the Stars*" (1 presentation/activity 20 students)
- *AREN* Presentations/Activities at UMES (multiple, 40+ students, 4 faculty)
- Student Presentations at UMES (21 students)
- Participation in AVSC 310 ("*Aerial Operations in Remote Sensing*") and ENGE 150 ("*Modern Engineering Design*")
- Line Handling Challenge (multiple, 15 students)
- *AEROKATS* Prototyping, Tests and Training (multiple)
- *AEROKATS* Hardware dissemination (updates, 5 new early adopters)
- *ROVER* Field Tests at Anacostia River (*X-5/X-6*, 6 team members)
- Eclipse 2017 Presentation at Pisgah Astronomical Research Institute (150+ participants)
- *Gains in the Education of Mathematics and Science* - Engineering Program (288 students)

Montana State University

- (3 events, 45 educators)

University of South Florida

- Earth Day/Kite Flying Day (1 event, 30 participants)
- Summer BullsEYE/AEROKATS Program (15 pre-engineers, 30 students)
- Fall Engineering Design (8 students)

Chesapeake Bay Environmental Center

- Multiple events (6 schools, 80 students total)

Public Lab

- Online Presentation (18 educators)

Contributions from the AREN User Community

Users are actively involved in the AREN Project throughout the United States. Users include:

Rouge Education Project -- The Rouge Education Project (REP) is school-based environmental education program involving elementary, middle, and high schools from across southeastern Michigan. Students learn about the Rouge River in their classroom, and then perform hands-on scientific exploration of the river on a field trip to its banks.

Gibraltar Public Schools -- Educators preparing students for the challenges in the field of science.

SABENS Group, NH - Researching the use of AEROKATS to collect data on Albedo and atmospheric light conditions responding to land cover, soil and water conditions. Works with the SABENS Group, a New Hampshire based consulting firm, aiding entities to bridge from traditional to emerging learning systems.

UMES AVSC 310 "Aerial Operations in Remote Sensing" course - four students joined flight crew of Vanilla Aircraft's *VA001* unmanned ultra-long-endurance aircraft record breaking five-day mission

UMES *TerraKite Productions* - Wind Tunnel prototyping and tests

UMES ENGE 150 "Modern Engineering Design" course - Wind Tunnel design and fabrication

State University of New York at Fredonia -- Two kite building and AEROKATS events (27 teachers and 31 students)

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 - Vicki Paulas, Alissa Quinton, and Judy Wink
- Goddard Space Flight Center -- Geoff Bland, Brian Campbell, Patrick Coronado, Ted Miles, Kay Rufty, Sallie Smith
- Montana State University -- Kelly Boyce, Jamie Cornish, Kim Obbink, Suzi Taylor
- Public Lab -- Becki Chall, Shannon Dosemagen, Jeffrey Warren
- University of Maryland Eastern Shore -- Willie Brown, Chris Hartman, Xavier Henry, Abhijit Nagchaudhuri
- University of South Florida -- Jonathan Gaines
- Washington College -- Jemima Clark, Doug Levin
- Wayne RESA -- David Bydlowski, Andy Henry

AREN Management Team

A management team is 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 NASA 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 GLOBE Annual Meeting
- Review of the AREN Project timeline
- Other issues impacting the AREN Project

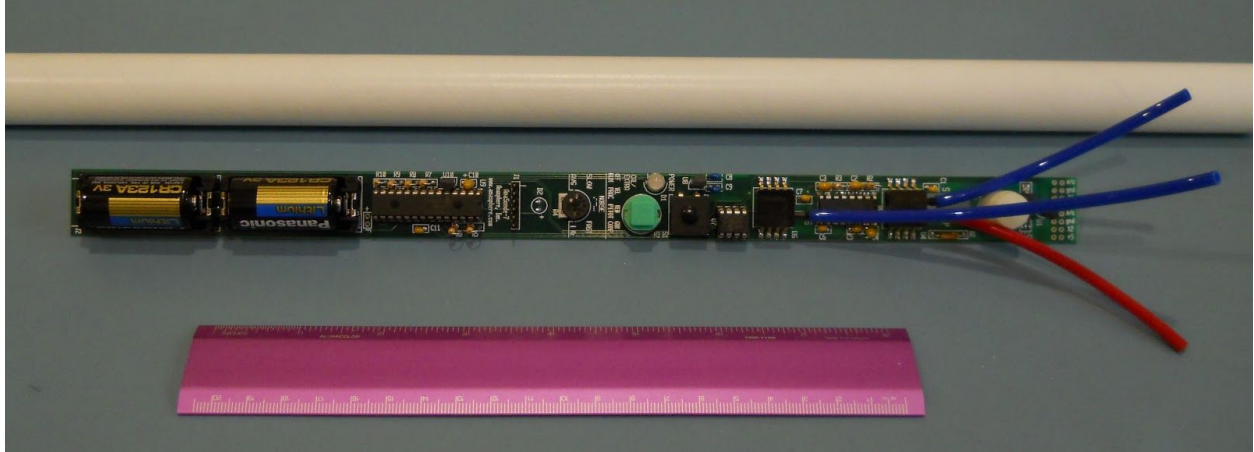
Anasphere, Inc.

New lower cost *Profiler Aeropod*:

License free radio telemetry options were assessed and feasible options identified. Two general categories of transmitter were identified as having the most promise in this context. One category would be a kit-built transmitter subject to FCC Part 15 regulation as an unlicensed transmitter operating at nominally 49.86 MHz; this kit could be modified for unlicensed European (or at least UK) use at 40.68 MHz (presumably subject to European approvals analogous to FCC approvals), and most advantageously could also be modified for use in the licensed amateur 6-meter band (nominally 50 MHz) worldwide. This transmitter would transmit Morse code data, and would only need a suitable radio receiver for operation. Alternatively, a digital link could be implemented using Bluetooth radio modules; this would be a worldwide solution, but being digital would require the associated use of a PC or tablet to process data. Range would also be limited, and would be subject to the particular Bluetooth hardware in use at the transmitting and especially receiving end; this limitation can be overcome by controlling the hardware used at the receiving end (e.g., by supplying a receiver dongle) – the latter solution is presently implemented in Anasphere's *LiteTether* tether sonde.

Range tests of visual (LED) telemetry. Variants of Anasphere's *AnaSonde-E* radiosondes were modified with higher-power LEDs. It was determined that, with the unassisted eye, a useful telemetry range of 100-140 meters could be obtained as defined by easily reading the reported temperature in Morse code. Increasing LED power further beyond a certain point did not help range; rather, the problem then became one of optical resolution. Use of even very weak binoculars (say, 7x35) will easily enable optical telemetry ranges of 350 meters or more, thereby meeting the internally-set 1,000 ft range target with this telemetry mode.

With regard to the new *Profiler*, the new circuit design was completed and a printed circuit board has been designed and fabricated. The *Profiler* will run on two CR123A batteries and be housed in a model rocket BT50 body tube (just under 1 inch in diameter) with a length to be determined but overall around 18 inches. Model rocket components will be used for light weight and low cost. The core circuit/sensor board has a mass of 38.2 grams, and the two CR123A batteries add another 32.7 grams.



With regard to collaboration with MSU-NTEN, the course proposal for Experimental Atmospheric Science for the Classroom was submitted for approval. Dr. Bognar is learning how to successfully teach online courses.

Dr. Bognar has been reworking the course with the core mission as the primary objective: deliver background content knowledge about atmospheric science. One objective is to focus on the stated title of the course, which includes "...for the classroom." Many activities will be suitable for indoors and things teachers can easily do in a classroom (and in a class period). The activities and background knowledge should prepare the teachers for teaching atmospheric principles and discussing real-world atmospheric measurements. AREN and GLOBE will be introduced in the context of where teachers can go from this course and places where they can apply their new knowledge.

Chesapeake Bay Environmental Center (CBEC)

Much work was spent preparing materials for recruiting teachers and classes, as well as, materials for AREN education programs and workshops at CBEC.

- Created AREN Flyer to bring to science teachers at schools around the community to recruit spring classes
- Updated information and pictures on PowerPoint to present to anyone interested in CBEC's AREN programs
- Initiated launch of AREN webpage on CBEC's website. Compiled pictures and detailed information on AREN education programs and equipment.

To improve methods of data collection and analysis they started to use Lenovo N22 Chromebooks on missions. They have successfully livestreamed data from the Labquest 2 with the Graphical Analysis app, but not the Kestrel 5500 used on the current *Profiler Aeropod*. The Chromebook software isn't compatible with the Kestrel LINK app, however, according to Google support, Chromebook software will update sometime in 2017 and resolve this issue. In the meantime, they will continue to use a personal computer or smartphone to livestream and export Kestrel data.

