The Radio Amateur Satellite Corporation

AMSAT North America
A status Report

Presented by
Richard M. Hambly, W2GPS
AMSAT President

AMSAT-DC Meeting and Space Seminar
www.patkilroy.com/amsat-dc
April 8, 2006

Historical Electronics Museum
1745 West Nursery Road, Linthicum MD 21090
In Pioneer Hall, www.hem-usa.org

AMSAT-NA Presentation

- Introduction to Satellites
- AMSAT-NA Today
- Today's Satellites, especially
  - » AMSAT Oscar-51 ("Echo")
  - » SuitSat
- What's Next?
  - » Phase 3E
  - » Eagle satellites
- AMSAT Needs Your Help!
- 2006 AMSAT Space Symposium

When in doubt see AMSAT's new Web site at

www.amsat.org

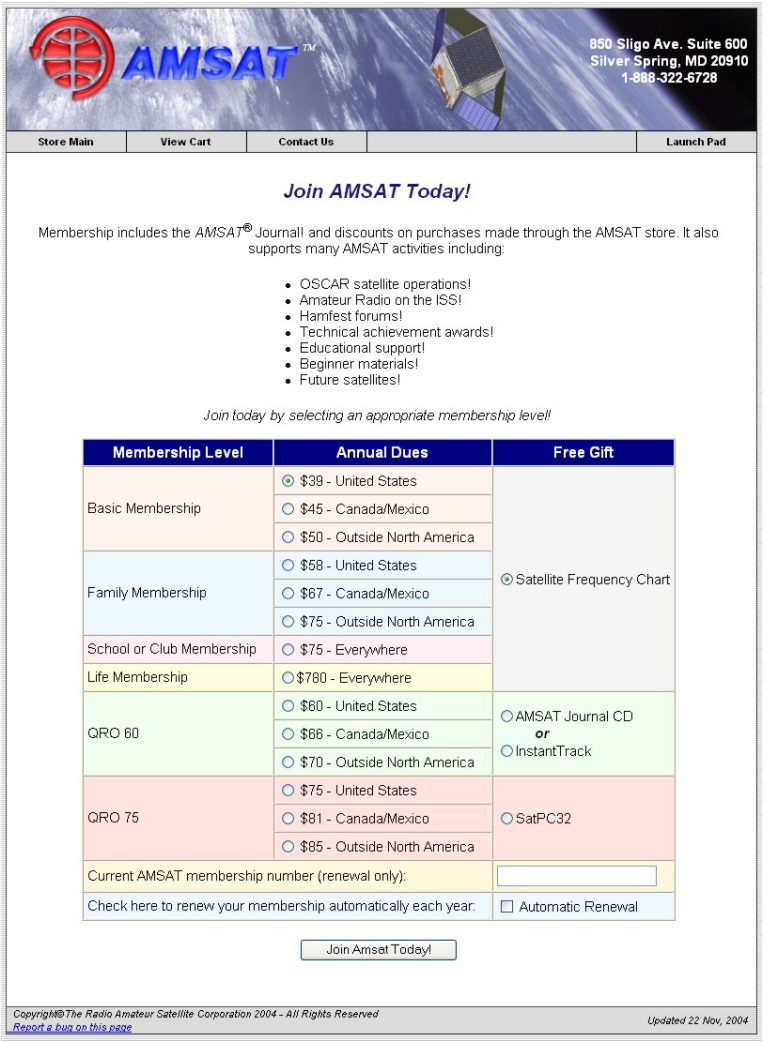
AMSAT's New Web Site
www.amsat.org

Main Web Page

6/04

The AMSAT Store is open!

11/04



What is an Amateur Satellite?

Excerpted with permission from Emily Clarke N1DID (ex W0EEC)

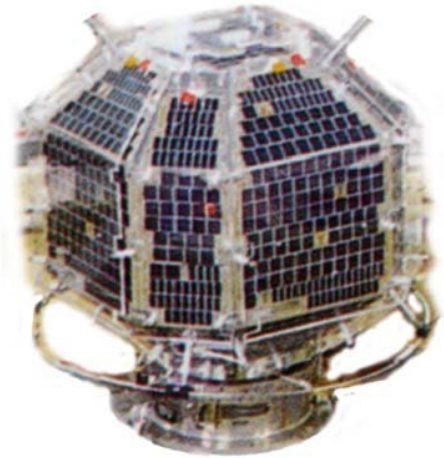
- In the late 1950's, Project OSCAR was formed to put amateur radio equipment in space
- An OSCAR is an Orbiting Satellite Carrying Amateur Radio
- Built for non-commercial purposes
- OSCAR-1 Launched in 1961 carried a beacon
- Project OSCAR also launched OSCAR-III - the first "repeater" in space (in band 2m repeater)
- AMSAT formed in 1969 to take the amateur satellite effort worldwide

Chuck Towns K6LFH in his garage with OSCAR-II

So what should I know about OSCARs?

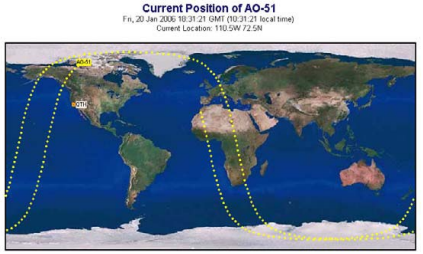
Excerpted with permission from Emily Clarke N1DID (ex W0EEC)

- Amateur satellites are built by volunteers.
- OSCARs are space qualified vehicles and stand up to long duration space flights.
- Builders need support (plug – if you like this presentation please give AMSAT a donation)
- Satellite operations can be frustrating and gratifying. The more you know, the better the experience.
- Most answers are on the AMSAT website and if they aren't, let us know.
- AMSAT works hard to build up "user services." Volunteers called Area Coordinators will help anyone who asks.

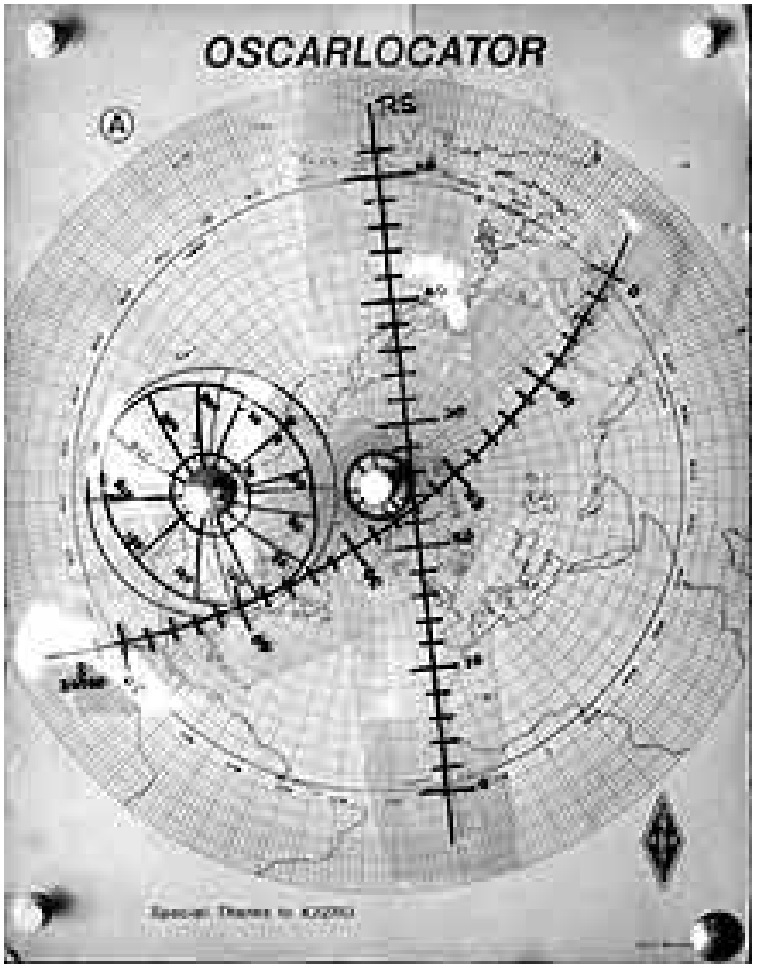


JAS-2 (Fuji-OSCAR 29)

Satellite Tracking



- "In the good old days…" There was the OSCARLocator, a manual tracking system.
- OSCARLocator plotted the satellite location based on equator crossing times.
- By 1978 there was ***Orbit*** and by 1980 ***QuickTrak***, programs written in Basic that ran on several computers.
- Now we have complex graphical programs to track satellites, control rigs, handle Doppler correction and control antenna pointing.



