

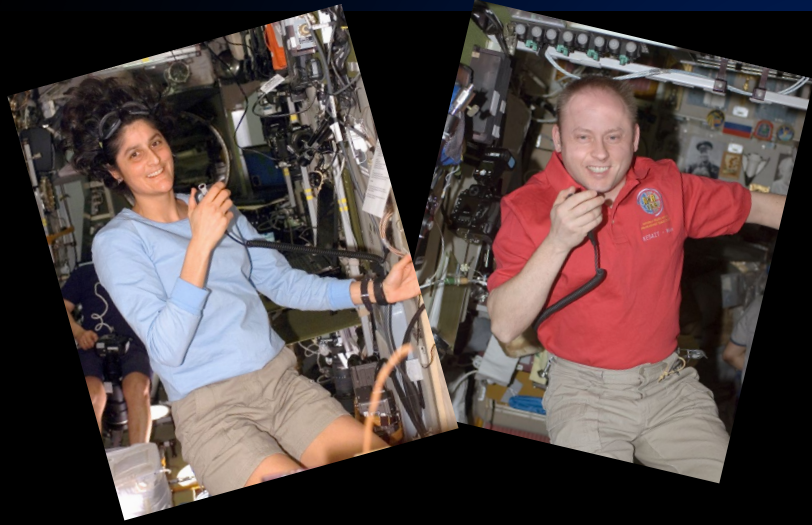
ARISS: CURRENT STATUS AND FUTURE VISIONS



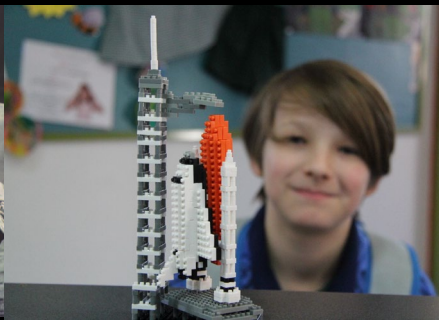
Sterling Park Amateur Radio Club
Frank H. Bauer, Executive Director ARISS-USA
October 7, 2020

Amateur Radio on the International Space Station (ARISS)

Inspire | Explore | Experiment



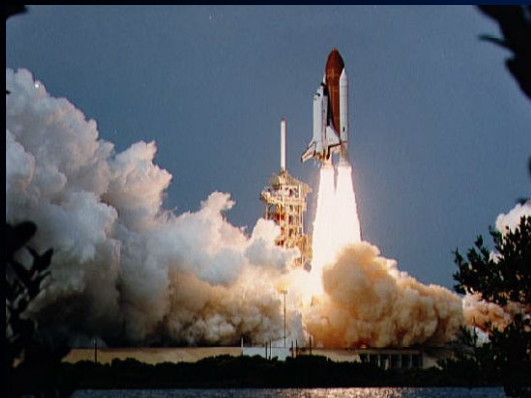
- K-16 international program that inspires, engages and educates youth in STEAM through 10 minute immersive opportunities to talk directly with the on-orbit crew via amateur radio
- Students & Public learn about:
 - Challenges of space exploration
 - Space research and space communications
 - Radio science and technology with amateur (ham) radio



Amateur Radio On Human Spaceflight Missions

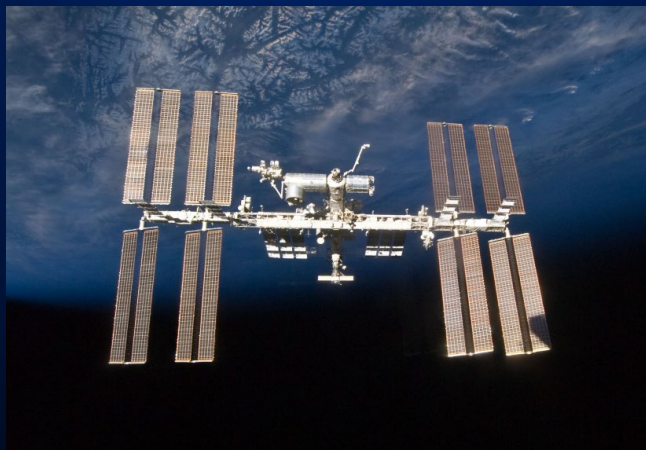


Since 1983, international amateur radio organizations have worked with the space agencies to fly amateur radio and to support Educational Outreach on:



**Space Shuttle
(SAREX)**

**ISS
(ARISS)**

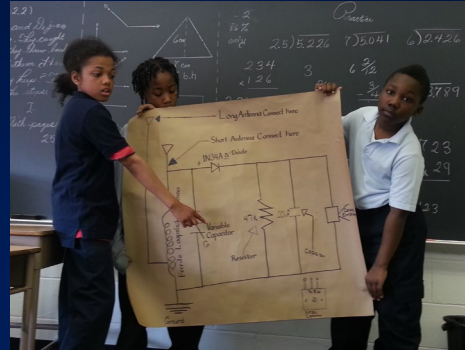


**Mir
(Mirex/SAREX)**

ARISS PRIME INITIATIVES



**STEAM
Education**



**Spaceflight/Hardware
Development**



Spaceflight Operations

MOST IN-DEPTH AND COMPREHENSIVE TEAM EFFORT IN 20+ YEARS!!



Education

- Education committee
- School radio kits

Operations

- 1-2 contacts/week
- Pandemic Ops
- SSTV ops
- APRS
- Voice Repeater

Space Agency Collaboration

- ARISS-I “Ear to Ear” meeting
- Lunar Gateway

Experimentation

- MarconISSta

Sustainment

- NASA SCaN
- ISS National Lab
- Web-based donations
- Fundrazr
- ARISS-USA

HAMTV

- Return to Earth
- Repair
- Launch

Hardware Development

- Next Generation Radio System—IORS
- L-Band Repeater
- ARISS-Pi

ARISS Outcomes: By the Numbers



1st Operational Payload on ISS



60-120 Educational Opportunities per Year



1,300+ ARISS Connections



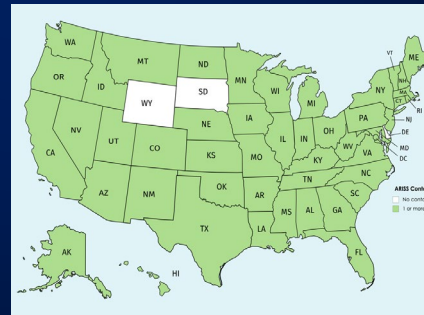
15K-200K Students Engaged Each Year



12-15 Million Witness Contacts from Media Sources



\$5M In-Kind Volunteer Support Per Year



48 of 50 States in the USA



60 Countries Around the World



WORLDWIDE SCHOOL PARTICIPATION

SINCE 1ST ARISS CONTACT DEC 2000

1331 SCHOOL/GROUP CONTACTS (1398 INDIVIDUAL SCHOOLS)
50 US STATES & TERRITORIES, 62 OTHER COUNTRIES

ARISS Reach	1QFY20	2QFY20	3QFY20	4QFY20
Students direct	10,223	5,429	15,325	3,588
Students indirect	12,289	6,199	600	296
Educators direct	3,240	778	3,058	484
Educators indirect	1,821	576	60	9,618
Public direct	2,487	5,598	2,188	4,750
Public indirect	8,165	14,007	11,082	8,816
Totals	38,225	32,587	32,313	27,552



Telebridge ARISS school contact between students from Poland with NASA astronaut Chris Cassidy, KF5KDR from ISS in space.



