Amateur Radio On The International Space Station (ARISS)

AMSAT-DC

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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

ISS

Mir

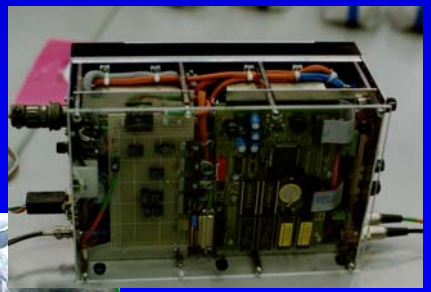
ARISS Objectives

Spark Student's Interest
In Science & Technology

Crew Family Contacts
(Crew Psychological Ops)

Promote Interest
In Amateur Radio

Human Spaceflight
Awareness



Experimentation

Development & Operations on the International Space Station (ISS)

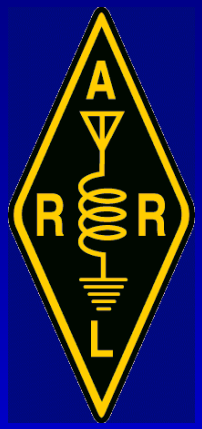
Working with our international partners to develop & operate Amateur Radio on the International Space Station (ARISS)

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)

ORGANIZATIONAL ROLES

ARRL - Sets Educational goals & objectives

AMSAT

- **Provide technical & satellite expertise**
- **Provides program management expertise**
- **Provides leadership on**
  - **Flight hardware development**
  - **Flight operations support**
  - **Crew training**
- **Develops & maintains ground station infrastructure that enables satellites & human spaceflight vehicles to effectively communicate with ground-based radio amateurs and schools.**

HARDWARE DEVELOPMENT PLANS

Development to be conducted in four phases

- **Initial Amateur Station (Part 1 of Phase 1 is on-orbit)**
- **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)**

Capabilities of Initial Station
ISS Ham Phase 1

2-way voice/packet operations on VHF & UHF

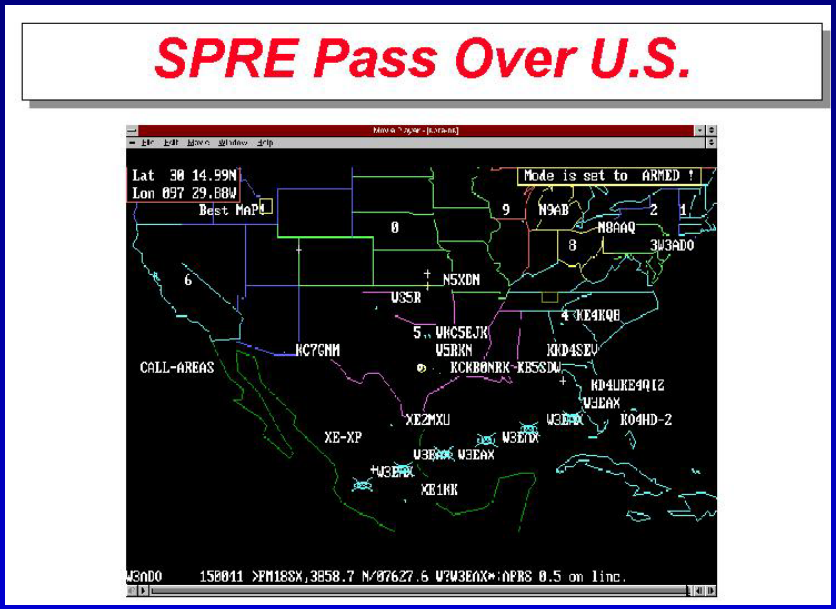
Planned Capabilities for Phase 2 Station

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

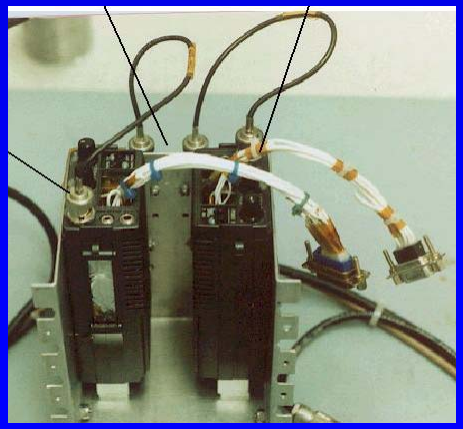
Supports Multi-Band, Multi Operator Autonomous and Crew-tended Modes

Future Capabilities

Amateur TV
(Standard, Spread spectrum, & MPEG)



R/T Internet TLM using amateur radio



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

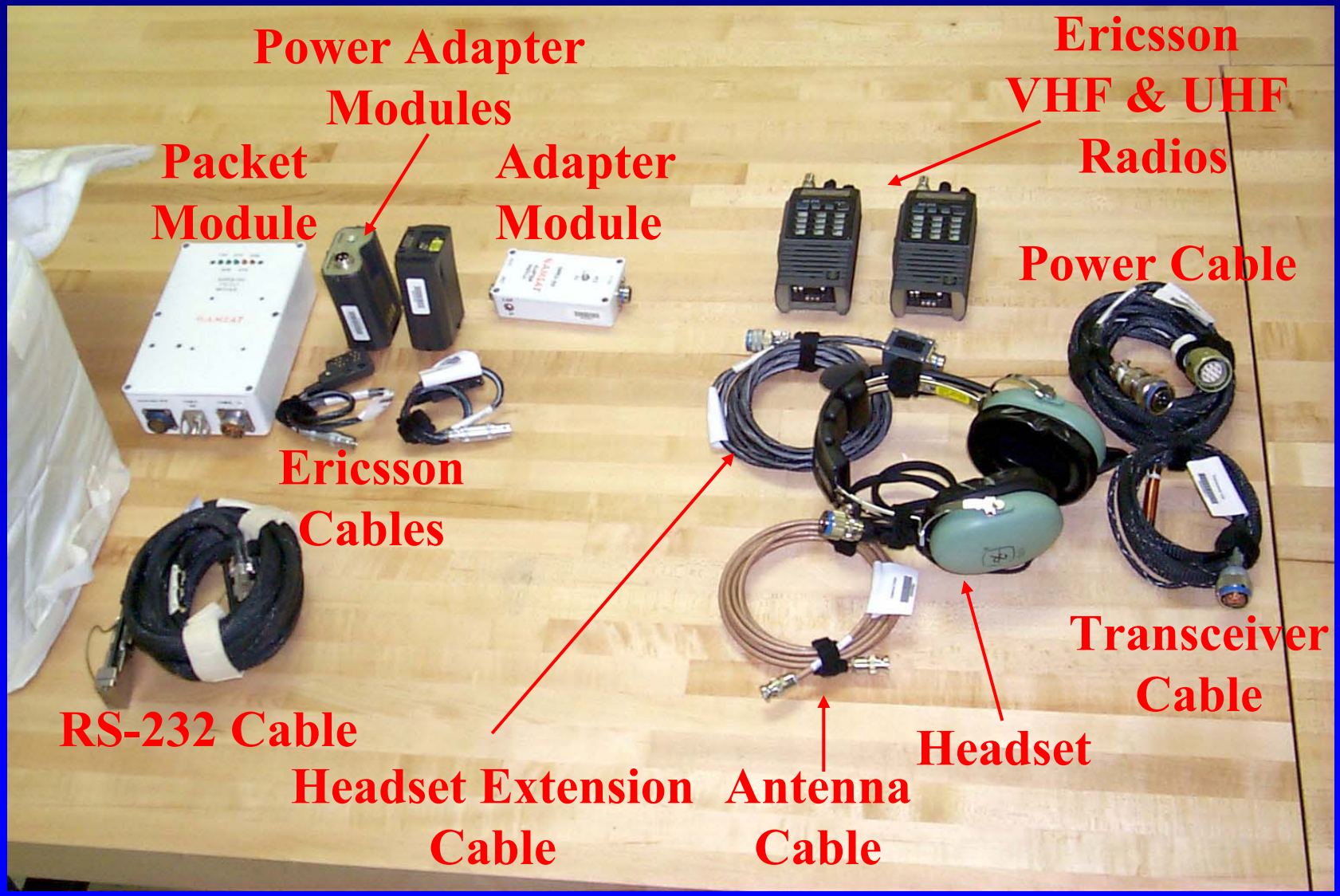
Initial Amateur Station Part 1

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'l 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

