INSPIRE
INTERACTIVE NASA SPACE PHYSICS
IONOSPHERE RADIO EXPERIMENTS

The INSPIRE Journal

VOLUME 22 SUMMER / FALL 2016

A publication of The INSPIRE Project Inc.

Contents

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Letters and submissions for *The INSPIRE Journal* should be emailed to:
Editor@TheINSPIREProject.org

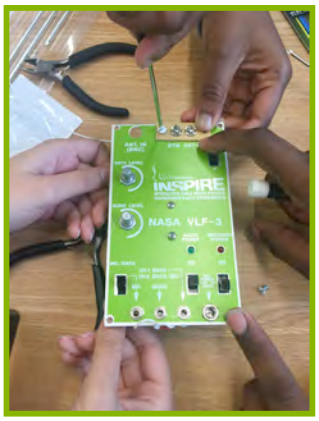
INSPIRE'S LEGACY
Dr. William (Bill) W. L. Taylor was a leader in the field of space science education and public outreach. He co-founded and was president of INSPIRE, one of the pioneering successes in NASA Sun Earth Connection Education. NASA Goddard Space Flight Center honored the late William W. L. Taylor with an *Excellence in Outreach in Science* Award for his accomplishments.

MISSION
The INSPIRE Project Inc. is a non-profit scientific, educational corporation whose objective is to bring the excitement of observing natural and manmade radio waves in the audio region to high school students. Underlying this objective is the conviction that science and technology are the underpinnings of our modern society, and that only with an understanding of science and technology can people make correct decisions in their lives, public, professional, and private. Stimulating students to learn and understand science and technology is key to them fulfilling their potential in the best interests of our society. INSPIRE also is an innovative, unique opportunity for students to actively gather data that might be used in a basic research project.

- William W. L. Taylor and William E. Pine, Co-Founders

In 2006, The INSPIRE Project's mission was expanded to develop new partnerships with multiple science projects. Links to magnetospheric physics, astronomy, meteorology, and other physical sciences are continually being explored.

From the Managing Editor



Eva Kloostra

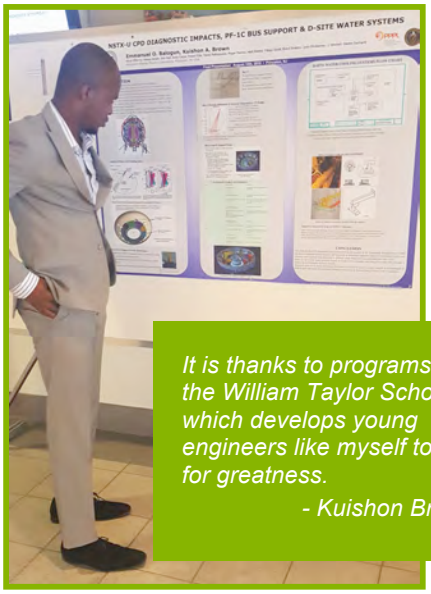
Twenty-seven years ago in Redondo Beach, California, a NASA space scientist and a high school teacher had a vision to engage our youth in Science, Technology, Engineering and Mathematics (STEM) disciplines by "bringing the excitement of observing natural and manmade radio waves in the audio region to students". Today over 3,300 INSPIRE VLF (very low frequency) radio receiver kits have provided students around the world a hands-on opportunity to experience the sounds of space.

INSPIRE's VLF-3b kit continues to be incorporated in middle and high school science curricula, as well as university programs both nationally and internationally. In July 2016, INSPIRE partnered with Howard University to sponsor workshops during their summer STEM program in Washington, DC. Teams of high school students assembled INSPIRE VLF radio receiver kits with Howard faculty, staff, and undergraduate/graduate student mentors. INSPIRE's Board President Dr. Phillip Webb provided an overview of VLF and the kit prior to assembly, and discussed STEM career opportunities with the students.

INSPIRE President Phillip Webb presenting VLF to students at Howard University's summer program (Photo courtesy of Timothy Brown)
Below: Students assembling INSPIRE VLF-3b receiver kits (Photo courtesy of Karin Edgett)

Interest in VLF radio continues to increase both nationally and globally, and will most likely spike on August 21, 2017 during the first total solar eclipse in North America since 1979. A special thanks to Mitzi Adams of NASA Marshall Space Flight Center for her submission on this epic event, which includes preliminary information on coordinated VLF observations *(see page 20)*.

INSPIRE's educational STEM programs for middle/high school educators, students, and college/university students continue to expand. To date, INSPIRE has awarded 108 STEM scholarships and internships thanks to the generous support of program sponsors, partners, friends and volunteers.



It is thanks to programs like the William Taylor Scholarship which develops young engineers like myself to strive for greatness.
- Kuishon Brown

In INSPIRE's 2015-16 teacher survey, 100% of Space Academy for Educators scholarship recipients reported that they are utilizing materials and knowledge acquired via the program in their classrooms – directly impacting 2,700 students in 27 Washington, DC area schools *(see page 15)*.

In 2010, the Space Academy for Students program launched. Two of the first scholarship recipients to attend INSPIRE's Space Academy for Students at the US Space & Rocket Center in Huntsville, Alabama are now both computer science majors in college. The brother and sister team developed an app this year to 'tackle' a social issue on campus *(see page 14)*.

In July 2016, INSPIRE awarded the 2016 William Taylor Scholarship to Kuishon Brown, an engineering student at Howard University *(pictured left at Princeton University during his 2016 summer internship in the Plasma Physics Lab)*. All *Journal* submissions by program recipients convey how each of the programs are exciting, engaging and attracting students to STEM disciplines.

On behalf of the Board of Directors, thank you to our friends, colleagues, volunteers and corporate partners for your continued support of The INSPIRE Project's mission of inspiring our next generation of scientists and explorers.

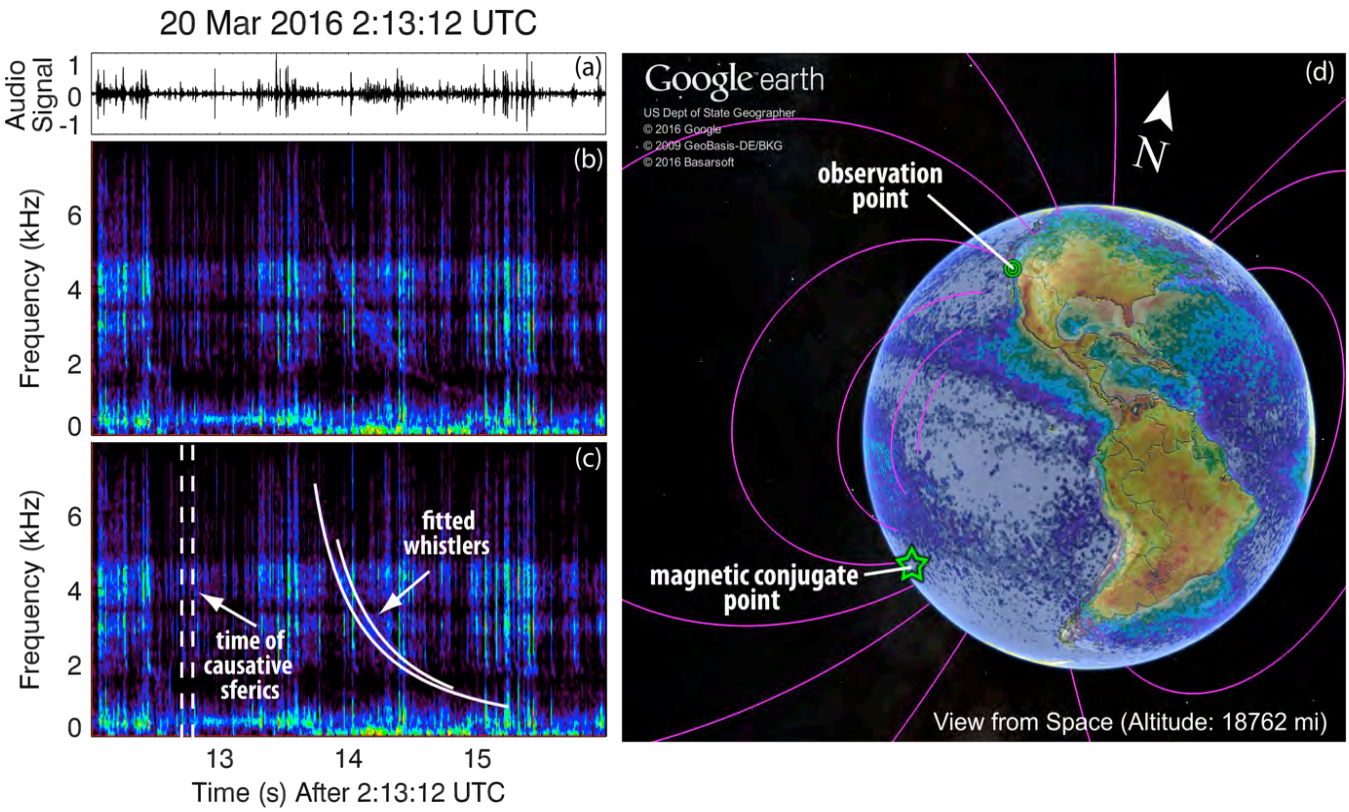
Special thanks to INSPIRE Advisors Dennis Gallagher, Mitzi Adams and Leonard Garcia for technical editing; Jay Friedlander for providing the cover image (NASA photo taken from the International Space Station); Gail Breeze for graphic design services; and to all who contributed to this volume of The INSPIRE Journal.

Beginners Luck

Cami Collins

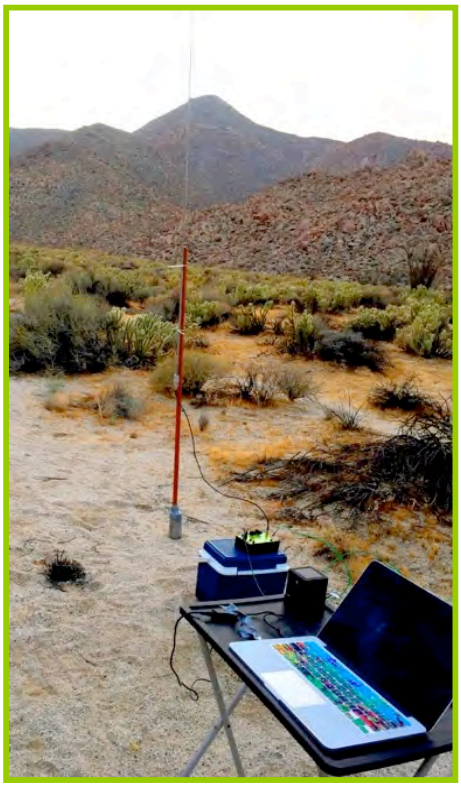
My story begins when I was Christmas shopping for one of my nieces. I couldn't believe it when I googled 'whistler wave kit' and found the INSPIRE website. Who in their right mind would search for such a thing? Well, it turns out I'm a plasma physicist, and I have a niece who loves astrophysics and is on her way to college to major in physics. So, I was looking for a hands-on plasma physics project that could reinforce interest, yet still be fun and let her just enjoy physics in nature. The INSPIRE VLF-3 kit was perfect!

I couldn't stand the idea that my niece might get to hear a whistler wave before I did, so I went ahead and ordered another kit for myself. I completed my soldering just in time for the spring equinox weekend. On March 19, 2016, my husband (who is also a plasma physicist!) and I ventured out into the Anza Borrego desert, just outside of San Diego, CA. We ensured that we were 3 miles away from the nearest power line, propped the antenna up in a yucca plant, and connected the receiver audio-out to a portable speaker. Within the first 5 minutes of turning the thing on, we heard our first whistler wave! The next 3 came in the 30 minutes after sunset. I don't think I'll ever forget hearing my first whistler – it's like seeing your favorite rock band live!



