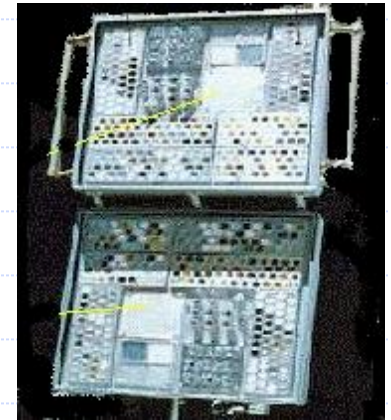


PCSAT2, Synergy in the Amateur Satellite Service



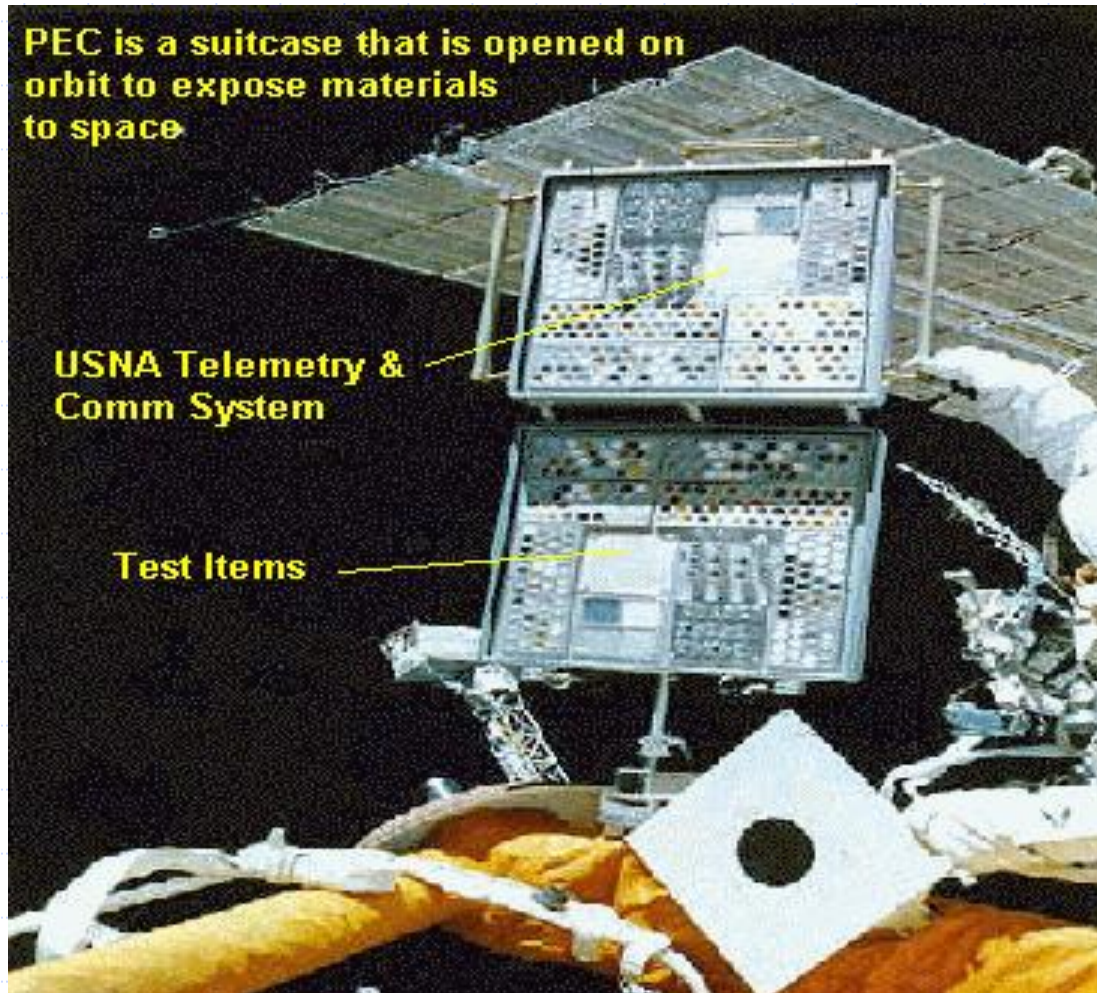
Bob Bruninga

US Naval Academy Satellite Lab

Amateur Satellite Service partnering with DOD and ARISS

- ◆ Very short development time
- ◆ Simplicity and off the shelf
- ◆ Educational Project
- ◆ Usable communications service to Users
- ◆ Telemetry for Space Environment
- ◆ Configuration controlled on the ground

