The Radio Amateur Satellite Corporation

ARISSat-1 Overview

2012 Space Symposium @ Orlando, FL

October 26, 2012

Background

- Evolved from “SuitSat-2” Program with loss of spacesuit in 2009
- Shipped to NASA-JSC in October 2010
- Shipped by NASA-JSC to Russia in December 2010
- Prepped by RSC-Energia for shipment to ISS
- Flown to ISS in January 2011 on Progress 41P
- Deployed during Russian EVA on 3 AUG 11
- De-Orbited on 4 JAN 11
- NASA requested a report that summarized accomplishments of ARISSat-1 (Report submitted 8 FEB 12)
  - » Focus on educational accomplishments
  - » Student educational outreach the primary focus
  - » “Life Long Learning” benefited as well

Satellite Purpose: Education Outreach

- Student Experiments
  - Three experiment ports
  - Ground station telemetry collection software (PC and Mac versions)
  - ARISSat-1 had one student experiment: Kursk State Technical University
- SSTV Downlink of Images
  - 4 onboard cameras transmitting in SSTV format (Robot-36)
  - Free software for decoding
  - Forward received images to the ARISS SSTV Gallery
- Student Voice Greetings
  - 24 messages in 15 languages
  - “Secret Word” contest

Satellite Purpose: Education Outreach

- Telemetry Downlink
  - Spacecraft condition
  - Student experiment data
  - New protocol (BPSK-1000) capable of reception using a SSB receiver and AMSAT ground station software (PC and Mac)
- Voice Telemetry on FM Downlink
  - No need for PC/software
  - Listen to “spoken” parameters
- Orbital Analysis
  - “Chicken Little Contest” to predict when satellite would de-orbit
  - Contest for students and individuals

Satellite Purpose: Technology Demonstrator

- Communications Technology Platform: Testbed for SDX
  - 4 different carrier frequencies transmitted simultaneously
  - Different transmission modes (CW, FM, Digital Data, Transponder)
  - First amateur radio satellite to have both its receiver and transmitter ("transponder") operate as software defined units
- Power Management Technology Platform: MPPT
  - Maximum Power Point Trackers are dc-to-dc power converters
  - Designed to maximize power provided by solar panels (19 watts of power from each panel) independently of ground control'
  - Each solar panel had a MPPT attached to it
- Use of commercial off-the-shelf video cameras provided SSTV imagery

Satellite Purpose: Technology Demonstrator

- Demonstration of a new Data Communications Protocol
  - BPSK-1000 protocol developed by Phil Karn, KA9Q
  - Designed to allow a significant amount of data (satellite telemetry and student experiment data) despite signal nulls and fading
  - Significant performance improvement over earlier protocols
- Amateur Radio Transponder
  - 70CM uplink/Two meter downlink w/16 KHz wide bandwidth
  - Four independent sets of conversations at one time
- CW (“Morse Code”) Reception
  - Transmission of amateur radio callsigns of key individuals who made contributions to amateur radio in space
  - Focus on “trying CW”
  - Served as “relative tuning indicator” as well as to indicate which telemetry downlink was in operation (BPSK-1000 vs. BPSK-400)

Satellite Purpose: Commemoration

- 50th Anniversary Commemoration of Yuri Gagarin's Flight
  - First manned flight to orbit the earth in April 1961
  - RSC-Energia renamed satellite from RadioSkaf-V to Kedr (Gagarin's callsign)
  - Satellite was activated in low power mode in April 2011 onboard ISS
    - Powered by satellite's Orlan battery
    - Uplink/Downlink connections to ISS antennas
  - Transmissions not heard on the ground
    - Antenna connections?
    - Battery condition?
  - Deferral of satellite deployment from February to August 2011 to ensure ARISSat1-1/Kedr was available for April 2011 commemoration

Ground-Based Activities

- ARISSat-1 Website
  - Developed solely to support the ARISSat-1 Mission
  - News items about the mission
  - Display of latest received telemetry values
  - Links for downloading ground station software
  - FAQs about satellite hardware
  - Highlight various contests
- Ground station software (satellite telemetry/experiment data)
  - Utilized new BPSK-1000 protocol
  - Decode CW transmissions
  - Windows (KA2UPW/5) and Mac (N3RZN) versions
  - “ARISSatTLM Software Quick Start Guide”

