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Empowering the Next Generation Through Spaceflight

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Abstract

Amateur Radio on the International Space Station (ARISS) is a program that enables students to talk with astronauts on the International Space Station via amateur radio. The work presented here examines the ways that young amateur radio operators are committed to sustaining the future of the space industry by using their radio skills to bring ARISS contacts to their communities. Through an exploration of Science, Technology, Engineering, and Mathematics (STEM) activities and radio communications, students at these contacts learn about life on the International Space Station and understand radio's important role in spaceflight's continued success. The goal of organizing these contacts is to teach the next generation of radio operators the necessary skills for successful communications and inspire attendees through direct conversation with an astronaut. Two specific types of ARISS contacts successfully planned and executed in the last several years were a direct contact by the Embry-Riddle Aeronautical University (ERAU) Amateur Radio Club and three telebridge contacts at Youth on the Air (YOTA) summer camps. The ERAU Amateur Radio Club is a student-led university club, which coordinated a successful ARISS contact that connected a NASA astronaut with students from various middle schools in Florida. This provided opportunities for the university students to take leadership roles and apply their technical skills to inspire young minds through space communication and STEM oriented classroom activities. Youth on the Air is an organization that connects young amateur radio operators across North, Central, and South America and culminates in a week-long camp for youth ages 15-25 during the summer. YOTA Camp has successfully hosted three ARISS contacts over the past few years via telebridge ground stations in South Africa and Italy. This provides campers, many of whom are the only young amateur radio operator in their home area, with an opportunity to apply their technical skills in a high impact event only possible through amateur radio. The results of multiple ARISS contacts at camp is a distribution of knowledge needed for successful spaceflight communication, a better understanding of the critical skills needed for radio communications for future spaceflight missions, and increased motivation from campers to improve their skills so they can organize and host ARISS contacts in their home communities. This work will show that it's possible to bring the technical wonder of spaceflight communications to students of all ages and that amateur radio is a key component of spaceflight now and into the future.

Keywords: Amateur radio, ARISS, Radio communications

1. Introduction

Amateur radio has had a place in human spaceflight since the early days of the Space Shuttle, when in 1983 Owen Garriott, W5LFL brought his radio aboard the Shuttle Columbia on STS-9 [1]. Since then, from the Shuttle to Mir, to the International Space Station, and now even Crew Dragon, astronauts with their ham licenses have been bringing other radio operators and students to space with them on their journey. In addition to the sustainability provided by amateur radio being a backup form of communication for flight, their goal is to inspire others and bring their love of space to those on the ground such that the next generation may be raised up knowing all that is possible and be inspired to pursue STEM careers and sustain space exploration.



Fig 1. Owen Garriott, W5LFL with his radio aboard the Space Shuttle Columbia

Embry-Riddle Aeronautical University (ERAU) has a mission to raise the next leaders in aerospace, and the ERAU Amateur Radio Club seeks to train the next generation of radio operators. The school brings some of the brightest students together and gives them opportunities to grow as innovators and leaders. Additionally, the club provides a place for members to grow as individuals and as a team, to learn and build, and to discover the joys of amateur radio. The students' shared love of aerospace and of amateur radio creates an environment in which members are encouraged to learn from their peers and fellow enthusiasts. In April 2024, the team worked with each other and with local schools to successfully host a direct contact with astronaut and amateur radio operator Matthew Dominick on the International Space Station.

Youth on the Air (YOTA) is an organization whose mission is to connect young, licensed amateur (or ham) radio operators from North, Central, and South America. YOTA hosts a variety of on-air operations throughout the year, culminating in a week-long summer camp for ham radio operators ages 15-25. The first two camps were held in Cincinnati, Ohio at the Voice of America museum, followed by two years in Canada in Ottawa, Ontario and Halifax, Nova Scotia. This summer, the 5th edition of camp will be held in Denver, Colorado. During the week, campers are given time to meet and befriend amateur radio operators their own age from a wide range of regions and participate in many workshops on amateur radio activities. In previous years, these have included building antennas, building various electronic kits, talking around the world on high frequencies from both permanent and portable ham radio stations, learning how to operate using Morse Code, launching and tracking high-altitude balloons, communicating through amateur radio satellites, and more. YOTA is dedicated to connecting young people through amateur radio communications and STEM activities, and so integrating ARISS contacts into this workshop schedule has been a perfect culmination of camp activities. For the 2021, 2023, and 2024 camps, ARISS telebridge contacts were held with good success that brought ham radio in a new way to dozens of youth.