(a) Audio signal recorded from an iPhone and (b) corresponding spectrogram with (c) fitted whistler waves. (d) Observation point and magnetic conjugate along with magnetic field lines (from http://mage-p.org) and an accumulated overlay of global distribution of lightning (from http://thunder.nsstc.nasa.gov).

We managed to record a few whistlers with our iPhones (you can hear it here: https://youtu.be/mfzrZRBk8Tk). The audio quality wasn't ideal, but I was able to convert the recordings to a .wav file and roughly fit the travel time of the whistler wave propagating along a geomagnetic field according to Eq. 4 in [1] using dispersion D_0=70.3 sec$^{1/2}$, nose frequency f_n=12 kHz, and a fairly uncertain 'eyeball' of T, the difference in time between the recording start time and causative sferic. Then, (using the diffusive equilibrium model in [2]), I found the seemingly reasonable parameters where the equatorial radius of the whistler duct was L=3, the local electron density at the geomagnetic equator was n_e=1040 cm^{-3}, and the equatorial electron gyrofrequency was f_{HE}=32.55 kHz (which corresponds to magnetic field strength B=0.0116 Gauss). If you look really closely at the spectrogram, it appears that a second time-delayed whistler propagated in the same duct with the same dispersion, probably originating from a multiflash lightning event.



Refined setup with antenna mounted to a broomstick in a fishing pole holder, with simultaneous recording to computer and audio out through a bluetooth speaker.

With this first impression, whistler wave detecting seemed easy! So, on April 30, 2016 we returned to the desert for a full-out whistler wave camping trip. This time we mounted the antenna to a broomstick supported by a fishing pole holder, listened through the portable speaker, and simultaneously recorded audio directly with a MacBook. We recorded through sunset and into the evening, and again at 5:30 a.m. We heard plenty of sferics and tweaks, but no whistlers.

Most recently, I travelled back to my home state of Montana for the annual camping/fishing family reunion. My niece was ready to test her whistler wave detector, and I figured for sure the northern latitude would be a whistler wave hotspot. At sunset on the evening of July 3rd, we hopped in my dad's pickup truck and drove north of the house a few miles. But, no whistlers! We could see lightning flashing in the distance and the signal was overwhelmed with an incredible amount of sferics and tweaks. Since then, my niece has been listening in her free time, but she's yet to hear a whistler. We're waiting for a good solar storm and hope to record simultaneously. Until then, we enjoy http://abelian.org/vlf/.

Well, I have to say, I haven't studied terrestrial whistler waves in detail, but I have encountered their counterparts in the laboratory. I once worked on a helicon plasma experiment. Helicon waves are low frequency whistler waves in a plasma with bounded geometry. They are often used to efficiently couple RF power to the electrons in order to produce dense, uniform plasmas, which is especially useful for industrial plasma processing. Helicons are also being explored as a means for driving electrical current in tokamak plasmas, which is really important for sustaining the plasma discharge and creating fusion energy.

Another plasma wave that is reminiscent of a whistler is an Alfvén wave. Alfvén waves also propagate along the magnetic field, and in tokamaks they can chirp in frequency. Similar to how whistlers can accelerate charged particles in Earth's radiation belts, Alfvén waves can accelerate fast ions in a tokamak.

It's not so easy to duplicate the absolute plasma parameters of Earth's magnetosphere in a laboratory experiment, but many people have studied the basic mechanisms of whistlers by matching the relevant scaled conditions that govern their behavior. For example, for the whistler measured here, the ratio of the electron plasma frequency to the cyclotron frequency is about 9, which could be created at modest laboratory parameters of n_e=1x10^{10} cm^{-3} and magnetic field strength B=35 Gauss.

Thanks to the INSPIRE VLF-3 kit for inspiring current and future scientists!

Whistler wave hunting with my nieces in northern Montana. Maybe plasma physics runs in the family? Or maybe it's just from growing up stargazing in "Big Sky" country.

[1] Tarcsai, G., *Routine whistler analysis by means of accurate curve fitting*, JATP **37**,1447 (1975)

[2] Park, C.G., *Methods of determining electron concentrations in the magnetosphere from nose whistlers,* Tech. Rep. 3454-1, Radioscience Laboratory, Stanford University, (1972)

About Cami Collins, PhD

Cami Collins is a scientist currently researching fusion energy at the DIII-D National Fusion Facility. She received her PhD from the University of Wisconsin Madison, where she built a laboratory astrophysics experiment to study accretion. Cami loves dogs, coral reef aquariums, and is active in STEM outreach events.

INSPIRE's NASA Goddard Space Flight Center 2016 Summer Interns Report on Research Projects

INSPIRE partnered with NASA Goddard Space Flight Center and the District of Columbia Space Grant Consortium to offer paid internships at Goddard. This ongoing competition is open to District of Columbia undergraduate and graduate college students. During the past five years, INSPIRE has awarded twenty-two NASA GSFC internships. Each intern is paired with a mentor and works on a STEM research project. For more information, visit TheINSPIREProject.org.

Science Directorate (Multimedia)

Blake Teres, American University

I am studying Audio Technology and Computer Science at American University. Thanks to The INSPIRE Project, I had the wonderful opportunity to intern at NASA Goddard Space Flight Center (GSFC) during the summer of 2016. I worked in the multimedia/graphics/video office with Jay Friedlander and Britt Griswold to help with the daily functions of their positions. Some of the things we did included livestreaming, recording, and editing various talks given on GSFC's campus, displaying assorted posters across campus, and setting up events. However most of my time has been spent working on my main project, a video for Science-On-A-Sphere, a spherical video presentation format which is primarily used to show 360-degree images and videos of planets' surfaces. The video is directed towards children, teaching them about Titan, Saturn's largest and Earth-like moon. Being able to work on NASA's GSFC campus is an incredible experience. I got to meet amazing people and watch interesting talks and presentations I would have otherwise been unaware of. Through this experience I have sharpened my video editing and digital design skills, specifically with Adobe Premiere CC and Adobe InDesign CC. This experience has sparked my interest in postgraduate studies to pursue a graduate degree in audio, acoustic, or engineering sciences.

Blake Teres in the Multimedia office at NASA Goddard Space Flight Center

Tiasa Berra with Dr. Leonard Garcia at the NASA GSFC summer interns' poster presentation held in August 2016

Innovative Technology Partnerships Office

Tiasa Bera, Gallaudet University

As I got my acceptance letter from The INSPIRE Project for the Goddard Flight Space Center (GFSC) summer internship, the first question that came to mind was how can a Deaf intern be a great asset for the team. Given my background in the Deaf community, the Deaf community proved to be my safe haven when seeking career guidance. I started working at Gallaudet University, learning how networking is precious and can build trust from the start. As my undergraduate career came near its end, I sought after a job where I would be building relationships between federal agencies and the deaf clients and the interpreters we send from our headquarters. Federal agencies had their own protocol as I learned. After I graduated in May of 2014, I decided to go back to Gallaudet to pursue my master's degree in the Fall of 2015, which led me to The INSPIRE Project to learn about NASA, and how the office functions as a team. My internship title was marketing outreach intern. Marketing is a completely new zone for me, but through my ten weeks at NASA GFSC, marketing has proved to be one of my niches! Communication was the priority in the office for myself as the intern and as a team player in the office. Everyone immediately welcomed me with warmth, and gave me challenging projects to present to the team. Vocalizing my needs for an interpreter, the office honored my request with their efforts of being mindful. The office delegated a responsibility to me where I was able to work with one of the computer scientists, John Schnase, who worked on a product entitled "Modern Era Retrospective Analysis" (MERRA). MERRA is a NASA reanalysis climate database to study the historical trend of climate changes. During my ten weeks at NASA, I was able to understand how NASA products really shape America, where we currently stand as one of the countries which invests the most in

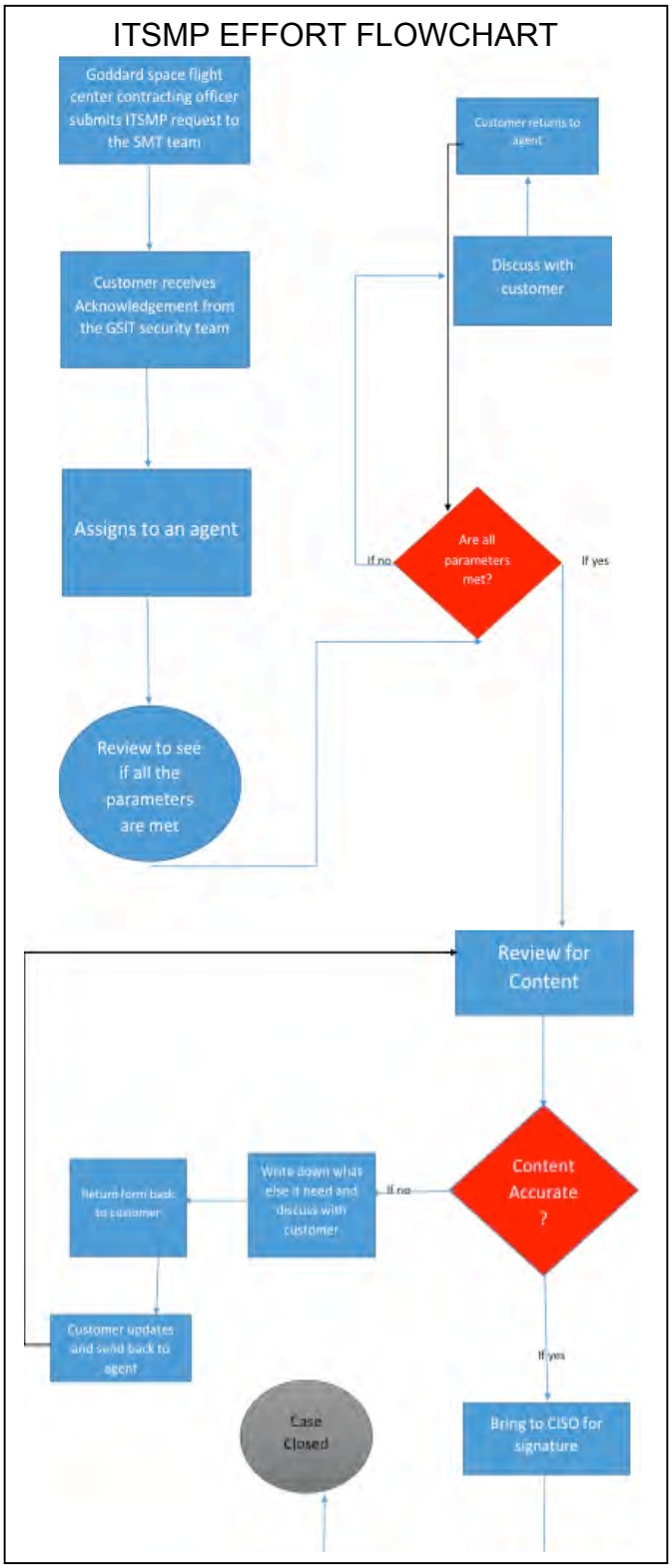
Science, Technology, Engineering, & Mathematics (STEM). MERRA actually helps people make critical decisions in providing the best services for our citizens. For instance, hurricane insurance companies rely on MERRA to make decisions whether their prices should stay the same or increase due to the forecast of the hurricane season based on historical trend analysis. Thanks to The INSPIRE Project, I was able to learn how to edit a tech brief magazine for the Strategic Partnership Office. It was a great honor to read the exciting technology advancement NASA has administered for the last several years. Many thanks to my mentor Erin Majerowicz from the Strategic Partnership Office (SPO) for the guidance in completing my understanding of MERRA along with strong foundations of marketing techniques.

