



**INSPIRE**  
INTERACTIVE NASA SPACE PHYSICS  
IONOSPHERE RADIO EXPERIMENTS



# The INSPIRE Journal

VOLUME 21 SPRING / SUMMER 2015

A publication of The INSPIRE Project Inc.

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Letters and submissions for The INSPIRE Journal should be emailed to:

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## 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.

## CO-FOUNDER/EMERITUS

William E. Pine

## IN MEMORIAM

Kathleen Franzen, President 2005 - 2010  
Jack Reed, INSPIRE Board Member 1992 - 2009  
Jim Ericson, INSPIRE 1st Vice President 1981 - 2006

## 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, INSPIRE Advisor*

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

Interest in Very Low Frequency (VLF) radio continues to increase both nationally and globally. Over 3,200 INSPIRE VLF radio receiver kits have provided students around the world the opportunity to experience the sounds of space firsthand ~ propelling INSPIRE's co-founder Dr. Bill Taylor's vision of engaging our youth in Science, Technology, Engineering and Mathematics (STEM) disciplines.

Last year, the INSPIRE VLF kit was incorporated in a summer physics program at Chapman University in Orange, California. Students, including a Summer Undergraduate Research Fellowship (SURF) recipient, constructed the VLF kits, conducted observations, and presented their research at a poster presentation and a SURF research conference. Across the globe, INSPIRE's VLF kit is now a permanent fixture in the gardens of Tay Nguyen University in Vietnam (*page 19*). At the University of Alaska in Fairbanks, INSPIRE's VLF kit observations were used to create an electro-acoustic reinterpretation of the Northern Lights to build a bridge between artists and scientists (*page 5*).

INSPIRE's STEM educational programs established and launched by our late executive director and "fearless leader", Kathleen Franzen, continue to flourish. During the past seven years, 94 STEM scholarships and internships have been awarded thanks to the generous support of program sponsors, partners, friends and volunteers of INSPIRE. The Journal submissions by a recent William Taylor Memorial Scholarship recipient, NASA Goddard Space Flight Center summer interns, and Space Academy for Educators & Students astronaut trainees clearly convey how each of INSPIRE's programs are exciting, engaging and attracting students to STEM disciplines.

We hope you enjoy the Spring/Summer 2015 volume of the INSPIRE Journal.



*Chapman University students constructing INSPIRE VLF-3b receiver kits (Photo courtesy of professor Dr. Eric Minassian)*

*Special thanks to INSPIRE Advisors Dennis Gallagher and Leonard Garcia for technical editing; Jay Friedlander of NASA for providing the cover image (NASA photo of auroral activity over the Southern Hemisphere taken from the International Space Station); Gail Breeze for graphic design services; and to all who contributed to this issue.*

## Yahoo VLF Discussion Group ~ 14 Years and 1600+ Members

*Shawn Korgan, Founder & Group Moderator*

One day back in December 2001, when there were only a dozen VLF enthusiasts communicating via email with each other, I ventured to start a Yahoo discussion group for those interested in VLF emissions. I never thought it would one day consist of over 1600 members!

The Yahoo VLF Group is an open group. Anyone can join the group and participate in the discussions. Files and photos are not accessible until a person signs in with a Yahoo account; this is a Yahoo limitation which we have no control over. Older posts have a lot of discussion with regards to the types of sounds that can be received while newer posts touch on a number of topics many of which have to do with setting up home based VLF receivers. (*continued page 4*)



## Yahoo VLF Discussion Group *continued*

It never ceases to amaze me what VLF radio amateurs think of to discuss on the Yahoo VLF Group email reflector. Recently they have been discussing bat detectors. I have often wondered if a person could use a bat detector to shift higher frequency whistlers (ultrasonic whistlers) down into the audible range?

Mark Karney is now the VLF Group Administrator and I remain as a Moderator of the Group. We attempt to keep the group professional and on topic as much as possible which I believe has led to its success. It is my sincere hope the group continues 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](https://groups.yahoo.com/neo/groups/VLF_Group/info)  
To subscribe, email: [VLF\\_Group-subscribe@yahoogroups.com](mailto:VLF_Group-subscribe@yahoogroups.com)

### About Shawn Korgan

Shawn Korgan was born and raised in Northern Colorado. He became interested in radio astronomy while in Middle School during the 1980's in large part due to reading a magazine article advertising VLF receivers which could tune into the amazing sounds of the Northern Lights and whistling sounds generated by lightning. In the late 1990's when the Internet became available where he resides, he discovered how to construct a VLF receiver and listen to the amazing sounds of nature personally. His most active period of VLF monitoring was between 1998-2009. Shawn has always enjoyed the VLF discussion group as it allows members to work together to accomplish otherwise impossible tasks such as designing software to eliminate power line interference and setting up almost a dozen online VLF audio streams from around the world. Visit: <http://www.abelian.org/vlf/>

## William Taylor Memorial Scholarship Recipient Receives Google Engineering Internship

Hannah Clark, @HMClarkk

*In honor of INSPIRE's co-founder Dr. Bill Taylor, The INSPIRE Project with its partners at the District of Columbia Space Grant Consortium, NASA Goddard Space Flight Center and other science and technology organizations established Dr. William W.L. "Bill" Taylor Memorial Science Scholarship to help ensure our next generation of space explorers. Scientifically oriented undergraduate and graduate college students and high school seniors who are majoring in a STEM discipline and are currently (or will be) attending a District of Columbia college or university are encouraged to apply. Since the program's launch seven years ago, INSPIRE has awarded eleven scholarships.*



Receiving the Dr. William W.L. "Bill" Taylor Memorial Science Scholarship has enabled me to control my schedule and concentrate on long-term priorities. It has helped me to finance daily needs, be more efficient, and eliminate the need for a part-time job. As a result, I allocated more time for internship applications and the interview preparation.

Last summer I was one of the roughly 1,500 people who received a paid Google Engineering Practicum Internship in Mountain View, CA where I was chosen from a pool of 40,000 applicants. The 12-week program provided me with hands-on work experience in Computer Science via a software project, skills-based training and professional development. I worked in System Infrastructure, writing programs which parsed through data resulting from regular benchmarks which tested code performance.

This scholarship has not only assisted in financing my undergraduate degree in computer science, it enabled me to excel academically and secure a valuable summer experience! (This summer I am interning at a tech start-up in DC.)

Receiving the William Taylor Scholarship was an encouraging reminder that has spurred me forward toward my goals. Although obtaining an undergraduate tech degree is a daunting process, programs like the INSPIRE Project helped me to see beyond my current challenges and access a network of supportive STEM professionals and opportunities.

# Hissing Chorus of Dawn - A multidisciplinary performance generated from aurora activity

*Simon Bouchard*

## The Project

The *Hissing Chorus of Dawn* project was founded by the University of Alaska Fairbanks Collaborative Arts Council. The project consisted of utilizing data collected from aurora activity in Fairbanks, Alaska to create a performance that was an electro-acoustic reinterpretation of the Northern Lights. We wanted to produce a piece that would change the common way scientists look at this phenomenon. And in doing so, we could inspire the public to look at it in a different way too. Ultimately, the main goal of this project was to help to build a bridge between artists and scientists, and have them collaborating and stimulating each other.

Diverse devices such as INSPIRE's VLF receiver, homebuilt antennas, satellite reports, recorders, radios, spectrum readers and the HAARP super radio transmitter facility were used to collect our data. The sound information was used to create a musical piece that served as a guideline for the performers. The optical data was processed through 3-D software to generate animations showing the natural phenomenon. The animation was mixed live on stage, following both the soundtrack and the musicians, on March 3, 2014 at the Salisbury Theater ~ University of Alaska Fairbanks for the *Thaw Out Student Film Festival*.

A special thanks to Stephen McGreevy for allowing us to use his recordings of the mythic chorus and to Miho Aoki of the University of Alaska Fairbanks for her support and advice on this project.

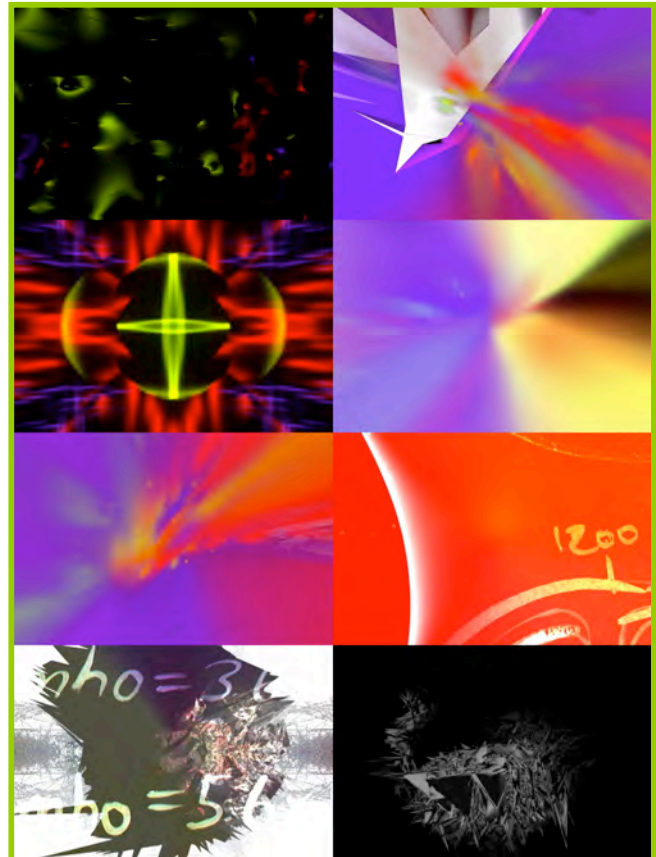
**To view the video of the performance:**

