



Analysis of Argos 3 Technology on Buoy Platforms

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Purpose of Study

- Controlled tests with same host controller for:
 - Argos 2
 - Argos 3
 - Iridium SBD
- Positive findings from Argos 3 and Iridium Pilot Projects
- Manufacturer participation within Iridium and Argos Pilot Projects
 - Uncertainty of Argos 3 implementation
 - Iridium SBD vs. Argos 3 power consumption
- Shortened Argos 2 drifter lifetime with Kenwood YTR-3000 PMT



Figure: Clockwise from Top Left: Argos 2, Iridium SBD, and Argos 3



SIO SVP: Float



- 15" Diameter Hull
- Injection molded ABS
- Re-sealable O-ring design
- 316 Stainless Steel band for sealing and impact protection



Figure: Injection molded re-sealable hull with sealing ring



SIO SVP: Controller



- Onboard capabilities:
 - GPS Module
 - Temperature and Strain gauge
 - Real Time Clock and Calendar (RTCC)
 - Non-volatile memory (EEPROM)
- Support of:
 - Argos Kenwood YTR-3000 PMT
 - Iridium 9602 SBD Modem
 - Honeywell HPB Barometer
 - Additional external devices

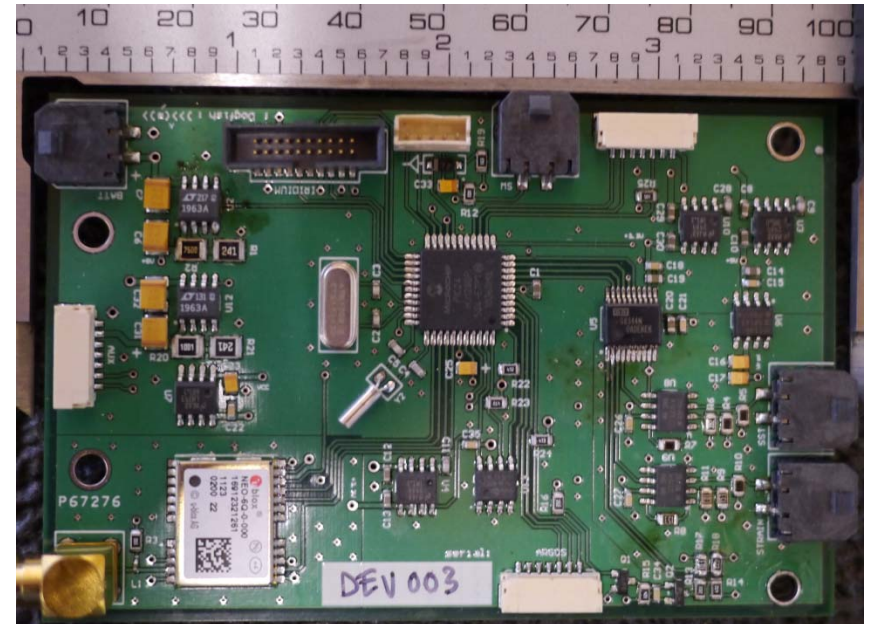


Figure: In-house developed micro-controller



Setup: All systems

- SIO controller
 - SVP sensor payload:
 - Temperature
 - Strain gauge
 - Battery voltage
- Sealed in SIO hull with an O-ring
- Placed on roof at SIO
 - Placed in 5 gallon bucket of water for cooling
- 2.5 Amp-hour battery pack
 - 8 AA-cell Alkaline batteries in series

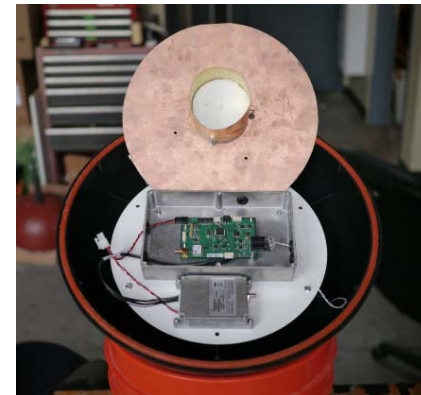


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Battery Pack



- Endurance Test Battery Pack
 - 2.5 Amp-hour capacity
 - 8 Alkaline AA-cell batteries in series
- Typical SVP Battery Pack
 - 56 Amp-hour capacity
 - 4 parallel strings of 8 Alkaline D-cell batteries in series
 - 70 Amp-hour capacity
 - 5 parallel strings of 8 Alkaline D-cell batteries in series