*** 15. HOW OFTEN DO YOU CLEAN THE ISS AND WHY IS IT SO IMPORTANT?**

The student is at Kazimierz Wielki Secondary School in Kolo.

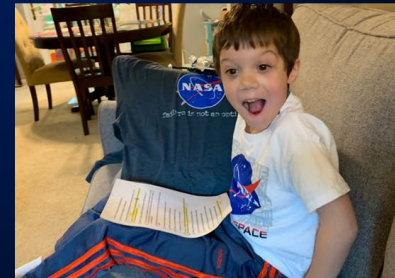
*** MARIKA**

*** KMO KOLSKA WYSPA**

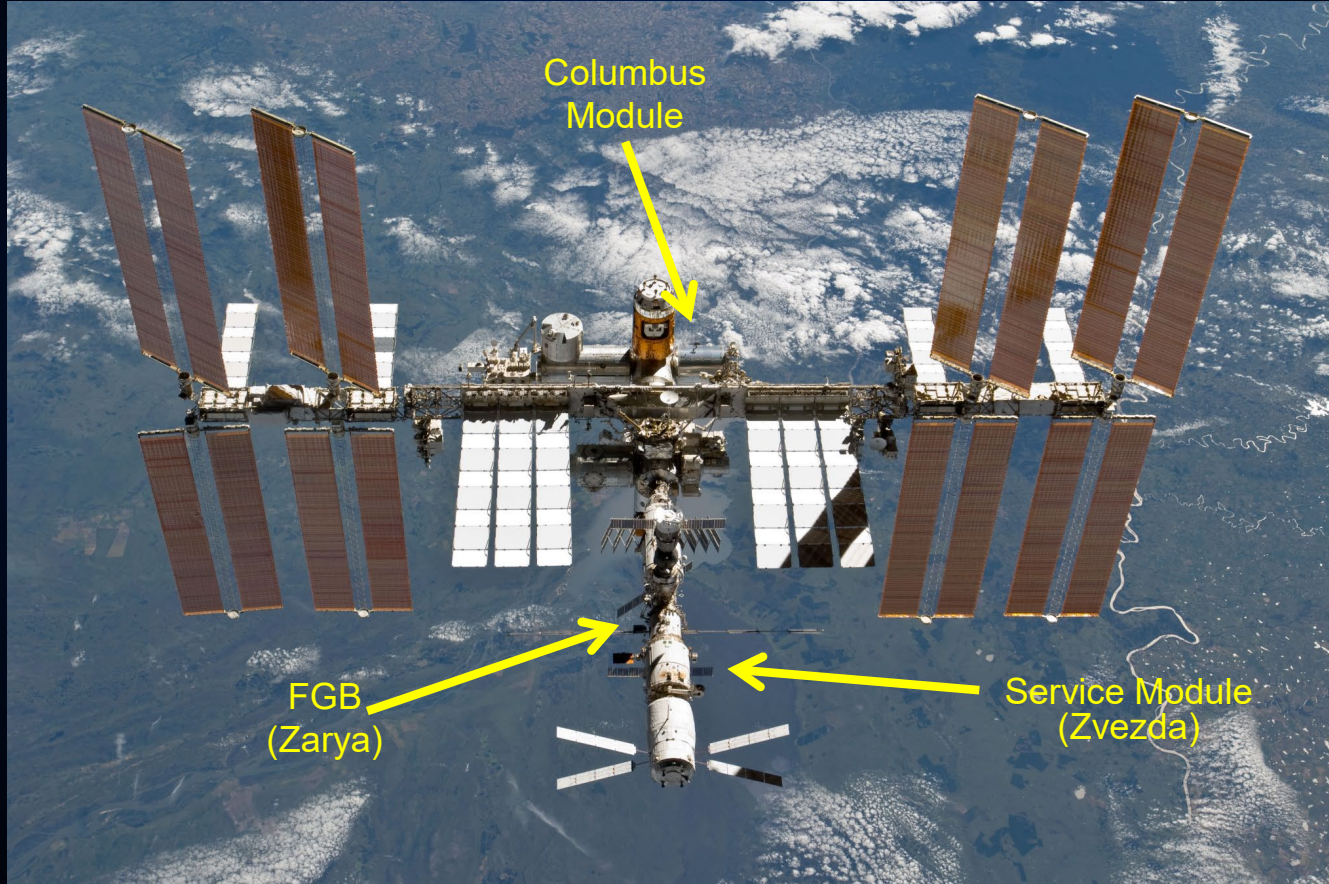
- * MARTINJARY INSURGENTS PRIMARY SCHOOL IN BRODOW
- * KAZIMIERZ WIELKI SECONDARY SCHOOL IN KOLO
- * ADAM MICKIEWICZ PRIMARY SCHOOL NO. 2 IN KOLO WITH PRESCHOOL AND SPORTS DEPARTMENTS



2nd September, 2020, Kolo (Poland)



ARISS In The International Space Station



Columbus
Module

FGB
(Zarya)

Service Module
(Zvezda)

ARISS ON-ORBIT CAPABILITIES THAT PROMOTE STEAM EDUCATION



2-Way Voice



Zvezda Russian Service Module

Slow Scan TV (SSTV) (Picture uplink and downlink)



Ham TV Video Downlink

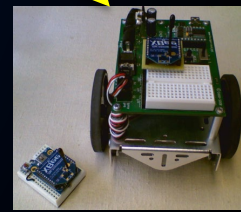
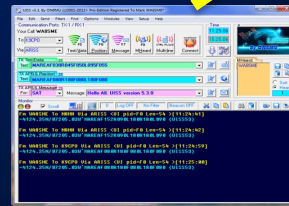


Computer/Digital Links (APRS, Telemetry)

Fm JA0CAW To CQ Via RS0ISS-5*
<UI pid=F0 Len=24 >[17:08:35]
:SAT :Hello via ISS



Robot Remote Commanding



Columbus Module

SSTV TRANSMISSIONS CELEBRATE COSMONAUTICS DAY – APRIL 11-14, 2019



Commemorating Cosmonautics Day
First and Last Space Shuttle Crews
STS-1 and STS-135, 1981-2011



RSOISS

NA1SS

7/12



Commemorating Cosmonautics Day
First ESA Astronaut in Space, Ulf Merbold
STS-9 Nov 28-Dec 8, 1983



RSOISS

NA1SS

11/12



Images commemorating Russia's Yuri Gagarin's first flight into space & notable NASA and ESA historic firsts, including the first launch of the Space Shuttle on April 12, 1981