Goldie Brown with Dr. Leonard Garcia at NASA GSFC

Services and Integration Group (CSIG)

Goldie Brown, University of the District of Columbia

As a 2016 summer intern at NASA Goddard Space Flight Center, my project was to develop an Information Technology Security Management Plan (ITSMP) tracking effort. The ITSMP tracking effort details where the customers are in the process, as well as knowing how the ITSMP will mitigate some of the risks to the environment. The purpose of the ITSMP is to ensure that all applicable security requirements are met when the customer/vendor begins contract work at Goddard. How the ITSMP works is that a customer sends in the ITSMP to the Cybersecurity Services Division. The agent is then assigned to review it and to make sure that the parameters are met and the content is accurate. Next it is sent to the Chief Information Services Officer (CISO) for the final approval. The flowchart explains this process in more detail (*see ITSMP Flowchart*). I would like to thank NASA Goddard and The INSPIRE project for the wonderful experience here in this summer internship. I would also like to thank my mentor, Sergio McKenzie, and the Service Management Team-Tammy Tuttle QiAnna Knox, Dan Corso, and Matthew Zipper for ensuring that I had an awesome experience as well as guidance throughout the summer on different types of projects. This summer internship allowed me to learn all about the different aspects of IT and realize that Cybersecurity is most important, especially in today's ever-changing technological world. I also learned how increasingly important communicating with customers is when dealing with Cybersecurity. I plan to pursue my master's degree in IT focusing on how to best show non-technical people how to work the technological complexities of computers and other devices.



Electrical Engineering Division Code 562

Grace Maglieri, Georgetown University

I am a physics major at Georgetown University. I was fortunate enough to be able to participate in my first internship at NASA Goddard Space Flight Center in Code 562. Aside from my project, the intellectual environment was remarkable and challenging, providing a new perspective and enriching my understanding of the Goddard project life cycle and the pivotal role of my department in mission success. My project was to investigate the corrosion of coin silver. I was tasked with determining corrosion rates expected on a component of the Hubble Space Telescope's (HST) gyroscopes due to the presence of certain elements in the gyro fluid. This effort contributes to a larger investigation into failure mechanisms and reliability prediction of the HST gyros, which have failed on-orbit in the past due to the corrosion of the gyroscope's flexible leads. I was responsible for design, testing, and analysis of an experiment which showed a dependable relationship between the conductance of the lead over time in a corrosive environment and the concentration of the corrosive material. Through that and other smaller projects in my department, I learned about the process of research at a more rigorous level. I was exposed to a large variety of testing methods and able to practice different ways of analyzing my sample. I was introduced to the advantages and nuances of each. This experience solidified my devotion to research and inspired me to want to investigate material science further. I have had merely an introduction into the highly complex interactions between metals, and I want to explore more. My experience at NASA has shaped my career plans. I am grateful for this opportunity to explore the possibilities at NASA and I am thankful to The INSPIRE Project for making this possible for me. Within the STEM field, it is important to have access to a variety of opportunities in different labs and fields of research, and this was an important start to my experience.

INSPIRE Annual NASA GSFC Intern Lunch – August 1, 2016

The INSPIRE Project hosts an annual lunch for their NASA Goddard Space Flight Center summer interns to meet, network, and discuss their research projects and experiences at NASA. *(Pictured left to right) INSPIRE Board President Dr. Phillip Webb, Grace Maglieri (intern), Dr. Leonard Garcia of NASA GSFC who volunteers as a Space Physics Advisor for INSPIRE, Blake Teres (intern) and Goldie Brown (intern).*

The INSPIRE Project would like to thank NASA Goddard Space Flight Center and the District of Columbia Space Grant Consortium for their support of this program; the NASA GSFC Education Office for the facilitation of the internship awards; and the dedicated mentors for their inspiration and guidance.

A special thanks to Dr. Leonard Garcia for his assistance with INSPIRE's NASA GSFC Internship Program each summer.

Visit TheINSPIREProject.org for Complete Program Information

INSPIRE Educational STEM Programs

College / University Scholarships

Dr. William W.L. "Bill" Taylor Memorial STEM Scholarship

Scholarship Awards: Up to $4,000 per recipient
Application Deadline: Ongoing

In honor of INSPIRE's co-founder Dr. Bill Taylor, The INSPIRE Project with its partners at the District of Columbia Space Grant Consortium and other science and technology organizations established this STEM (Science, Technology, Engineering, Mathematics) scholarship to help ensure our next generation of scientists and explorers. Undergraduate/graduate and high school seniors who are majoring in a STEM discipline and are currently or will be attending a Washington DC college or university are encouraged to apply.
Apply Online at TheINSPIREProject.org – College/University Scholarships

INSPIRE's co-founders Dr. Bill Taylor (right) and Bill Pine (left)

Eligibility Requirements

All applicants must meet the following requirements and submit the required documents as outlined below:

- U.S. citizenship
- Demonstrate above-average performance in academic work through his/her GPA
- Be registered as a full-time student in good standing at a Washington DC college or university
- Must be majoring in a STEM (Science, Technology, Engineering, Mathematics) discipline
- Submit current transcript
- Submit two letters of recommendation with at least one from a teacher or faculty member
- Submit a 300 to 500 word essay discussing how this scholarship award will help you advance in STEM disciplines and the positive impact it will have on your future career plans

College / University Internships

NASA Goddard Space Flight Center Summer Internship Program

Internship Awards: $6,000 Undergraduate / $7,500 Graduate Students
Internship Session: Early June - Early August (10 weeks, full-time)
Application Period: November - February *(see NASA website for dates)*

With support from the District of Columbia Space Grant Consortium and other partners, The INSPIRE Project offers paid full-time summer internships at NASA Goddard Space Flight Center.

Internship Description

NASA summer internships are educational hands-on opportunities that provide unique NASA-related research and operational experiences for undergraduate and graduate students. The internships integrate participants with career professionals emphasizing mentor-directed, degree-related, real-time world task completion.

NASA Goddard Space Flight Center aerial photo courtesy of NASA

NASA Goddard Space Flight Center Summer Internship Program *continued*

During the 10-week summer internship, participants engage in scientific or engineering research, development, and operations activities. Through these internships, participants leverage NASA's unique mission activities and mentorship to enhance and increase their professional capabilities and clarify their long-term career goals. Upon completion of internships, recipients are required to submit an article on his or her research project for inclusion in The INSPIRE Journal.

Eligibility Requirements

Below are the NASA Goddard Space Flight Center internship requirements:

- U.S. citizenship
- Minimum 3.0 GPA on a 4.0 grading scale
- Applicants must be enrolled full-time in a degree-granting course of study appropriate to NASA's long-term professional workforce needs
- INSPIRE summer internship applicants must be undergraduate or graduate students enrolled at a Washington DC college or university

Applicants must complete the required NASA internship application which includes a letter of recommendation and current college/university transcript

For more information and to apply, visit the NASA internship website:
Intern.NASA.gov

Middle & High School STEM Educators

Kathleen Franzen Memorial Space Academy for Educators Scholarship Program

Weeklong Summer STEM Program at the U.S. Space & Rocket Center in Huntsville, Alabama
Summer 2017 Application Deadline: May 1, 2017

The INSPIRE Project has teamed up with the U.S. Space & Rocket Center, District of Columbia Space Grant Consortium, Washington Space Business Roundtable and other partners to offer Washington DC middle and high school teachers /administrators full scholarships to attend Space Academy for Educators in Huntsville, Alabama.

The weeklong program during the summer includes authentic astronaut training simulators and activities developed to promote learning in a classroom setting. Curriculum includes NASA content and is correlated to the Next Generation Science Standards (NGSS).

Trainees in Space Academy for Educators can earn 45 professional development hours and educators get access to a shared website with lesson plans, networking opportunities, and tips to adapt many of the workshop activities to individual class environments.

Workshop topics/activities include:

- Engineering Design Challenges
- Rocket Construction
- Math Workshops
- Living and Working in Space
- Orion Spacecraft
- Space History
- Mars & the Moon

Teachers participate in two simulated space shuttle missions, simulate walking on the moon and working in the frictionless environment of space on astronaut simulators and weather permitting, spend an afternoon at Aviation Challenge simulating parachute landings and helicopter rescues in the water.

Space Academy for Educators full scholarships include:

- Round-trip airfare from the Washington DC metro area to Huntsville, AL
- Six nights lodging and meals
- Program materials, flight suit, T-shirt and USSRC exhibit ticket
- Transportation to/from the airport in Huntsville

Apply Online at TheINSPIREProject.org – Space Academy for Educators Scholarships

INSPIRE's late president Kathleen Franzen founded the Space Academy for Educators and Students programs. She is pictured with her husband, INSPIRE's co-founder Dr. William Taylor

Middle & High School Students

Kathleen Franzen Memorial Space Academy for Students Scholarship Program

INSPIRE's Weeklong Summer STEM Program for Washington DC Area Middle School & High School Students at the U.S. Space & Rocket Center in Huntsville, Alabama
Summer 2017 Application Deadline: May 1, 2017

The INSPIRE Project has teamed up with the U.S. Space & Rocket Center, Washington Space Business Roundtable and other sponsors to offer full scholarships to Space Academy in Huntsville, Alabama for Washington DC area high school and middle school students.

Space Academy is an action packed 6-day program for students world-wide to participate in classroom, laboratory and training focused on space science and space exploration. Space Academy encourages teamwork, problem solving, communication skills and self-confidence. Students take part in astronaut-style training and simulations, as well as STEM activities to ensure our next generations of space science and technology explorers!

- Tumble and spin in the Multi-Axis Trainer
- Float on air in the 5-Degrees of Freedom Chair
- Walk like Apollo astronauts in the 1/6 Gravity Chair
- Experience a world without friction in the MMU
- Challenge yourself and support your Team at Area 51
- Pilots/Commanders land the Space Shuttle
- Mission Specialists walk "in space" on an EVA (Extra Vehicular Activity) to repair the Hubble Space Telescope
- Live and work in space operating the ISS life support
- Perform scientific experiments on soil samples from Mars

Space Academy for Students full scholarships include:

- Round-trip airfare from Washington DC to Huntsville, Alabama *(INSPIRE chaperone accompanies students)*
- 5 Nights lodging & meals at the U.S. Space & Rocket Center
- Program materials, flight suit, team patch, T-shirt & DVD
- Transportation to/from the airport in Huntsville

Apply Online at TheINSPIREProject.org – Space Academy for Students Scholarships

Special Thanks to The INSPIRE Project's Program Sponsors, Supporters and Volunteers!

NASA | District of Columbia Space Grant Consortium | Washington Space Business Roundtable
U.S. Space & Rocket Center | International Launch Services | Space Ad Agency

INSPIRE VLF-3 Kit in the Attic

Wire… ...We're Waiting

Paul Bower

So you've just wired up your VLF Receiver, now what? Ever the impatient soul (and because it was raining) I conducted my first test in the attic with a piece of wire and learned a valuable lesson regarding the insidious nature of AC noise.

Next I considered a more permanent solution in the garden. The aluminum framed greenhouse, the support frame for the raspberry patch (there's over 30m of wire in that), or maybe just some sort of simple dipole, or monopole, or…

In terms of an antenna - less is more right?

I decided on a few tests to select the best antenna arrangement. I had a couple of old domestic earth spikes that I found in the garage so I set up a couple of spots in the garden. Both the greenhouse frame and raspberry support wires performed pretty poorly, and after re-reading my VLF notes under the apple tree, something hit me (it wasn't an apple).

Ideally the VLF-3 needs a two-meter vertical wire.

Aha – The Newton Antenna

I decided to use some 55/0.1mm flexible cable for my antenna. It's the sort of stuff used to make test leads and is cheaply available in short lengths from your favorite auction website. I cut a 2m length with a large loop tied at one end to hang from a branch, and a smaller loop at the other end to hang a weight from. This smaller loop also feeds the antenna connection to the VLF-3 Receiver.