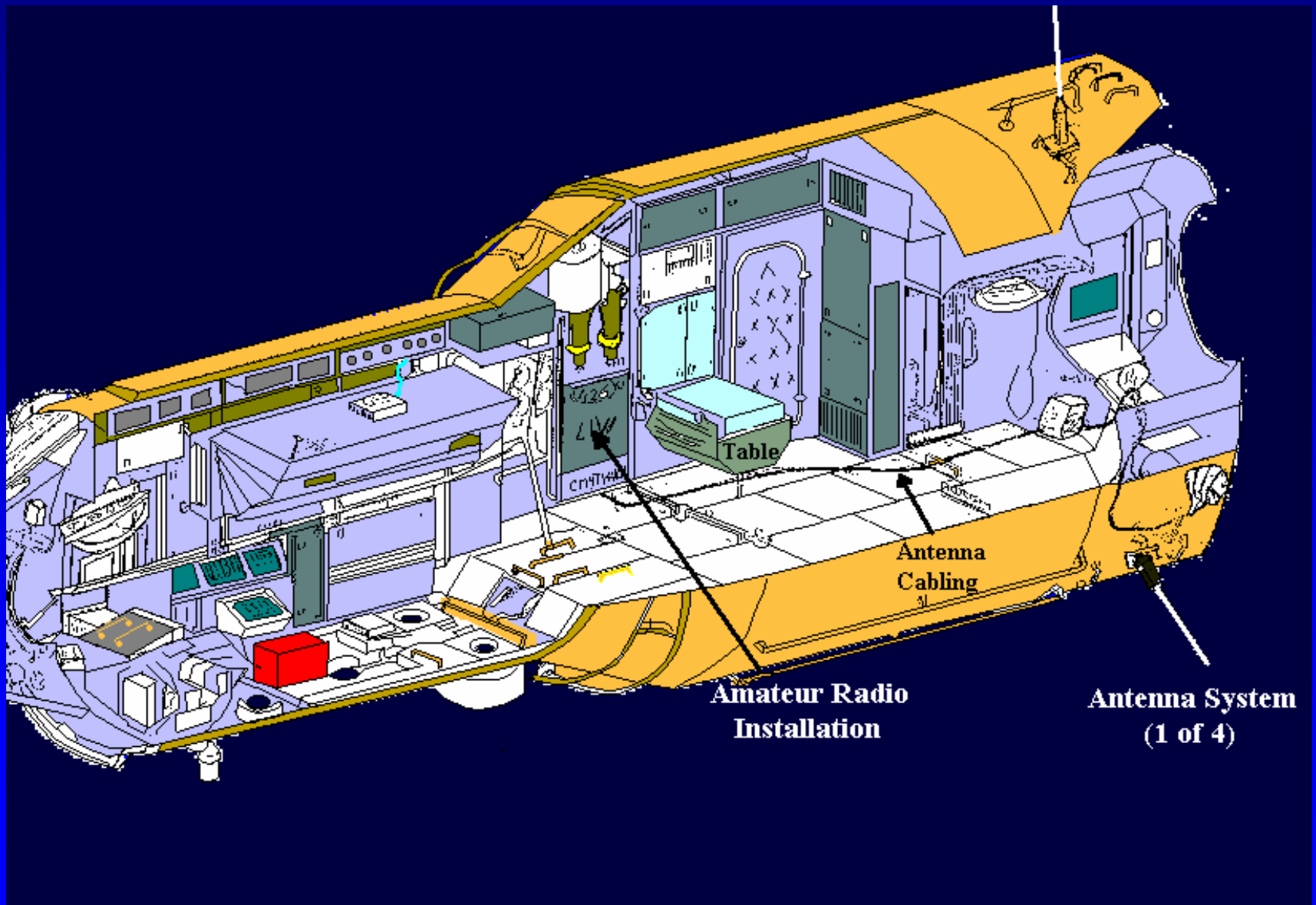
Packet Module Bench Review

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

Ham Station Location: Service Module and FGB

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

ARISS / ISS HAM
Location in and on the Service Module

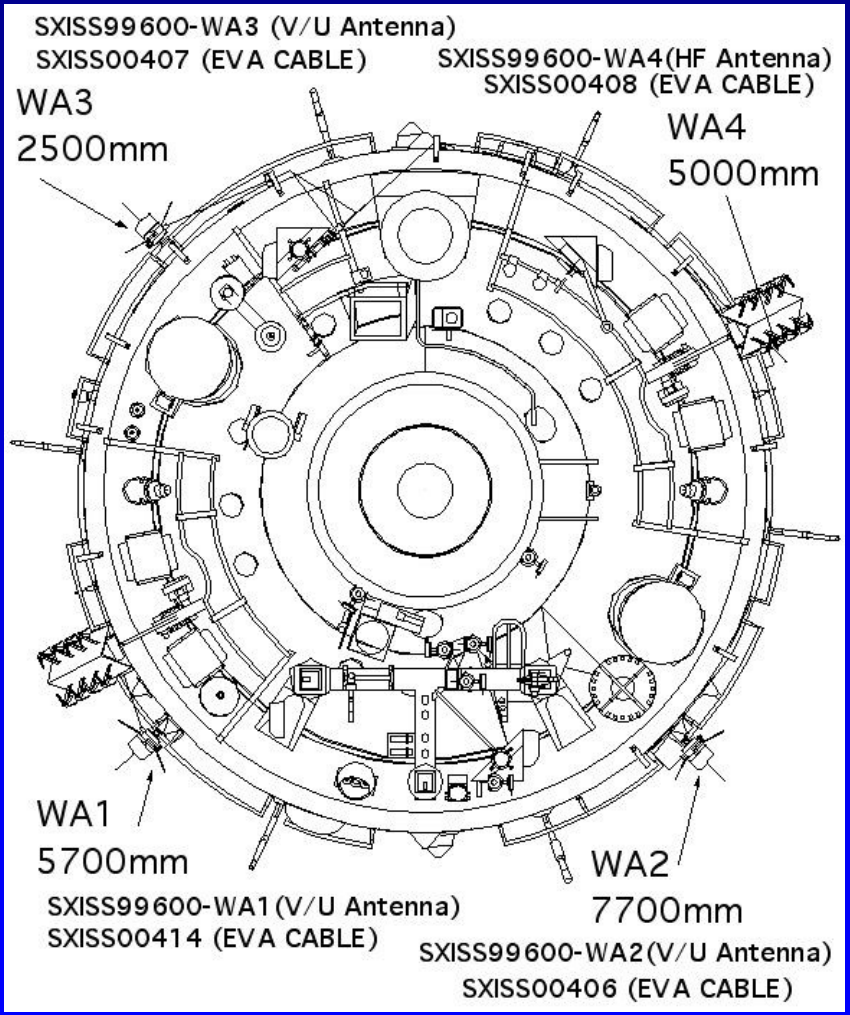


ARISS Hardware Location in Service Module

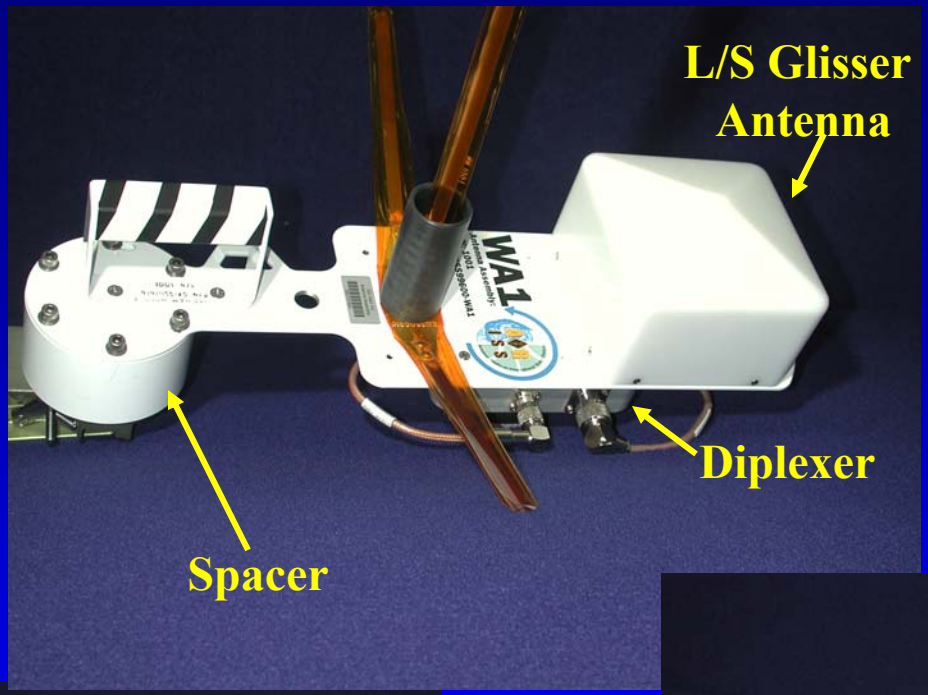
ARISS Team Members Sergej Samburov (Russia), Frank Bauer (US) & Alberto Zagni (Italy) (L to R) in front of ARISS Hardware Installation Area