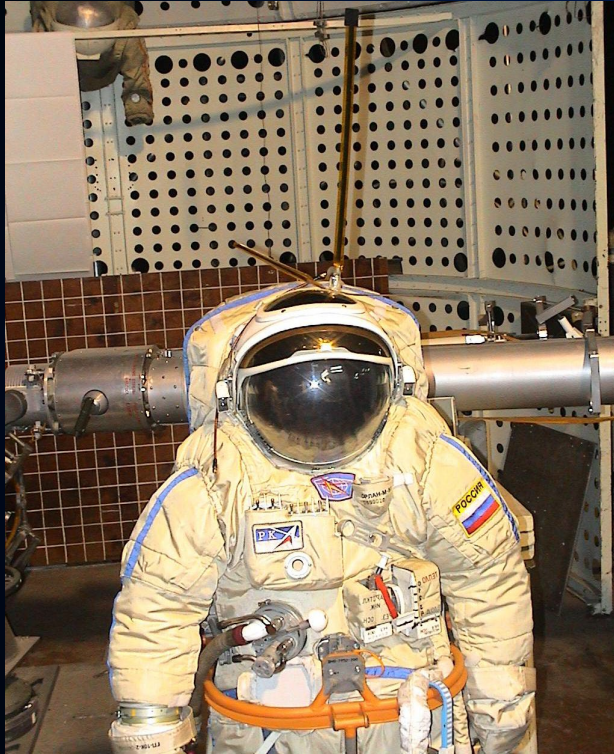
ARISS PAST ACCOMPLISHMENTS

PIONEERING FIRSTS

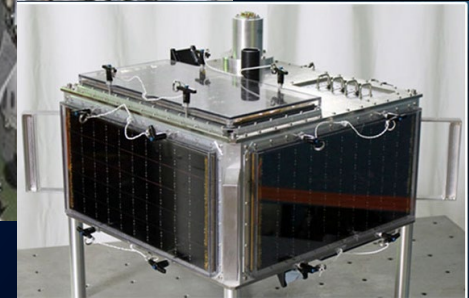
- First human tended amateur radio in space (1983)
- First communications between astronauts and people outside official NASA channels (1983)
- First pictures uplinked and downlinked to Shuttle (1985)
- First astronaut-student interviews (1990)
- First scheduled crew contacts with families & friends (1990)
- First computer-to-computer radio links (1990)
- First Television uplink on Human Spaceflight vehicle (1991)
- First backup communications during TDRSS outage (1992)
- First direct contact between the Space Shuttle and Space Station Mir
- Most frequent flyer payload in Shuttle Program (25 Flights on all 5 Shuttles)
- Operational less than 2 weeks after first crew arrival making **ARISS the first and longest continuously operating payload on ISS** (2000)
- First Live Television downlink from ISS outside the NASA and RSA channels (2014)

ARISS Educational Satellites Deployed From ISS

SUITSAT-1 & ARISSAT-1



SuitSat-1--Amateur Radio
Extra Vehicular Activity
(EVA) In a Space Suit



ARISSat-1—Educational
Experiments on hand-
deployed Nanosatellite

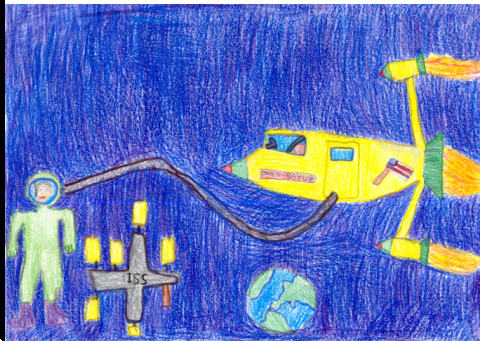
Suitsat School Spacewalk Pictures, Artwork And Signatures From Students Around The World

Mrs. Delaney
 John Reina
 Daniel K. #K9
 Alyssa Lannuzzi
 Kristina Maley
 Ruth Cole!
 Kristen Enochs
 Taylor M...
 Mrs. Delaney's Class
 wishes the universe peace,
 love, and happiness.
 John P. Mc Kenna School
 Massapequa Park, N.Y.
 June 8, 2005
 Kevin Gibbons
 Timothy Woods
 orlando
 no lone



A collection of handwritten signatures and names, including:

 Michelle, Mrs. Delaney's Class, Alyssa Lannuzzi, Kristina Maley, Ruth Cole!, Kristen Enochs, Taylor M..., Mrs. Delaney's Class, John P. Mc Kenna School, Massapequa Park, N.Y., June 8, 2005, Kevin Gibbons, Timothy Woods, orlando, no lone, and many others.



flowerswatercolor!
Linda Winder student at
Art Academy of Cincinnati

Kamishirane Elementary School, Yokohama Japan



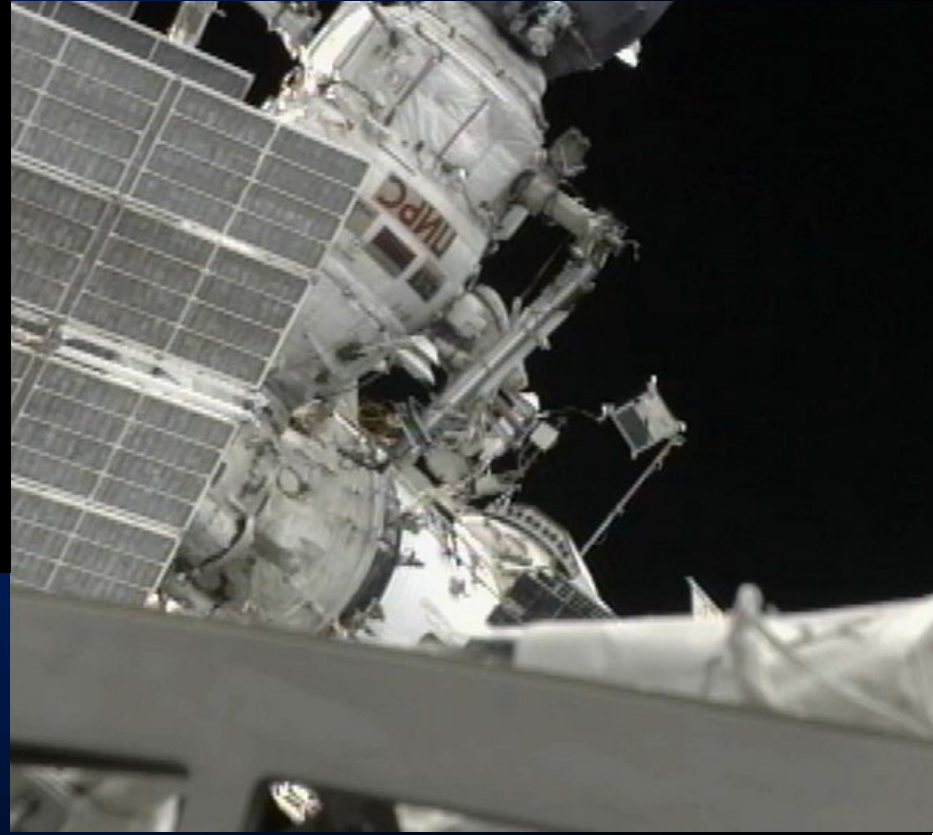
みんななすマイル 30年の思いを胸に キラッと輝く上根っ子
 横浜市立上根小学校 創立 30周年記念

Deployments

ARISSat-1
Aug 2011



SuitSat-1
Feb 2006





Astronaut Tim Peake, KG5BVI and Principia Mission



School Contacts in the UK and Around the World

Astro-Pi Goes Live

Esme, Age 4 Talks to Tim Peake through ARISS



Anniversary!

ARISS OPERATIONS BEGIN! NOVEMBER 13, 2000



Сергей Самбуоров (на переднем плане) и Владимир Загайнов не могут сдержать своих эмоций – связь с МКС на любительских диапазонах установлена!