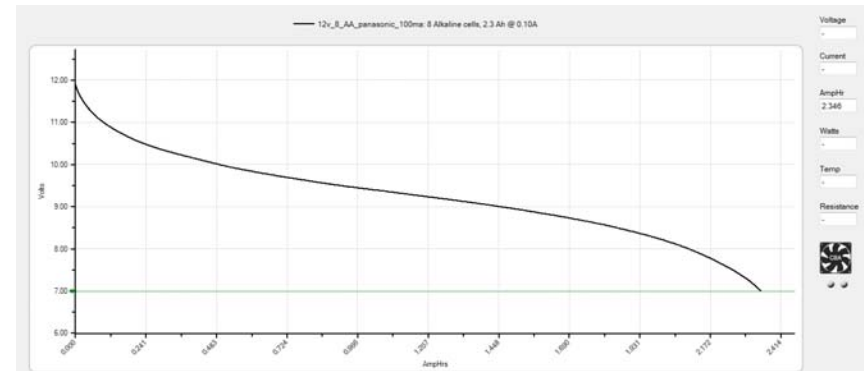


Figure: AA-cell discharge curve at 100mA constant draw, 2.35Ah¹

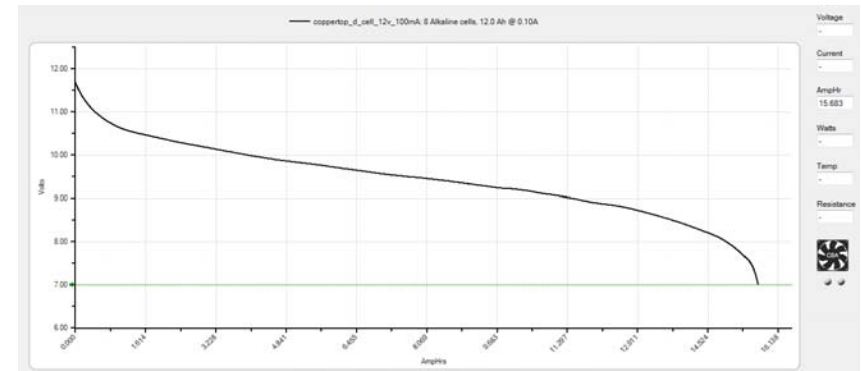


Figure: D-cell discharge curve at 100mA constant draw, 15.68Ah¹

¹ Measured with CBA III Computerized Battery Analyzer



Setup: Argos 2



- SVP payload
 - Sensors:
 - Temperature
 - Strain gauge
 - Battery voltage
 - **15 minute** sensor observations
- Modem configuration
 - Kenwood YTR-3000 PMT in PTT mode
 - Recommend settings by CLS for PTT operation
- Antenna
 - Argos 2 capable by Hirschmann
 - Wide band Tetra specification
 - 380 – 430 MHz
 - 808 – 870 MHz

[Table: Kenwood YTR-3000 configuration for Argos 2 PTT](#)

	Argos 2
YTR-3000 Mode	PTT
Transmission mode	A
BPSK Transmitter	1 watt
GMSK Transmitter	Disabled
H WUP	Disabled
Receiver	Disabled
Interactive-Ack	N/A
Pseudo-Ack	N/A
Nb tries for Pseudo-Ack	N/A
Repetition Rate	90 seconds
GPS option	N/A
Checksum	No



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Setup: Argos 3



- SVP payload
 - Sensors:
 - Temperature
 - Strain gauge
 - Battery voltage
 - **15 minute** sensor observations
- Modem configuration
 - Kenwood YTR-3000 PMT in PMT mode
 - Default PMT configuration except:
 - GMSK transmitter
 - H_WUP pin
 - Pre-loaded with Orbital parameters and PMT location for satellite pass prediction
- Antenna
 - Argos 3 design used by Clearwater Instrumentation

[Table: Kenwood YTR-3000 configuration for Argos 3 PMT](#)

	Argos 3
YTR-3000 Mode	PMT
Transmission mode	C
BPSK Transmitter	1 watt
GMSK Transmitter	Disabled
H WUP	Disabled
Receiver	Enabled
Interactive-Ack	Enabled
Pseudo-Ack	Enabled
Nb tries for Pseudo-Ack	5
Repetition Rate	30 seconds
GPS option	Disabled
Checksum	Enabled (FCS)



Setup: Argos 3



- SVP payload
 - Sensors:
 - Temperature
 - Strain gauge
 - Battery voltage
 - 15 minute sensor observations
- Modem configuration
 - Kenwood YTR-3000 PMT in PMT mode
 - **Default PMT configuration except:**
 - GMSK transmitter
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 - **Pre-loaded with Orbital parameters and PMT location for satellite pass prediction**
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Receiver	Enabled
Interactive-Ack	Enabled
Pseudo-Ack	Enabled
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Repetition Rate	30 seconds
GPS option	Disabled
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Setup: Argos 3



- SVP payload
 - Sensors:
 - Temperature
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 - Battery voltage
 - 15 minute sensor observations
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 - Default PMT configuration except:
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Setup: Iridium SBD



- SVP payload
 - Sensors:
 - Temperature
 - Strain gauge
 - Battery voltage
 - **GPS**
 - 1 hour sensor observations
 - Mandatory 30 second GPS timer
- Modem configuration
 - Iridium 9602
 - 1 hour transmission schedule
- Antenna
 - Dual element by Hirschmann
 - Active GPS
 - Certified Iridium