Where do I transmit and receive?

Excerpted with permission from Emily Clarke N1DID (ex W0EEC)

HF Bands	29.300 – 29.500	200 KHz	Primary	Uplink & Downlink
V Band	145.800 – 146.000	200 KHz	Primary	Uplink & Downlink
U Band	435.000 – 438.000	3 MHz	Secondary	Uplink & Downlink
L Band	1260 – 1270	10 MHz	Secondary	
S Band	2400 – 2450 3400 – 3410*	10 MHz 10 MHz	Secondary	Uplink & Downlink Uplink & Downlink
C Band	5650 – 5670 5830 – 5850	20 MHz 20 MHz	Secondary	Uplink Only Downlink Only
X Band	10.45 – 10.5 GHz	50 MHz	Secondary	Uplink & Downlink
K Band	24.0 – 24.05 GHz	50 MHz	Primary	Uplink & Downlink
Q Band	47.0 – 47.2 GHz	200 MHz	Primary	Uplink & Downlink
W Band	75.5 – 76.0 GHz	500 MHz	Primary	Uplink & Downlink

OSCAR Satellite Status Summary
As of 10-May-2005

- **Operational**
- **Semi-Operational**
- **Non-Operational**
- **Future Launch**

OSCAR Satellite Status Summary As of 18 January, 2006

Name	Beacons	HF	VHF	UHF	L-Band	S-Band	C-Band	X-Band	K-Band	APRS	Packet	Comments
AO-51 (Echo)	↑		↑	↑	↑	↑					↑	Check Schedule
XO-53 (SSETI)	↓			↓		↓						Recovery
VO-52(Hamsat)	↑		↑	↑								Operational
PCSat2		↑	↑	↑						↑		Operational
AO-7	↑	↑	↑	↑		↓						See the schedule!
UO-11	→											Nearing EOL
RS-15	→	→	→									Intermittent
AO-16	↑										→	Digipeating
LO-19	↑		↓	↓							↓	CW Beacon Only
AO-27	↑		↑	↑								
FO-29	↑		↑	↑							↓	
GO-32	↑										↑	
SO-41			↓	↓								Not heard
NO-44										→	↓	Low Batteries
MO-46	↓										↓	Reported Dead
SO-50			↑	↑								
ARISS			↑	↑						↑	↑	
RS-22			↑	↑								
P3-E Express	↑		↑	↑	↑	↑	↑	↑	↑			

Amateur Satellites = Amateur Science

OSCAR 5	1970	First use of passive magnetic stabilization
OSCAR 6	1972	Codestore (CW Store and Forward) Message System) First satellite-to-satellite relay of communications (See OSCAR 7).
OSCAR 7	1974	Battery Charge Regulator, Analog Store and Forward of Medical Data, Synthetic High Efficiency Power Amplifier (HELAPS), SARSAT First satellite-to-satellite relay of communications (See OSCAR 6)
OSCAR 11	1984	Imaging, Dust Impact Detectors, Geiger Counters, Digital Communications
OSCAR 14	1990	Packet Radio, 9.6K Data Rate, Imaging, Digital Store and Forwarding
OSCAR 23	1992	Wide and Narrow Imaging, Cosmic Ray detection, radiation dose monitor
OSCAR 24	1993	2.4GHz S-Band Transponder
OSCAR 25	1993	Imaging, IR Sensor Experiment
OSCAR 28	1993	38k4 Digital Link, GPS Experiment, Star Sensor, Cosmic Ray Detection, DSP
OSCAR 34	1998	Direct Sequence Spread Spectrum
OSCAR 36	1999	1 MBISec Digital, Viterbi encoding
OSCAR 38	2000	First Automatic Launcher (6 Picosatellites)
OSCAR 39	2000	Space Plasma Experiment
OSCAR 40	2000	NASA GPS experiment
OSCAR 43	2001	Solar Cell and Mirror Experiment
OSCAR 45	2001	Tunneling Horizon Detector (JPUStanford), Digital Camera
OSCAR 51	2004	Simultaneous Voice and High Speed Data
OSCAR 53	2005	Cold Gas Attitude thrusters, High Resolution Color Imaging, Cubesat Launcher

Emergency Communications

- Existing AMSAT satellites are less than practical for large scale disasters:
  - » Weak signals from HEO satellites
  - » Short duration of a LEO pass
  - » Operation: Antenna steering, Doppler correction, etc.
- AMSAT successes: See http://spaceflight.nasa.gov/station/reference/radio/amsat.html
  - » OSCAR satellites have also been used to transmit medical data.
  - » Were employed in early tests of the concept that led to the joint US/Soviet Search And Rescue Satellite, or SARSat, system.
  - » Amateur satellites have also proven useful in a variety of emergencies from hurricanes to earthquakes.
- AMSAT/ARISS
  - » Ham Radio was one of the first communications sources for the Mir crew when the Progress collision occurred.
  - » Provided backup comm on the Shuttle during unplanned TDRS outages.
  - » NASA considers us to be an emergency backup on ISS....specifically because of what happened on Mir.

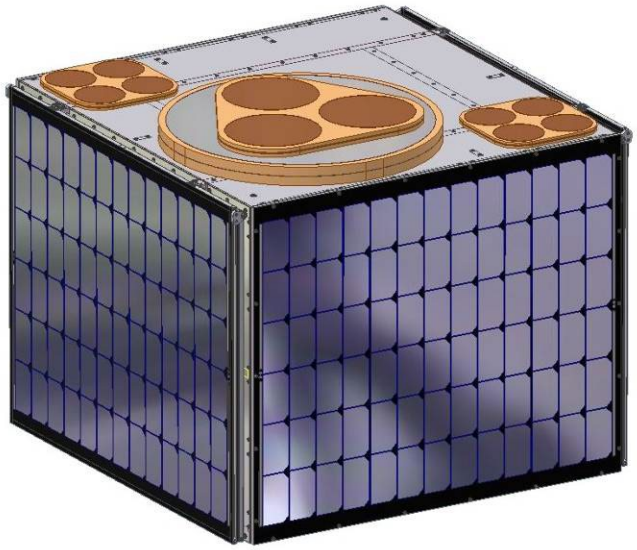
The "New" AMSAT

- Strategic Planning
  - » Begun February 2004
    - – Discovery process, the "State Of The World"
    - – Decision stage, "AMSAT in 45 Seconds"
    - – Ten Stakeholder Questions
  - » Results → Mission and Vision statements
  - » Biweekly teleconferences
- Tactical Planning
  - » It is the responsibility of AMSAT's officers to implement the Board's strategic planning directives.
  - » In October 2004 we changed AMSAT's executive organization
  - » Fewer Officers and a new emphasis on teamwork and cooperation.

- Who are you?
- What do you do?
- Who will care?
- Why will they care?
- How many will care?
- How do you get to those who do?
- How will you "make" money?
- How are you unique and how will you defend your space?
- Do you have the team to pull it off?
- How much money do you need and where does it take you?

AMSAT's Strategic Plan
Mission Statement

AMSAT is a non-profit volunteer organization which designs, builds and operates experimental satellites and promotes space education. We work in partnership with government, industry, educational institutions and fellow amateur radio societies. We encourage technical and scientific innovation, and promote the training and development of skilled satellite and ground system designers and operators.



AMSAT's Strategic Plan
Vision Statement

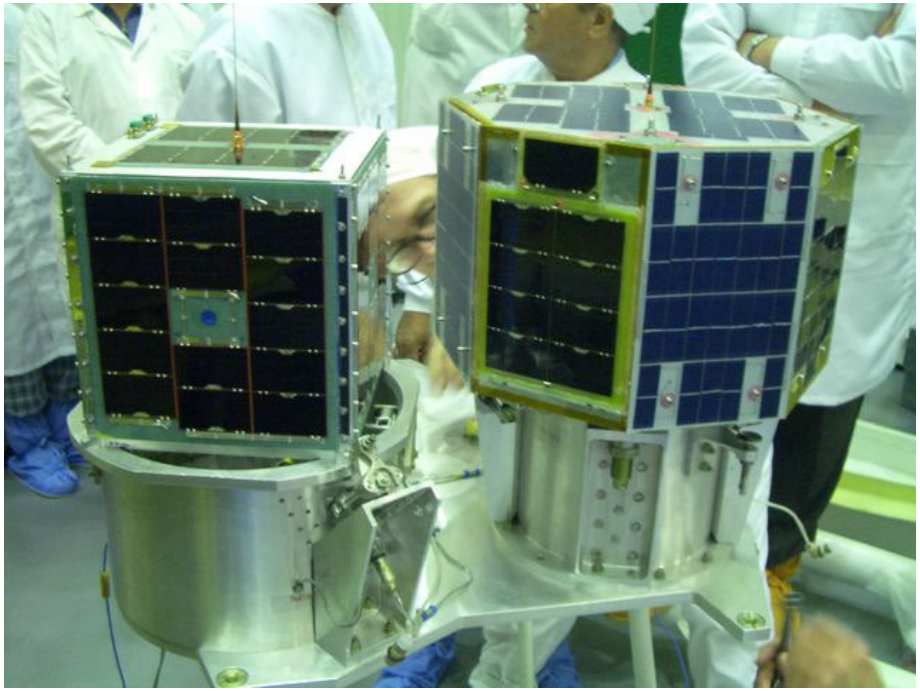
Our Vision is to deploy high earth orbit satellite systems that offer daily coverage by 2009 and continuous coverage by 2012.