2. Amateur Radio Specifics

Amateur Amateur radio is a service and a hobby that enables two-way communications around the world and, more importantly for this work, in space. Amateur radio operators are licensed by government communications

agencies, the Federal Communications Commission (FCC) in the US or the Canadian Radio-television and Telecommunications Commission (CRTC) in Canada for example, earning a unique callsign and access to a wide range of frequencies. Common communication modes include voice communication via single sideband (SSB), frequency modulation (FM), amplitude modulation (AM), Morse Code (CW), digital modes such as FT-8, and picture transmission via Slow-Scan-TV (SSTV) frequency modulation. By having privileges on high frequency (HF), very high frequency (VHF), and ultra-high frequency (UHF) bands, amateur radio operators can communicate short and long distances for exciting contacts.

Amateur Radio on the International Space Station (ARISS) is the first and longest continuously operating educational outreach program to fly on the International Space Station (ISS) [2]. Amateur radio was deployed and operated on the ISS within two weeks of the first expedition crew's arrival in 2000 and has continued with both organized crew contacts and unscheduled contacts ever since. Because of ARISS's continuous presence with NASA and the other four international space agency partners, many astronauts aboard the ISS are licensed and amateur radio is the emergency backup communications for the space station. Currently, contacts are possible with astronauts on the ISS through split-frequency communications on VHF and with other stations on earth by sending signals through a VHF/UHF crossband repeater onboard.

Currently, there are two VHF/UHF radio stations onboard the ISS for amateur radio communications. The Kenwood TM-D710GA radio resides in both the ISS Columbus Module and the ISS Service Module (Zvezda). These radios support operations on both the 2m (145 MHz) and 70cm (437 MHz) bands with a maximum power of 25 watts. The Columbus Module radio primarily supports FM voice and dual band (2m/70cm) voice repeater communications while the ISS Service Module radio primarily supports FM voice, digital packet radio and SSTV (picture downlink) radio communications. ARISS has a publicly published downlink frequency of 145.80 MHz for direct contacts, with the uplink frequency varying slightly between ITU Region 1 (145.90) and ITU Regions 2 and 3 (144.49).



Fig 2. The Columbus Module VHF/UHF antenna being installed by Astronaut Randy Bresnik

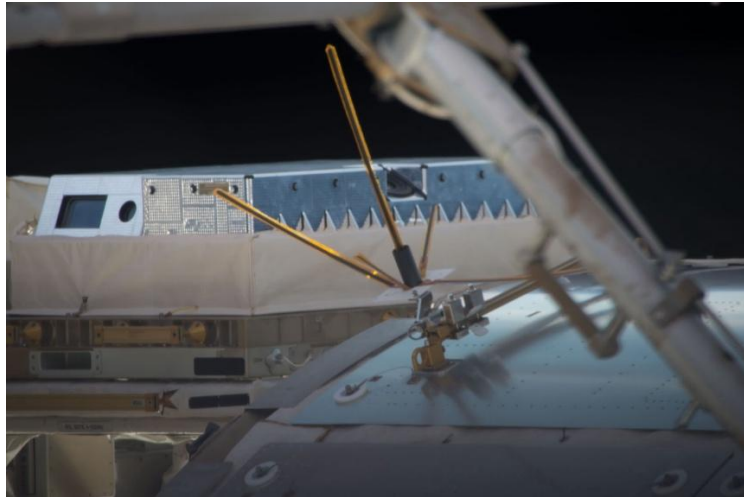


Fig 3. The ISS Columbus Module VHF/UHF antenna after installation

Communicating via satellites, including the ISS, is a line-of-sight radio communication. Typically, ground stations use cross-polarized antennas with a 2m/70cm FM transceiver to accurately track the ISS in both azimuth and elevation. The ISS must be above the horizon for a particular ground station to hear and talk to the astronauts. Because of this limitation, ARISS contacts are designed to occur in three ways: direct, telebridge, or multi-point telebridge. To best understand how the ARISS contacts have impacted students and campers at Embry-Riddle Aeronautical University and Youth on the Air summer camp, it is important to understand how these contacts take place. Direct contacts occur exactly as the name describes, the ground station communicating with the ISS is set-up in the same location as the students' asking questions, and those students will be communicating directly with the ISS via the on-site radio.



