### **Amateur Radio On The International Space Station (ARISS)**



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### Amateur Radio on Human Spaceflight Missions

Since 1983, organizations in the U.S. (SAREX), Germany (SAFEX) and Russia (MIREX), have worked with the space agencies to fly amateur radio and to support Educational Outreach on:



#### **Space Shuttle**







Mir

### **ARISS Objectives**







# Spark Student's InterestCrew Family ContactsIn Science & Technology(Crew Psychological Ops)

Promote Interest In Amateur Radio



Human Spaceflight Awareness







**Experimentation** 

### **Development & Operations on the International Space Station (ISS)**

Working with our international partners to develop & operate Amateur Radio on the International Space Station (ARISS)

#### **ARISS Organization**

- Nine international partners thus far—Belgium, Canada, France, Germany, Italy, Netherlands, Japan, Russia and United States
- MOU—Formed ARISS to represent the amateur radio community to the ISS Program
- All volunteer organization



### **USA Sponsors**



National Aeronautics and Space Administration (NASA)





American Radio Relay League (ARRL)

Radio Amateur Satellite Corporation (AMSAT-NA)

# **Capabilities of Initial Station ISS Ham Phase 1**



### 2-way voice operations on VHF & UHF

# **Capabilities of Initial Station ISS Ham Phase 1 (Continued)**

Computer-to-Computer Radio Links

Amateur Radio E-mail from Mike Foale after Progress collision with Mir Spektr Module Posted : 06/28/97 17:58 To : ALL From : R0MIR Subject: Mir Status

We have now got the base block, the module Kvant 2 back on line, leaving 2 more modules. Working very hard, lights in our mouths, in the dark, moving batteries about, to enable better charging, with solar arrays. O2 electrolysis soon, in old Kvant. Much interest from control center to do internal eva to reconnect power to lost Spkektr module, to receive its substantial electrical power from its large arrays.

Thanks for all your good wishes. Mike.

CMD(B/H/J/K/KM/L/M/R/S/SR/V/?)>

# Planned Capabilities for Initial Station ISS Ham Phase 1



Slow Scan TV (Photos/JPEG Images)

# Planned Capabilities for Phase 2 Station



- Phase 1 VHF & UHF Systems
- Higher power (25 W) VHF & UHF FM Radio System
- HF (shortwave) radio system for ionospheric experimentation
- Packet Radio
- SSTV

Supports Multi-Band, Multi Operator Autonomous and Crew-tended Modes

### **Future Capabilities**



### **Amateur TV** (Standard, Spread spectrum, & MPEG)



#### SPRE Pass Over U.S.



**R/T Internet TLM using amateur radio** 

Express Pallet & External Payloads---w/ antennas & student experiments

### HARDWARE DEVELOPMENT PLANS

**Development to be conducted in four phases** 

- Initial Amateur Station (Part 1 of Phase 1 is onorbit)
- Transportable Amateur Station—Phase 2 (Developing)
- Permanent Amateur Station (Future)
- Express Pallet/External Experiments (Developing & Future)

### **Initial Amateur Station Part 1**

- Improved Packet Module (Computer-to Computer Radio Link) (U.S. Built)
- Ericsson VHF Radio & UHF Radio for Voice ops (U.S. Built) *Qualified & On-Board ISS!*
- Multi-band Antennas (Italian, U.S. & Russian Built) Qualified & On-Board ISS!

### **Initial Amateur Station Part 2**

- Speaker-Mic System (U.S. Built)
- SSTV (U.S. Built)

### Ham Station Location: Service Module and FGB

FGB Service Module (Zarya (Zvezda)

- Initial ops in FGB
  - Using Phase 1 VHF radio system
- Primary ops in Service Module
  - Multi-mode, multioperator capability after installation of 4 antenna systems

### SIRIUS ANTENNA LOCATION ON ZARYA



### **Initial Amateur Station Part 1**



#### Initial Amateur Radio Station Undergoing EMI Tests at GSFC

### Installation/Launch Status (2000-2001) 4 Launches in 2 Years!!

- STS-106 (2A.2B), September 2000
  - delivered Phase 1 VHF & UHF Ericsson radios to ISS
  - VHF FM (144 MHz) radio system installed in Zarya (FGB) & attached to Sirius antenna system
  - Supports voice & packet ops
- Soyuz Flight 2R
  - Increment 1 crew activates VHF equipment on November 13, 2000 (14 days after crew arrives)
- STS-105 (7A.1) August 2001
  - Delivered new packet module to support simultaneous 2 radio (VHF/UHF) ops in FGB & Service Module
- Progress 6P flight, November 2001
  - Delivered Russian antenna hardware
- STS-108 (UF-1) December 2001
  - Delivered antenna systems and add'1 hardware to support 2 radio ops

### **ARISS Provided Hardware to ISS HAM at SPACEHAB for Launch on STS-106 (2A.2b)**





### Sergei Krikalev, U5MIR in the FGB ham shack



Launched on STS-105 (7A.1) August 2001 POWER OUT

AKETHЫЙ MOAYJIB PACKET MODULE

> BKJ NUT POWER ON

ВКЛ ПИТ POWER ON 17.