AMSAT will continue active participation in human space missions and support a stream of LEO satellites developed in cooperation with the educational community and other amateur satellite groups.

Tom Clark W3IWI, Gerald Youngblood AC5OG and Bruce Paige KK5DO working on AMSAT's Strategic Plan.

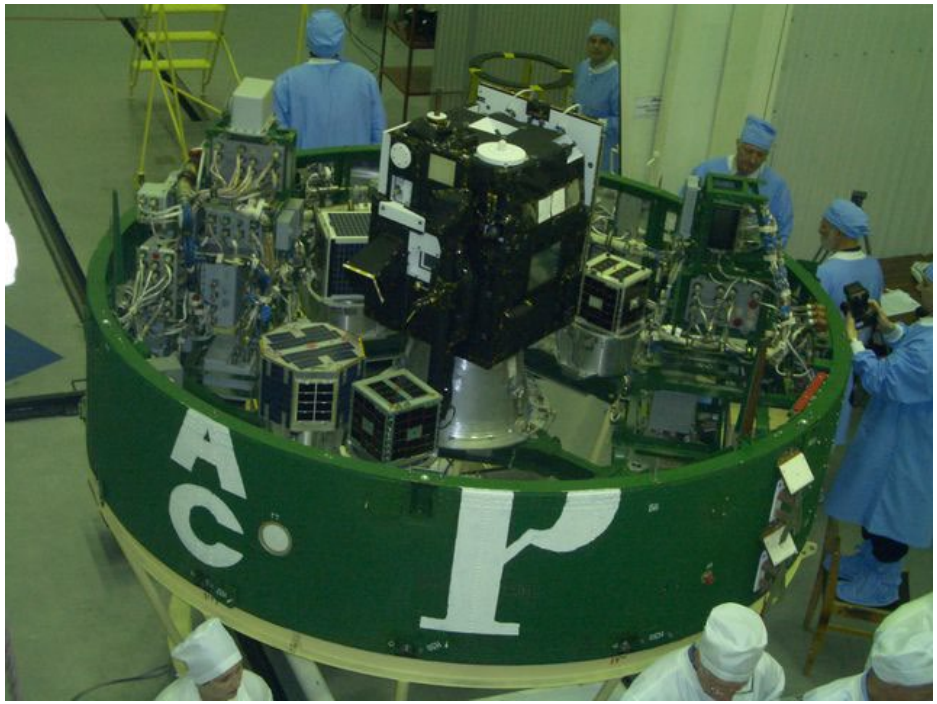
AMSAT OSCAR Echo Launch Campaign
June 2004

Chuck Green, N0ADI with Echo enroute to Baikonur



Echo (left) with UniSat-3 mounted on dispenser plate

On Time Launch
6/29/2004 0630 UTC



Echo (in the foreground) mounted on the launch platform next to UniSat-3.

Dnepr LV (SS-18) launch from Baikonur Cosmodrome in Kazakhstan, 29 JUN 04

AO-51 Mode as of 19:30 UTC

Voice Up	Voice Dn	Beacon	Digital Up	Digital Dn	Up Baud	Dn Baud
145.920 FM	435.300 FM	435.150 FM	145.860 PBP	435.150 PBP	9600	9600

Analog Uplink:	145.920 MHz FM	(PL - 67Hz)
	145.880 MHz FM QRP	(no PL)
	1268.700 MHz FM	(PL - 67Hz)
Analog Downlink:	435.300 MHz FM	
	2401.200 MHz FM	
PSK-31 Uplink	28.140 MHz USB	
Digital Uplink:	145.860 MHz	9.6 Kbps, AX.25
	1268.700 MHz	9.6 Kbps, AX.25
Digital Downlink:	435.150 MHz	9.6 Kbps, AX.25
	2401.200 MHz	38.4 Kbps, AX.25
Broadcast Callsign:	PACB-11	
BBS Callsign:	PACB-12	
Launched	June 29, 2004	

AO-51 Analog Operating Techniques

- Listen to who is talking - Note the callsign
- Make a short call to this specific station
- Give your name, callsign, and gridsquare
- Have a means to record contacts
- Have patience-LEO satellites are busy, so it may take a few passes until you make a contact

Robin Haighton VE3FRH, Keith Pugh W5IU and Rick Hambly W2GPS at the 2004 Central States VHF Symposium, Toronto, ON July 2004

AO-51 Digital Operating Techniques

- **Digital mode**
  - 145.860MHz up, 435.150MHz down at 9600 baud.
  - Store and forward bulletin board system (BBS) using PACSAT Protocol Suite.
  - Ground stations use WiSP or equivalent
  - Digital downlink will also contain telemetry.
  - Whole orbit data will be available for download.

Mike Seguin N1JEZ decoding AO-51 telemetry during the Central States VHF Conference, Toronto July 2004. Rick Hambly W2GPS is aiming the Arrow Antenna.

SuitSat-1, A Unique Satellite

Excerpted with permission from Gould Smith WA4SXM

CD-ROM prepared by

Deanna Lutz K7DID

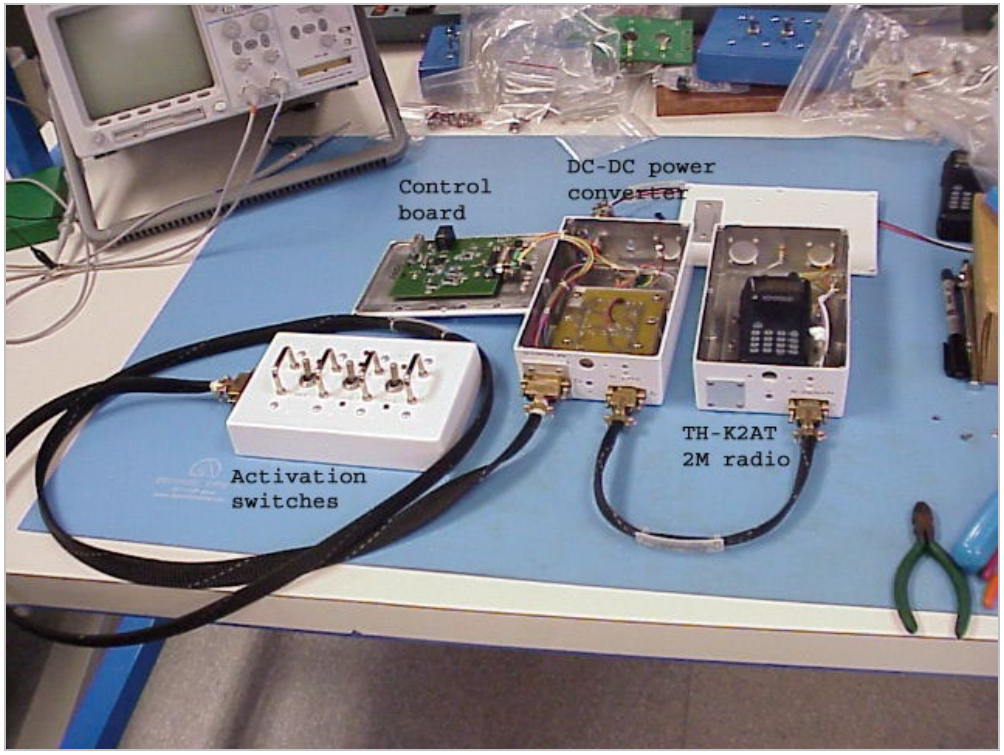
AMSAT Member and President of the Alexandria Radio Club (W4HFH)

