Human Spaceflight, ARISS & Future SuitSat Missions

Amsat Symposium
Oct 27, 2007

Frank H. Bauer, ka3hdo@amsat.org
Building & Operating Spacecraft Means Paying Attention to the Details
Amateur Radio on the International Space Station (ARISS)

What is ARISS?

- International program that inspires students, worldwide, to pursue careers in science, engineering and mathematics through communication with the ISS on-orbit crew via amateur radio
- Local community drawn into this once-in-a-lifetime human spaceflight pursuit
- Provides an experiment platform for new telecommunications techniques
- Promotes interest in the amateur radio (ham radio) hobby as a link to better engage students in science and math

ARISS development, operations and student mentoring is performed almost exclusively by a world-wide network of amateur radio volunteers who are passionately committed to the above objectives
ARISS Capabilities & Impact

- FGB-mounted 2 m Ericsson radio for voice & packet
  - Operational less than 2 weeks after first crew arrival making **ARISS the first payload on ISS**
- Developed 4 multi-band antenna systems; mounted on the periphery of the Russian service module via 3 EVAs → **2 m, 70 cm, L band, S Band, HF and GPS**
- Developed and installed 2 L/S-band antennas on European Columbus Module
- Installed UHF/VHF Kenwood D-700E in Service Module, near the dinner table and window
- Successful completion of over **330** international schools—kudos to the operations team and volunteer mentors on a job well done!
- **16 consecutive ISS expedition crews** used our radio system to conduct thousands of QSOs with hams on the ground since November 2000
- Over **15,000** students touched each year
- **Millions, worldwide** have heard an ARISS connection
- **Millions, worldwide** see ARISS contact on ISS IMAX film
- Witnessing students, worldwide, become scientists and engineers as a direct result of the ARISS connection
- The first Spacesuit satellite—SuitSat-1/Radioskaf deployed from ISS; **SuitSat-2 on the horizon.**
ARISS Total history running count from Expedition 1 Docking

Expedition 3
Frank Culbertson
KD5OPQ

Expedition 12
Bill McArthur
KC5ACR

Expedition 14/15
Suni Williams
KD5PLD

Current date and time
School Contacts Per Year

- 2000: 70
- 2001: 42
- 2002: 1
- 2003: 47
- 2004: 55
- 2005: 39
- 2006: 35
- 2007: 40
### Crew School Contact Statistics

<table>
<thead>
<tr>
<th>Top 5 expedition school contacts:</th>
<th>Top 5 individual school contact counts for a single tour:</th>
</tr>
</thead>
<tbody>
<tr>
<td>2) Exp 12—38</td>
<td>2) Suni Williams – 33—Exp 14/15</td>
</tr>
<tr>
<td>4) Exp 10—23</td>
<td>4) Frank Culbertson – 22—Exp 3</td>
</tr>
<tr>
<td>5) Exp 3—22</td>
<td>5) Clay Anderson – 21—Exp 15/16</td>
</tr>
</tbody>
</table>

Suni Williams
KD5PLD
Anousheh Ansari

Charles Simonyi

Sheikh Muszaphar Shukor
Sputnik 50th Anniversary
ARISS Contact
Air & Space Museum
Sept 29, 2007
Crew Ops Observations & Expectations

- Past few crews have been very prolific in performing school contacts (Bill McArthur, KC5ACR, Suni Williams, KD5PLD, Clay Anderson, KD5PLA)
- General QSOs sporadic; dependent upon crew interest
- High crew workload over next 6 months will result in little and at times no school or general QSO contacts on Expedition 16
  - Install and c/o US Harmony Node starting now
  - Install and c/o European Columbus Module Next Shuttle flight
  - Install and c/o Japanese Kibo Module follow-on Shuttle flight
  - 3 Shuttle flights
  - 2 Soyuz flights
  - Inaugural ATV (Europe Automated Transfer Vehicle) flight
- Packet ops will continue on 145.825 simplex
- Mid-2009 change to crew of 6 will significantly change ops dynamics
  - Many more schools and general QSOs??
<table>
<thead>
<tr>
<th>LAUNCH DATE</th>
<th>CDR</th>
<th>FE-1</th>
<th>FE-2</th>
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<tbody>
<tr>
<td>Exp. 15 Shuttle up</td>
<td>June 2007 (13A.1)*</td>
<td>Clay Anderson KD5PLA</td>
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<tr>
<td>Exp. 16 Soyuz up</td>
<td>October 2007*</td>
<td>Peggy Whitson KC5ZTD</td>
<td>Yuri Malenchenko RK3DUP</td>
</tr>
<tr>
<td>Exp. 16 Shuttle crew</td>
<td>Oct 2007 (10A)*</td>
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* Indicates planning date as of May 2007. Subject to change.