AREN team members became certified GLOBE teachers. They also created an initial schedule for weekly data collection and submission to the GLOBE website. Main focuses are currently the land cover and green up protocols for remote sensing sites of invasive marsh grasses.

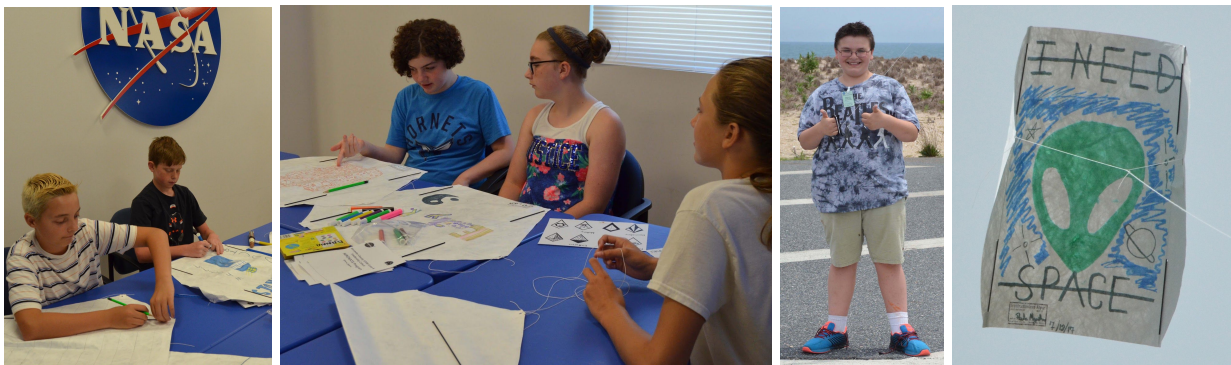
Additional work included:

Working on curriculum development for informal STEM education experiences with ROVERs. They completed 6 ROVER and AEROKATS Missions, set up the scope of work for a year round study of marsh invasives, and developed a grid marsh area for studying invasive encroachment.

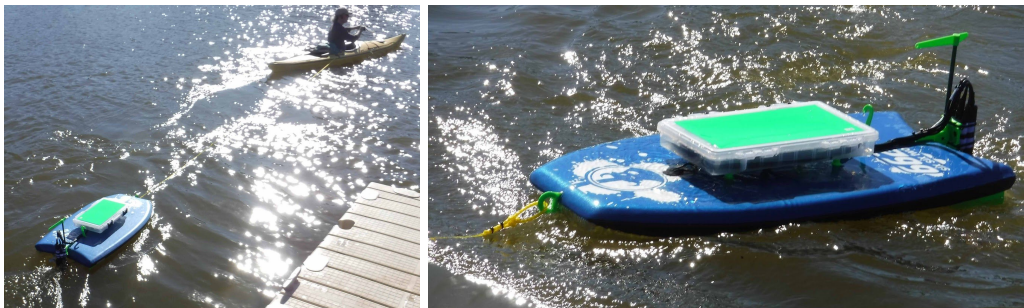
Also met with a group of citizens (committee) to engage them in collecting atmospheric data within the county. There has been one meeting so far and everyone was interested (8 people in the group). Subsequent meetings will involve using equipment, data collecting, areas assigned, etc. They are in very early stages of getting a group of citizens involved in data collection. They plan to do a similar meeting with volunteers working with CBEC.

Goddard Space Flight Center (NASA/GSFC)

Participants from Goddard include Geoff Bland (610.W), Sallie Smith (606.3), Patrick Coronado (606.3), Brian Campbell (610.W/WFF), Kay Rufty (610.W/WFF), and Ted Miles (Zinger Enterprises). Activities included participation in the University of Maryland Eastern Shore (UMES) Department of Engineering and Aviation Sciences *Aerial Operations in Remote Sensing* (AVSC 310) and *Modern Engineering Design* (ENGE 150) classes, coaching several schools involved with "Project Lead the Way" engineering challenges (e.g.; line handling), presentations and flight experiments at the 2017 Eclipse event at the Pisgah Astronomical Research Institute, support for the Wallops "Reach for the Stars" summer kite flying program (Sherman, et al), participation in the GLOBE annual meeting in New Haven CT, and technical and science content support for other *AREN* partners such as the Chesapeake Bay Environmental Center, Washington College, and the University of South Florida.



"Reach for the Stars" Summer 2017



Gene Feldman (NASA/GSFC) tows the ROVER X-6 on the Anacostia River for initial trials



ROVER X-5 is tested in Anacostia River to begin long-term monitoring of water quality improvement efforts (as suggested by Ming-Ying Wei). We anticipate local high school rowing clubs and concerned citizen scientists to participate in this observation activity.



AEROKATS were part of two Pacific Ocean cruises as part of our scientific research testing and verification efforts - for example Stephanie Uz (NASA/GSFC) captured images when aboard the R/V *Falcor* of the Schmidt Ocean Institute.

Montana State University (MSU)

The MSU team has continued to fly kites and payloads, experimenting with and learning about the equipment, mainly on the MSU campus but also in the Bridger Mountains. They have flown Aeropods with both the weather profiler and camera. They also flew kites during the Solar Eclipse in Island Park, ID.

Montana State University continues to move forward with developing a series of online graduate-level courses via its National Teachers Enhancement Network. These courses will provide Earth science content that complements participation in the hands-on aspects of AREN. The first course proposal -- Experimental Atmospheric Science in the Classroom -- was approved by the MSU Earth Sciences department head after a meeting with Kelly Boyce and Suzi Taylor. The online course, to be developed and taught by John Bognar, is currently scheduled to run in Fall 2018. The MSU team is solidifying issues of promotion, instructor support and other logistics.

MSU has brought on undergraduate student David Rodriguez, who is newly transferred to MSU from Chief Dull Knife College in Lame Deer, MT. David is a physics and applied mathematics major and was part of the Montana Space Grant Consortium's high-altitude ballooning eclipse project.

Created an AREN Webpage on the National Teachers Enhancement Network website (<http://eu.montana.edu/nten/aren>)

Workshops

- July 2017: Flew kites with teachers who were visiting MSU as part of the Master's of Science in Science Education program. Colin Quinn (MSU graduate student) and John Bognar also participated.
- Oct. 2017: Held an AREN teacher workshop hosted at MSU on October 19, 2017. 15 educators from across Montana participated, and they represented both K-12 classrooms (elementary, middle and high school) and out-of-school/afterschool programming. The workshop included a presentation on the AREN project, overview of kites and equipment, short talk by Bozeman-based GLOBE trainer Lynn Powers, a short (but successful) flight with several kites, a mission debrief and a workshop evaluation. Each teacher received a Hata to take home as well as one Frustrationless Flyer. The workshop was featured in the university president's weekly email to campus and the larger community. <http://www.montana.edu/news/17188/msu-to-host-teacher-workshop-on-nasa-kite-flying-project-oct-19>



Safety is always stressed. Even the Montana State University mascot, Champ, wears gloves when flying!

Presentations

- April 2017: Included AREN in guest lecture to MSU undergraduate class about communicating climate science. (31 students, mainly upper division Earth Science and Ecology majors, professor Jia Hu)
- April 2017: Included AREN in presentation to MSU faculty about STEM outreach – 12 faculty members from many disciplines. Sponsored by Center for Faculty Excellence.
- September 2017: Representatives from Bozeman, Montana / Montana State University met with visitors from Rikkyo University in Tokyo who are interested in university outreach. Shared information about several MSU projects, including AREN. Japan has a huge kite-flying culture, and they were quite interested in the project.
- September 2017: Attended the National Girls Collaborative Forum and shared information about Montana outreach projects, including AREN, with members from across the country. NGC brings together organizations throughout the United States that are committed to informing and encouraging girls to pursue careers in STEM.
- October 2017: Attended the Montana Education Association meeting in Missoula, MT and shared information about AREN with teachers of all grade levels.