<https://vimeo.com/94458253>

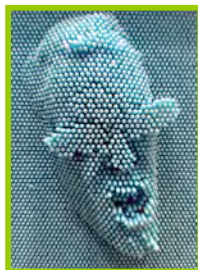
**To listen to the soundtrack:** <https://soundcloud.com/hissingchorusofdawn/the-hissing-chorus-of-dawn>

**To view animations of the Northern Lights generated from the data:**

<https://vimeo.com/94453709>   <https://vimeo.com/94451608>



*A collage of images from the live Hissing Chorus of Dawn performance at the University of Alaska Fairbanks*



## The Collaborative

Simon Bouchard, Sound and Video Performance Artist

Teal Booth, M.F.A. Artist and Folk Singer

Sean Dowgray, M.F.A. Percussionist

Chris Fallen, Ph.D., Research Assistant Professor, Arctic Region Supercomputing Center

Jessica Lindsey, D.M.A., Clarinetist and Bass Clarinetist

## About Simon Bouchard

*Simon Bouchard is a Canadian artist based in Montreal, Quebec. He graduated from the Visual and Media Art School of the University of Quebec in Montreal in 2014 and his work now focuses on experimental music and animations. His most recent project is Ordalia, an electro-acoustic music duo which integrates VLF, radio transmissions and drones to acoustic instruments. To view: <https://vimeo.com/120842656>*



# INSPIRE's NASA Goddard Space Flight Center 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 college and graduate level students. During the past four years, INSPIRE has awarded eighteen NASA GSFC internships. Each intern is paired with a mentor and works on a STEM research project.*

## Multimedia Communications

### Sheyla Cornish, Howard University

I am studying Telecommunications Management at Howard University and this was my first summer internship at NASA's Goddard Space Flight Center. While at NASA, I created and edited informational posters and content for online and display use. The posters were created to support the Sciences and Exploration Directorate Code 600. The divisions in this directorate include: Earth Sciences, Astrophysics, Heliophysics and Solar System Exploration. There are over 25 labs and offices throughout the directorate that were represented by these posters. Through this project I was able to learn about the broad range of scientific investigations that are actively taking place at the Goddard Space Flight Center. The computer applications that I used during my internship were Adobe Illustrator CS6 and Adobe Photoshop CS6. These applications opened up graphic possibilities I hadn't considered. My summer experiences have taught me how to be a better graphic designer. I know that what I have learned here can be taken with me and help me to further my exploration of the communications field. I am very grateful for this opportunity and hope to work with NASA in the future.

*Interns are invited to participate in a poster presentation at Goddard where they present their summer research project to the scientific community and to their peers. Sheyla Cornish and INSPIRE Space Physics Advisor, Dr. Leonard Garcia, pictured on the right.*



*Veronique Merritt with 3-D printer*

## Innovation Lab & Office of Patent Counsel

### Veronique Merritt, EdM, Howard University

This summer I was an intern at NASA Goddard Space Flight Center in dual roles ~ as educational team lead in advanced manufacturing and as patent paralegal in the Office of Patent Counsel. I was able to engage creatively with the process for documenting and protecting mission specific spontaneous intellectual property events. I oversaw the parts production, assembly, and storage on a competition sensitive invention that might have important applications in space flight. I was able to take part in the design & production phase of this work with this internship. Although the other part of my role as Innovation Lab Team Lead was focused on the educational process of 3-D parts printing, the NASA process for documenting New Technology Reporting was the most inspiring. Such important involvement in the creative process and protecting emergent technologies convinced me that I am now more certain than ever that my future is in Patent Law with an emphasis in social justice as it relates to equal and fair access to protection of the law. Without

this internship award, I would have never had the opportunity to explore how the creative science and engineering process is facilitated by intellectual property protections at NASA.



## Information Technology Project Management Office

**Nicole Wall, George Washington University**

This summer I worked in the Information Technology Project Management Office (IT PMO) at Goddard Space Flight Center. My project was to develop a standardized document that would encompass project requirements for specific life cycle phases and stage gate reviews. The project comprised using existing requirements documents such as the NPR 7120.7 and the Lifecycle Procedural Guidelines document for the IT PMO. From these baseline documents I was able to derive top level requirements and goals for each IT Project Management phase, Initiating, Planning, Execution, Monitoring and Control, and Closing. For each phase there are also stage gate reviews that have both entrance and success criteria that were included. The phases and stage gate reviews were aligned to the different phases

from the NPR 7120.7, Pre-phase A, Phase A, Phase B, Phase C, Phase D, Phase E and Phase F. Once all of the information and requirements were compiled the next step was to develop a Program Control Board Charter that would be used to outline the responsibilities of a Board to review IT projects based on the compiled requirements documents. The Charter describes membership, goals, responsibilities, meeting procedures, among other facets that will help the IT & Communications Directorate govern the review process for the stage gate reviews for different projects. In addition to working on my project, while at Goddard I was able to meet incredible people who were not only inspiring but also encouraging and supportive throughout the internship. The Goddard environment is one of innovation and inclusion and each person here makes that possible. I would specifically like to thank my mentor Cheri Ward for her help and guidance throughout my project, and NASA Goddard and the INSPIRE Project for this incredible opportunity.

## Medical & Environmental Management Division and Occupational Safety & Health Division

**Rachel Elliott, Catholic University of America**

This summer, thanks to the INSPIRE project, I had an exciting internship at NASA Goddard Space Flight Center. I interned with both the Medical and Environmental Management Division (Code 250) and the Occupational Safety and Health Division (Code 350). During my time with the Medical and Environmental Management Division, I worked with Occupational Medicine team where I observed routine medical procedures and examinations as well as the treatment of injuries sustained on the job. With the Occupational Safety and Health Division, I worked with the Industrial Hygiene team by assisting in conducting comprehensive surveys, indoor air quality assessments, mold assessments, and managing the hearing conservation program. The main project I worked on was the Hearing Conservation Program, which works to identify employees that work in noise hazardous environments

and to ensure that these employees receive the training and protection that they need to maintain their hearing. Working on this project allowed me to see how the members of the Occupational Medicine and Industrial Hygiene teams work together to keep the workforce safe. If an employee is exposed to noise pollution for an average of 82 decibels over an eight hour period as determined by a personal noise dosimeter, he or she is enrolled into the Hearing Conservation Program. This employee will receive baseline audiometric testing courtesy of Occupational Medicine and will continue to receive annual audiometric testing as long as they are in the Hearing Conservation Program in order to track any potential hearing loss. In addition, all employees enrolled in the Hearing Conservation Program will receive training on protecting their hearing on the job. In order to educate the Goddard community about the work of the Occupational Medicine and Industrial Hygiene teams, I collaborated with fellow intern, Mikaela Johnson, to create and give a presentation on the Hearing Conservation Program and other methods employed by Goddard to protect workers' hearing on the job. Before interning at Goddard I had not realized the importance of the interactions between different divisions of a workplace. Without the collaboration of the Occupational Medicine and Industrial Hygiene teams, the Hearing Conservation Program would be unable to function and provide a safe work environment for NASA's employees. I greatly enjoyed my time with the Industrial Hygiene team and am now considering becoming an industrial hygienist after college. I had such an amazing time during my internship at NASA that I would love for others to have a similar experience. I enjoyed every aspect of the internship, from getting on the job experience in my intended career area to being a part of the NASA family. Working at NASA didn't include just the job, but bonding with co-workers, code picnics, various clubs, presentations and an amazing learning experience. It was wonderful to be in an environment where everyone is so passionate about their work.



*INSPIRE would like to thank NASA GSFC and the DC Space Grant Consortium for their support of this program; the NASA GSFC Education Office for the facilitation of the scholarship awards; and the dedicated Mentors for their inspiration and guidance. Special thanks to Dr. Leonard Garcia at NASA GSFC for his assistance with the implementation of this program each summer. Dr. Garcia serves as a Space Physics Advisor for INSPIRE.*

Visit [TheINSPIREProject.org](http://TheINSPIREProject.org) for Complete Program Information

## INSPIRE Educational STEM Programs and Opportunities

### Dr. William W.L. "Bill" Taylor Memorial Science Scholarship Competition

**Scholarship Awards: Up to \$4,000 per recipient**  
**DC Undergraduate and Graduate College Students**

In honor of The INSPIRE Project's co-founder Dr. Bill Taylor, INSPIRE with its partners at the DC Space Grant Consortium, NASA Goddard Space Flight Center and other science and technology organizations established this science scholarship to help ensure our next generation of space explorers. Scientifically oriented undergraduate and graduate college students, and high school seniors who are majoring in a STEM discipline and will be attending a District of Columbia college or university, are encouraged to apply.



### NASA Goddard Space Flight Center Paid Internship Program

**Internship Awards: \$6,000 per recipient ~ DC Undergraduate and Graduate College Students**

With support from NASA Goddard Space Flight Center, District of Columbia Space Grant Consortium and other partners, the INSPIRE Project is proud to offer paid internships at NASA Goddard Space Flight Center. Students are paired with a mentor at NASA Goddard Space Flight Center. Each student works with their mentor to design a project that they work on throughout the duration of the internship. Internships at NASA Goddard Space Flight Center are focused on STEM research. Full-time and part-time internships are available. For complete information and to apply online, visit the NASA Internship Site: <https://intern.nasa.gov> (apply under INSPIRE Project Internships).

### U.S. Space & Rocket Center, Huntsville AL Kathleen Franzen Memorial Space Academy for Educators and Students Scholarship Program

**Teachers/Administrators, Middle and High School Students**  
The INSPIRE Project teamed up with the U.S. Space & Rocket Center in Huntsville, Alabama, the District of Columbia Space Grant Consortium, and the Washington Space Business Roundtable to offer full scholarships to Space Academy.

**Space Academy for Educators** is a 5-day program offered for teachers and administrators to participate in 45 hours of intensive classroom, laboratory and training time, focusing on space science and space exploration. Teachers also take part in astronaut-style training and simulations, as well as activities designed to promote life-long learning in a classroom setting. All lessons and activities link to National Science and Math Standards and are classroom ready.