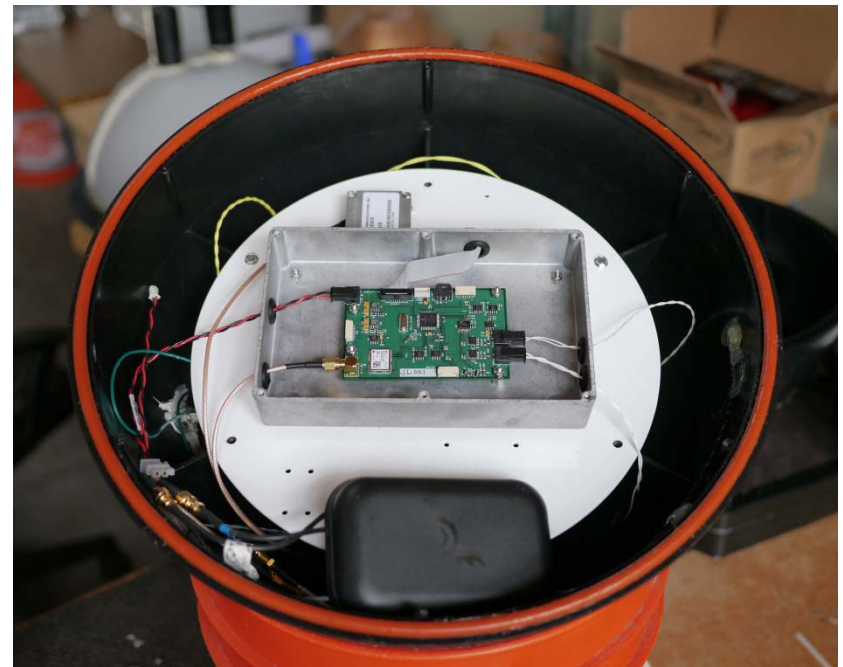


Figure: Electronics package for Iridium SBD test system



Battery Endurance

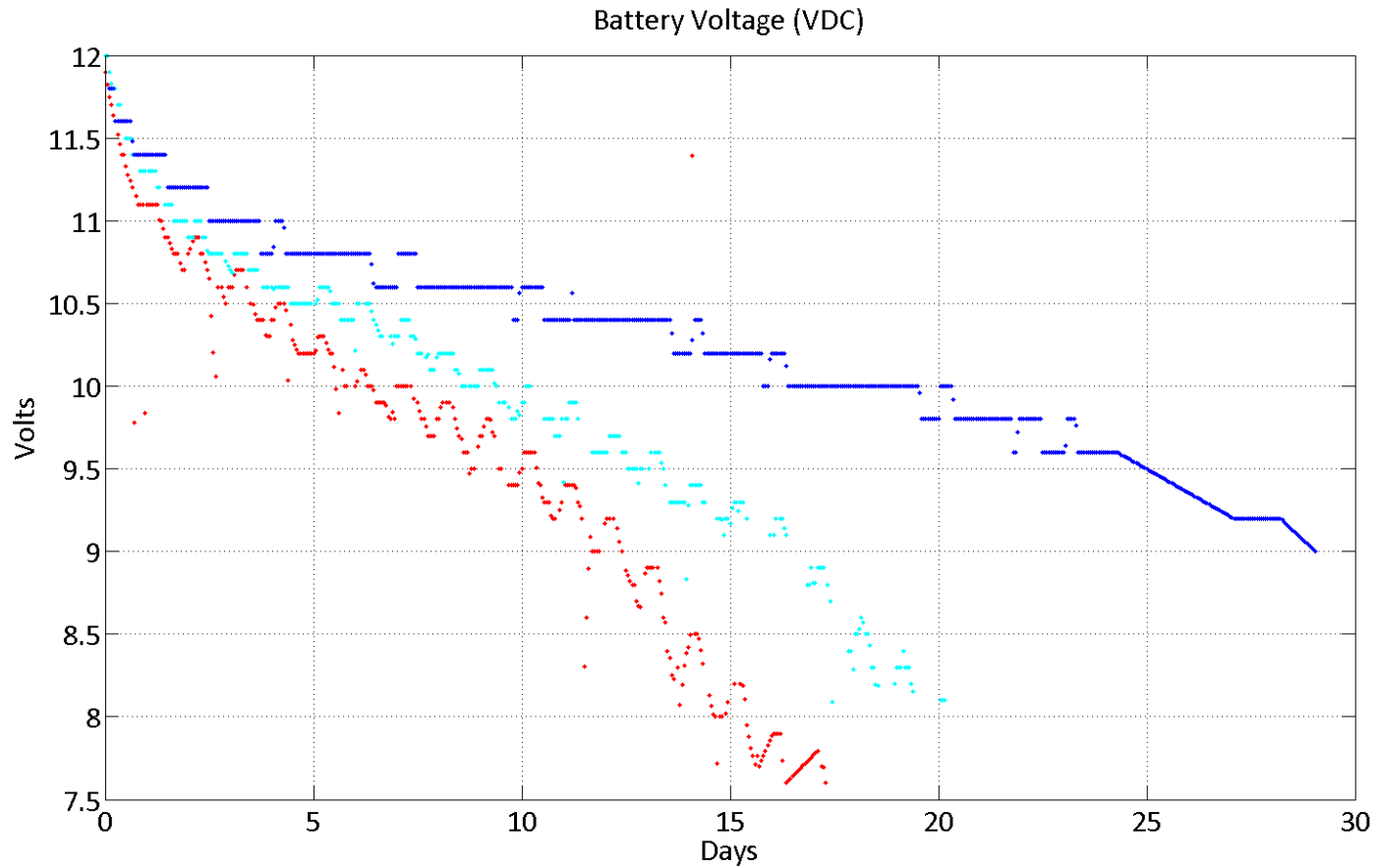


Figure: System battery voltage vs. Time

Cutoff voltage for Argos 2 (red) = **7.6 volts**, Argos 3 (cyan) = **8.0 volts**, and Iridium SBD (blue) = **9.0 volts**



Battery Endurance



- Sharp rise in missed observations at end of life
 - End of life biases all statistics due to short duration of test
- AA-cell pack behavior at end of life differs from D-cell packs
 - Argos 2 D-cell cutoff: **6.2 volts**
 - Iridium SBD D-cell cutoff: **6.8 volts**
- Statistics computed without end of life portion of dataset for all tests