Ground-Based Activities

- Server site to receive telemetry and payload data
  - Ground station software provided option to forward data to a centralized server (arissattlm.org)
  - Central site forwarded latest received values to arissat1.org website
  - Mobile device displays latest values as well
    - Allows individuals to monitor latest condition of the satellite
    - Students could monitor data without access to amateur radio equipment to receive signals
- Management of reception certificate requests
  - Voice Telemetry Reception Certificae
    - 232 Canadian and US requests
    - 125 requests from other countries
  - Greeting/Secret Word Contest
    - Given individuals who e-mail secret password
    - 334 US/Canadian participants plus 423 from overseas

Ground-Based Activities

- Management of reception certificate requests
  - "Chicken Little" Contest (deadline 15 OCT 11)
    - Predict date/time of de-orbit
    - Various categories (Middle School, High School plus adult categories)
      - 53 submissions from 13 countries and 6 continents
  - CW Contest
    - Minimum of six properly identified callsigns
    - Recognition Certificate
    - 19 entries received
  - SSTV Image Reception
    - FM downlink (145.950 MHz) with PC software
    - 138 US and Canadian certificates were received
    - 198 received from other countries
- Total certificates issued as of 7 JAN 12: 1,450

Ground-Based Activities

- Participation impacted by spacecraft limitations (sunlight only)
  - » Unclear what impact would have been if available at night (e.g. no battery failure)
- A total of 3,592 SSTV images submitted to archive
  - » First images uploaded only hours after operational status
  - » Last image uploaded was about 12 hours prior to de-orbit
  - » 153 days of operation=23.5 images uploaded to Gallery daily
- Non-AMSAT Media Outlets
  - » NASA-TV broadcasts deployment live
  - » "NASA Express" message released on 4 AUG announces deployment
    - – 18,516 Express Subscribers
    - – 1,285,892 NASA Twitter Account Subscribers
  - » AA4KN's article in February 2011 QST (156,000 subscribers)
  - » KB1SF articles in February 2012 Monitoring Times

ARISSat-1 Media Impact

- Non-AMSAT Media Outlets (Cont'd)
  - Terry Douds, N8KI column in World Radio
  - AA2TX writes article on SDX, published in November 2011 CQ Magazine
  - ARRL Special Bulletin released on 4 AUG 11 and ARRL Letter 11 AUG 11
- AMSAT Media Outlets
  - AMSAT News Service Bulletins (ANS) with world-wide audience
  - ANS Bulletins read on Nets
  - AMSAT Journal
    - Technical details on ARISSat-1
  - AMSAT-bb—Public mailing list
  - "Proceedings of the AMSAT Space Symposium"
    - 100 attendees each year

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- Non-Amateur Radio Outlets
  - PR effort led by Dave Jordan, AA4KN and Keith Baker, KB1SF
  - List of over 100 key news organizations (newspapers, TV, radio)
  - List of key NASA education personnel and foreign AMSAT organizations to receive AMSAT news releases
  - AMSAT News Releases forwarded on 3 AUG, 7 OCT, and 5 JAN 12

ARISSat-1 Media Impact

- You Tube Videos on ARISSat-1
  - » Bob Allison, WB1GCM interview of Gould Smith, WA4SXM
  - » Steve Bible, N7HPR interview on “Ham Nation”
  - » Over 320 “You Tube” Entries pertaining to satellite reception
  - » Overall degree of interest on You Tube and Vimeo is compelling
  - » Assuming 100 hits per item, a total of 320,000 “hits” generated
- On-Line Blogs
  - » Steve Bible’s series, “Chips n Space-Building an Amateur Radio Satellite” with 10 articles in EE Times
- Search of the term “ARISSat” on Google produced over 625,000 hits