Fig. 4. Samantha Cristoforetti operating the ARISS radio system aboard the ISS

Direct contacts cannot always occur, however, due to the ISS orbital path, crew schedules, and school schedules. Because of that, telebridge contacts are extremely common. For these contacts, the ground station is an experienced amateur radio operator located somewhere in the world with an orbital footprint at a time that works for both the crew and the students. At the scheduled time, the ground station establishes contact with the ISS. Both student questions and astronaut answers are relayed via a telephone or Zoom link for the contact. Normally, the students are in one location together, so audio from one microphone captures the students' questions and relays them to the station. However, a multi-point telebridge contact system was created during COVID-19 to ensure that students socially isolated at home could still complete their ARISS contacts with multiple inputs from multiple homes. Over the past

four years, Embry-Riddle Aeronautical University (ERAU) Amateur Radio Club hosted a direct contact while Youth on the Air (YOTA) summer camps have hosted three telebridge contacts.



Fig 5. Campers, staff, volunteers, and university guests waiting for the telebridge ARISS contact at the 2023 YOTA Camp in Ottawa

3. ARISS Contacts Led by Youth

The goal of this work is to explain how the youth-led ARISS contacts at ERAU and YOTA have had such a profound impact on the students involved in organizing the contacts and asking questions. ARISS contacts are extremely popular as a collaboration between schools and experienced amateur radio clubs across the world. As such, these contacts are well known in spaceflight circles. However, it is not quite as common for all steps of the ARISS contacts to be organized and run by students and young adults, since the average age of local amateur radio clubs is in the 60s or 70s depending on location. Our goals for the ARISS contacts from YOTA Camp and ERAU was to use students in all aspects of the contact, with assistance from older operators and ARISS mentors, to fulfill the mission of bringing ham radio to the younger generations.

In the last two years, there have been about 196 ARISS contacts successfully completed via both direct and telebridge communications with organizations around the world [3]. ARISS has a dedicated team that organizes the contact with NASA and interfaces with the hosting (contact) organization. Each contact has specific timelines and roles, with an ARISS Technical mentor to assist with technical questions and steps, an educational ambassador to assist with the education side of it, a contact lead/host from whoever is organizing the contact, and a ham radio lead for the on-site amateur radio work. Often, these contact and ham radio leads are both older ham radio operators and teachers who are involved in radio education. However, the unique situations of experienced ham radio youth operators in leadership roles for both ERAU and YOTA have enabled these organizations to flip this statistic around and ensure that students are involved with mentors for youth-led contacts.

The direct contact hosted by the Embry-Riddle Amateur Radio Club brought middle and elementary school students, their families, their teachers, and ERAU students and staff aboard the ISS with Matthew Dominick to greet them. This contact connected the community in their efforts to inspire the middle and elementary school youth to learn about science, technology, engineering, and math. It challenged the youth to formulate well-researched questions for the opportunity to receive answers from an astronaut who could recount their firsthand experiences of spaceflight. Their teachers welcomed ERAU students into their classrooms to teach about rocketry, satellite orbits, circuitry, radio, and more to these amazing youth. These classroom activities not only created opportunities for the middle schoolers and those who would ultimately have their questions selected for the contact, but also for the students of ERAU. The outreach efforts provided leadership and mentoring opportunities, giving them a mission and a drive to inspire the classes with whom they worked. In striving to realize their goals of bringing space a little closer to the younger students, they learned logistics and grew more mature as individuals. The nature of the direct contact provided yet more opportunities for the students of ERAU to grow, as they took it upon themselves and worked as a team to learn to run all necessary hardware and software. Many members were inspired to earn their amateur radio licenses in the months

prior to the contact, and everyone learned invaluable amateur radio operating skills and radio theory, thus furthering the missions of the university, the club, and perhaps most importantly ARISS.



Fig 6. The student participants and organizers of the direct ARISS contact at Embry-Riddle Aeronautical University

A key goal of YOTA camp is to have all the workshops, including the ARISS contacts, led by youth under 30. Ruth has been the YOTA contact host since she was a camper in 2021, and her prior experience with years of ham radio satellite communications has provided an excellent foundation for building her skills related to ARISS contacts. For telebridge contacts, much more of the necessary preparations involve understanding the audio system to ensure that the contact can occur, along with prepping for any possibility of direct contact and ensuring that the event will be engaging for all the campers. YOTA staff Neil (WB9VPG) and Jocelyn (KD8VRX) and ARISS mentors assigned to the contact helped train Ruth and other campers for a successful contact.