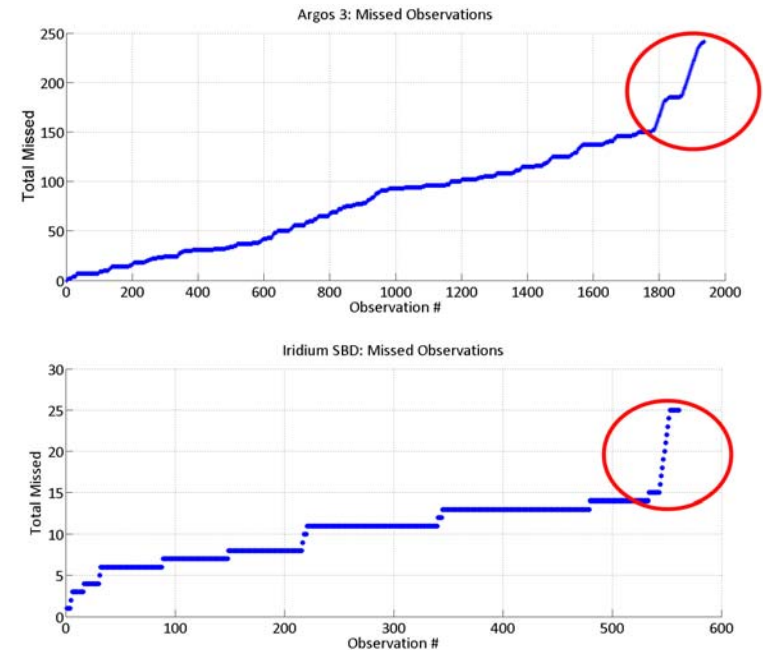


Figure: Sharp rise in missed observations near end of life for (top) Argos 3 and (bottom) Iridium SBD



Argos 2: Results



- Throughput
 - **29.6%** of observations received¹
 - Average of **47.9 minutes** between observations received²
- Latency
 - Maximum observation age was **15 minutes** from collection
 - Observation cycle
 - Argos ground station processing
- AA pack Endurance
 - **16 days**

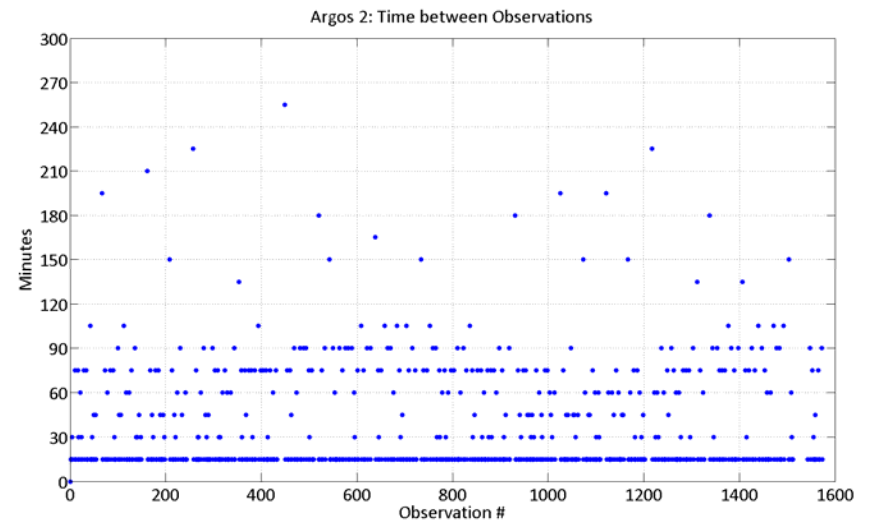


Figure: Minutes between observation vs. Observation count.
Argos 2 resolution was an average of **47.9 minutes** between collected observations.