DOD MISSE-5 Opportunity



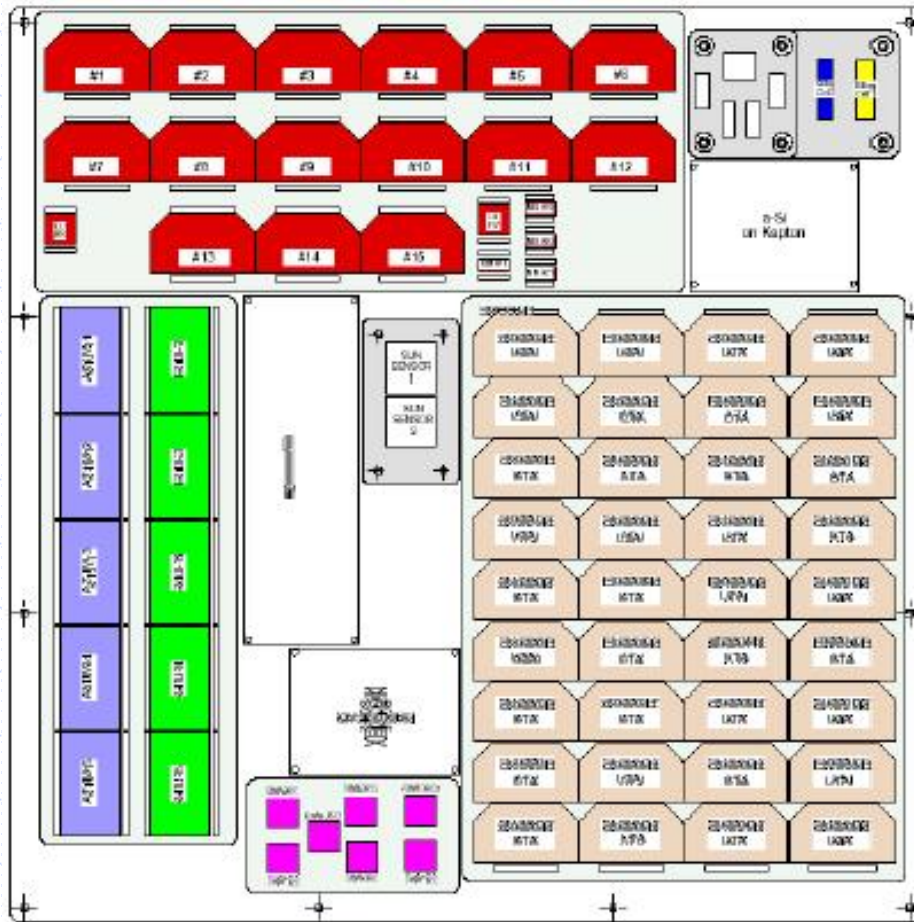
Passive Experiment Container - PEC

25" square by 6" thick Suitcase

Opens to expose samples to space

We got back half!

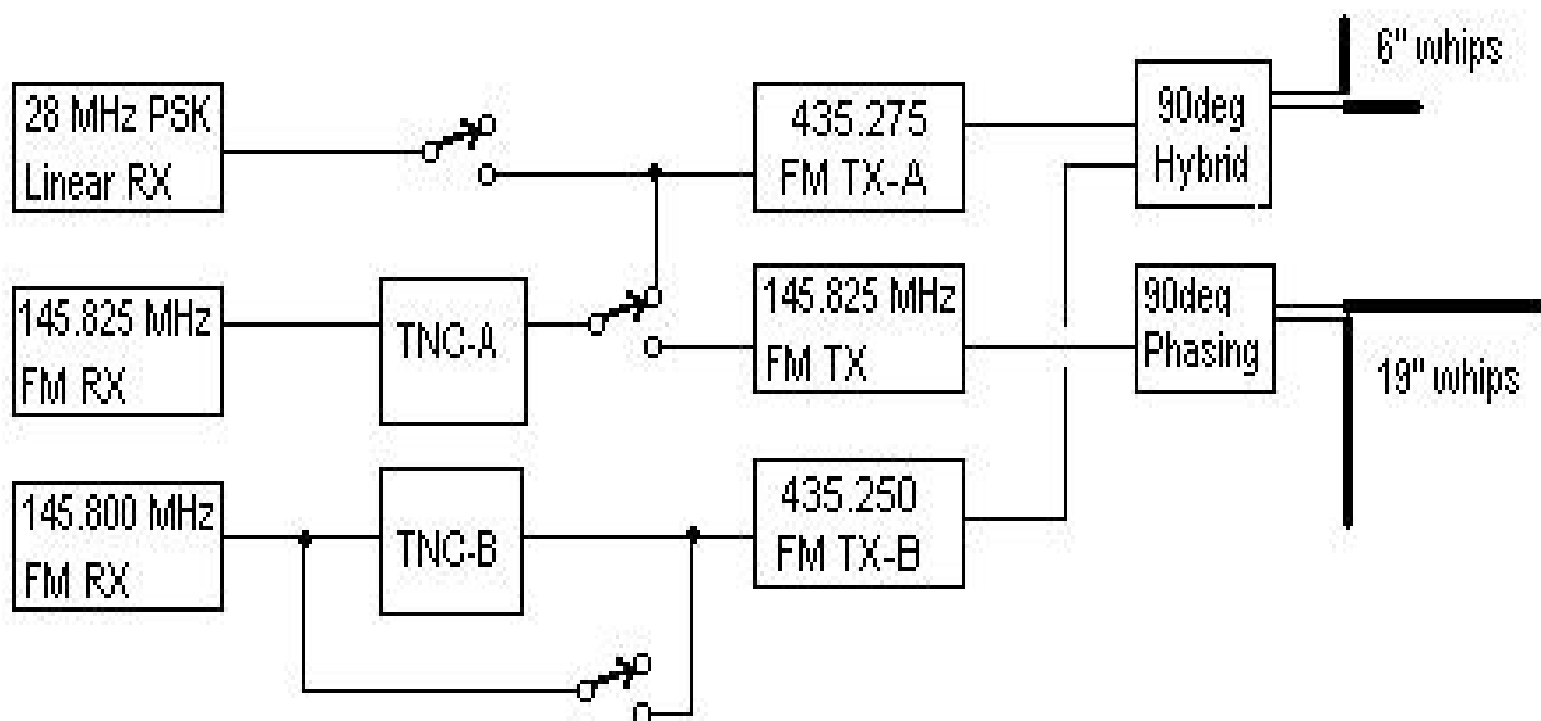
Solar Cell Experiment



40 Solar Cell Samples
Latest triple junction
technology

Amateur Satellite Transponders

PCsat2 COMMS FUNCTIONAL BLOCK DIAGRAM



Based on PCsat Experience



- **Launched 30 Sept 2001**
- **Served over 2000 separate users worldwide**
- **Operated 22 months to 10 July 2003**