**Current Crew Complement (Not including Shuttle Crew)**

- Suni Williams KD5PLD
- Fyodor Yurchikhin RN3FI
- Oleg Kotov
- Peggy Whitson KC5ZTD
- Sandy Magnus KE5FYE
- Koichi Wakata KC5ZTA
<table>
<thead>
<tr>
<th>Exp. 14/15 Shuttle up</th>
<th>December 2007</th>
<th>CDR</th>
<th>FE-1</th>
<th>FE-2</th>
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</thead>
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<tr>
<td></td>
<td></td>
<td>Fyodor Yurchikhin RN3FI</td>
<td>Oleg Kotov</td>
<td>Suni Williams KD5PLD</td>
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<tr>
<td>Exp. 15 Soyuz up</td>
<td>April 2007</td>
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<tr>
<td>Exp. 15 Shuttle up</td>
<td>June 2007 (13A.1)*</td>
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<td>Oct 2007 (10A)*</td>
<td></td>
<td></td>
<td>Dan Tani KD5DXE</td>
</tr>
<tr>
<td>Exp. 16 Shuttle crew</td>
<td>Dec 2007 (1E)*</td>
<td></td>
<td></td>
<td>Leopold Eyharts KE5FNO</td>
</tr>
<tr>
<td>Exp. 16 Shuttle crew</td>
<td>Feb 2008 (1J/A)*</td>
<td></td>
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<td>Garrett Reisman KE5HAE</td>
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<tr>
<td>Exp. 17 Soyuz up</td>
<td>March 2008*</td>
<td>Sergei Volkov</td>
<td>Oleg Kononenko RN3DX</td>
<td>Sandy Magnus KE5FYE</td>
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<tr>
<td>Exp. 17 Shuttle crew</td>
<td>July 2008 (15A)*</td>
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<td></td>
<td>Koichi Wakata KC5ZTA</td>
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<td>Exp. 17 Shuttle crew</td>
<td>Oct 2008 (ULF2)*</td>
<td></td>
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<tr>
<td>Exp. 18 Soyuz up</td>
<td>October 2008*</td>
<td>Michael Fincke KE5AIT</td>
<td>Alexander Kaleri U8MIR</td>
<td>Greg Chamitoff KD5PKZ</td>
</tr>
<tr>
<td>Exp. 18 Shuttle crew</td>
<td>Jan 2009 (2J/A)*</td>
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ARISS Update—Team, Hardware Status, Future Opportunities
2007 Delegate Changes

Stepping Down

Ken Pulfer, VE3PU
Canada

Robin Haighton, VE3FRH
Canada

Stepping Up

Daniel Lamoureux, VE2KA
Canada

Stefan Wagener, VE4NSA
Canada
Two L/S Band Antennas Installed on European Columbus Module!!

Installation & C/O Completed Week of October 20, 2007
Hardware Development/Ops
Lessons Learned

• ISS is not like Mir → don’t expect the same type of ops

Differences:
  – Mir crew relied on ham radio equipment to support family contacts, radiograms, air to ground comm
  – Ham radio on Mir was the prime external outlet for the crew
  – ISS communications system much more robust
  – IP Phone on ISS requires very few ARISS family contacts

Similarities:
  – Proven educational outreach capability that requires nearly zero setup overhead
  – “Dyed in the wool” hams use the equipment extensively

• After 7 years of continuous operations little crew time for hardware installation, checkout or troubleshooting

Lesson Learned
Future ARISS hardware needs to be Satellite-like (i.e. completely autonomous and commandable)
ARISS Phase 3 Hardware Concept

- Use SuitSat-2 core hardware to support multi-band autonomous ops
  - Voice
  - Packet
  - SSTV
  - Student Experiments
Current/Future Telebridge Stations

New VE4NSA Bridge Station
Proposed Augmentation of Bridge Stations
(South America and High Latitude)
SuitSat-1--Amateur Radio Extra Vehicular Activity (EVA) In a Space Suit

- 2-week battery-operated satellite station
- Capabilities:
  - International Student Message Downlink
  - SSTV Picture
  - Telemetry
  - School Spacewalk—DVD with school name, artwork and student names included
- Deployment: Feb 3, 2006
- Re-entry: Sept 7, 2006
The Amateur Radio on the International Space Station (ARISS) Team