¹ Throughput computed as ratio of observations received to observations taken

² Measured as time between unique observations as indicated by Argos satellite timestamp



Argos 3: Results



- Throughput
 - **90.9%** of observations received
 - Argos 3 Interactive-Ack session
 - Downlink receiver active for average of **6.6 minutes** per Argos 3 pass
 - FCS checksum
 - **93%** Interactive-Ack pass
 - **86.2%** Pseudo-Ack pass
- Latency
 - Average **6.2 hour** latency¹
 - Maximum of **18.3 hours**
 - First in First Out (FIFO) buffer
- AA pack Endurance
 - **20 days**

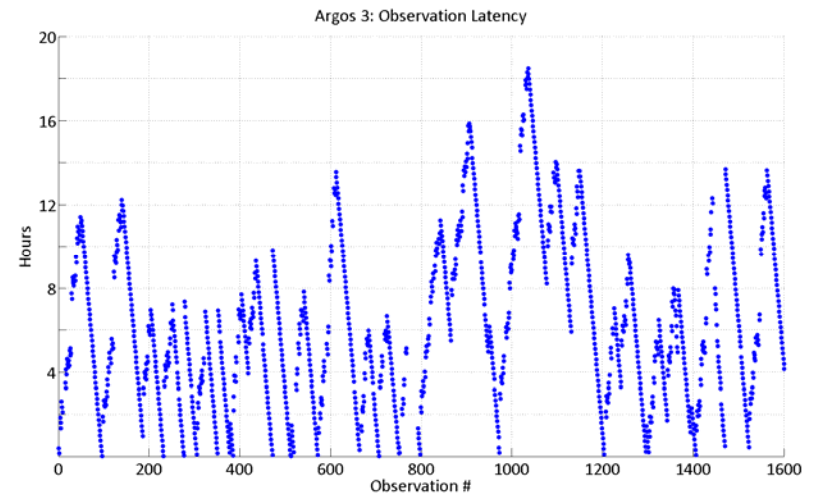


Figure: Argos 3 hours of latency vs. Observation count.
Average was **6.2 hours**, Maximum was **18.3 hours**

¹ Latency measured as elapsed time between sensor timestamp and Argos satellite timestamp



Iridium SBD: Results



- Throughput
 - **97.5%** of observations received¹
- Latency
 - Average latency of **1.89 minutes**²
 - Host system waiting for Iridium satellite lock
 - Iridium Gateway processing
- AA pack Endurance
 - **24 days**³

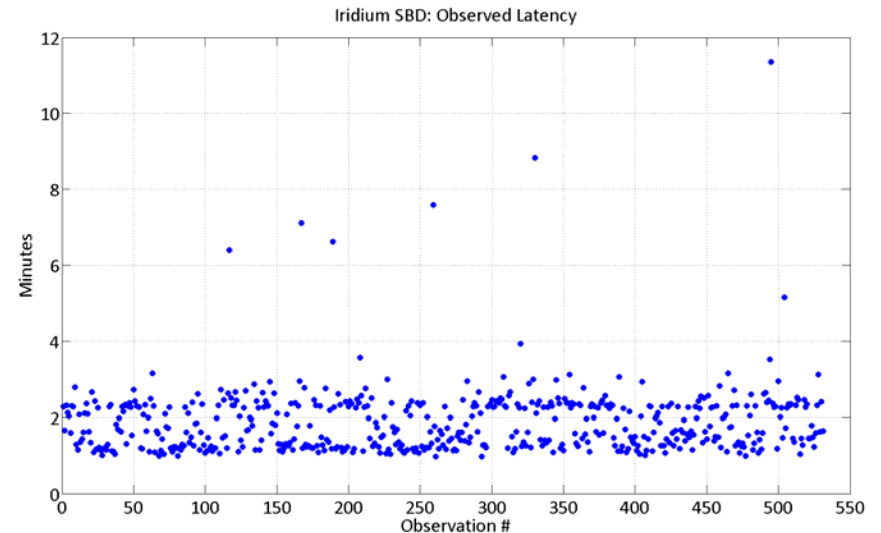


Figure: Iridium SBD minutes of latency vs. Observation count.
Average latency was **1.89 minutes**

¹ Ideal test conditions due to constant line of sight to the sky throughout testing

² Elapsed time between GPS sensor timestamp and file timestamp on SBD server at SIO

³ Dependant on GPS and transmission management implemented by the host system



Argos 3 Reliability



- Failure to lock Argos 3 downlink signal
 - Satellite pass prediction would be affected in the field
 - Orbital parameters valid for **2 months**
 - PMT location valid for **3-5 days** for a drifter
 - Datasets were dropped due to limited buffer capacity
 - Transmission protocol limited to Pseudo-Ack
 - Can be caused by de-tuning of antenna at downlink frequency

