



A New Use For The Whole Orbit Data Algorithm

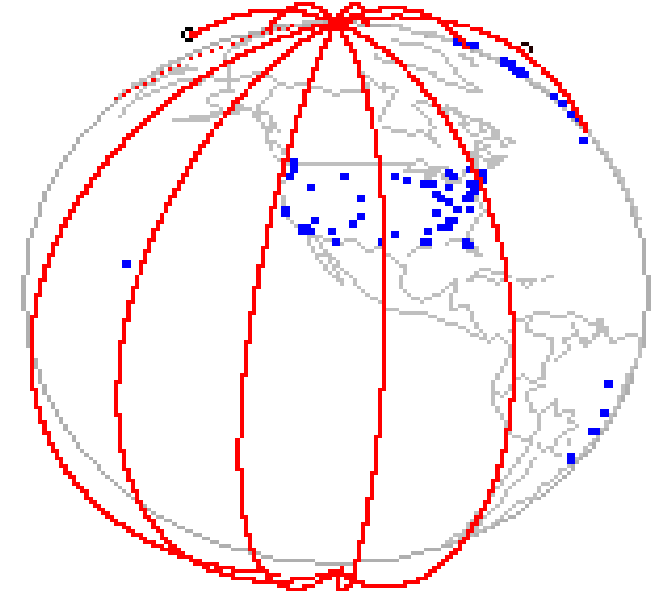
Burns Fisher (WB1FJ)
Radio Amateur Satellite Corporation



What is WOD?

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- **WOD means Whole Orbit Data**
- **How do we get data over locations with no ground stations?**
 - **Answer: Send data when in range of a ground station that was collected earlier in the orbit**
- **But bird does not know when there is a ground station listening!**
 - **Answer: Send the same data over and over and over...**



How We Do WOD

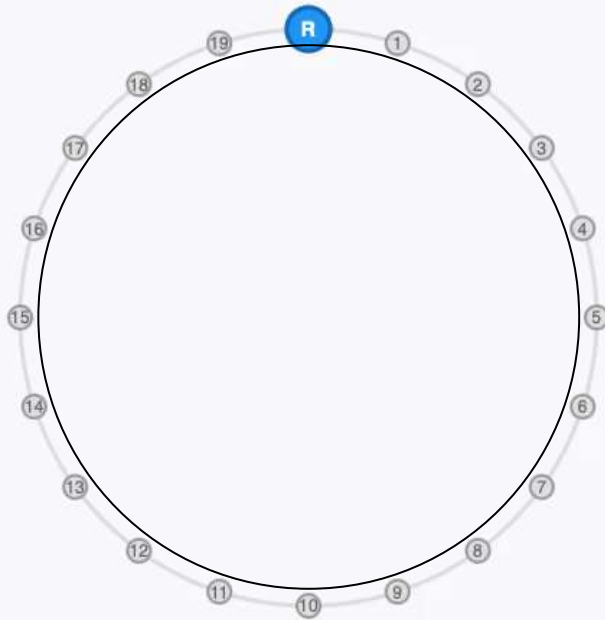
Radio Amateur Satellite Corp.

- ❖ All our satellites since Fox have “MRAM” non-volatile memory
 - ❖ Essentially infinite write cycles
 - ❖ High tolerance to radiation
- ❖ Older FM Foxes used it for ‘Voice of Fox’ and Min/Max
- ❖ Since Fox-1e/HuskySat it also stores WOD
- ❖ MRAM organized as a circular buffer
- ❖ Collect data 1/minute and store in MRAM
- ❖ Transmit many data packets for each one that is collected



Ring Buffer

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- Blue: Where we read from to downlink
- Green: Where we write a new set of data
- This example show each entry being read (and transmitted) about 7 times before it is overwritten

Created by Claude AI

How Much WOD To Save?

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- In other words, how big is the ring buffer? The truth is surprising!
 - No matter how big the memory, we still transmit each WOD packet the same number of times (31 in Fox-1e)
- Consider:
 - Small amount of memory:
 - a given packet is sent more frequently
 - but does not stay in the MRAM as long/sees fewer ground stations
 - More memory:
 - a given packet is sent less frequently, but spread over a wider area on earth
- How much memory use is optimal?

Carl Wick, N5MIM, found out!

Optimal WOD Size

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- ❖ What is the optimal memory size?
- ❖ Carl did a simulation including a typical polar orbit, and noting the locations of ground stations that typically collect data for AMSAT satellites.
- ❖ Then answer: 150!

For math and details, see papers for 2017 Symposium, Fox-1E Telemetry by W2BFJ and N5MIM

WOD Credits

Radio Amateur Satellite Corp.

