Decoding Satellite Telemetry from ARISSat

Douglas Quagliana, KA2UPW/5

In 2010 “The Future” Prediction:

- Received telemetry will be sent to an Internet telemetry reflector using KA9Q satellite telemetry protocol (STP) - √ done
- “Live” telemetry via the Internet to anyone who wants a live copy of the data - √ done
- Archived telemetry frames will be available via the Internet - √ done

Overview

- ARISSatTLM software available for Windows PC, Apple/Mac
- Telemetry web pages for PCs and mobile devices
- Uses modified KA9Q BPSK1000 software demodulator plus modified AA2TX sound card I/O plus KA2UPW GUI decode and display program

Overview *II - SUCCESS!*

- More than 92,000 spacecraft telemetry frames received
- More than 83,000 KURSK experiment frames received
- More than 260 different ground stations have submitted telemetry via the Internet

Countries Submitting Telemetry

Argentina, Australia, Belgium, Brazil, Canada, Croatia, Czech Republic, Denmark, England / UK, Finland, France, Germany, Greece, Guernsey / UK, Ireland, Israel, Italy, Japan, Malaysia, Malta, Netherlands, New Zealand, Norway, “Other”, Poland, Portugal, Russia, Scotland / UK, Serbia, Slovak Republic, South Africa, Spain, Sweden, Switzerland, Thailand, Turkey, Ukraine, United Kingdom, United States, Vietnam, Wales / UK

New telemetry decoding “schemes”

- Yet another layer of abstraction
- Programmer doesn't need to know the values (1=LOW, 2=HIGH, etc) just use the variable names and #define constants (if telem.mode = HIGH...)
- Absolute byte position in the telemetry becomes unimportant
- “Just” recompile
- Lookup tables and decoding equations

ARISSatTLM Live telemetry page

ARISSat-1 Telemetry - Full Decode

This telemetry was received on Sat, 05 Nov 2011 13:26:52 UTC

Uptime:3176 seconds - 00d:00h:52m:56s - Mode: HIGH PWR

Battery

Batt Voltage	36.016
Batt Current	-0.025
PSU Vdd	5.064
5V VDD	5.064
Charging A.h	0.001
Discharging A.h	0.010
Net A.h	-0.009

Battery is Discharging

Power Consumption

Camera	0.086	6665452
Experiment	0.235	55527838
IHU	0.198	28122416
SDX	0.247	36020178
5 Volt	0.675	84964067
RF (8V)	0.425	52671904

ARISSatTLM Live telemetry page

Status

IHU	ACTIVE	Camera1	OFF	Experiment	ACTIVE
PSU	ACTIVE	Camera2	OFF	5 Volt	ACTIVE
SDX	ACTIVE	Camera3	OFF	8 Volt	ACTIVE
		Camera4	OFF		

Temp

IHU PCB	53°C	Top Camera	55°C
PSU	56°C	Bottom Camera	33°C
RF	59°C	Control Panel	49°C
Batt	33°C	Experiment	49°C
RF Enc	39°C		

+X PPT-0

Energy	11643714
Solar temp	31°C
Diode temp	42°C
Ind_temp	43°C
sp_current_adc_raw	0.000A
sp_voltage_raw	44.035V
osc_ccp_current_setpt	0.032V
aged	Current
corrupt	1

-X PPT-1

Energy	13983178
Solar temp	38°C
Diode temp	41°C
Ind_temp	42°C
sp_current_adc_raw	0.002A
sp_voltage_raw	15.193V
osc_ccp_current_setpt	0.032V
aged	Current
corrupt	0

+Z PPT-2

Energy	2236864
Solar temp	-7°C
Diode temp	41°C
Ind_temp	41°C
sp_current_adc_raw	0.004A
sp_voltage_raw	0.000V
osc_ccp_current_setpt	0.032V
aged	Old
corrupt	0

-Y PPT-3

Energy	13080547
Solar temp	38°C
Diode temp	47°C
Ind_temp	48°C
sp_current_adc_raw	0.078A
sp_voltage_raw	44.035V
osc_ccp_current_setpt	0.032V
aged	Current
corrupt	0