Service Module Closeout Photos
Radio Station Location

Antenna System Installation on Service Module



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

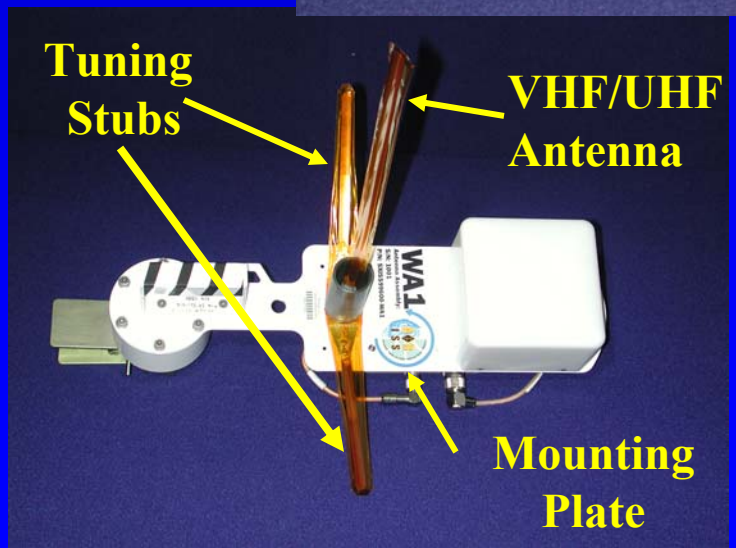


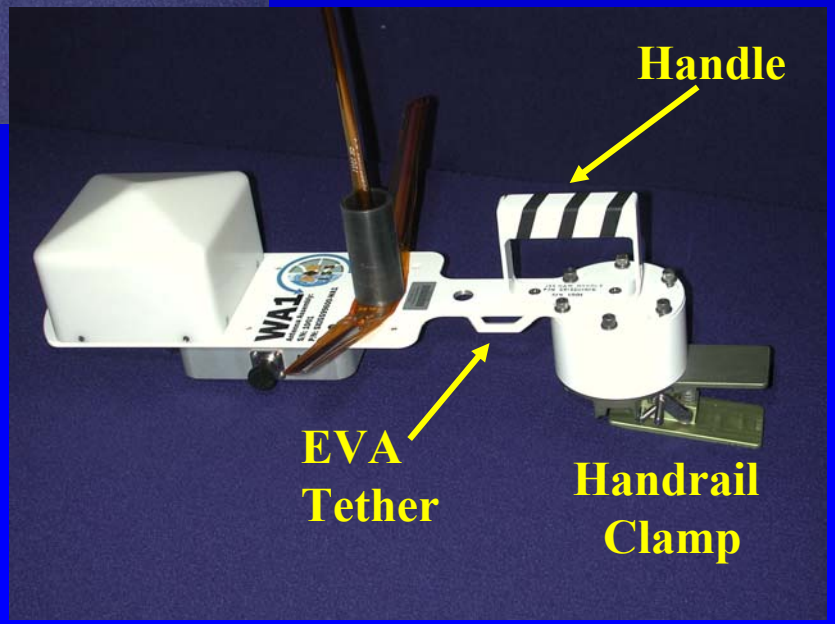
Internationally Developed

Italian Contribution:
- Microwave Antennas
- Diplexer

US Contribution:
- Mounting Plate
- Handle & Spacer
- VHF/UHF & HF Antennas

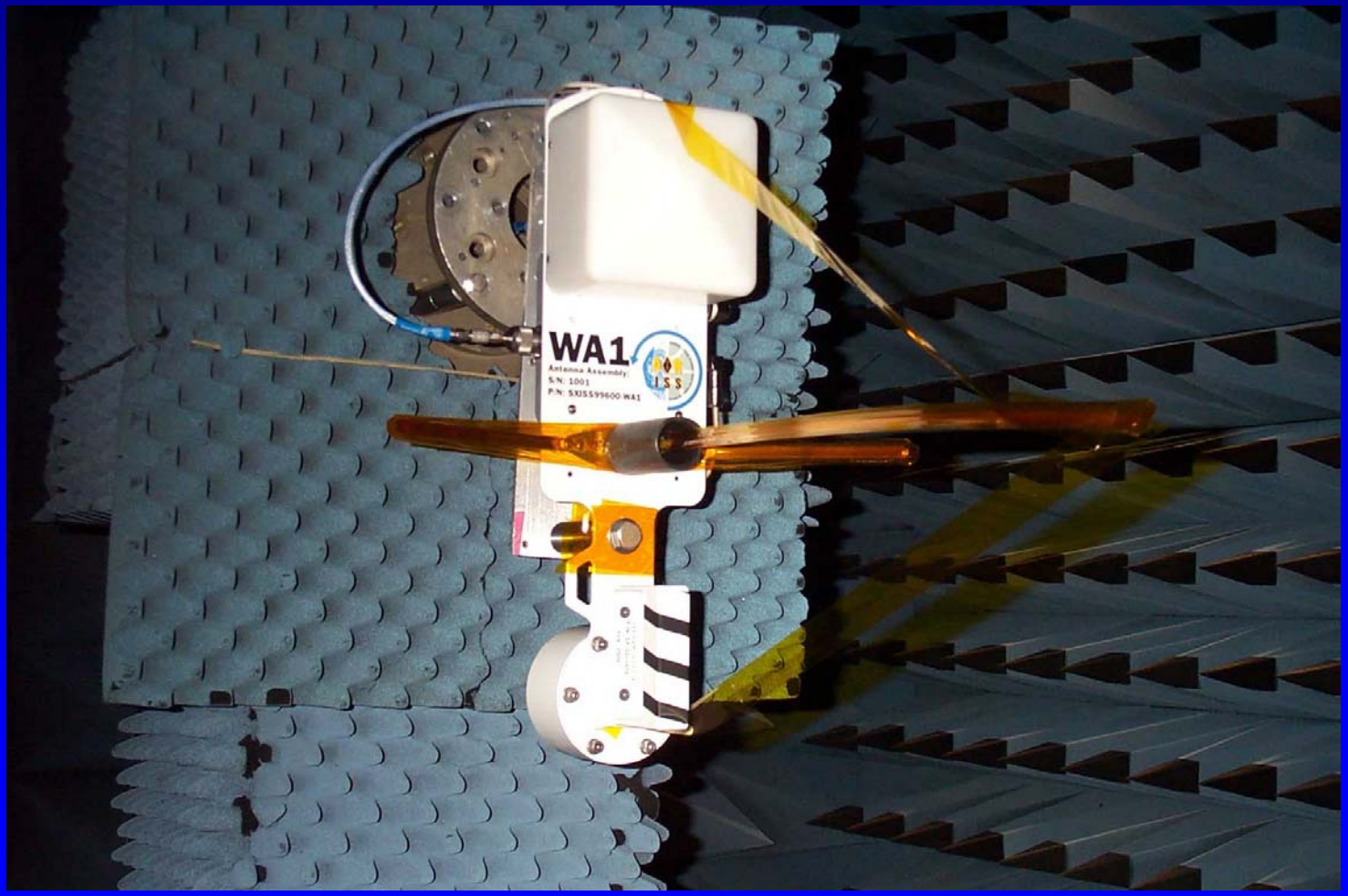
Russian Contribution:
- Handrail Clamp
- Interconnecting Cables