- **Carl Wick, N3MIM -- WOD Simulation**
 - See paper in 2017 Symposium Proceedings
- **Chris Thompson, AC2CZ/G0KLZ – FoxTelem**
 - See [GitHub/AC2CZ/FoxTelem](#)
- **Mike McCann K2GHZ – WOD Initial Proposal**
 - See references in W2BFJ 2017 Symposium Paper
- **Burns Fisher, W2BFJ/WB1FJ – Fox Telemetry Transmission**
 - See paper in 2017 Symposium Proceedings

Telemetry Speed

Radio Amateur Satellite Corp.

- **Fox-1A – Fox-1D: 200bps DUV**
- **Fox-1E, HuskySat-1, MESAT1: 1200bps BPSK**
 - Amount of data to collect did not change much.
 - Used 6x speed to send WOD!
- **Golf Satellites more complex—more data required!**
 - Health data is ~similar, but...
 - ADCS commissioning
 - Future pictures???

Telemetry Speed

Radio Amateur Satellite Corp.

- Why not faster?
 - LIHU/Fox-1E-type modulator designed for BPSK and can't go much faster
 - Golf-TEE uses LIHU as “fallback” in case newer RT-IHU/transmitter fails
 - Later may use RT-IHU only
 - RT-IHU/DCT has higher speed capability.

But for now, how to deal with 1200bps and larger data quantities?



How Much Data How Often

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- **ADCS Commissioning:** Will need multiple data sets at different times. Ex:
 - Raw Magnetometer readings
 - Raw Gyro Readings
 - Coarse Sun Sensor data
 - Some collected every 10 seconds for a full orbit
- Remember one downlink frame is 669 bytes.
- Several needs and non-needs:
 - Data needs to have been collected sometimes seconds apart
 - Data needs to be timestamped
 - But does not need to reach the ground within seconds

Summary of Requirements

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- **Collect Data Frequently**
- **Downlink to sparsely-located ground stations**
- **...but not necessarily immediately**
- **Sound familiar?**
- **~Like WOD!**

How Does LDS Differ From WOD?

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LDS

- Large but limited qty of data
- Must not lose any data
- Only done a few times in mission
- Fits in MRAM memory

WOD

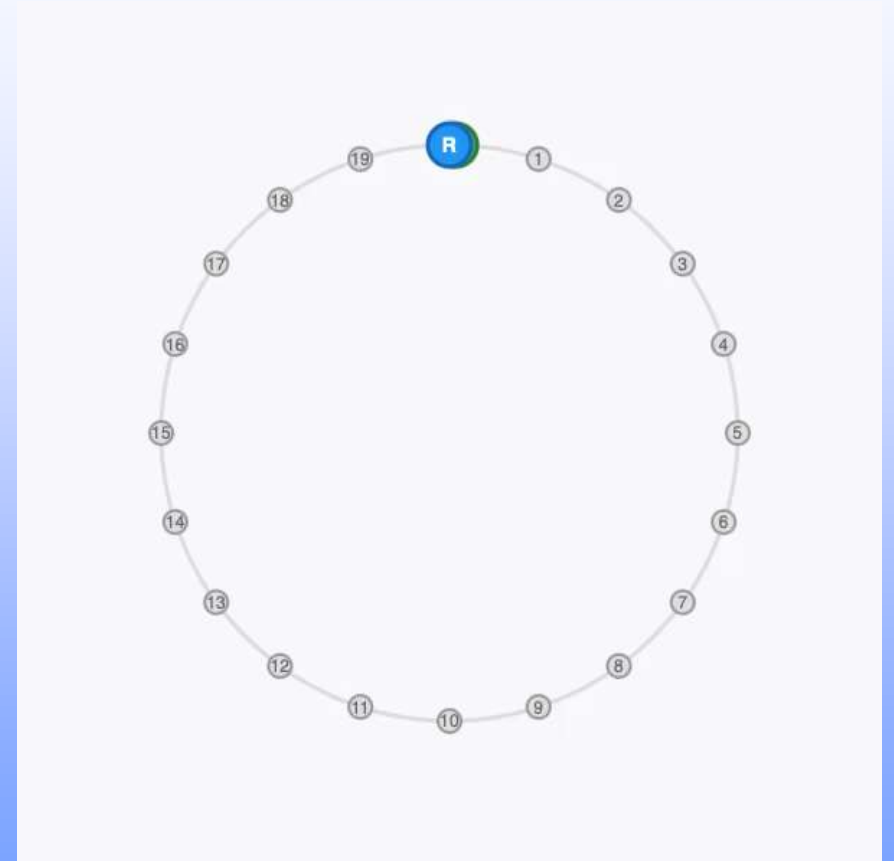
- Continuously collected
- Best not to lose but not a tragedy
- Collected and transmitted for life of mission
- Total far more than MRAM size

Can We Modify WOD Algorithm To Accommodate These Differences?