+Y PPT-4

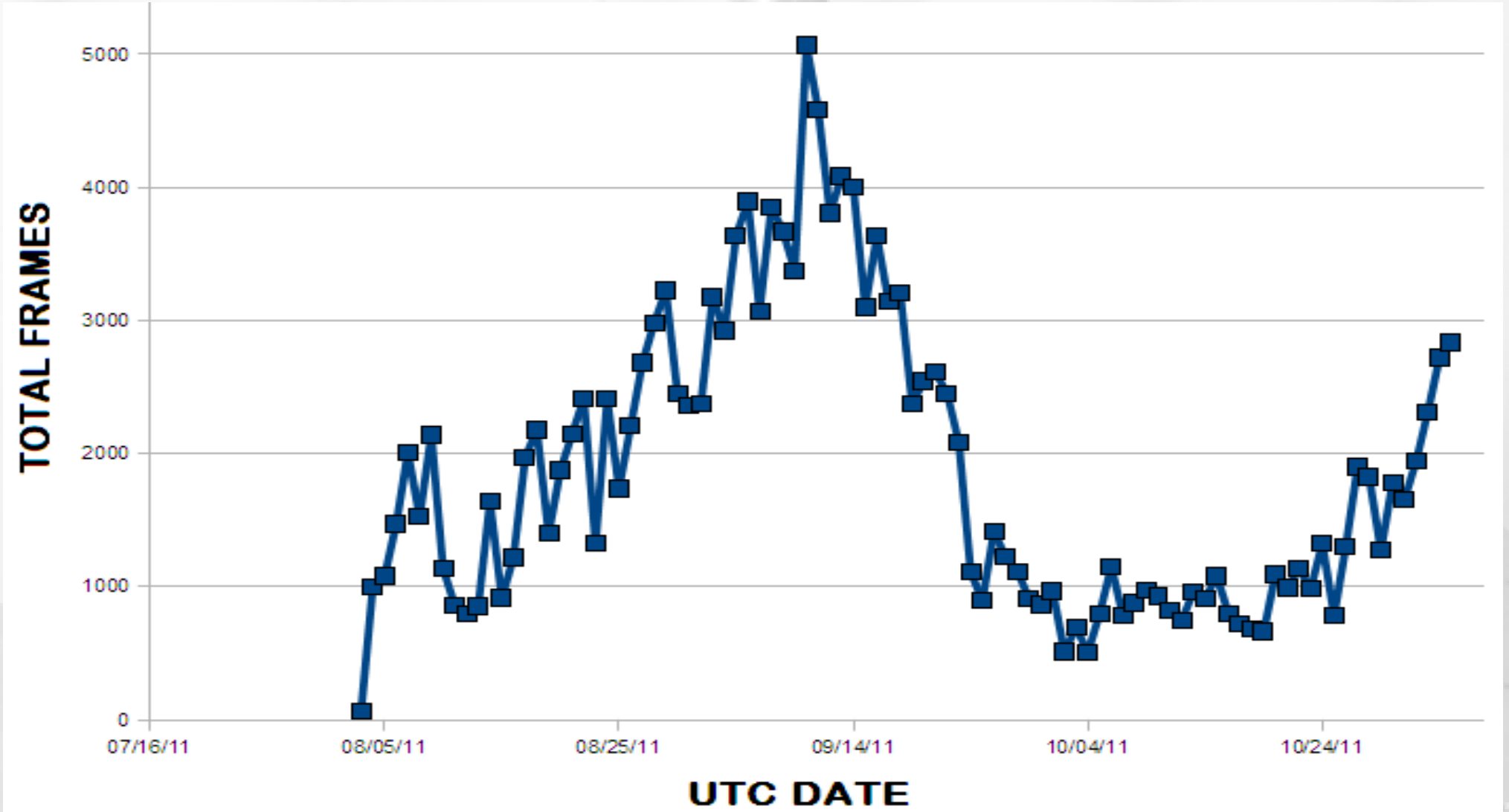
Energy	12948608
Solar temp	33°C
Diode temp	48°C
Ind_temp	50°C
sp_current_adc_raw	0.004A
sp_voltage_raw	16.996V
osc_ccp_current_setpt	0.032V
aged	Old
corrupt	0

-Z PPT-5

Energy	71486059
Solar temp	75°C
Diode temp	48°C
Ind_temp	57°C
sp_current_adc_raw	0.184A
sp_voltage_raw	38.627V
osc_ccp_current_setpt	0.213V
aged	Current
corrupt	0

ARISSatTLM website by
Douglas Quagliana, KA2UPW/5
Gilbert Mackall, N3RZN
Version 0.03

