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RAX General Station Client

File View Server

Summary Panel

RAX-Data			Communications			External Panels		
Name	Value	Unit	Name	Value	Unit	Name	Value	Unit
RF1 Mag X	11.23	Volts	RF1 Noise	0.00	µV/meter	V1 Current	1	mAmps
RF1 Mag Y	11.17	Volts	RF1 Radio Temp	27	deg C	V2 Current	0	mAmps
RF1 Mag Z	11.16	Volts	RF1 P101	113	dB	V3 Current	1	mAmps
Gain X	17.31	dBdBS	Output Status	0	dB/dBts	V4 Current	12	mAmps
Gain Y	17.4	dBdBS	RF P 01	0	dBm	V5 Voltage	11.74	Volts
Gain Z	17.88	dBdBS	RF P 02	0.00	dBm	V6 Voltage	12.78	Volts
Gain Mag 1	15.22	Volts				V7 Voltage	13.13	Volts
Gain Mag 2	17.18	Volts				V8 Voltage	13.13	Volts
Gain Mag 3	17.32	Volts						

Power System				Spectrum State			Stack Temperature		
Name	Value	Unit		Name	Value	Unit	Name	Value	Unit
V1 Current (0.0V)	0.0	mAmps	PR	Enabled			RF1 Temp	26.02	degrees C
V2 Current (0.0V)	0.0	mAmps	PTX	Enabled			RF2 Output Key Temp	23.13	degrees C
V3 Current (0.0V)	0.0	mAmps	QRP	Enabled			RF3 Board Temp	27.77	degrees C
V4 Voltage (0.0V)	4.16	Volts	ALC	Enabled			RF4 Board Temp	25.0	degrees C
V5 Voltage (0.0V)	0.33	Volts	PTB	Enabled			RF5 Board Temp	27	degrees C
V6 Voltage	11.90	Volts	RFV	Enabled			RF6 Board Temp	26.13	degrees C
			RFW	Enabled			RF7 Board Temp	25.5	degrees C
			RFZ	Enabled					
			Remote Switch	Off					
			Power/Status Switch	Off					
			Command Channel	0	µV/meter				

20 Nov 2010 05:59:27 GMT
26 Nov 2010 05:59:47 GMT
06 Nov 2010 05:59:59 GMT
06 Nov 2010 05:59:27 GMT
06 Nov 2010 05:59:47 GMT
06 Nov 2010 05:59:59 GMT
26 Nov 2010 05:59:41 GMT
26 Nov 2010 05:59:59 GMT
26 Nov 2010 05:59:29 GMT
26 Nov 2010 05:59:48 GMT
26 Nov 2010 05:59:48 GMT
26 Nov 2010 05:59:28 GMT
26 Nov 2010 05:59:58 GMT

RAX Telemetry Decoding Effectiveness Experiment

Radio Aurora Explorer (RAX)



The objective of the RAX mission is to understand the microphysics that lead to the formation of magnetic field-aligned plasma irregularities (FAI), an anomaly known to disrupt communications with orbiting spacecraft.

Objective of the Experiment



Objective:

“Analyze the effectiveness of a Radio Amateur Satellite Station to serve as a Ground Station (GS) for RAX”

Method:

During 24 hours the GS monitors independent and fully automated (computer controlled) the RAX downlink.