How to do LDS

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- ❑ Write frame-sized chunks of data in MRAM
 - Include timestamp
 - Amount written must be less than MRAM size (no over-writing)
 - Collect and write just once
- ❑ When done writing, treat data as circular buffer to read from
 - Transmit same list of data over and over



The Ground Side

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- FoxTelem receives on the ground
- To FoxTelem LDS looks identical to WOD
- Requires adding new payloads and tabs with WOD-like data
- Thanks to Chris Thompson G0KLA/AC2CZ/VE2TCP for help and quick work!

AMSAT Telemetry Analysis Tool

File | File | Decoder | Spacecraft | Help

Inp Input **FoxPlus-A** **Golf-T**

Health Health VU VU WOD **WOD** Diagnostics ADCS Telem Logs Measurements

Golf-Golf-T ADCS Log Payloads Decoded: 10

ADCSLog

Last

LogType: 1

LogFrameNumber: 8

LogTy	LogType	LogFra...	B0	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15	B16	B17	B18	B19	B20	B21	B22	B23	B24	B25	B26	B27	B28	B29	B30	B31	B32	B33	B34	B35	B36	B37	B38		
1			90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
1			84	3	3	3	3	0	d2	6e	9a	66	0	8	af	2f	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1			70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	b4	6e	9a	66	0	8	af	2f	0	0		
1			60	0	0	0	0	0	0	0	0	3b	c1	1a	0	38	28	1	0	96	6e	9a	66	3f	3	96	6e	9a	66	0	8	af	2f	0	0	0	0	0	0	0	0	0	0
1			53	3	3	0	6e	6e	9a	66	0	8	af	2f	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6e	6e	
1			40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	6e	9a	66	0	8	af	2f	0	0	0	0		
1			30	0	0	0	0	0	0	d7	c0	1a	0	db	ee	5	0	cf	6f	9a	66	3f	3	cf	6f	9a	66	0	8	af	2f	0	0	0	0	0	0	0	0	0	0	0	
1			23	0	a7	6f	9a	66	0	8	af	2f	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	a7	6f	9a	66		
1			10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	89	6f	9a	66	0	8	af	2f	0	0	0	0	0		
1			080	c0	81	0	0	73	c0	1a	0	3d	68	4	0	6b	6f	9a	66	3f	3	6b	6f	9a	66	0	8	af	2f	0	0	0	0	0	0	0	0	0	0	0	0	0	

☐ Show Raw Bytes ☐ Display Raw Values ☐ Display UTC Time

Version 1.13j - 19 Jul 2025 Logs: C:\Users\burns\FoxTelemData

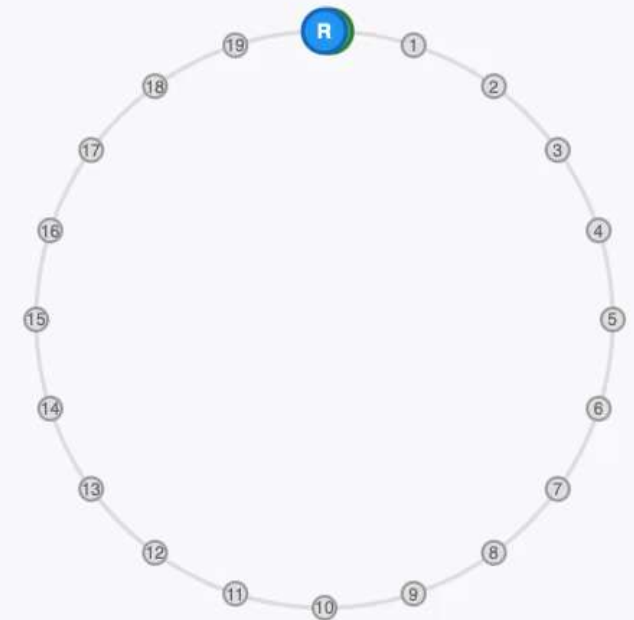
SDR Errors: 0 / 0 Audio missed: 0.0% / 0 Frames: 22 Payloads: 413 Queue: 0

Last 180 samples

Partial Transmission

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- ❑ What if we are just missing a few?
 - Command to send only missing range
 - Animation: Transmit only 6, 7, 9,10



LDS Summary

Radio Amateur Satellite Corp.

- Can collect many thousands of bytes quickly
- Send them slowly in small timestamped chunks
- Repeat sending over and over hoping most get received
- Command only missing chunks to be sent until we have everything -- HOORAY



Thanks for listening!



STS-125 Atlantis Launch