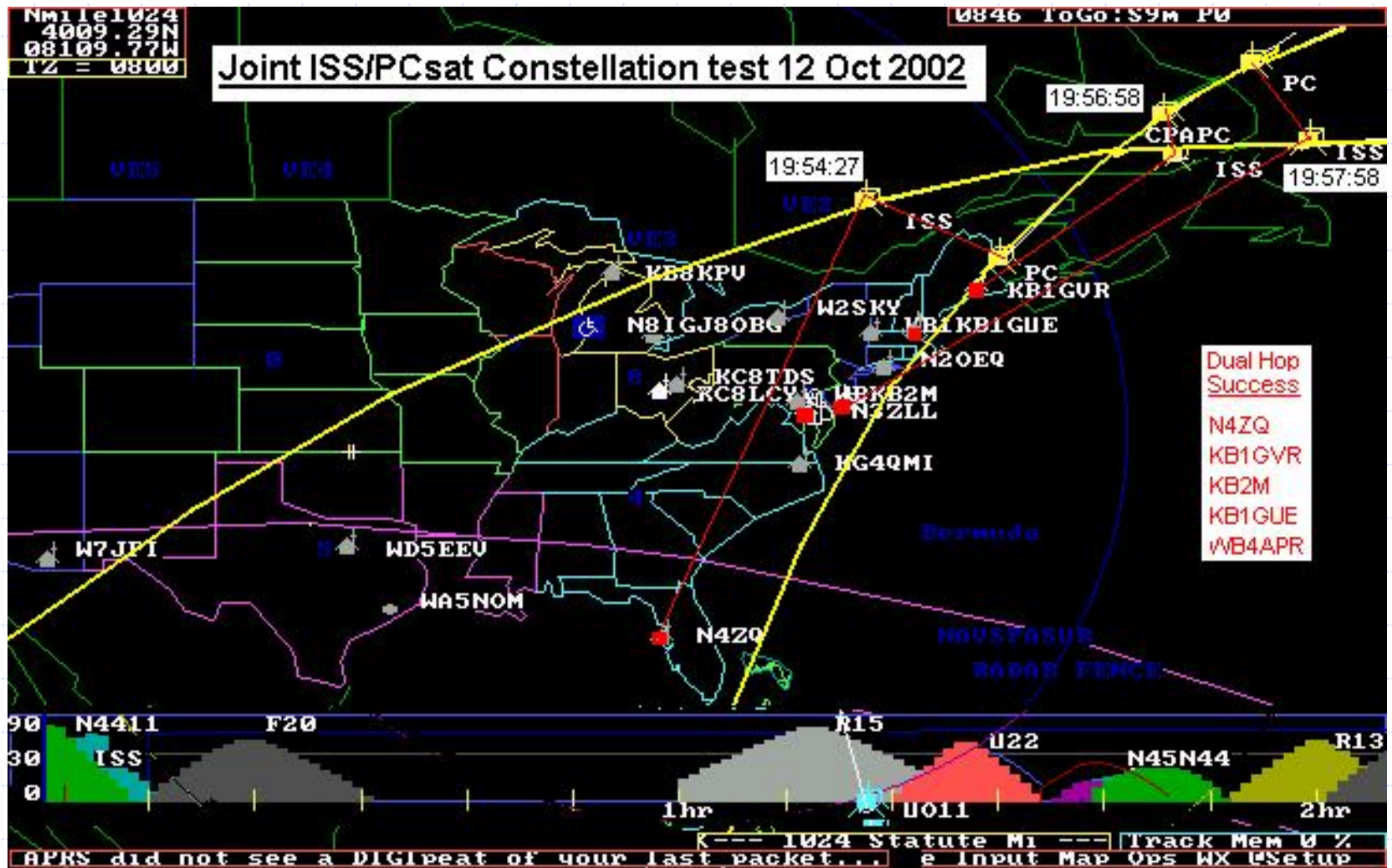
The PCSAT2 Student Team



Typical Student User Station



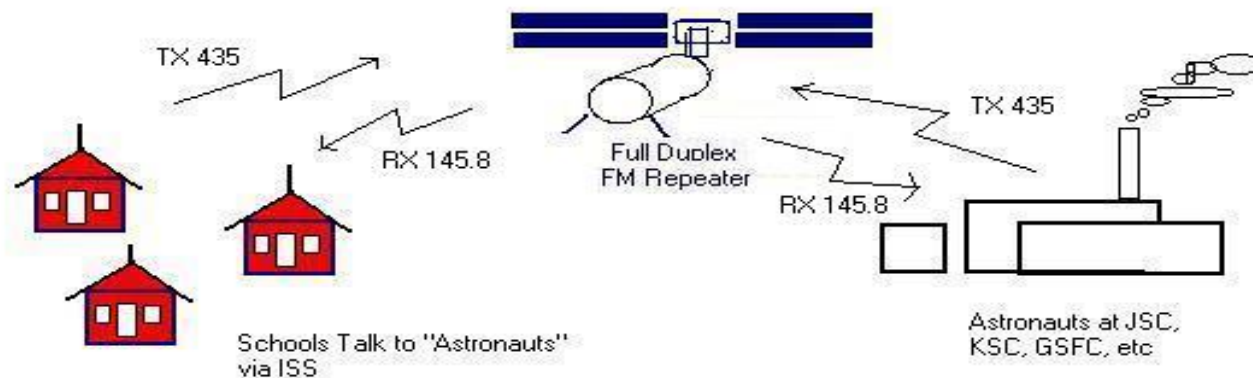
APRS Packet Operation



Optional, Full Duplex Voice for ISS Crew

Eliminate School Backlog with Astronaut QSO's

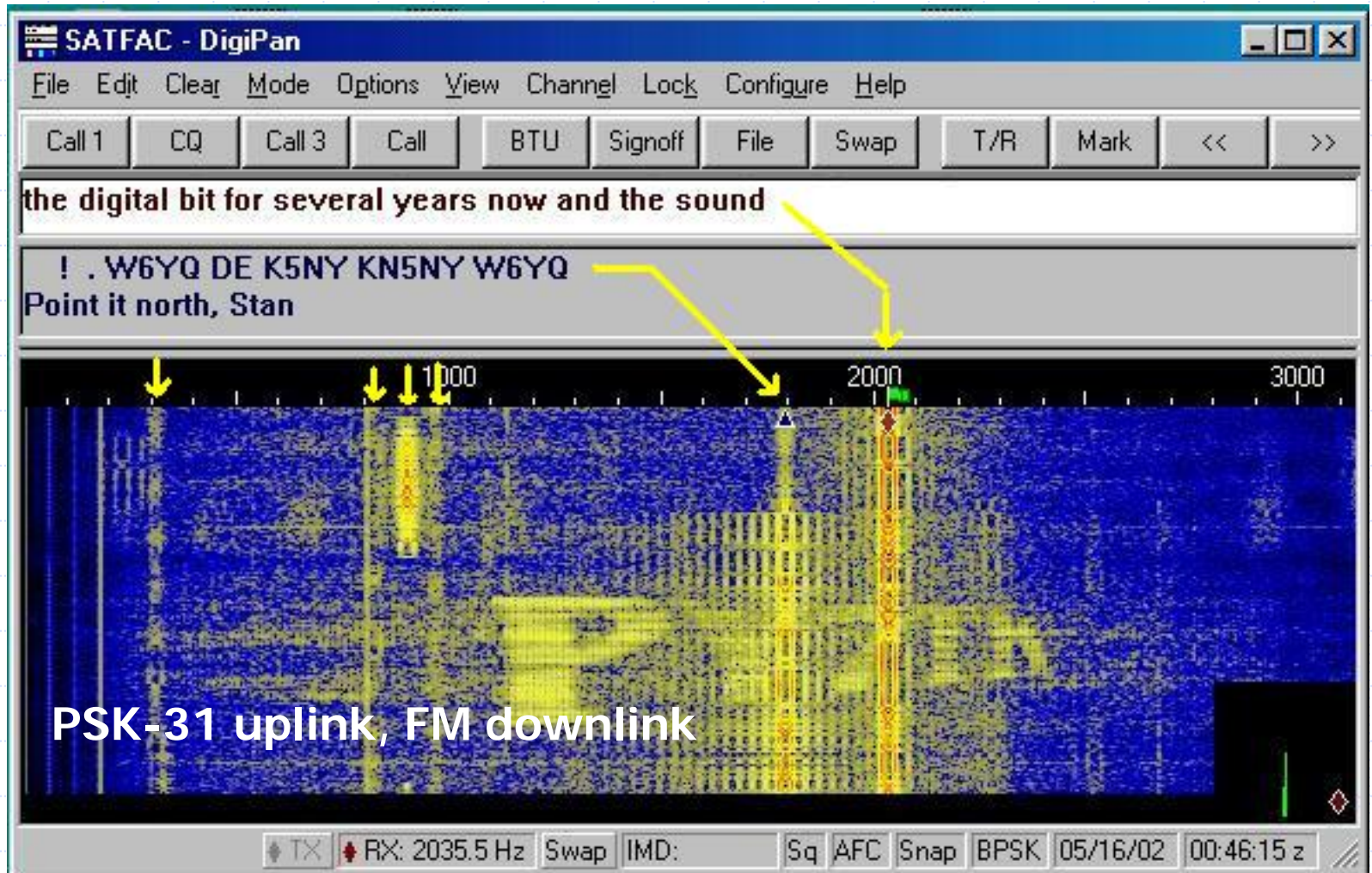
7 Dec 2002, WB4APR



Using Full Duplex Crossband FM Voice Repeater

- * Schools talk to Astronauts with NO BURDEN on ISS Crew
- * 20 times more Astronauts Available.
- * No On-board scheduling
- * Any Pass, Any time (only scheduling is on ground)
- * ALL schools may monitor and will hear UPLINK and DOWNLINK
- * All schools will hear all questions the same as Astronaut
- * Full duplex lets School hear own uplink for quality control