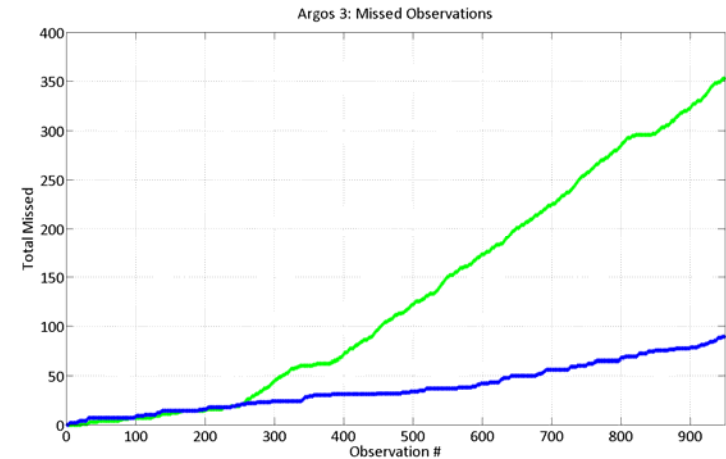


Figure: Number of missed observations for a well performing Argos 3 (blue) and problematic Argos 3 (green)

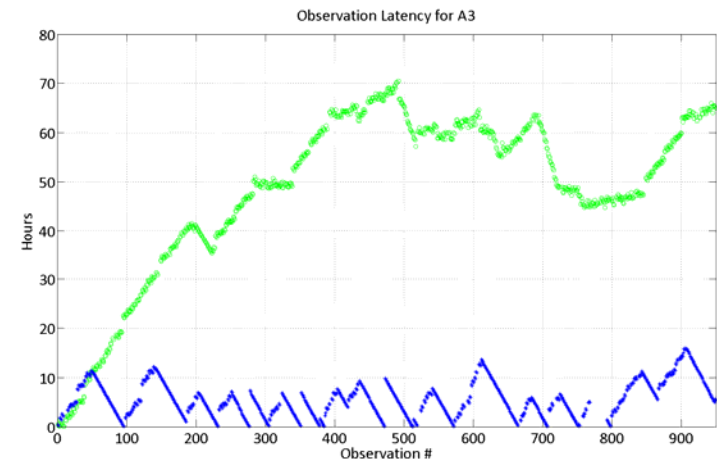


Figure: Observation latency in hours for a well performing Argos 3 (blue) and problematic Argos 3 (green)



Findings



Argos 2

- Shortest lifetime
- Lowest throughput
 - Improve by passing historical observations
 - i.e. SVP-B type drifters

Argos 3

- Performance vs. Argos 2
 - **25%** battery endurance increase
 - **207%** throughput increase
- Argos 3 Antenna
 - Custom designs
- Latency
 - Unable to provide near real-time data using PMT buffer management
- Downlink receiver
 - Active for average of **6.6 minutes** per Argos 3 pass
 - Interactive-Ack handshaking

Iridium SBD

- Performance vs. Argos 2
 - **50%** battery endurance increase
 - **229%** throughput increase
- AA-pack cutoff voltage
 - Less severe on D-cell battery packs in the field
 - **6.8 volt** Iridium SBD cutoff with 40 cell D-cell pack



Roadmap



Argos 2

- End of Life
 - Kenwood YTR-3000 PMT as PTT
 - Double battery packs for Kenwood YTR-3000 based Argos 2 fleet
- Future developments should utilize Argos 3 and/or Iridium SBD

Argos 3

- Downlink receiver power consumption
 - Disable Interactive-Ack to manually set downlink receiver
 - CLS recommends **60 seconds**
 - Scale with additional Argos 3 satellites
- Need for robust certified antenna
 - Delays to development
 - Potential for buoy failure
- Improve Latency
 - Last In First Out (LIFO) buffer
 - Random mode
- Backup mode behavior
 - Special applications i.e. Hurricane Drifters

Iridium SBD

- Improve battery performance
 - Iridium transmission and GPS management
- Throughput
 - Historical observations