**Space Camp for Students** is an action packed 6-day program for students that promotes teamwork, problem solving, communication skills and builds 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!

*A Special Thanks to INSPIRE's Educational Program Sponsors, Supporters, and All of the Volunteers!*



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





# Auroral Chorus in the Lone Star State

**Kevin Palivec**

Down here in Texas we get a lot of lightning, storms and... Sferics, Tweeks, Whistlers and even the occasional deer chewed antenna cable. What we don't get are opportunities to hear actual Auroral Chorus on our INSPIRE VLF receivers! My name is Kevin Palivec and I live about 15 miles North-West of Abilene Texas in the North Central part of the state, about 160 miles West of Dallas-Ft/Worth. I work in Information Technology as a network engineer for a local medical clinic. I've been interested in lightning and VLF for quite a while – we get a lot of lightning here!

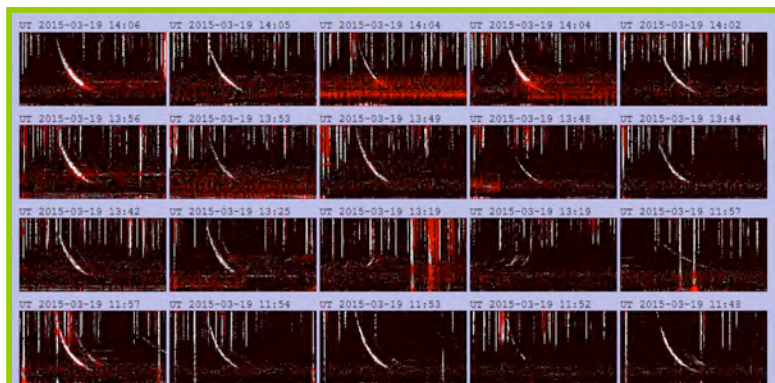
I have an INSPIRE VLF-3 receiver I use to listen to natural radio. It sits out in the oak trees about 140 feet away from the house protected in a modified ammo can. For an antenna, I have a 1-inch diameter, 20 foot steel pole supported with a tripod roof antenna mount. Power runs to the receiver through an RG-6 Coax and Audio comes back through a second RG-6 coax.

A PC running Ubuntu Linux and a suite of open source VLF software provides 24-hour monitoring and recording of VLF activity. (see *VLFrxTools*, page 11)

This year on March 9th and 10th, a series of solar flares hurled several CME's towards earth. As they approached on the 16th and 17th, they combined and the waves of material from the sun shook the earth's magnetic field.

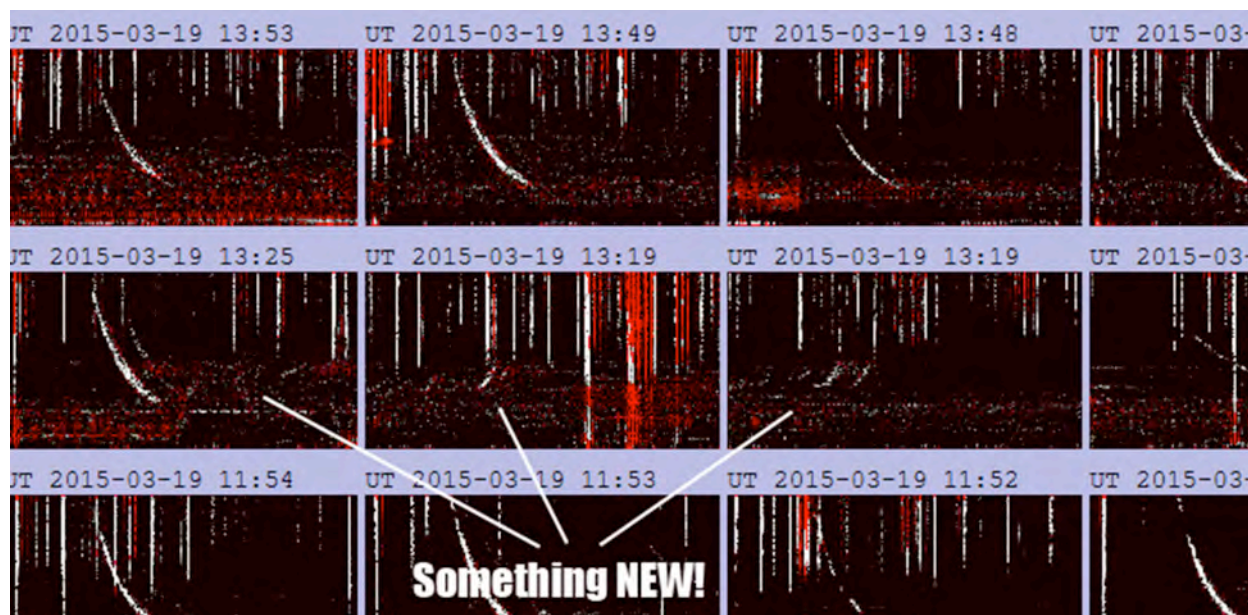


The result? Strong auroral activity, whistler storms and all manner of radio disruptions! I subscribe to the VLF Group on Yahoo and a few days later, reports were coming in of Whistler storms across Europe so I started checking my VLF feed for any activity that might also be occurring here in the U.S.



When I checked my VLF feed page on <http://abelian.org/vlf/>, I found a few Whistlers but nothing out of the ordinary. On the night of March 18th I started seeing increased whistler activity! We get whistlers here in Texas but they're not common by any means. Then on the 19<sup>th</sup>, when I checked to see what had been picked up I noticed something odd.

Mixed in with the whistler detections were 2 strange looking captures. I thought it was going to be power line noise so I went to the detection clips and listened to them.

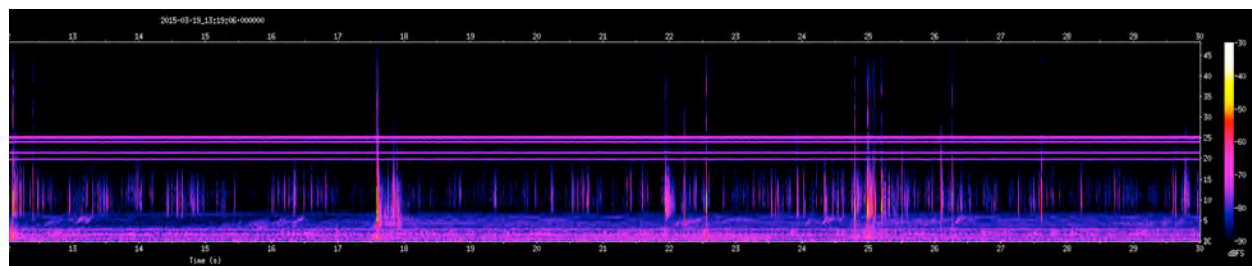
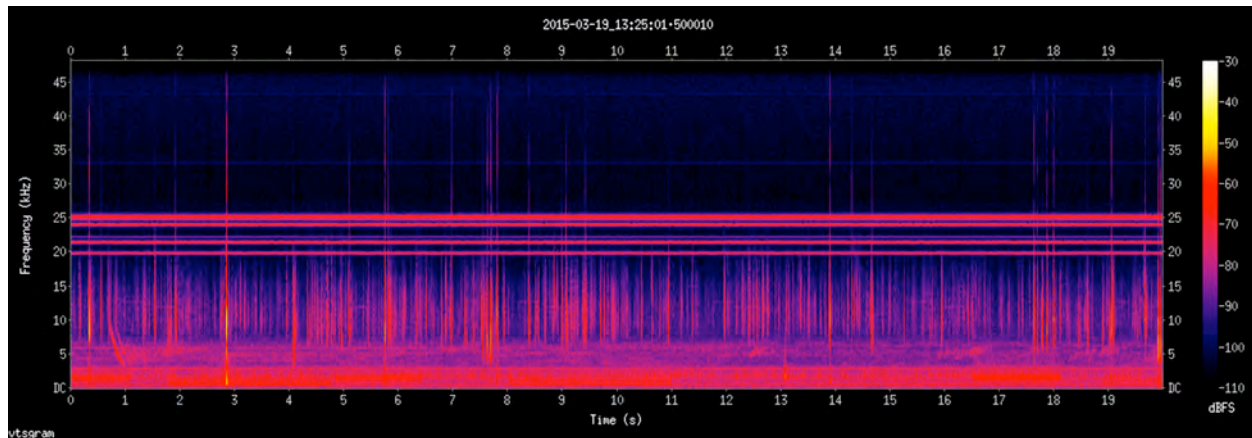


It sounded like Auroral Chorus but I thought it couldn't be! Not this far south! I've had VLF receivers for years and I've never picked up Chorus before!

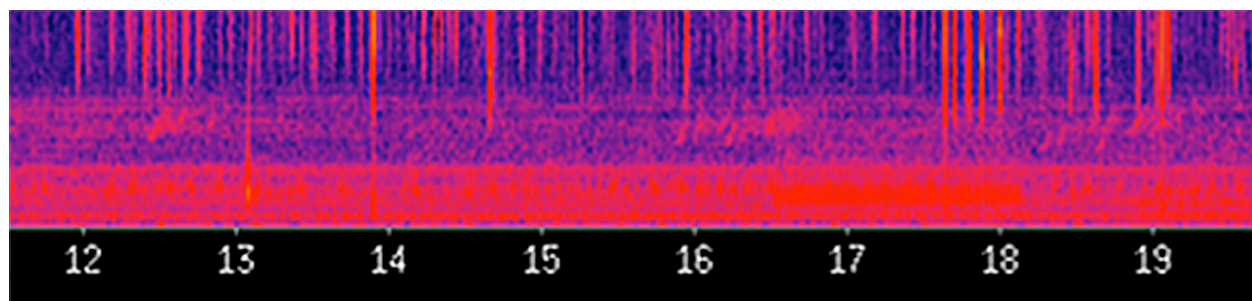
I used my local VLFrxTools PC to pull the audio from my hard drive and play it back and generate some spectrographs to see what it might be. I've built a little PHP web-based page to simplify extracting data from my recordings archive. Now mind you, I pick up weird things all the time but they always turn out to be power line noise or radio interference so I wasn't getting my hopes up too much at first.