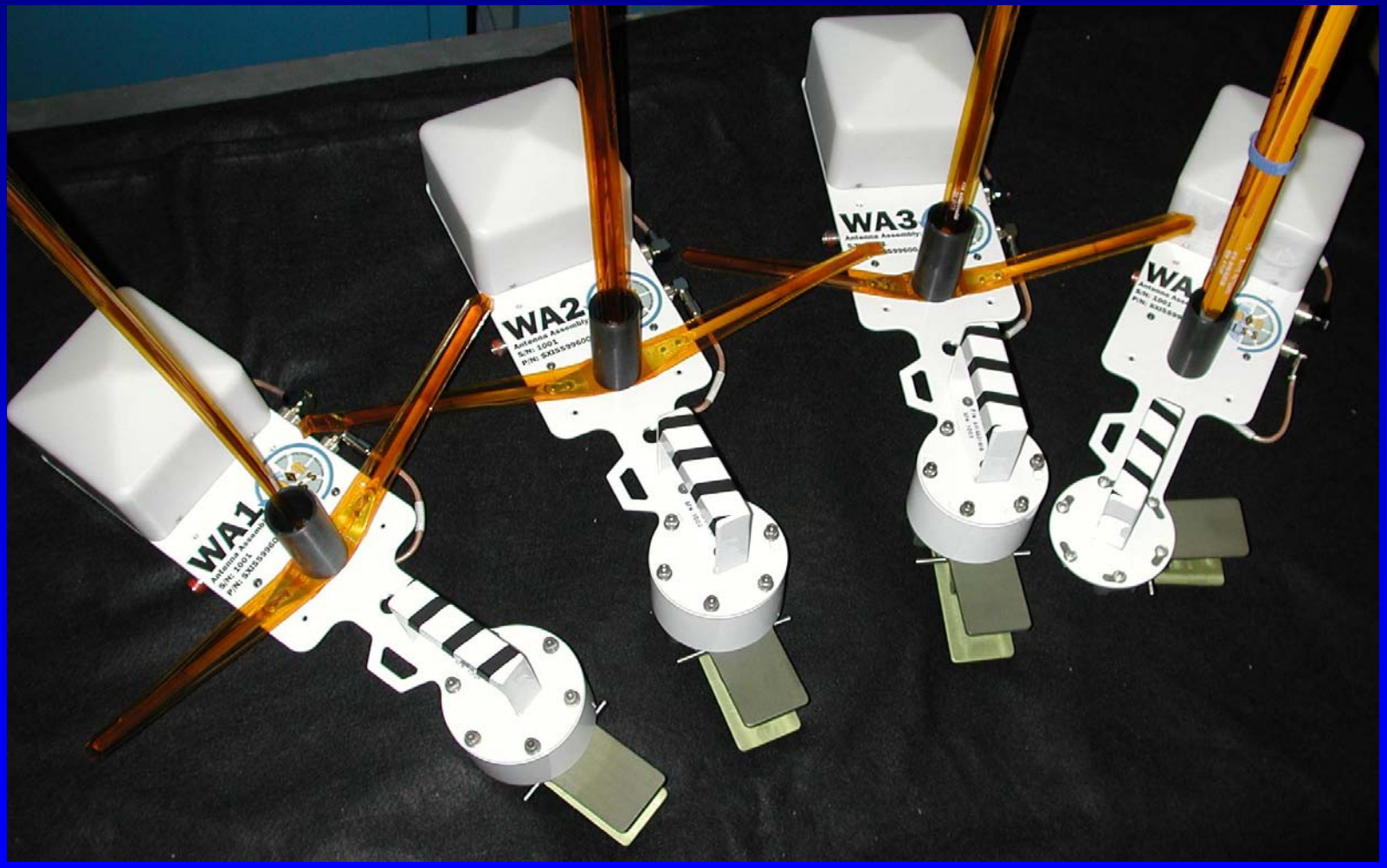
Antenna System Testing

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



Antenna Testing at GSFC

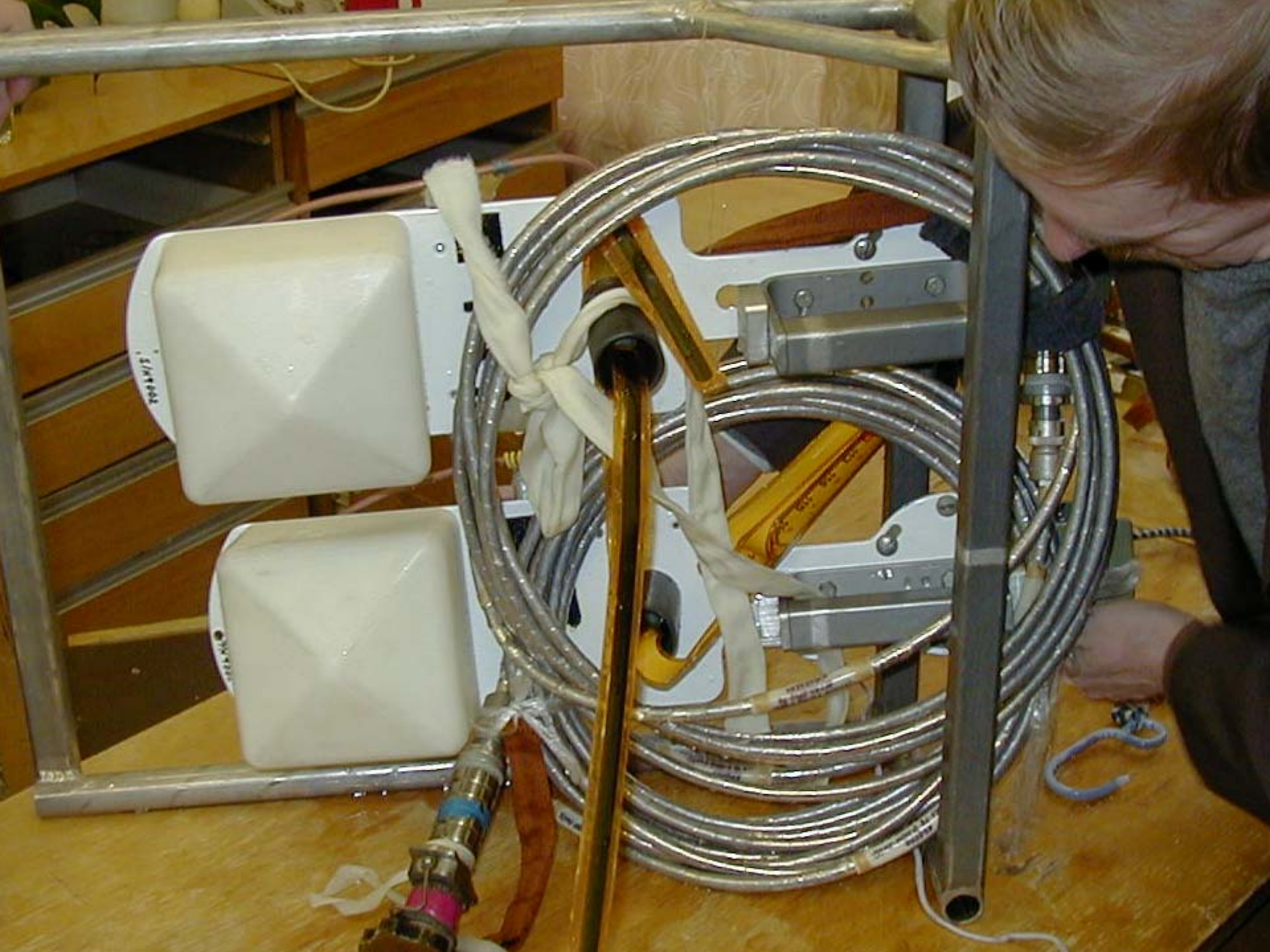
Antenna Systems WA1-WA4

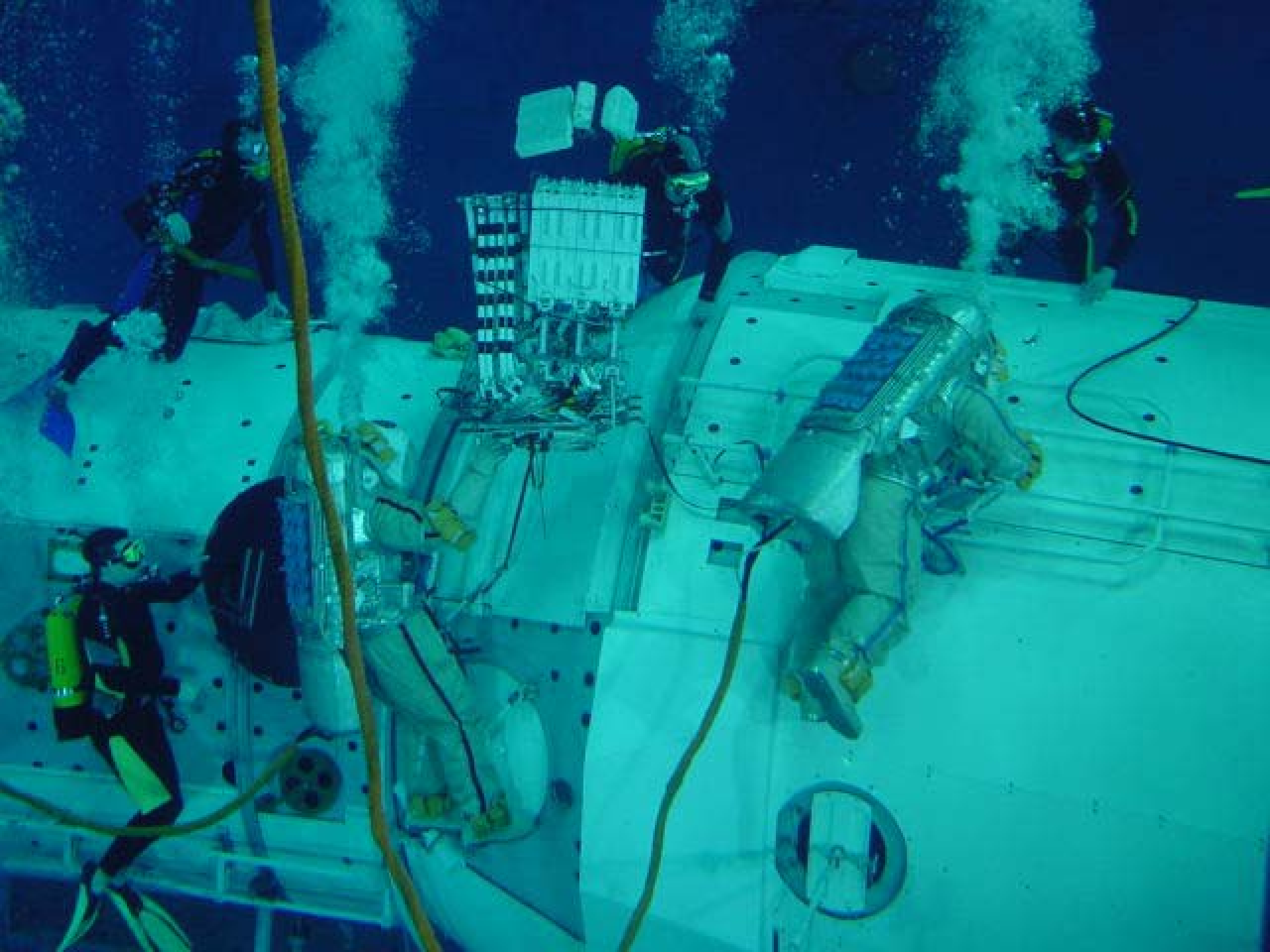


EVA Operations

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