Sergei Krikalev
U5MIR on ISS



Russia Station Checkout



US Ground Station Checkout

FIRST SCHOOL CONTACT BURBANK SCHOOL DECEMBER 21, 2000



Burbank
Contact Patch



Burbank Students and
Educator Rita Wright



Charlie Sufana, AJ9N,
Making the call



Alex Bandyk asks a question



Cmdr. Shepherd signs
autographs



Commander Shepherd with
Mrs. Wright After Exp. 1 Flight



EDUCATION

ARISS-US EDUCATION COMMITTEE



- 22 Educators with ARISS Experience
- Leading Education Call for Proposals/Selecting Schools
- Education Ambassadors guiding contact hosts on educational matters
- Supporting educator conferences & presenting papers
 - ARISS Education Summit, College Park, MD
 - Space Exploration Educators Conference, Houston
 - NASA 3-D Printed Habitat Challenge, Edwards, IL
 - Space Port Area Conference for Educators, KSC, FL
 - ISS R&D Conference, Atlanta, GA
 - Satellite Educators Conference, LAX, CA
 - International Astronautical Congress, Washington DC
- Supported ARISS-International meeting in Montreal
- **Supporting the development of a “Radio Kit” to be distributed to ARISS schools**
- Sharing STEAM lessons and resources with educators hosting contacts; Developed Educator Facebook Page to share ideas and facilitate communications



ARISS-SUPPORTED BALLOON RACE—JUNE 1-2, 2020

CHART 1 OF 3



- 4 Educator Teams Compete in Mid-Altitude Balloon Race thanks to ARISS Educator Joanne Michael
 - *ARISS activities for educators and youth and families stuck at home*
 - *Launch: 8:30 AM PST, 4 balloons--3 in CA: 1 in WA*
 - *ARISS lessons and internet viewing of balloon telemetry: predicting results, map paths, etc. ; One went missing. One had telemetry interruptions, adding suspense.*
 - *At 29.5 hours, Pasadena balloon won race, reporting crossing Eastern Time Zone.*
- Public responses:
 - **Scout master: “My scout group followed the 4 balloons and the scouts were fascinated!”**
 - **Parent: “My 6-year-old girl & 3-year-old boy each picked a balloon to track on a paper map. They marked the map morning & night, talked about the state or province, learned the map. It was great fun.”**



Joanne working on a balloon project

ARISS-SUPPORTED BALLOON RACE—JUNE 2, 2020

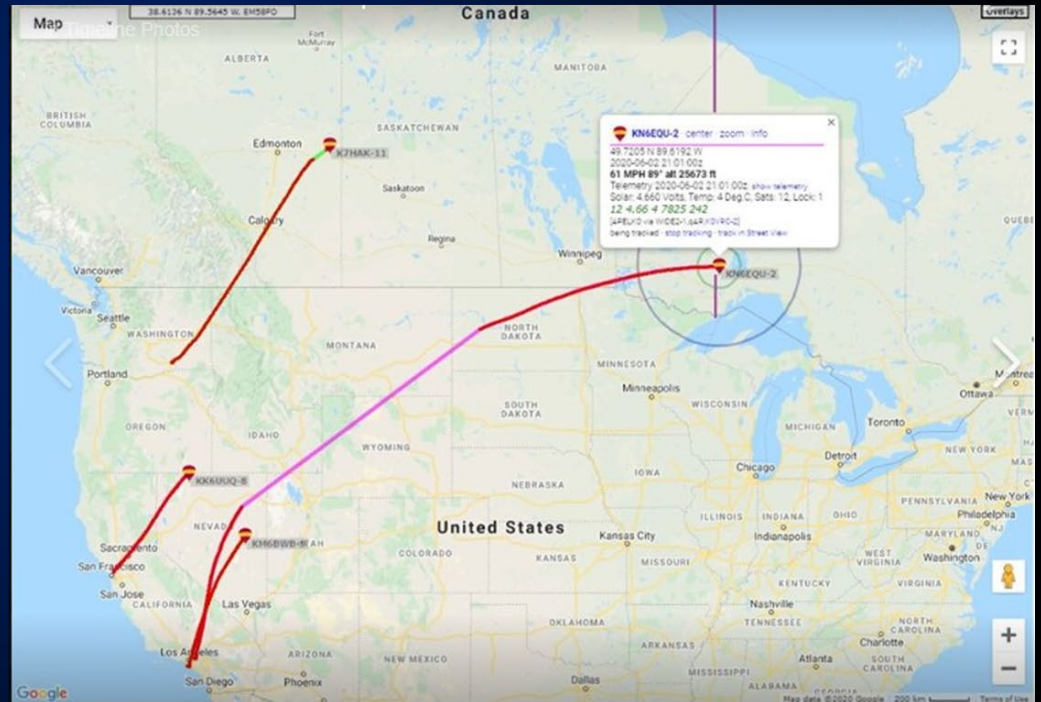
CHART 2 OF 3



Race Map

Huge Increase in ARISS Web Page Views & Visits

Date	ARISS Web Page Views	ARISS Web Page Unique Visits
5/24/2020	632	438
5/25/2020	707	463
5/26/2020	772	535
5/27/2020	3171	2536
5/28/2020	1364	925
5/29/2020	917	626
5/30/2020	8449	7242
5/31/2020	30630	25832
6/1/2020	6096	4790



ARISS-SUPPORTED BALLOON RACE...RESCUE!

CHART 3 OF 3



- **Winning Balloon from Pasadena Rescued for Future Flight...Becomes Educational Activity**

- *Balloon lands outside Liverpool, NS, Canada. Signal from APRS payload heard by ham operators from Annapolis (NS) Valley Amateur Radio Club & Annapolis Royal Space Agency (ARSA)*
 - *ARSA members and college students Abigail & Derek set up rescue mission, trekking on foot through swampy woods, tracking beacon's transmissions until spotting*
 - *Electronics still fully functioning. Student team members want to relaunch balloon next year for potential travels to Europe.*
 - *Students and team interviewed by Canadian Broadcast Company (CBC)*





ARISS RADIO KIT

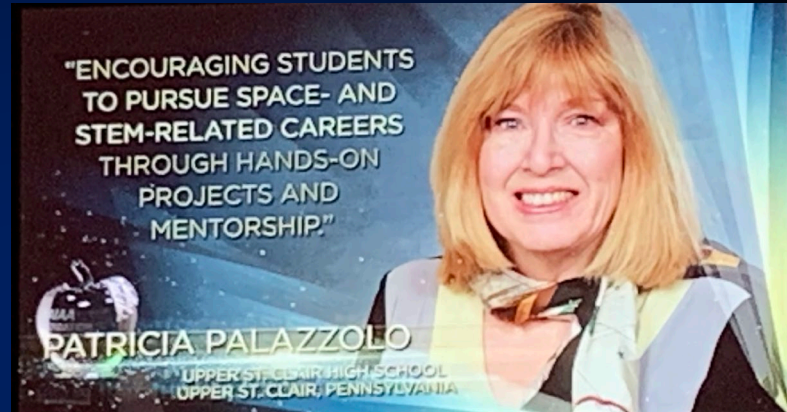
- ARISS-US Education Committee team developing electronics teaching kit focused on radio technology for elementary through high school students
 - Hands-on lessons-- on basic electronics & communications concepts: Waves & Wave Propagation, Series & Parallel Circuits, Codes & Ciphers, plug & play ARISS Radio Pi Software Defined Radio
 - ARISS Radio Pi: Raspberry Pi, ARISS-developed software, RTL-SDR dongle that plugs into the Pi and attaches to the provided antenna.
 - ARISS Radio Pi enables students to investigate radio signals across the radio spectrum and track and listen to satellites, including the ISS.



