Laboratoř Experimentálních Družic
UREL FEKT VUT v Brně

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http://www.urel.feec.vutbr.cz/esl/

http://www.urel.feec.vutbr.cz/esl/files/Othact/U3V/7.pdf

IREL FEE and CS BUT



Telemetry and Command Station

AMSAT

Phase 3-D Spacecraft

CSG Kourou
Ariane 5



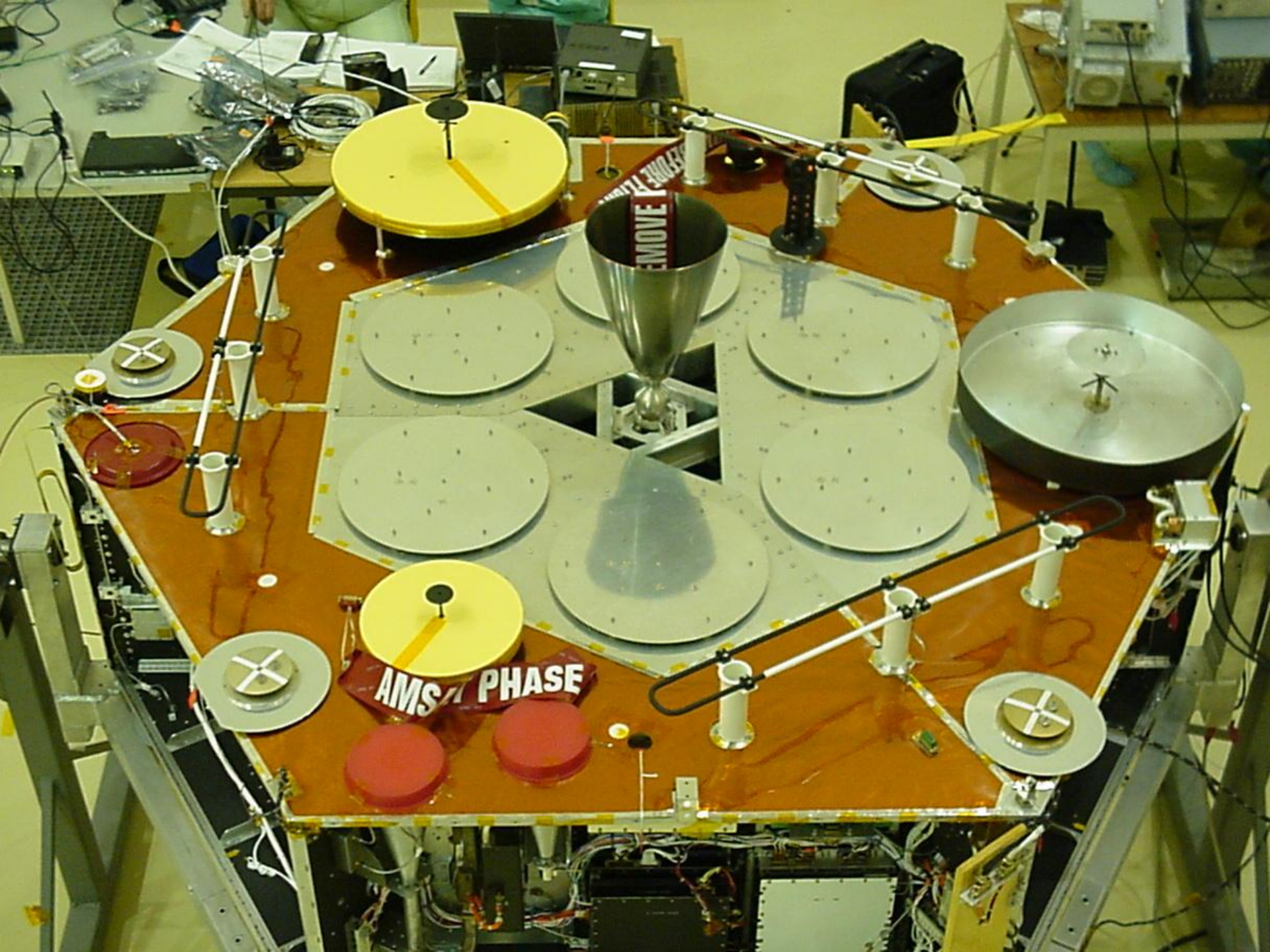
Miroslav Kasal

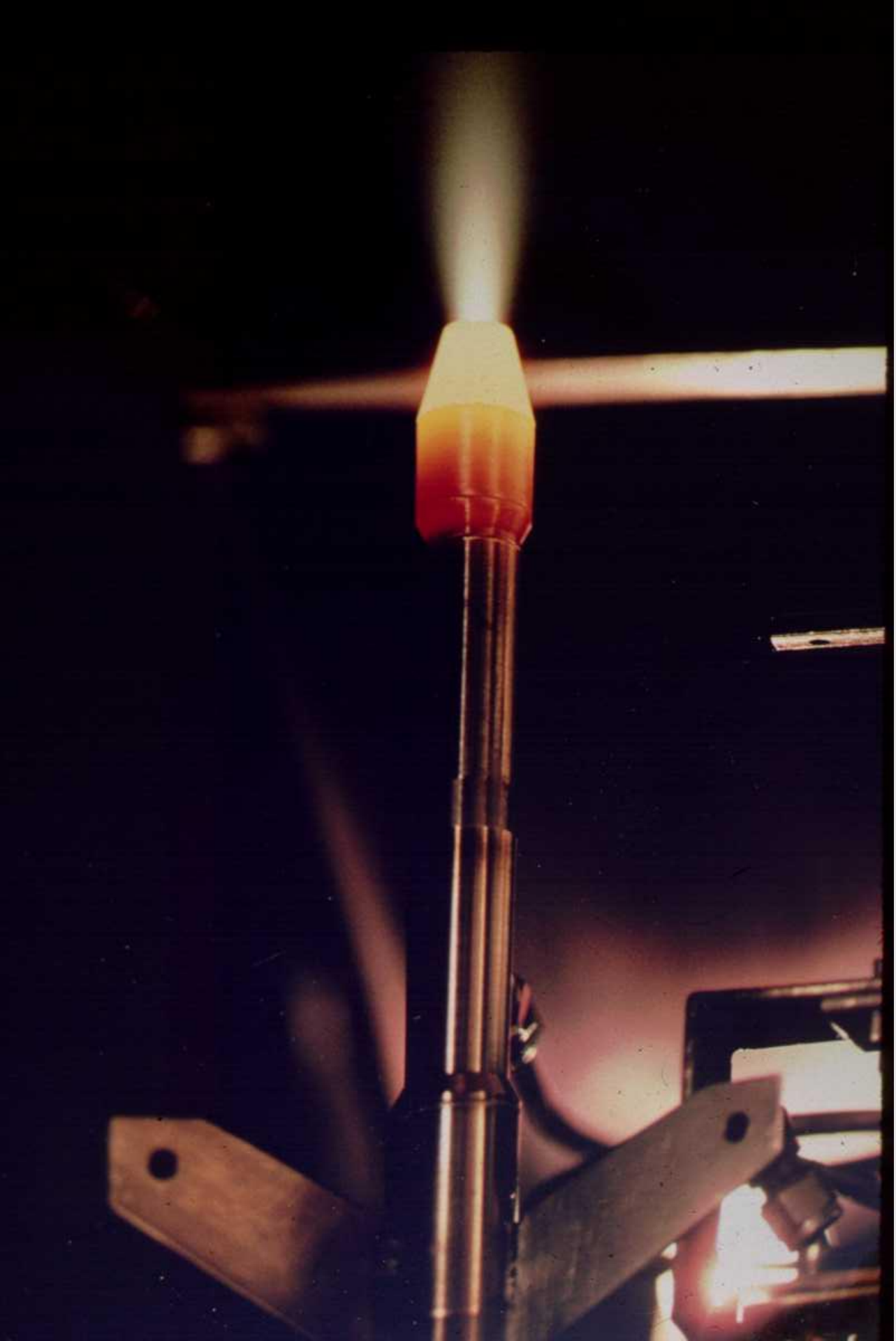
pictures: AMSAT-DL W.Gladisch

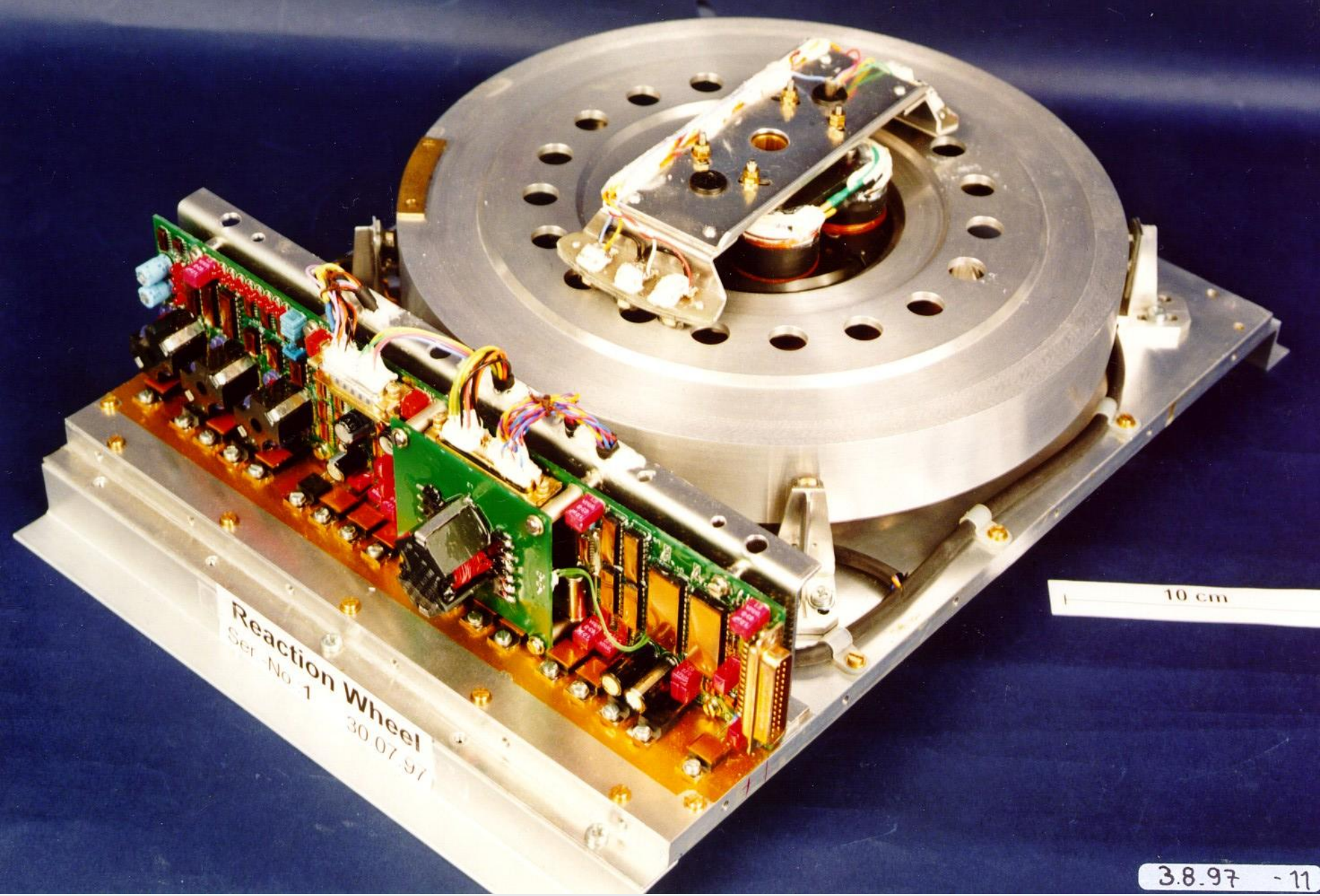
AMSAT P3D Satellite

Prof. Dr. Karl Meinzer

- Spin and three axis mode on HEO
- Momentum wheels with magnetic bearing
- Two high resolution color cameras
- GPS navigation system (NASA)
- Arcjet - plasma propulsion engine 0,1 N
- CEDEX
- Matrix transponder
- LASER experiment


PHASE




Reaction Wheel
Ser. No. 1
30.07.97
10 cm
3.8.97 - 11



AMSAT P3D
L-Band Receivers Arrangement



PREAMP 2

1269 MHz

PREAMP 1

F = 1,1 dB
G = 16 dB

DIVIDER

- 3 dB

Receiver 1
COMMAND

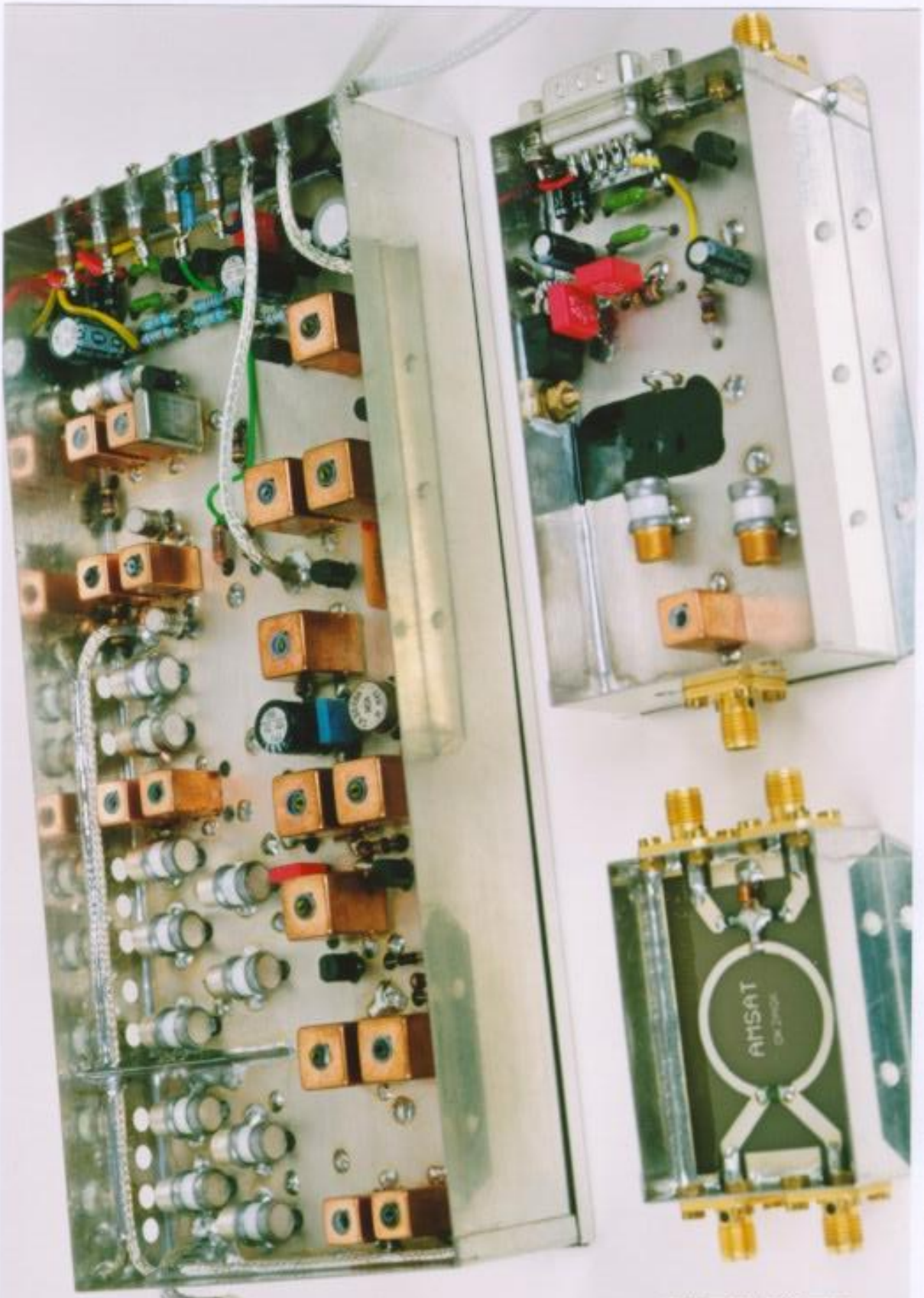
IHU

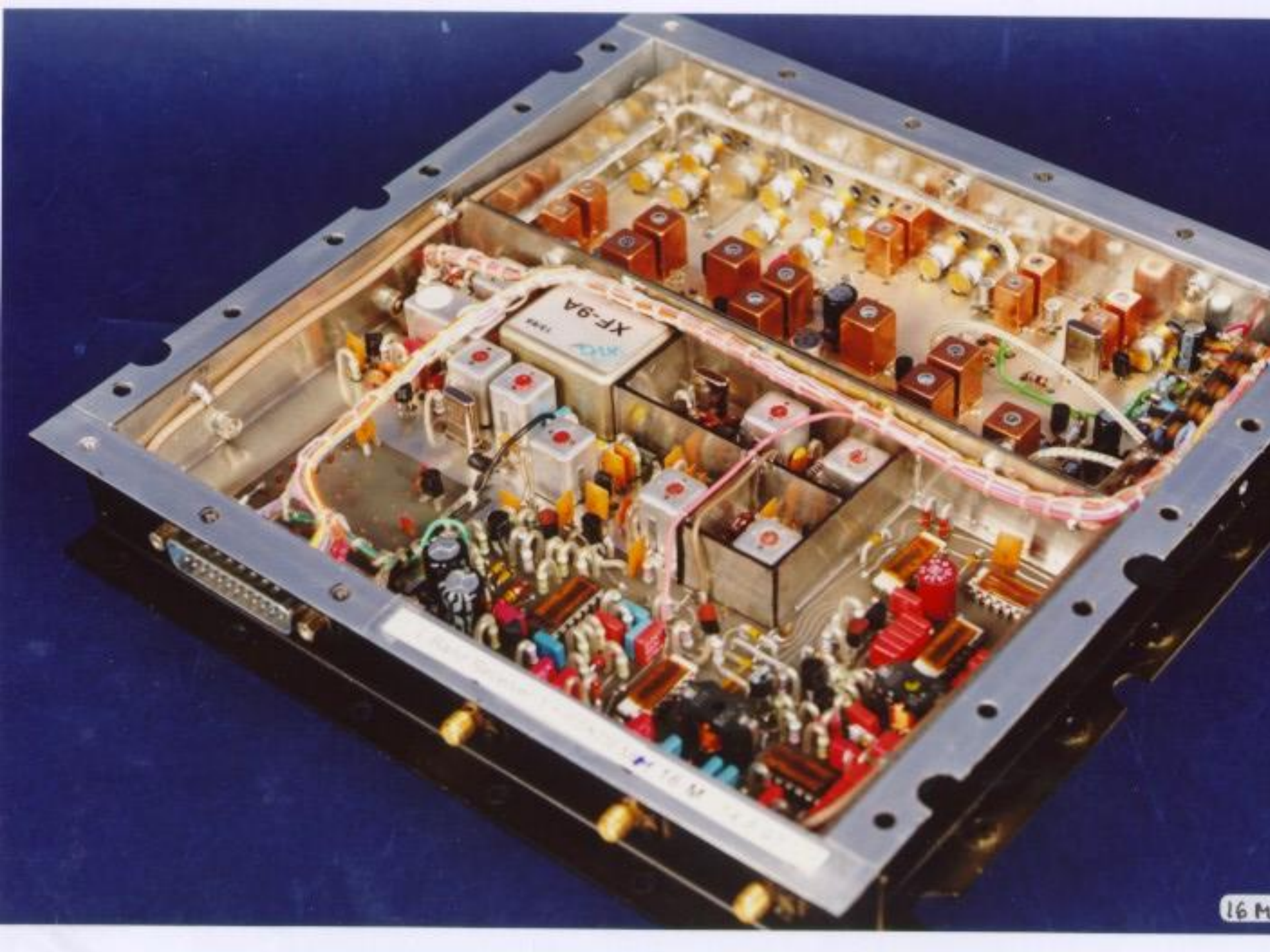
Receiver 2
MATRIX

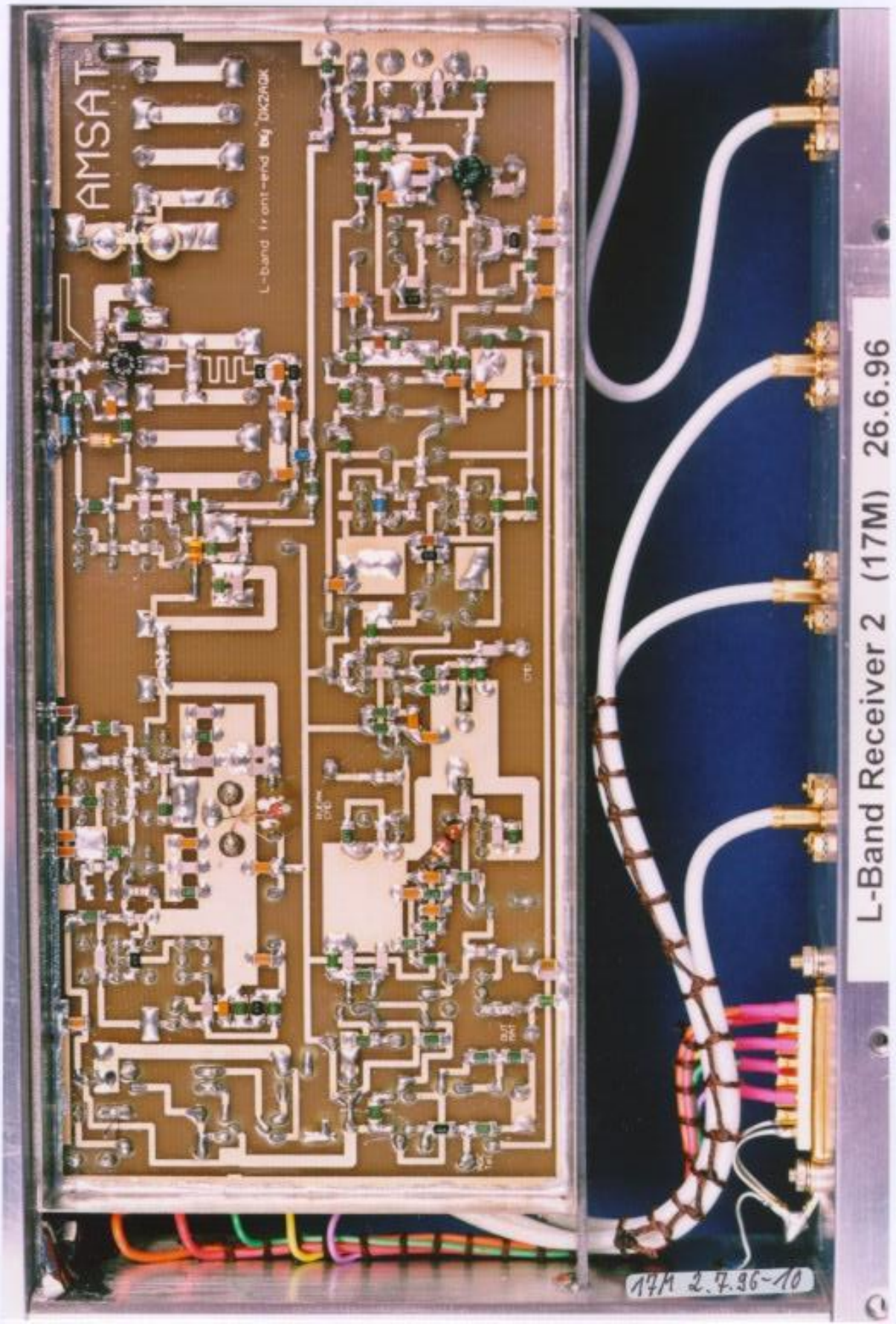
TRANSPONDER

G > 73 dB (AGC)