ARISS - A Joint NASA, AMSAT, ARRL Program

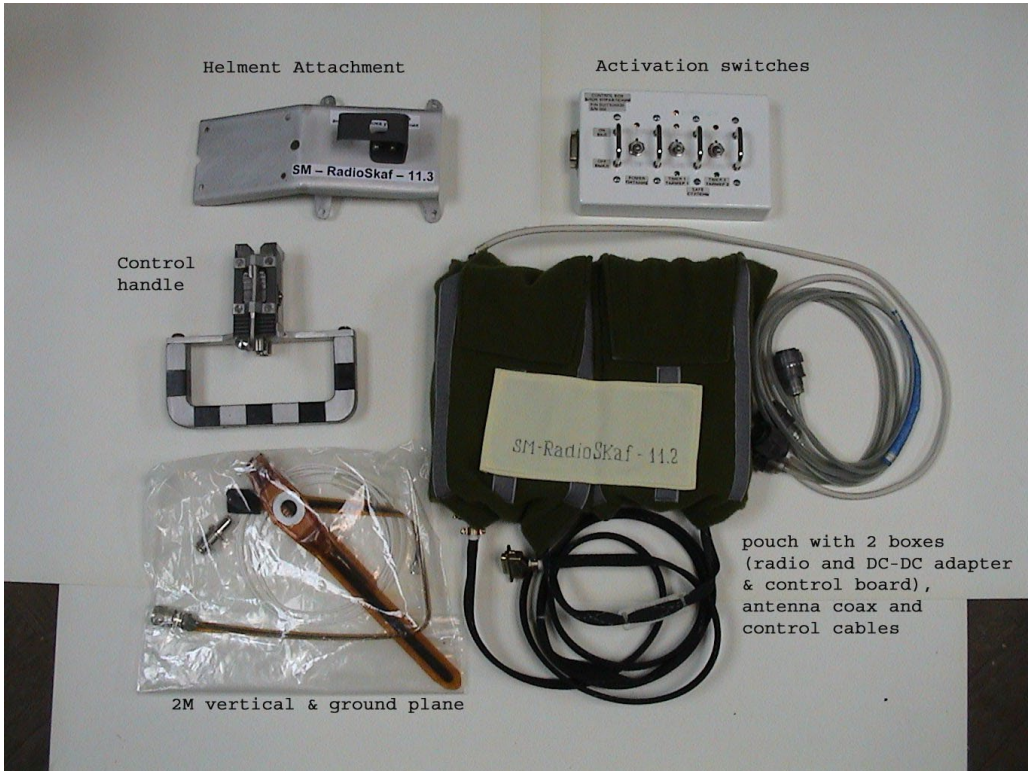
- SuitSat was proposed by Sergey Samburov at the International ARISS meeting in Washington, DC October 2004 to honor the 175th Anniversary of the Bauman Moscow State Technical University

SuitSat Design

The U.S. ARISS group (AMSAT) designed and built the SuitSat controller, voice generator and switch box ***in only one month***.



SuitSat was adapted to the spacesuit and tested in Russia



SuitSat flight hardware delivered to ISS in September 2005

Cosmonaut Valery Tokarev installs the hardware on the Orlan space suit

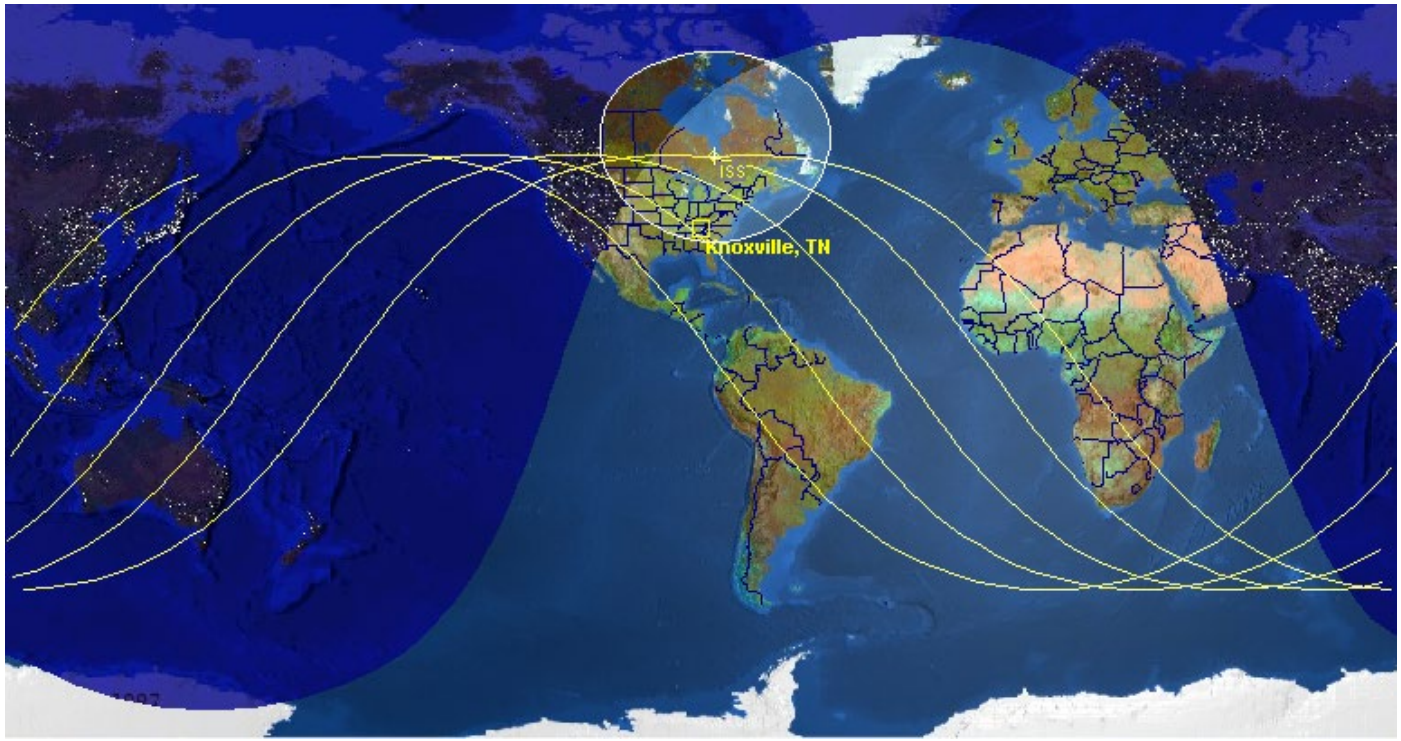

S114E7219

SuitSat launched from the International Space Station 3-Feb-06 and designated AO-54

The CD on SuitSat contained over 300 messages from students.

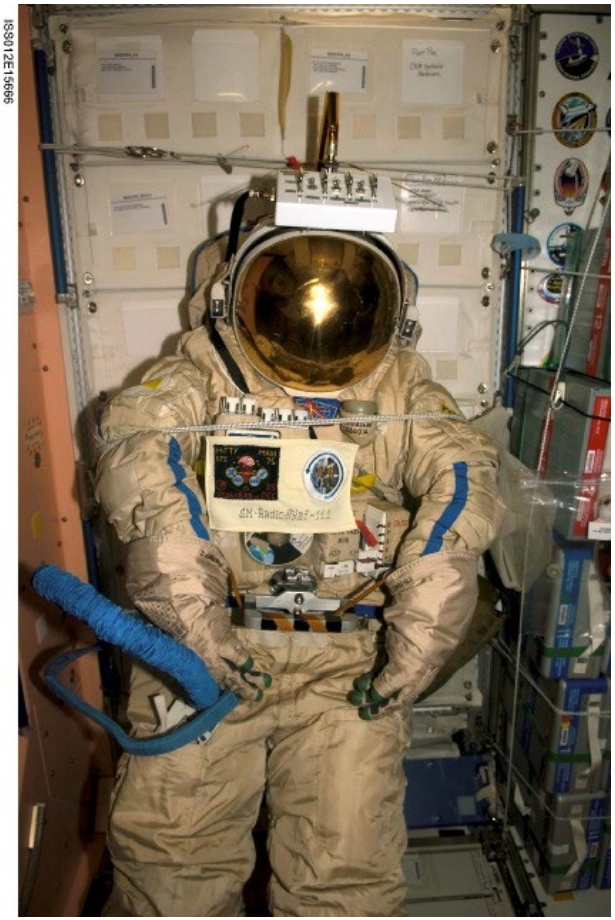
SuitSat Orbit

The orbit will covered most of the populated areas of the earth. It was intended that many people would be able to listen to the SuitSat signal, during its' short lifetime.