Multi-User Data Transponder

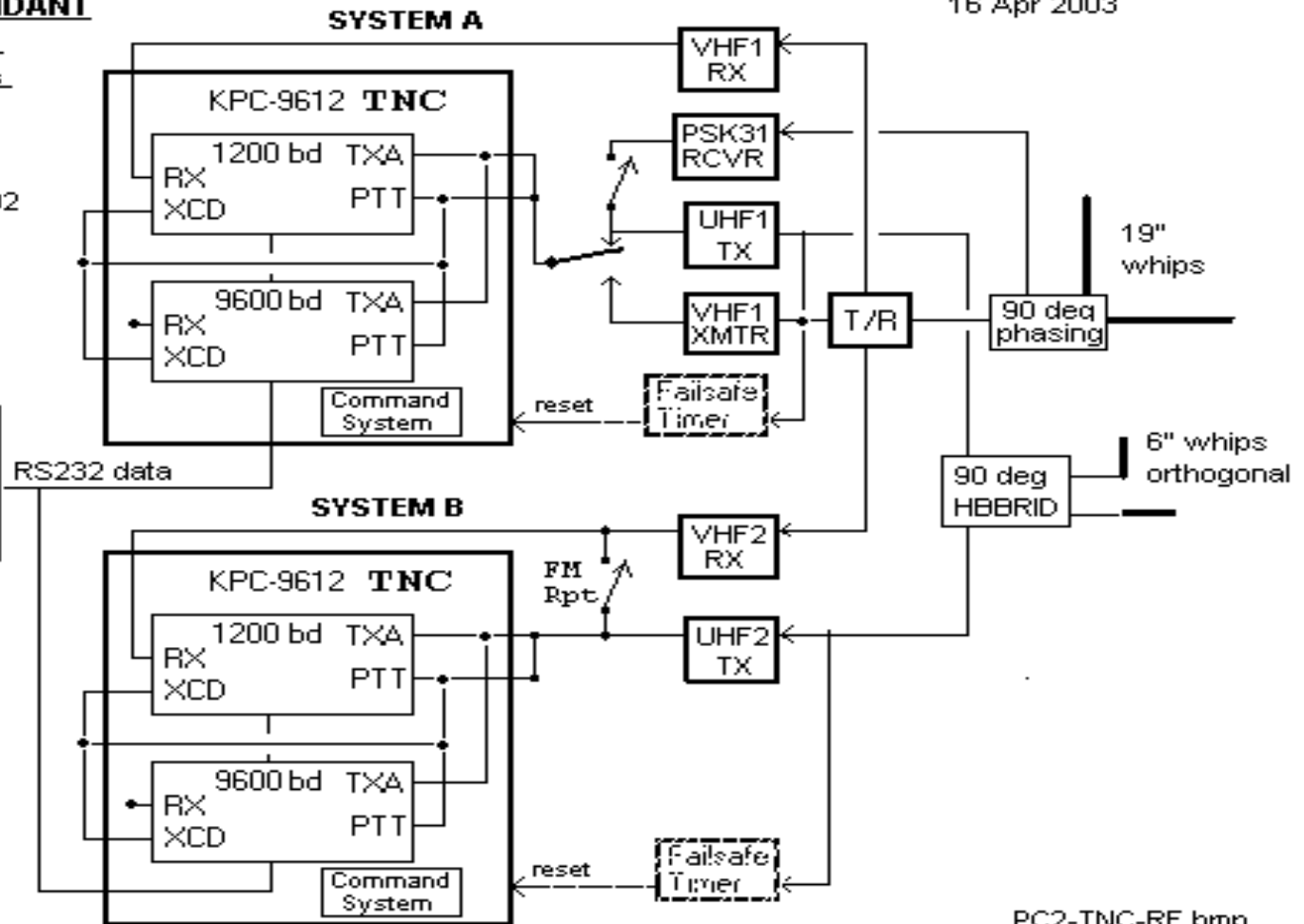


Based completely on KPC-9612+ TNC's

DUAL REDUNDANT TELEMETRY, COMMAND & COMMS

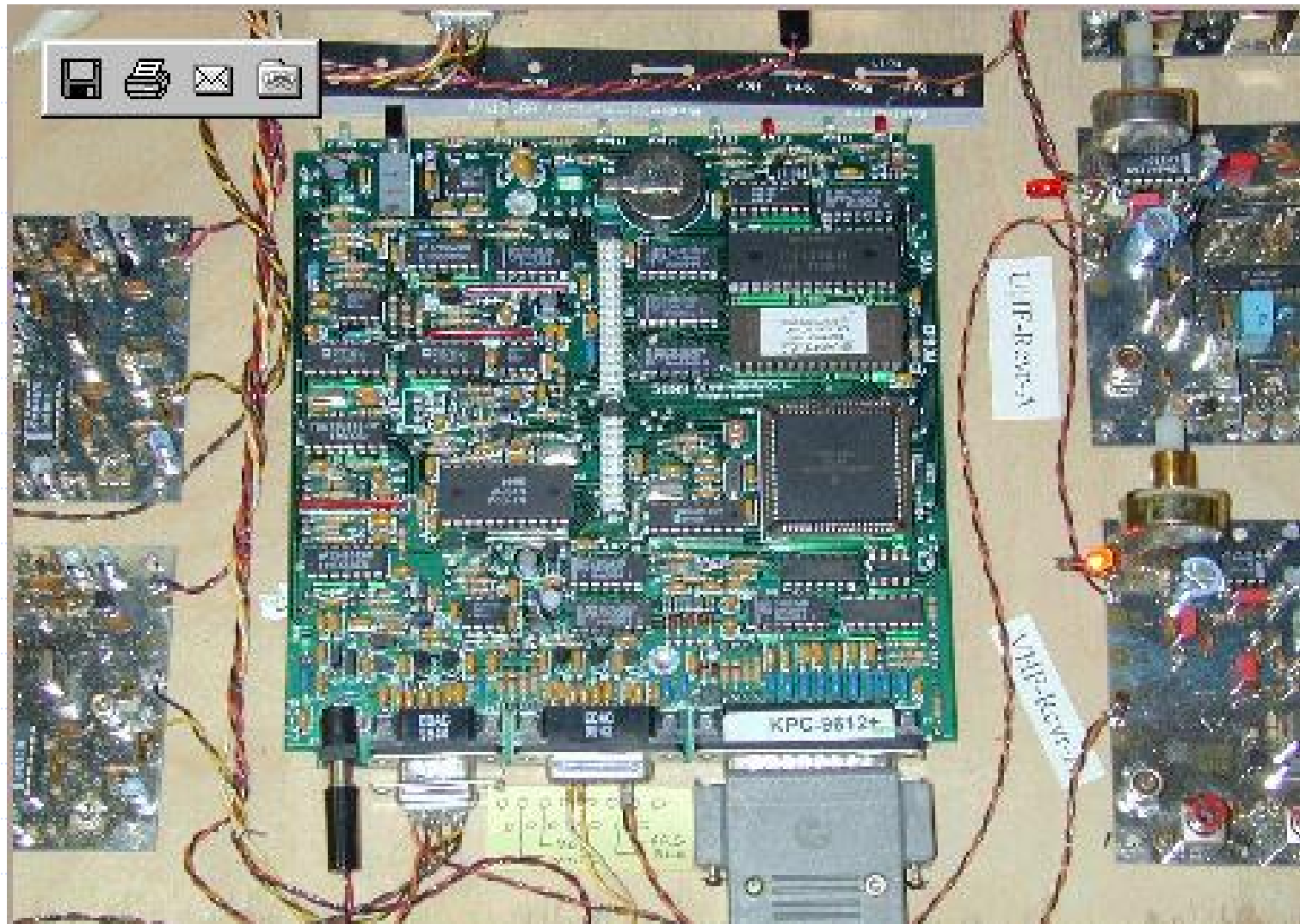
DWG NO:
MI-RF-5300-02

Solar
Panel
Telemetry
System



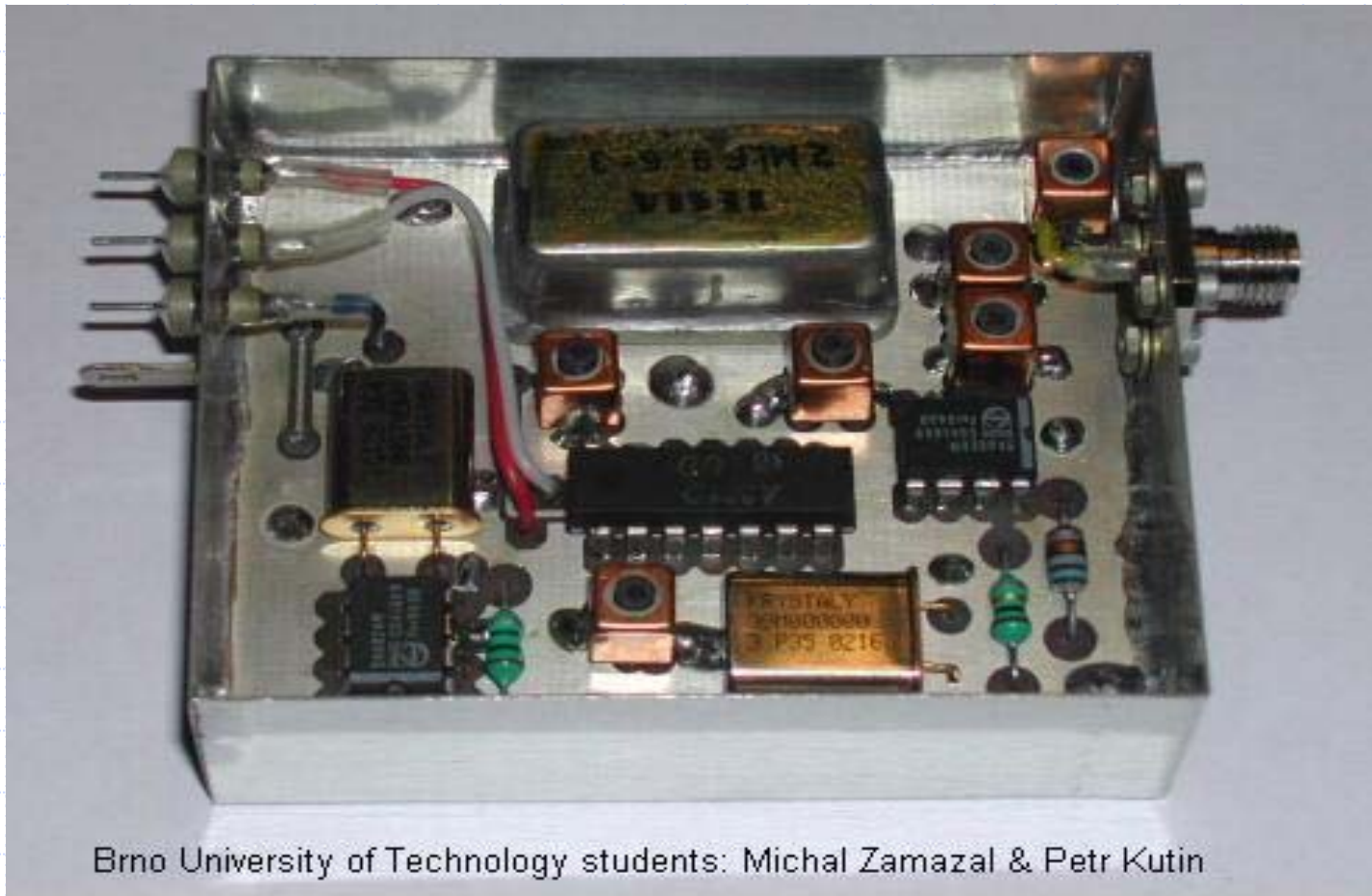
...PC2-TNC-RF.bmp

KPC-9612+ System



10m Uplink SSB Receiver

Mirslave Kasal



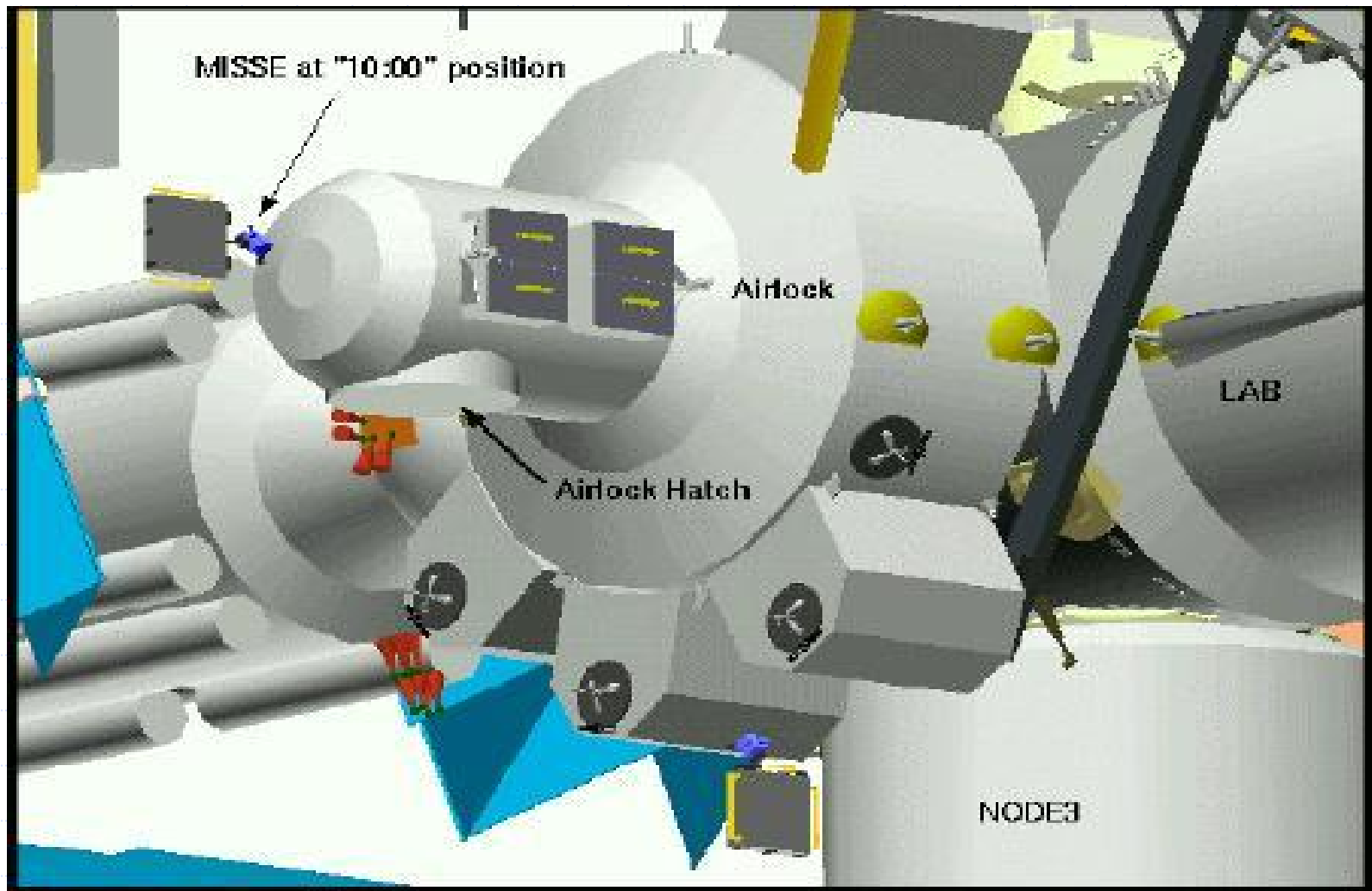
OK2AQK's 10m Flight Receiver

We Wanted Constant Sun



The preferred location for PCSAT2 is out on the ISS Solar array, beyond the alpha joint so that it gets full sun when ISS is in Sun. Our preferred location is shown with the arrow.

We Got Some Sun



Amateur Satellite Service

RULES:

"Amateur-Satellite Service: A radiocommunication service using space stations on earth satellites for ...the purpose of self-training, intercommunication and technical investigations carried out by amateurs, that is, by duly authorized persons interested in radio technique solely with a personal aim and without pecuniary interest." [RR S1.56]