L Band Receiver 1 ComMand Detector 1 16 M

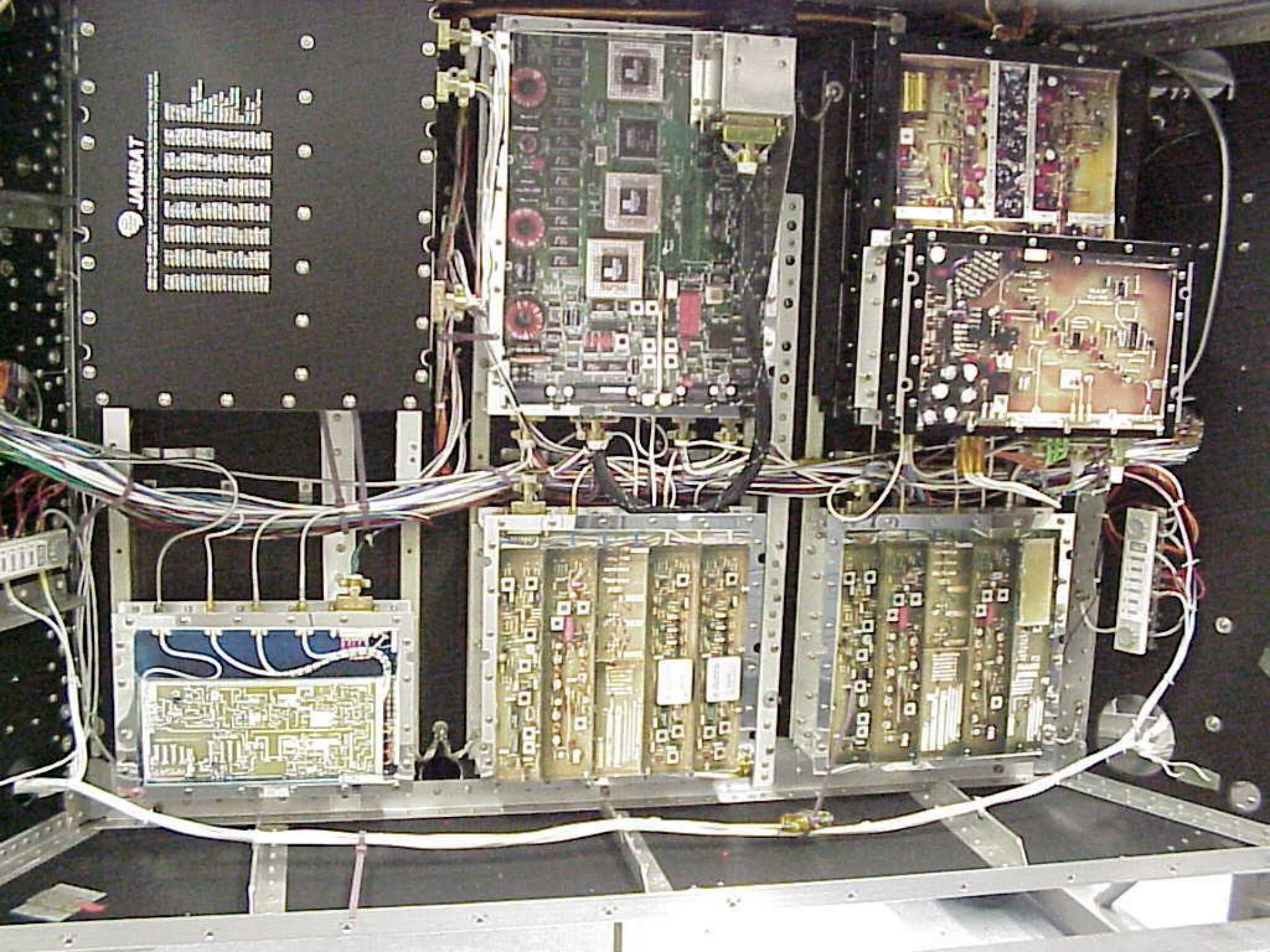


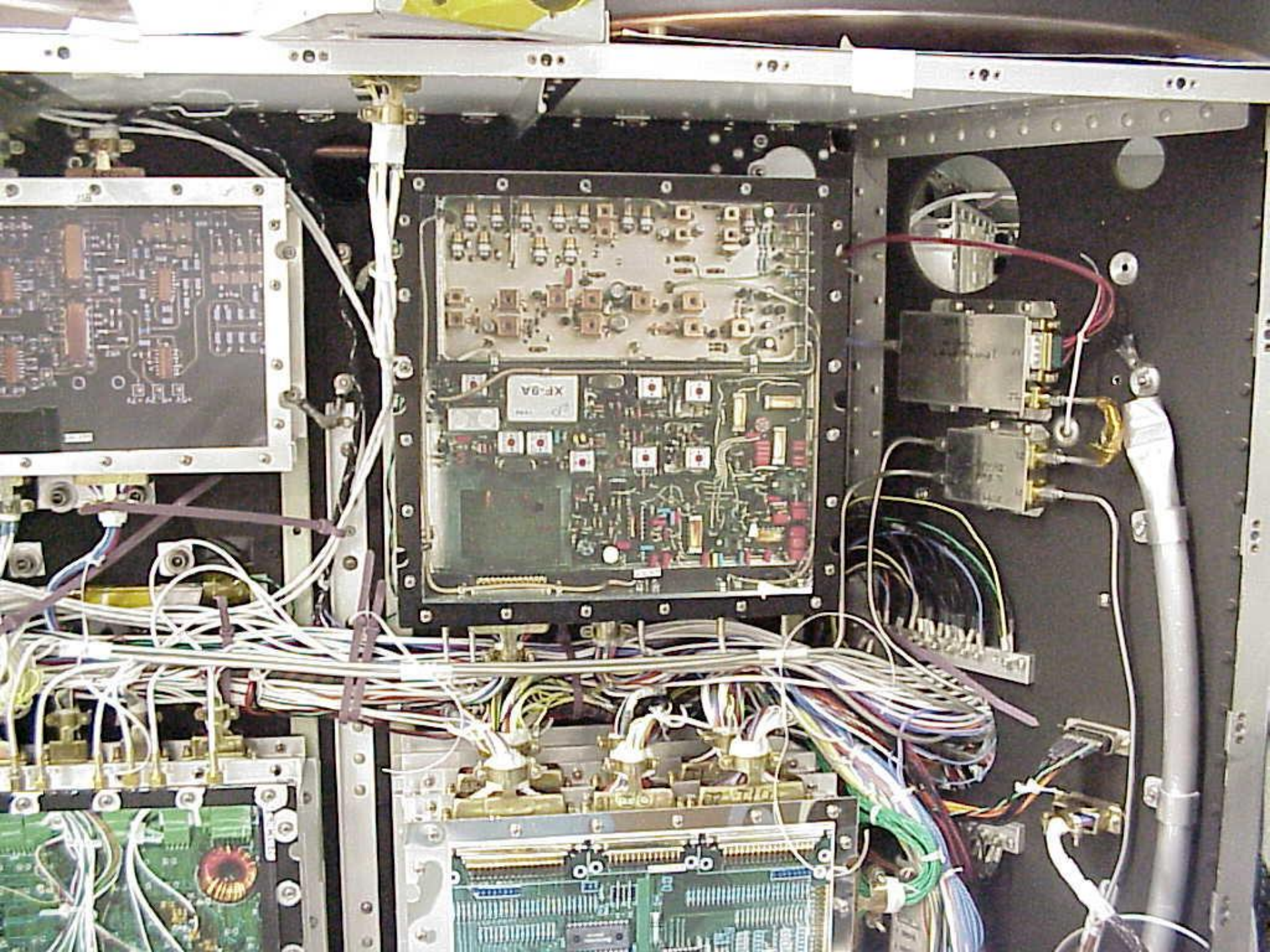

XF-9A

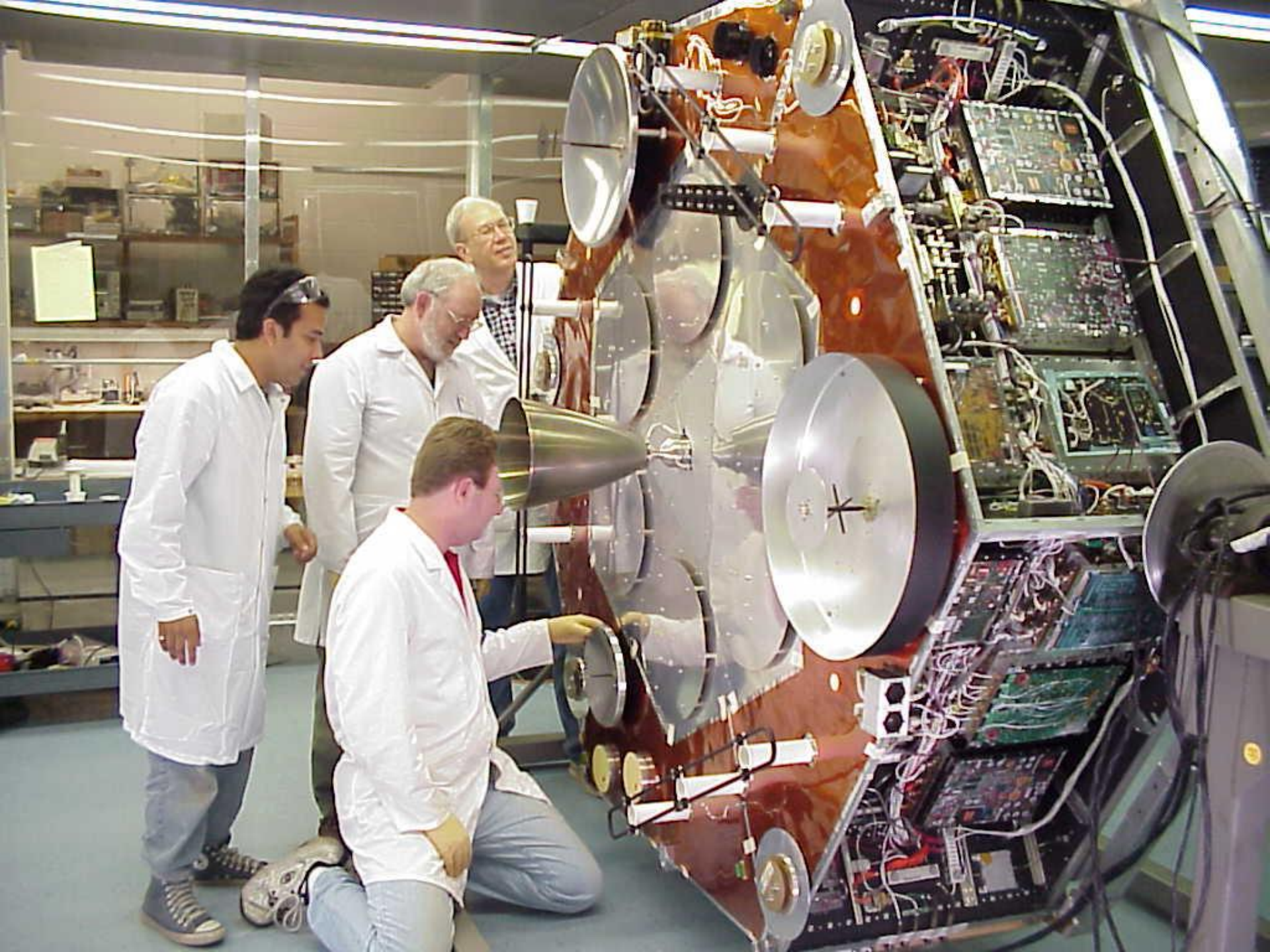

AMSAT
L-band front-end by DK2WAK
L-Band Receiver 2 (17M) 26.6.96
17M 2.7.96-10

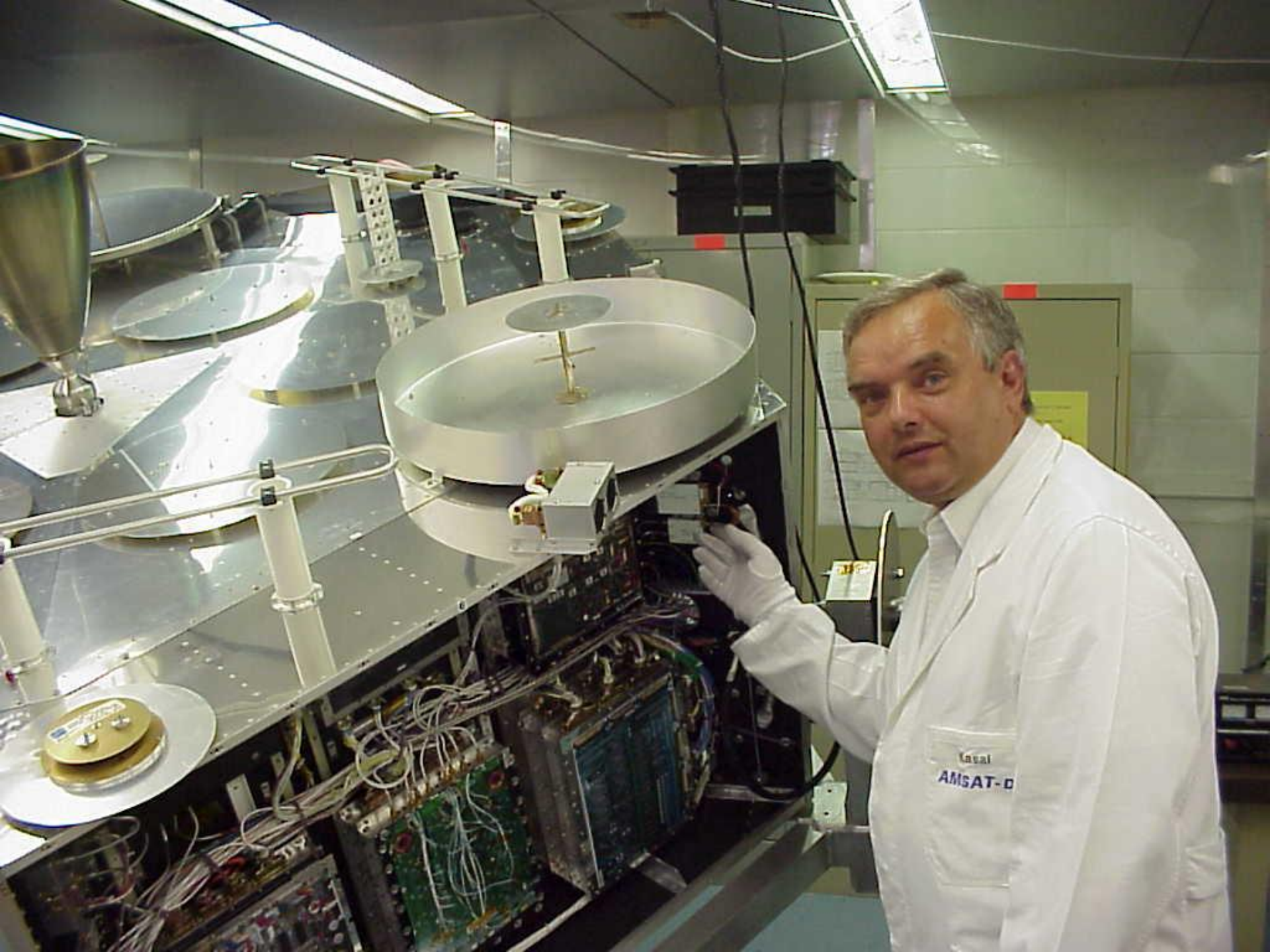

L-Band Receiver 2 (17M) 26.6.96
17M 2.7.96-3

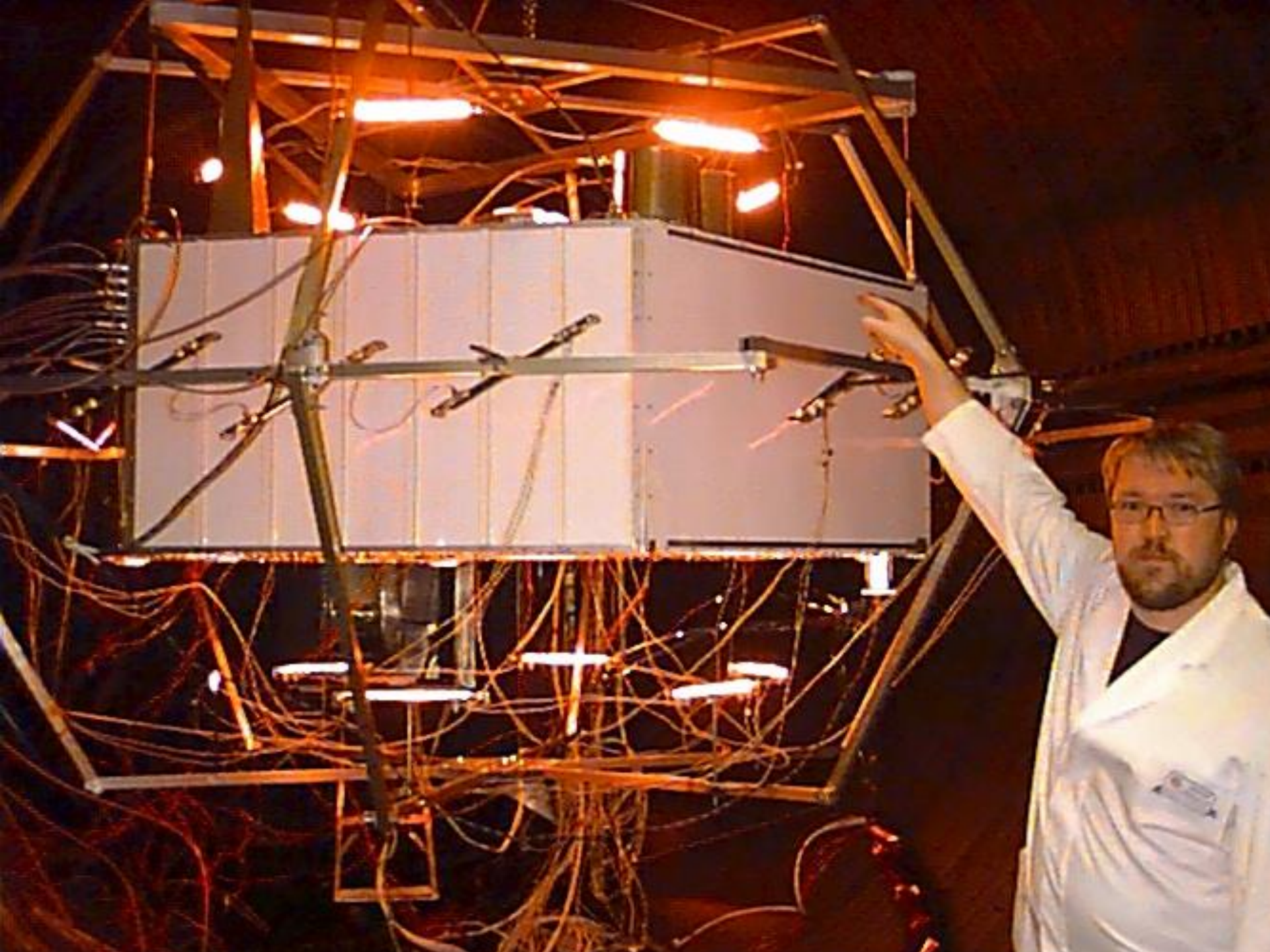


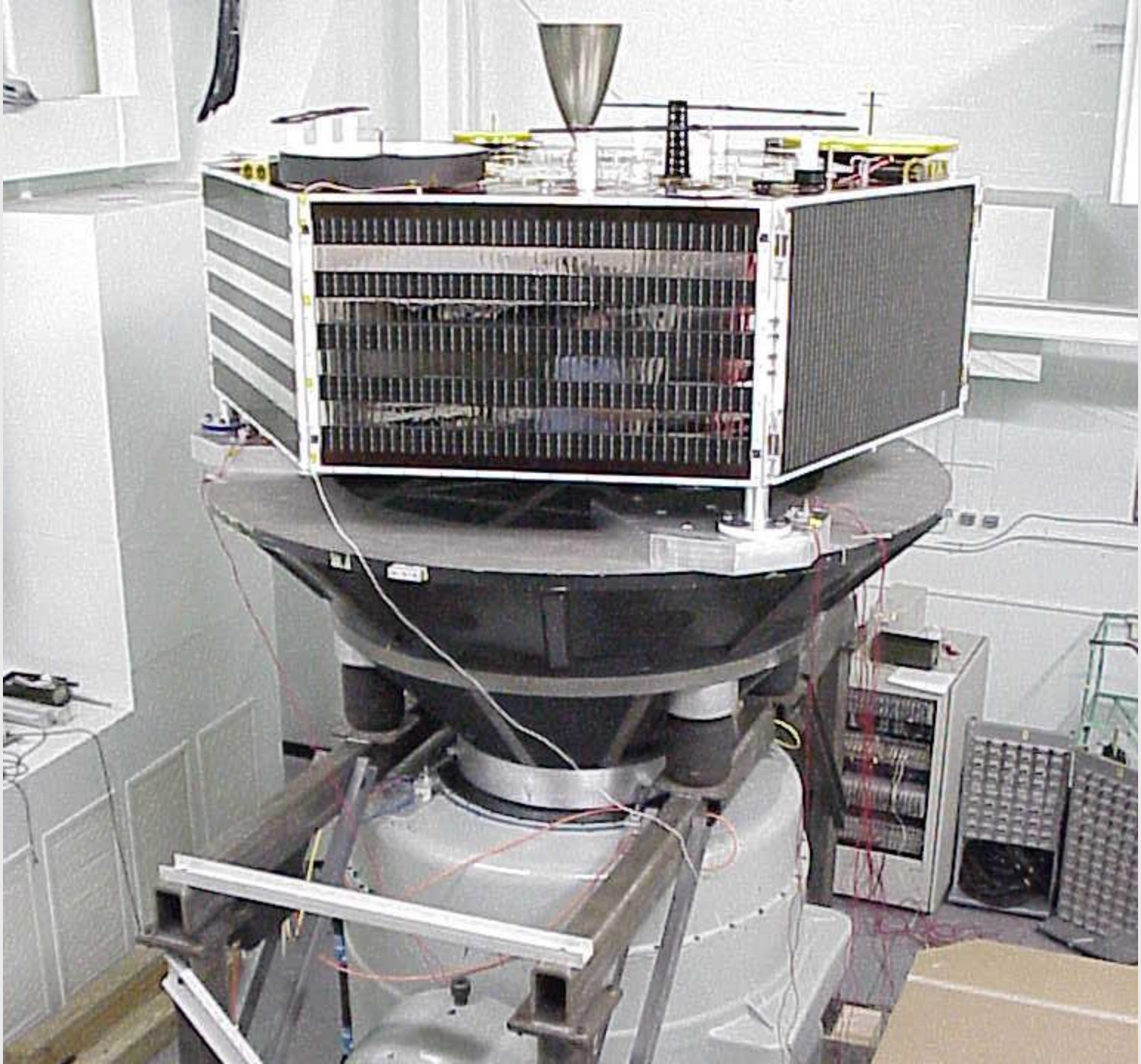

JAMSAT


XF-9A




AMSAT-






NORTH
ATLANTIC
OCEAN
Les Hattes
Mana
Moengo
Albina
Saint-Laurent
du Maroni
Saint-
Jean
Iracoubo
Sinnamary
Iles du
Salut
Kourou
Tonate
Cayenne
Iles
Remire
Macouria
Montsinéry
Matoury
Rémire
Roura
Gare Tigre
Saint-Elie
Apatou
Langatabiki
Maroni
Fleuve
Mana
Fleuve
Sinnamary
Comté
Rivière
Kaw
Régina
Guisanbourg
Baie de
L'Oyapok
Ouanary
Approuage
Fleuve
Rivière
Abounamy
Tapanahoni
Rivière
Grand
Santi
SAINT-LAURENT
DU MARONI
CAYENNE
Saint-Georges
Oiapoque
Clevelândia
do Norte
Lawa
Cottica
Maripasoula
Saül
Crique
Aratayé
Approuague
Fleuve
Oyapock
Fleuve
SURINAME
Anapaike
Rivière
Camopi
BRAZIL
Rivier
Tampok
Camopi
Litani
Rivière
Marouini
Rivière
Rivière
54
53
52
5
4
3
French Guiana
(FRANCE)
International boundary
Arrondissement boundary
Capital
Arrondissement capital
Railroad




HOTEL DES ROCHES
BIENVENUE




Bienvenue Welcome
CENTRE SPATIAL GUYANAIS
Port spatial de l'Europe
Europe's Spaceport
esa
cnes