I found that I had indeed picked up something new in a region of the spectrogram I hadn't seen before and having heard Auroral Chorus on VLF samples and on some other VLF live feeds, I decided it looked enough like the real thing to ask around for opinions.



I posted my findings on the Yahoo VLF Discussion Group to have others who live in more Chorus prone areas to look at and get their opinions. They all said it was actual Auroral Chorus I'd picked up down here in Texas!



Looking closer I could see the chorus down around 5000Hz just below most of the Sferics but above the residual Hum elimination noise. I decided this was unusual enough of an event that I should post it to [www.SpaceWeather.com](http://www.SpaceWeather.com).

### About VLFrxTools

VLFrxTools is a suite of open source software written and distributed by Paul Nicholson. He provides a place where those who have VLF receivers can stream their receiver's audio for the public to listen to. I have to take a moment and sing his praises! Paul provided invaluable help when I was first setting up my receiver. He gave me tips on how to cut down on power line Hum, how to isolate the receiver's audio feed, and most importantly, how to timestamp the VLF data feed so it's timed to 1us. This allows events from several VLF data streams to be compared. If you're a Linux User I highly recommend it! Visit: <http://abelian.org/vlfrx-tools/>

# VLF Recordings and Sound Installation Exhibit in Chile

*Fernando Godoy*

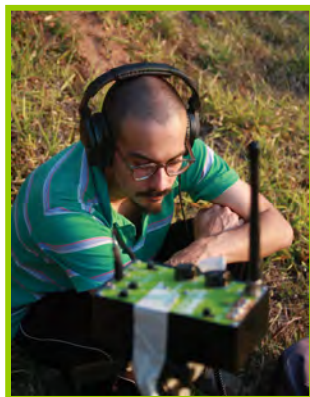
Field recording is a practice born in the decade of the 1970s that is being developed nowadays within the field of sound art. This practice consists in investigating and recording the natural or cultural environment, from an acoustic perspective and mainly for artistic purposes. Thus, every territory can be known by listening to its special qualities and situations that befall it.

Personally I consider it interesting when this exploration is expressed in levels beyond what is ordinarily perceptible, i.e. not only investigate the sound that is transmitted through the air, but also the sound traveling through different media, such as water or within bodies/objects or through electromagnetic means of propagation. It is here that the study of natural radio emissions can be of interest from an artistic perspective and the observation and recording of such emissions can perfectly be part of a creative process.

During December of 2012, along with Peter Kutin and Flo Kindlinger (both from Austria), we drove across the Atacama Desert. Our objective was to investigate and record the natural landscape and the traces of abandonment in the desert, always from a sound perspective. The impromptu tour route took us to diverse places and allowed us to map a part of the Chilean coast, desert, and plateau. During the trip I was able to conduct VLF observations, taking advantage of the low electromagnetic pollution conditions of the desert, and among those I found particularly interesting the ones made at 4273 meters of altitude in a place called Lagunas Altiplánicas (Highland Lakes), where the intensity of the reception of emissions was especially loud and clear. It is possible to listen to this observation at: <http://audiomapa.org/?loc=395>.

This project resulted in the composition of a radio piece for German public radio WDR, and also a sound installation exhibited during 2013 in three Chilean cities: Antofagasta, Valparaíso and Concepción. Both works used only sounds recorded during the trip, which included ambient, hydrophonic, contact, and VLF recordings. The installation was developed so that the public could explore, via headphones, the sounds of the journey on a map drawn with wires.

All of the recordings of the project can be heard and downloaded, under Creative Commons license, from the [audiomapa.org](http://audiomapa.org) platform, a project started in 2012 that seeks to explore and share soundscapes in a collaborative manner. This platform, within its functionalities, allows selective auditions by categories, one of which is labeled as electromagnetic and where you can listen to various VLF observations made in Chile. Visit: <http://audiomapa.org/>

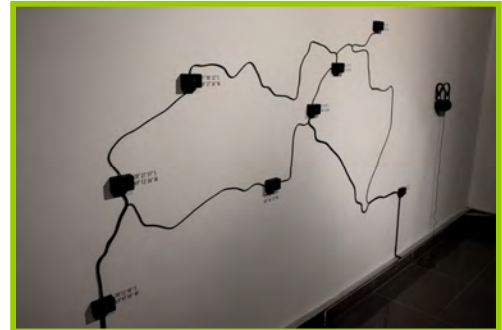


## About Fernando Godoy

*Fernando Godoy is a musician and sound artist from Chile. His work uses diverse means and media to investigate acoustic phenomena in fields such as the soundscape, the link between art and technology, auditory phenomena, and its relationship with territory and the perception of time. His practices include live performance, installation web projects, composition, and the development of DIY electronics. Since 2012 Godoy has maintained the project [Audiomapa.org](http://audiomapa.org), a platform dedicated to explore and share field recordings. In addition he directs Tsunami International Sound Art Festival in Valparaíso, Chile, a platform for the dissemination and development of contemporary sound practices. Visit: [www.Tsunami.cl](http://www.Tsunami.cl)*



*VLF observations at Lagunas Altiplánicas*



*Interactive sound installation exhibited in Chile*



## Kathleen Franzen Memorial Space Academy Scholarship Program

# Space Academy ~ Propelling Our Future Space Scientists and Explorers

*I was recently watching CBS' new TV drama Madam Secretary and one of the characters, a political speechwriter, was being interviewed for a trendy blog. When asked what was the one thing that changed his life, his response was 'Space Camp'. He described in detail about going to Space Camp when he was 10 years old and how it gave him the confidence to achieve his dreams; and how he proudly wore his flight suit to the first day of 6<sup>th</sup> Grade, not caring about the bullies at school, and still has it in his closet. Having accompanied INSPIRE scholarship recipients to Huntsville for the past six years and personally witnessing the positive impact the program has on both students and teachers, I had to smile as I watched the show, as it was obvious to me that one of the TV show's 'actual' writers had more than likely attended Space Camp. ~ Eva Kloostr, Space Academy Program Coordinator*

The Kathleen Franzen Memorial Space Academy Scholarship Program, renamed in 2011 to honor its founder, is in its seventh year and continues to grow in popularity. The INSPIRE Project teamed up with the U.S. Space & Rocket Center (USSRC), Washington Space Business Roundtable (WSBR), District of Columbia Space Grant Consortium, Patriots Technology Training Center, EADS North America, International Launch Services and other partners to send Washington, DC educators to the weeklong workshop at the U.S. Space & Rocket Center in Huntsville, Alabama offered every summer for teachers from around the world to participate in 45 hours of intensive classroom, laboratory and training time. Focusing on space science and exploration, the educational program includes authentic astronaut training simulators and 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 curriculum materials (via their own website with lesson plans) to excite, engage and attract elementary, middle and high school students to the STEM disciplines. In INSPIRE's annual survey of past participants (school year 2013-14), 100% of Space Academy for Educators scholarship recipients reported that they have utilized materials and knowledge acquired via the program in their classrooms directly impacting 2,504 students in 47 Washington, DC area schools. Past recipients represent INSPIRE at workshops and programs as Ambassadors and continue to be actively involved in the organization. In 2010, a second scholarship program, Space Academy for Students, was established in response to numerous inquiries from students that learned about the program through past educator participants.

The past two summers at Space Academy were very exciting. In 2013, five educator scholarship recipients participated in the USSRC's new 6-day workshop held July 6 – 11<sup>th</sup>, Advanced Educator Space Academy ~ an opportunity previously reserved for past Boeing Educator Scholarship recipients only. A highlight of the week was a visit from INSPIRE Board Member and NASA Payload Specialist, Dr. Rick Chappell, who spent an afternoon with the trainees. He discussed the importance of STEM education and creating our next generation of space scientists and explorers. Dr. Chappell also observed Team Boeing's student training in the scuba tank and shared that he had his NASA astronaut scuba training with Homer Hickam in the same tank in the 1980's. He spoke one-on-one with each student and conveyed that he was confident each would achieve his or her dreams with hard work and dedication – a true inspiration and memory the students will never forget.



(Above) INSPIRE Board Member Dr. Rick Chappell with INSPIRE Advanced Space Academy Educator scholarship recipients in Huntsville (Below) Dr. Chappell inspires student trainees at the Underwater Astronaut Training Tank



In 2014, scholarship recipients were invited to attend International Space Academy held July 19-25<sup>th</sup>. The program commenced with formal Opening Ceremonies on Saturday evening in which the INSPIRE's students were invited to lead the Parade of States & Nations. The event featuring forty United States "Teachers of the Year" representing their individual states. International teachers and students from Australia, Austria, Bangladesh, Belgium, Germany, Greece, Latvia, New Zealand, Norway and Turkey also participated. Each gave entertaining presentations with highlights and interesting facts about their countries and/or states. Astronaut Dr. Don Thomas gave a motivational speech describing his boyhood desire to become an astronaut, which he directly attributed to his elementary school teacher, and the trials and tribulations he experienced until he finally achieved his dream on the fourth attempt at age 39. The evening concluded with a welcome dinner in Saturn V Hall. The official astronaut training commenced on Sunday, July 20, the 45<sup>th</sup> Anniversary of Apollo 11.



