Deep Space Exploration Society

A Non-Profit Corporation Dedicated to the Excitement of Hands-on Space Exploration

Society of Amateur Radio Astronomers Western Regional Conference 2017

Presenters:

Dr. Richard Russel, President
Bill Miller, Secretary
Dave Molter, Board Member
Glenn Davis, Member

DSES.science

DSES Presents 3 Papers at SARA Western Conference

- DSES was well represented at the Society of Amateur Radio Astronomers 2017 Western Conference
- Dave, Bill and Rich presented their papers and received a lot of interest from the very knowledgeable people present. Glenn was unable to make the meeting. Steve also attended.
- Awards were given to the presenters as well as having their papers published in the proceedings.

Attendees were given a special VLA Tour

Magdalena Historic Telescope Museum

Rutherford’s Telescope

Papers

Efficiency Analysis of the Plishner Radio Astronomy and Science Center

Solar Power Systems

Bill Miller

Deep Space Exploration Society

Plishner Radio Astronomy and Space Science Center

60-Foot Dish Position Indication System Development

David Molter — Deep Space Exploration Society

Glenn Davis — Deep Space Exploration Society

Richard Russel — Deep Space Exploration Society

Plishner Radio Astronomy and Space Science Center

The Use of Statistical Process Control to Improve the Detection of Extraterrestrial Radio Sources

Richard Russel

Deep Space Exploration Society


Paul Plishner
Radio Astronomy and
Space Sciences Center
This site is owned and operated
by the Deep Space Exploration
Society with offices in Longmont
Colorado. Further information can
be obtained on our website:
http://dses.org or leaving a
message at 719-337-2112
Deep Space
Exploration Society

Paul Plishner DSES Site

- The Beginning: National Bureau of Standards project started in the early 1950's . Operational from 1955 to 1974.
- A 500 foot tower constructed for VHF TV channel research. How close can the same TV channel be assigned to geographical areas.
- Dish operational 1959, used for Tropospheric radio propagation studies for design of communications systems in Northern Latitudes in the construction of the DEW Line from Alaska to Greenland.
- This site was one of several similar sites located from Boulder, CO to Arkansas.

1972

GOVERNMENT PROPERTY FOR SALE

NEAR HASWELL, COLORADO

Approximately 16.5 acres of land, an underground research facility and a parabolic reflector, situated 5± miles south of Haswell.

The land is nearly square in shape and is generally level. A 22'x 50' underground concrete block structure, two small metal sheds and a 60' aluminum parabolic reflector are included.

The range of potential uses is limitless!

SEALED BID SALE: March 22, 1984 10:00 a.m.

Mike Hughes
206-931-7548

All bids must be submitted on GSA forms which contain terms and conditions applying to this sale offering. Bid forms may be obtained at the General Services Administration, Business Service Center, Room 440, Federal Building, Seattle, WA 98174. Telephone (206) 442-5556.

The Bunker

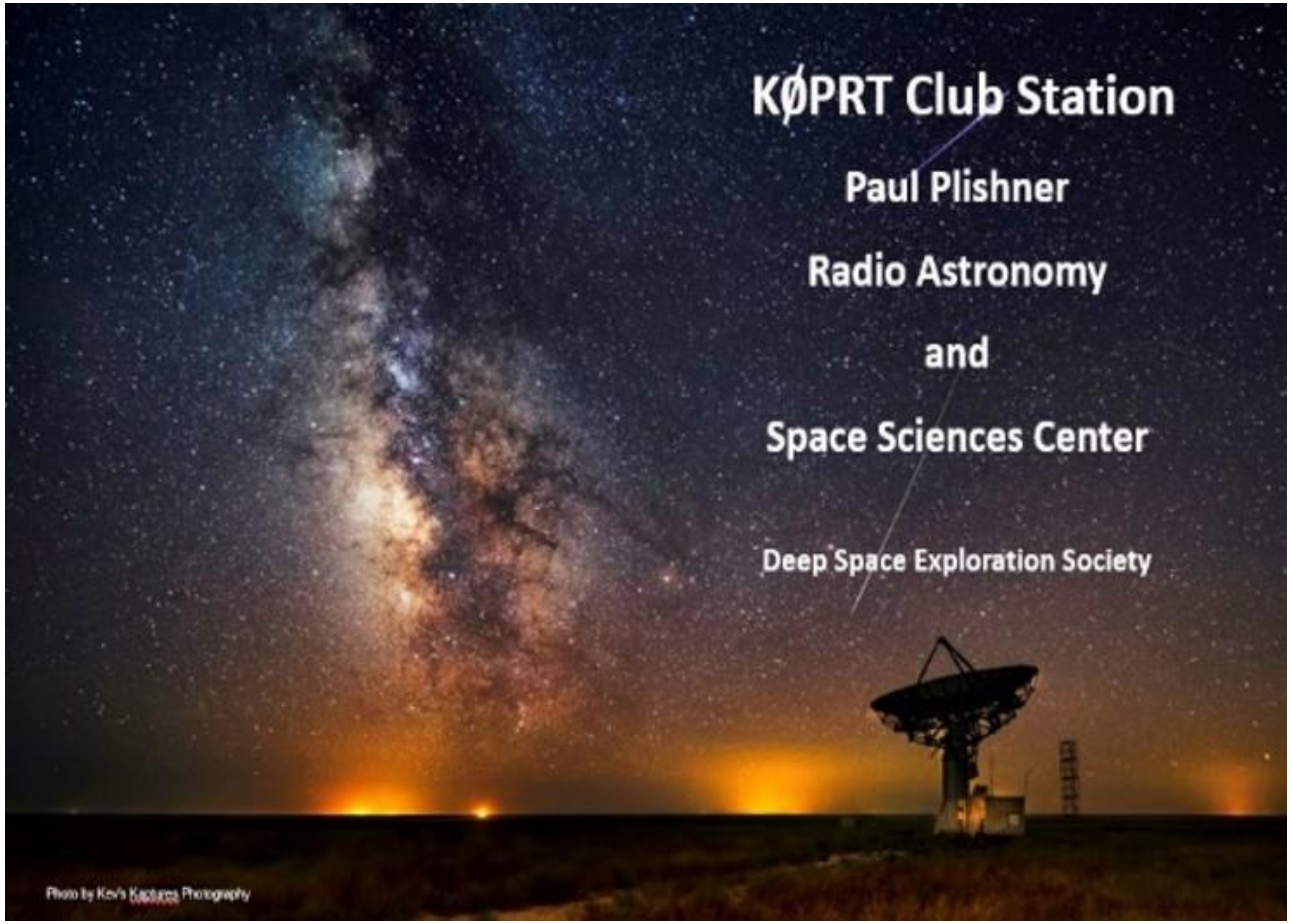
Communications Trailer and Generator Building