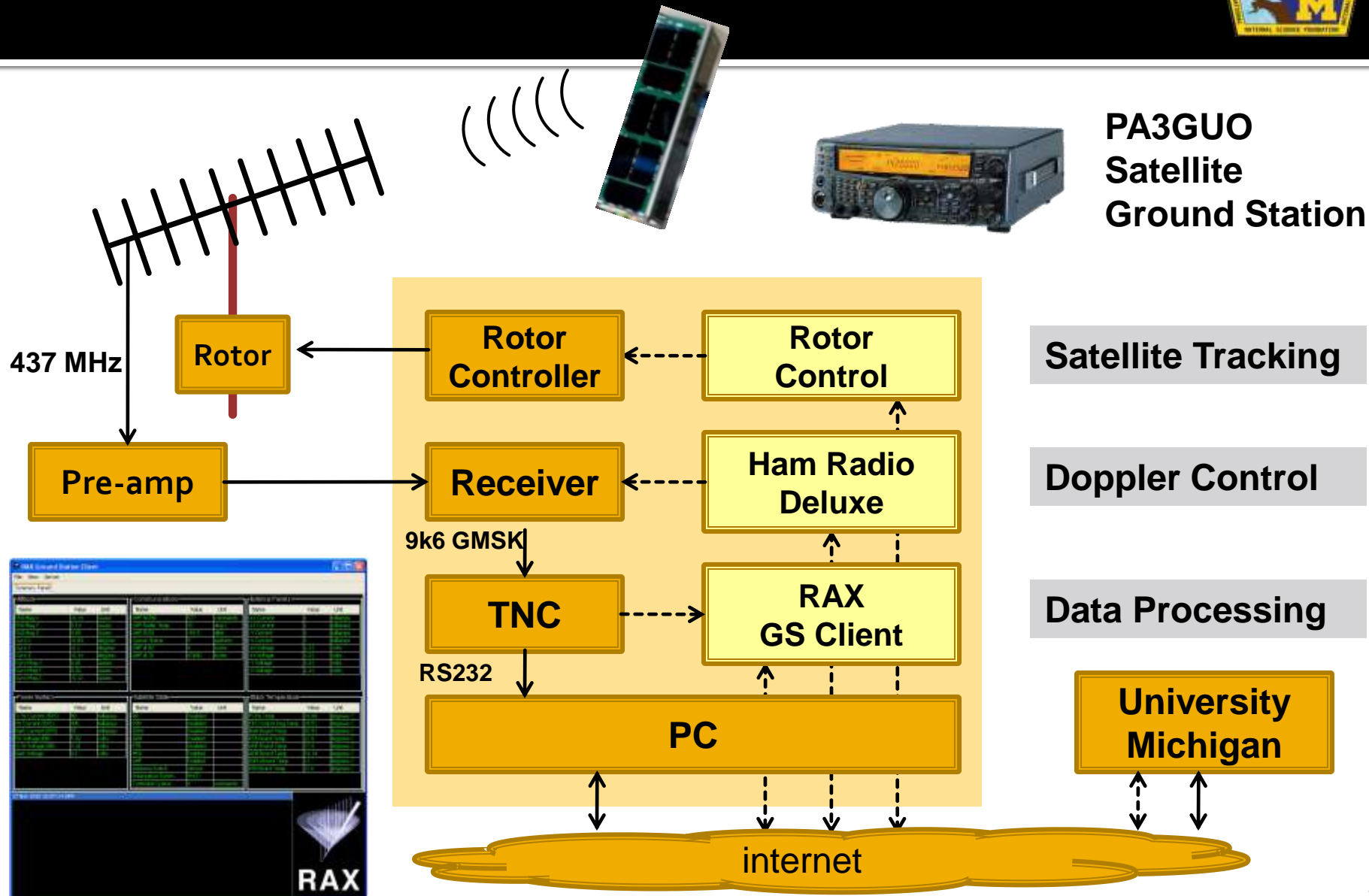
RAX sends each 20 seconds a data packet.

Based on the amount of successfully decoded telemetry packets an indication for the **“RAX decoding effectiveness”** can be derived.