ARISS TEACHER EARNS 2019 AIAA EDUCATOR ACHIEVEMENT AWARD



- Upper St. Clair HS, PA Education Coordinator Pat Palazzolo receives AIAA Educator Achievement Award at AIAA Gala Event on May 15
- AIAA recognized three outstanding STEM educators at Gala
- Patricia's students conducted ham radio contacts with astronauts on the Space Shuttle and the ISS.
- Patricia gave a presentation on her STEM programs at the 2004 AMSAT Symposium in Washington DC



**Patricia Palazzolo &
Former Student Amy
Kaminski, PhD at
AIAA Gala**



OPERATIONS



TRANSFORMING ARISS OPERATIONS TO ENSURE PANDEMIC SAFETY



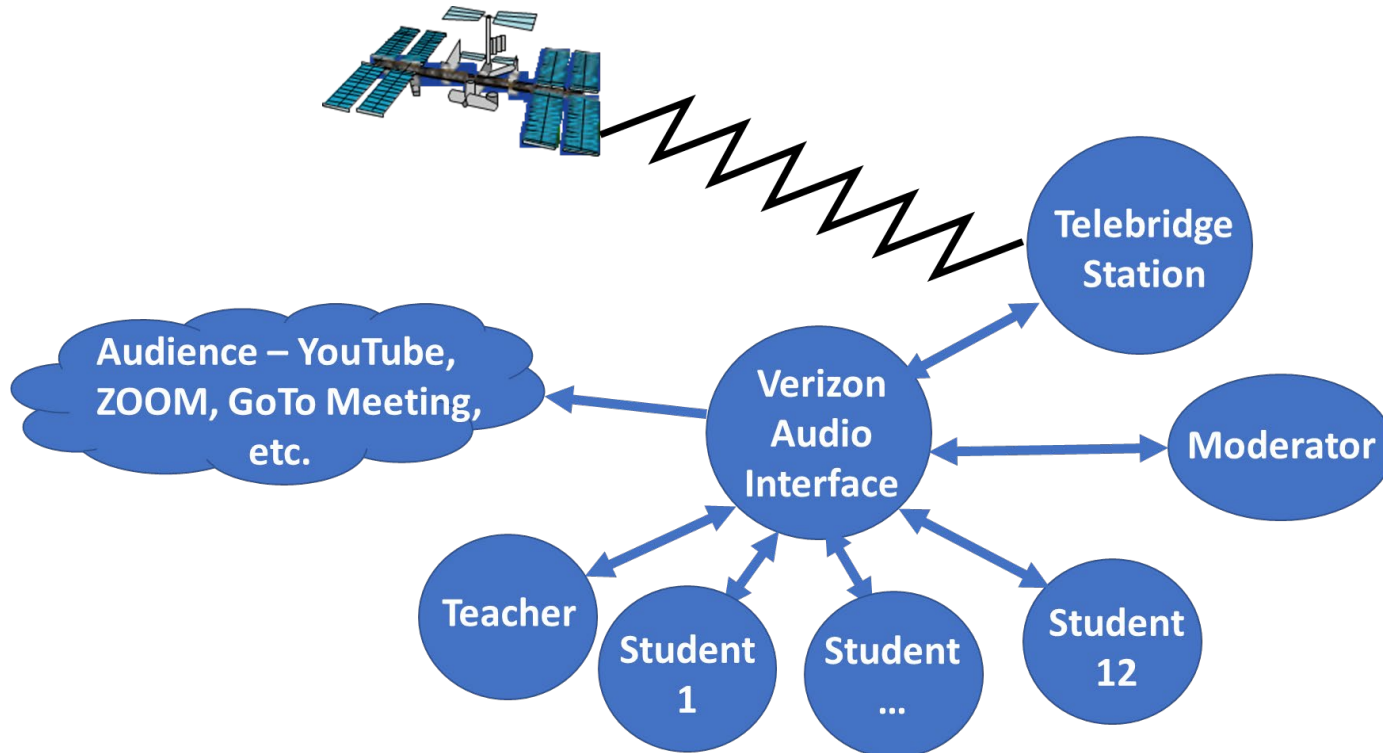
Issues

- All ARISS contacts after April 2020 cancelled or postponed due to Pandemic
- Four ground stations closed because they were located at NASA facilities (GSFC, JSC) or at universities or public locales

ARISS Response

- Through guidance from retired physician ARISS leader, developed COVID-19 policy
- Pivoted the program to support all initiatives with all participants (students, educators, public and ARISS volunteers) remote from each other—Multipoint Telebridge via Amateur Radio
- Installed and certified two new ground stations in the homes of amateur radio operators (New Hampshire and South Africa)
- Developed YouTube channel to distribute audio contact mixed with pictures and videos to a wide audience, including schools and the public
- Performed Two successful experiments of technique; now an operational capability
- New outreach/engagement tool will be an outstanding future resource, even beyond COVID-19

WHAT DOES A MULTIPOINT TELEBRIDGE CONTACT LOOK LIKE?





SPACE AGENCY COLLABORATION

ARISS-INTERNATIONAL ANNUAL MEETING, JUNE 22-26, 2020



**2020 ARISS-International Annual Meeting Pivoted to 5-Day GoTo Meeting
62 attendees from 12 countries and all 5 ARISS Regions**

- Day 1: 20 years of continuous ops; commercial crew updates; future strategies
- Day 2: Ops Day—New Ops during Covid with all students at home, add'l ops enhancements during Covid, crew scheduling challenges
- Day 3: Education Day—ARISS balloon race, US Radio Kit, ESA ESERO ARISS education resources
- Day 4: Lunar Gateway Development Day
- Day 5: Wrap-up Day-Delegate decisions; future meetings, planning for 20th anniversary celebration



About half of meeting participants

November 13, 2020 represents 20 years of continuous amateur radio operations on the ISS!