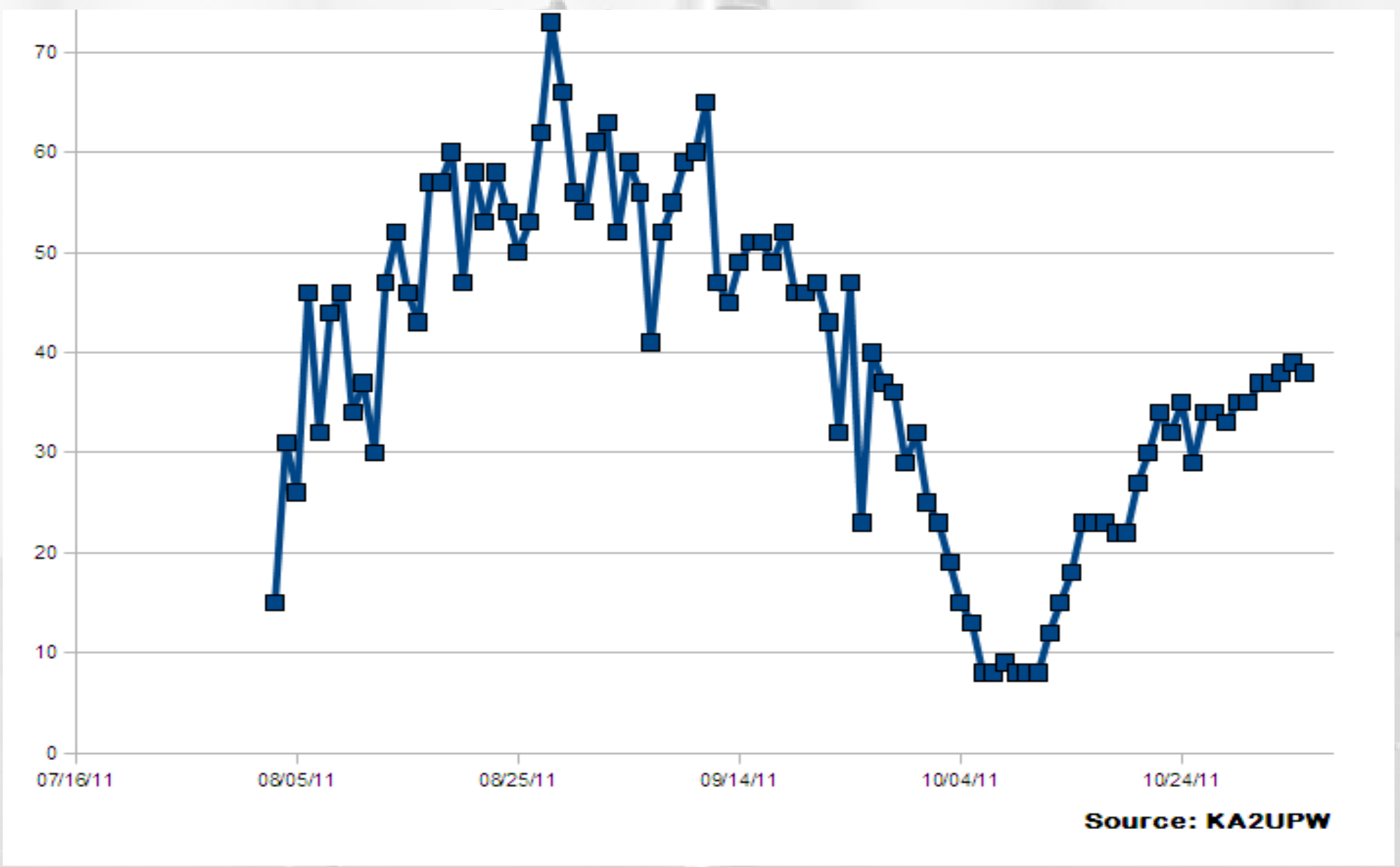
Total telemetry frames per day



Total telemetry frames (spacecraft and KURSK experiment telemetry, including duplicate frames) received by the Internet Telemetry Server per UTC day from 2011-08-03 to 2011-11-04

Source: KA2UPW

Total ground stations per day



Why these curves?

- Number of ground stations participating drives the total frames received
- More stations/increased proficiency/better station configuration drives totals higher
- Interest level (newness wears off) AND
- Satellite passes during eclipses yield no telemetry frames / some stations see no daylight passes for days at a time
- Ground stations again see daylight passes

Lessons Learned: Problems

You will have problems.

You can exchange your current problem set for some other *different* problem set, but you will still have some non-zero number of problems.

While there is a non-zero lower limit to the number of problems, there does not seem to be any upper limit on the number of problems.

Lessons Learned: what you think is going to happen doesn't matter

My pre-deployment expectation: a few dozen stations will submit telemetry for a few weeks, and we would get a few thousand frames at most. Then interest will fade.

Reality: 260+ ground stations, 3+ months and still going, 175,000+ telemetry frames

Have a plan for success

Lessons Learned: Biggest resource drain

During development if the telemetry format changes, then the software MUST be able to determine that a new format is being received (fixed definition for “A” block, if revise then switch to “B” block, etc)

Lessons Learned: Biggest gains

- Reuse/recycle other people's open source code
- Application log files greatly assist your debugging
- Forward error correction means lots of telemetry is going to be *received*
- Automated telemetry submission via the Internet (especially with automated ground stations) results in LOTS of data being *submitted*

Lessons Learned

- Test, Test, TEST: recordings, Internet streaming audio, KURSK simulator
- When you think you're done, test again.

Lessons Learned: For next time

Send rapidly changing telemetry more often: solar panel voltage & current - spin rate versus telemetry *frame* rate

Have a better plan for success (email submissions take time)

Use an application framework

Lessons Learned: for next time

- Test with non-English version of Windows

Thanks!

Phil Karn, KA9Q, (BPSK1000 code),
Tony Monteiro, AA2TX (sound card software routines used in ARISSatTLM)
Gilbert Mackall, N3RZN (assistance and collaboration with ARISSatTLM, and especially for writing the telemetry decoding software that outputs the decoded telemetry as HTML code. His software became part of the Internet telemetry server software and is used every time one of the web pages is updated)
Gould Smith, WA4SXM, and Lou McFadin, W5DID, for testing version after version of the ARISSatTLM software and reporting plenty of bugs
Mark Hammond, N8MH, for extended testing and late night ARISSatTLM debugging sessions.
Joe Armbruster for the telemetry audio stream used during testing

Special Thanks!

Everyone who submitted and continues to submit telemetry

Questions?

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What questions do you have?

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