MSU AEROKATS Aerial Image

Public Lab

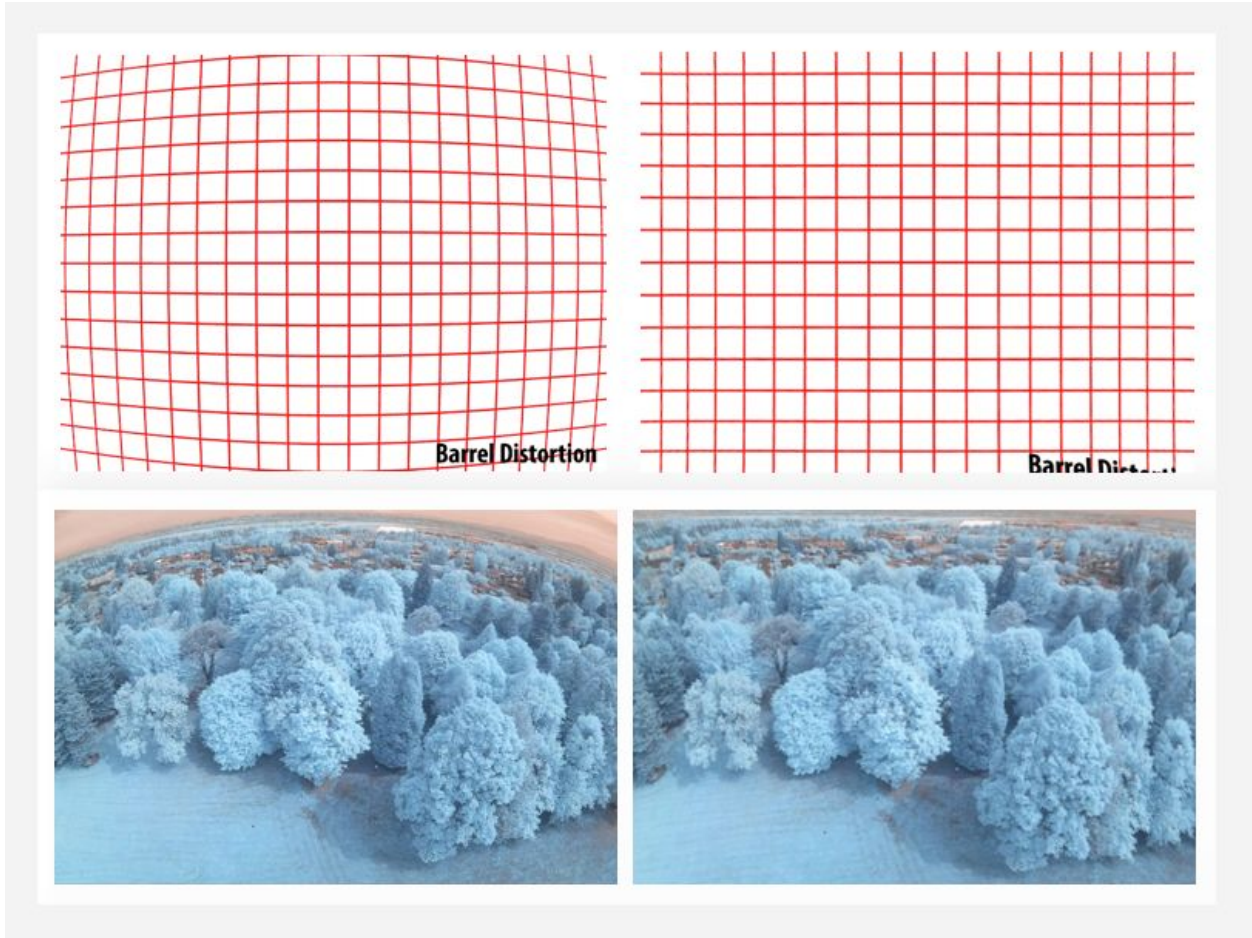
Used SMDEPO.org to connect with other NASA CAN awardees. They Identified project partners to do evaluation of AREN tools and techniques. They assisted with the distribution and production of Aeropods. They continued to participate in AREN monitoring and evaluation of AREN protocols and equipment.

Public Lab developed a step-by-step lesson for wind speed monitoring and lift estimation with TALA. They explored lining up the Public Lab website with the GLOBE website. They developed “kites in the classroom” materials, assisted with the Line Handling campaign, and finalized kite kits.

They completed a Public Lab.org activity for analog thermometer calibration to GLOBE standards. They integrated a Weather Station into GLOBE, including calibration and automatic submission data. They developed a guide for teachers about how to use publiclab.org's collaboration features with students and revised Public Lab provided materials, lessons, and kits based on feedback.

Public Lab staff was in transition as Jeff Warren stepped in for Mathew Lippincott partway through Q2, but progress picked up towards the end of the period. Reprioritization of partnership goals led to an emphasis on remote sensing, image analysis and multispectral imaging work, resulting in the revival and completion of a lens distortion removal tool, implemented as a microservice-style website for aerial photographers. Documentation and guides will follow along with similar work on multispectral image processing and orthorectification, along with similar microservices for various image analysis operations in support of aerial photography image processing.

Public Lab developed back-end infrastructure for image processing systems (microservices) they plan to roll out for student use, based largely around the Image Sequencer library and the initial demo usage of FisheyeGL -- a tool for removing fisheye distortion from images. This last was an exciting first step as it proved out an interface model for a microservice-based workflow, while also opening up a range of low-cost cameras for aerial photography use, which had previously been unusable due to the extreme barrel distortion of lenses on cameras like the GoPro.



FisheyeGL - image distortion correction tool



Jeff Bouwman's class *AEROKATS* aerial image with Image Correction applied

Public Lab's attendance at the New Haven GLOBE meeting was a great opportunity to learn more about the broader AREN project, make connections with other team members and network with the broader Globe community, while getting more specific input and feedback to inform the remote sensing tools they are developing.

They engaged with Public Lab community members to test the AREN profiler payload alongside a low-cost open hardware wind sensor, resulting in simultaneous flight of both payloads and some good comparative data between the two platforms. They look forward to finding more overlaps between the AREN project and the interests of the broader Public Lab network, as this was a win-win on several fronts, from modeling study design approaches to piloting low-cost possible payloads for AEROPODS to testing out data logging and analysis workflows that may scale to the K-12 audience.



Comparison of Aeropod Prolifer with hot-wire anemometer system - see: <https://publiclab.org/notes/cfastie/10-17-2017/winds-aloft-sensor-overload>

University of Maryland Eastern Shore (UMES)

The accomplishment and work progress at the University of Maryland Eastern Shore (UMES) has been highlighted by the success of developing and offering a three (3) credit course titled: AVSC 310 Aerial Operations in Remote Sensing. This course offering currently is a part of the Department of Engineering and Aviation Science's curriculum along with 19 students enrolled in the course during Spring 2017. The course was offered on days of Tuesday and Thursday at times of 2:00 PM to 3:15 PM. According to the course description approved by the University of Maryland Eastern Shore, the course covers the operation of aerial platforms as it relates to remote sensing in support of various scientific endeavors. In addition, the description explained that students will engage in a research project, and collect and analyze data in accordance with the objectives of the project. Note in the development of the course content these objectives were aligned with AREN's project outcomes. The course prerequisite was AVSC 390 Aviation Applications of Statistics and Research Design or MATH 210 Elementary Statistics. If the student did not obtain the course prerequisite, the student could also receive permission of instructor of record according to the course description. The course was team-taught and the instructor of record was Dr. Willie Brown and Dr. Xavier Henry. The meeting dates range from January 30, 2017 to May 26, 2017.

The faculty and staff in the Department of Engineering and Aviation Science also obtained the Institutional Review Board's (IRB) approval letter on March 1, 2017 that confirms set protocol defined by the AREN's project. The IRB's approval letter supported the student activities and deemed the study as exempt with the classification of category 2. This classification presents that the research involves the use of education test such as cognitive, survey procedures and observation. This approval allows for data collection of human subjects through surveys in order to capture the student first year experience with AREN related projects in a classroom environment. The data will be use as a method of analyzing AREN's activities and the delivery practices (e.g., training and learning objectives in an education environment).

In addition to the AVSC 310 course, the selected UMES students who were involved in the AREN project expanded on the protocols for kites and flying proficiency. The students identified as the TerraKites Production introduced a training video to enhance and expand on operation safety practices and the use of checklist procedures. The development of the kite training videos will aid in proper methods for safe practices and prevention, operational preparedness and standards, mission planning and technology configuration for the AREN community.