EXPERIMENTATION



MARCONISSTA EXPERIMENT RESEARCH RESULTS PRESENTED AT IAA SMALL SATELLITE SYMPOSIUM

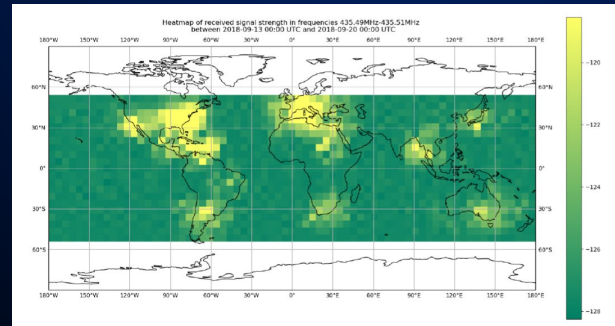
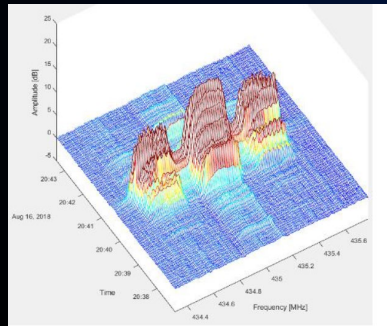


- ARISS sponsored on-orbit spectrum experiment on VHF, UHF, L & S bands to analyze use & availability of bands for satellite communication
- Martin Buscher, TU Berlin PhD research project
- 2 papers on MarconiSSta results presented at IAA Symposium on Small Satellites
- Cooperative agreement transfers on-orbit MarconiSSta hardware to ARISS for future research
- Snapshot of UHF Flight Results:

LimeSDR ARISS Antenna Feedlines Astro-Pi (Computations, C&DH)



MarconiSSta On-Orbit Configuration





SUSTAINABILITY AND FUNDING



ARISS-USA—ARISS TEAM NOW A LEGAL ENTITY



- ARISS team in the USA now ARISS-USA, a Non-profit Corporation
 - *ARISS-USA strategies remain the same as before: To Inspire, Engage and Educate students and the public in STEAM via amateur radio on the ISS*
 - *All USA initiatives will remain with planned enhancements in operations capabilities and stronger educational outcomes*
 - *Will continue to maintain ops on ISS with proposed expansion beyond low Earth Orbit, including the Lunar Gateway*
 - *Will continue to keep strong ties with ARRL, AMSAT, NASA, ISS NL*
 - *ARISS-USA now able to sign agreements and solicit grants*
 - *ISS NL agreement in place; working with NASA on new Space Act Agreement*



ARISS USA Sponsors Benefactors/Stakeholders



NASA/Space Communication and
Navigation (SCaN)



American Radio Relay League
(ARRL)

Amateur Radio Leadership



AMSAT
Radio Amateur Satellite Corporation

Includes real (money) contributions and in-kind (support) contributions
Volunteer team provides >\$5M in-kind support per year

SPECIAL THANKS TO OUR OTHER MAJOR SPONSORS:



JVCKENWOOD

In-Kind support of D710 GA Radios and Engineering Modifications



Bill Tynan
W3XO

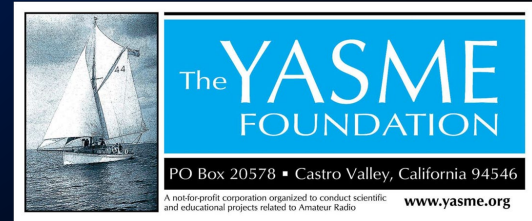


MFJ



Ham Jam

Joe Lynch
N6CL



HARDWARE DEVELOPMENT

NEXT GENERATION RADIO SYSTEM INTEROPERABLE RADIO SYSTEM (IORS) ON THE AIR!



- Radio provides improved reception of Columbus Module downlink signal with higher power radio
- Standardized JVC Kenwood radio & ARISS/AMSAT built power supply-- interoperable across all ISS segments & modules; ARISS-US led requirements verification, safety certification, & flight operations
- First flight unit launched on SpaceX-20, March 6, 2020; Chris Cassidy installed in Columbus module September 2, 2020!
- Second flight unit (for Service Module) complete; total of 10 units to be fabricated, 4 flight & flight spare units, 6 for crew training & ground testing



NEXT GEN IORS IN COLUMBUS MODULE

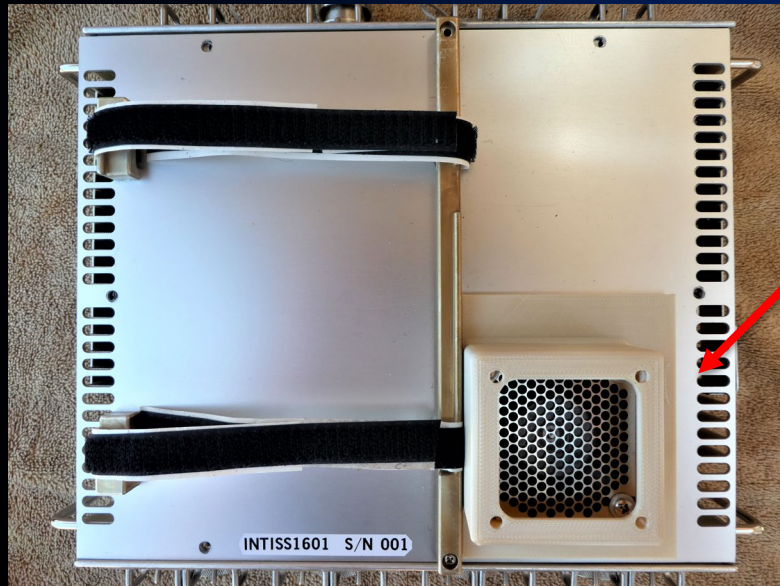




HUNCH 3-D PRINTED FAN COVER ON POWER SUPPLY



Fan Cover
Fabricated by
HUNCH (student) Team



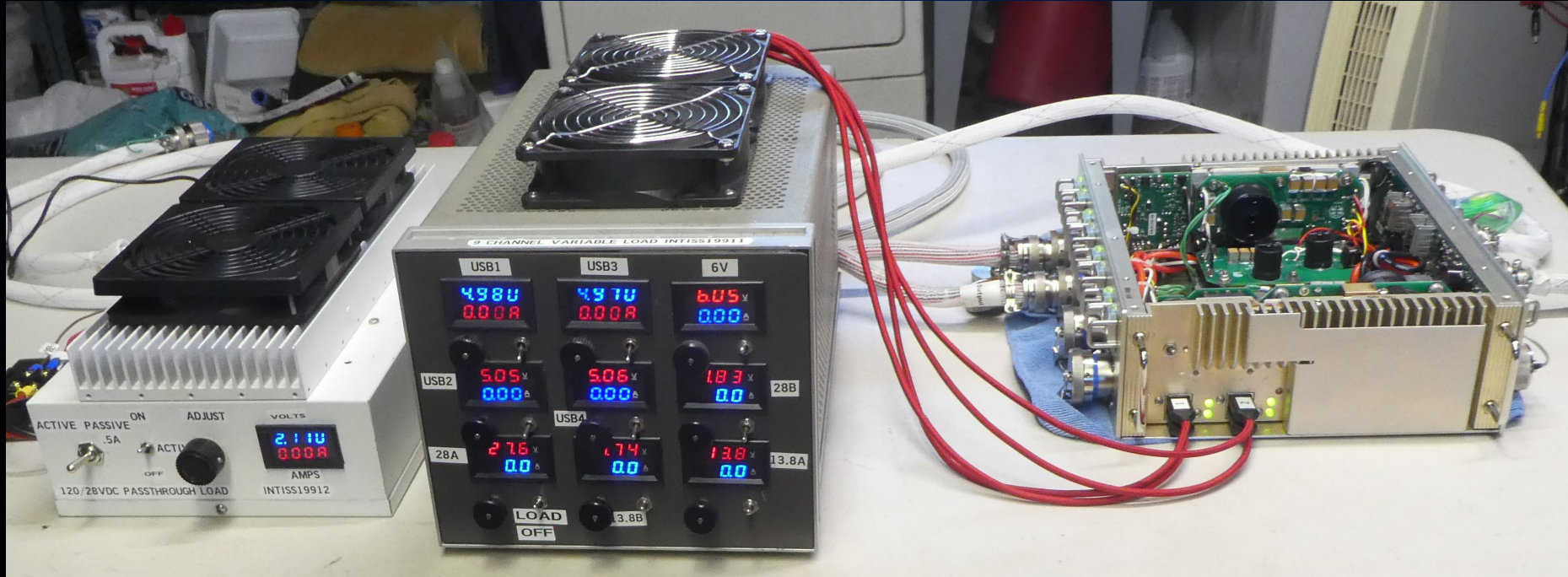
EMI TESTING AT JSC APRIL 2019



KERRY BANKE'S TEST SETUP



FLIGHT MODEL SN 1001



ARISS DATV SYSTEM (HAM TV) REPAIR



Background

- ESA-developed Ham TV system & ARISS S-band antennas supported real-time video downlink for ARISS school contacts; failure in system required return to Earth for repairs