A2: Resolution

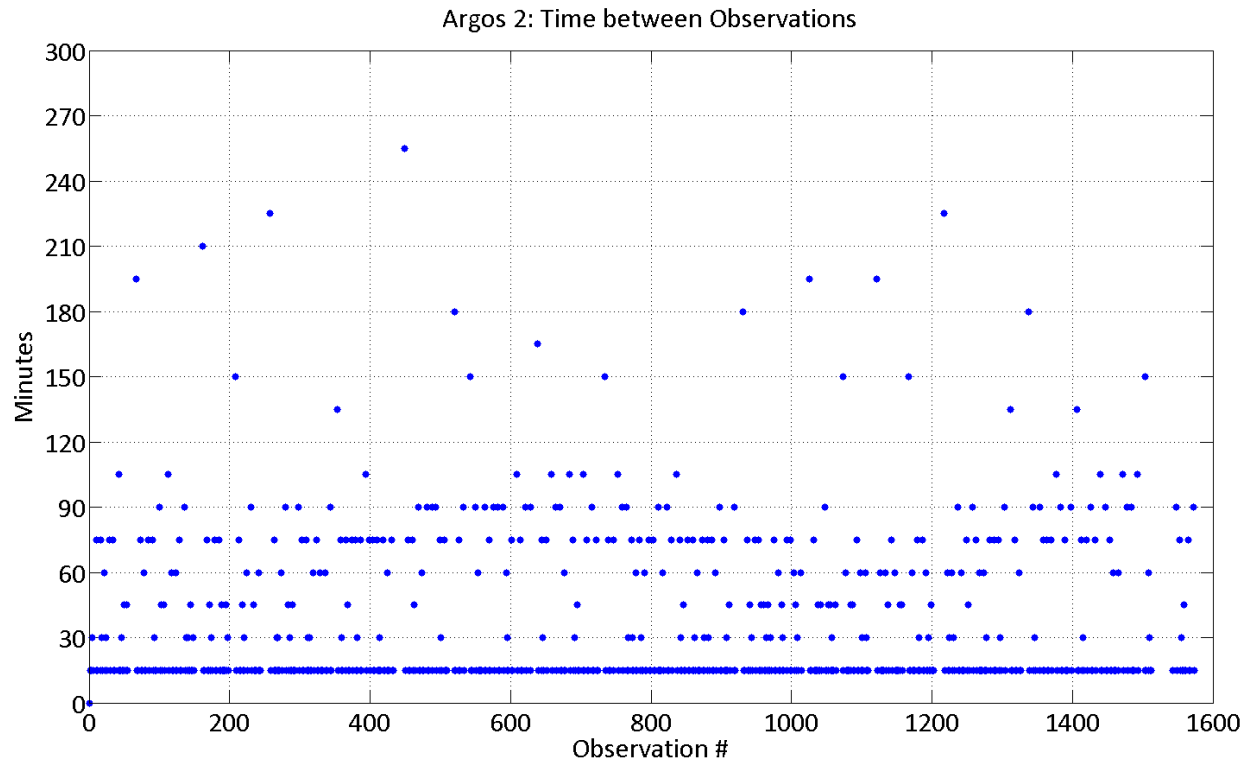


Figure: Argos 2 time between observations vs. Observation count
Average time between received observations was **47.9 minutes**.
29.6% of observations were received by Argos constellation