Centre Spatial Guyanais

M17290

15/09/04

M

AMSAT DL

038653

MIROSLAV

KASAL

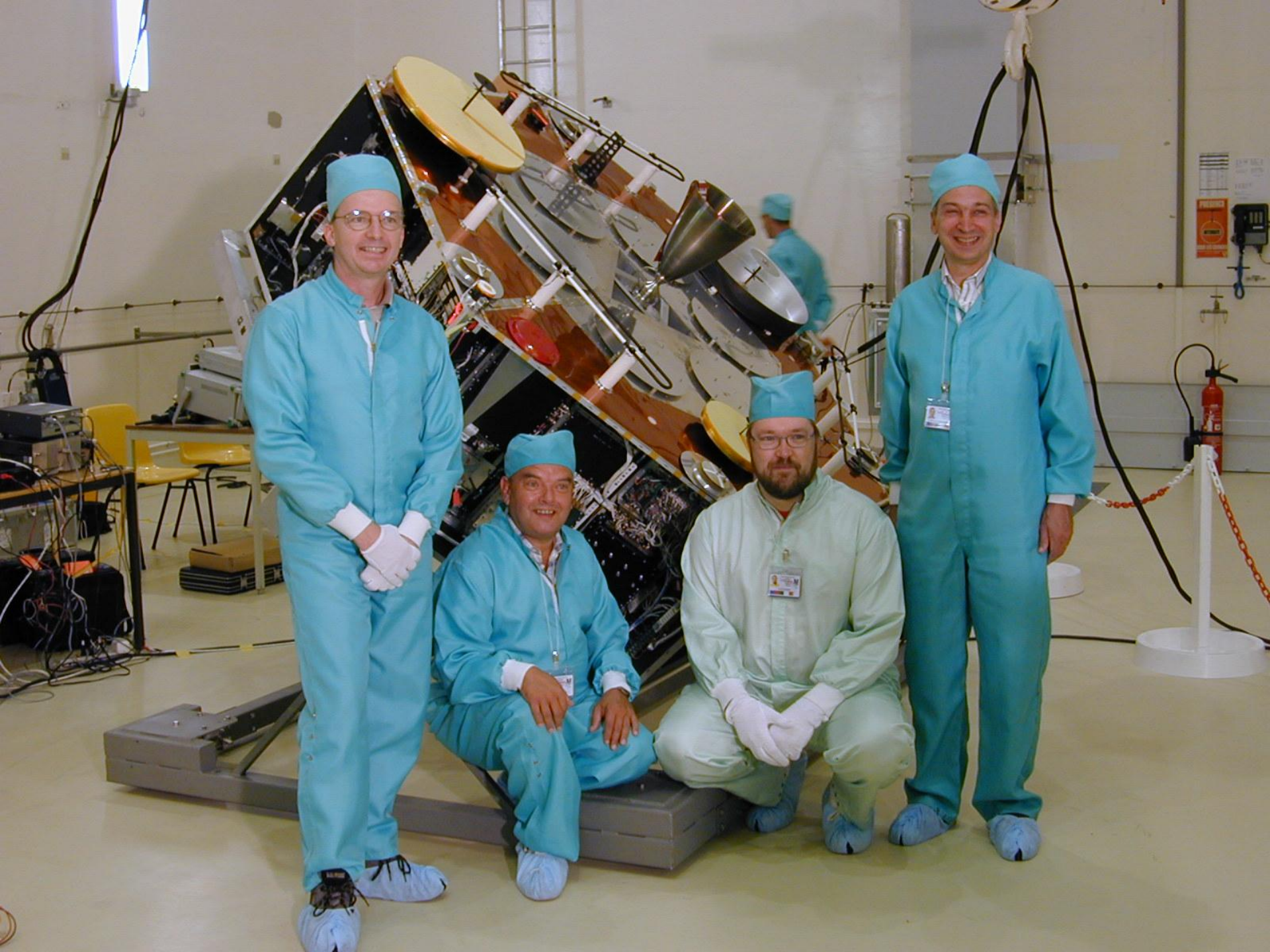

esa

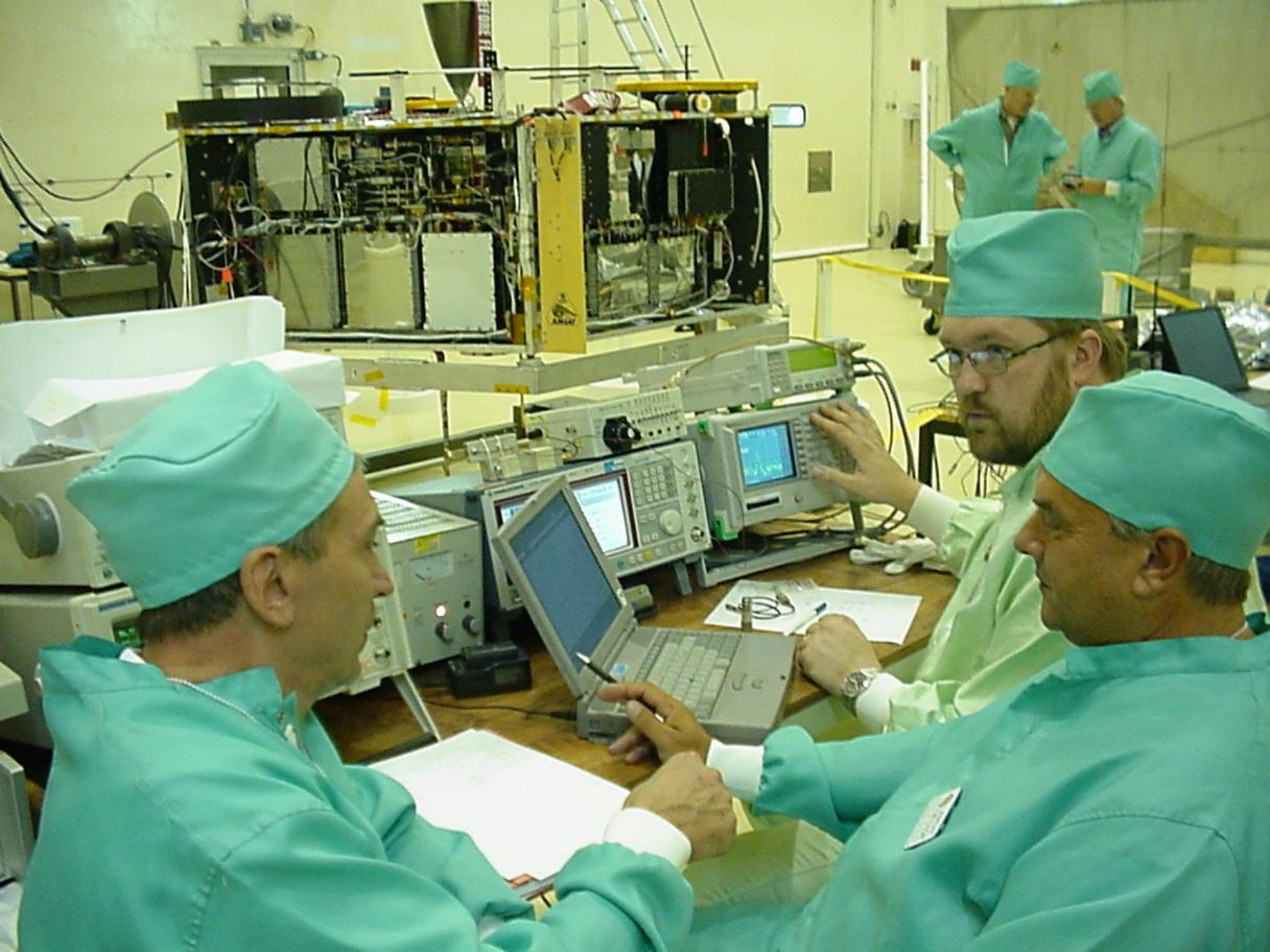

HAZARDOUS AREA
NO SMOKING
BEYOND THIS POINT
LALOYERU
60 80


esa
european space agency
agence spatiale européenne
S3A
BATIMENT REMPLISSAGE ET ASSEMBLAGE SATELLITE
SPACECRAFT FILLING AND ASSEMBLY BUILDING

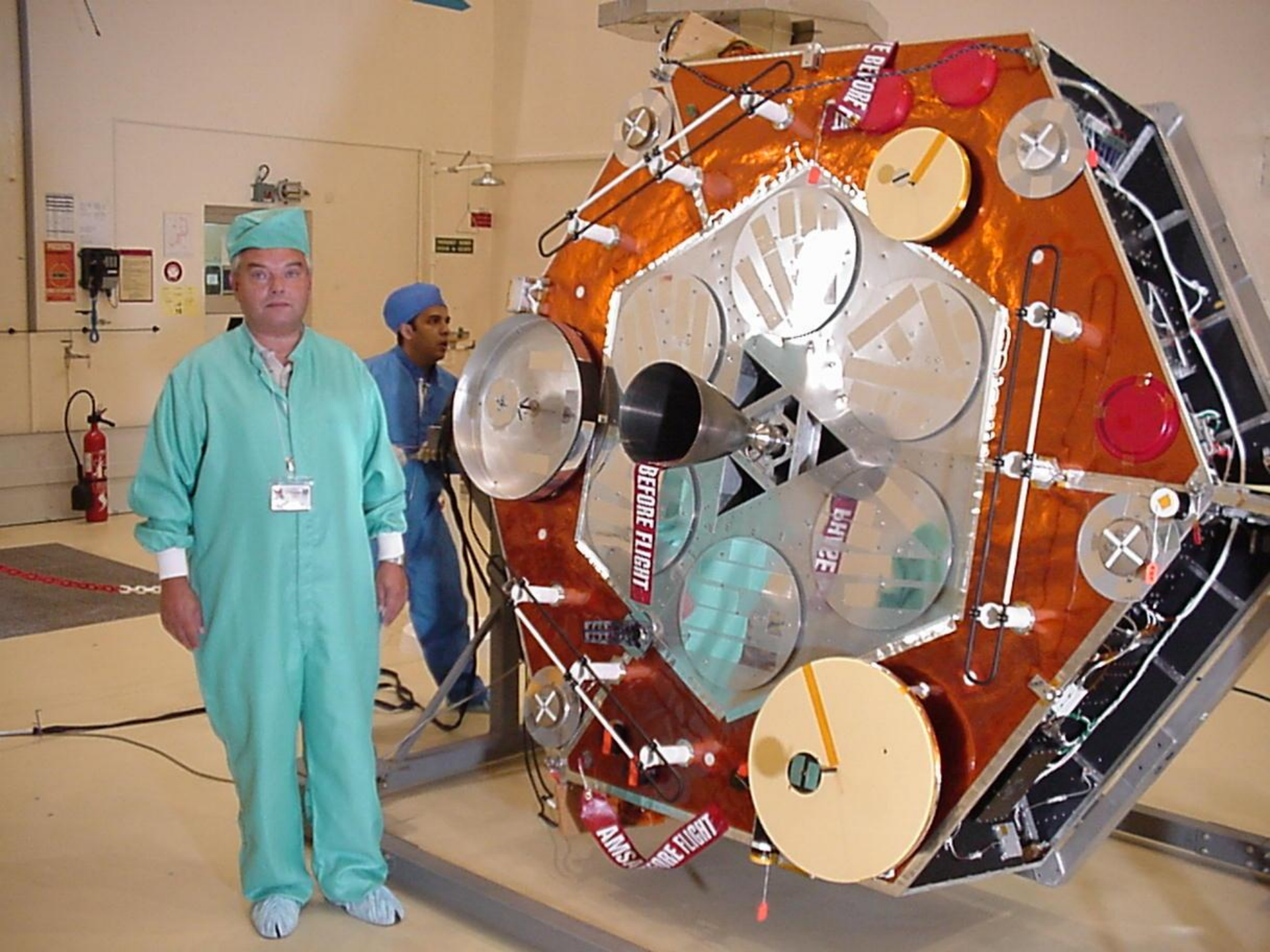

ENTREE S3A


B
BEFORE FLIGHT








BEFORE FLIGHT
BEFORE FLIGHT


ARAGO




esa
ariane
CENTRE DE LANCEMENT N°3




NEWTON




SERVICE SURETE PROTECTION
CYA17677









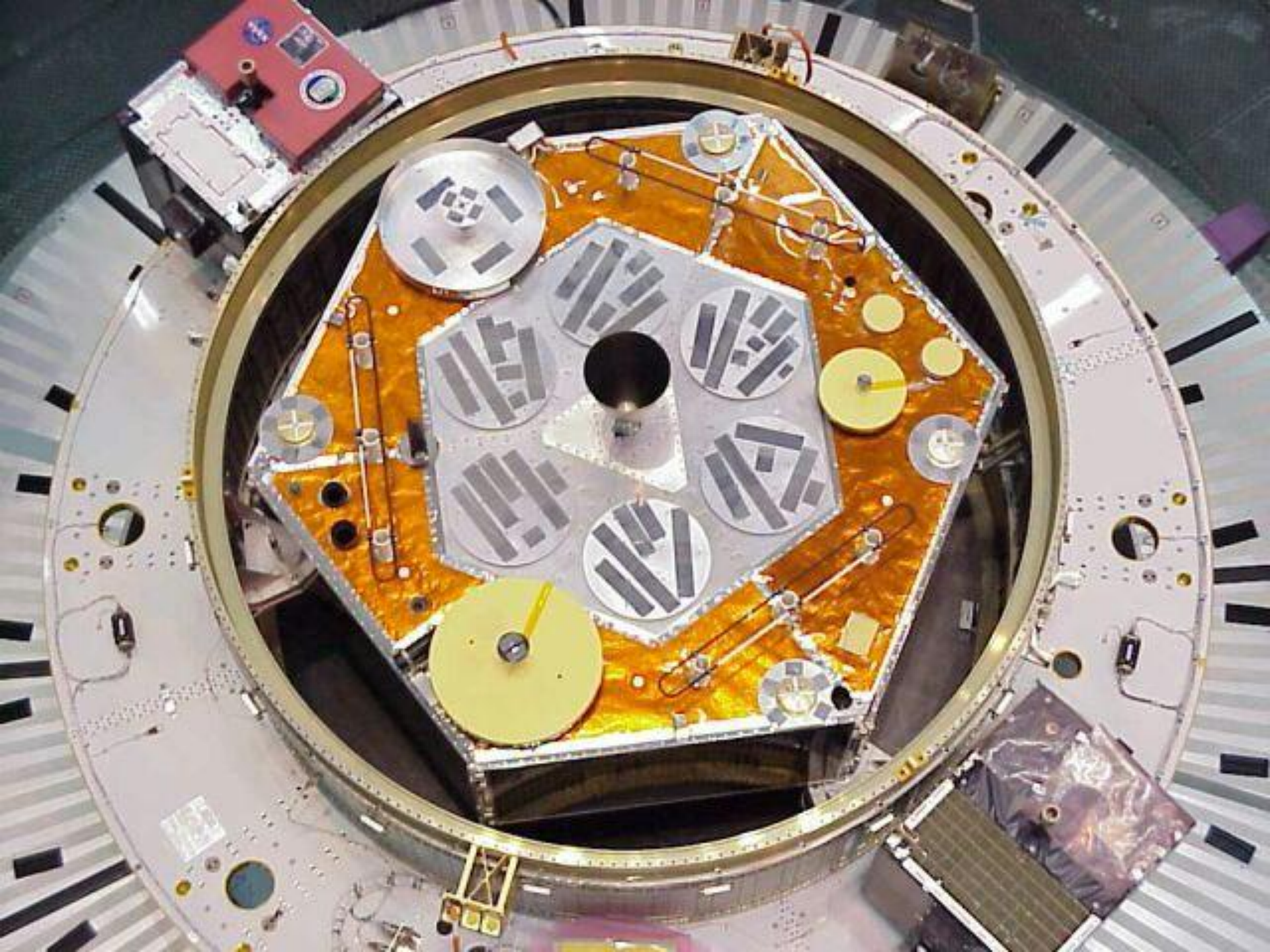

cnes
cnes

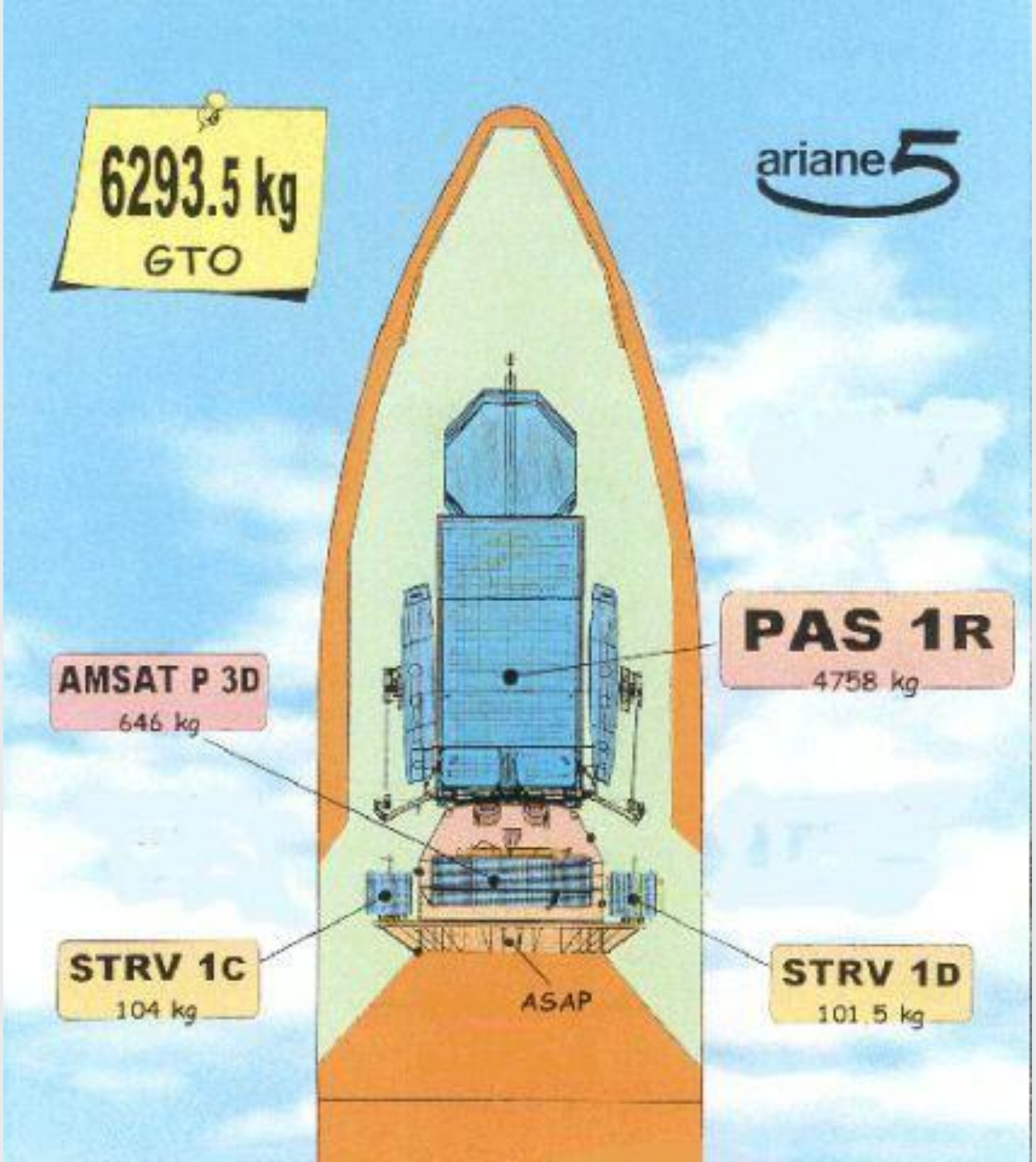

esa


esa
ariane
V 125








6293.5 kg
GTO
ariane 5
PAS 1R
4758 kg
AMSAT P 3D
646 kg
STRV 1C
104 kg
ASAP
STRV 1D
101.5 kg


AMSAT Office


02.12
PAS 1R
AMSAT P3D
Peter GULZOW
P3D Mission Director AMSAT
arianespace


01.40
arianespace

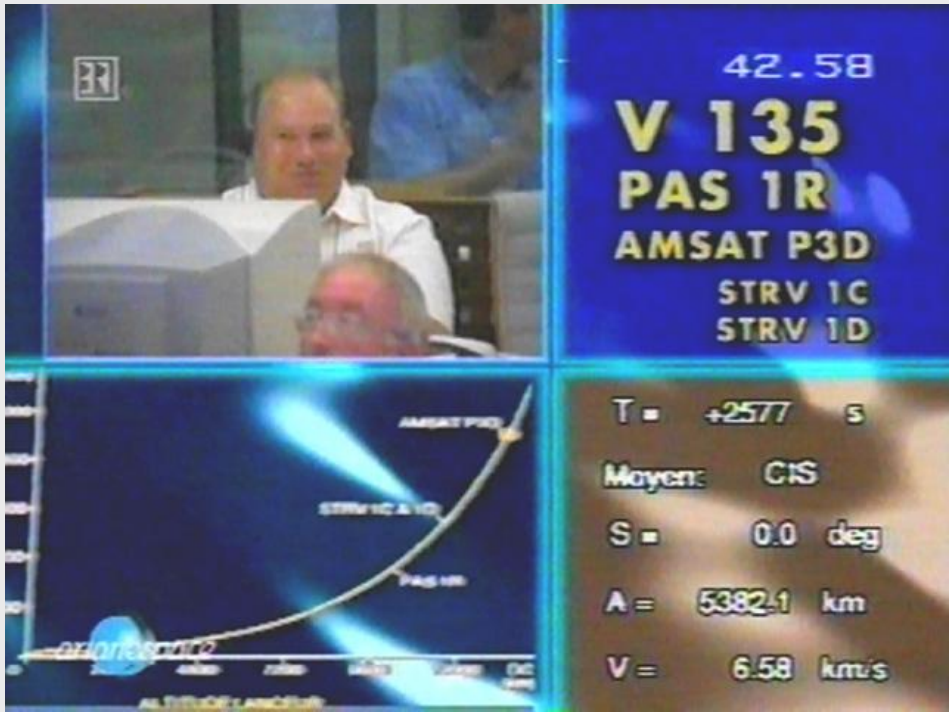

00.00
arianespace


00.08
arianespace

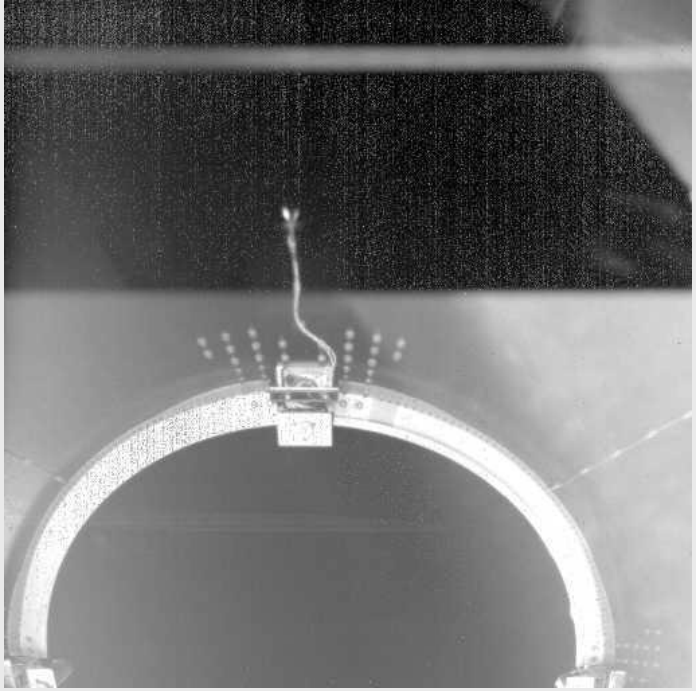

00.15
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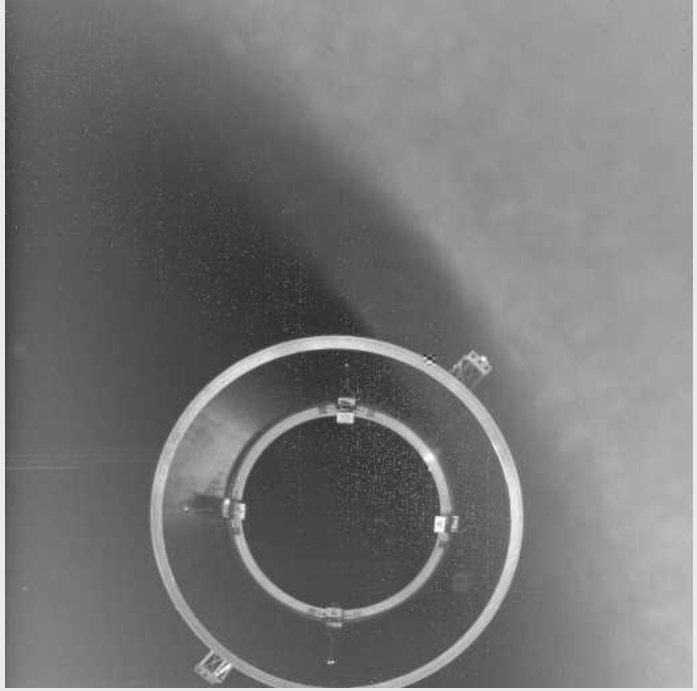