PCSAT2 COMMENT:

Sponsoring Organization:	US Naval Academy
Operating Organization:	USNA Amateur Radio Club
W3ADO	
Station Trustee:	Bob Bruninga, WB4APR
Satellite Station Licensee:	Ryan Johnson, K3FOR

Amateur Satellite Service

RULES:

"VI. OPERATIONAL GUIDELINES based on interpretations by IARU of the Radio Regulations and good amateur practice, are intended to help in planning the missions, management, and control of satellites planned to operate in the Amateur-Satellite Service.

- A. The purposes of an amateur satellite should be:
- (1) To provide communication resources for the general amateur radio community and/or
 - (2) To conduct technical investigations in all respects consistent with the Radio Regulations.

PCSAT2 COMMENT:

- (1) **Three HAM communications transponders**

Amateur Satellite Service

RULES: (2) To conduct technical investigations in all respects consistent with the Radio Regulations.

Technical investigations in the Amateur-Satellite Service should be relevant to the development of "radio technique," that is, have a reasonable possibility of application to the development of radio communication systems.

Examples include: propagation studies, analysis of protocols for digital voice and data, development of attitude determination methods, of command and control procedures, studies of radiation effects on components, studies of meteor trail reflection, and measurement of the orbital environment useful in designing future amateur satellites.

PCSAT2 COMMENT:

(2) Advanced Technology Solar Cell experiment

Amateur Satellite Service

RULES: B. Station Control.

Space and Earth stations, must be controlled by "duly authorized persons," that is, licensed amateur radio operators who must be acting "solely with a personal aim and without pecuniary interest."

Commonly, the licensee is an unpaid member of the organization which owns the amateur station equipment or is a volunteer acting in close association with it. In these cases, the owner's interest and the licensee's "personal interest" are usually the same.