Messages from SuitSat

- Voice telemetry (mission time, temperature, battery voltage)
- Russian message
- Europe student message (Spanish & German)
- Bauman Institute message in Russian
- Canada student message in French
- Mr. Alexandrov message in English
- Japan student message in Japanese
- USA student message in English
- SSTV picture transmission



Linton Springs Elementary School
Eldersburg MD, February 6, 2006

Mr. Lyons and one hundred 5th graders welcome Mr. Pat Kilroy N8PK from NASA/AMSAT. A flier on "SuitSat", a demo, a lively Q&A session and a student video interview were the highlights of the morning at LSES on Monday, February 6, 2006.

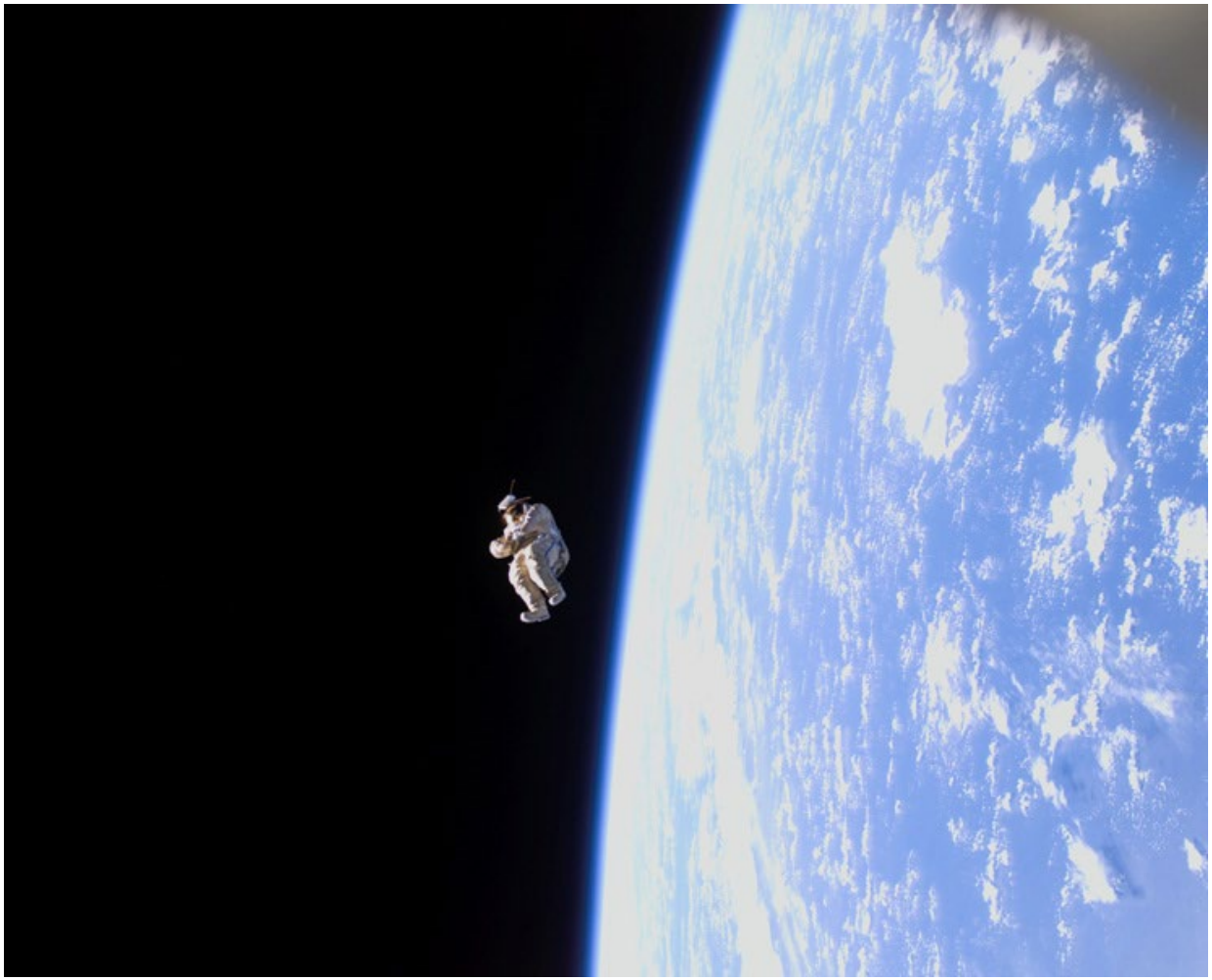
SuitSat-1: A Spacesuit Floats Free

Credit: ISS Expedition 12 Crew, NASA

Dubbed Suitsat-1, the Russian spacesuit was fitted with a transmitter and was pushed out by the space station crew to orbit the Earth.

Suitsat-1 orbited once every 90 minutes until it burned up in the Earth's atmosphere within a few weeks.

The lifeless spacesuit was photographed as it drifted away from the space station.



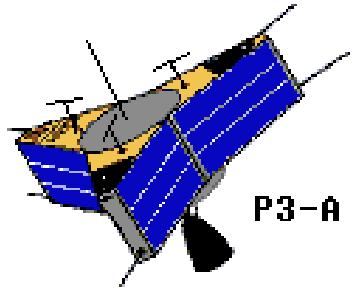
SuitSat Telemetry
by Richard Crow N2SPI

N2SPI Update Number	Telemetry message heard @: Mo	Day	Time UTC	SuitSat Mission Time in Minutes	SuitSat Temperature in Degrees Celsius	SuitSat Battery Voltage (Volts)	File name for source audio: (".wav" file)
	Feb	8	13:49:41	006607	12	26.-	8Feb1340z_telem
	Feb	9	12:37:29	0--967	--	-6.7	9Feb1237z_telem
2	Feb	10	06:39:29	009-44	13	26.7	10Feb0639z_telem
3	Feb	11	07:04:41	010501	--	26.7	11Feb0704z_telem
4	Feb	11	11:50:53	010786	--	26.7	11Feb1153z_telem
5	Feb	12	05:52:34	01--62	14	26.-	12Feb0552z_telem
6	Feb	13	04:39:57	01-222	--	26.6	13Feb0439z_telem
7	Feb	13	06:18:18	--3320	14	2-.6	13Feb0618z_telem
8	Feb	14	05:05:24	0-4680	15	26.6	14Feb0505z_telem
9	Feb	15	03:52:54	016040	--	26.5	15Feb0348z_telem
10	Feb	16	04:18:32	0--49-	16	26.3	16Feb0411z_telem
11	Feb	17	03:05:45	------	--	25.2	17Feb0300z_telem
12	Feb	17	10:59:42	0--3-9	15	18.3?	17Feb1057z_telem

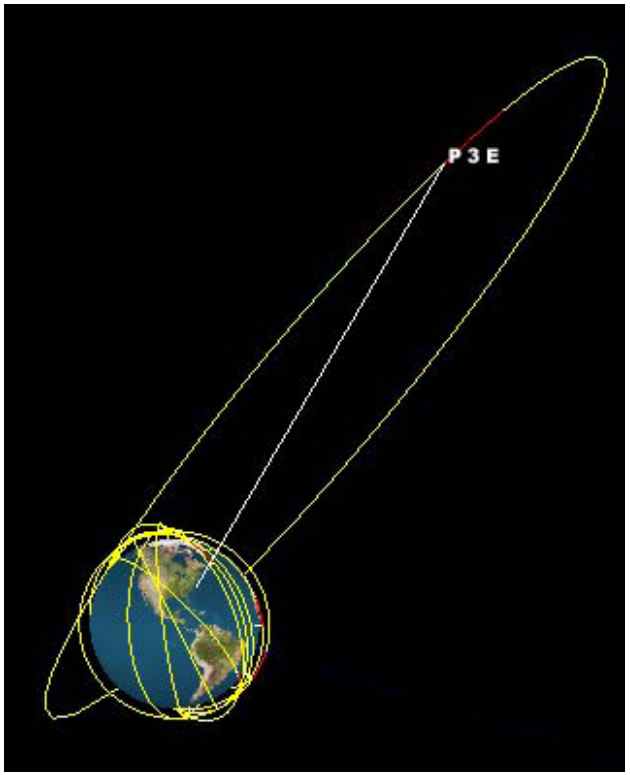
Pass1@	Feb 18	01:49:30	Nothing heard
Pass2@	Feb 18	03:22:45	Nothing Heard
Pass3@	Feb 18	04:58:30	Nothing heard
Pass4@	Feb 18	06:34:30	Nothing heard --- Farewell SuitSat-1!