Ground Station Architecture



PA3GUO
Satellite
Ground Station



Satellite Tracking

Doppler Control

Data Processing

University
Michigan

Ground Station Equipment



Hardware

- Antenna 12 elements, vertical polarization
- Pre-amp SSB Electronics SP-7000
- Rotor Kenpro KR-500 + KR-400
- Receiver Kenwood TS-2000X
- TNC AEA PK-96

Software

- Doppler Control Ham Radio Deluxe
- Rotor Control PA3GUO
- Data Analysis MSI RAX GS Client

Ground Station Components



Antenna:

12 elements directional yagi (PE1ITR)

Vertical polarization

Satellite tracking in steps of <5 degrees (azimuth & elevation)

UHF (437MHz) SSB Electronics pre-amp used for improved SNR

Receiver:

Kenwood TS-2000x, multi-mode transceiver

Frequency control (Doppler compensation) via HamRadioDeluxe

PK96 TNC to decode the 9600 GMSK downlink of RAX

Software:

Alogger to initialize the TNC into KISS mode & 9600 baud

RAX GS Client to decode and store & forward the telemetry

24 hour window: Nov 25 2010



Passes:

RAX passes a GS each day multiple times.

Some passes have a high maximum elevation during which many packets are decoded due to the good S/N ratio.



Low elevation passes (<20 degrees) typically result in fewer data.

Nov 25 – Nov 26 had these 5 passes:

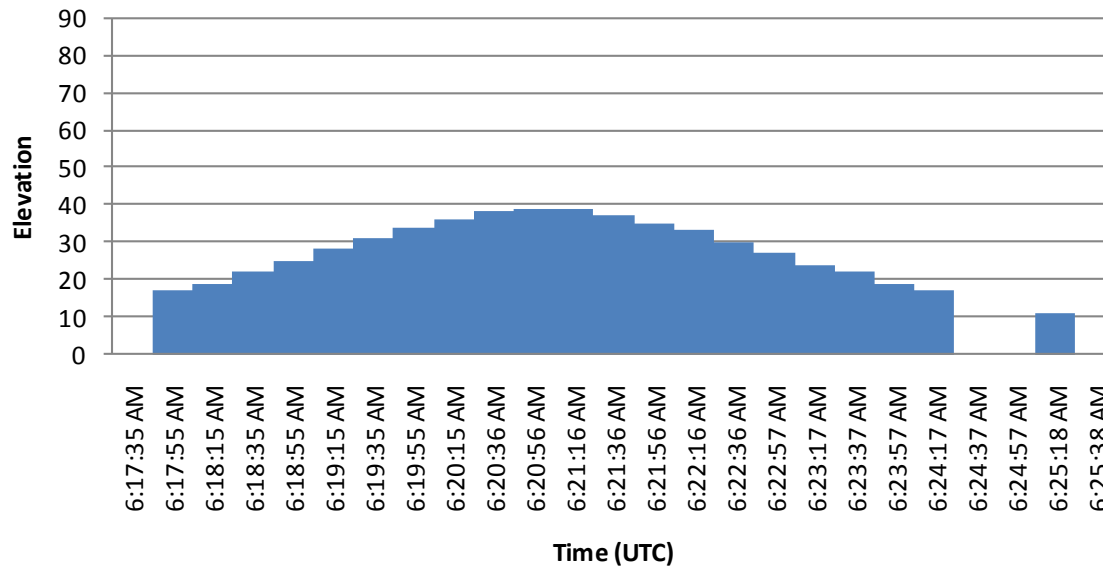
06:20utc	40°	elevation
08:00utc	11°	elevation
13:05utc	28°	elevation
14:45utc	52°	elevation
05:05utc	68°	elevation

Analysis – 06:20 UTC pass



RAX Telemetry Decoding

PA3GUO 25 Nov 2010



Maximum elevation	40
Pass duration	7 minutes
Transmitted packets	23
Decoded packets	21
Missed packets	2
Effectiveness	91%