The goal of the wind tunnel project with AREN is to focus on exploring engineering concepts that capture the intent for system development and testing. The wind tunnel will offer a critical first step to analyze, design, development, monitor, test, and evaluate the system behaviors within a control environment using test models. This project will enable the AREN team to demonstrate and interpret these aspects of data collection needed for system modeling of performance and stability. The project will explore innovative measures and educational outcomes through a comprehensive study of wind-tunnel designs and requirements. The educational outcomes will be identified using a theoretical approach known as problem-based learning (PBL) to model engineering practices, technology and science application. The PBL

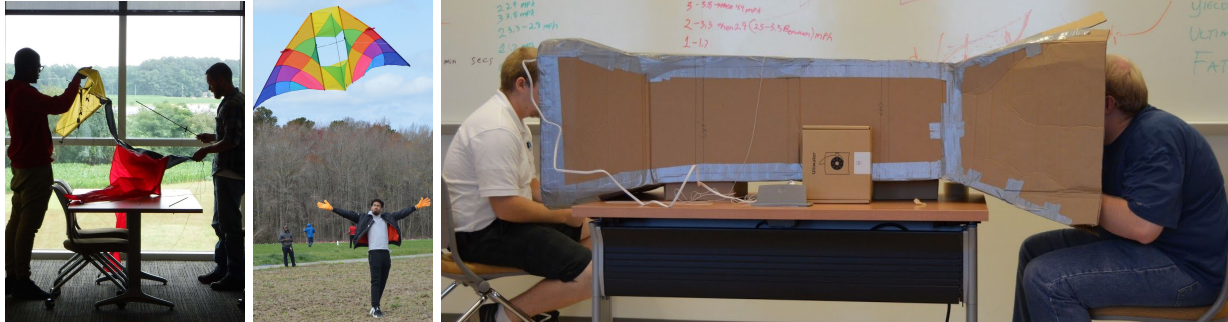
theory has been recognized as a way for students to investigate and discover meaningful solutions in the field of study through design and industry requirements. Therefore, this design approach will serve for the advancement of NASA's "Aeropod" technology – the results is intended to identify innovative efforts tailored to the requirement specification in order to meet emerging Earth-science research and industry needs. The engineering students in ENGE 150 - Modern Engineering Design for Fall 2017 will be tasked to develop and design a wind-tunnel system that supports the mission objectives for system testing and performance evaluation with regard to the specific test models identified as NASA's technology and their requirements specification. The design requirements for the engineering students in Fall 2017 are as follow:

- Wind Tunnel Design Requirement 1: Wind-tunnel design must be able to support the test model and flow conditions using a full scale or sub-scale *Aeropod*.
- Wind Tunnel Design Requirement 2: Wind-tunnel design must be able to display airspeed measurements at multiple points within the test sections.
- Wind Tunnel Design Requirement 3: Wind-tunnel design must be modeled with an understanding of Bernoulli's Principle based on the flow of air through a Venturi tube (according to requirement one).
- Wind Tunnel Design Requirement 4: Wind-tunnel design should have a system mount with a configuration adjustment for the *Aeropod*.
- Wind Tunnel Design Requirement 5: Wind-tunnel design must have a minimum speed of 10 mph.

Lastly, four (4) AREN students at UMES partake in the Vanilla Aircraft mission. They completed a 121.4 hour nonstop flight of the VA001 unmanned aircraft from the Wallops airport and within the restricted airspace over the nearby coastal areas. The total instrument payload weight was 22 lbs, and included a multispectral imager (Geoff Bland/610.W) and a DoD experiment package. This mission was part of the flight envelope expansion efforts by the Vanilla Aircraft team (Falls Church VA), and moves the system significantly closer to full operational status from its start from a NASA/GSFC Small Business Innovation Research (SBIR) project. The flight crew for this five day mission included four aviation students from the University of Maryland Eastern Shore (UMES). These students are also participants in the NASA CANS sponsored AEROKATS and ROVER Education Network (AREN) effort at UMES. The Wallops Range was coordinated by Alice Rew (840) and the student flight team was enabled by Pete Bale (Sentinel Robotics Solutions). The design endurance of this aircraft is 10 days, with approximately a 30 lb payload.

UMES will continue to focus on developing training protocols that support professional development practices of students by promoting the necessary process with regard to retention efforts in STEM disciplines. The demonstration of training protocols will be conducted through active learning techniques and scientific discovery. This demonstration and model will be critical to design of teaching strategies using aviation and engineering procedures

based on the familiarization with checklists, risk management and mission planning.



Classroom AREN activities at UMES



Vanilla Aircraft's five-day endurance unmanned aircraft mission from the Wallops Flight Facility included four UMES/AREN/Aviation students as part of the flight crew (the next generation workforce in NASA service!)

University of South Florida (USF)

The University of South Florida continues to incorporate NASA technologies in informal and formal educational settings. The collaborative relationship has always focused on impactful initiatives that involve middle school youth and the framing of activities through GLOBE protocols. One other aspect of USF's work has been a focus on engineering design to improve the educational technology. Work has been completed to use NASA technology in formal and informal settings again this year with a novel approach to engineering design for new Aeropods. The design component has focused on developing the project's rapid prototyping capability and framing design activities within a service learning context. The two major initiatives discussed in this report that have been a focus of the USF collaboration are its Bulls-EYE Mentoring outreach program and AEROPOD use in its freshman level design course. The accomplishments of each initiative will be discussed along with ties to the goal of the project.

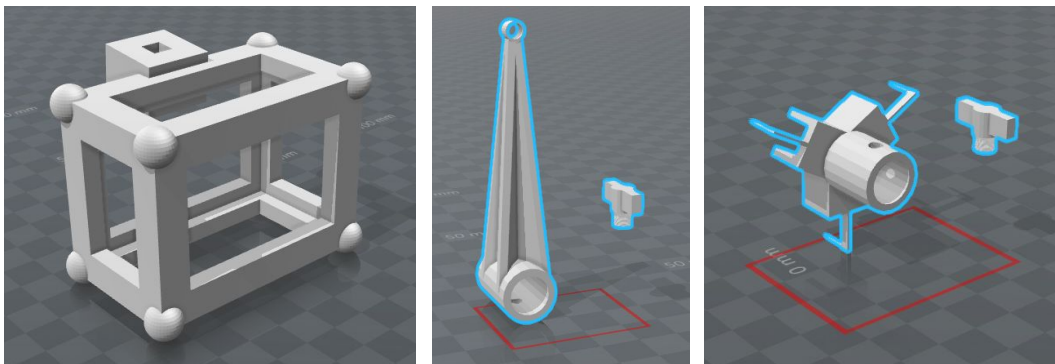
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1. Development of new approaches to learn using NASA technologies: USF's Bulls-EYE Mentoring program developed activities and protocols for AEROPODS. Youth 3D printed and constructed all AEROPODS. The process introduced learning about rapid prototyping to AREN activities. The Bulls-EYE program is 5-weeks during the summer so the USF collaboration also developed a systematic approach to training middle school youth and preparing them for remote sensing tasks. The first week, youth started out with hata training kites and worked with undergraduate students to learn and develop new communication methods in the field. Week 2-3, youth applied those protocols by learning how to fly 9' alpine delta kites. Week 4-5, youth finalized the construction of their AEROPODS and flew these payloads onboard the kites. One challenge the project has is answering the question of how to involve new participants in a safe and robust way. The USF collaboration and experiences this past year help to better understand how middle school youth should be trained.
2. Development of learning plans: New learning plans and approaches were developed in both formal and informal settings. Through the Bulls-EYE summer program, the USF collaboration focused on developing training materials for middle school youth in rapid prototyping. Youth were able to develop the skills to 3D print their Aeropods on their own and adjust settings such as infill and layer height within the software as needed. Activities were also developed around use of the monocam Aeropod. Initial plans were to do some remote sensing;

however, because of time restrictions, the team was limited to teaching the kids about remote sensing and even hosted a video conference with Co-PI's Geoff Bland and Andy Henry on this topic. In formal educational settings, two design teams of six students each were created to redesign the Aeropod. One team's design focused on use of a 3D printer filament called Ninjaflex which would address some of the challenges with Aeropod and camera reliability. Ninjaflex is flexible/rubbery which should protect the front end of the Aeropod and camera from breaking. The second team focused on redesigning the tail of the Aeropod to make it more aesthetically pleasing and effective. Learning plans were developed for these students to go through a design process so one of their deliverables was the CAD files used to make these new designs.

3. Development of hardware tools: Last year, the USF collaboration focused on development of rapid prototyping in support of ROVER. This year, the work of the aforementioned freshman design teams has resulted in novel Aeropod platforms. The new ninjaflex based Aeropod could ultimately combine the efforts of both freshman design teams.