Current Status

- Repairs by Kayser-Italia delayed due to Covid-19; repairs completed; Launch date unknown



VHF/UHF ANTENNA CABLE REPLACEMENT DUE TO BARTOLOMEO INSTALL

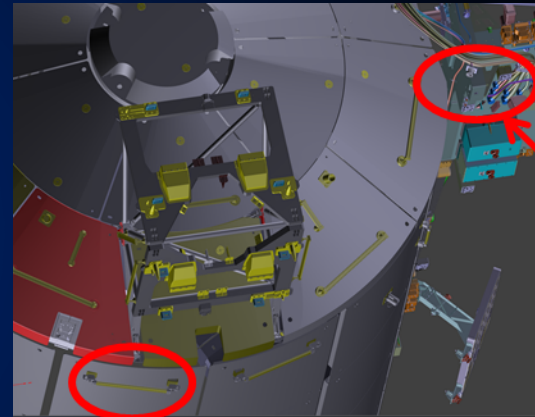


Background

ESA/Airbus Bartolomeo external attached payload capability on Columbus requires removal & replacement of ARISS/AIS antenna feedthrough; internal and external replacement of ARISS feedline required

Current Status

Bartolomeo launched on Spacex-20; ARISS waiting for fall EVA to change out RF cable



EVA
Connector
Bracket

ARISS Antenna Location on
Bartolomeo



THE FUTURE OF ARISS



OVERVIEW



- ARISS-International is proposing a new strategy for the future
- Integrated initiative encompassing education, operations and hardware development
- Also encompasses multiple human spaceflight vehicles

INTRODUCTION



- ARISS has developed and is implementing an Education Strategy that is realizing stronger, deeper and more extensive educational outcomes in formal and informal educational venues—**our customers**
 - *In Schools (all ages)*
 - *With the Maker, Coder and Do-it-Yourself (DIY) community*
 - *With the amateur radio community*
- Primary goal: To Inspire, Engage and Educate students and others in life-long learning
- Key strategies:
 - *Accomplish above through new on-board and ground-based hardware and software systems that reduce dependence on crew interaction and expand educational opportunities*
 - *Develop lesson plans and integrate other ground systems (e.g. radio kit and balloon races, etc.) to augment ARISS contacts with additional radio/space STEAM learning*



CHANGES—PLANNED AND UNEXPECTED

- COVID-19 totally transformed contact operations
 - *Expect use to continue for at least for a year*
 - *Plan: available permanently for periodic use*
- Installation of Next Generation Radio System (IORS and augments) into Columbus and Service Modules
- Less crew time for school contacts due to increased research
- L-band duplexer being readied for voice repeater ops on L/UHF
- Ham Video redeployment within the year (COVID delayed)
 - *Include video text generator*
- In next year, expect expansion of on-board crew tourists/spaceflight participants via commercial crew program
 - *Astronauts & cosmonauts*
 - *Length of stay: varied from 14 days to 6 months*
- ARISS-Pi could enable payload commanding (through ISS or via amateur radio) & telemetry downlinks
 - *Reduces crew workload on ARISS and expedites IORS/HamTV mode changes*
 - *Enables for frequent/regular SSTV*
 - *Supports development of school “mission control center” (proposal)*
- MarconiSSta Phase II Payload Commanding and Telemetry Downlink
- Gateway amateur radio system testbed on ISS
- Lunar Gateway ops in parallel with ISS ops

ACHIEVING “STRONGER, DEEPER, MORE EXTENSIVE” EDUCATIONAL OUTCOMES



- Critical enabler: ISS L/S antenna systems with DVB-S transmission/reception to enable high bandwidth uplink and downlink of digital signals (Data, Photos, Video, experiment results, etc.)
- Working closely with ISS National Lab team and Space Station Explorers on several educational experiments and opportunities to further enhance and extend ARISS educational outcomes
- Operations Plan:
 - *L-band high-speed uplink for commands and data*
 - *L-band uplink of student voice and low-rate robot commanding (2nd antenna)*
 - *S-band downlink of educational content in digital (DVB-S) form that can be easily received at schools, by DIY/Makers and amateur radio operators*
 - *ARISS-Pi supporting the interface amongst these systems*
 - *Interoperable radio system and ham video are foundational elements of this strategy*
 - *Crucial amateur radio testbed for planned education station at Lunar Gateway*

OPERATIONS MODEL OF THE FUTURE



- ARISS **customers** are employing systems on multiple vehicles 24/7/365
 - *Current ISS capabilities employed by schools, DIY and amateur radio operators to verify their ground stations prior to critical events*
 - *Customer critical events include school contacts, data downloads, certified ground station uplinks*
 - *Simultaneous operations on Lunar Gateway with easier antenna pointing but more challenging (weaker signal) communications*
 - *24/7/365 ops helps schools and others to build, test and improve their ground stations and gather science/engineering data, pictures and video from ISS or Lunar Gateway*
- Operations is similar to a “crowd sourcing” model where data is retrieved by volunteers (e.g. school groups, after school activities, amateur radio operators) and sent to a central repository
- Data storage retrieved by student “Mission Control” interface to enable science/engineering investigations of stored data
- Offering communications services from low-rate to high rate, depending on **customer** expertise and capabilities
- Multi-vehicle, multi-mode capability, which will require new ARISS operations interface—Ops 2.0

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**TRANSFORMING STEAM OUTREACH FROM LOW EARTH ORBIT
TO CISLUNAR SPACE: ARISS TO LUNAR-GATEWAY**

**International Astronautical Congress (IAC)
October 21, 2019**

Photo Courtesy of NASA

Short Quiz

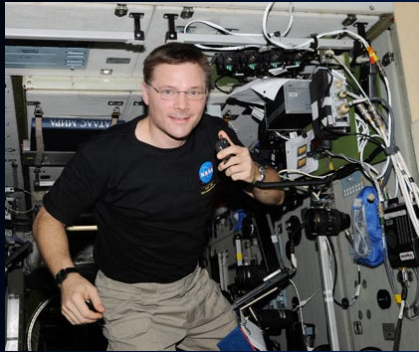


Q: STEAM Education in Deep Space using Amateur Radio Infrastructure: Is this feasible?