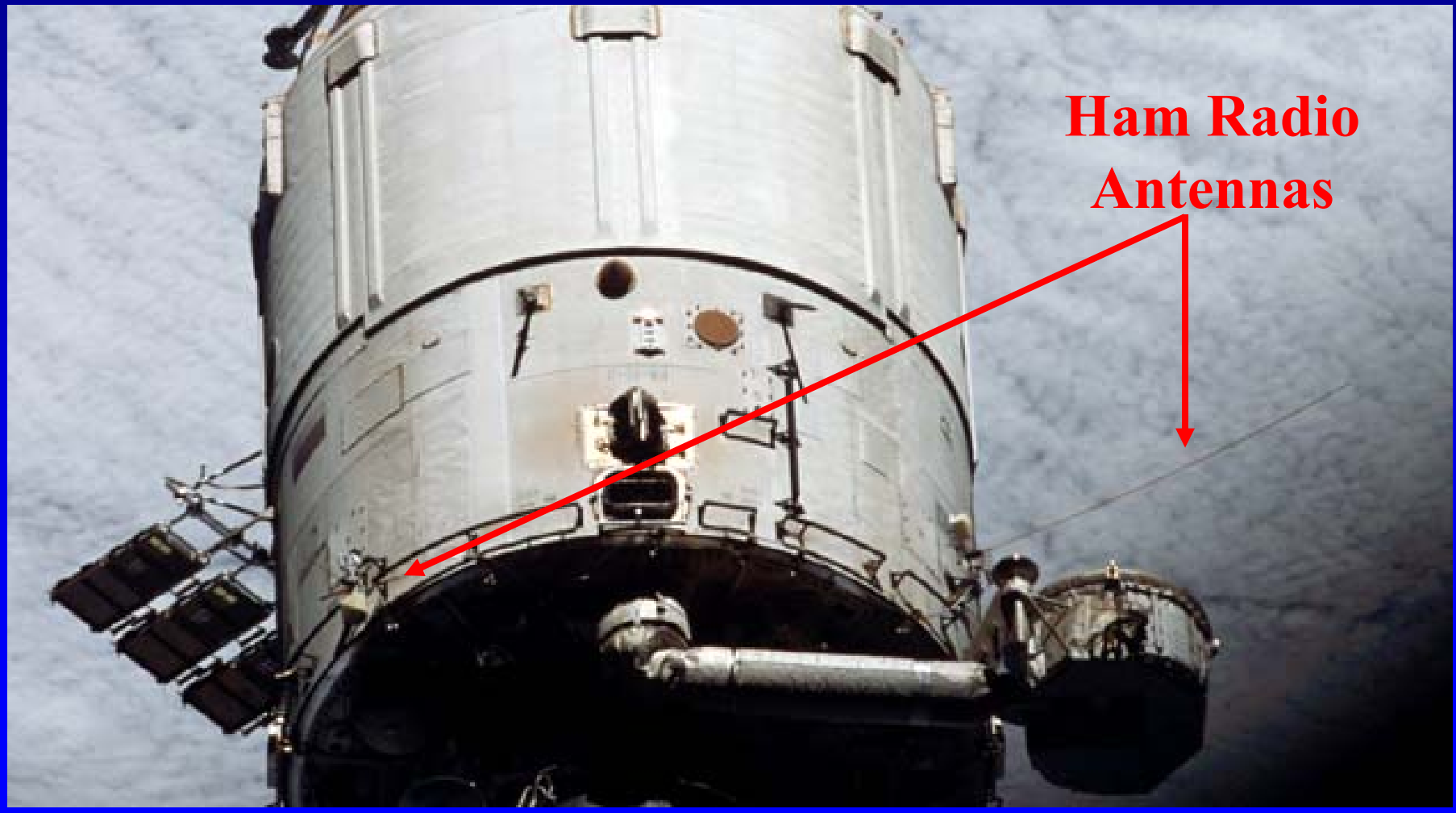


Antenna Installation EVA Activity

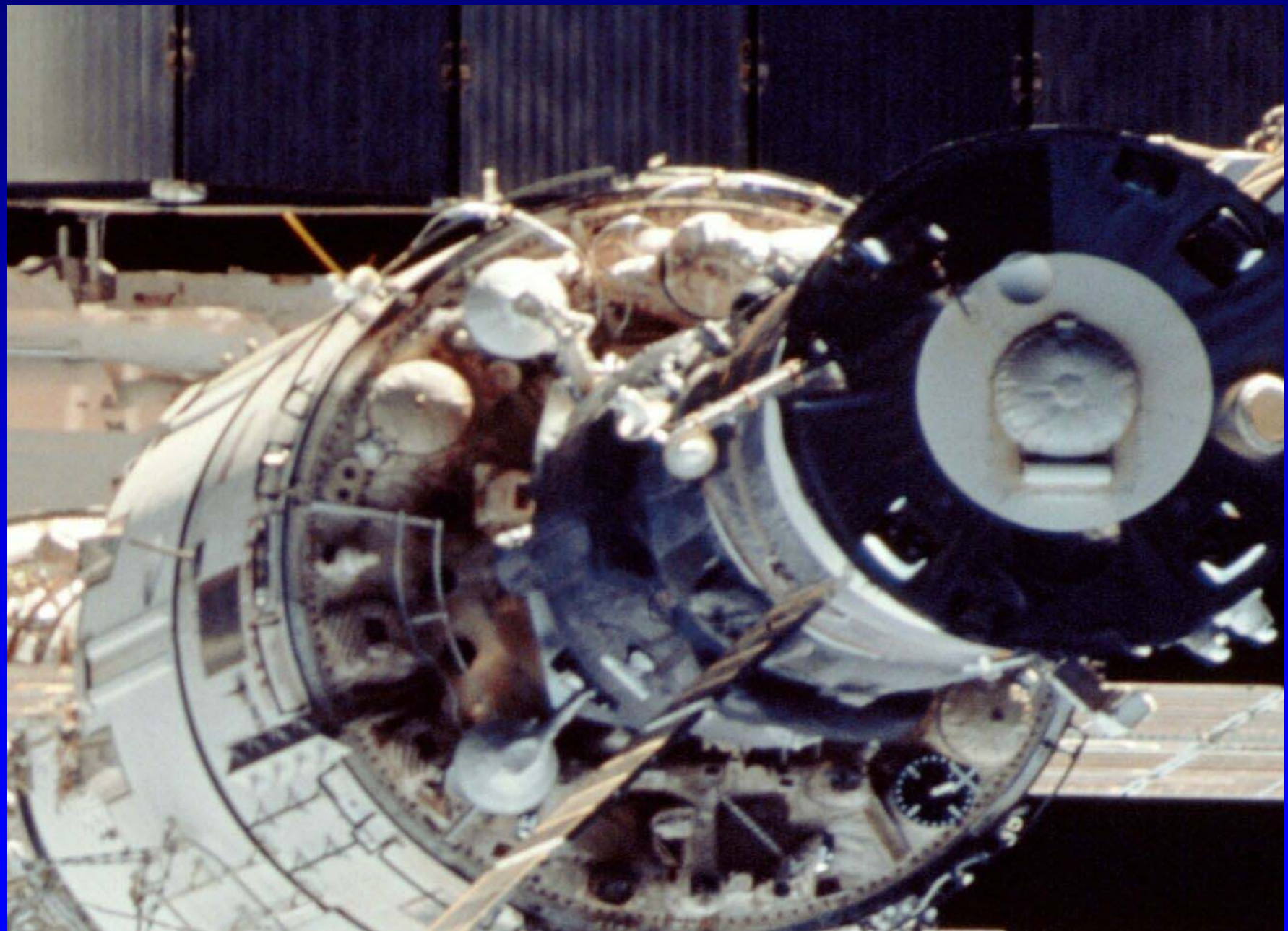
- Progress 6P flight, November 2001
  - Delivered EVA cable clips and velcro straps
- STS-108 (UF-1) December 2001
  - Delivered 4 antenna systems to ISS
  - Delivered additional Phase 1 hardware to support 2 radio (VHF/UHF) ops