4. Targeting of all ages and socioeconomic statuses: The Bulls-EYE program was created to target middle school kids within a 15 mile radius of the University of South Florida. The program hires undergraduate students so a ration of 2:1 to 3:1 is achieved between undergraduates and middle school youth. This is done in order to specifically target a considerable proportion of youth from underserved backgrounds. The community around USF is approximately 66% free and reduced lunch. Targeted mailers are typically sent out to those that live in this community so participants are diverse. In addition, the USF collaboration successfully targeted participants from middle school to college. With the incorporation of engineering design through the freshman design course, the partnership was able to target students early in their matriculation. In addition, the mentors that are hired for the Bulls-EYE program range from sophomores to seniors.



USF Engineering student designs for Aeropod components

Washington College

Used funds (independent of the NASA AREN program) from the Math Science Partnership program of the Maryland State Department of Education to purchase 20 kite systems to support the AREN program. These systems include 20 Aerokats , 20 V-Tech Aerial Video Cameras, 10 Kestrel Bluetooth Atmospheric Profilers and protective packing for shipping. These represent a shared resource that can be shipped nationwide for AREN partner use in Kites in Technology Education (KITE) programs.

Kites in Technology Education (KITE) has been added to the One Watershed Program Catalog at Washington College. Educators are attending professional development workshops or being showed in one-on-one settings how to bring the KITEs into K-12 classrooms. This has been part of the Professional Development Modules of the NOAA funded Making STEM REAL program. The kites are a shared resource for 22 schools in the Queen Anne's and Kent Counties school system. The shared resources will also be available for use to all ARENS program partners, they must furnish shipping costs. KITE has been delivered to over 20 middle school students in the Maryland school systems.

Educators of the St. Andrews Math and Science STEM school and the leads of Charleston, SC school community were introduced to the AREN Kite program as a pre workshop program as part of the National Marine Educators Association annual meeting.

Washington College received funds from the Math Science Partnership Program and a private donor to create a wireless hub in the STEM Mobile. This will be developed to deliver virtual field trips allowing remote mapping using a TerraRover and AquaRover.

Kites in Technology Education (KITE) has been presented at the National Marine Educators Association Conference in Charleston (June) at the Asian Marine Science Educators Association Conference in the Philippines and at teacher/student workshops in Taiwan (2017). KITE was also presented at the European Marine Science Educators Association conference in Malta (2017). In Taiwan and in Malta, professors who contribute data to GLOBE were engaged.

With the Total Eclipse occurring in Charleston, South Carolina August, 1000 eclipse glasses were shared with middle schools there.

The water quality buoy was launched in the Chester River. Aqua-Rovers are being readied and advanced to test water quality between the buoy and the dock mounted water quality measurement system.

This buoy has been deployed in the Chester River and will be



used to calibrate the Rover sensors against the Hach HP3 Sonde in the Buoy.

Independent of the NASA-ARENS project funds, A Hach HL4 was purchased and will be integrated on a prototype Aqua-Rover Pro, a waterborne water quality measurement system. The goal is to test the Vernier/Pasco probes against scientific probes approved to report data to federal data portals (NOAA).

Assistance was provided to the test launch and pilot of the Aqua Rover X5 in the Anacostia River.

Wayne RESA

Wayne RESA is the fiscal agent for the AREN Project. As such, quarterly meetings are held with the Finance Department at Wayne RESA. Partner specific activities include:

- Coordination with the GLOBE Program
- Scientific Literacy - Alignment with the Next Generation Science Standards
- AEROKAT and ROVER development, testing and training
- Training and supporting local middle and high school cohorts
- Website design and maintenance

The PI attended the GLOBE North American Regional Meeting (NARM) at the University of Arkansas. The PI and CO-PI attended the 21st Annual Globe Conference in New Haven, CT. The AREN Project went online at:

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

AREN educator presentations were given at the GLOBE NARM meeting; Wayne County Science Leaders Meeting; Wayne County Engineering Share-a-Thon; Michigan Science Teachers Association Conference; National Science Teachers Association Conference; Annual GLOBE Conference; Madonna University; and the Metropolitan Detroit Science Teachers Association Conference reaching an audience of over 300 educators.

AREN student presentations were given at the Rouge River Water Festival; Wayne County Green School Celebration; and the Odyssey of the Mind International Event reaching an audience of nearly 300 students.

The AREN Project developed a cohort of middle and high school teachers in the Rouge Education Project and the Gibraltar School District. The purpose of this cohort is to support their current work in water quality testing and integrate GLOBE and the AREN Project into their defined work. Testing took place during the Spring and Fall. It was aligned to coincide with the Rouge River Water Testing Weeks. The following tasks took place during this project: Aerial Imaging of Study Site; Collection of Atmospheric Data; Collection of Digital Data from Water Samples; and Entry of Data into the GLOBE Database. Equipment used includes AEROKAT Kite Systems, WindMate Weather Meters, LabQuest 2's, and Vernier Probes. GLOBE protocols used

by this cohort include those dealing with the Atmosphere and Hydrosphere. Hydrosphere protocols will include: Conductivity (Total Dissolved Solids); Dissolved Oxygen; pH; Salinity (just to test in fresh water, not part of the Rouge Education Project); Study Site: Temperature, and Turbidity (water transparency). The AREN PI and CO-PI assisted 10 schools, composed of 13 teachers and 300 students with the testing of the Rouge River water quality testing. The Rouge Education Project “Year in Review” report, with data from “AREN Schools,” can be found at:

<https://docs.google.com/viewer?a=v&pid=sites&srcid=dGhlcm91Z2Uub3JnfGZyaWVuZHMtb2YtdGhlLXJvdWdlfGd4OjVkJmExNjNlYmVmMTc5Y2Y>



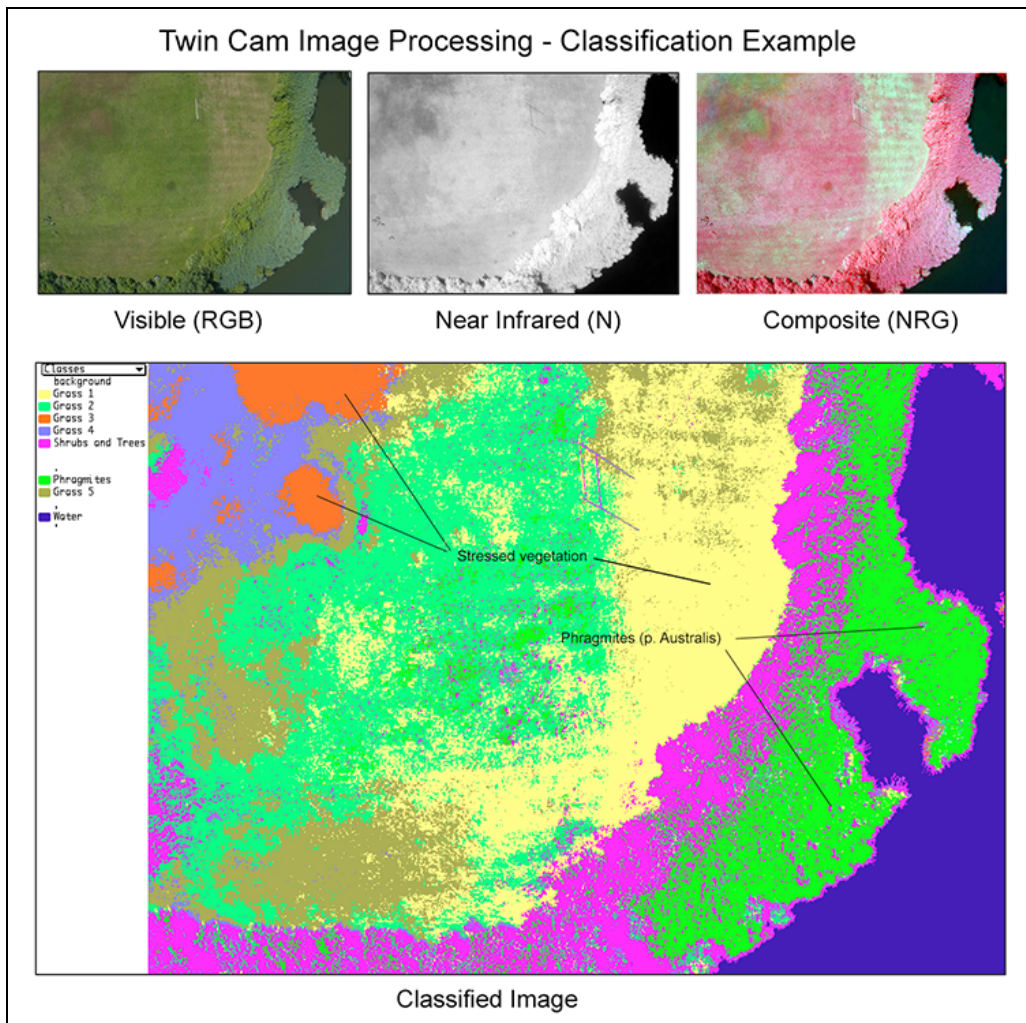
The PI helped with the coordination of the Midwest GLOBE Regional Science Symposium and accompanied 20 students from Michigan to share their research. Wayne RESA was selected to host the 2018 Midwest GLOBE Regional Science Symposium at Wayne State University in Detroit. Anil Aranha, evaluator, will be the liaison between AREN and the University.