Decoding threshold: 15° elevation

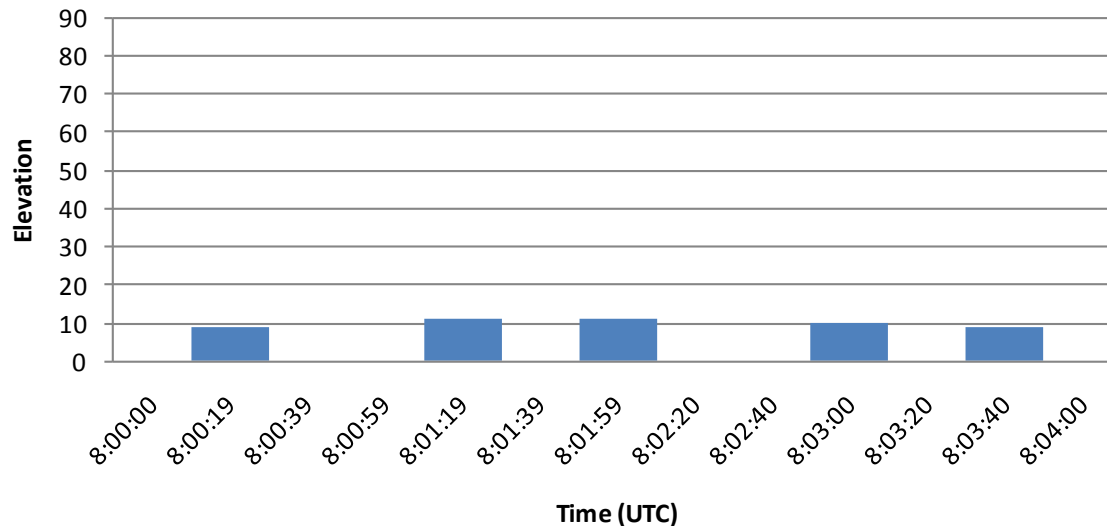
Medium elevation pass → 91% decoded

Analysis – 08:00 UTC pass



RAX Telemetry Decoding

PA3GUO 25 Nov 2010



Maximum elevation	11
Pass duration	4 minutes
Transmitted packets	11
Decoded packets	5
Missed packets	6
Effectiveness	45%

Decoding threshold: 9° elevation

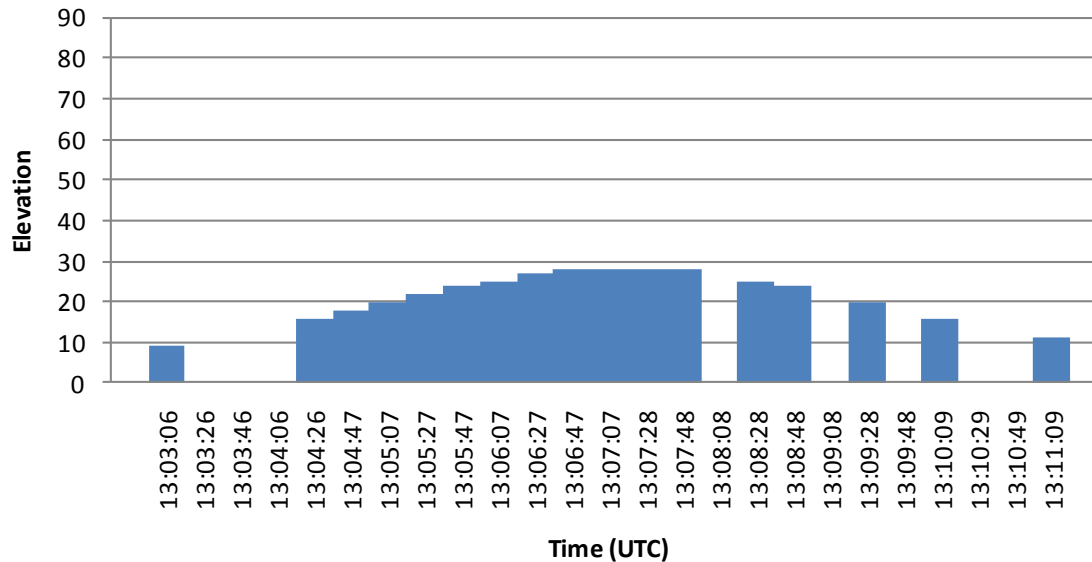
Low elevation pass → 45% decoded

Analysis – 13:05 UTC pass



RAX Telemetry Decoding

PA3GUO 25 Nov 2010



Maximum elevation	28
Pass duration	9 minutes
Transmitted packets	25
Decoded packets	17
Missed packets	8
Effectiveness	68%