00.31
arianespace

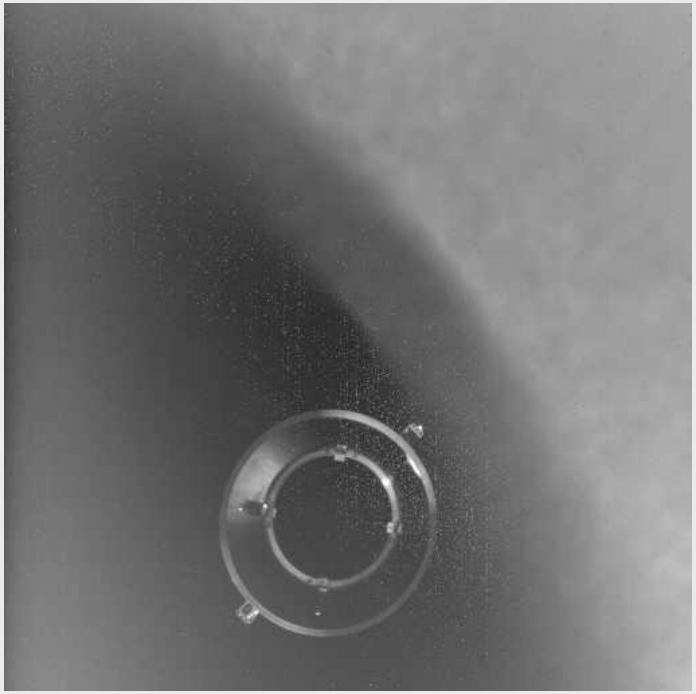

02.32
A = 73.6 km
V = 2.11 km/s
CINE
arianespace

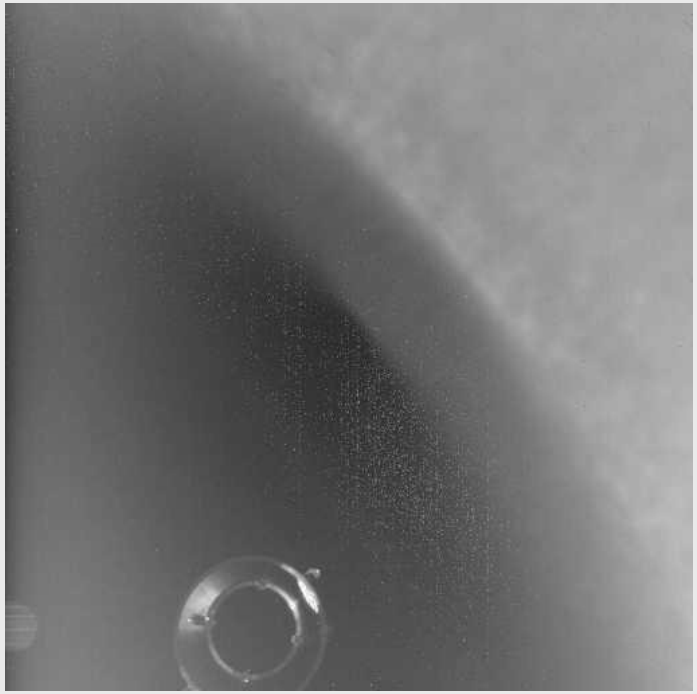

42.58
V 135
PAS 1R
AMSAT P3D
STRV 1C
STRV 1D
T = +2577 s
Moyen: CIS
S = 0.0 deg
A = 5382.1 km
V = 6.58 km/s
arianespace

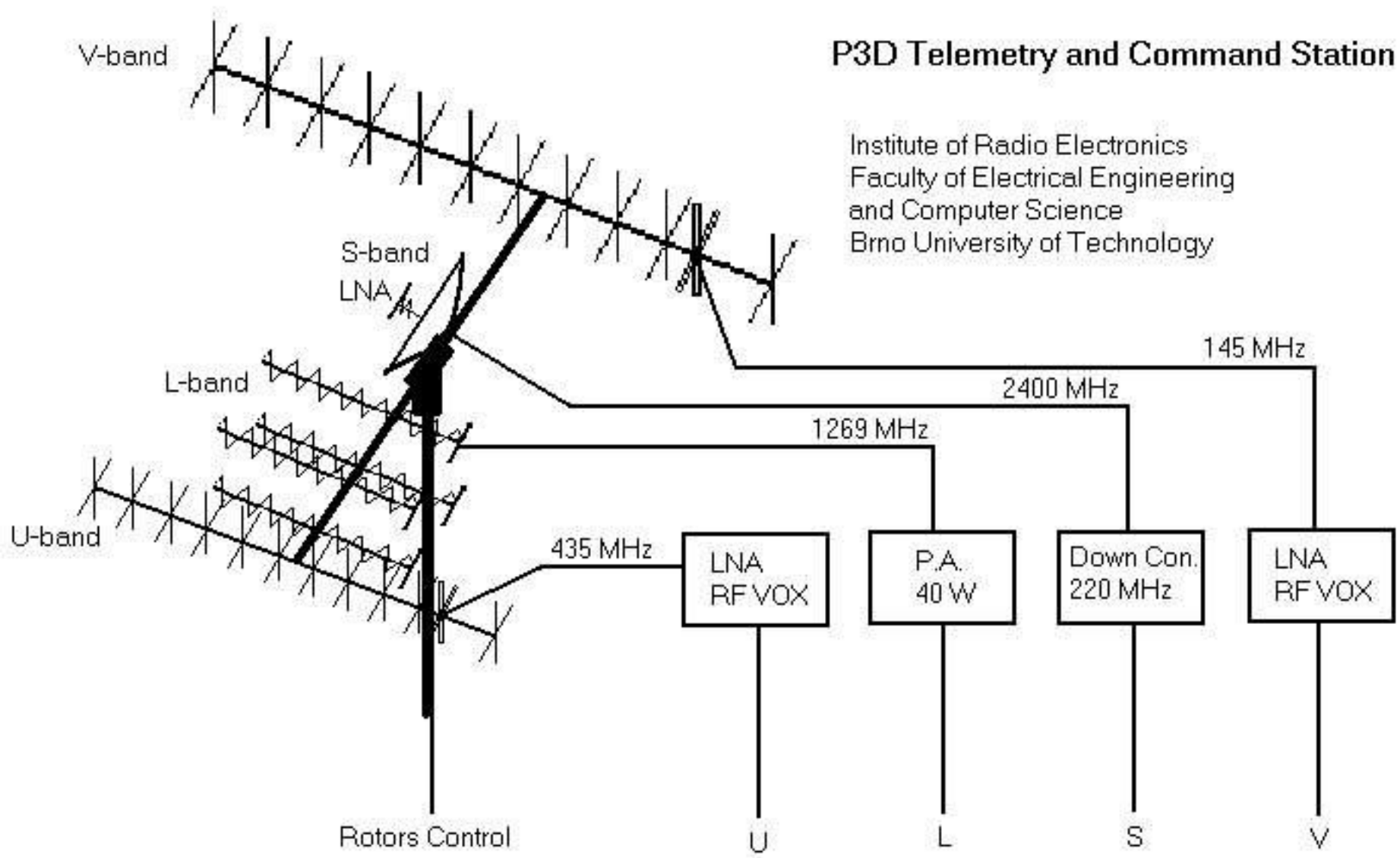

41.13
A = 4939.7 km
V = 6.78 km/s
arianespace





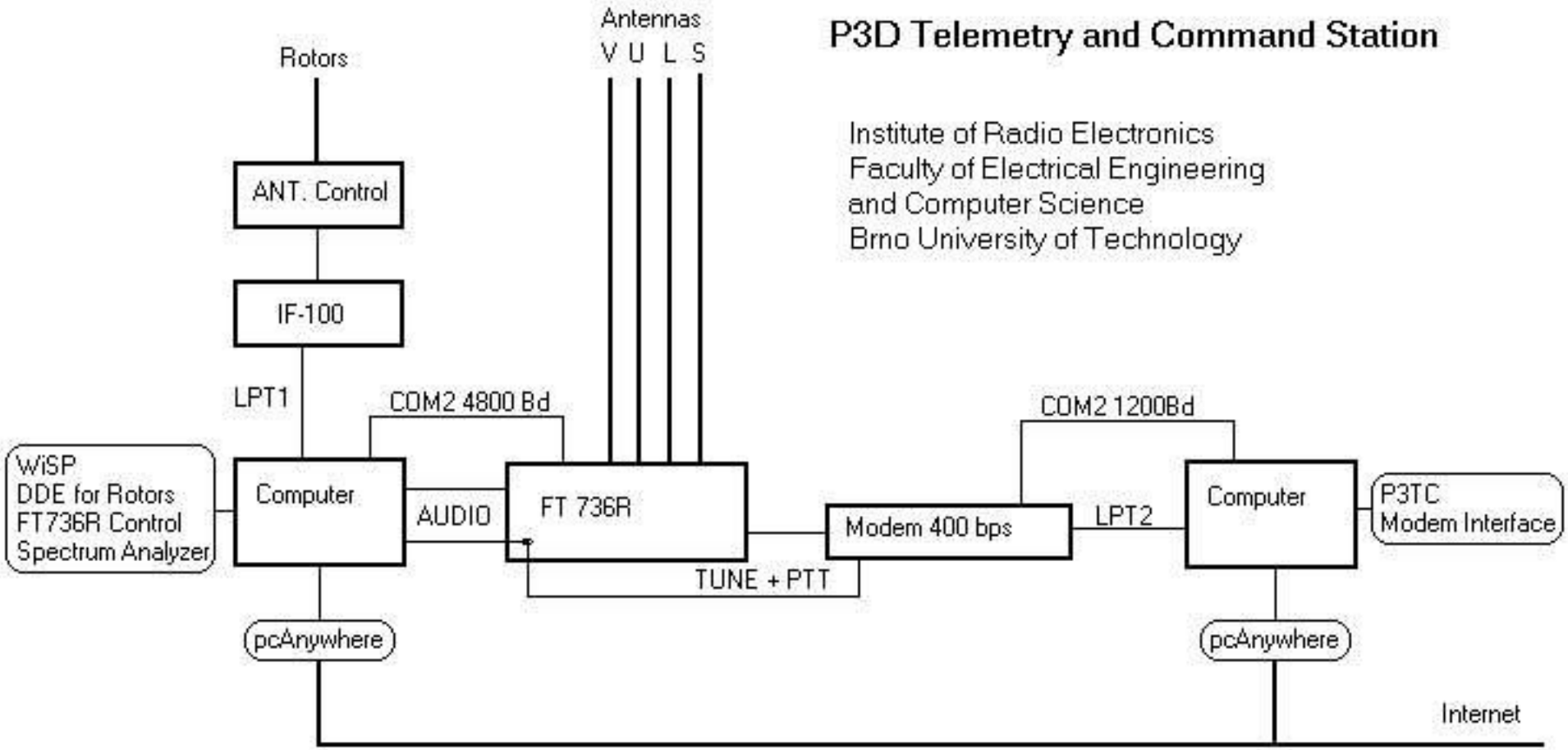


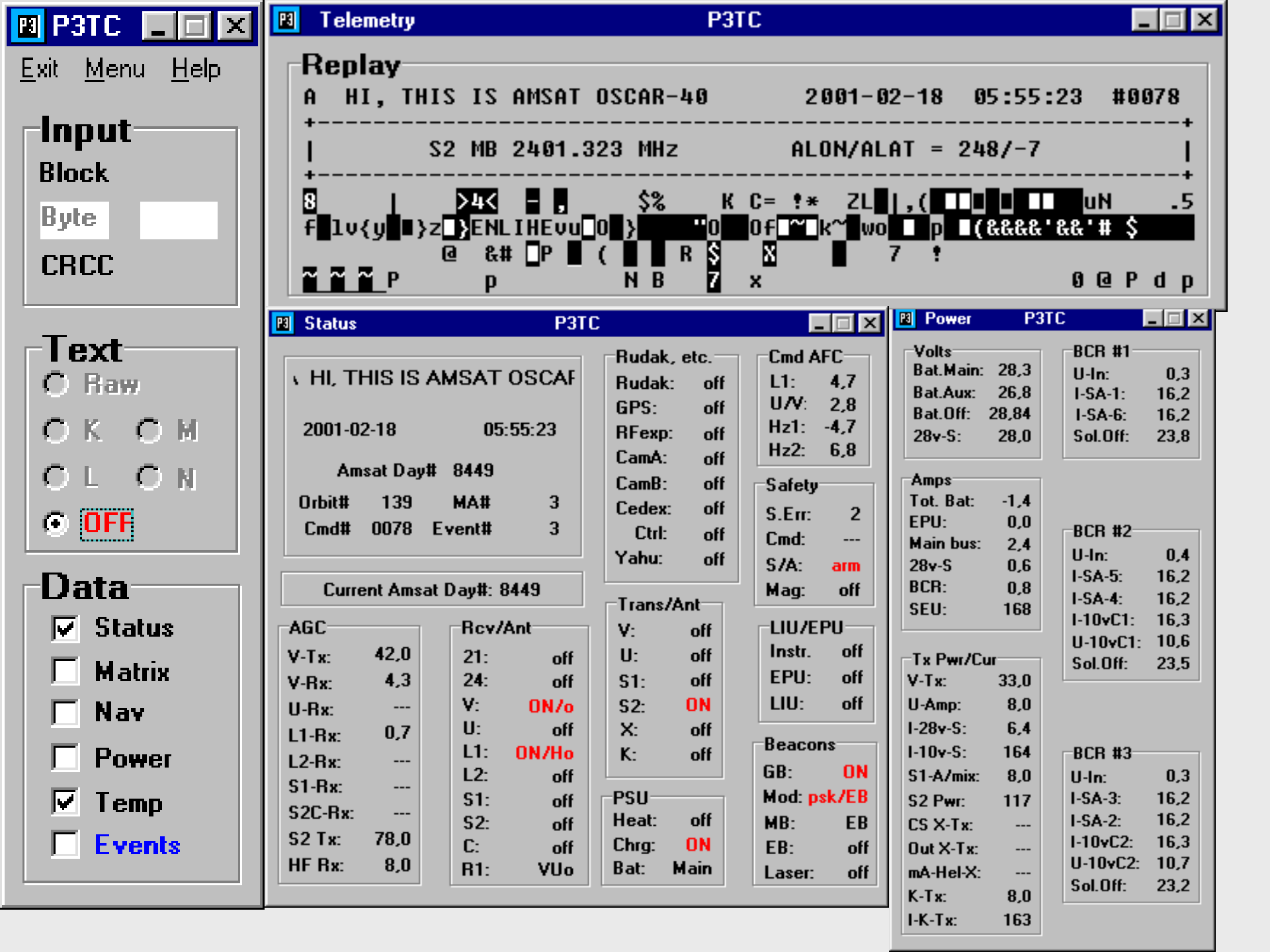



P3D Telemetry and Command Station
Institute of Radio Electronics
Faculty of Electrical Engineering
and Computer Science
Brno University of Technology
V-band
S-band
LNA
L-band
U-band
145 MHz
2400 MHz
1269 MHz
435 MHz
LNA
RF VOX
P.A.
40 W
Down Con.
220 MHz
LNA
RF VOX
Rotors Control
U
L
S
V

P3D Telemetry and Command Station

Institute of Radio Electronics
Faculty of Electrical Engineering
and Computer Science
Brno University of Technology

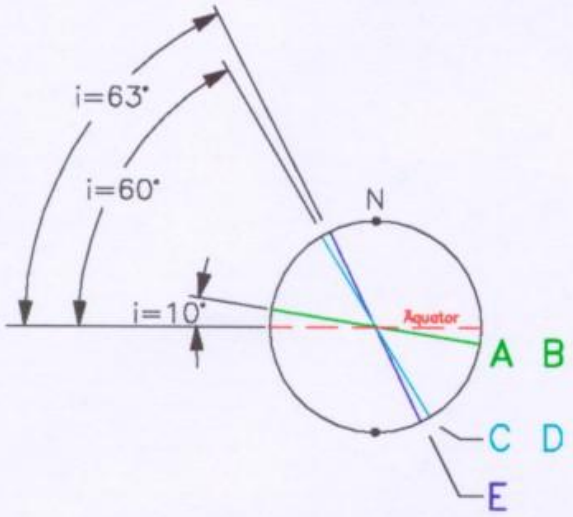


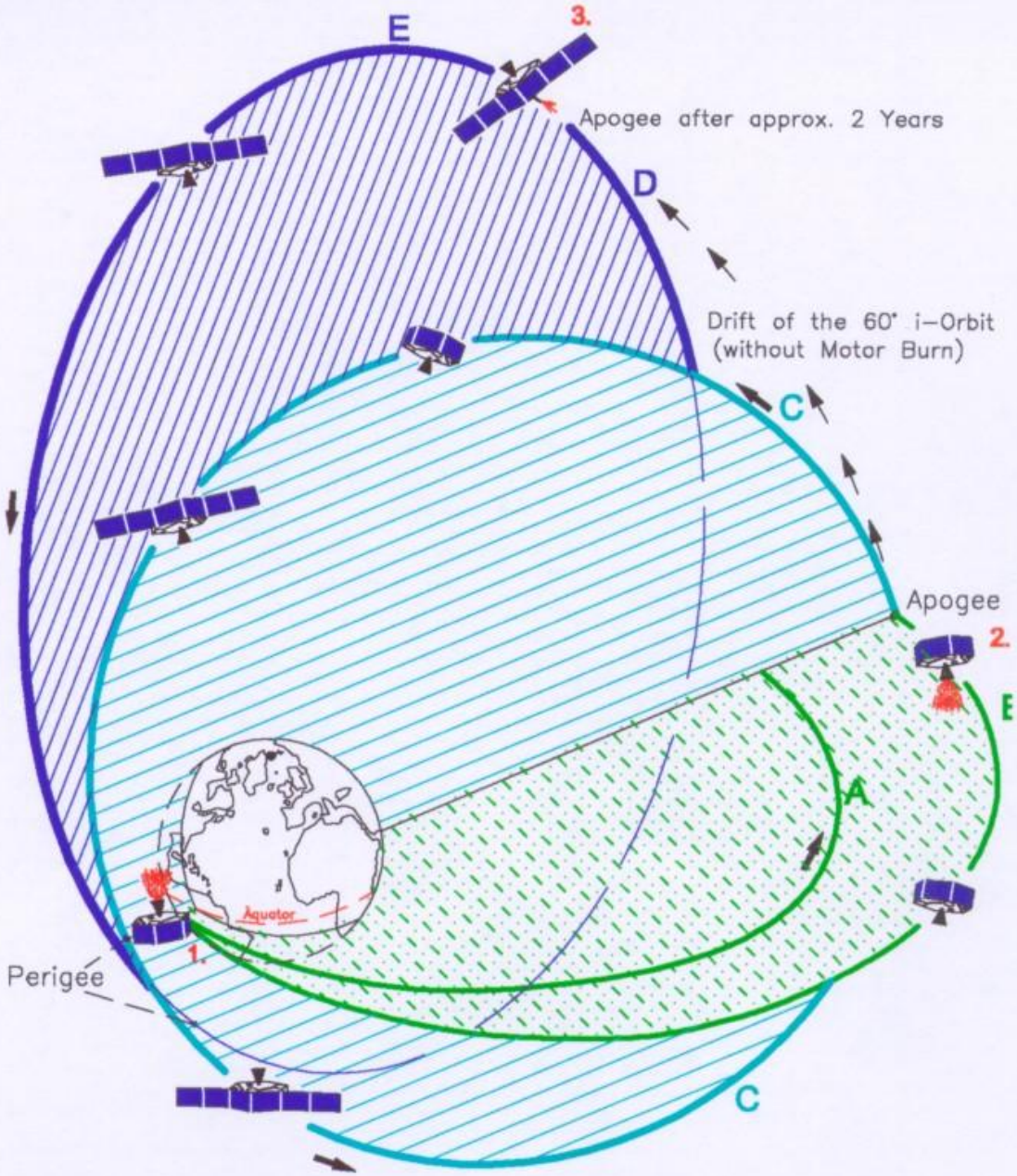

P3TC
Exit Menu Help
Input
Block
Byte
CRCC
Text
Raw
K M
L N
OFF
Data
Status
Matrix
Nav
Power
Temp
Events
Telemetry P3TC
Replay
A HI, THIS IS AMSAT OSCAR-40 2001-02-18 05:55:23 #0078
S2 MB 2401.323 MHz ALON/ALAT = 248/-7
Status P3TC
HI, THIS IS AMSAT OSCAF
2001-02-18 05:55:23
Amsat Day# 8449
Orbit# 139 MA# 3
Cmd# 0078 Event# 3
Current Amsat Day#: 8449
AGC
V-Tx: 42,0
V-Rx: 4,3
U-Rx: ---
L1-Rx: 0,7
L2-Rx: ---
S1-Rx: ---
S2C-Rx: ---
S2 Tx: 78,0
HF Rx: 8,0
Rcv/Ant
21: off
24: off
V: ON/o
U: off
L1: ON/Ho
L2: off
S1: off
S2: off
C: off
R1: VUo
Rudak, etc.
Rudak: off
GPS: off
RFexp: off
CamA: off
CamB: off
Cedex: off
Ctrl: off
Yahu: off
Trans/Ant
V: off
U: off
S1: off
S2: ON
X: off
K: off
PSU
Heat: off
Chrg: ON
Bat: Main
Cmd AFC
L1: 4,7
U/V: 2,8
Hz1: -4,7
Hz2: 6,8
Safety
S.Err: 2
Cmd: ---
S/A: arm
Mag: off
LIU/EPU
Instr. off
EPU: off
LIU: off
Beacons
GB: ON
Mod: psk/EB
MB: EB
EB: off
Laser: off
Power P3TC
Volts
Bat.Main: 28,3
Bat.Aux: 26,8
Bat.Off: 28,84
28v-S: 28,0
Amps
Tot. Bat: -1,4
EPU: 0,0
Main bus: 2,4
28v-S 0,6
BCR: 0,8
SEU: 168
Tx Pwr/Cur
V-Tx: 33,0
U-Amp: 8,0
I-28v-S: 6,4
I-10v-S: 164
S1-A/mix: 8,0
S2 Pwr: 117
CS X-Tx: ---
Out X-Tx: ---
mA-Hel-X: ---
K-Tx: 8,0
I-K-Tx: 163
BCR #1
U-In: 0,3
I-SA-1: 16,2
I-SA-6: 16,2
Sol.Off: 23,8
BCR #2
U-In: 0,4
I-SA-5: 16,2
I-SA-4: 16,2
I-10vC1: 16,3
U-10vC1: 10,6
Sol.Off: 23,5
BCR #3
U-In: 0,3
I-SA-3: 16,2
I-SA-2: 16,2
I-10vC2: 16,3
U-10vC2: 10,7
Sol.Off: 23,2

Motor Burns

Orbit	Incli-nation	Distance from Earth (km) Perigee	Apogee
A	i=10°	500	35000
B	i=10°	500	47000
C	i=60°	4000	47000
Drift without Motor Burn			
D	i=60°	4000	47000
E	i=63,4° stable Orbit	4000	47000

1. 400N
2. 400N
3. ATOS





AO-40 on 13. 12. 2000 at 11:20 UTC
by M. Kasal

1. by James R. Miller based on ranging after 1. burn Attempt #2 (12. 12. 2000):

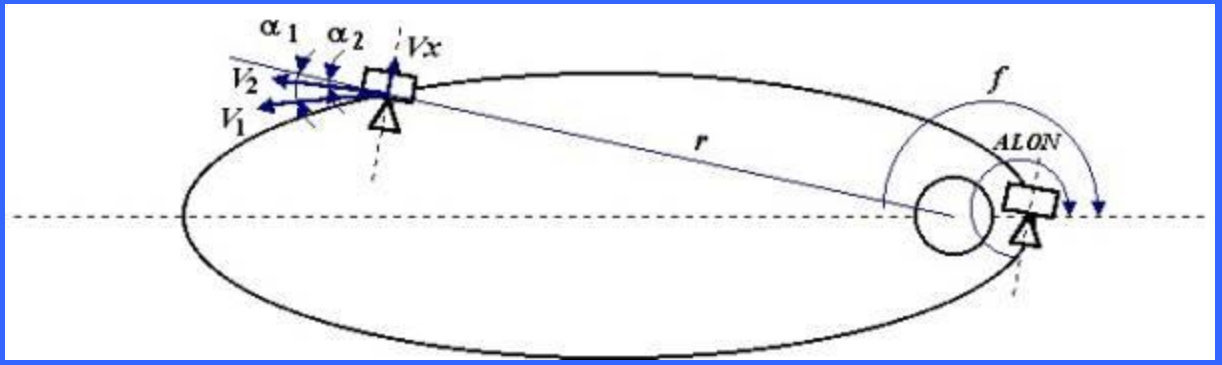
```
AO-40
1 26609U 00072B   00346.67280000  .00000000  00000-0  00000-0 0    89
2 26609   6.4207 239.2459 8088586 192.0906   0.4805  1.25602300   521
```

2. by NORAD based on multiple tracking (20. 12. 2000)