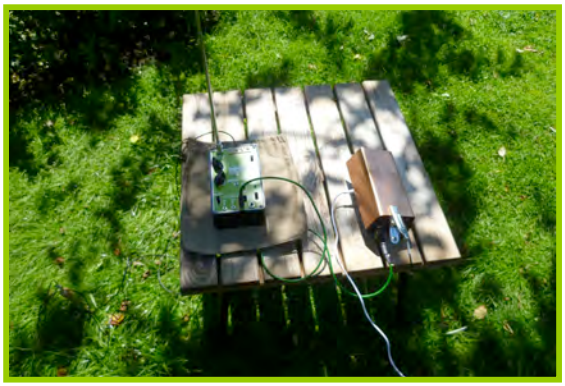
For the return (ground) connection, I cut a 30cm length of 3mm galvanized wire and made a little screw connector. I soldered a little tag onto the return wire for easy connection to the ground spike.

The Newton Antenna attached to the VLF-3 Receiver (top right)
The wire attached to the ground spike (above)
The Newton Antenna component parts (right)

I found that I was getting a little interference, possibly processor noise from my Tascam recorder. Sometimes simply re-orientating the receiver and/or recorder 90 degrees can mitigate the induced noise, but not on this occasion. Using a little copper sheet, I made a quick shield for the Tascam and connected it to the ground spike too.

Here are two audio files. The first illustrates the kind of reception I achieved with the Newton. You can also hear the effect of adding the copper shield ten seconds into the recording. The second file illustrates the capacitor effect of touching the antenna once it is set up (around 47 seconds into the recording). *Note to self: Don't touch the antenna…*

Audio File – Adding Shield:
http://theinspireproject.org/downloads/audiofiles/Test1-AddingShield.wav
Audio File – Touching Antenna:
http://theinspireproject.org/downloads/audiofiles/Test1-TouchingAntenna.wav



(Above) BNC Whip Antenna set-up
(Below) Greenhouse set-up

BNC Whip Antenna

In my second test, I used a simple 75cm BNC whip antenna purchased cheaply from that same well-known auction website. I used the same ground spike as before and used the copper shield to reduce noise. With less than half the length of antenna, as expected, the receiver output was much quieter but I obtained a fairly clean reception.
Audio File – BNC Whip:
http://theinspireproject.org/downloads/audiofiles/Test2-BNCWhip.wav

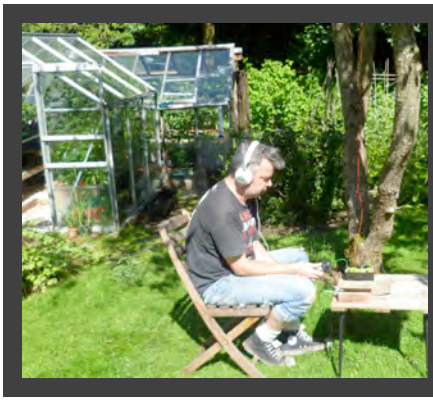
Greenhouse Test

My third test involved the greenhouse. I stuck a simple 30cm wire rod into the ground outside and used a heavy-duty croc clip to attach the antenna wire to the greenhouse frame (after cleaning a patch first to ensure a good connection). The shield had little effect, which makes me think the ground spike was poorly positioned. All in all, the greenhouse was fairly poor for VLF reception, although I might bring my shortwave receiver down there.
Audio File – Greenhouse:
http://theinspireproject.org/downloads/audiofiles/Test3-Greenhouse.wav

Raspberry Canes Test

My final test took me down to the raspberry canes. Here we have around 30m of wire strung horizontally in six rows. In retrospect, this was not an ideal VLF antenna at all. In practice I picked up a lot of noise, plus the capacitor effect of the raspberry canes (which are grounded at one end) rubbing against the antenna wire.
Audio File – Raspberry Patch:
http://theinspireproject.org/downloads/audiofiles/Test4-RaspberryPatch.wav

So there you have it. The Newton wins. A simple length of wire strung from a tree.
Audio File - VLF Recording 3rd July 2016: http://theinspireproject.org/downloads/audio files/VLFRecording3July2016.wav



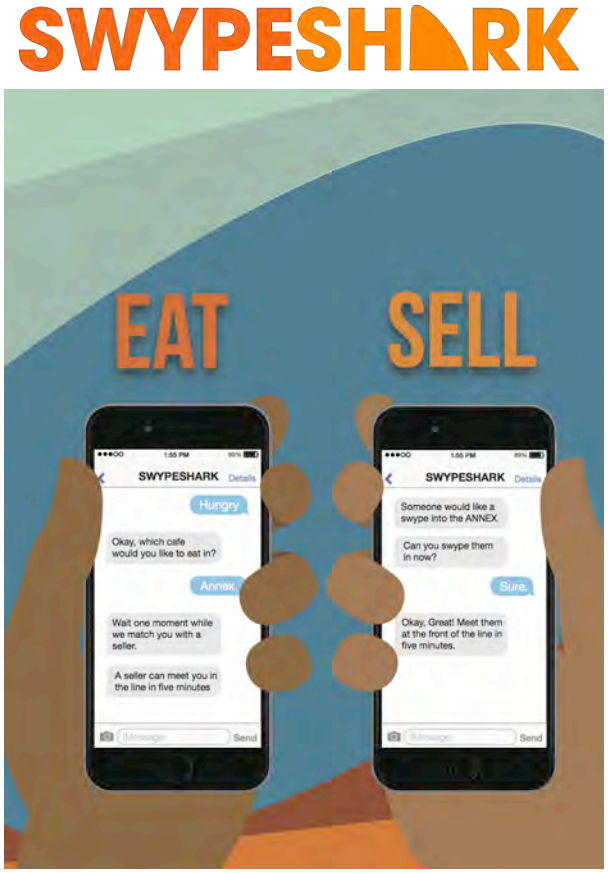
About Paul Bower

Based in Sheffield in the United Kingdom, Paul Bower is a music industry veteran and incorrigible experimenter.

unrecordings.co.uk

SwypeShark App Launched to Tackle Social Issue on College Campuses

Alston Clark



Alston Clark and his sister Hannah were awarded the first INSPIRE Space Academy for Students scholarships at the US Space & Rocket Center in Huntsville, Alabama when the program launched in 2010. The underlying mission of this INSPIRE program is to attract students to STEM disciplines, ultimately to help create our next generation of scientists and explorers. During the past seven years, both Alston and Hannah have received numerous STEM awards including Google Engineering Practicum summer internships in California. The INSPIRE team is very proud of Alston and Hannah's vast accomplishments and dedication to both helping other students succeed in STEM areas and "giving back" to their community; and looks forward to their future success.

During my older sister Hannah's second year in college at Howard University, she noticed a problem. There appeared to be a large amount of students with extra meal points at the end of each semester. On the other hand, she noticed a population of students without meal points. A year later Hannah and I decided to do something about this problem. Together we created SwypeShark, a service that allows college students to buy and sell unused meal points. Such meal points, also known as swypes, are the currency that allows students to eat in the cafeteria.

Since both Hannah and I are computer science majors at Howard University in Washington DC, we had an idea about how to get started with the tech side of the venture. We took a class called *Bison Accelerate* which helped us launch and iterate our new product. Also, Howard University has been a great place to learn about entrepreneurship and leveraging one's community to progress a new idea.

SwypeShark is tackling a social issue on college campuses. As college students increasingly struggle to pay tuition, collegiate food insecurity is becoming more of a problem. In the near future, we hope to spread this technology to other universities in order to widen the impact.

Hannah and I have a long history of working on projects together. In fact we created our first business in elementary school - Minty Fresh, "a mixture of mouthwash and toothpaste for busy professionals who do not have enough time to use both." I created the slogan and made the crayon labels, while Hannah perfected the formula in the bathroom sink!

We are extremely grateful to The Inspire Project for awarding us scholarships to attend Space Camp in middle school. This experience gave us unparalleled exposure to applied science and engineering. For me, Space Camp served as my first introduction to computer programming.

Creating this venture has been an extremely educational experience for the two of us, and we hope to encourage other youth to use science and engineering to develop solutions for issues in their communities.

To learn more about SwypeShark visit: SwypeShark.com or Facebook.com/swypeshark

About Alston Clark

Alston Clark loves working on difficult problems and relating abstract concepts into realistic solutions. Born in St. Paul, Minnesota, Alston developed a love for science and technology at an early age. Currently a computer science major at Howard University, he enjoys finding ways to use technology to help positive social causes. In his free time, Alston can be found playing guitar or exploring the city with his brothers and sister. After college, Alston plans on working as a software engineer.

Alston and his sister Hannah at Howard University in Washington DC

Kathleen Franzen Memorial Space Academy Scholarship Program

2015 Space Academy ~ A Successful Mission

During the past eight years, 29 educators and 56 students have been awarded full scholarships to participate in this weeklong, educational STEM program. In INSPIRE's 2015-2016 School Year Program Survey, 100% of Space Academy for Educators scholarship recipients reported that they are utilizing materials and knowledge acquired via the program in their classrooms directly impacting 2,700 students in 27 Washington, DC area schools. Past recipients continue to be actively involved in the organization and serve as Ambassadors representing INSPIRE at workshops and events. Special thanks to INSPIRE's sponsors including the U.S. Space & Rocket Center, Washington Space Business Roundtable, District of Columbia Space Grant Consortium, Patriots Technology Training Center and private donors for their continued support and inspiring our next generation of scientists and space explorers.

INSPIRE's Kathleen Franzen Memorial Space Academy Scholarship Program is weeklong educational program for middle and high school educators and students held at U.S. Space & Rocket Center, NASA's official Visitor Information Center for Marshall Space Flight Center, in Huntsville, Alabama. Space Academy promotes science, technology, engineering and mathematics (STEM) through hands-on activities and missions based on teamwork, leadership and decision-making.

On July 24th, INSPIRE's 2015 Space Academy crew of five educators and six students departed for Huntsville to join fellow astronaut trainees from around the world at the U.S. Space & Rocket Center. Trainees flew simulated Space Shuttle missions to the International Space Station (ISS). Once aboard the ISS, the crew participated in experiments and successfully completed extra-vehicular activities (EVA) and space walks. The crew returned to earth in time to hear retired Space Shuttle astronaut Dr. Don Thomas' motivational speech.

Educators learning a solar/lunar eclipse simulation, a hands-on activity provided by NASA's educational program, which can be easily implemented in their classrooms

The action-packed week included 50+ hands-on STEM activities and experiments. Aside from astronaut training, the Space Academy for Educators program included intensive classroom, laboratory and training focusing on space science and exploration activities developed to promote learning in a classroom setting. The curriculum includes NASA content and is correlated to the National Science Education Standards. This hands-on program equips teachers with knowledge, activities and materials to excite, engage and attract students to STEM disciplines.

Space Adacemy concluded with a graduation ceremony on July 31st in Saturn V Hall in the Davidson Center for Space Exploration. To celebrate, INSPIRE hosted a private lunch with guest speakers Dr. Rick Chappell, INSPIRE Board Member and NASA Payload Specialist, and INSPIRE Advisors Dennis Gallagher and Mitzi Adams from NASA Marshall Space Flight Center. Students and teachers had the opportunity to ask a "real astronaut" and NASA scientists questions about both the space program and working in space science at NASA. At the conclusion of lunch, each student was presented with a personally signed copy of Homer Hickam's *Rocket Boys* book as a graduation gift. One student was so inspired by the experience that she has decided to change her future career goal of being a Civil Engineer to a being an Aerospace Engineer. And in her words, "Space Camp is an experience of a lifetime".

INSPIRE Board Member Dr. Rick Chappell and INSPIRE Advisors Dennis Gallagher and Mitzi Adams of NASA Marshall Space Flight Center with the 2015 Space Academy crew at the U.S. Space & Rocket Center in Huntsville, Alabama

Space Academy for Educators ~ Inspiring Explorers

INSPIRE's educator scholarship recipients have propelled STEM education in our Nation's Capital and beyond engaging thousands of students in new curricula and hands-on activities in hundreds of area elementary, middle and high schools during the past seven years. In addition to impressive accomplishments in the classroom, their outstanding work has been recognized by numerous awards including the prestigious National Science Foundation Albert Einstein Fellowship, National Science Teachers Association Distinguished Service to Science Award and the Sheikh Zayed Outstanding STEM Educator Award.