Hear source telemetry audio at "www.aj3u.com".

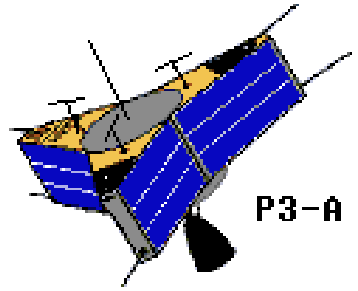
AMSAT-Phase 3E Satellite (P3E)



- Communication and scientific platform.
- High elliptical orbit.
- P3E is being created in a joint process together with the P5A Mars mission by an international team under leadership of AMSAT-DL.
- Continues the successful series of AMSAT-Phase-3 satellites.
- Technology test bench for the Mars mission.
- Launch is planned in 2006/7.

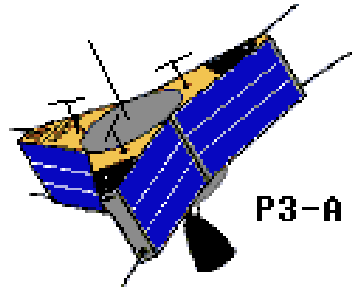


P3E Meeting in Marburg Germany,
January 29, 2005



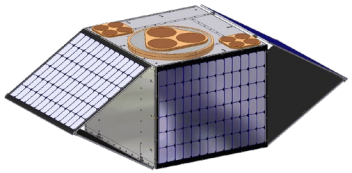
AMSAT-DL President Peter Guelzow DB2OS, AMSAT-NA President Rick Hambly W2GPS, Prof. Dr. Karl Meinzer DJ4ZC, and Hartmut Paesler DL1YDD examine the P3E spacecraft frame.

P3E Proposed Frequency Chart

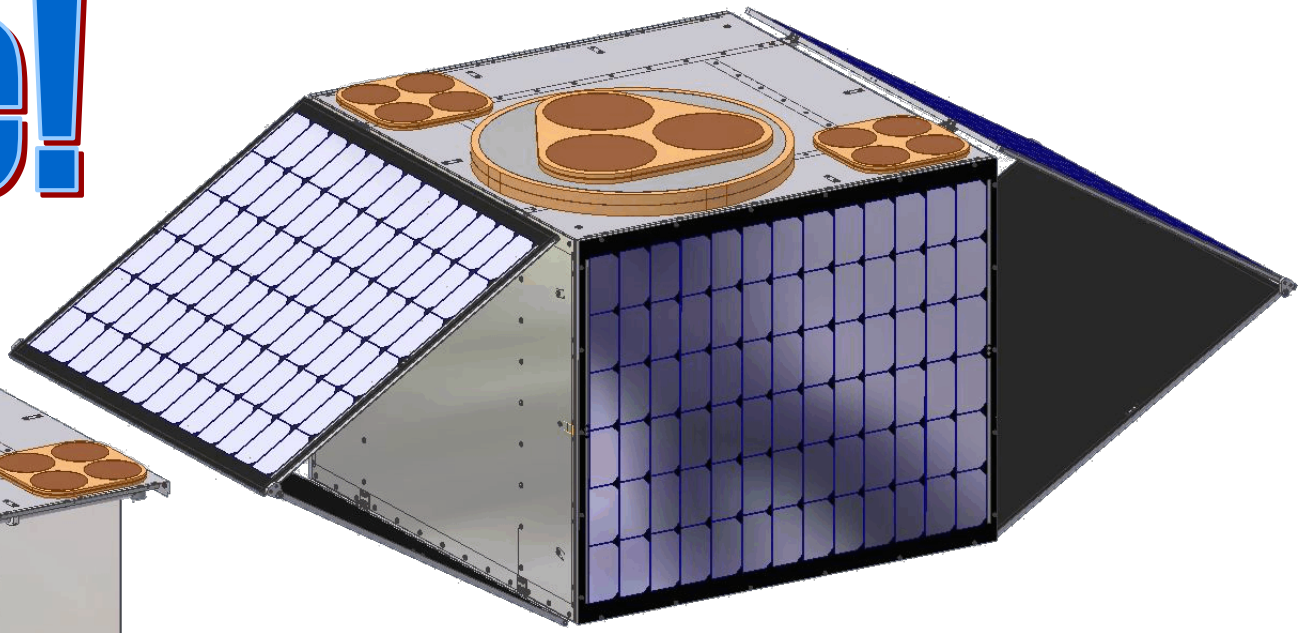


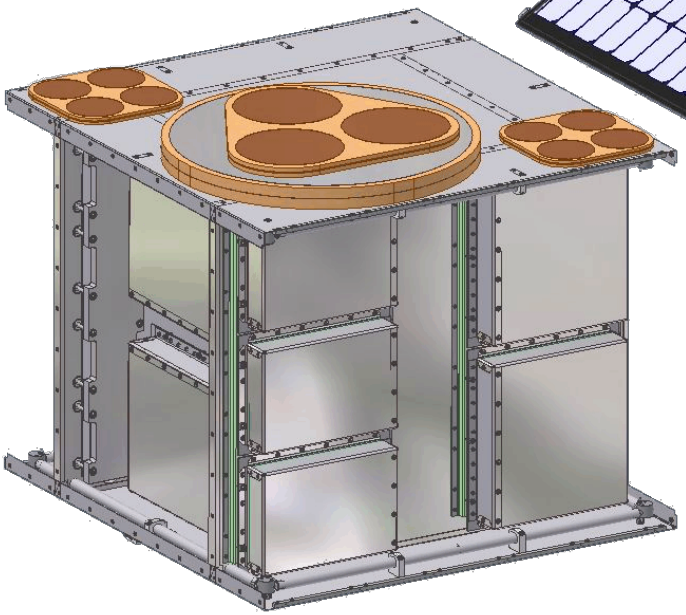
AMSAT-Phase 3E Transponder Frequencies				
Band	Analog Uplinks	Analog Downlinks	RUDAK Uplinks	RUDAK Downlinks
10 M			29.500 +/- 5 kHz	
2 M		145.845 - 145.945		145.837 - 145.837
70 cm	436.050 - 436.150		436.200 - 436.350	
23 cm (1)	1268.600 - 1268.750		1268.775 - 1268.925	
23 cm (2)	1260.100 - 1260.250		1260.275-1260.425	
13 cm (1)		2400.275 - 2400.425		2400.600 - 2401.000
13 cm (2)	2450 +/- 50 kHz			
6 cm	5668.600 +/- 25 kHz			
X-Band		10450 +/- 50 kHz		
K-Band		24048.300 +/- 25 kHz		
R-Band		47088.300 +/- 25 kHz		

AMSAT's Eagle Satellite Project



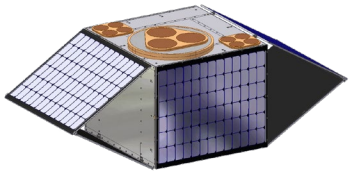
Eagle!





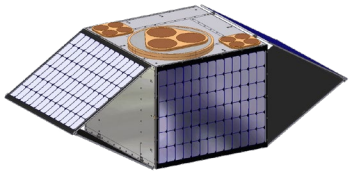
- **6 cu ft, ~50Kg**
- **High Elliptical Orbit**
- **80+ Watt power budget**

Eagle's History



- "So You Want to Build a Satellite" by Dick Jansson WD4FAB presented at AMSAT's 18th Space Symposium in Portland Maine on Oct 28, 2000.
- Project Committee met July 14, 2001 in Denver, Colorado.
- Eagle Design Team met Sep 28, 2002 in Orlando FL.
- Eagle Design Team met the weekend of Jul 17, 2004 in Orlando FL.
  - Key design parameters were chosen.
  - Team leadership assignments were made.
- Eagle Design Team met Oct 7-9, 2005 in Pittsburgh PA.
- Eagle RF Design Team met Nov 26, 2005 in Princeton NJ.