BXOA TINT POWER IN

BXOД ПИТ POWER IN

COEA

COC

PADIO CT. RADIO

PADIO CT. RADIO

540

1PA

HECYL

ENABLE

BKU

AMSAT NA

147

17

DIARA

0

in the

### Ham Station Location: Service Module and FGB

FGB Service Module (Zarya (Zvezda)

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### **ARISS / ISS HAM Location in and on the Service Module**



### **ARISS** Hardware Location in Service Module



ARISS Team Members Sergej Samburov (Russia), Frank Bauer (US) & Alberto Zagni (Italy) (L to R) in front of ARISS Hardware Installation Area

### Service Module Closeout Photos Radio Station Location



# Antenna System Installation on Service Module



#### Antenna System w/ VHF/UHF Antenna Installed (1 of 4) Internationally I



Mounting

Plate

Internationally DevelopedL/S GlisserAntennaDiplexerUS Contribution:Mounting PlateHandle & SpacerVHF/UHF & HF AntennasRussian Contribution:Handrail ClampInterconnecting Cables

Handle

MI

Handrail

Clamp

EV

**Tether** 

### **Antenna System Testing**

Initial antenna system construction completed fall 1999
Antennas patterns and SWR tested at GSFC (12/99 & 8/01)



#### Antenna Testing at GSFC

## Antenna Systems WA1-WA4



# **Russian Cable Clip**



### **EVA Connector**



### Service Module Closeout Photos EVA Connectors



### **Antenna Handrail Closeout Photos**









# **EVA Operations**

#### Top-level plan

- Pre-EVA Activities:
  - Use velcro to "segment" each loop of EVA cable
  - Interface EVA Cable to diplexer
  - Using clamp, attach antenna systems to frame or spacesuit
- EVA Activities:
  - Traverse along SM to location of EVA RF Connectors
  - Fasten each antenna system to each handrail & lock in place
  - Deploy and tie-down EVA cable as each antenna system is routed to the specifically depicted handrail
  - Attach RF connectors for WA1-WA4










#### **Antenna Installation EVA Activity**

- Progress 6P flight, November 2001
  - Delivered EVA cable clips and velcro straps
- STS-108 (UF-1) December 2001
  - Delivered 4 antenna systems to ISS
  - Delivered additional Phase 1 hardware to support 2 radio (VHF/UHF) ops
- Expedition 4 & 5 crews install 4 antennas during Extra Vehicular Activities (EVAs)
  - WA3 on January 14, 2002
  - WA4 on January 25, 2002
  - WA1 & WA2 on August 26, 2002

#### WA4 Antenna Ready for January 25, 2002 EVA



### **Preparations for August 26, 2002 EVA**



Valery Korzun, RZ3FK Commander with Antenna WA1

#### Peggy Whitson, KC5ZTD with Antenna WA1



# **Antenna Installation EVA**



# WA3 and WA4 Antennas on Service Module



# WA3 Antenna







# Installation/Launch Status (2003-2004) 3 Launches in 2 Years!!

- Progress 12P flight, August 30, 2003
  - Delivered Kenwood D-700E Radio System Hardware to ISS for Phase 2
  - Delivered Energia Power Supplies
- Progress 14P flight, January 30, 2004
  - Deliver Yaesu FT-100D Radio System Hardware for Phase 2
  - Deliver SSTV Hardware and Software
  - Deliver Phase 1 Headset & Headset extension cable
- Shuttle Return to Flight, (LF1) September 2004
  - Deliver MISSE-5/PCSAT2 External Payload

**Transitioning to Joint Operations in FGB and Service Module** 



Progress 12P w/ ISS Ham Hardware Prepares to Dock with ISS

#### International Technical Interchange Meeting June 23-July 1 2003 Houston, Texas



Finalization of Kenwood D-700 and SSTV Designs



# Service Module Hardware Architecture (Phase 1 70 cm and Phase 2)



# Service Module Antenna Utilization (Phase 1 70 cm and Phase 2)







### **On-Orbit Layout of ISS Ham Equipment in Service Module**



# **Power Distribution Assembly**



# Kenwood D-700E User Interface

- 5 Program Modes using specially developed MCP software
- 200 frequency pairs w/ CTCSS/PL
- Packet radio defaults in EEPROM
- Right side of radio---primary interface w/ crew
- Left side of radio---special uplink capabilities



# Kenwood D-700E Closeout Photos 5 Program Modes



#### PM 1 Voice



PM 3 APRS



#### PM2 Crossband Repeater



PM 4 Packet



#### PM 5 Emergency % 9600 Packet

#### **Future Hardware Deployments**

- SSTV—Mid-2004
- Phase 2 Yaesu hardware—Mid-2004
- External payload—1st payload (MISSE-5/PCSAT2)—Late 2004