*INSPIRE's 2014 trainees participate in International Space Academy's Opening Ceremonies*

### **Space Academy for Educators ~ Advancing STEM Education in the Nation's Capital & Beyond**

INSPIRE's educator scholarship recipients have engaged thousands of students in hands-on STEM activities in hundreds of DC area elementary, middle and high schools during the past six years. Below are just a few of the many program accomplishments.

INSPIRE's first scholarship recipient, high school Physics teacher, Ellen McLean, is participating for the third year in the NASA LEARN Project (Long-term Engagement in Authentic Research with NASA). This innovative program 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. Visit: <http://science-edu.larc.nasa.gov/LEARN/team.html>



Advanced Space Academy recipient Dr. Alesia Slocumb-Bradford, a 7th Grade Pre-Algebra/Algebra teacher, re-launched the Robotics Team at her new middle school in Washington, DC. This program been inactive for several years prior to her arrival to the school and she had 20 student participants her first year. In addition, Dr. Slocumb developed a new monthly student elective course entitled *Space Exploration*, as part her school's "Viking Time" program. She had ten 7th grade students per month participate and utilized the NASA materials acquired at Space Academy for the curriculum, including the NASA rocket construction book. This program is designed to give middle school students hands-on experiences in the space sciences and excite and engage them in STEM disciplines.



*Dr. Slocumb-Bradford during mission training*

Florentia Spires, Advanced Space Academy recipient, received a prestigious National Science Foundation Albert Einstein Fellow for the 2013-14 school year and promoted computer sciences curriculum to K-12 public schools throughout the U.S. and was one of two 2013 finalists for the Presidential Award for Excellence in Science Teaching for Washington, DC. Florentia was selected as a 2013-2014 NASA Master Educator for the GPM Project. Using the NASA Global Precipitation Measurement Mission project, she regularly provided GPM lessons to African American students at the Spaulding Public library leading up to the launch of the GPM satellite in February 2014. She led a Global Collaborative Science project with two classrooms of middle school students in Washington, DC and Nigeria. To read more about this project, visit: <http://today.ttu.edu/posts/2014/12/doctoral-student-connects-d-c-nigeria-in-global-science-project> Florentia was recently appointed as a Master Educator for the District of Columbia Public Schools where she evaluates teacher performance and coach novice teachers for STEM subject areas. She is also pursuing her PhD in Global Science Education at Texas Tech University.



Upon returning from Huntsville in 2010, Patriots Technology Training Center President, Thurman Jones, developed an annual Solar Competition to engage and excite Washington Metropolitan middle school students to STEM disciplines with INSPIRE's late Executive Director Kathleen Franzen. The 5th Annual Solar Competition ~ Mission to Mars ~ was held at NASA Goddard Visitors Center on April 22, 2015. The winning team of three middle school students and their team educator leader received scholarships funded by the Washington Space Business Roundtable to accompany INSPIRE's group to Huntsville in July 2015. (see page 18) Visit: <https://www.patriots-ttc.org/solar-system.html>

(Right) 2014 Solar Competition winning team members Olivia, Stephanie and Mary line up with their teammates for Graduation



As a science educator I am always finding innovative ways to present science curriculum to the students I teach. Attending the Space Academy for Educators and Advanced Space Academy for Educators provided me with the opportunity to learn more about astronaut-style training that further inspired me to build a unit plan on space sciences, as well as gave me the opportunity to network with other educators from different parts of the world. I want to make sure that my students have as much exposure to STEM careers as possible and through Space Academy, I was able to incorporate materials into the classroom that make science both educational and fun. One activity that particularly engaged my students was building their own version of the Mars Rover.

In March 2015, I received the National Science Teachers Association Distinguished Service to Science Award in Chicago. I was appointed as a USSRC Space Camp Ambassador and was selected by NASA for the 2015 SOFIA Airborne Astronomy Ambassadors Program ([http://www.sofia.usra.edu/News/news\\_2015/02\\_26\\_15/index.html](http://www.sofia.usra.edu/News/news_2015/02_26_15/index.html)).

I am in my second year pursuing a PhD in Curriculum and Instruction with a concentration in STEM Education from Texas Tech University hybrid program.

~ Jacqueline Fernandez-Romero, Science Teacher & STEM Coordinator, Latin American Youth Center Career Academy



Jacqueline Fernandez-Romero was presented with the Distinguished Service to Science Award by the National Science Teachers Association on March 13, 2015



## Space Academy for Students ~ An Action-Packed Week of STEM Activities Inspiring Our Future Generation

### International Space Academy 2014 ~ Destiny F.

In my time at Space Academy, I met many new people from places I've never been before. Once you meet and get to know all these people, you start to realize that there's more things to learn and people to meet. You learn that there's more to the world than just where you live. Before I went to Space Academy, I had very low confidence. Now I know I can do great things with my life just like everyone else. My teammates were amazing and fun to be around. We worked well together and worked hard to do our best. Even though we didn't get a team award at Graduation, it doesn't mean we did bad. We knew we did a great job, no one had to tell us that. My favorite part of training was building a cube in the scuba tank. We had ten minutes to build a cube out of pipes in the water. The timer only stopped when we got it on the side of the tank. My favorite ride was the Space Shot. Even after my first time on it, I would always scream. Even before it started! I won't forget anything I did or learned at Space Academy. But, the thing I will remember the most is the friends I made ~ my teammates.

### 2014 Solar Competition Winner ~ Stephanie S.

I was so excited when I first heard the news I received a scholarship to attend Space Camp 2014 in Huntsville, Alabama that I hugged the other two girls (Olivia and Mary) that I won the Solar Competition with. When we arrived in Huntsville on the 18th of July, I was so excited to learn what the week has in store for us. We were all in groups and I was on a team called Deimos. This was the team that I would be spending the week with. Everybody was so nice and I loved being at Space Camp. We had two missions that we had to complete. These missions brought out the best of us. We tried our hardest to do our best. I was CAPCOM for the first mission we had. This was a really fun job but it was tough at times. For the second mission I was the ISS mission scientist. I had many experiments to do. These were so fun and amazing. We also did a water activity. This was my favorite. We had the opportunity to work in groups of four and work together to build a 3D cube out of PVC pipes. I will also never forget the rides that they have at the Space Camp. I loved riding Space Shot, G-Force, and Mission to Mars. The briefings were educational and I learned a lot from them. This was a great experience that I will never forget. I made so many new friends that it was so hard to say goodbye. This is also a huge thanks for giving me the opportunity of a lifetime.



### My Space Camp Odyssey ~ Emily M.

Space Camp. What a week. Five days of intense learning and fun. What could be better than that? I had high expectations, but Space Camp went above and beyond all of them. Before Space Camp, I was just an average girl who loved science (especially in the topics of space, rocks, and fossils). At Space Camp I got to do a ton of fun stuff. I was Mission Scientist at Mission Control during one of our simulated missions. In another mission, I was a Mission Specialist, and I got to replace circuits and water filters. I got to rock climb at the Mars-themed climbing wall. In the Moon Base Challenge, we created a lunar base, and I got to present my team's design to the other teams and trainers. In the Heat Shield Challenge, we got to create a mini heat shield for a pretend astronaut. Then one of the trainers actually tested them out. We got to work in small groups in the Underwater Astronaut Training Tank (UAT) to build a PVC pipe cube above the water. I learned a lot about space history, travel and astronaut training at Space Camp. Did you know that Apollo 10 was a dress rehearsal for Apollo 11? They were so close to landing on the moon. They actually had enough fuel to get there, but not enough fuel to get back if they landed on the moon. I also got to meet and work with a lot of kids, and some of them are great friends that I'll know for a lifetime. I even met a couple of astronauts! Overall, Space Camp was extremely, outstandingly, unbelievably fun! Space Camp really changed me. I now know exactly what I must do to get to the point where I'm finally able to become a real astronaut and go into space, hopefully to Mars. Like I said, Space Camp was super fun and was an unforgettable, life-changing experience.



*Emily and her fellow 2013 Space Academy recipients pose for the Washington Space Business Roundtable sponsor photo in USSRC Rocket Park*



## The One Thing I Will Always Remember About My Week At Space Camp Is...

... that many problems can occur during a mission but with teamwork and cooperation we can solve those problems. Meeting people from all over the world has opened my eyes and introduced me to many new cultures. I have many memories, all good memories, with my new friends from Space Camp.

~ Alexa, 11<sup>th</sup> Grade



... the friends I made during the course of the week. I will also remember the simulations. They showed me how hard it is to walk on the moon, the power of 4 Gs and how a tumble fall in space feels. I will always remember the crew trainers that were fun and kept me safe. And finally, all of the information I learned will ALWAYS stay with me forever and help me with the rest of my scientific and engineering career. ~ Khari, 8<sup>th</sup> Grade

... the inspirational presentations done by astronauts and other people in similar occupations. They encouraged me that the world of STEM is constantly growing and there is more and more equality for women in STEM also. I will always remember my experience at Space Camp, all of my new friends, and the inspiration I gained from this camp. ~ Isodora, 9<sup>th</sup> Grade

... the simulator mission. Now I see what NASA employees have to deal with. I learned how to socialize with strangers and open up and how to communicate with people within a team. Without communication there is so much hurly-burly and problems arise. ~ Olivia, 7<sup>th</sup> Grade



... the new people I met. All of them were really nice and understanding. Also the one thing was the missions. I was the commander. Although I didn't get to do the fun part (the landing) because they were like 'we are going to die!!!' so they made me switch seats with the pilot. It was all good as we landed safely. It was cool, I had fun! ~ Mary, 7<sup>th</sup> Grade



... Graduation as many things made it memorable. For one, you could see all of your friends receiving awards, even though Team BOEING (my team) should have won the Most Outstanding Team Award. Also, the new Dream Chaser was revealed at this graduation – Can you believe it?!! Graduation allowed me to meet and shake the hand of an astronaut. In conclusion, I will remember graduation the most because it was awesome! ~ Joshua, 8<sup>th</sup> Grade

... **SPACE CAMP ROCKS!**

# 5th Annual Solar System Competition at NASA Goddard Space Flight Center ~ April 2015

## INSPIRE Project Late President's Vision Still Inspiring Our Next Generation

*Thurman Jones, Patriots Technology Training Center*

*Six years ago upon returning from Space Academy in Huntsville, Patriots Technology Founder & President Thurman Jones and INSPIRE's late President Kathleen Franzen conceived an annual Solar System Competition to attract and engage middle school students to STEM disciplines. The first competition was held in 2011 in honor of Kathleen and Thurman and his non-profit organization continue to keep her vision alive.*

Eight teams of middle school students (grades 6-8) from Maryland and Washington DC schools participated in the 5th Annual Solar System Competition ~ Mission to Mars ~ on April 22nd held at the Visitors Center at NASA Goddard Space Flight Center. Students spent the evening presenting their research on the possibilities of traveling and living on Mars. Using critical thinking skills, teams researched a topic and applied the information to real-world problems and created solutions that would allow human exploration, travel and colonization on the Red Planet.