Eagle Requirements List



1 Introduction

2 Payloads

2.1 Transmitters

2.2 Receivers

2.3 GPS (NASA)

2.4 Camera Characteristics

2.5 Telemetry

2.6 Redundant, independent command uplinks shall reside in the U and L-band receivers

3 Structure and Physical Properties

3.1 Mass

3.2 Size

3.3 Stabilization

3.4 Orbit

3.5 Attitude Control

3.6 Propulsion

3.7 Structure

3.8 Magnetic Environment

3.9 Thermal Control

4 Power Generation and Energy Storage

5 Housekeeping

5.1 IHU-3

5.2 CAN-Do! Information Buss

6 Antennas

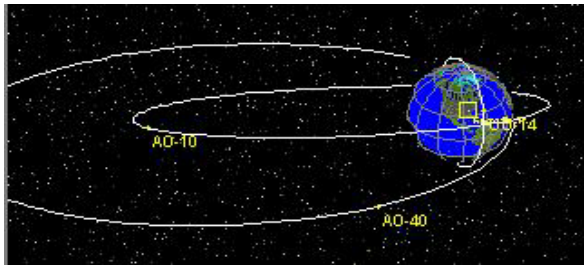
6.1 High Gain +Z Face

6.2 Omni Antennas, -Z Face

6.3 Omni Antennas +Z Face

7 Definitions

Eagle's Specifications
1.0 Payloads



1.1 Transmitters

- V band using SDR techniques, BW 50 - 100KHz.
- Two S-Band Tx, 100 KHz BW
- C-Band wideband digital
- All bands should be capable of being operated simultaneously

1.2 Receivers

- U band 100 KHz bandwidth. (SDR)
- L band 100 KHz bandwidth. (SDR)
- C band wideband digital.
- Command uplink shall be on at least U and L-band receivers

1.3 GPS (NASA)

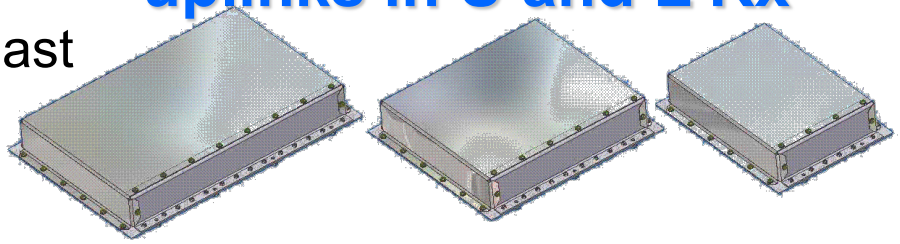
1.4 CEDEX (Surrey)

1.5 Cameras

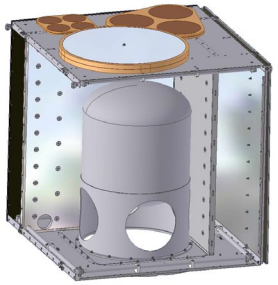
- Narrow Field of View +Z axis
- Wide FOV on –Z axis
- Cameras should survive all beta angles

1.6 Telemetry on all Tx's

1.7 Redundant command uplinks in U and L Rx



Eagle's Specifications
2.0 Structure and Physical Properties



2.1 Mass
- 100Kg or less

2.2 Size
- Compatible with launcher

2.3 Stabilization
- Spin stabilized

2.4 Orbit
- High apogee elliptical

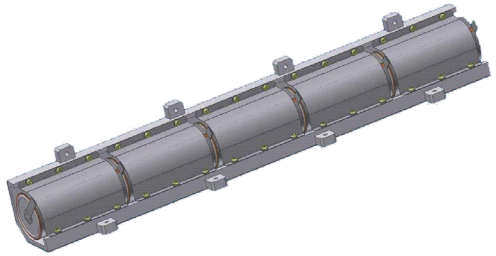
2.5 Attitude Control
- Magnetorquers and nutation dampers
- Sensors (Sun and Earth)

2.6 Propulsion
- Simplest system for desirable orbit. Modular.

2.7 Structure
- As necessary to meet mission package. Accommodate the possibility of side mounting

2.8 Magnetic Environment
- Magnetically clean as practically achievable

Eagle's Specifications
Other Specs

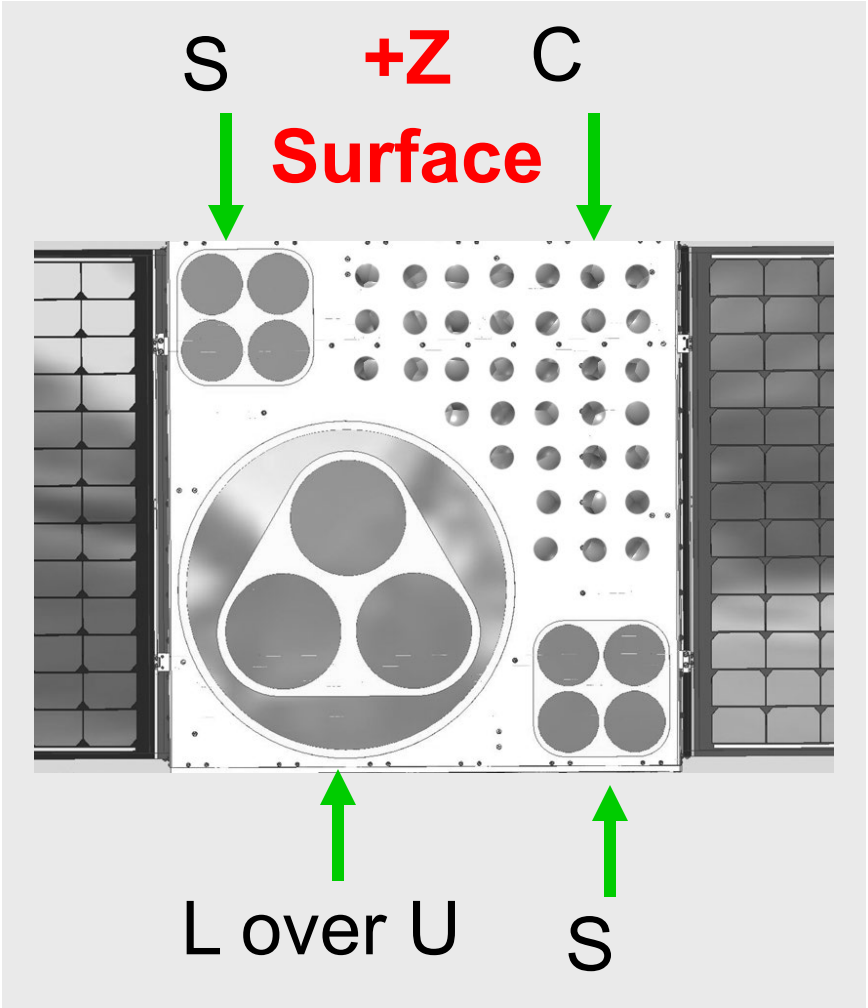


3.0 Thermal Control
- Battery temp ±15C.
- Electronics -25 to +40C

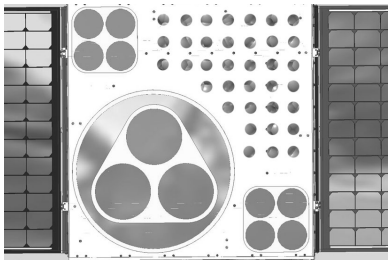
4.0 Power Generation
- 2 fixed + 4 solar panels.
- Fault tolerant.
- 10 to 14 volt buss, 100 Watt nom.

5.0 Housekeeping
- IHU-3 and CAN-Do! buss

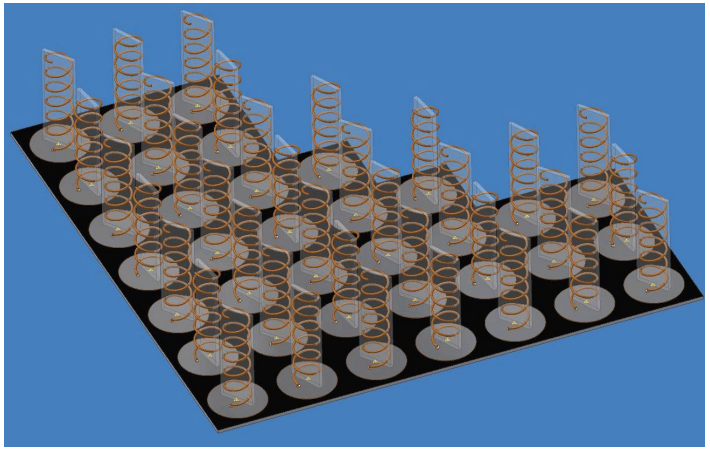
6.0 Antennas
- 6.1 High Gain +Z for U, L, S and C
- 6.2 Omni -Z for V, U, L and S
- 6.3 Omni +Z U, L and S



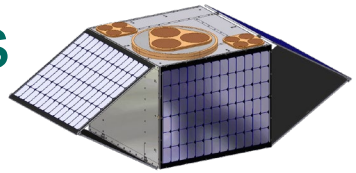
C-C Rider Antennas
An Alternate Approach



- Array of C band helical antennas
  - » Half RHCP for transmitting and
  - » Half LHCP for receiving.
- Have a proven assembly method, care of Lou McFadin.
- Half the elements but higher gain of the individual antenna element.
- Would halve the transmitter power and the power dissipation.
- ISSUES:
  - » The two-wavelength-spaced elements may be too far apart for good performance.
  - » Getting good beam-steering from gain antennas.
  - » The individual helical elements will need to be very carefully matched.