Data Collection- A Technical Achievement

- World-wide interest in collecting/forwarding data to the central server
  - Total ground stations participated: 295
  - Total telemetry frames: 139,959
  - Total Kursk frames: 125,513
  - Grand total of all telemetry frames received: 266,472
- Success is significant despite loss of operation in darkness
- Last frame received in Japan less than one hour prior to de-orbit
- Successful demonstration of data collection may well provide future opportunities
  - Fox-1 Satellite will have telemetry and payload data
  - New ground station software being developed

Education Impact

- Student Involvement-Activities prior to launch
  - Student greetings and “secret words” incorporated into SD Card
  - “Fly a file” campaign involves 123 students internationally
  - Rebecca Jordan recorded the satellite’s voice ID and helped in assembly
  - Another student recorded the voice telemetry files that provided the basis for forwarding telemetry values on FM downlink
  - Total of 149 students involved with providing materials to be incorporated into ARISSat-1

Education Impact

- Anecdotal Student/Teacher Involvement-During the Mission
  - » Lakeland, FL: 800 students from four elementary schools see broadcast on local school TV. About 50 students attempt to hear the satellite
  - » Matt Severin, N8MS is a school principal of Dowagiac Middle School, MI had 17 students involved with data collection
  - » Peter O'Mechair, EI7GK reports 96 students heard his interview by a local radio station about ARISSat-1 that was done in Gaelic
- Documented involvement of students: 1,103

Education Impact

- Steve Bible Survey
  - Results presented at 2011 AMSAT Space Symposium
  - Over 600 survey participants
  - 40% of respondents report involving children with their ARISSat-1 experience
  - Based upon type of student involvement, about 1,440 students/youth were exposed to ARISSat-1
- Overall, this suggests that 2,729 students were “touched” by ARISSat-1
  - Does not include student impacts in Russia and CIS (former Soviet Union)
- In addition, adult “life long learning” also impacted by ARISSat-1

Post-Mission Development

- Initial Focus on providing telemetry data that can be easily accessed
  - » As of 4 FEB 12, all telemetry had been decoded and converted to comma separated variable (CSV) format
  - » Data in the CSV files reflect incorporation of telemetry equations to the raw spacecraft telemetry
- Student Engineering
  - » Penn State University-Erie senior project to develop a “super capacitor” storage device to replace the Orlan Spacesuit Battery in the event of a future ARISSat mission
  - » Prototype completed in May 2012 as part of a “capstone” project

Results

- Prototype of a new class of amateur radio satellites, ARISSat-1 demonstrated:
  - New technology in space (SDX, MPPT, BPSK-1000)
  - Development of dedicated web resources is critical
  - Development of ground station software for telemetry/data collection and forwarding to a central site
  - Incorporating student involvement (flight experiment, developing the spacecraft education outreach tools, and post-mission analysis opportunities)
  - Surprising impact of social media on satellite awareness
  - Significant ground user interest world-wide (certificates issued, contest participation, telemetry collection and forwarding)
    - However, the impact on the “target audience” was not sufficient to satisfy NASA Education expectations

Lessons Learned

- In a partnership, a document that outlines roles and responsibilities/expectations is critical to ensure mutual definitions of success
  - » AMSAT did not fully understand NASA's revised expectations about education outreach
  - » NASA did not take into account the difficulty in adding new expectations in the midst of a project that had major project management challenges
  - » Despite best intentions, AMSAT did not have the "depth of bench" to address NASA revised expectations
- Measuring success is more than whether a satellite's hardware and software worked as intended
  - » Impact on the ground is what drives future opportunities

Lessons Learned

- ARISSat-1 has caused AMSAT to re-examine how amateur radio satellites may be used to support STEM
  - » Appointment of Mark Hammond, N8MH as VP-Educational Outreach
  - » Educational Outreach is critical for justifying future launch opportunities
  - » "Building a satellite" now means more than creating hardware:
    - – AMSAT must either develop appropriate resources or partner with others to fulfill education outreach expectations
    - – Ground station software development to support a payload
    - – Must be able to "engage" the educational institution to get them interested
    - – Develop appropriate materials for teachers to utilize space-based assets
    - – Measure the results in terms of students impacted by the program
      - Inspiration
      - Engagement
    - – Consequently, program activities should be "measureable"

ARISSat-1 Overview

Questions?