A3: Latency

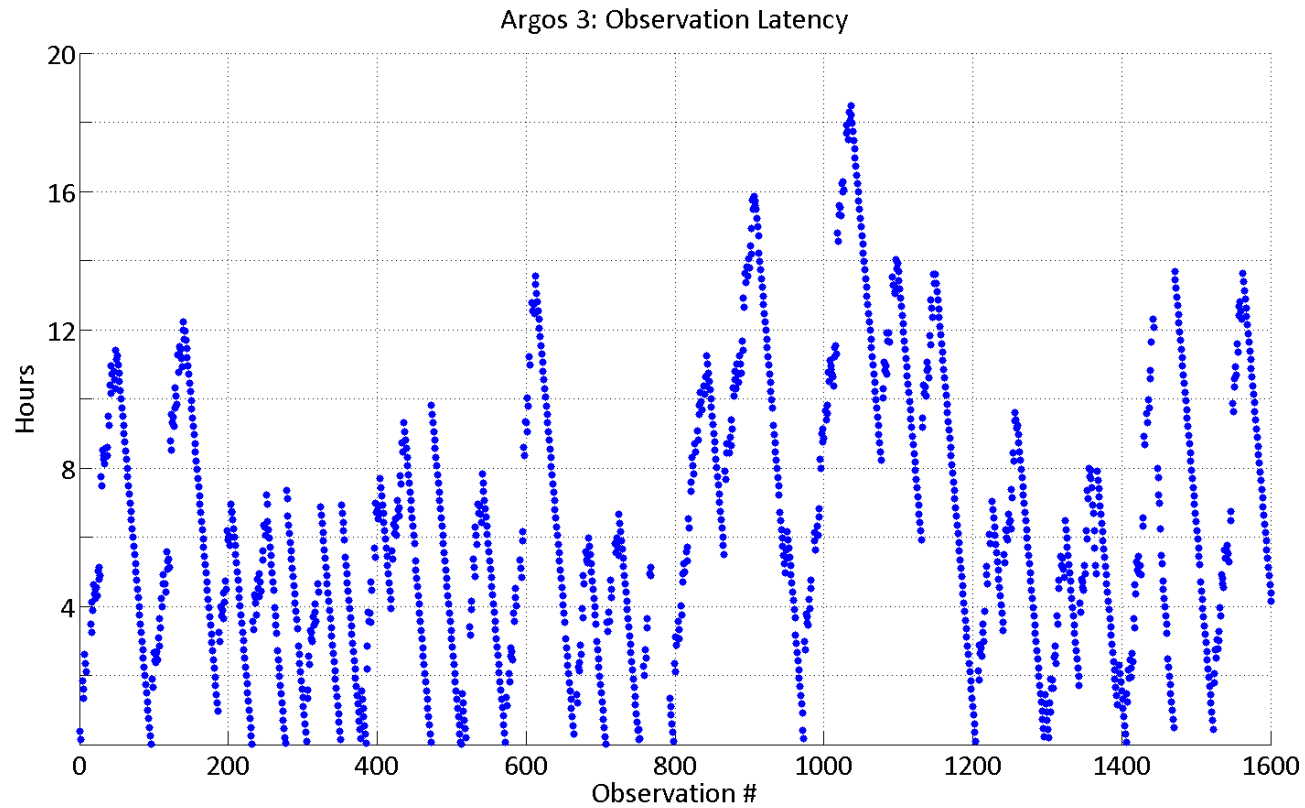


Figure: Argos 3 Observation latency vs. Observation count
Argos 3 average latency was **6.2 hours** with a peak of **18.3 hours**



SBD: Latency

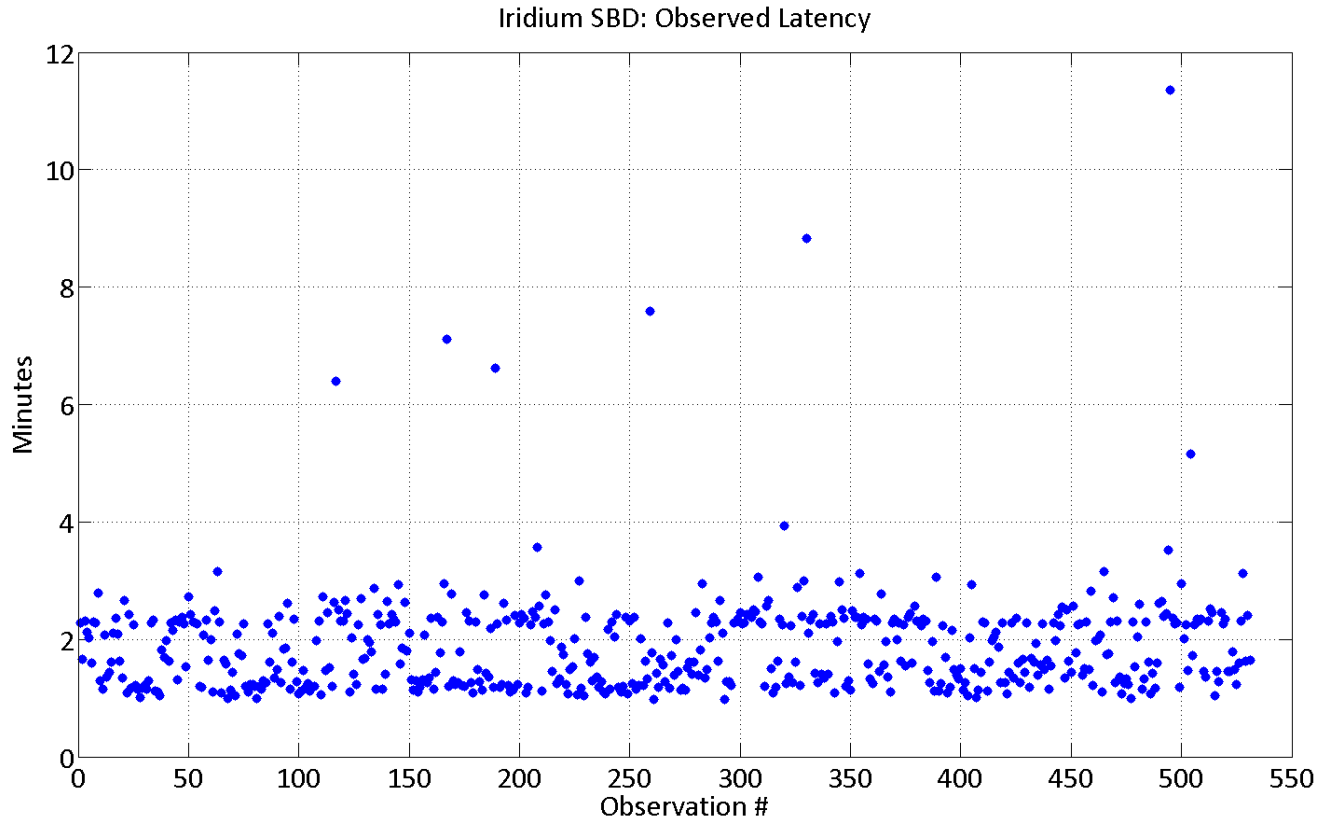


Figure: Iridium SBD observation latency vs. Observation count
Average Iridium SBD message latency was **1.89 minutes**