Wayne RESA ordered and distributed 3,000 pair of Eclipse glasses to the AREN team and educators and students across Michigan. They also supported 12 Eclipse 2017 events across the Metro Detroit region impacting over 1000 citizens. Wayne RESA also produced three podcasts on Eclipse 2017, as part of the “K12 Science” and “Middle School Matters” podcasts. The CO-PI shared and participated in Eclipse events at PARI (Pisgah Astronomical Research Institute).

Wayne RESA distributed 30 Earth Science Week Toolkit packets to earth science educators throughout Michigan.



MonoCam image of Hammonasset Beach State Park during GLOBE Annual Meeting



TwinCam aerial image classification from GLOBE Annual Meeting in New Haven CT

III. Status/Changes/ Issues

The only changes that took place during 2017 were staff changes. Personnel changes, associated with the AREN Project, occurred at:

- Chesapeake Bay Environmental Center - personnel change: Quinton replaced Spongberg
- Goddard Space Flight Center - added Ruffy for 3D printing support and Campbell for GLOBE and AREN Outreach
- Public Lab - personnel change: Warren replaced Lippincott

The impact of these changes on the AREN Project was generally positive in aggregate.

There are no major issues impacting the AREN Project, at this time.

IV. Dissemination Activities

AREN team members have been active in disseminating the AREN Project throughout the community during 2017. The following dissemination activities have taken place:

January - April -- Aviation 310 at the University of Maryland Eastern Shore (Willie Brown, Chris Hartman, Geoff Bland) in Princess Anne, Maryland *20 students participated in this course*

January 11 -- AREN Project Lightning Talk (David Bydlowski) at the GLOBE NARM Meeting in Northwest Arkansas *Thirty educators attended this presentation.*

February 7 -- "Joining the GLOBE Program" (David Bydlowski) at the Wayne County Science Leaders Meeting in Wayne, Michigan *Twenty-nine educators attended this presentation.*

February 23 -- "AREN Engineering" (David Bydlowski) at the Wayne County Engineering Share-A-Thon in Wayne, Michigan *Eighteen educators attended this presentation providing the following Evaluation of Meeting*

March 24 -- "Explore Environmental Phenomena with NASA's AREN Project" (David Bydlowski and Andy Henry) at the Michigan Science Teachers Association Conference in Novi, Michigan *(Approximately 28 educators attended this presentation providing the following Evaluation of Meeting.)*

March 24 -- "Earth Science Explorations Using Airborne and Ground Based Instrumentation" (David Bydlowski and Andy Henry) at the Michigan Science Teachers Association Conference in Novi, Michigan *(Approximately 18 educators attended this presentation providing the following Evaluation of Meeting.)*

March 24 -- "GLOBE Teacher Training Workshop for Middle and High School Teachers" (David Bydlowski and Andy Henry) at the Michigan Science Teachers Association Conference in Novi, Michigan *(Approximately 12 educators attended this presentation providing the following Evaluation of Meeting.)*

March 31 -- "Earth Science Explorations Using Airborne and Ground-Based Sensors" (David Bydlowski) at the National Science Teachers Association Conference in Los Angeles, California *(Approximately 16 educators attended this presentation providing the following Evaluation of the Meeting.)*

April 1 - 30 -- National Kite Month

April 1 -- "AREN: Doing Team-Based Field Investigations with a GLOBE Earth Science Partner" (David Bydlowski) at the National Science Teachers Association Conference in Los Angeles,

California *(4 educators attended this presentation providing the following Evaluation of the Meeting.)*

April 11 -- "Eclipse 2017" (David Bydlowski and Andy Henry) at the Wayne County Science Leaders Meeting in Wayne, Michigan *(Approximately 25 educators attended this presentation providing the following Evaluation of the Meeting.)*

April 22 -- Earth Day/Kite Flying (Jonathan Gaines) at the University of South Florida, Tampa, FL

April 28 - 30 -- Maryland International Kite Expo (CBEC team attending), Ocean City, Maryland

May 3 -- Rouge Education Project Water Testing (David Bydlowski and Andy Henry) with Clippert Multicultural Honors Academy, Detroit and Chandler Park High School, Harper Woods *(Approximately 60 students attending the water testing day, along with two teachers.)*

May 4 -- Introducing the ROVER Using "Old School and New School" to Measure the Physical Factors Affecting Fish in the Rouge River at the Rouge River Water Festival (David Bydlowski) for 5th Grade Students from Summit Academy North, Belleville; Johnson Elementary, Livonia; Howard Elementary, Dearborn and Snow Elementary, Dearborn at the University of Michigan-Dearborn Campus. *(Approximately 147 students attended this presentation, along with 5 teachers.)*

May 10 -- Rouge Education Project Water Testing (David Bydlowski and Andy Henry) with Inter-City Baptist, Allen Park; Garden City High School, Garden City and Huron Valley Lutheran School, Westland, MI *(Approximately 90 students attending the water testing day, along with five teachers.)*

May 11 -- NASA GSFC Activities at UMES for AVSC 310 (Willie Brown, Chris Hartman, Geoff Bland) at the University of Maryland Eastern Shore, Princess Anne, Maryland

May 16 -- Wayne County Green School Celebration (David Bydlowski) hosted by the AREN Project at Wayne RESA in Wayne, Michigan

May 17 -- Rouge Education Project Water Testing (David Bydlowski and Andy Henry) with Pierce Middle School, Redford Township *(Approximately 30 students attending the water testing day, along with two teachers.)*

May 19 - 20 -- Midwest GLOBE Regional Science Symposium (David Bydlowski) at Purdue University in Lafayette, Indiana *(Approximately 22 Michigan students attended, along with four teachers and two parents.)*

May 25 -- Odyssey of the Mind International Event NASA Classroom (David Bydlowski and Andy Henry) at Michigan State University in East Lansing, Michigan *(Approximately 45 students attended, along with approximately 30 adults)*

May 29 -- AREN Project cited in the Huron Valley Lutheran e-News School Newspaper from Huron Valley Lutheran High School in Westland, MI.

June 22 -- AREN mentioned in GLOBE's "Tip of the Week."

July 6 -- Flying Kites with the AREN Project, at Montana State University in Bozeman, MT. (Suzi Taylor, Kelly Boyce) (9 educators attended)

July 18 -- "Reach for the Stars" Worchester County Middle School Summer Program (Geoff Bland, Brian Campbell, Ted Miles, and Kay Rufty) at Wallops Island, VA. (21 students attended)

July 30 - August 3 -- "21st Annual GLOBE Conference" in New Haven, CT. (9 AREN Project members attended and contributions are highlighted in the embedded file.)

August 1 -- "CBEC Partners with NASA to Offer STEM Program" -- Article in the Star Democrat (with Judy Wink and Hannah Spongberg)

August 1 -- "Balloon/Kite Aerial Photography and Drones and How They Enhance Our Understanding of Science and the Environment, with Demonstration" (David Bydlowski and the AREN Team) at the 21st Annual GLOBE Annual Conference in New Haven, CT. (approximately 40 participants)

August 3 -- "GLOBE Alignment with NASA Resources" (David Bydlowski and the AREN Team) at the 21st GLOBE Annual Conference in New Haven, CT. (Approximately 35 participants)

August 14 -17 -- Northwestern High School Gains in Education in Math and Science AEROKAT Line Handling Design Challenge Hands-On Learning Experience (Sallie Smith)

August 21, 2017 -- Eclipse 2017 AREN Supported Event Locations:

- Plymouth District Library, Plymouth Township Park by the 4 Seasons Pavilion in Plymouth, MI, please contact Valerie Leveille.
- St. Andrews School of Math and Science (980 students) in Charleston, SC, please contact Doug Levin.
- Cesar Chavez Academy Middle School (over 500 students) in Detroit, MI, please contact Veronica Mroz.
- Boy Scouts Troop (50 Scouts) in Warren, MI
- Davis Junior High Raider Day (60 Students) in Sterling Heights, MI
- Wixom Christian School (30 Students) in Wixom, MI
- Maranatha Christian Academy (24 Students) in Windsor, Ontario
- Thirkell Elementary School (25 Students) in Detroit, MI
- Centerline Public Schools (25 Staff) in Centerline, MI
- Crestwood High School (40 Students and Community Members) in Dearborn Heights, MI
- Detroit Academy of Arts and Sciences (120 students and staff) in Detroit, MI
- Wayne RESA (200 staff and visitors) in Wayne, MI

- AEROKATS Flight Event and Mini Workshop (Geoff Bland, Brian Campbell, and Andy Henry) at PARI (Pisgah Astronomical Research Institute), Rosman, NC

September 6 -- Bozeman, Montana/Montana State University -- (Suzi Taylor) Met with visitors from Rikkyo University, in Tokyo, who are interested in university outreach. Shared information about several MSU projects, including AREN. Japan has a huge kite-flying culture, and they were quite interested in the project.