Fig 7. Excited YOTA campers including Hope (far left) and Ruth (third from the left in the front row) who talked to Aki Hoshide at the first YOTA ARISS contact in 2021

Camp locations change every year, so YOTA partners with local clubs to ensure that all the on-site details can be completed for successful activities, including ARISS contacts, as much as possible before camp. Once the ARISS contact is approved and campers have been accepted for the summer, they are brought into the picture. Campers are introduced to the ARISS program and its impact, and they are encouraged to submit questions prior to the camp. Once camp starts, they are taught the basics of satellite communications and other radio skills so ensure the smooth operation of the camp. There is only one week to do in-person activities for this contact, as opposed to a full year like regular schools, so it is important to use that time as efficiently as possible. As campers change from year to year, they are rotated in to help with the ARISS contact to further spread the knowledge of what is needed to run an ARISS contact and train the next YOTA ARISS leaders. This is important for multiple reasons. First, these students are already technically minded as having an Amateur radio license is required for camp attendance. Helping the students who are already interested in spaceflight to understand the process is important, especially as the radios are

not right in front of them for a telebridge contact. However, the second, and perhaps more important reason, is that it gives them skills to take back home. This experience of living through an ARISS contact, building knowledge of the process and steps for a contact, and creating connections with other youth that are equally excited about space are key connections that can be shared with their local schools and clubs to increase the impact that ARISS has on communities around the world. This gradual refining of skills throughout the years of camp operations has made it possible for YOTA to apply for their first direct contact in June 2025!



Fig 8. YOTA campers waiting for contact in July 2023 (left) and asking questions with the telebridge ground control on the screen behind them in June 2024 (right)

4. Results and Discussion

The full impact of the 2024 Embry-Riddle direct ARISS contact with Matthew Dominick (KC0TPR) will continue to be realized over the next several years. As each ERAU Amateur Radio Club member continues their education and their pursuit to be better leaders, mentors, and radio operators, a generation of space professionals rises and the efforts to usher in those who will follow continue. From within the many classrooms that were reached, the crowd of students, who for a moment were invited onboard the International Space Station through the radio, are the world's next generation of scientists, engineers, mathematicians, and space enthusiasts. Through opportunities like this, ARISS has ignited sparks of curiosity and discovery in thousands of youth and will continue in future contacts, outreach activities, and camps.

YOTA has had three incredible telebridge contacts with Aki Hoshide (KE5DNI) and South Africa telebridge station John Sygo (ZS6JON) in 2021, Steve Bowen (KI5BKB) and Italy telebridge station Claudio Ariotti (IK1SLD) in 2023, and Jeanette Epps (KF5QNU) and South Africa telebridge station John Sygo (ZS6JON) in 2024. Through these contacts, 26 students have had the opportunity to share their name and callsign with an astronaut on the ISS and over 40 questions have been asked of a resident of that orbiting laboratory. Each of these contacts has had different high points, with inspiring answers for both sentimental and technical questions. For example, this past contact with Jeanette was incredibly personal. She gave students amazing answers to questions, such as what the view of earth is like from space and what new technologies are being tested on the ISS that could be crucial for future space missions or have applications on earth.

From experiencing both direct and telebridge contacts, these authors have seen firsthand the impact of ARISS contacts on themselves and other students. It is encouragement from their heroes that they can pursue their dreams. It is proof that their developed radio skills can be used in inspiring ways. It is the satisfaction of successfully executing a challenging contact. It is seeing the look on students' faces when they realize they really are hearing live from an astronaut in space. It is an understanding of how ARISS contacts occur in both big and small ways, so students can volunteer their skills to assist with or lead a contact in their local communities in the future. It is the tangible reminder of the contact, in pictures and mission patches and QSL postcards confirming the contact. This blend of technical skill building and inspirational contacts are creating the next generation of amateur radio operators and amateur radio activities in space as we aim for the moon and beyond.

6. Conclusions

Amateur radio is a key component of space flight, providing critical communication skills to astronauts and inspiring generations of dreamers on earth through personal contacts. Amateur radio has earned its place among the stars, and organizations must embrace the skills necessary for ARISS contacts and train the younger generation to continue the work begun in 1983 by Owen Garriott. ARISS continues to provide the resources, mentors, and

opportunities for students of all ages to participate in making space more accessible. From the days of the Shuttle and Mir, now to the ISS and SpaceX Crew Dragon, and beyond, amateur radio will continue to bring opportunities like these to communities. The contacts organized by Embry-Riddle and Youth on the Air are only some of the thousands of successful ARISS experiences with more happening every week as amateur radio operators continue strengthening their efforts to inspire and empower the next generation. Through these collaborations and using space communications, ARISS is propelling the youth who will fuel the future of the space industry.

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We are so grateful for the ham radio operators who have mentored us throughout our ham radio activities and have inspired us to continue elmering the next generation.

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