Below are highlights of the vast program accomplishments:

The 2015 Space Academy crew with their Team Kibo at the U.S. Space & Rocket Center in Huntsville, Alabama

Daisy Rayela ~ Thomas Johnson Middle School

As of result of her participation in Space Academy for Educators in 2014, middle school STEM Coordinator Daisy Rayela has added a Flight and Space class and her classroom became more interactive and hands-on. Daisy conducted demo teaching to Science teachers on how to integrate STEM in the classroom. She gave students new design challenges using the engineering design process including Roller Coaster Design Challenge, Robotics Arm Design Challenge, Hovercraft Design Challenge and Rover Design Challenge. In addition, numerous STEM activities were added including STEM Career Day (for parents and students to give them background on why STEM is important), Engineer in the Classroom, participated as a Trainer in Mission 8 – SSEP (Students Spaceflight Experiment Program), and the STEM Festival held in June 2015 where her students of the Flight and Space Class presented their research about *Designing Mars Habitat* to a panel of STEM professionals. At STEM family night, she gave a presentation on the Space Academy program. The school year ended with Daisy being presented with the 2015 DiscoverE award. To learn more visit: http://daisyrayela.wix.com/tjms-stem-program

Daisy Rayela was presented with the DiscoverE Educator Award for inspiring tomorrow's generation of innovators

Britni Whitti ~ Rose L. Hardy Middle School

After attending 2014 Space Academy, STEM Enrichment Teacher Britni Whitti at Rose L. Hardy Middle School incorporated Kerbal Space Program, an online STEM-based teaching tool that she learned about via networking with past Space Academy program recipients and the rocketry curriculum at Space Academy. Kerbal Space Program is an online computer simulation where students build and design rockets, conduct launches, and collect data. Visit: https://kerbalspaceprogram.com/en/

In addition, Britni's students participated in the Team America Rocketry Challenge against 700 teams across the country, the majority of which were high school students. As the only middle school team and only one of two teams from the District of Columbia, her students constructed rockets after using RocSim to plan and simulate their launches. They battled the elements in February and March for their qualifying launches. One of her teams placed 104th and missed the cutoff for the Nationals by .75 points, which equals less than 1 foot in altitude. Finally, students in the STEM Academic Enrichment Classes celebrated World Space Week by designing Mars Habitats keeping the constraints of the Red Planet in mind, such as water, food, climate, and radiation. Teams could decide whether they wanted to create a map or create a model of their habitats. After the design competition, students Skyped with Astronaut Leroy Chiao where they got to ask about the probability of inhabiting Mars within their lifetime.

Britni Whitti's Rose Hardy Middle School students preparing for qualifying launches in the 2015 Team America Rocketry Challenge

"There is an exchange in education. My students encourage me to do my very best and in return I attempt to empower, uplift, and inspire them to live out their dreams, live out their destiny." - *Frank Matthews*

Frank Matthews ~ Kramer Middle School
Kramer Middle School's 8th Grade Science Teacher Frank Matthews, 2015 Space Academy for Educators program participant, was recognized in the 2015 - 2016 school year by the Washington Capitals as *Teacher of the Month* and Kramer received *School of the Month* recognition. In INSPIRE's annual survey, Frank Matthews wrote: The Washington Capitals recognized us for our efforts to utilize the Hockey Scholar program while incorporating the NASA Rockets Educator Guide provided by the Space Academy program. All of the activities this school year prepared our students with the history of rocketry, NASA's Space Launch System, rocketry principles, 6 forms of Energy, and practical rocketry. Thanks to my participation in INSPIRE's Educators Space Academy, I have be able to incorporate cooperative learning with the general educated population and our SPED population, introduce problem solving techniques, critical thinking, and hands-on involvement. The Space Academy program has allowed me to become more versatile in my approach to teaching.

To view Frank Matthews and Kramer Middle School's award visit:
https://capsinschool.monumentalsportsnetwork.com/2016/02/03/teacher-of-the-month

Tysheka Duffy ~ Kramer Middle School
After participating in the 2015 Space Academy program, Kramer Middle School Administrator and after school STEM Coordinator, Tysheka Duffy, expanded Kramer's after school program by forming new partnerships with community organizations to introduce hands-on science and technology programs at Kramer. New partnerships and after school STEM curricula at Kramer Middle School in Washington, DC include:

- TechBridge – An all-girls STEM program providing hands-on activities and field trips relating to science and technology.
- Robotics Program – Tysheka developed a new partnership with the U.S. Coast Guard to start this program. Students built robots and had to edit, share, save, simulate and submit programming codes to allow the robots to accomplish a task.
- LUMA LAB – The school partnered with HERO to develop the LUMA LAB, which exposes students to all facets of science and technology including start-up principles, user experience, software development and product management. Students also acquired skills to code and create mobile app prototypes.

Charles Butler ~ The School Without Walls

As a result of participating in 2015 Space Academy for Educators last summer Charles Butler, a High School Physics & Environmental Science Teacher at The School Without Walls of Washington, DC, launched the school's first Space Club. There were two branches of the club ~ one group built a rocket and another took the school's telescope out of the back of the storage closet and assembled it to use for observations. Charles is planning to expand the program next year. In addition, Charles integrated micro-gravity and gravitational potential energy into his AP Physics Class curriculum. He also utilized the hands-on egg heat shield experiment from Space Academy in his classroom.

Ellen Babcock ~ Woodson High School

INSPIRE's first Space Academy scholarship recipient (2009) Ellen Babcock, a high school Physics teacher, participated for the third year in the NASA LEARN Project (Long-term Engagement in Authentic Research with NASA) last summer. LEARN is an innovative program that provides educators with on-site research and training with NASA Scientists in the summer and guided research projects that continue on throughout the school year. Ellen's LEARN team conducts their own research with help of a team of NASA Scientists and share and integrate these projects into the classroom. Twenty of Ellen's high school students worked with her on a NASA LEARN project on a study of fracking. They looked at changes in criteria pollutants downwind from fracking sites in Central and Northern Pennsylvania and presented their findings in July 2015 at a LEARN NASA poster presentation in Langley Virginia. View Ellen's NASA LEARN fracking study poster: http://science-edu.larc.nasa.gov/LEARN/pdf/2014-2015LP/Babcock_FINALposter2015_Website.pdf

Space Academy for Students ~ 6-Day STEM Program Inspiring Our Next Generation

Houston…We Have Lift Off! ~ Charis H.

As a result of my team winning the Patriots Technology Training Center's Solar Competition, I had the chance to go to Space Academy in Huntsville. Going to Space Camp was probably one of the best experiences I have ever had in my life. There were so many activities and presentations to keep the week busy and fun. In one of the presentations, we got to meet former astronaut Don Thomas who explained to us the process he went through in order to become an astronaut and how it took him about 4 tries in order to get in NASA's program. One of the things that stood out the most was the team missions. In the Shuttle mission, the objective was to safely get the shuttle to dock with the ISS and come back home. I got the chance to be the Capcom, which is the person who relays commands and information back and forth between Mission Control and the shuttle. The second mission was the Lunar. The objective was to land the capsule on the moon and exchange crews in order to fix an electrical problem and broken window in one of the lunar modules. Much of the time at space camp is very fun and interactive. You get the chance to learn about the history of space exploration and what people are doing nowadays to prepare for future exploration. Space Camp is an experience of a lifetime – especially if you have a deep interest in space exploration. The experience really changes a person and allows you to see how and what resources you need to make your career dream come true – whether you want to be a scientist, engineer, etc. Hopefully from this experience I now know what I need to do in order to achieve my goal of one day becoming an aerospace engineer! *Thank you to all the sponsors (Patriots, INSPIRE and Washington Space Business Round Table) who made my trip possible!*

Space Academy 2015 ~ Clark G.

I am extremely grateful for The INSPIRE Project and that they selected me. Space Academy allowed me to better understand what is needed to pursue a career in aerospace. At space camp, I learned a lot of new things and made a lot of new friends from around the globe, like Great Britain and California. I really had a great time. We rode on machines that simulate different aspects of space travel. We also went on space missions and did lots of other cool stuff. Many of the activities were team-building exercises. When I was working with my team, we completed many different challenges. We learned to work better with one another and what it means to be part of a team. It makes you understand that you must rely on your teammates because it could be a matter of life or death. And there is no "I" in TEAM. We also learned about the many different space programs, like the Apollo and the shuttle programs. Throughout the week, we learned about physics and sciences. I am glad I had this wonderful opportunity, one that I will never forget.

My Time at Space Camp ~ Bryce S.

My time at Space Camp was very exciting. I learned and did a lot there. It is an experience that I would recommend to everyone who has the to chance to go. When I first got there, I was placed on a team, called Team Boeing with my winning Solar team members and others who I had not met before. There were even 2 people from London and 2 people from New Zealand who were in the same bunks. There were people from all over the world and even a group from China. I had the opportunity to talk to the Chinese group along with many other people and I learned a great deal from them. Before I left for Space Camp, I expected that we would be learning how to command missions, meeting astronauts, and learning about space history. When I got there, it was all that and so much more. I had two great crew trainers, got to look at a real Saturn rocket, rode on a ride where I was able to see the tops of most of the old rockets such as the rockets for the Mercury program. However, nothing was tall enough to let me see the top of the Saturn rocket. It was really cool and we were able to do lots of cool stuff there. The space mission simulations were an awesome experience. We had 2 missions during the week, a space shuttle mission and a moon mission. I was the commander of the space shuttle mission and it was lots of fun. We took off, did our procedures, and then landed the space shuttle. I was in mission control during the moon mission, making sure the mission scientists on the moon went through their procedures, and completed their experiment. During my time at Space Camp, I met several astronauts including Don Thomas, who I learned a lot from, and presided over the graduation ceremony, NASA employees and Astronaut Abby. I learned so much about their jobs, what it takes to become an astronaut (which is my dream), and much more. One of the most amazing moments at Space Camp was where I was able to sit with NASA scientists and have lunch with them at Wernher Von Braun's table! Wernher Von Braun made the Saturn rockets of the Apollo missions. My time at Space Camp has changed my view of space science and history. Somehow, I am even more excited about space, science, and history, and I was already in love with them!. If you get the chance, I strongly recommend going to Space Camp. This experience will change your life forever.

Thank You from Astronaut Jada J.

I want to thank you for doing a wonderful job in guiding me and the other INSPIRE kids. Space Camp was the best camp I have attended. I feel truly thankful for meeting different people. I am thankful for the cultural exchange with the Chinese kids. One girl from the Chinese group gave me a friendship letter written in Chinese and English. So to return the favor, I gave her a cool gift. I am also thankful for the fact that I got to have lunch with an astronaut and people who work in S.T.E.M. jobs at NASA. Meeting them made this the best lunch I have ever attended. I will never forget the advice one of them gave me. The other thing I will never forget is my team, "Boeing", I still remember the names of everyone in my group. I am also thankful that we got Sara and Frank to be our trainers. I really could go on and on about everything. But in conclusion, thank you. Space Camp was AWESOME!!!!!!!!

2015 The Right Stuff Award Recipient ~ Robert A.

While at Space Academy, I was assigned to Team Boeing and we came up with our own group chant:

We are going on a trip,
In our favorite rocket ship,
Zooming through the skies,
Little Boeingsteins,
*B O E I N G *6*
Boeing

I attended Space Academy right after I had completed my 8th grade year. As a group, we did the Space Shot and G Force experience, which was a lot of fun! We searched for a giraffe in the robot zoo and built our own model rockets. We learned about the Mercury and Apollo missions, and learned how the Challenger Mission changed the space program. We also visited the water simulator where we had to build a Satellite in 10 minutes. On the last day, we did our Mission Training for the Lunar Mission. I was named Flight Director. After our training we launched our final rockets using the B motor which is more powerful than the other motors that we had before. After dinner we started on our Lunar Mission. At first it was good but after liftoff anything that could have gone wrong did. At one point we had every single anomaly occur. But after all of the craziness we finished on time with everyone OK. I had a great experience at Space Academy and received the Right Stuff Award, which recognizes the top cadet in the camp. After attending Space Academy, I started High School and took the PSAT and scored the 2nd highest in the 9th grade at my school, attended the NSBE National Convention in Boston and competed in the Try-Math-A-Lon High School Math Competition and my team won 1st Place. I was also on the VEX Robotics team where my team's journey ended at the quarterfinals, and we realized we have a lot of work to do for next year. These are some of the accomplishments I have done after attending Space Academy, where I realized that I need to learn a lot if I want to be in the space and robotics industries. Space Academy is truly an inspiration, and anyone that attends space camp will have their life changed tremendously. I would like to attend the Advanced Space Academy in the next couple of years.