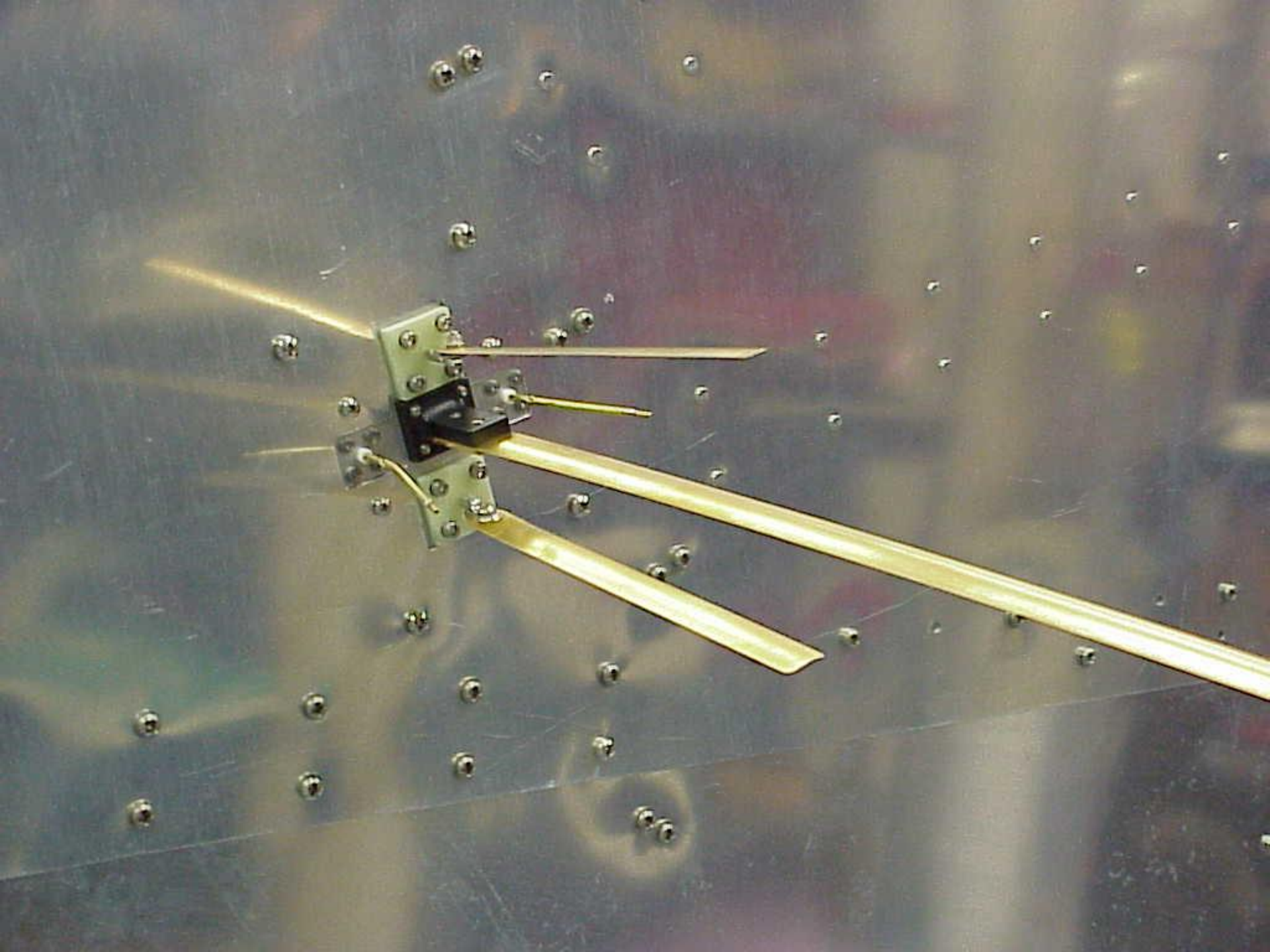
```
AO-40
1 26609U 00072B   00354.78150463  .00000000  00000-0  00000-0 0   124
2 26609   6.2479 237.0656 8128421 195.4843  97.8395  1.26834511   611
```

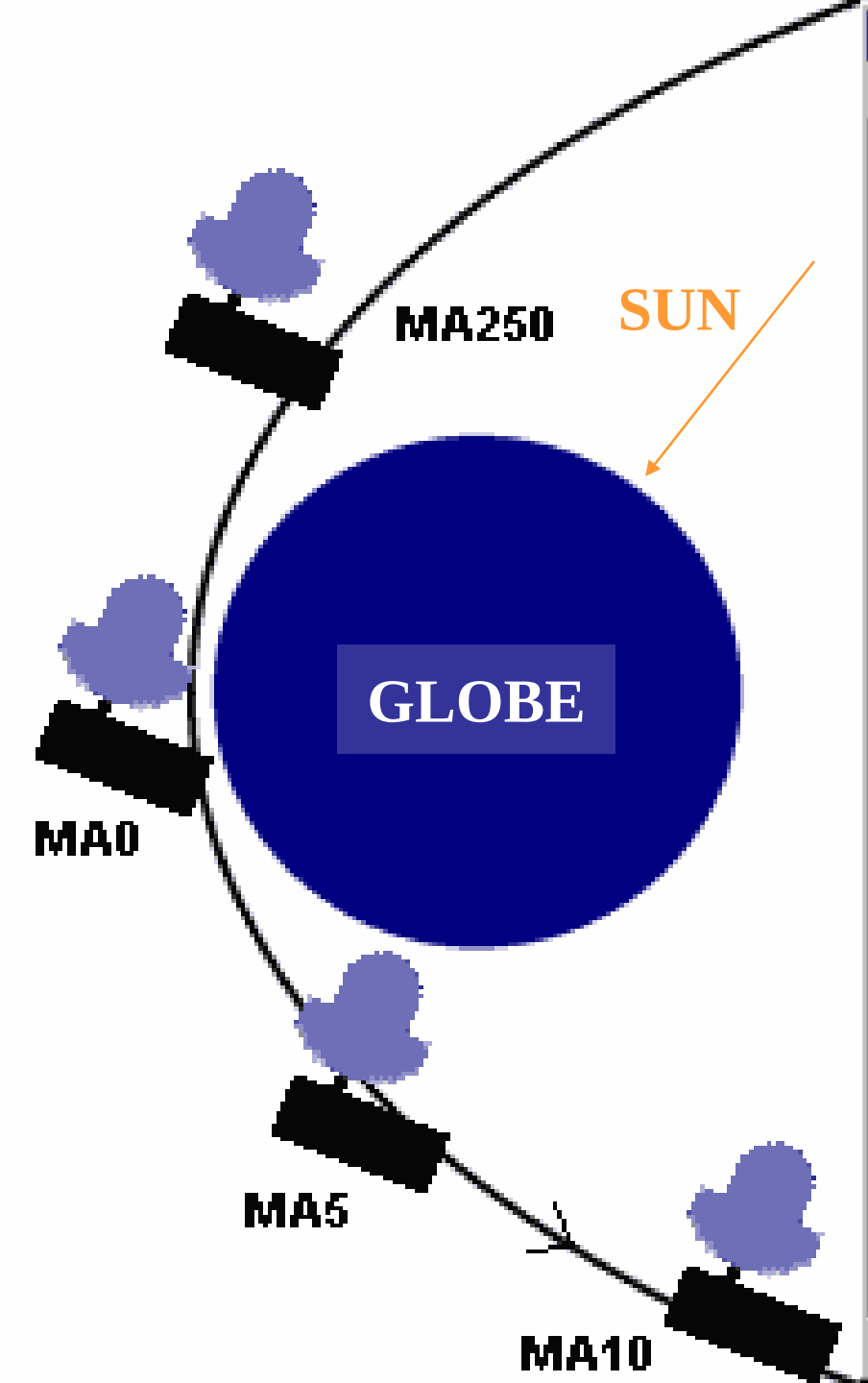
From both sets (of course, in Norad case back in the time) the satellite position is the same at the time of incident (13. 12. 2000 at 11:20:28).

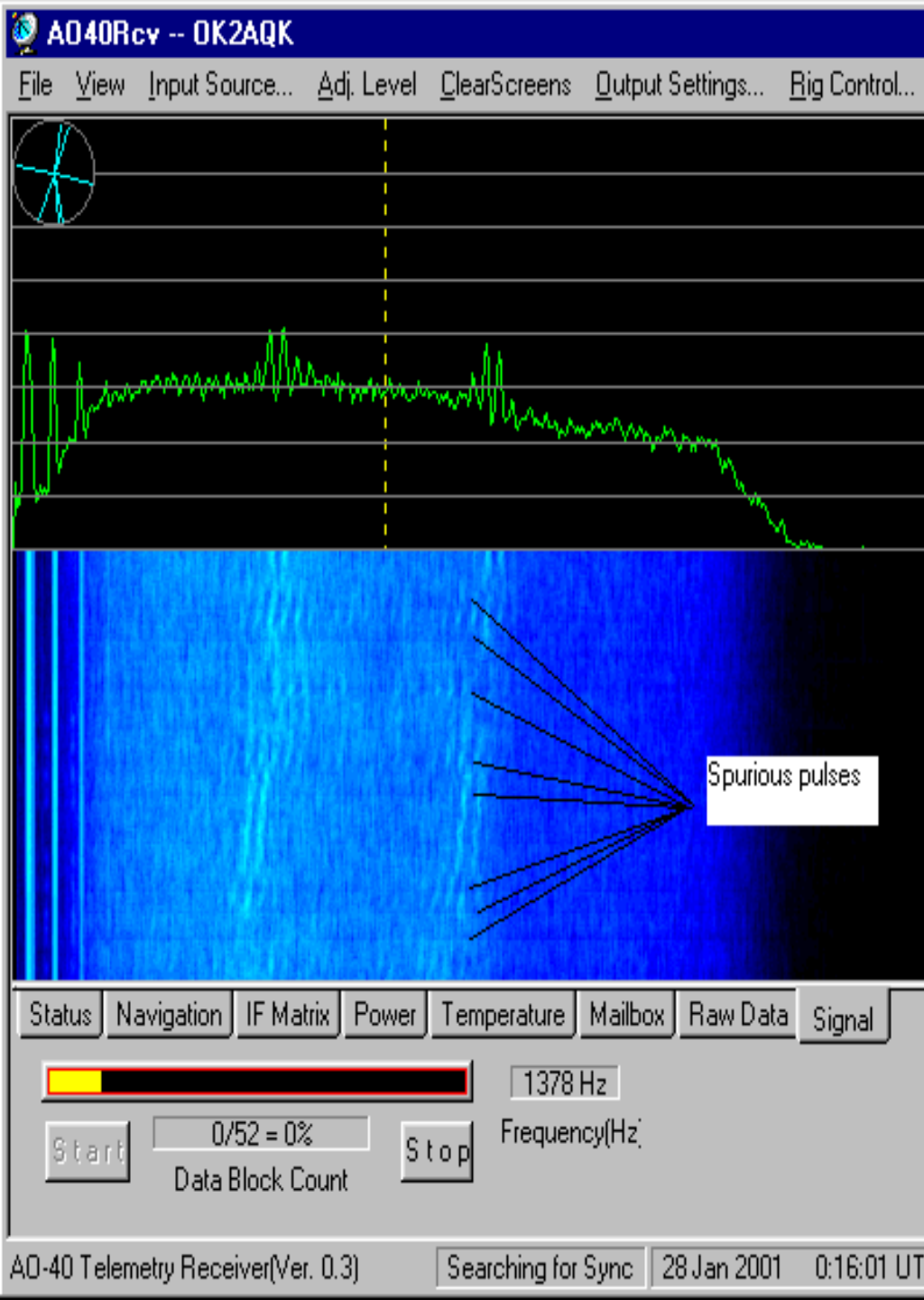
Conclusion: The satellite velocity was changed $\Delta V = V_2 - V_1 = -3{,}82$ m/s. At the moment of incident the s/c has been caused by vector ***Vx* = 12,17 m/s** in direction **108 deg** to the original velocity V_1.

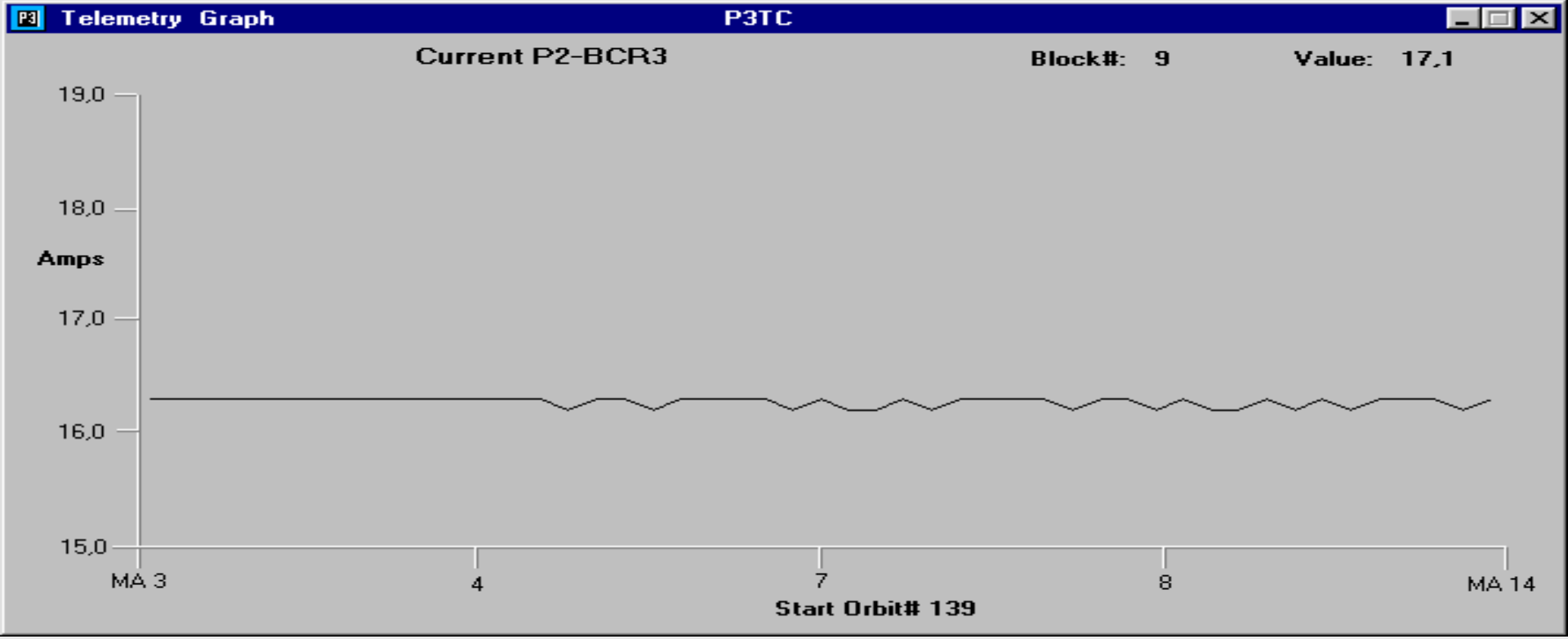


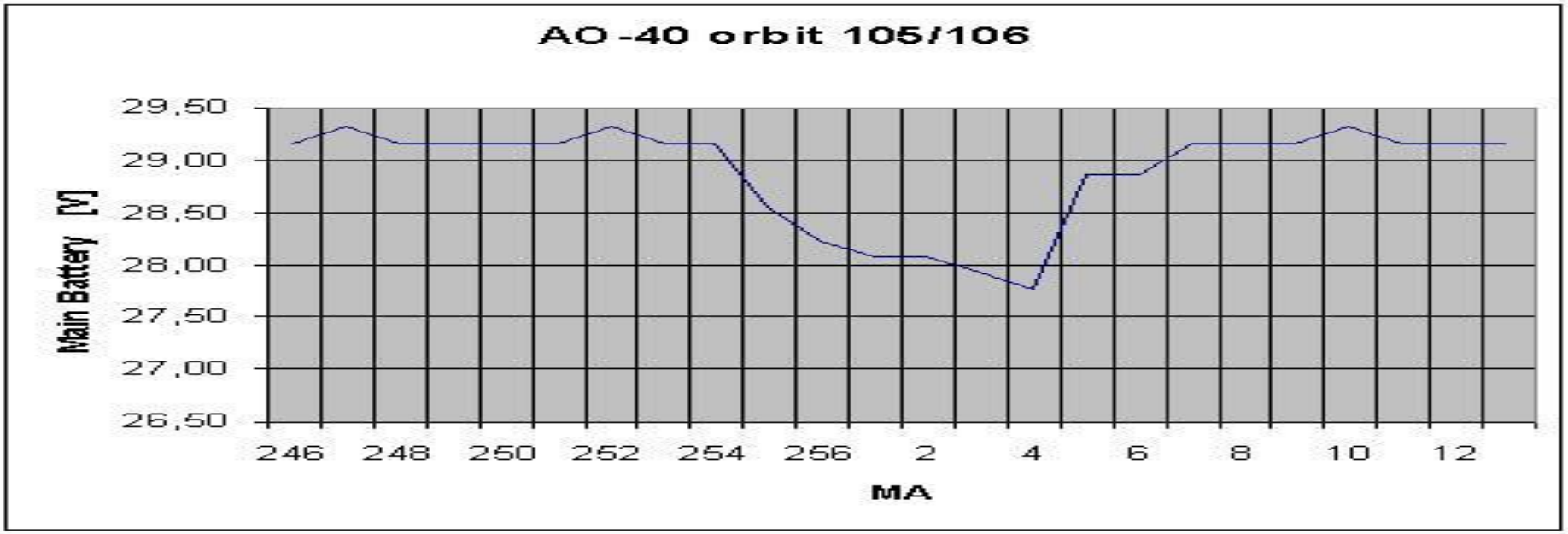
Damage (?)




MA250
SUN
GLOBE
MA0
MA5
MA10


AO40Rcv -- OK2AQK
File View Input Source... Adj. Level ClearScreens Output Settings... Rig Control...
Spurious pulses
Status Navigation IF Matrix Power Temperature Mailbox Raw Data Signal
1378 Hz
Start
0/52 = 0%
Data Block Count
Stop
Frequency(Hz)
AO-40 Telemetry Receiver(Ver. 0.3)
Searching for Sync
28 Jan 2001
0:16:01 UT


Telemetry Graph
P3TC
Current P2-BCR3
Block#: 9
Value: 17,1
19,0
18,0
Amps
17,0
16,0
15,0
MA 3
4
7
8
MA 14
Start Orbit# 139


AO-40 orbit 105/106
Main Battery [V]
29,50
29,00
28,50
28,00
27,50
27,00
26,50
246
248
250
252
254
256
2
4
6
8
10
12
MA

Surrey Satellite Technology Limited



California Polytechnic State University



U.S.N.A

JAMSAT
日本アマチュア衛星通信協会

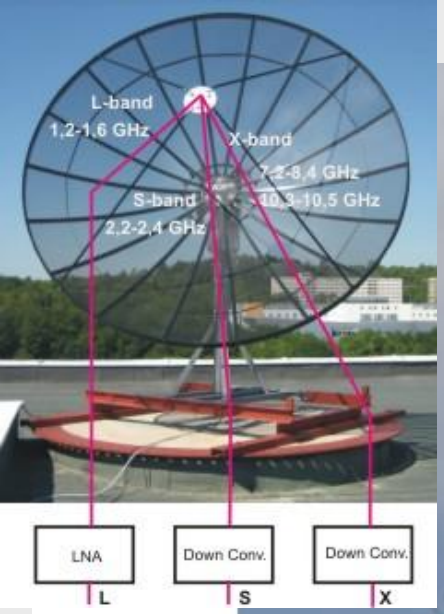
AMSAT

AMSAT-DL

AMSAT-OH

oz

AMSAT Australia





U-band

L-band

V-band

S-band

2400MHz

435MHz

145MHz

1269MHz

LNA
RF VOX

U

PA
40W

L

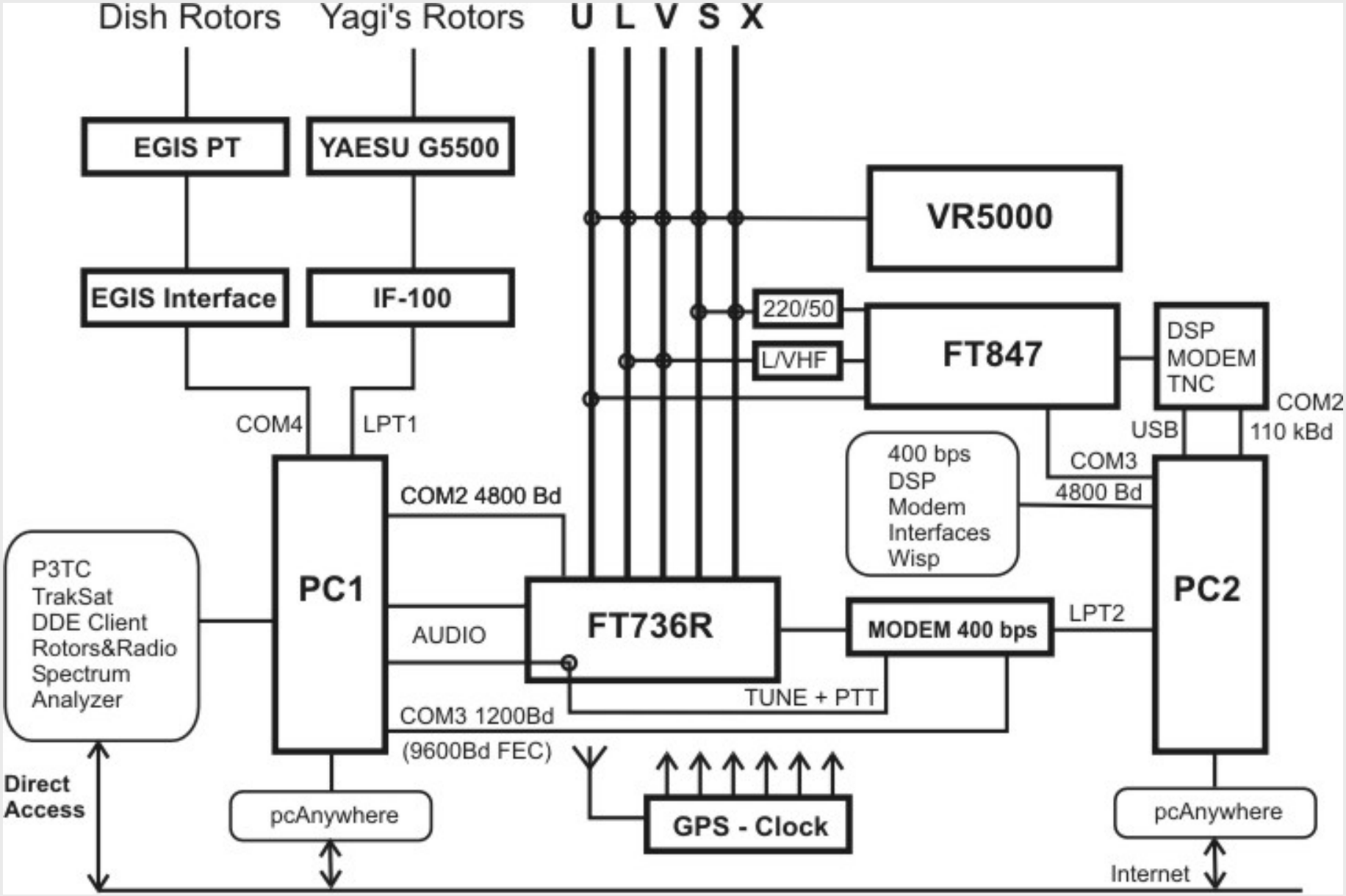
Rotors
Control

LNA
RF VOX

V

Down Conv
220 MHz

S

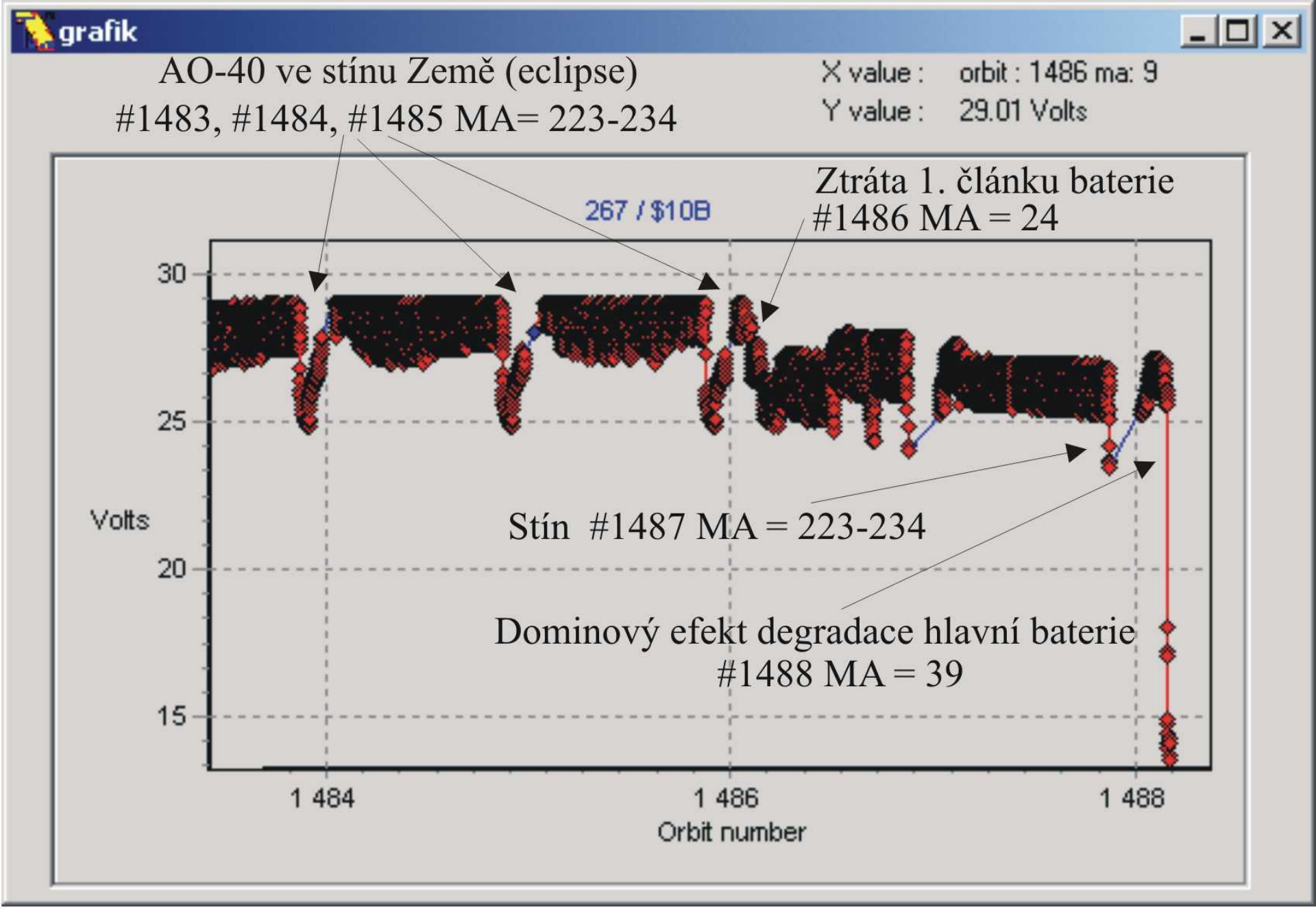

Dish Rotors
Yagi's Rotors
U L V S X
EGIS PT
YAESU G5500
VR5000
EGIS Interface
IF-100
220/50
L/VHF
FT847
DSP
MODEM
TNC
COM4
LPT1
COM2
USB
110 kBd
400 bps
DSP
Modem
Interfaces
Wisp
COM3
4800 Bd
COM2 4800 Bd
PC1
PC2
P3TC
TrakSat
DDE Client
Rotors&Radio
Spectrum
Analyzer
AUDIO
FT736R
MODEM 400 bps
LPT2
TUNE + PTT
COM3 1200Bd
(9600Bd FEC)
Direct
Access
pcAnywhere
GPS - Clock
pcAnywhere
Internet