SuitSat-1/Radioskaf-1/GO-54

Certificate of Recognition

presented to

William C. McArthur
KCSACR

Presented in recognition of your outstanding volunteer support to ensure the successful development, crew training, deployment, operations, educational outreach and information dissemination of the SuitSat-1 mission. As a result of your efforts, SuitSat-1 captured the imagination of people and students worldwide providing unprecedented outreach and visibility for a ham radio event.
The Amateur Radio on the International Space Station (ARISS) Team

**SuitSat-1/Radioskaf-1/AO-54**

**RS0RS, Commemorative Certificate**

presented to

**Frank H. Bauer**

**KA3HDO**

For Successful Reception of the SuitSat 1 radio downlink during its operation from February 3, 2006–February 18, 2006.
The Amateur Radio on the International Space Station (ARISS) Team

is proud to present the

Chicken Little Prognostication Award

to

Aaron Russo
Student K-8

As one of the "Select Few" to successfully predict the reentry of the SuitSat-1/Radioskaft-1/AO-54 satellite,

SuitSat Deployment: February 3, 2006 @ 23:03 UTC
SuitSat-1 Reentry: September 7, 2006 @ 16:00 UTC
SuitSat-1 Chicken Little Contest Winners  
Re-entry: September 7, 2006 at 16:00 GMT

<table>
<thead>
<tr>
<th>K-8 Student</th>
<th>High School Student</th>
<th>Adult</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aaron Russo - 10 August</td>
<td>Kaleb - 17 August</td>
<td>Brian W4OGU - 07 September</td>
</tr>
<tr>
<td>Kai Thomas - 12 August</td>
<td>Jconnop - 17 August</td>
<td>N3RCU - 07 September</td>
</tr>
<tr>
<td>Matt - 17 August</td>
<td>Joanna K W. - 17 August</td>
<td>SW6JIV - 07 September</td>
</tr>
<tr>
<td>Ralf Klebermass - 17 August</td>
<td>leila - 24 August</td>
<td>Beth Ransom - 07 September</td>
</tr>
<tr>
<td>Alexander Akers - 06 September</td>
<td>alex - 31 August</td>
<td>Kazumasa Ibata - 07 September</td>
</tr>
<tr>
<td>Joshuah - 11 September</td>
<td>Stanislav Babenko - 05 Sept</td>
<td>Reidar Larsen - 08 September</td>
</tr>
<tr>
<td>andy bond - 11 September</td>
<td>weathernut27 - 07 September</td>
<td>Chad Briggs - 08 September</td>
</tr>
<tr>
<td>Abriana - 15 September</td>
<td>mike - 08 September</td>
<td>kb3nds - 08 September</td>
</tr>
<tr>
<td>lucy bullfrog - 24 September</td>
<td>Addison Call - 10 September</td>
<td>nalro - 08 September</td>
</tr>
<tr>
<td>cameron... - 04 October</td>
<td>Richard - 03 October</td>
<td>kg6hsq - 09 September</td>
</tr>
</tbody>
</table>
SuitSat Future

• Design work underway for SuitSat-2
• Expected shipment to Russia: June 2008
• Expanded educational outreach
  – DVD with student pictures
  – Student audio downlinks
  – Pre-developed lesson plans (3 levels)
  – College students supporting hardware/software development
• Hardware Design features:
  – Proven SuitSat-1 safety interlock
  – Software Defined Transponder (SDX) system (RF & DSP)
  – New transmitter, receiver & antenna system
  – Solar arrays from NASA SMEX-Lite project
  – Additional sensors
  – SSTV with up to 4 cameras for SSTV downlink
  – Up to 4 experiment ports
Maricopa, Arizona Scouts Participate in SuitSat-2 Development
September 13, 2007
The Future

- ARISS team developing Exploration Initiative strategy.
- ARISS’s solid performance and outstanding international teamwork is recognized and respected by the Space Agencies.
- The challenges will be high due to the long path lengths.
ARISS Information

http://www.rac.ca/ariss
Backups
Voice Over Internet Protocol (VOIP)

IRLP, Echolink and Internet Streaming Provides a Wider Reach to Schools and Ham Radio Operators

Echolink
AMSAT and EDU_NET Servers

IRLP
9010 "Discovery" Reflector

www.amsat.org
Calendar of Events

www.discoveryreflector.ca
Columbus Module Antenna
Installation and Inspection

Installation
Inspection