September 17 - 19 -- Seattle, WA / National Girls Collaborative Forum: (Suzi Taylor) Shared information about Montana outreach projects including AREN, with members from across the country. NGC brings together organizations throughout the United States that are committed to informing and encouraging girls to pursue careers in STEM.

September 28 -- Anacostia River ROVER Test (Sallie Smith, Geoff Bland, Doug Levin and 3 other participants) in Maryland.

October 4 -- Rouge Education Project Fall Water Quality Monitoring (David Bydlowski) with Crestwood High School, Dearborn Heights, and Huron Valley Lutheran High School, Westland, MI (Approximately 60 students attending the water testing day, along with three teachers.)

October 5 -- Rouge Education Project Fall Water Quality Monitoring (David Bydlowski and Andy Henry) with Clipper Multicultural Academy Middle School, Detroit, and Chandler Park Academy High School, Harper Woods, MI (Approximately 60 students attending the water testing day, along with three teachers.)

October 17 -- GLOBE Training for Pre-Service Teachers (David Bydlowski) at Madonna University, Livonia, MI (10 pre-service teachers).

October 19 -- Community Science and Public Lab (Jeff Warren) an Online Presentation to the seven NASA CAN Awards within the Earth Science Mission Directorate (18 participants)

October 19 -- NASA AEROKATS and ROVERS Education Network Educator Workshop (Suzi Taylor and Kelly Boyce) at Montana State University, Bozeman, MT (Approximately 25 educators will attend)

November 11 -- "Grade 3 Weather and Climate with Elementary GLOBE Resources" (David Bydlowski) at the Metropolitan Detroit Science Teachers Association Conference in Warren, Michigan

November 11 -- "Aerial Exploration of Environmental Study Sites Using Kites, Cameras and Other Sensors" (David Bydlowski and Andy Henry) at the Metropolitan Detroit Science Teachers Association Conference in Warren, Michigan

It is too early in the project to do a research paper, but the work has been cited in newspaper articles. Examples include:

August 1, 2017 -- "CBEC Partners with NASA to Offer STEM Program," The Democratic Star --
http://www.stardem.com/life/article_0c4bd7af-b5f7-5156-b18b-a0b408e36cbb.html

The Chesapeake Bay Environmental Center, in a cooperative agreement with NASA, added a cutting-edge STEM educational program to its educational endeavors. This program is designed for middle and high school students.

The program comprises environmental sampling techniques using NASA-approved equipment and associated technology. Students will learn types of equipment and computer-related devices for sampling the local atmosphere and water. The students will collect, interpret and record data for use by scientists, institutions, agencies and general citizenry. The local data will be downloaded to the Global Learning and Observation to Benefit the Environment website at GLOBE.gov and will be available for researchers worldwide.

August 28, 2017 -- "Dearborn Heights Teen Spent Summer Interning with NASA Program,"
Press and Guide --
http://www.pressandguide.com/news/dearborn-heights-teen-spent-summer-interning-with-nasa-program/article_721d8a18-9809-5c9d-a7ff-26dd98186978.html

In late May, Crestwood High School (a Rogue Education Project school) sophomore Sara Komaiha received the news she had been anxiously waiting to hear for two months.

"I was so excited," she said. "I was actually at lunch going through my emails, and I saw it, and I was like, 'Oh my gosh, no way.'"

The news Komaiha received that day was her acceptance into the STEM Enhancement in Earth Science Summer Intern Program. Sponsored by NASA, the Texas Space Grant Consortium and the University of Texas at Austin Center for Space Research, the program offers incoming high school juniors and seniors across the country the chance to study NASA satellite data while working with engineers and scientists in their chosen field.

August 31, 2017 -- "Keeping Track: Crestwood Students Monitor Environment During Eclipse Project," Press and Guide --

<https://www.globe.gov/documents/23174792/24151782/KeepingtrackCrestwoodstudentsmonitorenvironmentduringeclipseproject.pdf/72f52e5e-4f94-4262-8d7b-510893b0625e>

Most people who watched the recent solar eclipse merely grabbed a pair of safety glasses and enjoyed the view. Not so for a group of Crestwood High School students.

The science students busied themselves collecting all sorts of environmental data as part of NASA's citizen science Total Solar Eclipse project through the Global Learning and Observations to Benefit the Environment Program.

Diana Johns, a Crestwood science teacher, led the effort and recruited student coordinators Leanne Alawieh and Ali Eter to round up volunteers for the research study.

About 30 students gathered at the high school to collect data both the day before the eclipse and during the Aug. 21 celestial event.

V. Evaluation, Collaborators and Cross-Collaboration Agreements Activities

AREN Project Evaluation - Anil Aranha, PhD, AREN Project Evaluator

The purpose of this report is provide an Annual Evaluation of the AREN Project for the year 2017. The AREN Project has been operational for a total of 18 months. Given the diverse nature of the nine Partner Institutions and the efforts of the Project Leadership Team in directing and streamlining project implementation, the accomplishments of the AREN Project Partnership Group towards NASA SMD's stated Project Goals are noteworthy.

On the basis of the 2017 activities, the AREN Project Impact Indicators are summarized below:

- 1) Societal: 3,400 individuals (General Public) at 14 Eclipse and 2 Earth Day/Kite Flying Events.
- 2) Education: i) *School Level* - 1,100 Students/Adult Learners, Parents and Teachers participated in GLOBE Science Symposia, Water Quality Testing and AEROKATS, providing course satisfaction evaluations; ii) *University Level* - 2 Undergraduate Aviation/Engineering Courses developed and offered to 40 Students, providing excellent course evaluations, 200 Science/Engineering students participated in presentations related to AEROKATS, Terrakites, and ROVERS; 4 Students participated as Flight Crew of 5-day unmanned flight of Vanilla Aircraft; iii) *Training* - 100 Educators trained, in classroom or virtually, on AEROKATS and GLOBE program implementation.
- 3) Product Development: i) Two Undergraduate Aviation/Engineering Courses; ii) AEROKATS Launch Video and Check-List; iii) Prototypes for AeroPods (Profilers, MonoCams, TwinCams, ThermoPods, MiniPods, VideoPods, AlbedoPods, ThermoCams, Anasonde Profiler) and ROVERS (X-5s, X-6s).

During the year 2017, the varied activities of the AREN project partnerships towards NASA SMD stated goal - 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 – clearly resulted in some significant achievements.

AREN Project Highlights: 1) Scientific impact on about 5,000 individuals, both formally and informally, 2) Development of University Level Aviation/Engineering Courses, 3) Production of a professional AEROKATS Launch Video / Check-List, and 4) Development of Prototypes for AeroPods and ROVERS and product evaluation for mass production of components.

However, a few challenges to successful AREN project implementation - which are on-going being addressed - remain.

AREN Project Challenges: 1) Quantifying the Scientific Impact of AREN Project and GLOBE Socially, 2) Enhancing the Role and Impact of some of the Partner Institutions, and 3) Development of appropriate instruments for quantifying and measuring outcomes at partner institutions.

In conclusion, it must be stated that considering the limited time the AREN Project has been operational, the diverse nature of the Partnerships, and the narrow window (< 100 days) to demonstrate or perform some of the Project activities, especially involving AEROKATS, the performance of AREN project towards the NASA SMD objectives has been reasonably good. Nevertheless, with greater participation of AREN Partners and implementation of other AREN Project activities, particularly ROVERs-related, an enhancement of performance during the forthcoming year is anticipated.