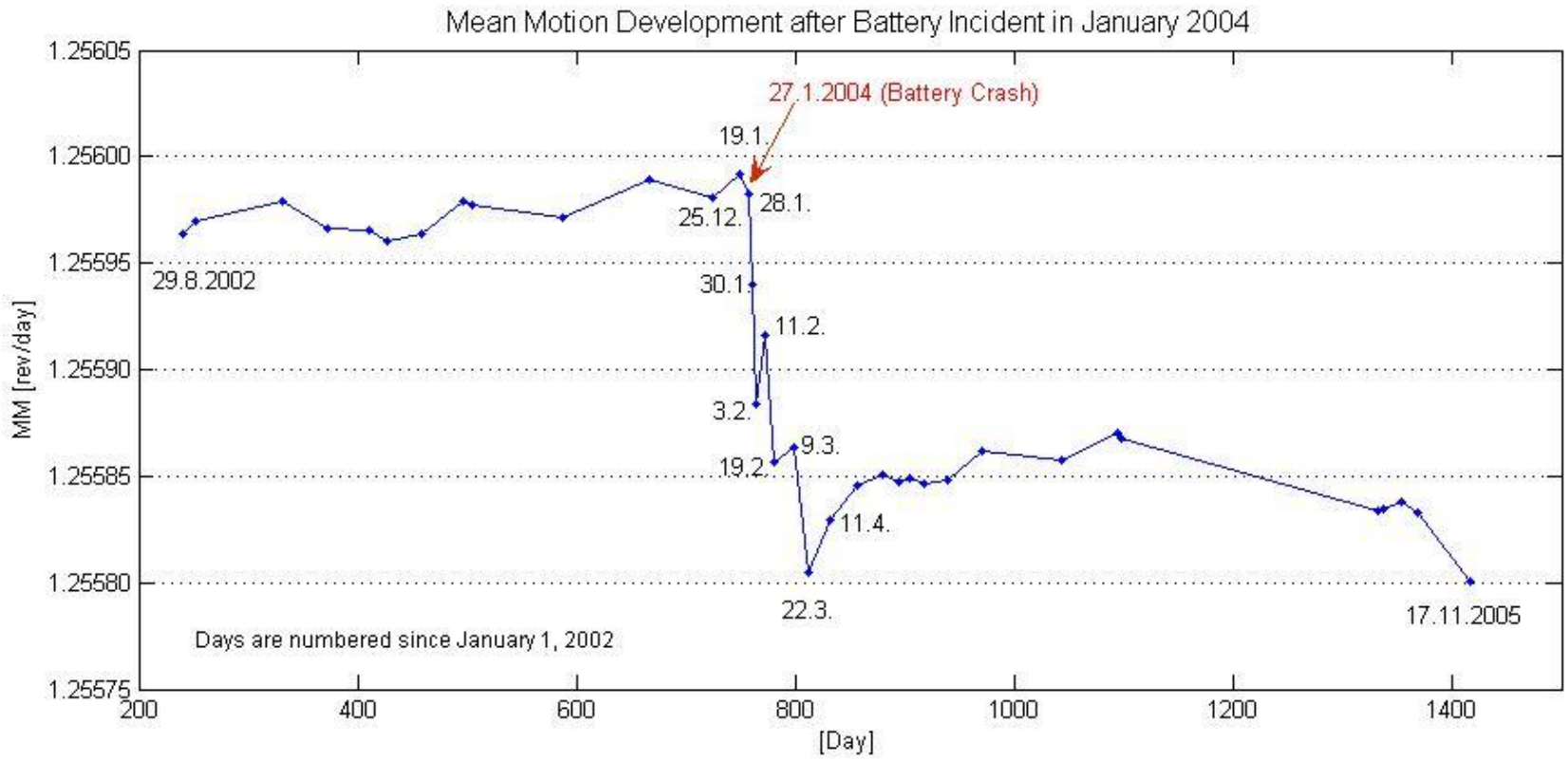




Telemetrické a povelovací pracoviště
ÚREL




grafik
AO-40 ve stínu Země (eclipse)
#1483, #1484, #1485 MA= 223-234
X value : orbit : 1486 ma: 9
Y value : 29.01 Volts
Ztráta 1. článku baterie
#1486 MA = 24
267 / $10B
Stín #1487 MA = 223-234
Dominový efekt degradace hlavní baterie
#1488 MA = 39
30
25
20
15
Volts
1 484
1 486
1 488
Orbit number


Mean Motion Development after Battery Incident in January 2004
MM [rev/day]
[Day]
1.25605
1.25600
1.25595
1.25590
1.25585
1.25580
1.25575
200
400
600
800
1000
1200
1400
27.1.2004 (Battery Crash)
19.1.
25.12.
28.1.
29.8.2002
30.1
11.2.
3.2.
9.3.
19.2.
11.4.
22.3.
17.11.2005
Days are numbered since January 1, 2002

Echo Solar Panel Telemetry

Solar Panels

+Z	15.4 V	327.7 mA	17.8 C	
+X	15.6 V	307.1 mA	11.9 C	
-Y	15.5 V	406.6 mA	10.3 C	
-X	15.4 V	11.9 mA	10.7 C	
+Y	14.5 V	5.7 mA	12.2 C	
-Z	15.4 V	258.8 mA		

Total Volts: 15.1
Total mA: 1072.3
To BCR System

Echo TX & RX Telemetry

UHF TX

	TX A	TX B
PWR (watts):	0.4	0.6
Enable:	ON	ON
PTT:	ON	ON
Temp (C):		-46.0

S Band TX

Exciter: OFF
Power Amp: OFF
Pwr Level: LOW

TX Current

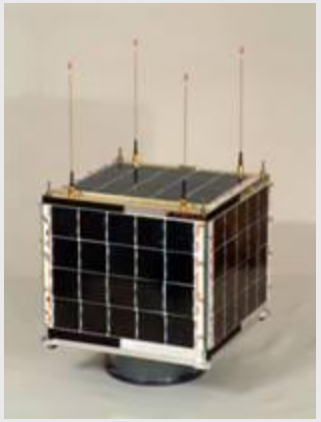
Amps: 1.0

SQRX

RSSI: 4095.0
Spkr: 4095.0
Temp: 11.0
Power: OFF
Antenna: L/S

VHF RX

Power: ON
RX1 Channel: PRI
RX2 Channel: PRI
RX3 Channel: PRI



Echo Battery & BCR Telemetry

BATTERIES

	1	2	3	4	5	6
	1.37	1.38	1.37	1.38	1.43	1.35
Volts:	1.37	2.75	4.12	5.50	6.93	8.28
Temp C:	12.4	11.5				

Bat V 8.28
Bat mA 387.0

BCR/Power System
Main V reg Temp 25.1
TX V reg Temp 17.9

Solar V 15.1
Solar mA 938.2
from Solar System

3.3 V 3.33
3.3 mA 66.5

4.6 V 4.60
4.6 mA 188.6

Low Volt
mA 58.0

+4V #1 4.03 V
+4V #2 4.03 V

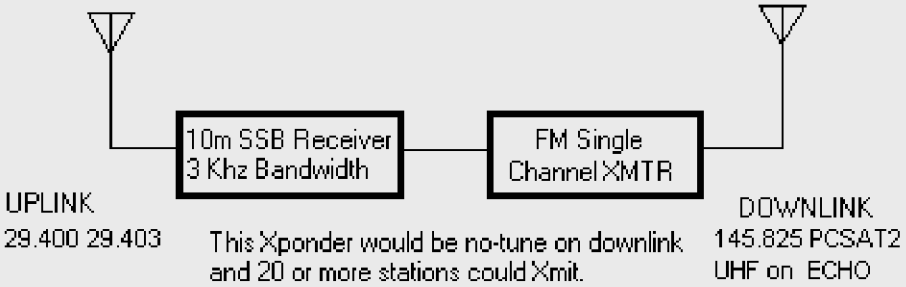
tlmEcho

File Setup TLM Help

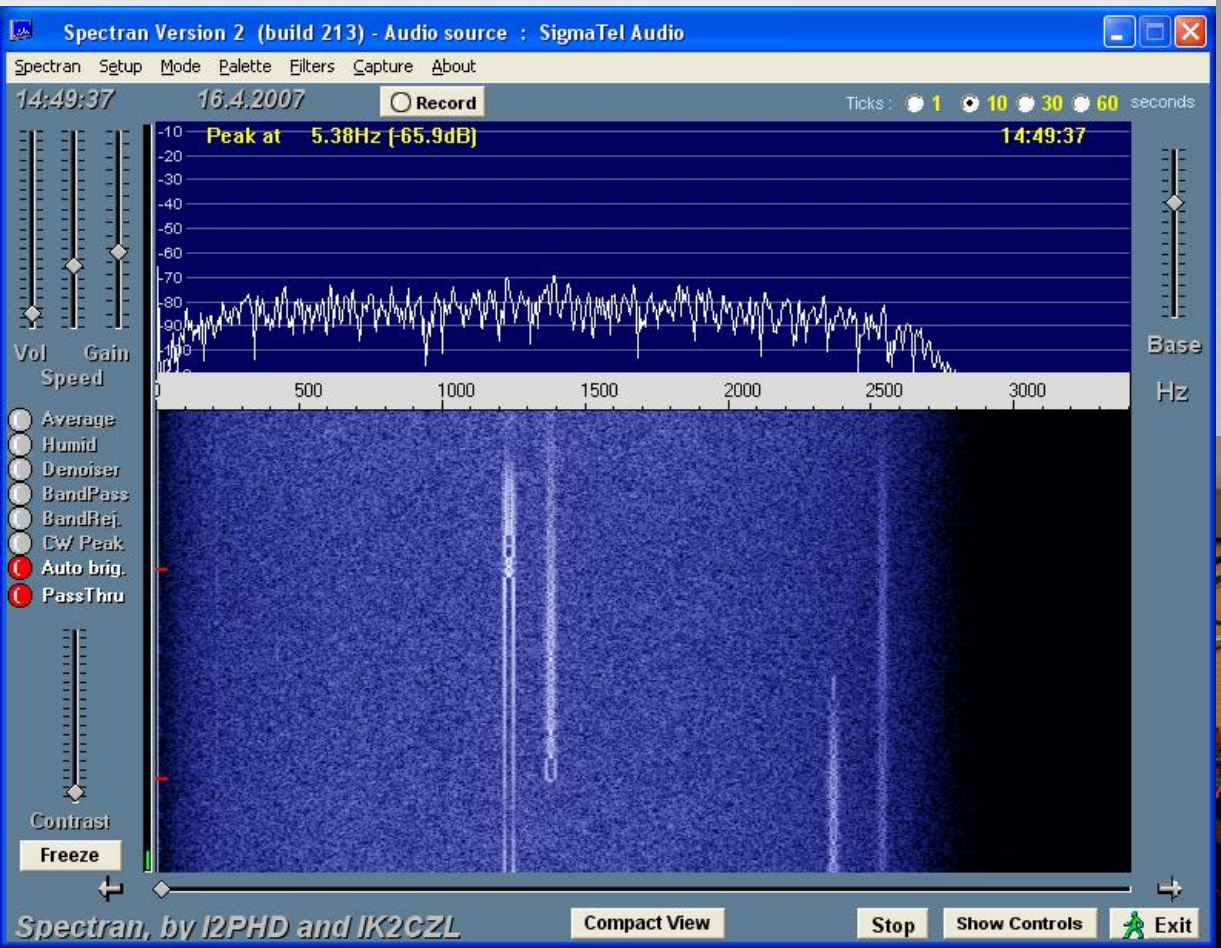
Downlink

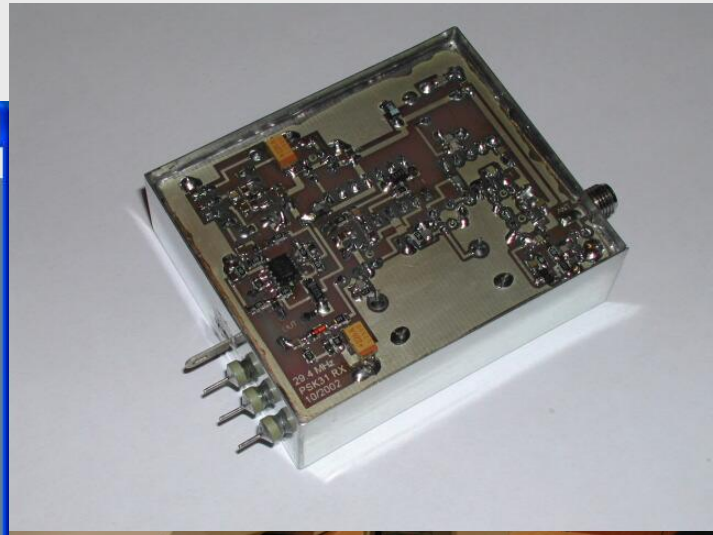
```
PECHO-12  > BBSTAT-0 :Open ABCD:
PECHO-11  > STATUS-0 :B: 20826936
PLCTL-8   > PLCTL-8  :PLCTL Mode:0 TXA:0 TXB:0 BatTrip:0
PACBLS-8  > PACBLS-8 :PACBLS S Meter = 0
PECHO-11  > PBLIST-0 :PB: Empty.
PECHO-11  > PBLIST-0 :PB: Empty.
PACB-1    > TIME-1   :PHT: uptime is 057/20:35:32.  Time is Sun Apr 15 09:17:59 2007
PACB-1    > TLMI-1   :<binary tlm>
PACB-1    > TLMS-1   :C0:05 C1:44 C2:76 C3:2F C4:04 C5:01
PACB-1    > TLMD-1   :WOD:0 ATP:0 BMW:1 BMS:0 CTS:1 CTN:168 CTL:149 CTE:Sat Apr 21 15:06:32 2007
PACB-1    > LSTAT-0  :I P:0x5469 o:0 l:23619 f:27320, d:0 st:6 e:17
PECHO-11  > PBLIST-0 :PB: Empty.
PECHO-11  > PBLIST-0 :PB: Empty.
PLCTL-8   > PLCTL-8  :PLCTL Mode:0 TXA:0 TXB:0 BatTrip:0
PACBLS-8  > PACBLS-8 :PACBLS S Meter = 0
```

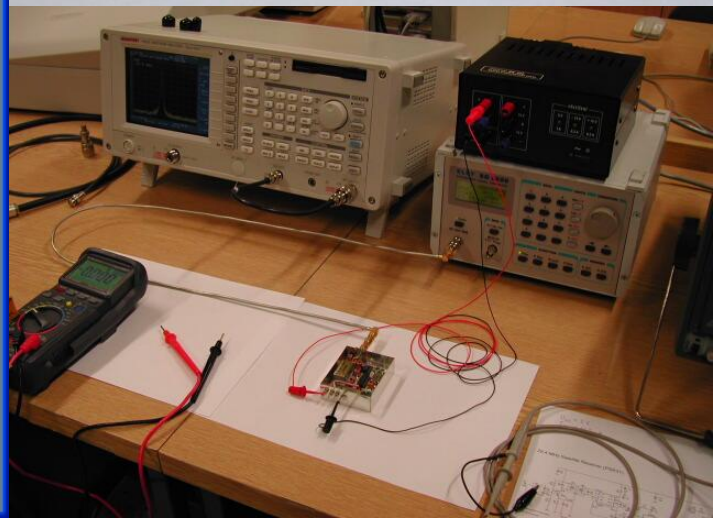
PSK-31 SSB=>FM Transponder



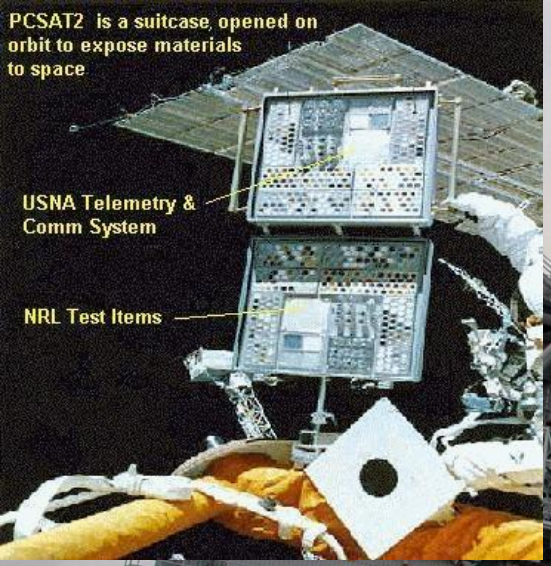
Brno University of Technology
Institute of Radio Electronics

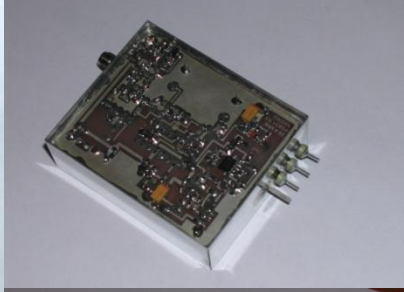


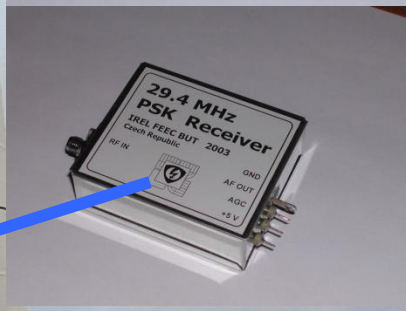




PCSAT 2





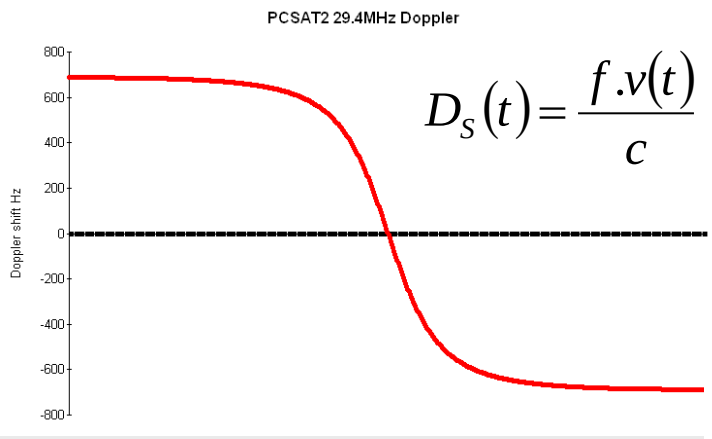


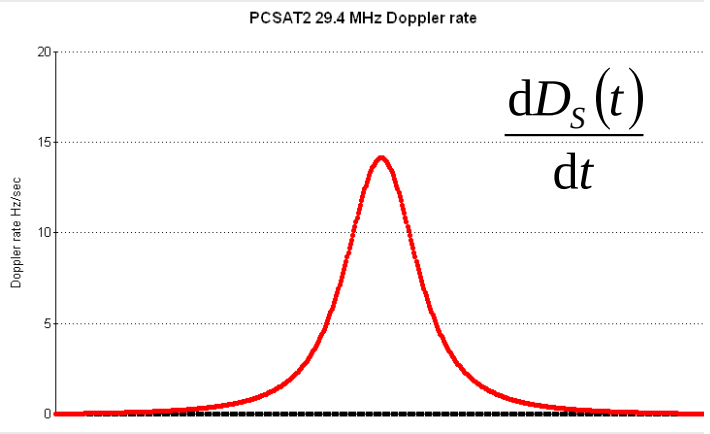
Discovery 26. 7. 2005

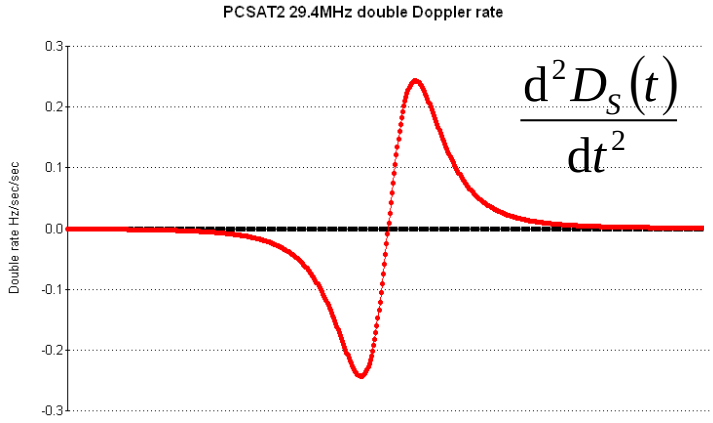
Úzkopásmový družicový transpondér pro pomalou datovou komunikaci – spolupráce s americkou Námořní Akademií