#### Yaesu FT-100





#### **SSTV Software**

#### **MISSE-5/PCSAT2**

# System Testing of SSTV Hardware & Software

#### Phase 1/SSTV System Testing

Stat Land State



#### SSTV Interface Hardware

#### SSTV Spacecam 1 Software

AMSAT- NA



#### **Express Pallet Opportunity**

- External payload mounted on ISS truss
- Prime, Earth viewing location
- 120 V DC and 28 V DC power available
- 1553, analog, and discrete interfaces available
- ARISS team discussing idea of soliciting "University/AMSAT Microsat" class payloads to fly as part of the amateur radio Express Pallet
- Future opportunities also available

## **Pedro Duque Crew Training at JSC**



# **Pedro Duque Crew Training in Russia**





## **Expedition 8 Crew Training in Houston**



Mike Foale, KB5UAC Receives Hardware Training From Sergej Samburov, RV3DR Mike Foale, KB5UAC Receives Operations Training From Frank Bauer, KA3HDO During Lunch



## **Expedition 8 Crew Training in Russia**



#### Sergej Samburov, Alexander (Sasha) Kaleri & Mike Foale

# **Expedition 9 Crew Training at Energia, Russia**



Bill McArthur, KC5ACR (l) Sergej Samburov, RV3DR (c) and Valery Tokarev (r)



# **Operations**

- Downlink:
  - Worldwide both voice & packet: 145.80
- Uplink:
  - Packet: 145.99
  - Region 1 voice: 145.20
  - Region 2 & 3 voice:
     144.49

- Callsigns:
  - DL0ISS
  - RS0ISS
  - NA1SS
- Crew Schedule
  - ~0700 to 1900 UTC
  - Off Saturday Noon to Sunday evening

# **Telebridge Communications Links**



### Telebridge Network



ARISS Contact Commemorating 100<sup>th</sup> Anniversary of Marconi's USA Transatlantic Contact





# **Princess Electra Marconi Receives ARISS QSL Card**



## **Marconi Station AO-40 Contacts**



### Kagawa, Japan ARISS Contact



### **School Statistics**

Crew Expedition	School Contacts	<b>b</b> 24 <b>c</b> 7
1	7	
2	14	<b>Total nun</b> 10 -2 -4
3	22	
4	17	
5	14	
6	18	-0000000000000000000000000000000000000
7	18	Elapsed time in days
Tourists/Taxi Flights	6	

## Ed Lu, KC5WKJ, Field Day Operations



Field Day Results:

•41 stations contacted
•Bonus Points:

•Solar Power
•Off Commercial mains

•Total points: 405
### Challenges

- First payload to fly on ISS
  - Space agencies focused on ISS system, not payloads
  - Unclear requirements for flight certification resulted in repeating tests up to four times to meet U.S. and Russian certification requirements
    - Shuttle
    - U.S. Segment ISS
    - Russian segment ISS (FGB)
    - Russian segment ISS (Service Module)
  - Certification/Qualification testing performed in U.S. (NASA GSFC, NASA JSC, & White Sands) and Russia (Khrunichev and Energia)
  - One additional series of certification tests in Russia must be performed to allow use of Service Module Antennas, SSTV & Phase 2 Hardware; planned for November 10-20, 2003

# Challenges (continued)

- Operations Challenges
  - "Volunteer time" has resulted in significant challenges in maintaining onboard hardware systems (e.g. packet module)
  - Mitigation: Working with space agencies to garner crew time for routine maintenance
- Cultural differences of international volunteer team
- Communication Challenges
  - Language and cultural barriers
  - Reliable E-mail delivery, especially into space agencies
  - Mitigation: USA/Russian Technical teleconference 2/month, ARISS-I Teleconference 1/month, ARISS-I face-to-face 2/year
- International Space Agency Issues
  - Example: Dennis Tito's request to use ISS Ham radio to talk to family during his flight
  - Mitigation: Close, working relationship with space agency and Energia managers

# **QSL** Card



### Conclusions

- ARISS-International team of volunteers developed first payload to be certified to fly and operate on ISS
- Phase 1 and a portion of the Phase 2 hardware has been delivered on ISS on 5 launches
- Payload provides an outstanding Educational Outreach foundation for ISS
- Phase 2 and SSTV systems will significantly enhance an already outstanding ham radio system
- Multi-mode, multi operations capability will soon be a reality on ISS



Frank Culbertson During Scout Jamboree on the Air

#### **ARISS Information**

# http://www.rac.ca/ariss



This Presentation is Dedicated to the Memory of Roy Neal, K6DUE

Roy's vision to develop a permanent amateur radio station on ISS was an inspiration to us all. We feel privileged to have realized his vision during his lifetime.