Thus, the individual responsibility of the licensed operator, effectively imposed by the Radio Regulations, works as a kind of legal safety check for the organization and the amateur to protect both of their interests as well as that of the Amateur Satellite Service itself.

PCSAT2 COMMENT:

Station Trustee:	Bob Bruninga WB4APR
Station Licensee:	Skip Johnson, K3FOR

Amateur Satellite Service

RULES: D. Plain Language and E. Open Access:

The international Amateur-Satellite service, involves communications between amateur stations in different countries and must be in plain language. [See RR | S25.2.] Including telemetry and data between users.

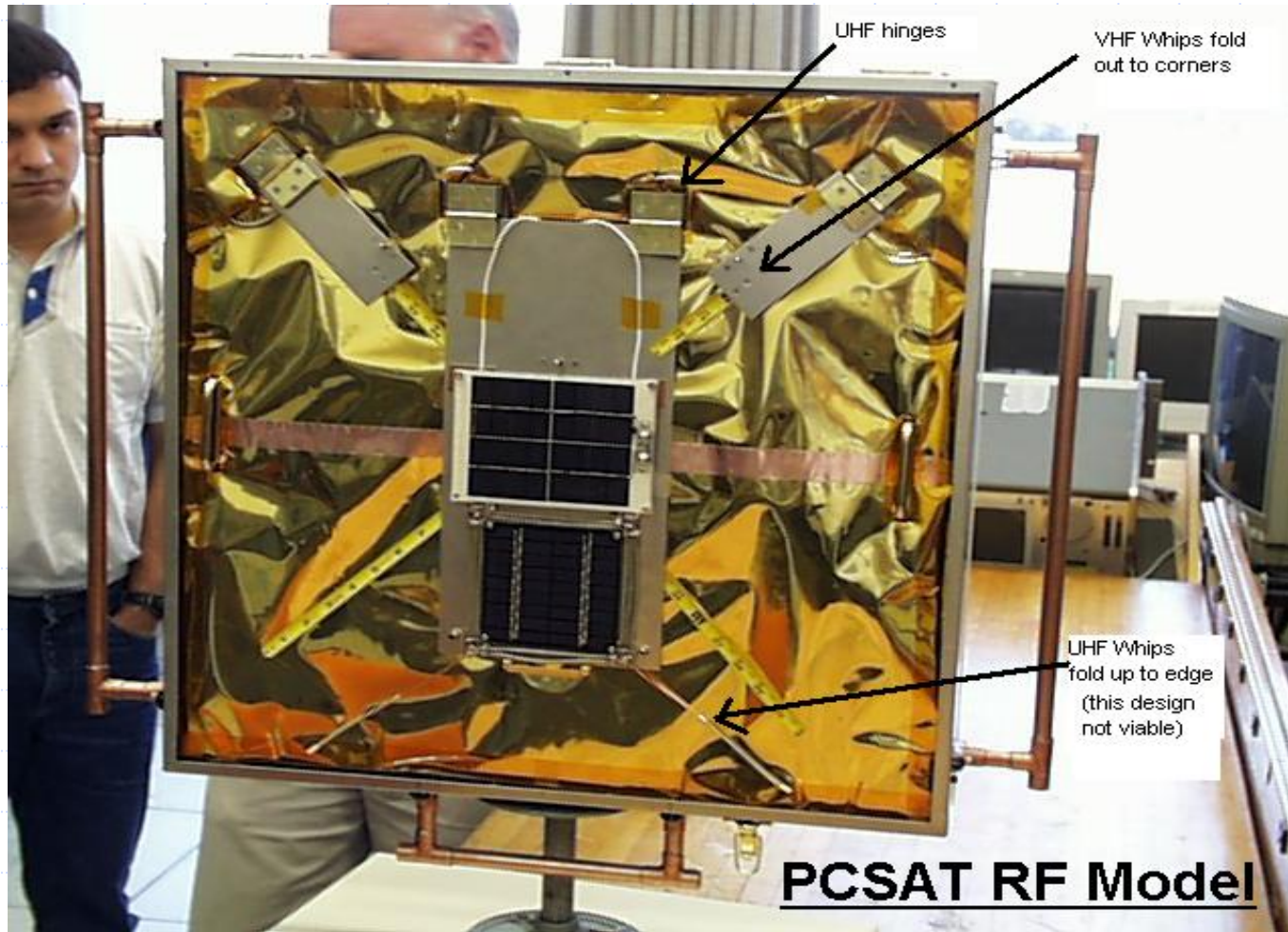
Technical descriptions of all emissions, codes, and formats must be made publicly available. No system intended to conceal the meaning of a transmission may be used.

All facilities, except telecommand, should be open for use by licensed amateur radio operators world-wide. All experiments should be freely available for use by radio amateurs world-wide and for reception by students and educators.

PCSAT2 COMMENT:

- **Voice Repeater, PSK-31 and AX.25 data Protocols.**
- **Full system design available on line WEB page.**

Our Solar Panel and Antennas



Not the final flight design

PCSAT2 Status:

- ◆ Integration Dec-2003 (complete)
- ◆ Thermal Vac, Jan-2003 (complete)
- ◆ Flight Vibration, Feb-2003 (complete)
- ◆ TQCM(outgassing), Mar 2003 (complete)
- ◆ Ship to KSC (TBD)
- ◆ MANIFEST on STS-114 1st return to flight currently scheduled for spring 2005.

Summary: Users will See:

PCSAT2 operations are fully coordinated with ARISS operations team:

- **APRS Packet downlink is on 435.275**
- **Optional PSK-31 downlink on 435.275 up 29.401**
- **Optional packet up/down on 145.825**
- **Optional Voice repeater on 437.975 up on 145.800**
- **OPTIONS COMMANDED ON THE GROUND**
- **User access dictated by User Service Agreement**