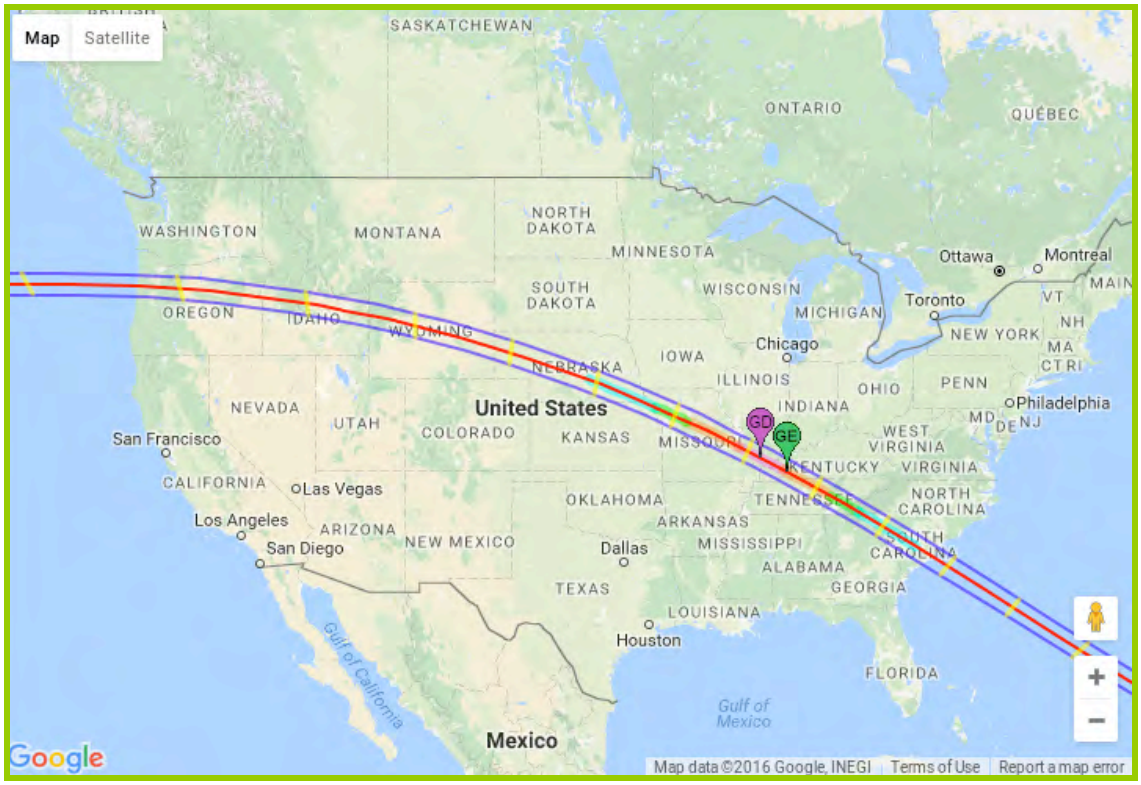
Total Solar Eclipse – August 21, 2017

Mitzi Adams, Solar Scientist
NASA Marshall Space Flight Center

They observed the eclipses of the sun and moon, but without understanding their causes. When there was a solar eclipse, they said the Sun was angry at some offense committed against him, since his face appeared disturbed like that of an angry man, and they foretold, as astrologers do, the approach of some grave punishment.
(Garcilaso de la Vega 1966:118-119 [1609: Vol. 1, Bk. 2, Ch.23])

Garcilaso de la Vega was born in Cuzco, Peru in 1539. Garcilaso, himself half Peruvian, chronicled the everyday life of the Inca, which included rituals and beliefs about the world around them, as seen in the quote above. Garcilaso lived in Peru until he was twenty one, at which time he moved to Spain and began to write. But during the first twenty years of his life, four total or annular eclipses were observed in the area of Cuzco, giving de la Vega first-hand knowledge of the customs of the Inca people when eclipses happened. At that time, Europeans could predict eclipses, but the Inca could not, perhaps another reason the Spanish gained power over the Inca people. Today, of course, eclipses can be predicted precisely, even many years into the future. We no longer expect "grave punishment" when the face of the Sun disappears. We even have video recordings of these events and predictions. When the last total solar eclipse occurred over the Pacific Northwest in 1979, ABC News covered the event, posting reporters along the path of totality. At the end of the broadcast, Frank Reynolds made the comment that "Not until August 21, 2017 will another eclipse be visible from North America, that's 38 years from now." As I write this, the countdown is less than one year. Will you be ready?

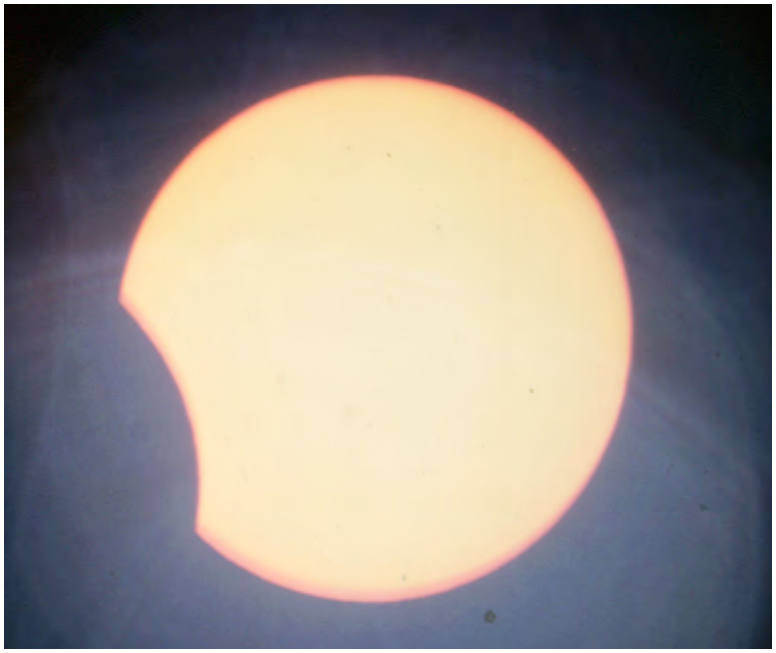
The path of totality of the total eclipse of August 21, 2017 will cross the continental United States, beginning in Oregon, moving through Idaho, Wyoming, Nebraska, Missouri, Illinois, Kentucky, Tennessee, Georgia, North Carolina, and South Carolina.



The map above is from NASA's website, http://eclipse.gsfc.nasa.gov/SEgoogle/SEgoogle2001/SE2017Aug21Tgoogle.html, which contains an interactive map that gives local circumstances (eclipse times and latitude/longitude) for any given position along the path of totality. To see the Sun totally eclipsed, you must be within this path. The closer to the centerline, the longer the duration. The position marked GE is the point of Greatest Eclipse, or the instant when the axis of the Moon's shadow cone passes closest to the center of Earth. The duration of totality for this location is 2 minutes 40.1 sec. GD marks the point of Greatest Duration, which is only 0.1 second different from GE; totality lasts 2 minutes 40.2 seconds here. GE is between Hopkinsville and Princeton, Kentucky. GD is very close to I-57, Goreville and Carbondale, Illinois. Carbondale has a unique position as total solar eclipses go, the city is within the path of totality for both the 2017 eclipse and for the next total solar eclipse visible from the United States on April 8, 2024.

What You Can Expect to See

The ancient Chinese described an eclipse as a dragon eating the Sun. As the eclipse begins, it does seem as if something is taking a bite out of the Sun. But this partial phase of the eclipse happens because the Moon, as it orbits Earth, is moving into position between Earth and Sun, partially blocking the light of the Sun, setting up for an awe-inspiring sight during totality.



Just before the Moon completely covers the Sun, sunlight shines through the jagged mountains of the Moon and we see beads of light around the edges of the nearly eclipsed Sun. The beads are called Baily's Beads, named for an English astronomer, Francis Baily, who popularized the phenomenon in 1836. The last bead to show, just before totality, is called the Diamond-Ring Effect (see Illustration 2).

Also visible at this time, is the chromosphere, the middle layer of the Sun's atmosphere. The chromosphere, from the Greek word chroma meaning color, was so named because of the reddish prominences seen around the edge or limb of the Sun/Moon during a total solar eclipse (again, see Illustration 2). Those prominences are loops of gas, held in place by magnetic fields. Some can be as large as ten times the diameter of Earth!

Illustration 1: *From the 2001 eclipse in Lusaka, Zambia, Africa. Photo by Mitzi Adams, NASA/MSFC.*

Illustration 2: *This image shows the Diamond-Ring Effect, as well as solar prominences, the reddish projections jutting out from the edges of the Sun/Moon. The image from the Jun 21, 2001 eclipse seen in Chisamba, Zambia, is used with the kind permission of Mr. Fred Espenak, http://www.mreclipse.com.*

As the bright light of the Sun's surface, or photosphere, is finally covered, the top layer of the solar atmosphere, the corona, is visible (Illustrations 3 and 4). The only time that we can see this part of the corona is during a total solar eclipse. A special telescope called a coronagraph can block out the bright light of the photosphere, but these instruments cannot be made so that they exactly cover just the photosphere, as does the Moon during a total solar eclipse. So, we can study the outer corona, but we miss the connection between the lower, inner corona and the chromosphere, the region where much of the solar activity occurs. For example, we often see flares begin in the chromosphere and sometimes coronal mass ejections (CMEs) will follow. Also, prominence eruptions that begin in the chromosphere can affect the corona. Understanding how the corona responds to activity in the chromosphere can help us with predictions of CMEs. Here on Earth, CMEs can affect power grids, satellite operations, airplane flights, and GPS signals.

Illustration 3: *Totality over Lusaka, Zambia, Africa, June 21, 2001. Photo by Mitzi Adams, NASA/MSFC*

Illustration 4: *Dr. Gordon Telepun was also in Africa for the June 21, 2001 eclipse, where he captured this image of totality. The image is used with permission.*

Observing an eclipse is an experience not easily forgotten. Even if the weather does not cooperate and there are clouds, anyone within the path of totality will experience darkness at an odd time of the day. As totality approaches, the wind will pick up and the temperature will drop. Birds and insects will respond as if it is night. Birds will go to roost and crickets, tree frogs, and katydids will make their noises. But totality is over all too soon. For this 2017 eclipse, totality will last a maximum of about 2 minutes 40 seconds.