One team shared plans for a 100 day Mars Cruise and resort stay on the planet complete with a spa, pool, gravity sleeping quarters and an exercise room to prevent passengers from developing muscle loss while being in a gravity free environment. Other teams described terraforming the planet to grow food and sustain human life, harnessing the natural resources on the planet to provide heat and shelter for inhabitants and creating functional and fashionable space suits.

The evening included a keynote address by Dr. Christyl Johnson, NASA Deputy Director for Technology and Research Incentives, and a computer programming challenge – The Mars Game. After an informative presentation of the NASA developed technologies we use every day here on Earth, Dr. Johnson encouraged the students to reach for the stars and believe they can achieve anything they want to do in life. The programming challenge was a highly immersive 3-D video game in which the students had to program a rover to repair its systems and find parts of its cargo that crashed landed on the surface of Mars.

The room, filled to capacity with nearly 100 students, coaches, family and industry partners, featured a Mars mural that made the atmosphere truly out of this world! Team Solar Phoenix won the competition and will travel with The INSPIRE Project to Huntsville, Alabama in July to attend Space Academy thanks to full scholarships provided by the Washington Space Business Roundtable. The Maryland Space Business Roundtable and the U.S. Department of Navy are also sponsors of the competition.



*Winning team, Solar Phoenix, presenting their Mission to Mars to NASA's Dr. Christyl Johnson*



*Barbara Freeman (The Mars Game), Team Universe Explorers and Carol Lynn Judge of the U.S. Navy*



*Dr. Christyl Johnson addressing the attendees*

### **About Patriots Technology Training Center**

*"Empowering Students Through Technology" has been the Patriots Technology Training Center's mission for 18 years by increasing the number of students, grades 5-12, entering science, technology, engineering, and mathematics (STEM), ultimately leading towards college education and career paths in these fields. They host annual conferences in the DC area including the Youth Summit on Technology, Video Jam Gaming Conference, STEM Carnival plus STEM Summer Camp. Patriots design and host over 10 STEM competitions each year including Cyber Security (Iron Bow Technologies), Flight Simulation (Southwest Airlines ~ winning team flies to their headquarters), Amusement Park Design (Six Flags), Renewable Energy (Department of Energy), Science Bowl (Prince George's Community College) and Computer Building (Customer Engineering Services). To learn more, visit: <https://www.patriots-ttc.org>*



# Observing Tweeks Using INSPIRE VLF-3 Receiver at Tay Nguyen University, Vietnam

*Le Minh Tan and VLF Group*

*Department of Physics, Faculty of Natural Science and Technology*

*Tay Nguyen University, Vietnam*

*Email: [lmtn@ttn.edu.vn](mailto:lmtn@ttn.edu.vn)*

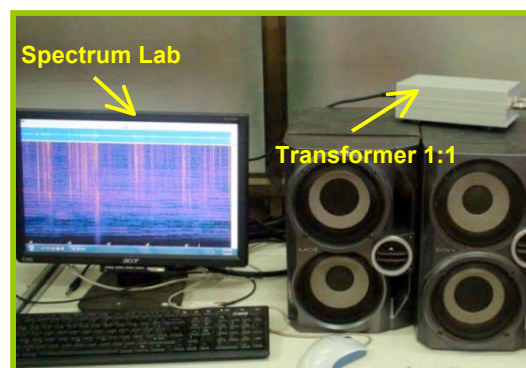
## Introduction

It is well known that lightning discharges can emit electromagnetic waves in the range of Extremely Low Frequency (ELF; 3 – 3000 Hz) and Very Low Frequency (VLF; 3 – 30 kHz), which propagate by multiple reflections in the waveguide bounded by the surface of the Earth (ground or sea) and lower ionosphere. The sferics generated by lightning discharges travel large distance due to low attenuation rate (2-3 dB/1000 km) offered by Earth – ionosphere waveguide (EIWG) (Davies, 1960; Barr et al., 2000). There is a type of sferics which produces the chirping sounds at loudspeaker of the receivers. This type of atmospherics is known as “tweeks” (Helliwell 1965, Yamashita 1978). The D layer (the lowest layer of the ionosphere) is in the altitude range of 60 - 90 km. It is relatively difficult to observe this layer by using the common methods for observation because in the nighttime, the electron density is very low ( $<10^3 \text{ cm}^{-3}$ ) (Budden, 1961). To observe this layer, scientists often evaluate the cut-off frequency captured from the tweek spectrogram to estimate the ionospheric reflection height, nighttime electron density of the D layer and tweek distance (e.g. Ohya et al., 2003, 2011; Kumar et al., 2008, 2009; Maurya et al., 2012, etc.).

## Experimental setup

The garden of Tay Nguyen University (12.65° N; 108° E) was chosen to install INSPIRE VLF-3 receiver and its antenna because this location is relatively quiet and far from the buildings and power lines. The system for the observation consists of the INSPIRE VLF-3 receiver, a magnetic antenna, a PC, and Spectrum Lab v2.77b22. We assembled the square loop with a side of about 1 m. This antenna has 14 turns of 18 AWG copper wire. The wires were wrapped with aluminum foil to remove background noise. The INSPIRE VLF-3 receiver was installed near the antenna and weatherproofed by a metal box. The ground isolation transformer was used with a wire ratio of 1:1 to break ground hum loops. We used two lines of cable with the length of 150 m, one for transferring the data from antenna to the PC and another one for providing +9 VDC to the amplifier.

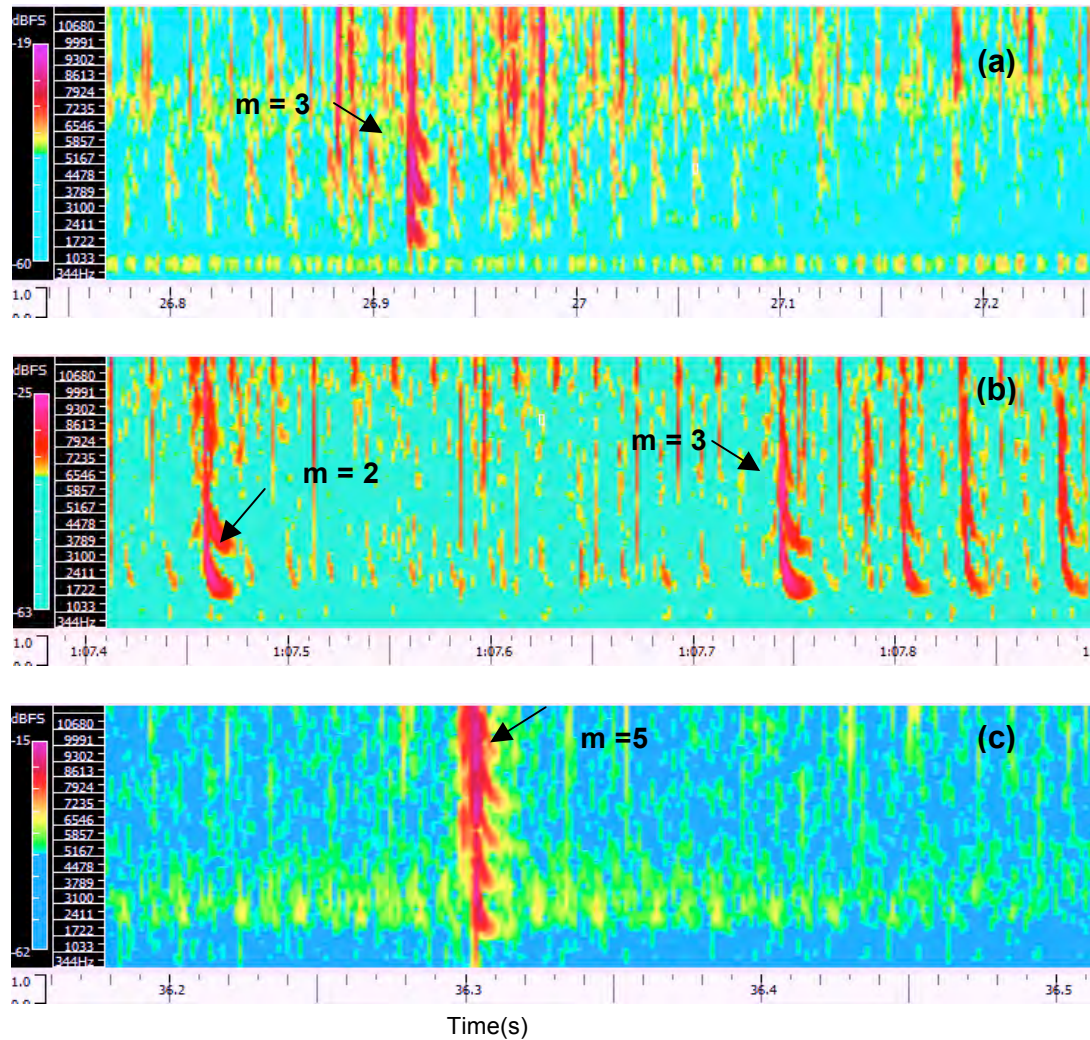
To record the data, we connected the DATA output of VLF-3 receiver to the PC's microphone port. The Spectrum Lab was used to record the sferics with audio files and was adjusted to the ADC's sample rate of 44.1 KS/s, 16 bit precision, and fast Fourier transform (FFT) input size of 512 to record the sferics. The waterfall was chosen to show the spectrogram with the frequency less than 12 kHz. The broadband data was recorded for 2 minutes at every hour, from 12:00 UT to 22:00 UT (17:00 LT – 05:00 LT) during some nights of October 2014. The tweeks are analyzed by Sonic Visualiser software.