PCSAT 2

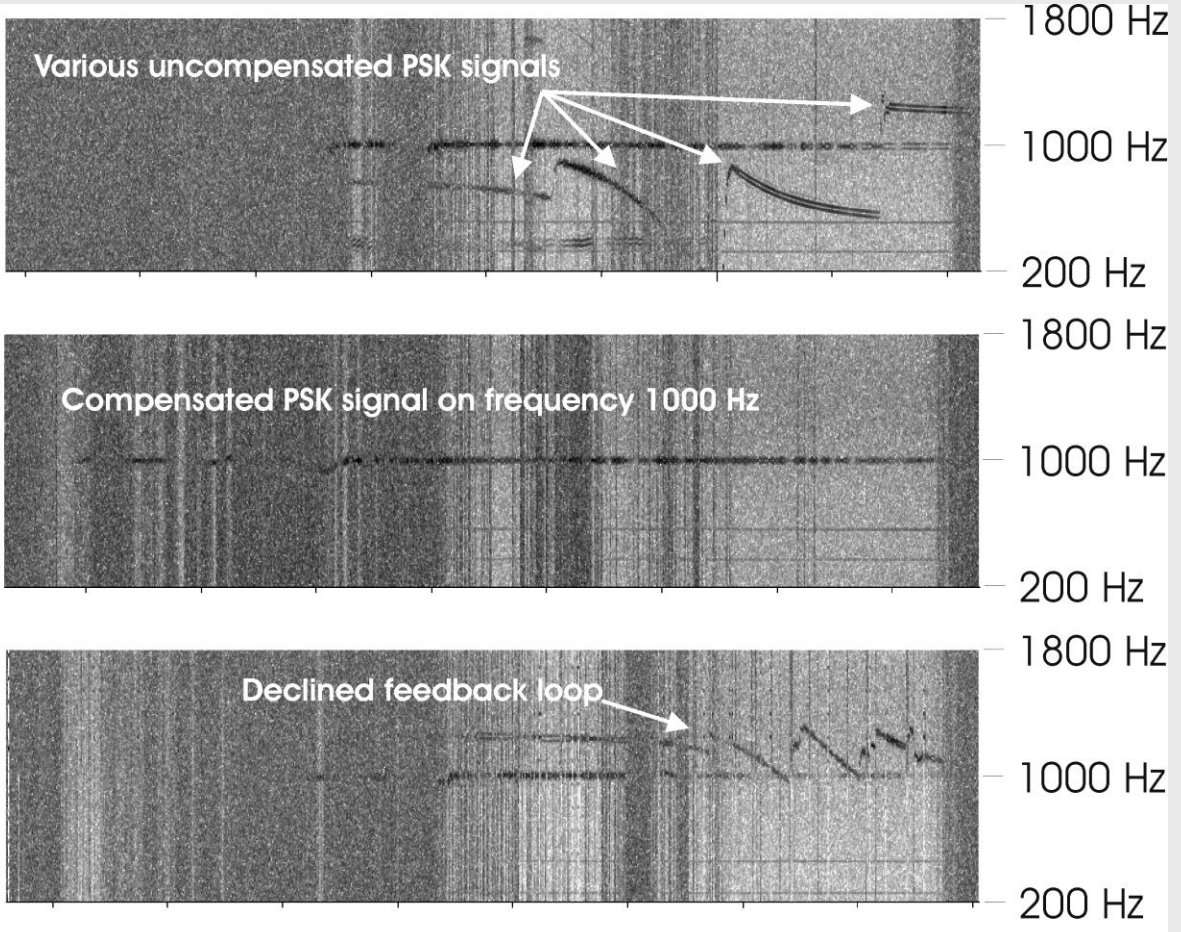
Dopplerův posuv v úzkopásmovém transpondéru na družici LEO



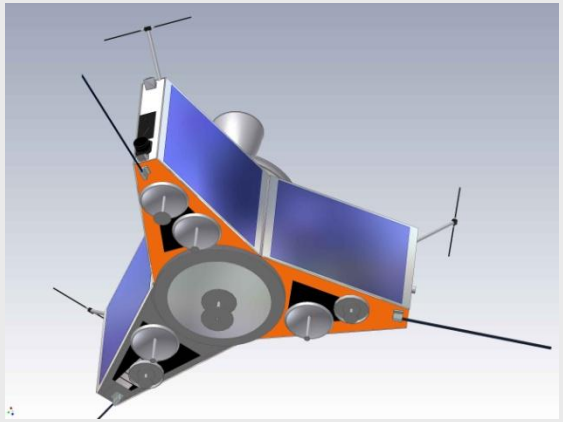


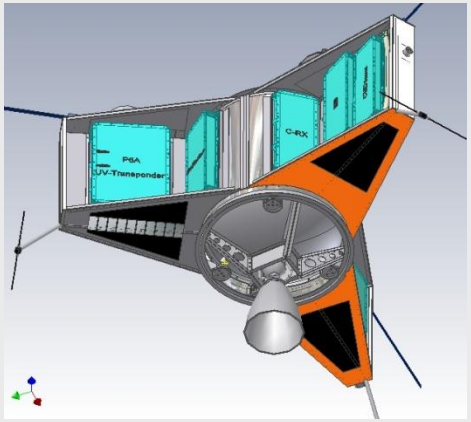


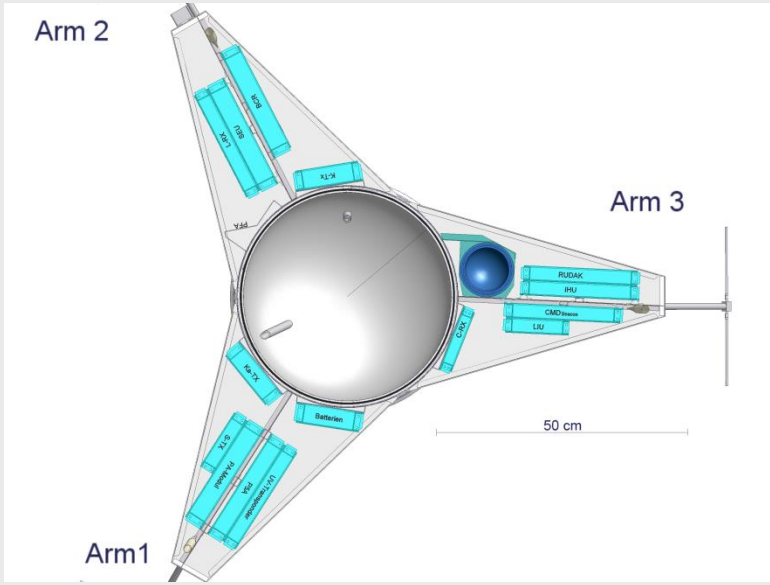
AOS time LOS

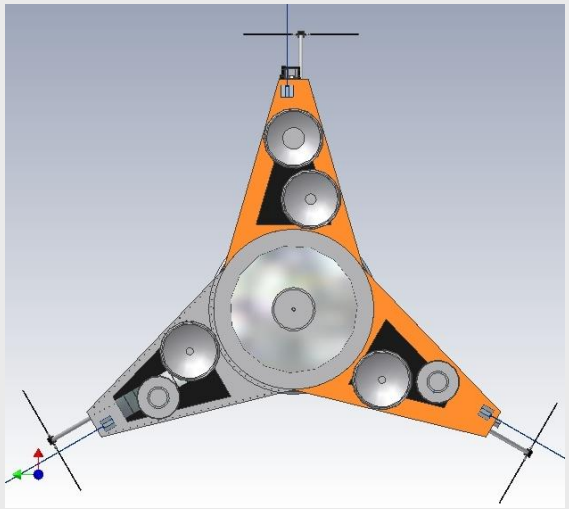


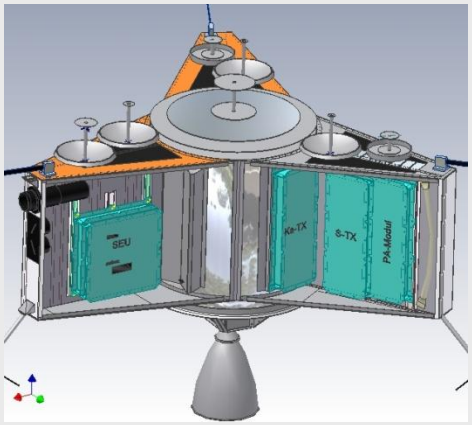
AMSAT Phase 3E

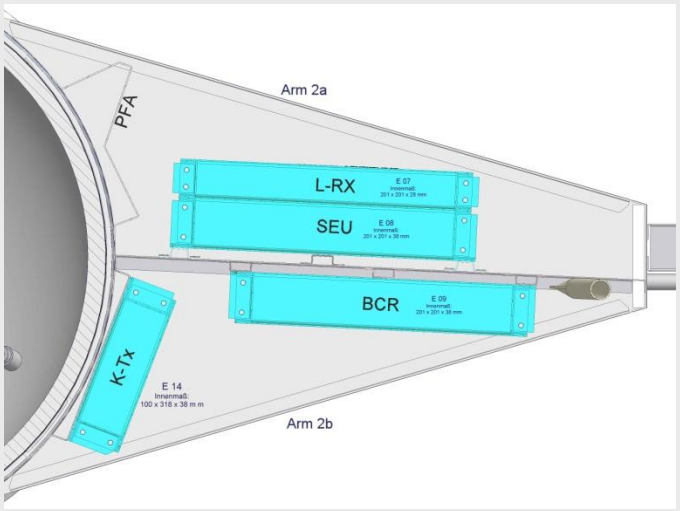


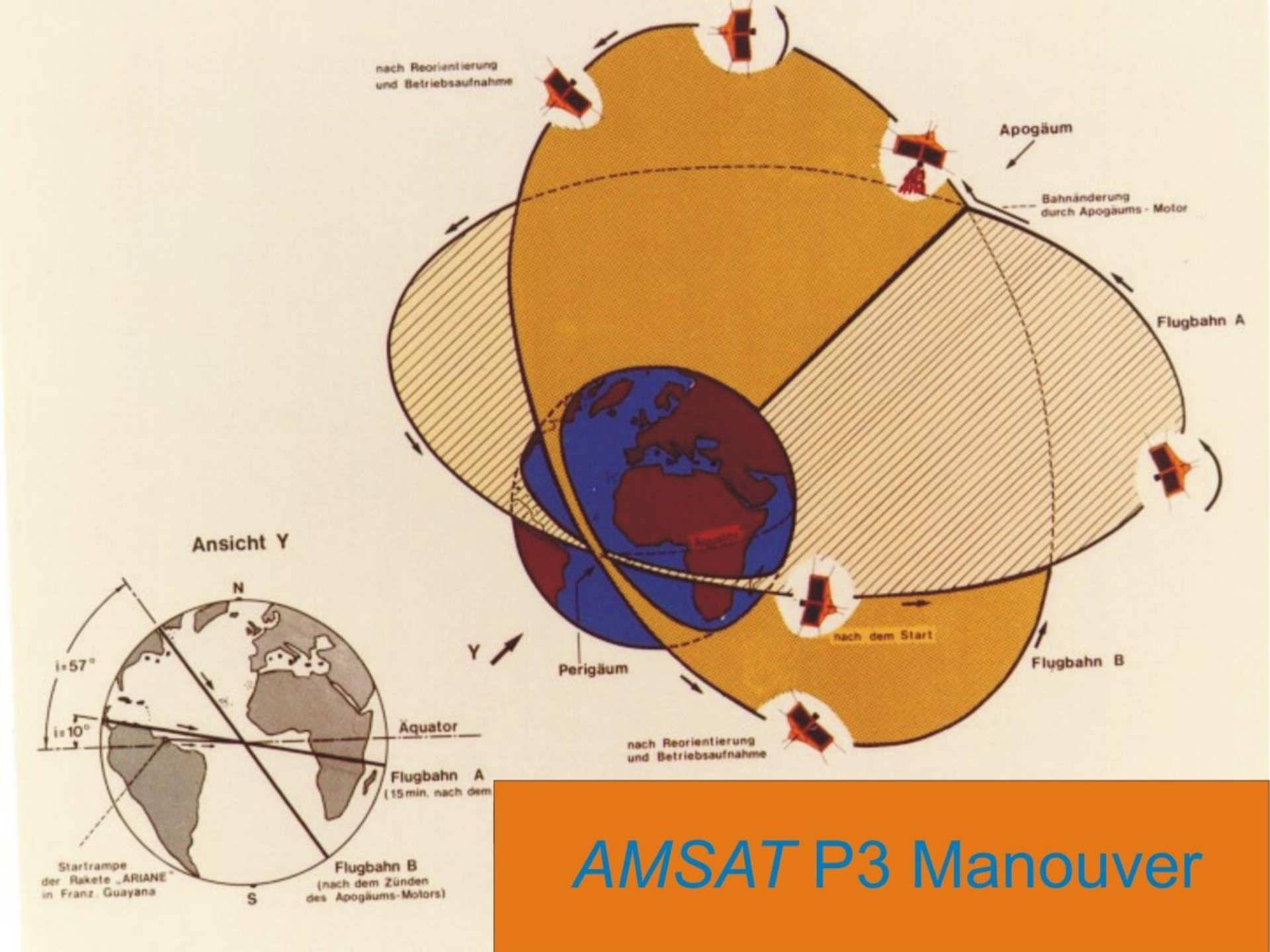




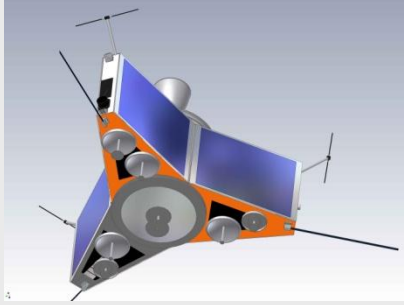




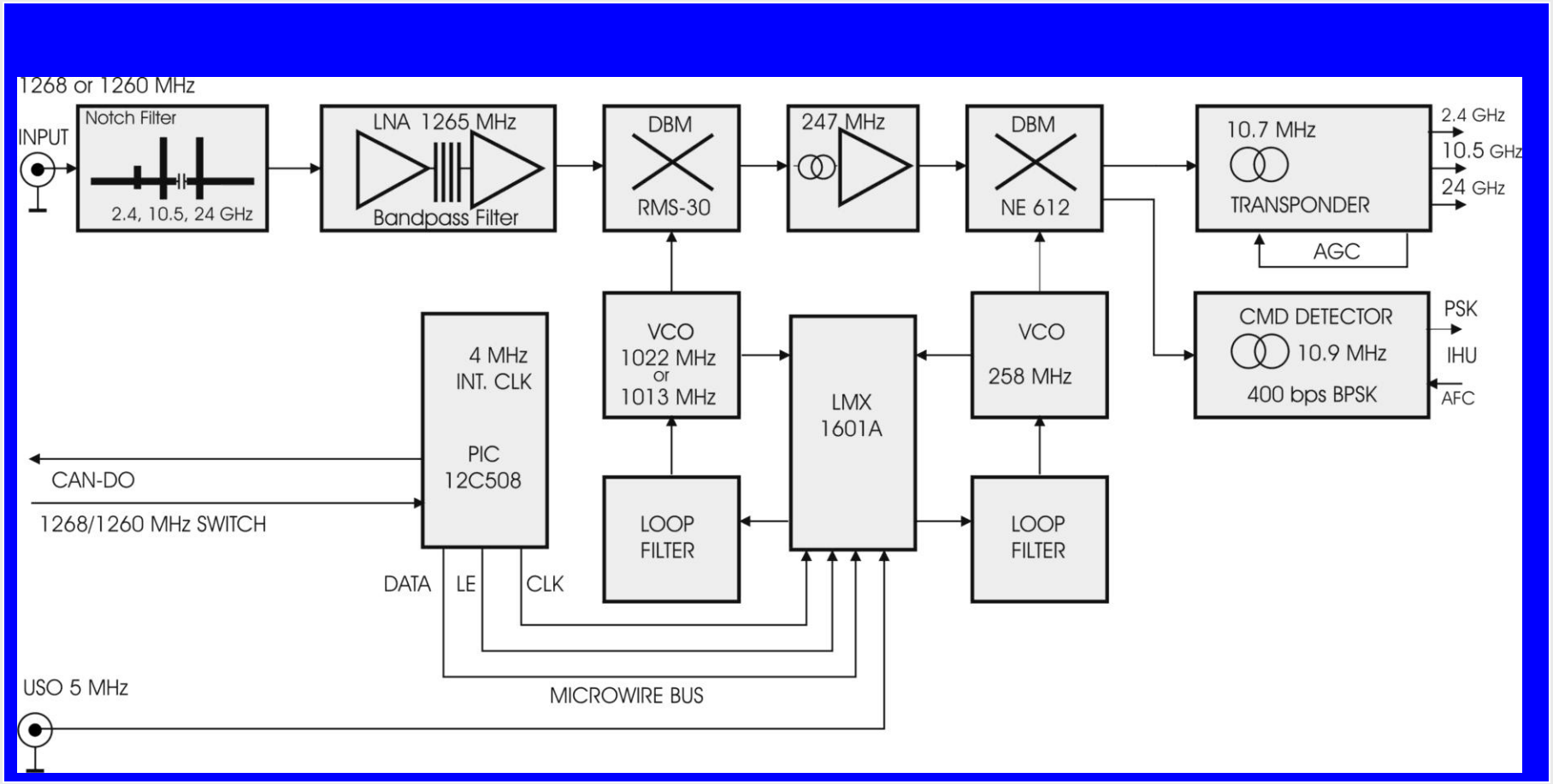


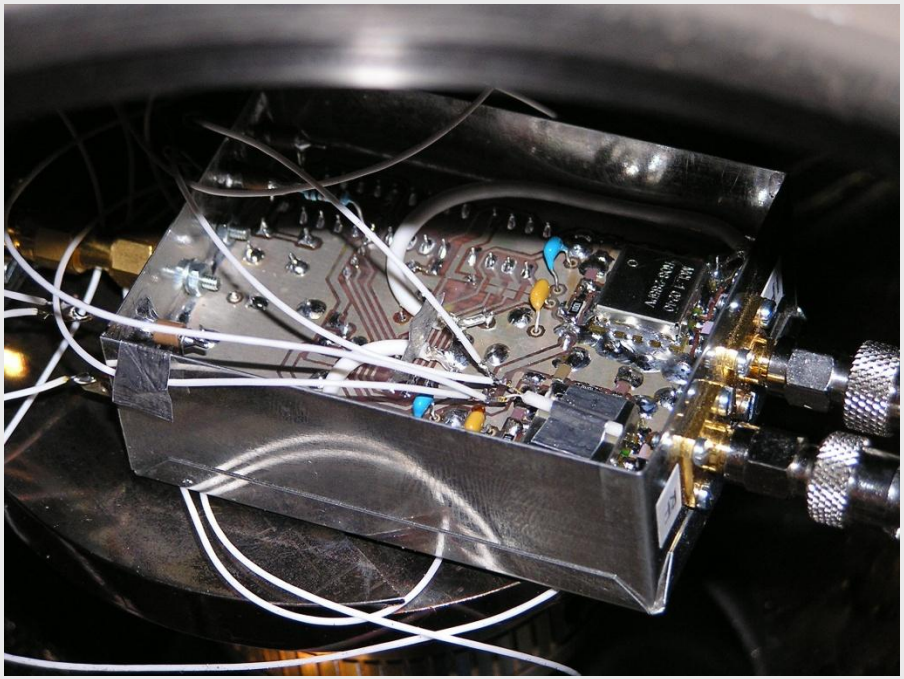


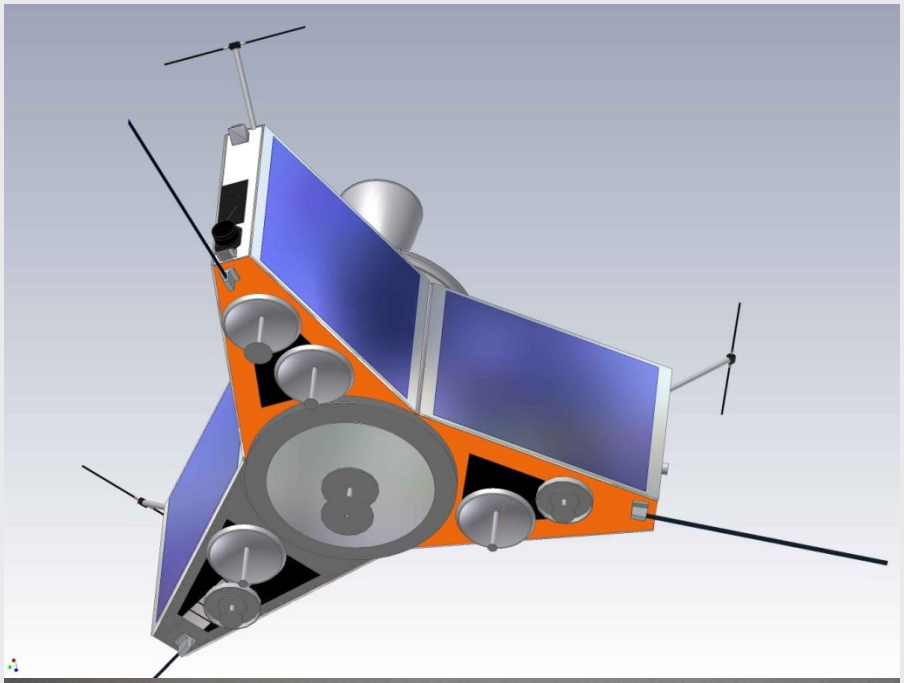
AMSAT P3 Manouver



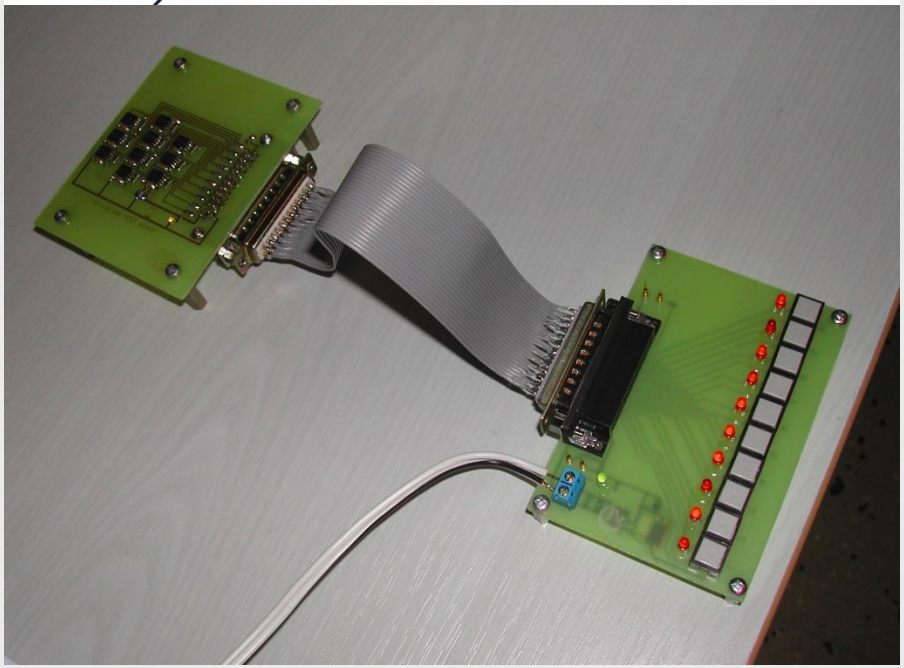
Přijímač pro pásmo L družice Phase 3E





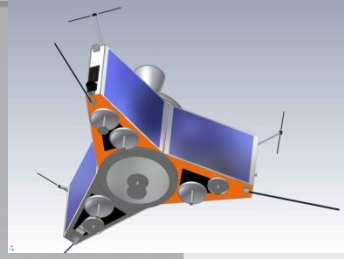


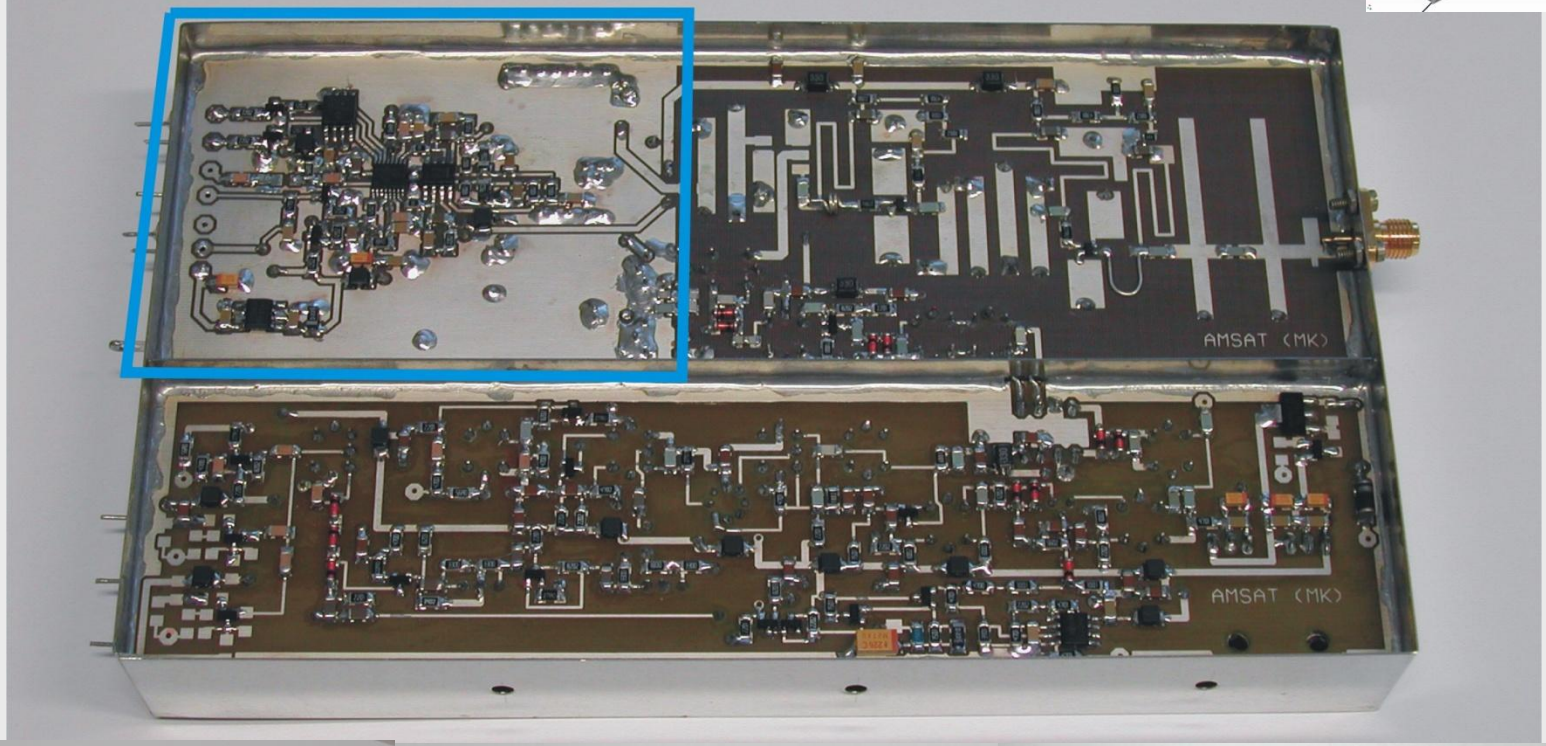
TV zkouška



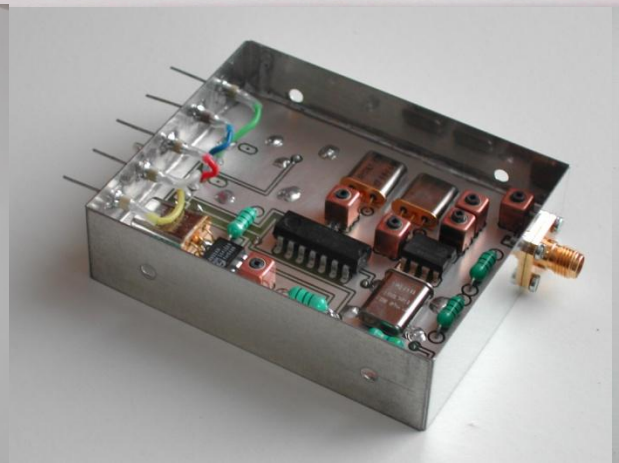
Zkouška radiační odolnosti řídícího procesoru