- Expedition 4 & 5 crews install 4 antennas during Extra Vehicular Activities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

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) 2005
  - Deliver MISSE-5/PCSAT2 External Payload

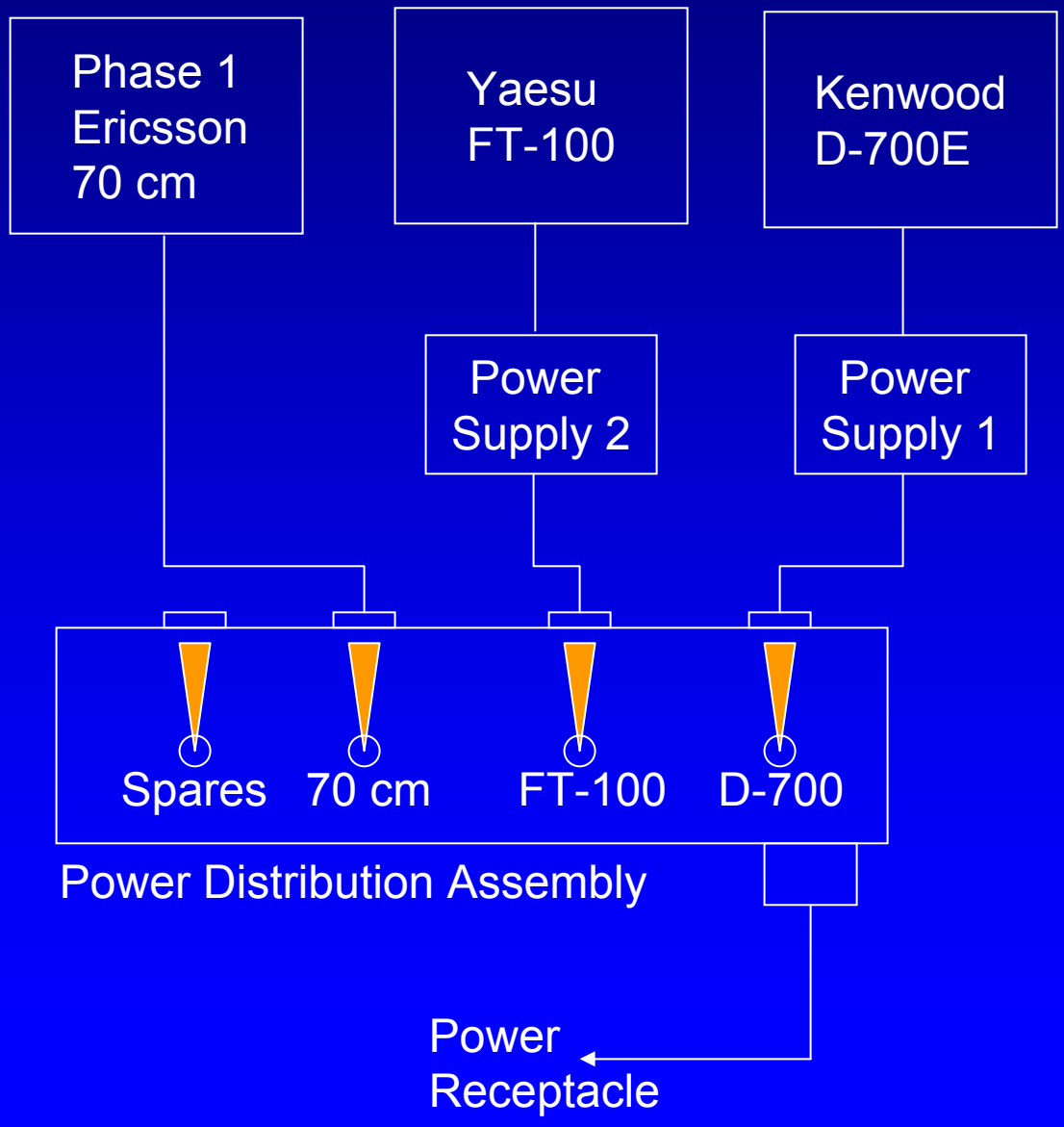
Progress 12P w/ ISS Ham Hardware Prepares to Dock with ISS