In addition to this formal evaluation, some AREN Project participants shared their thoughts on the project and also communicated how the project impacted them.

Josh Hubbard, AREN teacher at Inter-City Baptist School in Allen Park, MI:

Students are trying to answer a question about the cleanliness of river water and potential sources of pollution. The AREN Project requires students to get out into the field to gather data and then share that data with other people so the combined information can allow us to make informed decisions. The AREN Project also allows us to make use of actual data so that we can meet Next Generation Science Standards and school goals.

Alissa Quinton of the Chesapeake Bay Environmental Center:

The AREN project has taken science out of the classroom and into the field. This project of gaining science experience while operating new generation technologies fits the curriculum for grades 6th-12th. It is through our trial and error of this project that we have found that grades 6th-12th work best for our classes. These grade levels have a better comprehension of the use of the Rover for water monitoring the site's ponds. The students survey the diversity in the sites ponds using the field instruments to collect data. AREN's approach to hands on learning is one of many ways that science is making sense to the students. The NASA technology is taking science to the next level and students are excited to learn, work the equipment and analyze the data for solutions to real-life issues. The use of a real world setting and allowing students field opportunities are beneficial for retaining the knowledge of what they have learned using resources from the AREN program.

Daniel Hunte, Student at the University of Maryland Eastern Shore

The AREN Project was a new experience for me. It gave me a chance to learn and experience first-hand the process of research and gathering data. I enjoyed flying the kites and discovering which ones worked the best in which conditions. Thinking of new places to take the kites made me think in a more creative way. I learned that research is not always easy and that you will fail more times than succeed. In addition, I learned that kites can be a very effective way in gathering images and videos with the right equipment and weather conditions. I highly recommend the AREN Project for someone who is interested in research.

Austin Anderson, Student at the University of Maryland Eastern Shore

It has been one of the greatest pleasures in recent memory to take part in the AREN Program. When I initially began working with Mr. Geoff Bland during the Remote Sensing course at University of Maryland Eastern Shore, I don't think I realized it would grow into more than just a regular class. As time passed, I quickly learned that this would be one of my favorite courses ever. Most classes simply prepare you for a test and don't make a lasting impact as a result. The practical, hands on experience with the Remote Sensing course, and later working with a team on the AREN program, will stay with me for many years after I have graduated for several reasons.

Geoff Bland is a fantastic teacher and mentor, and I cannot commend him enough for his ability to articulate complex issues or concepts and present them in a manner that is easy to grasp and digest, and it is easy to see that he is rather passionate about educating others. Next, working in the field and getting hands on experience has a much greater impact on learning ability than anything else I've done. Perhaps this is because of my learning style, which is learning by doing, but I can recall almost every instance in which we set out with a goal and either met, or did not meet, expectations and what we learned. Last, but definitely not least, is we had to figure things out ourselves. This may go back to Mr. Bland being an excellent teacher, but the idea that he gave us a task to accomplish with a deadline, and then offered nothing more unless asked, goes a long way to cement this opportunity as truly unique. It was the first time I had the chance to put my own skills to the test and see if I could cope in a real world scenario, and adapt to any issues that arose in a timely manner. It was expected our teamwork, procedures and results were up to a certain standard, and then we were encouraged to raise the bar each time we did something. It allowed me to explore the various methods that could be used to lead a team and experiment to see which suited me best, allowing me to grow as a leader. None of this would have occurred if I had not been granted this opportunity.

In conclusion, working with Mr. Bland and the AREN Program has been one of, if not the single most beneficial opportunity I have had during my time at college thus far. I learned a great amount, not just about the AREN Program and what it does, but a lot about myself and those that I worked with, and I would encourage anyone to take advantage of the experience. I would like to take this chance to say that I am truly grateful for the opportunity I was given to participate in the AREN Program.

Evidence of results and impact of the AREN Project are identified in a case study:

Shumate Middle School -- Gibraltar, MI

Jeff Bouwman is a teacher of sixth and seventh grade students at Shumate Middle School (Gibraltar School District) in Gibraltar, MI. In the Spring of 2017, Jeff Bouwman joined forces with the Rouge Education Project to begin working on the AREN Project, bringing with him, two other teachers from the Gibraltar district. Shumate Middle School students are now taking aerial images and doing remote sensing while flying kites. Jeff is also an active GLOBE teacher. His students have collected over 60,000 data entries for the GLOBE database. Students at Shumate also interacted with Brian Campbell, from NASA, for multiple video-conferences during 2017. Students participated in the 2017 GLOBE International Virtual Science Fair with their project entitled "El Nino Comparison Project" -

<https://www.globe.gov/documents/10157/043363c2-0f30-49df-91e6-1ff24d3ff8cb>

AREN Flights can be viewed at:

<https://www.youtube.com/watch?v=vndk3Vleh0o&index=2&list=PL9mRHbnzUcezW6ON3Ho1J5dFlanHtOg0O>

<https://www.youtube.com/watch?v=v4pNuyel798&index=3&list=PL9mRHbnzUcezW6ON3Ho1J5dFlanHtOg0O>



Jeff's hashtag is [#GettingScienceDone](#)

The AREN Project continues its partnerships with SMD co-collaborations. They include:

- American Museum of Natural History -- "OpenSpace: An Engine for Dynamic Visualization of Earth and Space Science for Informal Education and Beyond"
- Institute for Global Environmental Strategies -- "NASA Earth Science Education Collaborative"
- Maine / Gulf of Maine Research Institute -- "Real World, Real Science: Using NASA Data to Explore Weather and Climate"
- NSO / Association of Universities for Research in Astronomy, Inc. -- "TE 2017: Geographically Distributed Citizen Scientist Training for the 2017 Citizen CATE Experiment"
- Southwestern Community College -- "TE: Smoky Mountains STEM Collaborative: Bridging the Gaps in the K-12 to Postsecondary Education Pathway"
- University of Alaska, Fairbanks -- "Arctic and Earth Signs"
- University of Colorado, Boulder -- "Enhancement of Astronomy and Earth Science Teaching Using High Resolution Immersive Environments"
- University of Toledo -- "Mission Earth: Fusing GLOBE with NASA Assets to Build Systemic Innovation in STEM Education"
- University of Washington, Seattle -- "Northwest Earth and Space Sciences Pipeline" (NESSP)

Cross - collaboration activities have included:

- The AREN Team attended the 2017 GLOBE Annual Conference.
- AREN attends quarterly meetings with GLOBE Liaisons, and has regular GLOBE phone conferences.
- AREN is in contact with "Mission Earth" and "Arctic and Earth Signs," regularly, to align with GLOBE and SMD. AREN, Mission Earth, and Arctic and Earth Signs collaborated to give presentations at the GLOBE Annual Conference, the National Science Teachers Association Conference and the Michigan Science Teachers Association Conference.
- AREN participates in monthly "Earthlings" Phone Conferences, which include all of the Earth Science and GLOBE collaborating CAN Awardees.
- AREN is part of the new SMD MakerSpace group which is developing.
- AREN participated and coordinated extensive work in 2017 during the Eclipse 2017 Collaborations.
- AREN is connecting NASA Wavelength resources in collaboration with the NASA Earth Science Education Collaborative.
- AREN distributed 30 Earth Science Week Toolkits because of SMD collaboration.
- AREN is developing "Engineering Challenges" for the SMD community and beyond.
- AREN is in preliminary meetings with WGBH to integrate AREN field studies into the virtual world provided by WGBH.

VI. Known Future plans

The AREN Project is looking forward to the future in 2018. Below is a list of some of the major plans for 2018:

- Emphasis on Evaluation Development
- ROVER Implementation for 2018: X-7 Aqua ROVER Prototypes underway, Terra ROVERS under development
- Hosting the 2018 Midwest GLOBE Student Science Symposia at Wayne State University School of Medicine in Detroit, MI
- Assisting with the 2018 Northwest GLOBE Student Science Symposia at Montana State University in Bozeman, MT
- Development of 3D printing capabilities and programming - integration of makerspace concepts (design and engineering) into AREN project - work with Makerspace collaborators
- Anasonde Profiler and Thermocam Development
- Implementation of Kite Physics
- New training cohorts -- Phase II
- Integration of AREN atmospheric data with weather stations, weather websites and the GLOBE database
- New technology tools -- Wind Tunnels, Lens Distortion Tools
- Development of AREN “Challenges”
- Increased partnership with WGBH to bring the “hands on of AREN” to the virtual world of WGBH.
- Earth Science Online Course for Educators will debut in 2018.