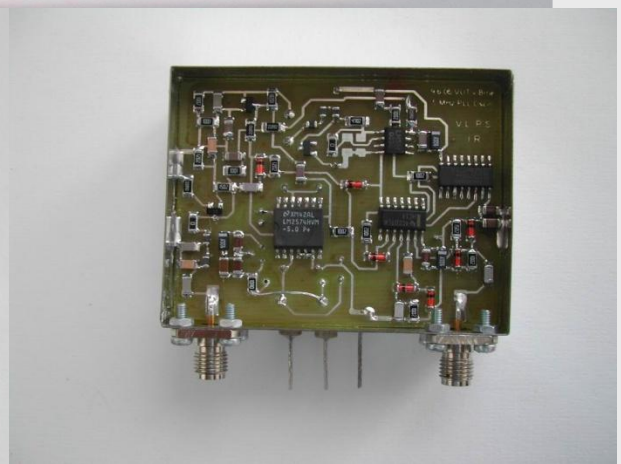
Syntezátor 2 x PLL

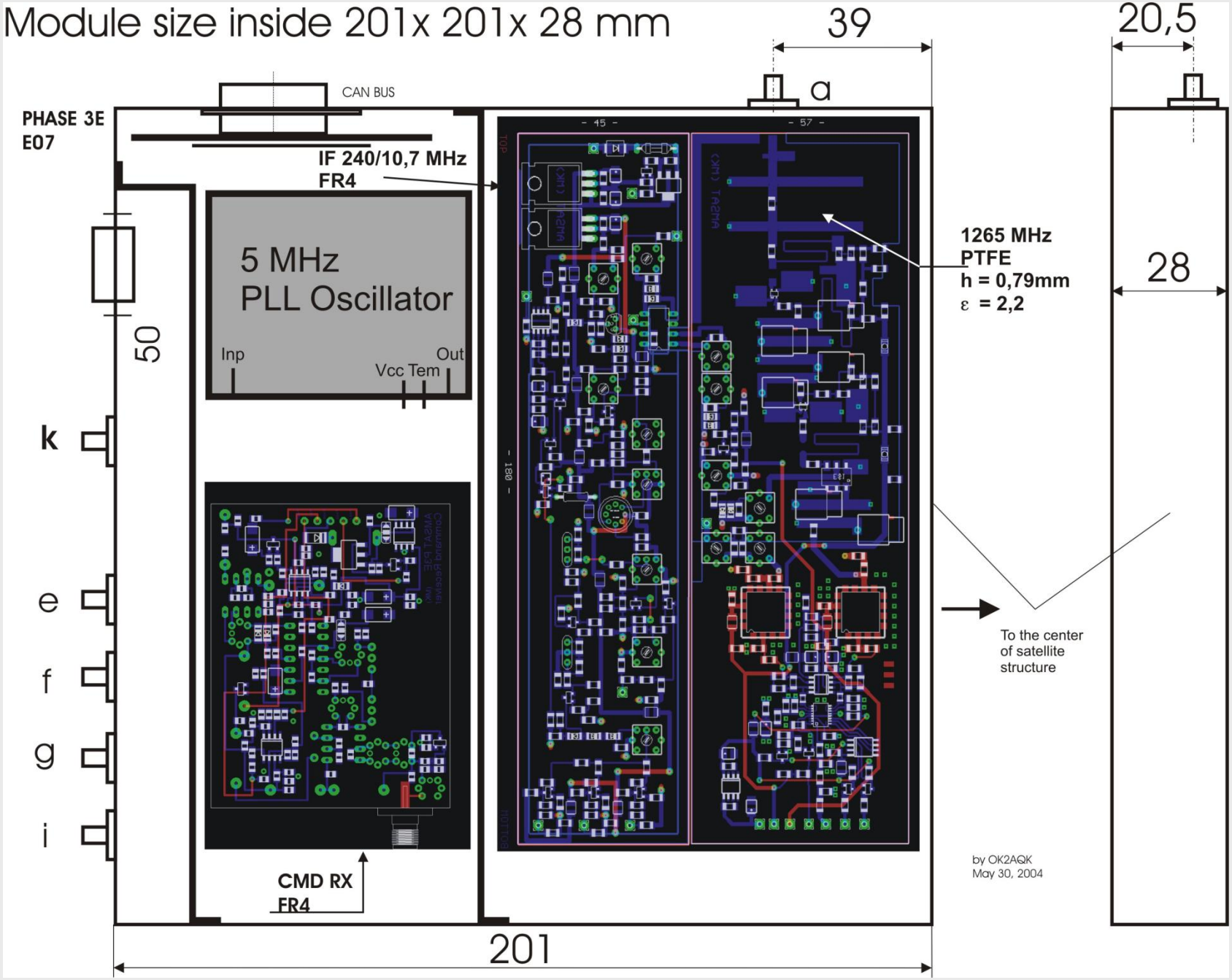


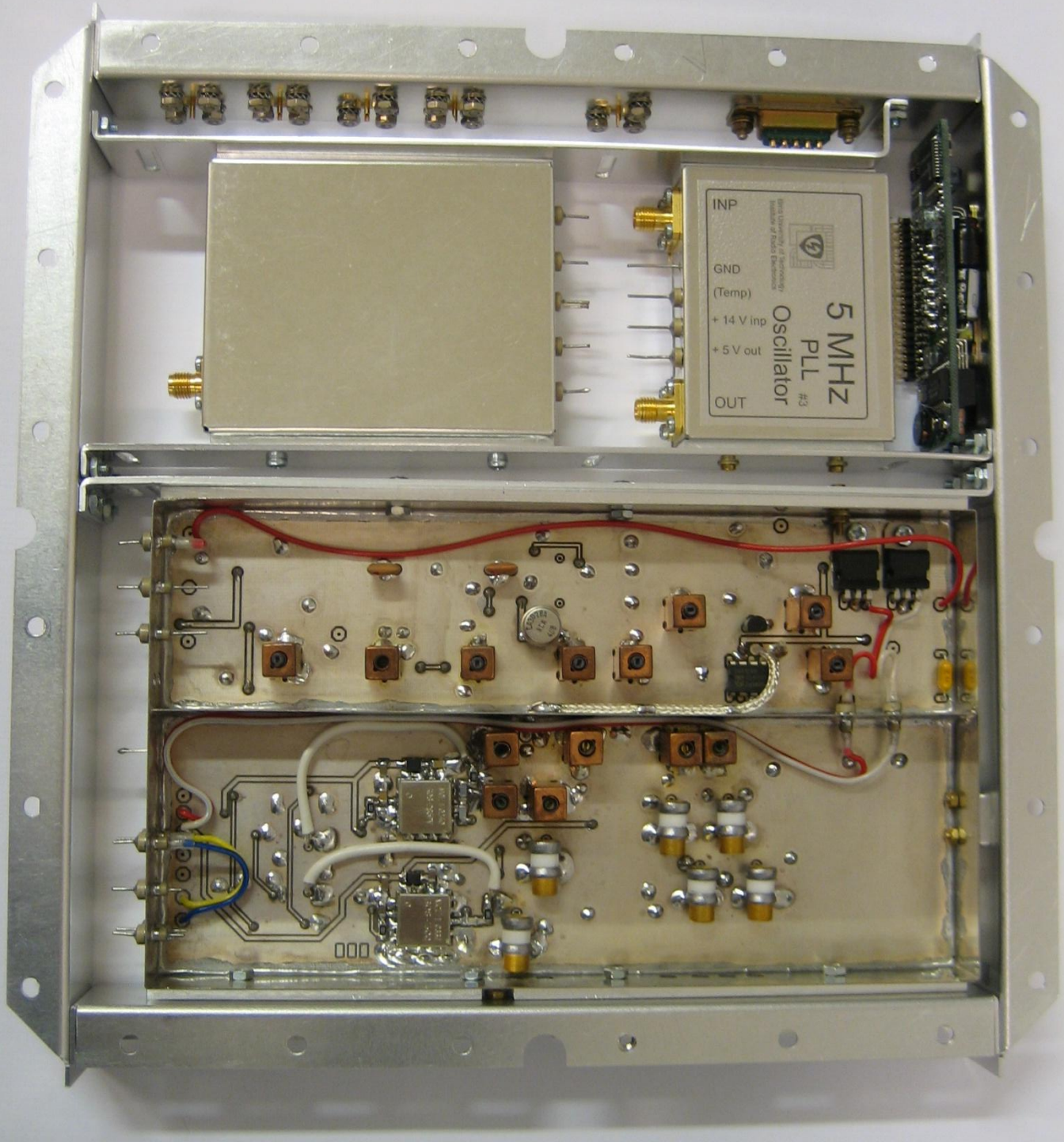


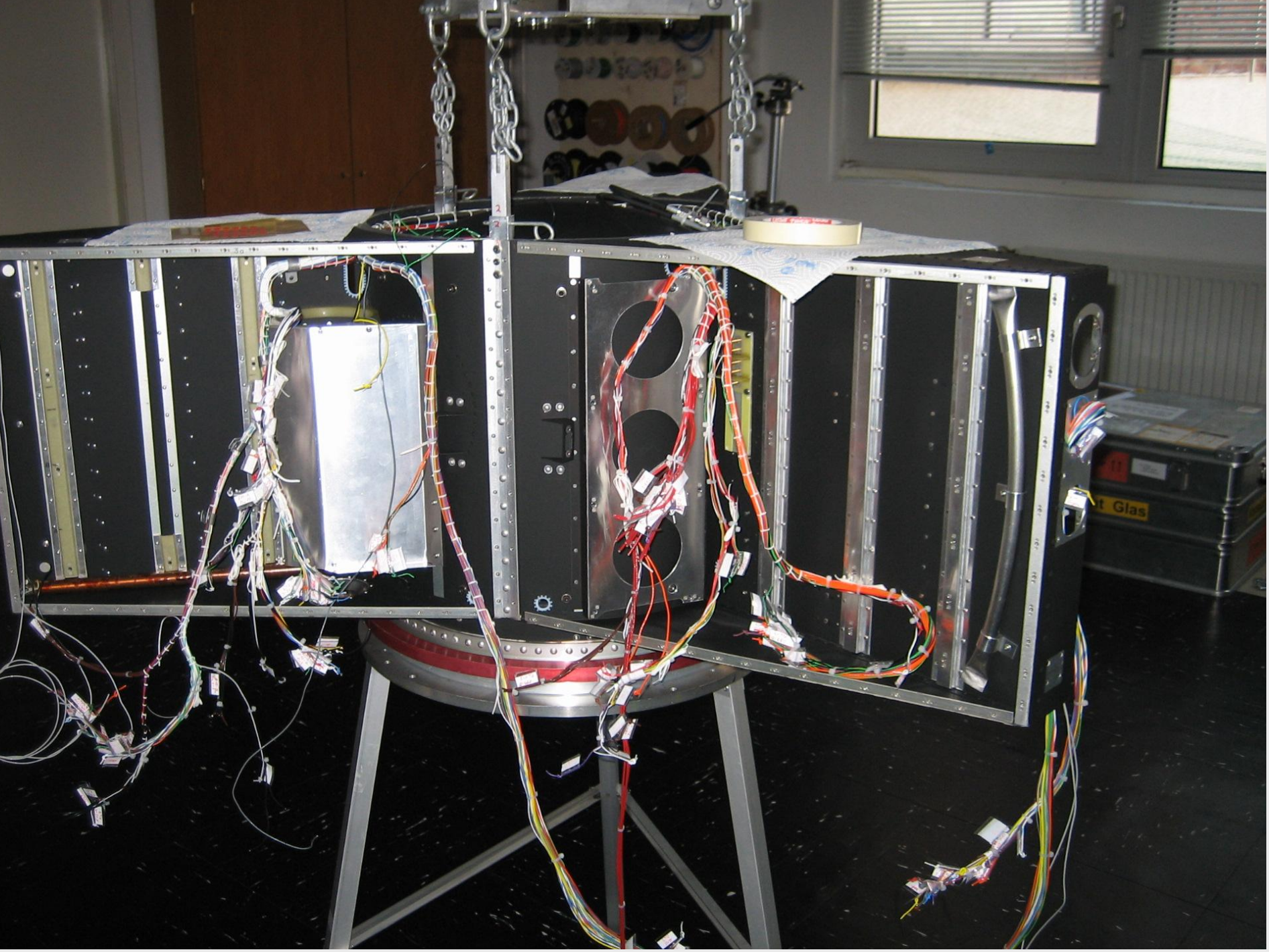


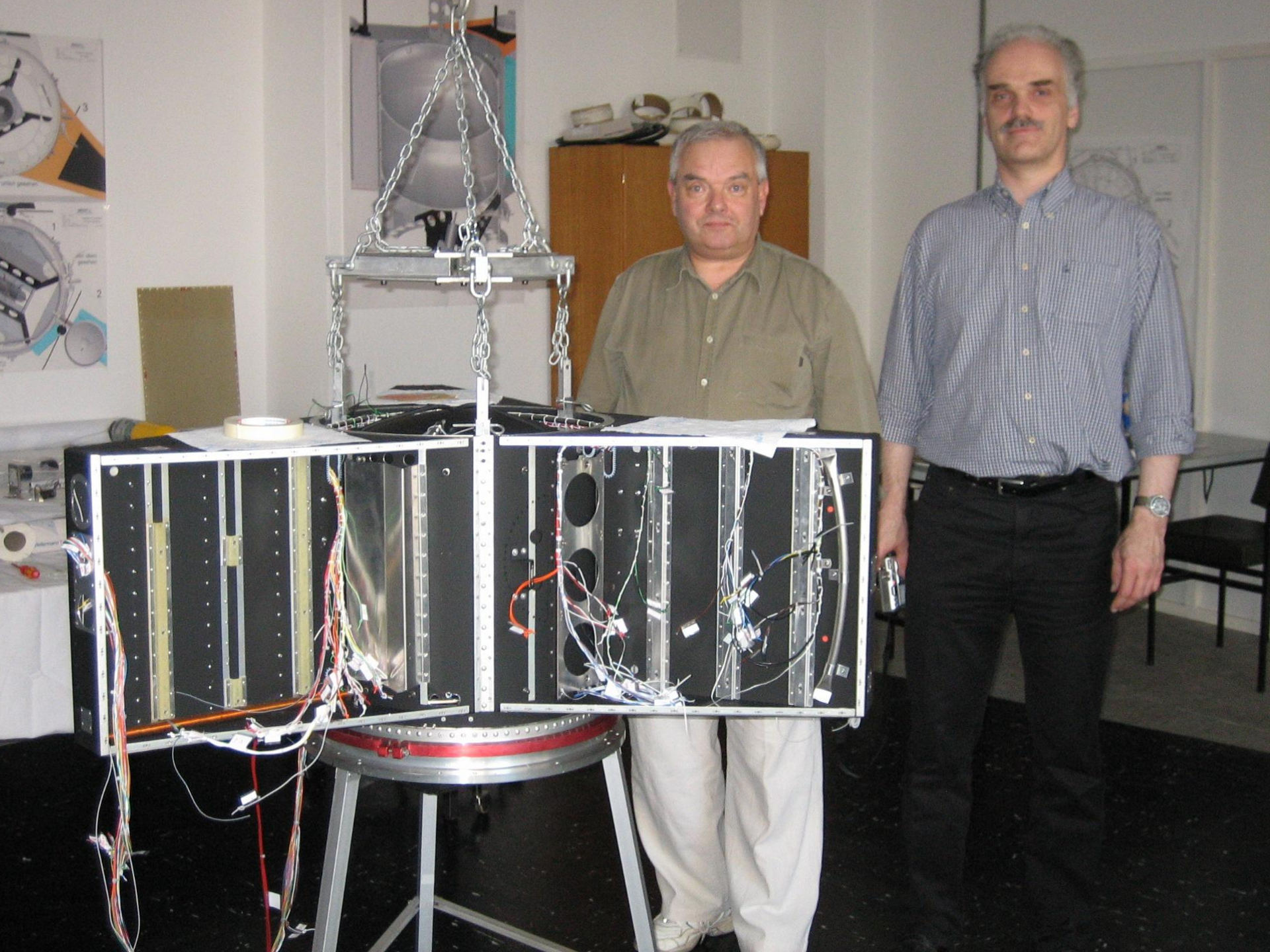





Module size inside 201x 201x 28 mm
39
20,5
a
CAN BUS
PHASE 3E
E07
IF 240/10,7 MHz
FR4
5 MHz
PLL Oscillator
Inp
Out
Vcc Tem
50
k
e
f
g
i
1265 MHz
PTFE
h = 0,79mm
ε = 2,2
28
To the center
of satellite
structure
CMD RX
FR4
201
by OK2AQK
May 30, 2004


INP
GND
(Temp)
+ 14 V inp
+ 5 V out
OUT
5 MHz
PLL
Oscillator
#3



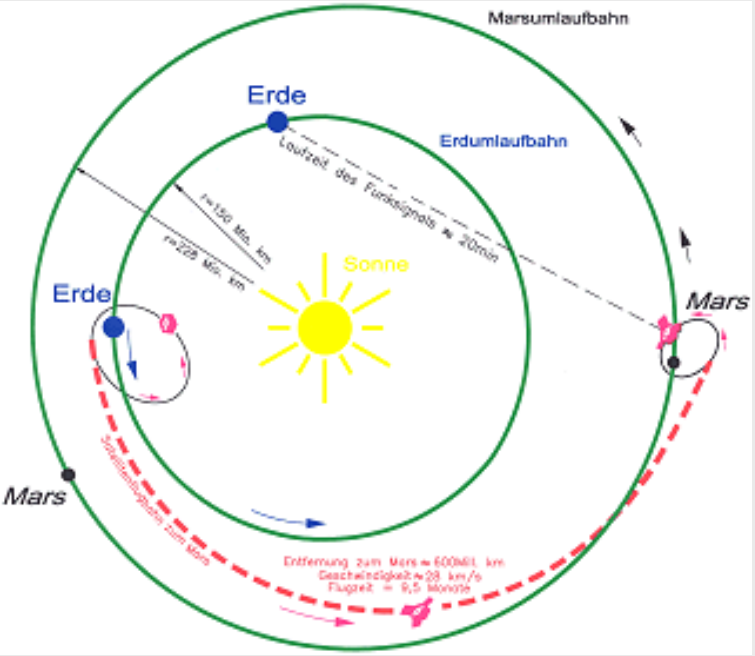


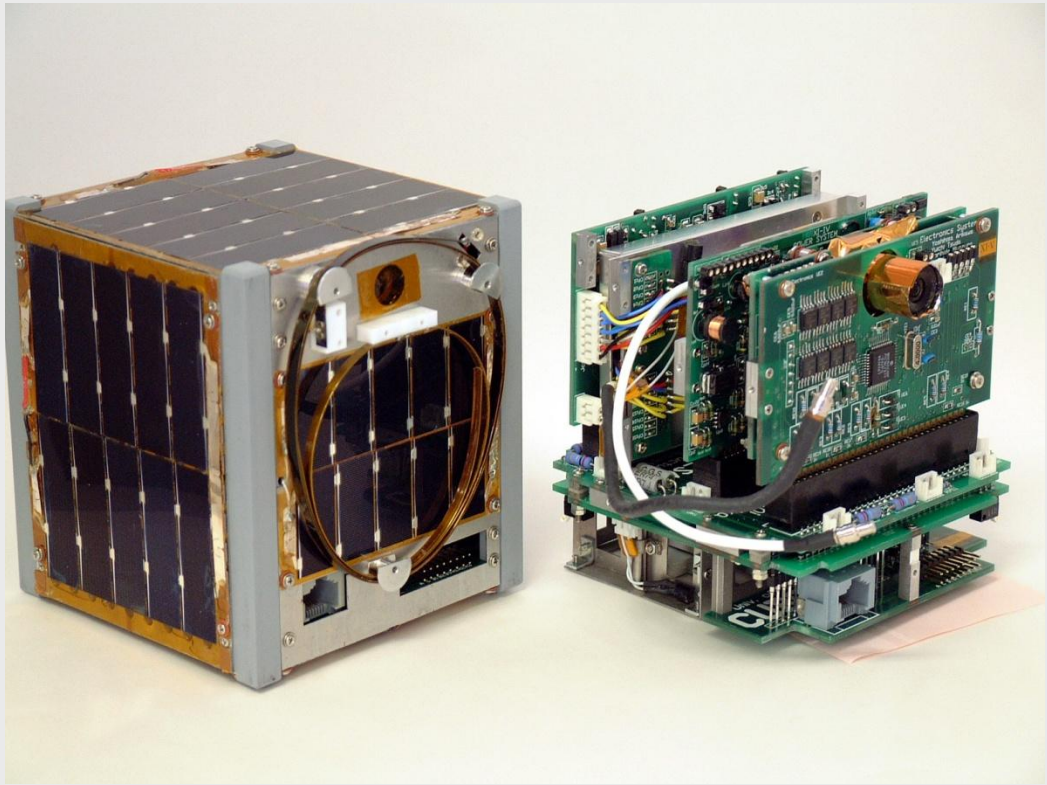


AMSAT Phase 5A

CubeSat

Hmotnost 1kg
Rozměry 10x10x10 cm





Poděkování

Vedení ÚREL

Prof. Z. Raida, Prof. J. Svačina

Spolupracovníci

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Ing. Jan Šebesta, Mgr. V. Lakkundi, Ph.D., Ing. J. Špaček,

Ing. P. Vágner, Ing. O. Baran, Ph.D., Ing. T. Urbanec,

Ph.D., Ing. F. Záplata, Ph.D., Ing. A. Povalač, Ph.D.

řada studentů bakalářských a magisterských studijních programů

Externí spolupracovníci

Dr. Stacey Mills, Ing. Pavel Ševčík, Mgr. Pavel Kasal

MŠMT

Grant FR VŠ č. FR470644, Grant FR VŠ č. F1-1549

VZ č. MSM 0021630513

GA ČR

Grant č. 102/04/0557, Grant č. 102/06/1672