Transitioning to Joint Operations in FGB and Service Module

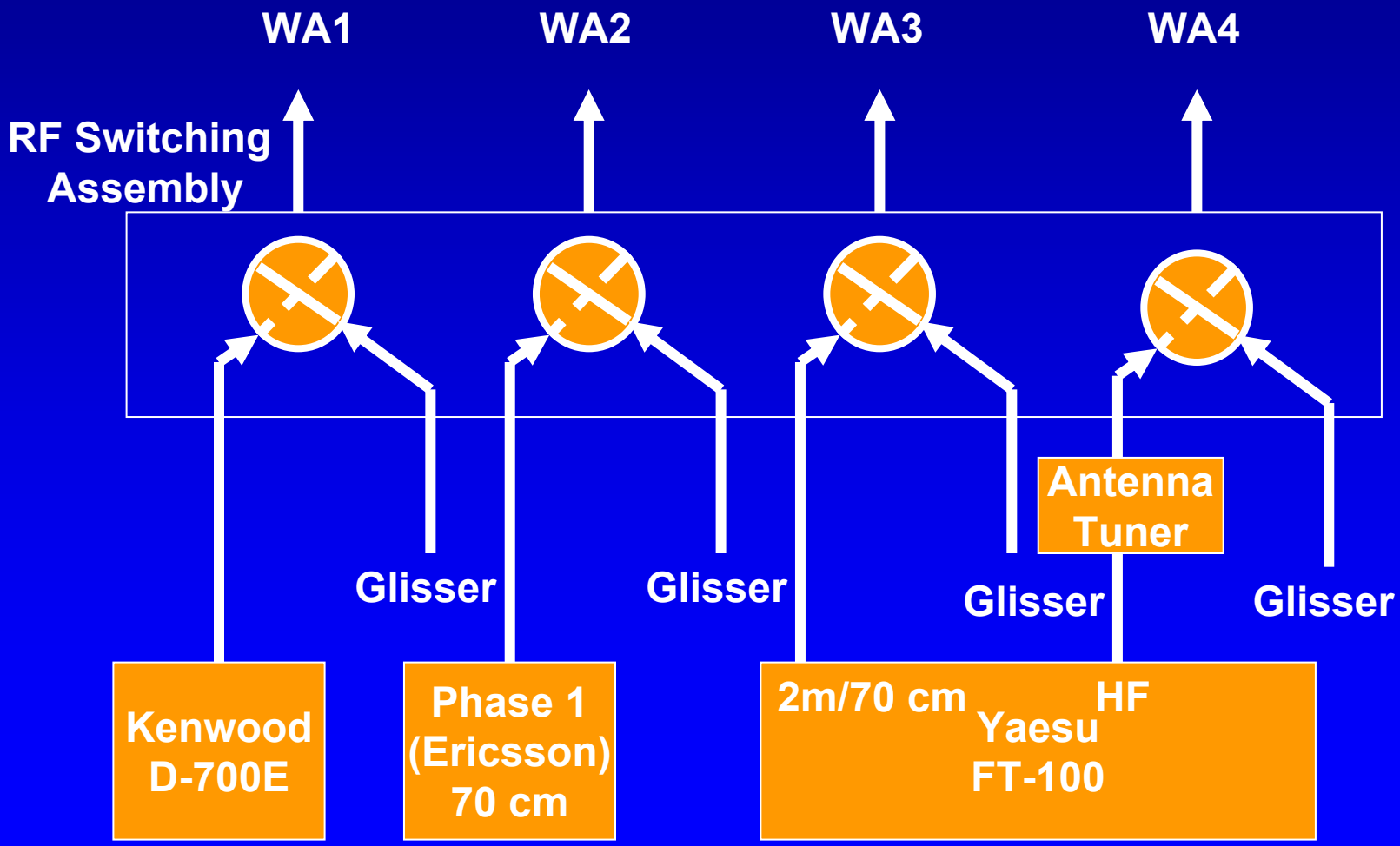
International Technical Interchange Meeting
June 23-July 1 2003
Houston, Texas

Finalization of Kenwood D-700 and SSTV Designs

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

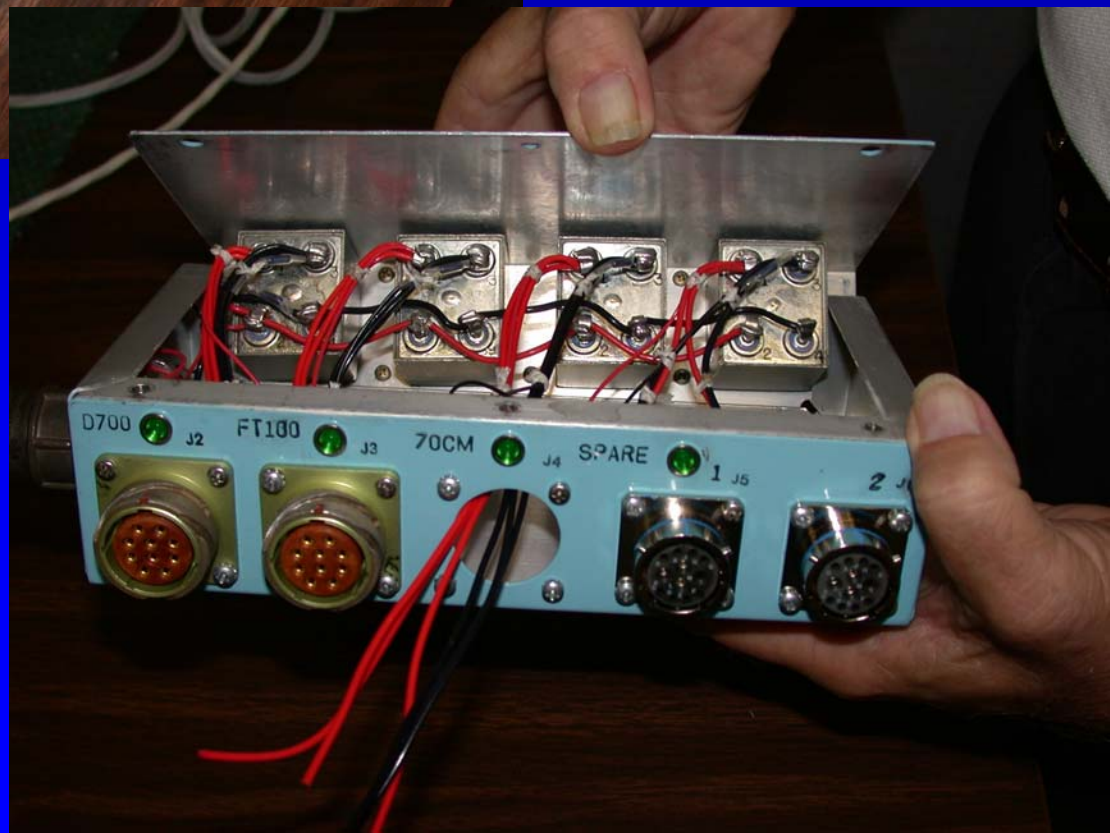


Service Module Antenna Utilization (Phase 1 70 cm and Phase 2)