Eagle Team Leadership Assignments



Project Manager: Jim Sanford WB4GCS

Chief Technical Officer: Rick Hambly W2GPS (acting)

Secretary: Stephen Diggs W4EPI

Structure and Thermal: Dick Jansson WD4FAB

Launch: Lee McLamb KU4OS (lead),
Tom Clark W3IWI (Russian launches)

Guidance and Control: Ken Ernandes N2WWD

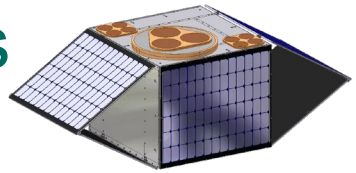
Sensors: Alan Bloom N1AL

Power Generation and Distribution: Lou McFadin W5DID

Propulsion: Stan Wood WA4NFY (lead),
Daniel Schultz N8FGV, Ken Ernandes N2WWD

Antennas: Stan Wood WA4NFY

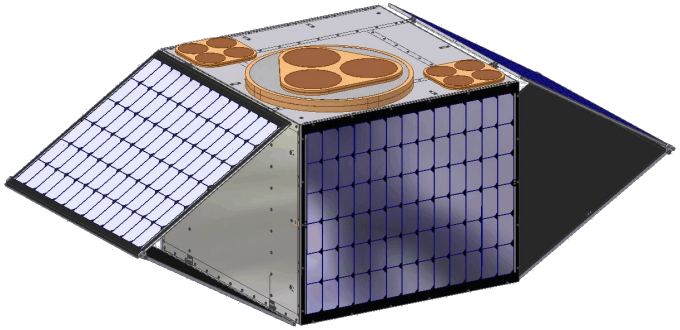
Eagle Team Leadership Assignments



Housekeeping: Bdale Garbee KB0G (data interface), Chuck Green N0ADI, Lyle Johnson KK7P (IHU-3)

Antennas: Stan Wood WA4NFY

Payloads: Bob McGwier N4HY, Daniel Schultz N8FGV, Tom Clark W3IWI



GPS: Lou McFadin W5DID

CEDEX: Robin Haighton VE3FRH

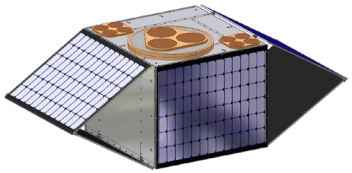
Cameras: Gunther Meisse W8GSM

Command and Control/Telemetry: Stephen Diggs W4EPI, Stacy Mills W4SM

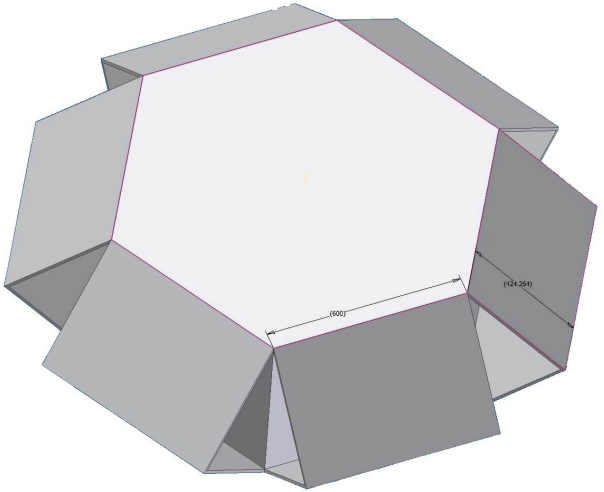
Radiation Environment: Steve Bible N7HPR

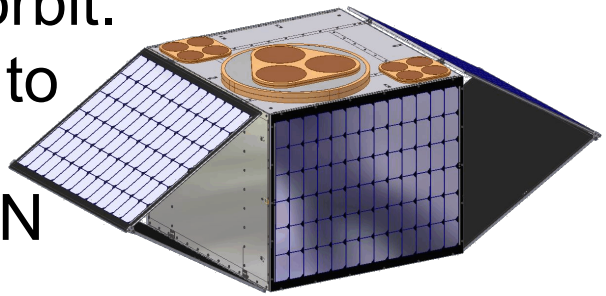
Eagle Design Change Proposal

by N4HY 26-Jan-06



- All the positive attributes of previous design, without the negatives.
- Huge power budget
  - » ß = 90°, Pg = 310.7W
  - » ß = 0°, Pg = 197.8W
- Largest dimension is 1200 mm (4 ft) Can be lifted by 3 people and carried through a door.
- Antenna space up from 0.36 m^2 to 0.98m^2.
- It would never have to leave equatorial orbit.
- We can increase the digital transponder to 100w and have a LOUD linear downlink.
- WHAT VEHICLES CAN THIS BE FLOWN ON? How to fit the available envelopes?

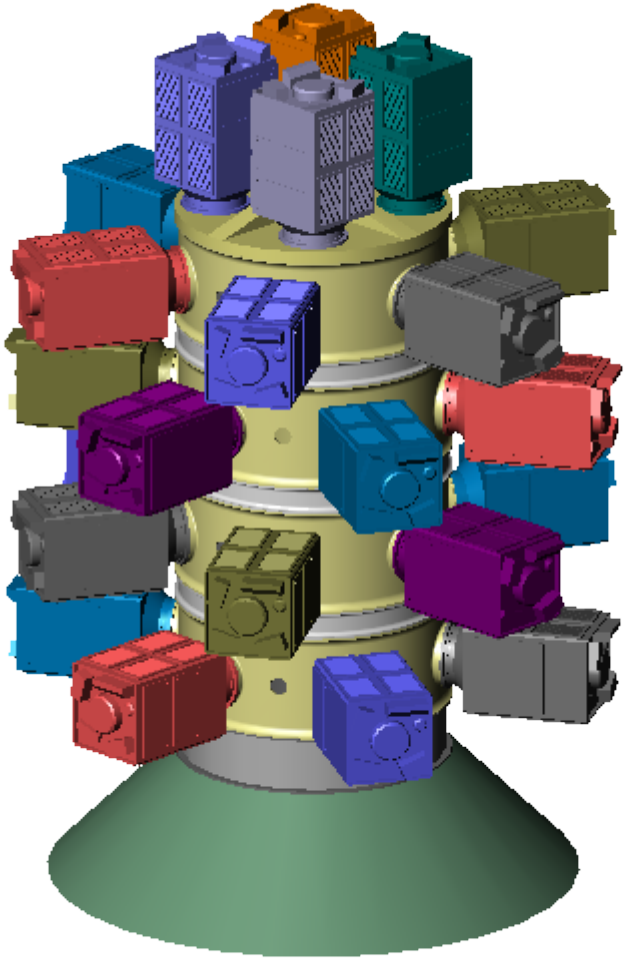




A Possible U.S. Launch Opportunity

STP-X: Tomorrow's Configuration

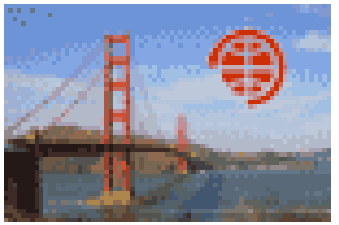
- 28 small satellites
- 4 ESPA rings
- 3 ESPA interface adapters
- ESPA lid



AMSAT Needs Your Help
Join AMSAT!

- To achieve these goals AMSAT needs new members, volunteers and money.
- You can help:
  - Volunteering to set up an AMSAT table at your local Hamfest
  - Join the Field Operations team
  - Encourage your Ham friends and Ham club members to join AMSAT
  - Send an annual contribution to AMSAT.
  - Give a presentation at your local Ham Club.
- Get information at www.amsat.org or call Martha in the AMSAT office at 301-589-6062.
- Contact any of your officers or Board members.
- Please help AMSAT reach its potential.

2006 AMSAT Space Symposium



- The 2006 Symposium will be held at the Crowne Plaza hotel in Foster City, October 6-8 2006
- Friday, Saturday and Sunday presentations and demonstrations
- General Membership Meeting on Friday
- Awards Banquet with keynote speaker on Saturday Evening
- Exciting Tours
- Door Prizes, Vendors and More!
- Sponsored by Project OSCAR