Illustration 5: *This composite image was made by Angie and Gordon Telepun. The location was Beitbridge, Zimbabwe for the December 6, 2002 total solar eclipse. The image is used with permission.*

Eye Safety

The Sun cannot be viewed safely during the partial phases of the eclipse, unless proper filters are used. Failure to use appropriate filtration may result in permanent eye damage or blindness! Now that I have your attention, safe solar filters include commercially available eclipse glasses, number 14 (or higher) welder's glass, full-aperture telescope filters. Do NOT use film, smoked glass, CDs, or solar filters that screw into eyepieces used in telescopes. There are also many indirect ways to view the partial phases of the eclipse, some of which may be found here: http://www.exploratorium.edu/eclipse/how-to-view-eclipse and http://astro.ukho.gov.uk/old/pparc_web/mirror.html

For more details on eye safety during an eclipse, see NASA's page: http://www.nasa.gov/content/eye-safety-during-a-total-solar-eclipse

Now, after all that, it IS safe to view the Sun/Moon during the total phase of the eclipse, but ONLY then. Actually, if you are watching the Diamond-Ring effect with eclipse glasses, as soon as that light disappears, you will see nothing with the glasses on. At that time, it is safe to remove your glasses and look at the eclipsed Sun without a filter. If you are taking photographs through a telescope, take the filter off now. Look at the sky. To the east of the Sun/Moon, you should see the planet Jupiter. Slightly below the Sun and also to the east will be Mercury. To the west of the Sun you should be able to see Mars and Venus. However, be very aware of the time until the end of totality; it is CRUCIAL that you stop looking at the Sun/Moon BEFORE TOTALITY ENDS. Be aware of when totality will end for your location. An interactive map can be found here: http://www.eclipsewise.com/solar/SEgmap/2001-2100/SE2017Aug21Tgmap.html

As totality comes to an end, you will see a brightening, some describe it as a crescent, on the opposite side of where the Diamond was seen at the beginning of the eclipse. PUT YOUR FILTERS BACK ON NOW. The ending of the eclipse will be a mirror of the beginning, going through partial phases, until the Moon moves completely away from the Sun. More details on safely viewing the eclipse can be found here:
http://eclipse2017.nasa.gov/sites/default/files/Solar_Eclipse_Safety_RTFv14.pdf

The INSPIRE Project VLF Coordinated Observations

During a solar eclipse, when the Moon blocks sunlight from reaching Earth's atmosphere, there are measurable changes in the ionosphere. To ionize the gases in the ionosphere, ultraviolet radiation and X rays are needed. Obviously, these are blocked during an eclipse. In the lower parts of the ionosphere, molecules recombine, effectively “un-ionizing” that part of the atmosphere, which can affect radio transmissions and GPS signals. The INSPIRE Project VLF receiver can be used before, during, and after the eclipse to investigate changes in VLF signals that result from the cooling of the atmosphere during the eclipse. It is expected that the amplitude and phase of VLF signals will change. Some research suggests that even atmospheric gravity waves (short period, minutes to hours) are contained within VLF signals.[1]

Focusing on various low, middle, and high frequency transmissions from sites in Europe during the 1999 total solar eclipse, a group of radio amateurs investigated the changes in signal strength during the eclipse.
(See https://misan.home.xs4all.nl/eclipse.htm)

Results are that the signal strength decreases as the path of totality crosses the line between the transmission site and the observer. After the eclipse, signal strength returned to approximately the same value as before the eclipse, in a relatively short time. Although outside the wavelength band of the INSPIRE VLF receivers (0-10kHz), a similar experiment, simply investigating strength of signal, could be performed using a shortwave radio with the reception of one of the U.S.'s timesignal radio stations, WWV (at 2.5, 5, 10, 15, and 20 MHz) and WWVB (60 kHz). See the Great Radio Atmospheric Propagation Experiment for more details (http://www.sweoc.org/GRAPE.html).

Lightning-generated atmospherics called Tweeks are in the wavelength range of the INSPIRE VLF receivers. Tweeks are created when waves generated by lightning travel through the atmosphere by multiple reflections in a waveguide formed between the ground and the low ionosphere. Because of the structure of the ionosphere, Tweeks are usually heard at night. Obviously then, Tweeks are good candidates for reception by INSPIRE receivers during a solar eclipse, when the ionosphere, at least partly, mimics nighttime conditions. During the total solar eclipse on August 31, 1932 in Conway, New Hampshire, Burton and Boardman[2] were the first to report Tweeks during an eclipse, receiving 17 Tweeks.

A study of the 2009 eclipse over India[3] reports differences between nighttime and eclipse Tweeks. Nighttime Tweeks are more intense and are more dispersed than those detected during an eclipse, because eclipse Tweeks do not travel as long a distance as compared to nighttime Tweeks. During the five minutes around totality, observers noted 26 Tweeks, four with second harmonics and four with third harmonics. Five minutes after totality, Tweek reception was slightly lower than before totality; observers detected ~20 before and ~17 after. The duration of the Tweeks returned to the approximate pre-eclipse value (~30 minutes before totality) within 90 minutes after totality, still during the partial phase of the eclipse (which ended 20 minutes later).

The INSPIRE VLF receiver can be used during the 2017 eclipse to detect Tweeks and possibly Whistlers. To do this, and to compare with the results of the Singh, et al. study (3), take some data for the total length of time of the eclipse (approximately three hours) during the night before the eclipse, possibly over several nights so the data can be averaged. Make note of thunderstorms within 1000 miles (1600 km) of your area, including the time you begin and end taking data within one second, if possible. You can use local time, as long as you also record your time zone. On eclipse day, begin observations five minutes before the beginning of the partial phase and continue until five minutes after the eclipse ends. Again make note of thunderstorms in the area. Follow the instructions given for field observations (see pages 29-31) or online: http://theinspireproject.org/downloads/INSPIRE_VLF_ObservationForms.pdf. Coordinated eclipse observation information and instructions on how to upload your observations and notes will be posted on The INSPIRE Project website in July 2017. A summary of results and characteristic spectrograms will be posted to the INSPIRE website within a month or two of the solar eclipse. (See page 27 for more information on VLF observations during the eclipse)

Good luck! Although partial phases and even the Diamond-Ring effect require approved filters for eye safety, totality does not. So, don't forget to actually LOOK at the eclipse during totality!!

For more information, activities, and events, visit: http://eclipse2017.nasa.gov/

References
1. *Low latitude sub-ionospheric VLF signal behaviour during the two recent solar eclipses: Observation and simulation*, IEEE Xplore, 20 October 2014, **DOI**:10.1109/URSIGASS.2014.6929557 (http://ieeexplore.ieee.org/document/6929557/).
2. Burton, E. T., and E. M. Boardman (1933), *Effects of solar eclipse on audio frequency atmospherics*, Nature, 131, 81–82, doi:10.1038/131081a0.
3. Singh, Rajesh, et al. (2011), *D-region ionosphere response to the total solar eclipse of 22 July 2009 deduced from ELF-VLF tweek observations in the Indian sector*, JGR, 116, A10301, doi: 10.1029/2011JA016641.

About Mitzi Adams

Mitzi Adams is a solar scientist for NASA's Marshall Space Flight Center (MSFC), where she studies the magnetic field of the Sun and how it affects the upper layer of the solar atmosphere, the corona.

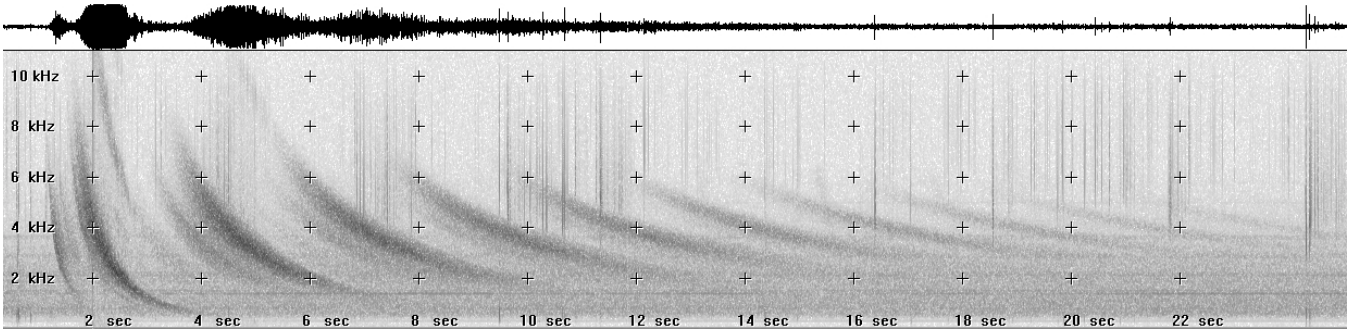
Ms. Adams, a daughter of Atlanta, earned a Bachelor of Science degree in physics with a mathematics minor from Georgia State University. In 1988, the University of Alabama in Huntsville and NASA made her an "offer she couldn't refuse" and she moved to Alabama, where she earned a Master of Science degree in physics and began work at NASA/MSFC.

With a professional interest in sunspot magnetic fields and coronal bright points, friends have labelled her a "solar dermatologist". Frequently involved in educational outreach activities such as viewing solar eclipses and transits of Mercury and Venus, Ms. Adams sometimes seeks innovative material in unusual places. While few women travel alone, she has often been seen alone and in groups in the wilds of Peru, northern Chile, Guatemala, and southern Italy.

Yahoo VLF Discussion Group

Mark Karney, Group Administrator
Shawn Korgan, Founder & Group Moderator

The Yahoo VLF Discussion Group was founded by Shawn Korgan in 2001 for those interested in VLF (very low frequency) emissions. Over the past 15 years the group has grown to almost 1,700 members. The Yahoo VLF Group is an open group and anyone can join and participate in discussions. Files and photos are not accessible until a person signs in with a Yahoo account; this is a Yahoo limitation which Mark and Shawn have no control over.



Amazing, very loud one-hop whistler with nine echoes! Don't expect whistlers to always be subtle in nature!
(Image courtesy of Shawn Korgan)

Older posts contain many discussions regarding the types of sounds that can be received while newer posts touch on a numerous topics, many of which have to do with setting up home based VLF receivers. Mark and Shawn attempt to keep the group professional and on topic as much as possible which has led to its popularity and success. It is their mission for the group to continue to prosper in their endeavor to explore and understand the scientific world we live in.

Visit: https://groups.yahoo.com/neo/groups/VLF_Group/info

To subscribe, email: VLF_Group-subscribe@yahoogroups.com

INSPIRE VLF-3b Receiver Technical Notes

Dr. Dennis Gallagher & Paul Schou
INSPIRE VLF Receiver Technical Advisors

The team at INSPIRE would like to recognize Dr. Dennis Gallagher with the sincerest appreciation and gratitude for volunteering to spearhead and update the VLF-3b receiver kit assembly instructions and the VLF observation forms. (Did you know the VLF-3b receiver kit has 114 parts?) The new user-friendly, kit assembly manual was completed in June of 2016 for use in a high school summer program in Washington, DC. Thanks to Gail Breeze for the cover design and Tony Bateman for the use of his amazing photo (right). Finally, thanks to INSPIRE Vice President Paul Schou for soldering the transistors to the circuit boards prior to kit shipment.

For 27 years, the INSPIRE VLF (Very Low Frequency) radio receiver kit has been designed with one underlying goal – to educate students about the sounds of space through hands-on experience. Building one's own electronic device is a step forward to opening the world of scientific exploration and showing that this complex world is made up of many simple components working together. To date over 3,300 INSPIRE radio receiver kits have provided students around the world the opportunity to experience the sounds of space firsthand and the interest in VLF kits continues to increase. INSPIRE VLF receiver kits have been incorporated in pre-college and higher educational curriculums throughout the world. In November 2011, INSPIRE completed its latest generation receiver kit, VLF-3b, with an improved circuit board design and design updates with the input from kit user and assembly suggestions The board design has many unique features such an internal battery / external battery connection and stereo audio plugs for listening to the VLF signals between 300 Hz up to 20 kHz.

Photo courtesy of Tony Bateman, Finland

VLF Receiver Initial Diagnostic Guide **Dennis Gallagher**

Diagnostics is always "fun". These are first steps in diagnostics. The steps can go further, but the further one goes the more complicated it becomes. If not comfortable with the process at some point, then it is often best to recruit someone else's help.

1. Visually inspect the board looking for solder bridges between connections that should not be there and connections that were not soldered. These two errors are far and away the most common. Clean up anything that looks suspicious by removing unnecessary solder. Solder things that need to be soldered. Sometimes a box cutter or other small knife is needed to insure removal of unwanted shorts between printed circuit board traces or solder pads. Of course be careful not to cut anything you didn't set out to cut, like yourself. Proceed to personal diagnostics, not covered here, if you cut yourself; seriously, don't hurt yourself.