On-Orbit Layout of ISS Ham Equipment in Service Module

Power Distribution Assembly

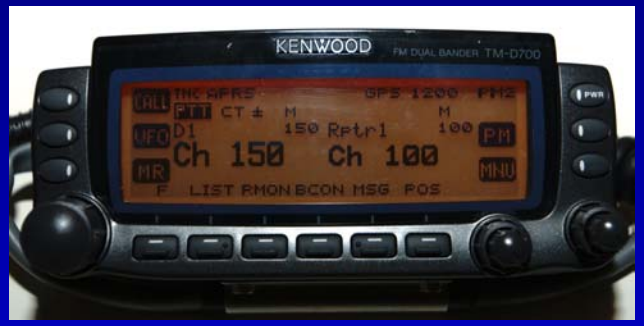


Kenwood D-700E
User Interface

- 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



PM2 Crossband Repeater

PM 3 APRS

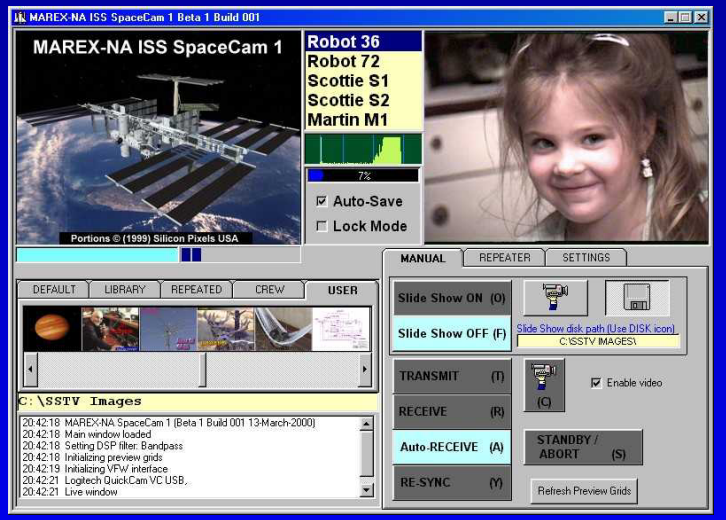
PM 4 Packet

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

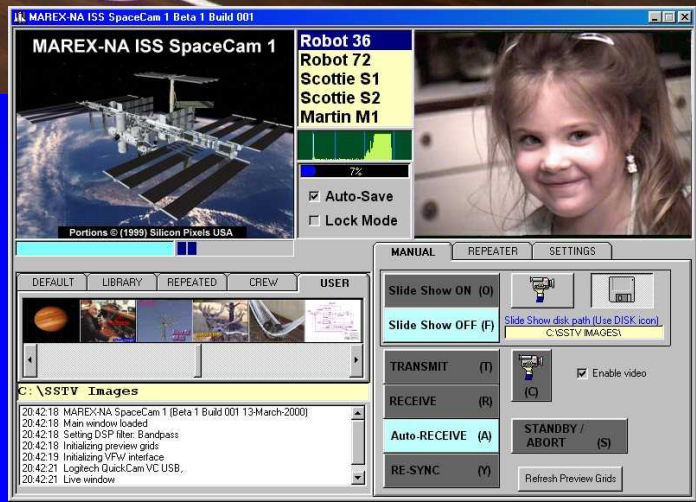
MISSE-5/PCSAT2

System Testing of SSTV Hardware & Software

Phase 1/SSTV System Testing

SSTV Interface Hardware

SSTV Spacecam 1 Software



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

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

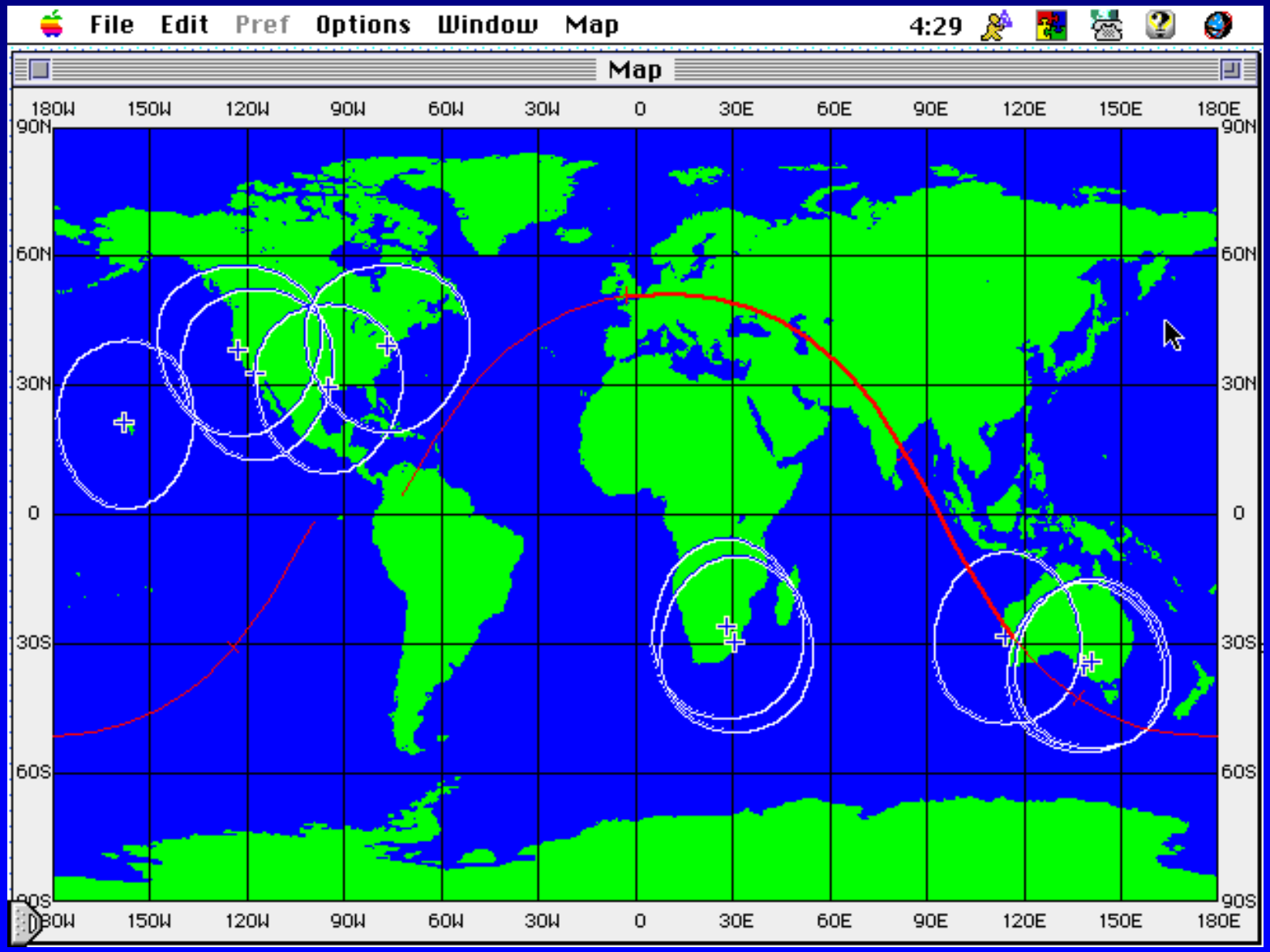
Sergej Samburov, Alexander (Sasha) Kaleri & Mike Foale

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

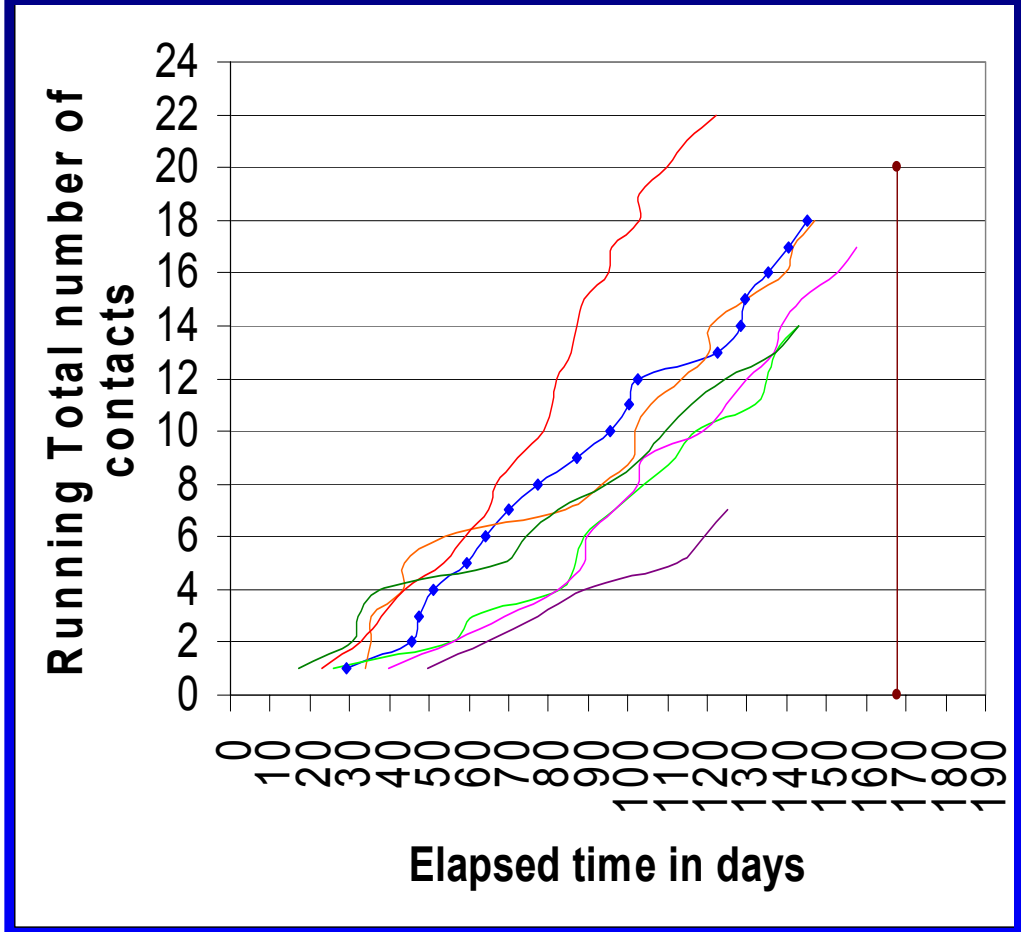
Telebridge Network



Kagawa, Japan ARISS Contact

School Statistics

Crew Expedition	School Contacts
1	7
2	14
3	22
4	17
5	14
6	18
7	18
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

Susan Helms – 1st Field Day on the ISS

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; mostly completed

Challenges (continued)

- Operations Challenges
  - "Volunteer time" has resulted in significant challenges in maintaining on-board 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
- Crew Availability
- Increasing press coverage & public recognition

QSL Card


RSØISS
NA1SS
A R
ISS
Amateur Radio on International Space Station

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 be a reality on ISS

Frank Culbertson During Scout Jamboree on the Air

ARISS Information

http://www.rac.ca/ariss

http://spaceflight.nasa.gov/station/reference/radio/index.html

Thank You AMSAT!

This Presentation is Dedicated to the Memory of Kalpana Chawla, KD5ESI

KC was an astronaut liaison to the ARISS programme until called to train for STS-107. Her sense of determination is an inspiration to us all.