*Preparing cables for the INSPIRE VLF-3 receiver and storing the data using a PC with SpectrumLab*

## Experimental Results

We captured tweeks during nights of October 2014. The third and fifth harmonic tweeks clearly occurred on the spectrogram.

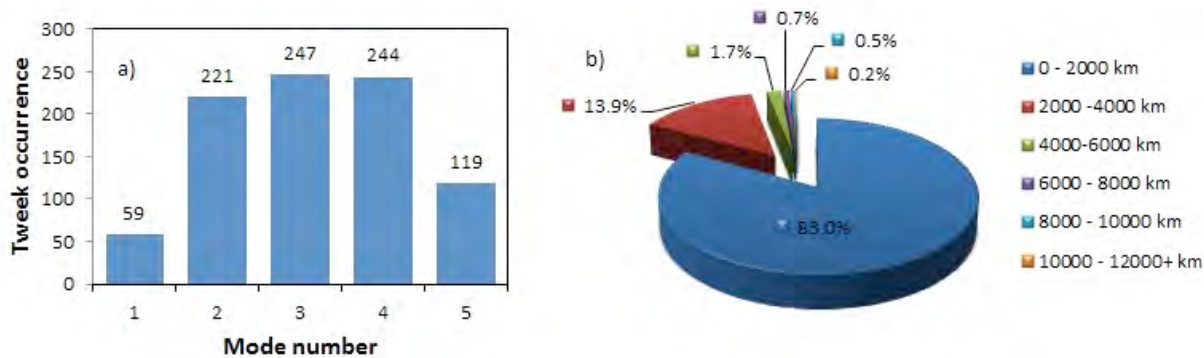


***Tweek spectrogram recorded at 17:15 UT on 14 October (a) at 19:15 UT on 15 October (b) and at 20:30 UT on 17 October 2014 (c)***

Using the tweek method of previous works (Ohtsu 1960; Budden 1961; Yamashita 1978; Ohya et al., 2008), we tried to estimate the ionospheric reflection height ( $h$ ), the electron density ( $N_e$ ) and the propagation distance of tweeks ( $d$ ) from the source to the receivers. The frequency and time resolution of the measurement are 35 Hz and 1 ms, respectively, which corresponds to the estimated error  $\sim 1.5$  km in the reflection height for first-order mode,  $\sim 0.6 \text{ cm}^{-3}$  in the electron density and  $\sim 900$  km in propagation distance for all modes.

We selected 890 tweeks recorded from 12:00 – 19:00 UT (19:00 – 2:00 LT) on 12 October 2014. The third harmonic tweeks are most popular (247 tweeks). We found that there are 59 first and 119 fifth harmonic tweeks which were not more frequent than other harmonic tweeks. The tweeks with the propagation distance less than 2000 km are dominant (83.0 %). The tweek distance is up to 12000 km. The propagation distance of higher modes is shorter than that of lower modes because the waves of higher harmonics are more attenuated in EIWG (Kumar et al., 2009; Maurya et al., 2012).





**Tweek occurrence vs. mode number (a) and propagation distance (b)**

From the table below, it reveals that the ionospheric reflection height increases from 71.2 - 89.0 km meanwhile the fundamental frequency decreases from 2.12 - 1.69 kHz as mode number increases. The electron density changes from 34.2 - 136.6  $\text{cm}^{-3}$  which corresponds to the modes from 1 - 5. These results are explained as follows. The waves having higher modes can penetrate more deeply into the lower ionosphere. The tweeks are reflected at the altitudes where the plasma frequency equals the individual cut-off frequency of each harmonic. Therefore, the waves of the higher harmonic tweeks can be reflected at higher altitude because the values of plasma frequency are higher (Shvets 1998).

$n$	$h$ (km)	$f_{cn}/n$ (kHz)	$N_e$ ( $\text{cm}^{-3}$ )
1	71.2	2.12	34.2
2	79.3	1.91	61.5
3	82.8	1.83	88.4
4	86.7	1.74	112.5
5	89.0	1.69	136.6

**Variations of mean reflection height ( $h$ ) and mean fundamental frequency ( $f_{cn}/n$ ) vs. mode number ( $n$ )**

To educate students, we explain some concepts relating to space science and encourage students to participate in installing the VLF-3 receiver. After that, we guide them to analyze the data and discuss the results. We hope that students who are studying Atmospheric Physics will have improved technical skills and can understand the behavior of the ionosphere and the use of natural phenomena to study the lower ionosphere.

### Summary

Based on the VLF-3 kit of The INSPIRE Project, we completely assembled the VLF-3 receiver. This receiver is set up to record sferics and tweeks at the low-latitude region. We also combined Inspire VLF-3 receiver with the PC and Spectrum Lab to store the broadband data. The sferics and tweeks are recorded to estimate some parameters of the D layer of the ionosphere. Installing the VLF-3 and estimating parameters of the lowest layer of the ionosphere can support students to improve their technical skills and understand the tweek method as well as the behavior of the ionosphere.



### About Le Minh Tan

Le Tan is a Lecturer in the Department of Physics, Faculty of Natural Science & Technology, at Tay Nguyen University in Vietnam and is a final year PhD student at Ho Chi Minh City University of Science. He has participated in the Stanford Super-SID monitor system of the International Space Weather Initiative (ISWI) since 2012; and his fields of interest include Space Physics, ELF-VLF (Extremely Low Frequency - Very Low Frequency) technique, and D-region physics. To contact email: [lmtn@ttn.edu.vn](mailto:lmtn@ttn.edu.vn)

*Editor's Note: Minor editorial changes in language usage to improve readability were made by INSPIRE's Chief Technical Advisor Dennis Gallagher, NASA Marshall Space Flight Center.*

# INSPIRE VLF-3b Receiver

## Technical Notes

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

For 26 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 3,200 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 has continued to increase both nationally and globally. 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 new board design has many unique features such as an internal battery / external battery connection and stereo audio plugs for listening to the VLF signals between 300 Hz up to 20 kHz. The updated receiver kit has similar functionality but the new design allows for increased ease of assembly and usage.

### VLF Questions from Kit Users

*Below are questions submitted during the past year to INSPIRE by VLF-3b kit users and INSPIRE Technical Advisors' responses:*

**Q: I am worried that a lightning strike nearby may induce damage to the device, are you familiar with this happening?**  
Lightning is always a risk, a risk that should be taken seriously. A whip antenna is typically used with the VLF-3b. If good 60Hz noise rejection is available, then the receiver and antenna can be located inside. The VLF-3b is designed to be hand held, but not for use when lightning is in the immediate area. Those that take the risk of locating a VLF receiver outside on a permanent or semi-permanent basis can implement a local grounding stake connected to the receiving antenna through a transient voltage suppression diode or other similar component. I would expect a direct strike would take out the receiver regardless. It is much more common for the high impedance front end of the receiver to develop an electrostatic charge as charged clouds pass overhead. This causes a sort of high-pitched whine in the received VLF signal that rises in pitch until it discharges in some way. That is more of a nuisance so far as the received signal, than a safety risk usually. Some have connected a grounded high value resistor to the antenna to bleed off that excess static charge.

**Q: I was just wondering, regarding the grounding, could I use this in a vehicle and ground it to the vehicle or MUST it be the earth?** Yes. Many people use their vehicle for a ground.

**Question: What type of antenna to do recommend using with the VLF Receiver?** Any whip antenna with an integrated BNC connection will work. There are several viable options available online. *Note: A 2 meter length of sturdy wire will work almost as well but is slightly less easy to transport.*



*Photo courtesy of Tony Bateman, Finland*

### VLF Online Resources

#### YAHOO VLF DISCUSSION GROUP

*(see page 3 of the Journal for more info)*

[https://groups.yahoo.com/neo/groups/VLF\\_Group/info](https://groups.yahoo.com/neo/groups/VLF_Group/info)

#### VLF GRAPH CONVERSION SOFTWARE

**Spectrum Lab:**

<http://www.qsl.net/dl4yh/spectra1.html>

#### VLFrxTools:

<http://abelian.org/vlfrx-tools/>

#### WHIP ANTENNAS

**Radio Shack 102":**

<http://www.radioshack.com/radioshack-102-stainless-steel-whip-element-for-cb-antenna/2100903.html#.VSpvBSjklv0>

#### Buddipole 114" (collapsible):

<http://www.buddipole.com/lotewh.html>

#### INSPIRE Kit Questions, VLF Observation Journal Submissions:

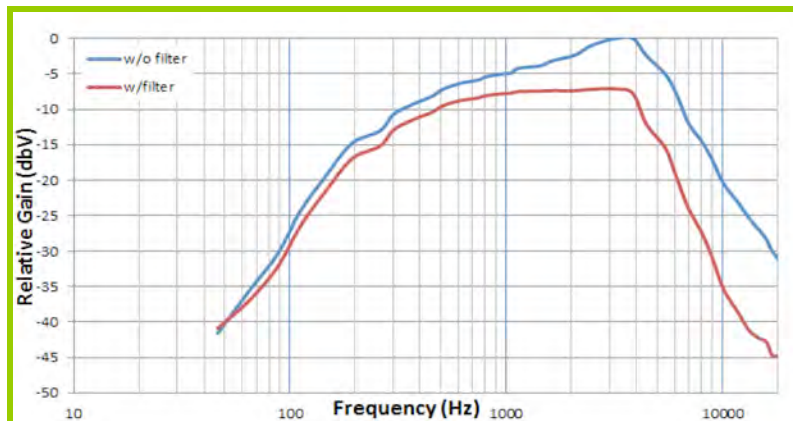
[CustomerService@TheINSPIREProject.org](mailto:CustomerService@TheINSPIREProject.org)

#### To Purchase an INSPIRE VLF-3b Kit & Assembly Instructions

<http://theinspireproject.org/default.asp?contentID=3>



**Q: I'm interested in a VLF kit that will record Schumann resonance (7.83 Hz) - is this possible with your kit?** INSPIRE VLF-3b is not likely to work well as a Schumann resonance receiver. See *INSPIRE VLF-3b Frequency Response Curve* below.