Decoding threshold: 9° elevation

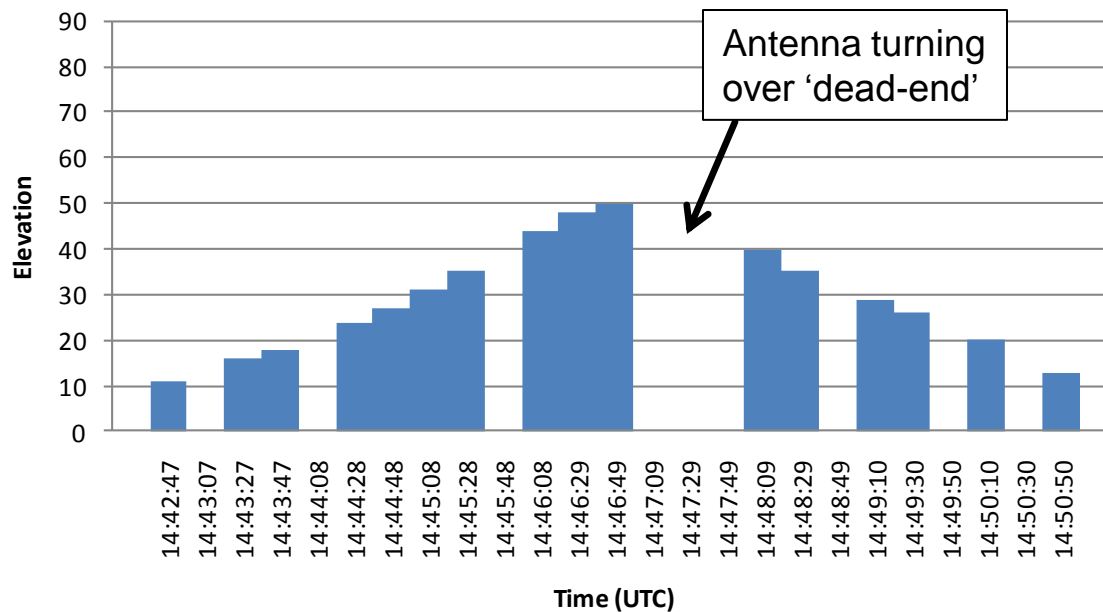
Low elevation pass → 68% decoded

Analysis – 14:45 UTC pass



RAX Telemetry Decoding

PA3GUO 25 Nov 2010



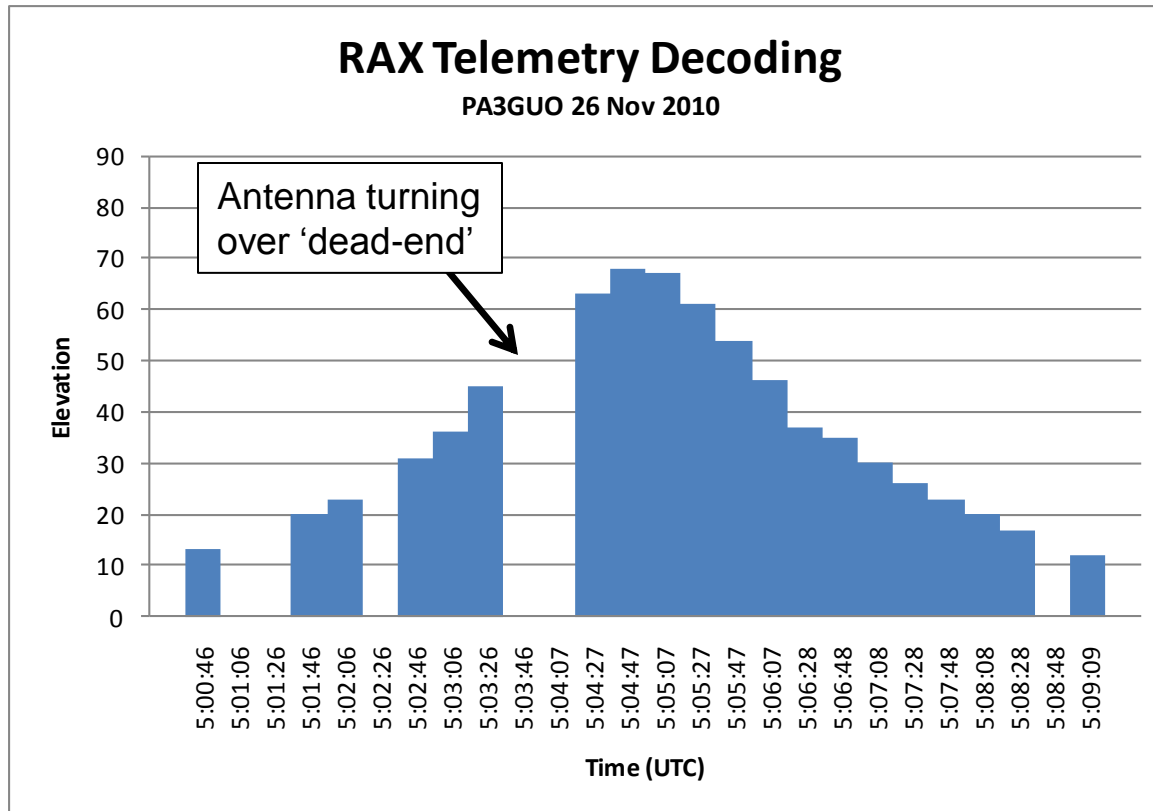
Maximum elevation	52
Pass duration	9 minutes
Transmitted packets	25
Decoded packets	16
Missed packets	9
Effectiveness	64%

Decoding threshold: 11° elevation

Medium elevation pass → 64% decoded

When compensated for antenna turning: 72%

Analysis – 05:05 UTC pass



Maximum elevation	68
Pass duration	9 minutes
Transmitted packets	26
Decoded packets	20
Missed packets	6
Effectiveness	77%

Decoding threshold: 12° elevation

High elevation pass → 77% decoded

When compensated for antenna turning: 85%

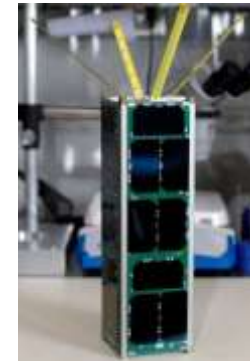
Analysis - summary



- Decoding threshold is $\sim 10^\circ$ elevation

- Decoding effectiveness:

06:20utc	40° elevation	91%
08:00utc	11° elevation	45%
13:05utc	28° elevation	68%
14:45utc	52° elevation	72%
05:05utc	68° elevation	85%



- Decoding low elevation passes: $\sim 55\%$
- Decoding med/high elevation passes: $\sim 85\%$
- 24 hours: 80 packets decoded, 31 missed: 72%
(when compensated for turning antenna: 77%)

Conclusions



- Radio Amateur satellite ground stations can contribute to space research and science missions
- Ground Stations (GS) can be made with relative simple, 12 elements, directional antennas
- In 24 hours 80 telemetry data packets were downloaded
- During medium and high elevation passes a ground station can achieve >85% 'RAX decoding effectiveness'

END