- Weak signal, long path length challenges are achievable and have been previously demonstrated by ARIS/AMSAT team
 - *Weak signal reception is an amateur radio operator challenge*
 - *AMSAT satellites demonstrated GPS weak signal reception beyond geostationary orbit; NASA now using GPS half-way to the moon*
 - *AMSAT/ARIS team tracked & received data from Voyager, Cassini, Venus Radar and several Lunar missions*
 - *Chinese Radio Amateurs recently operated LongJiang 1 & 2 around the moon*
 - *Prize for the first human amateur radio contact between the Earth and Mars*

A: YES!

GATEWAY PROPOSED ON-ORBIT OPERATIONS



Crew Engagement 1-2 months/year

- School Contacts (Audio only & w/video downlink)
- SSTV (Picture up/downlink)
- Experiment setup & (optional) ops
- Random Voice Contacts



Uncrewed-"Satellite Mode" 24/7/365

- Ham Video downlinks (Earth, Moon, AReX Experiments)
- Packet/APRS & Robotic commanding via APRS
- Voice Repeater
- SSTV Pictures & Educational Puzzles
- Experiment & Ham Station Telemetry

AREX OPERATIONAL SEGMENTS



Space Segment
Crew Tended | Autonomous



User Segment

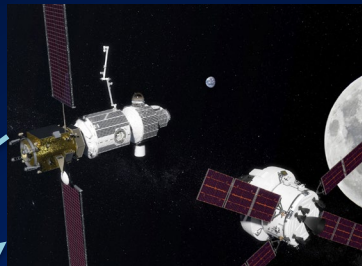
Educational Outreach | Amateur Ops | Experimental Scientific



Operations Control Segment

Nominal | Contingency Ops

AREX OPERATIONAL SCENARIOS



X-Band (10.45-10.5 GHz)

C-Band (5650-5670 MHz)

Operation Plan:

Nominal: X-band TX Prime; 70 cm Rx only

Contingency: 70 cm TX Prime; X-band TX off

70 cm Band (435-438 MHz)
AREX contingency ops

X-Band (10.45-10.5 GHz)

C-Band (5650-5670 MHz)



Users

- Schools & General Public (RX only)
- Amateur Radio Operators (RX & TX)
- Experimental/Scientific (RX & TX if licensed)

AREX Gnd Stations

- Cmd
- TLM
- Contingency



Bochum, GAVRT, &
Goonhilly



Telebridge
Network

BATC Server RX Distribution

AREX PAYLOAD CONCEPT

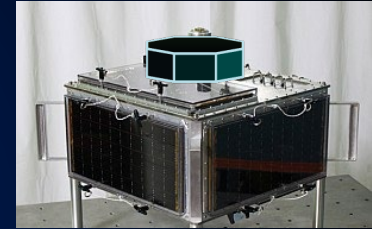


- **AREx Mark 1 System: Minimally Capable Educational Outreach System; Flown Soonest**
 - Externally mounted “satellite” payload with fixed antennas & cameras attached; optional deployable boom for greater visibility
 - Develop 2-3 spacecraft copies that will be externally attached to each Logistics Module flown to support lunar human spaceflight missions
 - Simple ground station using COTS components and AREx embedded soft/firmware & data interfaces
 - Gateway operations timeframe: Soonest on Gateway Phase 1; target delivery: early 2024
- **AREX Mark 2 System: Foundational Educational outreach system**
 - Fully capable system, internally mounted on Gateway employing RF feedthroughs to Earth-pointed 0.6 m dish or flat plate antenna
 - Simple ground station using COTS components and AREx embedded soft/firmware & data interfaces
 - Gateway operations timeframe: starting around 2026-2027

AREX MARK 1 SYSTEM OVERVIEW



- ARISSat spaceframe, human spaceflight certified; 3 units available
- Commandable antenna/camera array “communications/video hat” (CV Hat) eliminates pointing system
- Option: CV Hat on deployable boom; based on Earth visibility constraints
- Enhanced Software Defined Radio employing DVB-S2X technology for simple ground station transmit/receive & weak signal capture
- Experiment interface for STEAM student investigations
- Leverage systems and interfaces developed through ARISSat along with pioneering DVB-S2 capability employed on ARISS HamTV
- Supports voice, lunar/Earth pictures, Television (low bandwidth), experiment data, Twitter-like messages, telerobot commanding between schools

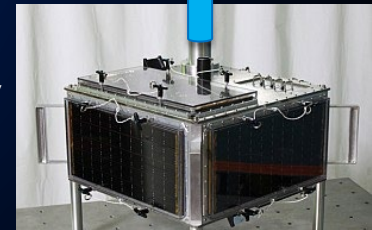


**ARISSat
With
CV Hat
on top**

AREx Mark 1

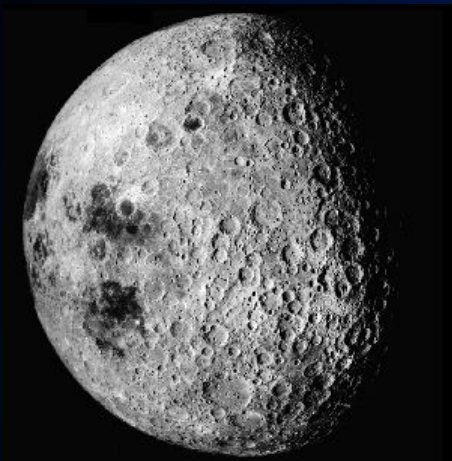


**Deployable
Boom**



AREx Mark 1 Option

GATEWAY EDUCATION



Far Side of the Moon

- Students could use code and program a camera on Gateway to take pictures of the moon, the Earth or other parts of the universe



Our Earth

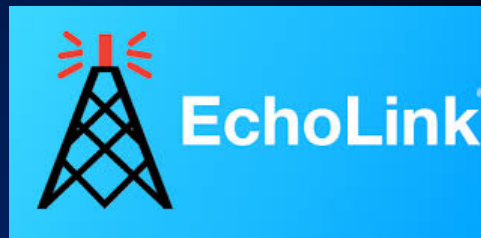
- With the visual footprint being so large, students could view pictures or video from Gateway and learn to identify parts of the Earth, learning about the culture, people and landforms.
- Can turn the camera to also look into deep space

GATEWAY EDUCATION



Science Experiments

- Students and astronauts conduct parallel experiments
- Results shared via radio or recorded to share later



EchoLink & Other Capabilities

- Radios can be expensive, but phone apps are cheap!
- Students could communicate with each other using an EchoLink node installed on Gateway
- Ham radio voice repeater also available for student to student chats
- Morse Code and other codes can be used by students and astronauts

Conclusions

- ARISS provides an outstanding Educational Outreach foundation for ISS
- ARISS's solid performance and outstanding international teamwork is recognized and respected by the Space Agencies
- ARISS continues to expand its Educational impact
- Poised for the future operations on ISS and the Lunar Gateway



Frank Culbertson During Scout Jamboree on the Air



WE NEED YOU

**... AND HOW CAN YOU CONTRIBUTE
TO THE SUCCESS STORY?**

This Presentation is Dedicated to the Memory of ARISS Silent Key Team Members:



Owen Garriott, W5LFL



Bill Tynan, W3XO



Keith Pugh, W5IU

**May their passion for human spaceflight ham radio
inspire us all to sustain and expand ham radio for all**

The ARISS Experience



ARISS Information

<https://www.ariss.org>