**INSPIRE VLF-3b Frequency Response Curve**

**Q: I have a multi-band dipole for HF amateur work. Would this antenna work? Otherwise it looks like a 6-foot telescoping antenna with a BNC connector should work especially for portable work?** A bare wire would work together with a good ground. A 6-foot telescoping antenna with a BNC connector mount would work too; it is designed to easily work with that. People have used a nail into a tree for the antenna. The antenna is forgiving, because it is essentially DC (<10 kHz). A bad ground can lead to noise problems.

**Q: I am an amateur solar observer and I am wondering whether I could use the VLF-3 to record SID's. If yes, have noted that the output is an audio signal. How could I convert this signal to a graph?** For a VLF receiver to recognize a SID there needs to be an ionospheric influence on VLF waves reflecting off the ionosphere and there needs to be a suitable VLF source that you can observe that demonstrates that influence. You could possibly look at the occurrence rate of spherics, but there would need to be an existing correlation of limited propagation of spherics with SIDs. That could have been done of course. So it is a possibility in general. I do not know if VLF noise is being used that way. Spectrum Lab offers a free software product that can be used to make a frequency versus time display of radio noise power. For more information or to download visit: <http://www.qsl.net/dl4yh/spectra1.html>


**Q: What power source does the VLF kit use?** It is normally powered by a 9VDC battery which is fine for normal observing intervals. If continuous observing over days is sought, more capable battery power will be needed or periodic battery replacement. Alternatives include using a photovoltaic (solar cell) panel, gel cell rechargeable battery, and voltage controller to provide power or to extend highly filtered DC power obtained directly from the local power grid.



### INSPIRE VLF Technical Advisors

**Dr. Dennis Gallagher** (left) is a Senior Researcher in the Science Research Office at NASA Marshall Space Flight Center and serves as INSPIRE's Chief Technical Advisor. Dennis answers VLF kit users' technical questions and is in the process of updating the VLF-3b Assembly Instructions. He has been actively involved with the organization since it was founded in 1986.

**Paul Schou** (Right) is a Research Analysis 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 solders the two transistors to the circuit board prior to kit shipment. As INSPIRE's vice president, Paul represents INSPIRE at conferences.





## Coordinated Observation Schedule

The Coordinated Observations will be held on the first weekend of October and the last weekend in April. This schedule will apply to all future Coordinated Observations. All data is welcome and should be submitted even if the conditions are quiet. Any data you can contribute is valuable. The procedure to use for coordinated Observations will be as follows:

1. Use the Data Cover Sheet and Data Log forms found at the end of the *Journal*. (Make copies as needed.)
2. Put a voice introduction at the start of each session indicating your name, your INSPIRE Team name, the date, local time and UT time.
3. Record for 12 minutes at the start of each hour that you can monitor on the specified days. Keep a detailed written log of all signals that you hear and indicate any items of interest. When you submit your recordings, spectrograms will be made of any parts of the recording that you indicate.
4. Place a time mark on the log for the recording on the hour and each two minutes for the next 12 minutes. Use Coordinated Universal Time (UTC) for all time marks.
5. Record at 8 AM and 9 AM LOCAL time.
6. In addition, record on other hours to compare results with those in neighboring time zones. For example, an observer in the Central Time Zone might record at 7 AM (8 AM EDT), at 8 and 9 AM CDT and at 10 AM (9 AM MDT).
7. When using tape use 60 minute tapes (30 minutes per side) with two sessions per side. It is preferred that you record on one side of the audiotape only.
8. Label all recordings and logs to indicate the sessions monitored and send to:

Internet via DropBox or Google Drive:  
[CustomerService@TheINSPIREProject.org](mailto:CustomerService@TheINSPIREProject.org)

Tape Cassettes:  
The INSPIRE Project  
107 S West Street PMB #425  
Alexandria, VA 22314-2824

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

9. Include a write up accounting your procedure, location, and observations and an article reporting on the results will appear in the next *Journal*.
10. NOTE: If you are hearing whistlers, rotate the recorder after 12 minutes with a "Whistler" recorder unit and continue recording with time marks every two minutes. If we get whistlers, this would be a good opportunity to try to determine the "footprint" of a whistler (the "footprint" is the geographical area where a whistler can be detected).





## Field Observation Schedule

Field observations may be made according to the following schedule: ANY TIME!

In addition to an article reporting on the Coordinated Observations, Field Observations may be made at any time and submitted for inclusion in the next *Journal*.

Use the same procedure as described for Coordinated 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).

Sample Spectrograms:

### Local Time to UT Conversion Table

EDT + 4 = UTC	EST + 5 = UTC
CDT + 5 = UTC	CST + 6 = UTC
MDT + 6 = UTC	MST + 7 = UTC
PDT + 7 = UTC	PST + 8 = UTC

To verify your UTC browse to <http://time.gov> and click on the link titled UTC

Frequency \_\_\_\_\_

Range \_\_\_\_\_

Time \_\_\_\_\_

Scale \_\_\_\_\_

Frequency \_\_\_\_\_

Range \_\_\_\_\_

Time \_\_\_\_\_

Scale \_\_\_\_\_

This spectrogram is for two minutes using a frequency range of 0 - 22 kHz.

This spectrogram is for 30 seconds using a frequency range of 0 - 11 kHz.



## Data Log Cover Sheet

INSPIRE Observer Team \_\_\_\_\_

Equipment: Receiver \_\_\_\_\_

Recorder \_\_\_\_\_

Antenna \_\_\_\_\_

WWV radio \_\_\_\_\_

Site description: \_\_\_\_\_

Longitude: \_\_\_\_° \_\_\_\_' W Latitude: \_\_\_\_° \_\_\_\_' N

Personnel: \_\_\_\_\_  
\_\_\_\_\_

Team Leader Name: \_\_\_\_\_

Mailing Address: \_\_\_\_\_  
\_\_\_\_\_

City, State, Zip, Country \_\_\_\_\_

Email: \_\_\_\_\_

### Local Time to UT Conversion Table

EDT + 4 = UTC	EST + 5 = UTC
CDT + 5 = UTC	CST + 6 = UTC
MDT + 6 = UTC	MST + 7 = UTC
PDT + 7 = UTC	PST + 8 = UTC

To verify your UTC browse to <http://time.gov> and click on the link titled UTC





## INSPIRE Data

INSPIRE Observer Team \_\_\_\_\_

Observation Date: \_\_\_\_\_ Receiver \_\_\_\_\_

Observation Start Time (UT) \_\_\_\_\_ Start Time (**Local** Time) \_\_\_\_\_

Local weather: \_\_\_\_\_

Code: **M** – Mark (WWV or Voice)  
**S** – Sferics  
**T** – Tweek  
**W** – Whistler  
**A** – Alpha  
**C** – Chorus

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

Time (UT) Entry Observer

_____	M-WWV M-V S T C W	_____	D: ____
_____	M-WWV M-V S T C W	_____	D: ____
_____	M-WWV M-V S T C W	_____	D: ____
_____	M-WWV M-V S T C W	_____	D: ____
_____	M-WWV M-V S T C W	_____	D: ____
_____	M-WWV M-V S T C W	_____	D: ____
_____	M-WWV M-V S T C W	_____	D: ____
_____	M-WWV M-V S T C W	_____	D: ____
_____	M-WWV M-V S T C W	_____	D: ____
_____	M-WWV M-V S T C W	_____	D: ____
_____	M-WWV M-V S T C W	_____	D: ____
_____	M-WWV M-V S T C W	_____	D: ____
_____	M-WWV M-V S T C W	_____	D: ____



## INSPIRE VLF-3b Radio Receiver Kit Ordering Information

INSPIRE VLF-3b Radio Receiver Kits can be ordered online at:  
[www.TheINSPIREProject.org](http://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](mailto:CustomerService@TheINSPIREProject.org)

## Invest Today for the Exploration of Tomorrow

The INSPIRE Project's STEM educational programs provide scholarship and internship awards to educators, middle and 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, the programs that are now offered have grown exponentially. In order to continue fulfilling our expanded Mission, INSPIRE is seeking additional forward-thinking partners and sponsors who understand the importance of providing educational opportunities to educators and students. INSPIRE's programs provide students the resources to pursue study in science, technology, engineering and mathematics. *Contributions are tax-deductible.*

For more information on individual and corporate giving opportunities, please contact INSPIRE's Educational Program Coordinator, Eva Kloostra, at [Editor@TheINSPIREProject.org](mailto:Editor@TheINSPIREProject.org).



*Photography by Eva Kloostra, U.S. Space & Rocket Center ~ Huntsville, AL*

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## Contact **The INSPIRE Project Inc.**

The INSPIRE Project Inc.  
107 S West Street PMB #425  
Alexandria, VA 22314-2824

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