2. Double check the wiring to the "data" and "audio" jacks to make sure they are going where they should go. Correct anything miss wired.

3. Connect the computer microphone input up to the "data" connector using a stereo 1/8" male to 1/8" male cable. Initially switch "mic/data" down on the VLF-3b to select "data", which should send the VLF signal to both the left and right outputs at the "data connector". Set the computer microphone level input to a modest level, perhaps 1/3rd maximum to start with. Set the receiver "data level" potentiometer fully counter clockwise (lowest level) and then turn the "receiver power" on. Gradually turn up the "data level" in the clockwise direction with your finger touching the "ant" connector. You should hear a strong hum coming out of your computer speakers. If you hear a hum that increases in volume as you turn up the "data level", then everything is working up to the point just before the audio amplifier section. If you do not have hum coming to the computer, even at the full "data level" setting, then there is a problem with the frontend of the VLF receiver and you'll need next to perform diagnostics there.

VLF Online Resources

YAHOO VLF DISCUSSION GROUP
(see page 25 of the Journal for more info)
https://groups.yahoo.com/neo/groups/VLF_Group/info

VLF GRAPH CONVERSION SOFTWARE
Spectrum Lab: http://www.qsl.net/dl4yhf/spectra1.html

VLFrxTools: http://abelian.org/vlfrx-tools

LOCAL TIME TO UTC CONVERSION
http://www.worldtimeserver.com/current_time_in_UTC.aspx

INSPIRE Kit Questions, VLF Observation Journal Submissions:
CustomerService@TheINSPIREProject.org

To Purchase an INSPIRE VLF-3b Kit & Download Assembly Instructions
http://theinspireproject.org/default.asp?contentID=3

Observing VLF Radio Noise During the 2017 Solar Eclipse **Dennis Gallagher**

A total solar eclipse provides a special opportunity to explore how VLF radio noise is affected by the shadow of the Moon on Earth's atmosphere, which should change the ionosphere. Changes in VLF radio noise during eclipse might mimic those that occur at dawn and dusk. However, the loss of sunlight is limited in time and space. Eclipse-related changes in Earth's ionosphere typical of crossing the day/night terminator may not happen. An eclipse provides an opportunity to speculate and hypothesize what might happen; to observe what happens, and to test the hypothesis using observations. The following is a list of recommended measurements. You do not need to make all of them to learn new things about how changing conditions influence VLF radio noise.

1. Measure VLF radio noise on many different days at the same time of the day and at the same location you will use for the eclipse. Identify what is typical for that time of day and location. These measurements provide you with a comparison for the eclipse measurements.

2. Measure before, during, and after sunset so that you know what is typical for VLF at the eclipse observing site. Again, these measurements can be compared against eclipse measurements to find similarities and differences.

3. On eclipse day, make measurements before, during, and after the eclipse.

For each of these observing sessions produce thirty-minute spectrograms. All spectrograms should be for the same length of time and for the same frequency range. Count the number of spherics, tweeks, whistlers, and other phenomena. Compare the spectrograms and the types and numbers of VLF features observed during each session. Note any differences or similarities. Also compare the background noise. Is background noise higher or lower during the eclipse?

Document the weather near your eclipse-observing site for each observing session. Include the weather in the hemisphere opposite yours near the same magnetic latitude and longitude (the magnetic conjugate location) and in both directions along the eclipse path through the atmosphere. You are looking for explanations of differences (or similarities) in VLF radio noise that may depend on the weather and/or on the eclipse. As the ionosphere/atmosphere recovers to daytime conditions, what changes do you see? Think through what you find. Can you conclude that you have seen an eclipse influence VLF radio noise? If not, what measurements are needed to reach a conclusion? Remember that a negative result can be as useful as a positive one. Consider and note how this experimental campaign could have been done better.

Whatever the influence of the eclipse on local VLF radio noise, it is there to be discovered. Happy hunting!

About Dr. Dennis Gallagher

Dennis Gallagher and Mitzi Adams discussed careers in STEM and answered questions from INSPIRE's Space Academy participants following their graduation at the US Space & Rocket Center (Huntsville, Alabama) in August 2016

Dr. Gallagher has worked at NASA Marshall Space Flight Center since 1984 doing research in space plasma physics. Dr. Gallagher was the study scientist for the Inner Magnetosphere Imager Mission concept that was realized in the first selected MIDEX Explorer mission, IMAGE, for which he was a Co-Investigator. He supported IMAGE mission planning and instrument requirements definition for the Extreme Ultraviolet imager and the Radio Plasma Imager instruments and has participated and led numerous studies of the measurements obtained by this first-ever magnetospheric imaging mission. He continues to be involved in the development of thermal plasma modeling and the study of IMAGE Mission observations. Through the years at NASA Dr. Gallagher has led and supported a diverse variety of studies including examination of the feasibility of using electrodynamic tethers at Jupiter for orbital capture and maneuvering, for the viability of the concept of plasma propulsion, for measuring the spin of individual dust grains suspended in an electrodynamic trap in the Dusty Plasma Laboratory at MSFC, and for deriving the electrostatic charging properties of radioactive dust as it decays and fissions in support of developing a fission-fragment in-space rocket engine. From 2006 to 2011 Dr. Gallagher served as Deputy and Acting Manager for the Space Science Office at NASA Marshall Space Flight Center. Researchers performed research in Heliophysics, Planetary Sciences, Space Weather, and Astrophysics. He has returned to primarily scientific research following serving as manager of the Heliophysics and Planetary Science Office from 2011 to 2013. Dr. Gallagher serves as INSPIRE's Chief Technical Advisor. Dennis answers VLF kit users' technical questions and updated INSPIRE's VLF Kit Assembly Instructions in June of 2016. He has been actively involved with the organization since it was founded in 1989.

About Paul Schou

Paul Schou is a Research Analyst for the University of Maryland Baltimore County and works with High Performance Computing (HPC) systems. Paul redesigned the VLF-3b receiver kit and circuit board in 2011. He performs soldering prior to kit shipment and has served as a chaperone for Space Academy. As INSPIRE's vice president, Paul represents the organization at conferences.

Submitting VLF Observations

The Very Low Frequency (VLF) observations performed throughout the world provide a powerful unifying theme for people of all ages and walks of life to share their experiences, their personal discoveries, and the mysteries they encounter in this part of our natural environment. INSPIRE offers an opportunity for VLF observers to share their technical and non-technical observations.

The procedure and format for your observations should be as follows. Only electronic submissions are requested. Scan paper logs as needed to produce PDF electronic versions.

1. Use the Data Cover Sheet and Data Log forms below. (Make copies for new entries in order to retain the blank forms.)

2. Include a voice introduction at the start of each audio recording session indicating your name, your INSPIRE Team name if you have one, the location (by geographic or societal coordinate, such as country, state, and town), the date, local time and Universal Time (UT) time. Include the same introductory information in the written Data Cover Sheet.

3. The specific length of recordings and when they are made will depend on whether you are simply observing for fun, going after a specific observing objective of your own interest, or participating in a coordinated observing campaign. If you are observing for fun or even as an excuse to get into the wilderness and away from society for a while, we recommend you record for at least 30 minutes. If you seek to understand something you've observed or as part of a campaign, the length, frequency, timing, and locations of your observations will be tailored to your needs or by the design of the campaign.

4. Document the time of each recording using the form below and by including audio WWV or a voiced time stamp at the start. The same time stamp should be entered into the audio recording every 30 minutes.

5. File names should uniquely identify you, the date, and the observing campaign if relevant. Two types of files make up your observing session. One is a document file following the forms below. The second is the recording or recordings themselves in a common digital audio format.

6. Files can be delivered to The INSPIRE Project using:

Internet via DropBox, Google Drive, etc. to:	Tape Cassettes (if necessary)*:
CustomerService@TheINSPIREProject.org	The INSPIRE Project 107 S West Street PMB #425 Alexandria, VA 22314-2824

**Your tapes will be returned with spectrograms of your data.*

7. Include a write up accounting your procedure, location, and observations and an article reporting on the results will be considered in the next *INSPIRE Journal.*

Field Observations

Field Observations may be made at any time and submitted for inclusion in the next *INSPIRE Journal*. This is in addition to articles reporting the results of Coordinated Field Campaigns.

Use the same procedure as described for Submitting VLF Observations (previous page). Since field observations can be made any time of year, the following table is provided for conversion from local time to Coordinated Universal Time (UTC).

> The conversion between your local time and UTC can be determined by knowing the current UTC time from a website like: http://www.worldtimeserver.com/current_time_in_UTC.aspx

Provided Spectrograms:

File Name: _____

Frequency Range: _____

Time Period: _____

Intensity Scale: _____

File Name: _____

Frequency Range: _____

Time Period: _____

Intensity Scale: _____

File Name: _____

Frequency Range: _____

Time Period: _____

Intensity Scale: _____

Spectrograms should be limited in frequency to half the sample frequency for your recording. The period of the lowest frequency (other than the DC component) is determined by the length of time of the recording. Spectrograms can have a logarithmic or linear frequency scale. A linear scale would normally have 0 Hz as the lowest frequency. The highest frequency shown on a spectrogram need not be greater than the highest frequency your receiver can measure.

Describe your experience, including any comments that relate to carrying out your field observations. Field photographs and spectrograms are welcome components of your submission, along with a short bio and photo to accompany your *INSPIRE Journal* submission.

Data Log Cover Sheet

INSPIRE Observer Name: _____

Educational Institution: _____
(or company, if applicable)

Equipment: Receiver: _____

Recorder: _____

Antenna: _____

WWV radio: _____

Site description: _____

Longitude: _____o _____ ′ W Latitude: _____o _____′ N

Participants: _____

_____

Team Leader *(if applicable)*: _____

Mailing Address: _____

_____

City, State, Zip, Country: _____

Email: _____

The conversion between your local time and UTC can be determined by knowing the current UTC time from a website like: http://www.worldtimeserver.com/current_time_in_UTC.aspx

Data Log

INSPIRE Observer Name: _____

Observation Date: _____ Receiver: _____

Observation Start Time (UTC): _____ Start Time (**Local** Time): _____

Local weather: _____

Code:
M – Mark (WWV or Voice)
S – Sferics
T – Tweek
O – Other (manmade or not)
C – Chorus

Sferic Density: D: ___ Scale of 1-5 (1 – Very Low, 3 – Medium, 5 – Very High)

Time (UTC) Entry Observer:

_____ M-WWV M-V S T W O C_____D: _____

_____ M-WWV M-V S T W O C_____D: _____

_____ M-WWV M-V S T W O C_____D: _____

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INSPIRE VLF-3b Radio Receiver Kit Ordering Information

INSPIRE VLF-3b Radio Receiver Kits can be ordered online at:
www.TheINSPIREProject.org

INSPIRE accepts purchase orders for multiple kit orders. Discounts are available for non-profit organizations utilizing kits in middle and high school STEM curriculums.

For more information, contact CustomerService@TheINSPIREProject.org

Invest Today for the Exploration of Tomorrow

The INSPIRE Project's STEM educational programs provide scholarships and internships to educators, middle/high school students, and university students to ensure the next generation of space science and technology explorers. We currently do fundraising through grants and corporate partners. However, programs that are now offered have grown exponentially. In order to continue fulfilling our expanded mission, INSPIRE is seeking additional partners and sponsors who understand the importance of providing STEM educational opportunities to educators and students. INSPIRE's programs provide students the resources to pursue study in STEM disciplines. *Contributions are tax-deductible.*

Photo by Eva Kloostra, U.S. Space & Rocket Center ~ Huntsville, AL in August 2016

For more information on individual and corporate giving opportunities, please contact INSPIRE's Program Manager Eva Kloostra at Editor@TheINSPIREProject.org.

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INSPIRE VLF Kit Information
CustomerService@TheINSPIREProject.org

The INSPIRE Journal Editor
Editor@TheINSPIREProject.org