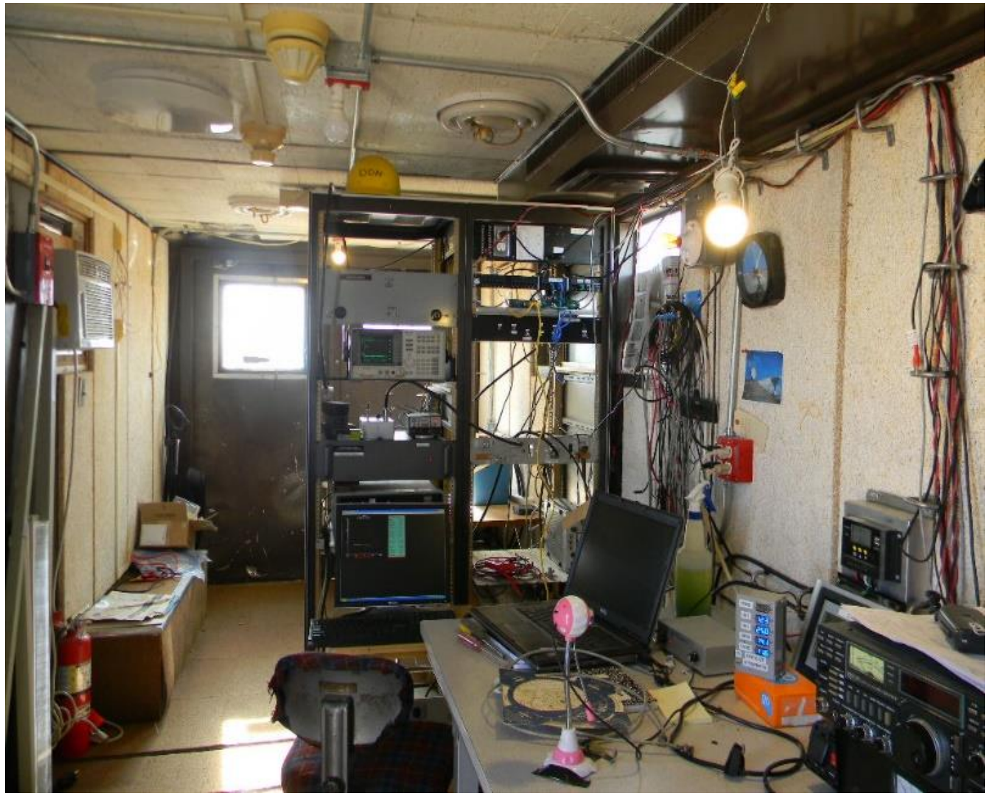
Antenna Specifications

Frequencies:	400 Mhz to 2 Ghz
Diameter:	60 feet
Antenna Gain:	42.5 dbi at 1 Ghz
Beam Width:	2.6 degree at 400 Mhz
	0.8 degree at 1.2 Ghz
Noise Temperature:	1-2db at 400 Mhz total system
Noise Figure:	0.8db at 400 Mhz w/20db LNA
Coverage:	Full Hemisphere
Slew Rate Max Az/El:	40/40 deg/min

Tri-Band Dish Feed; 144-432-1296 MHz;
Designed and assembled by Ray Uberecken, AA0L

K0PRT Club Station
Goal is all bands plus EME and tropospheric Communications





Efficiency Analysis of the Plishner Radio Astronomy and Science Center Solar Power Systems

Bill Miller

Deep Space Exploration Society

Plishner Site

System Criteria

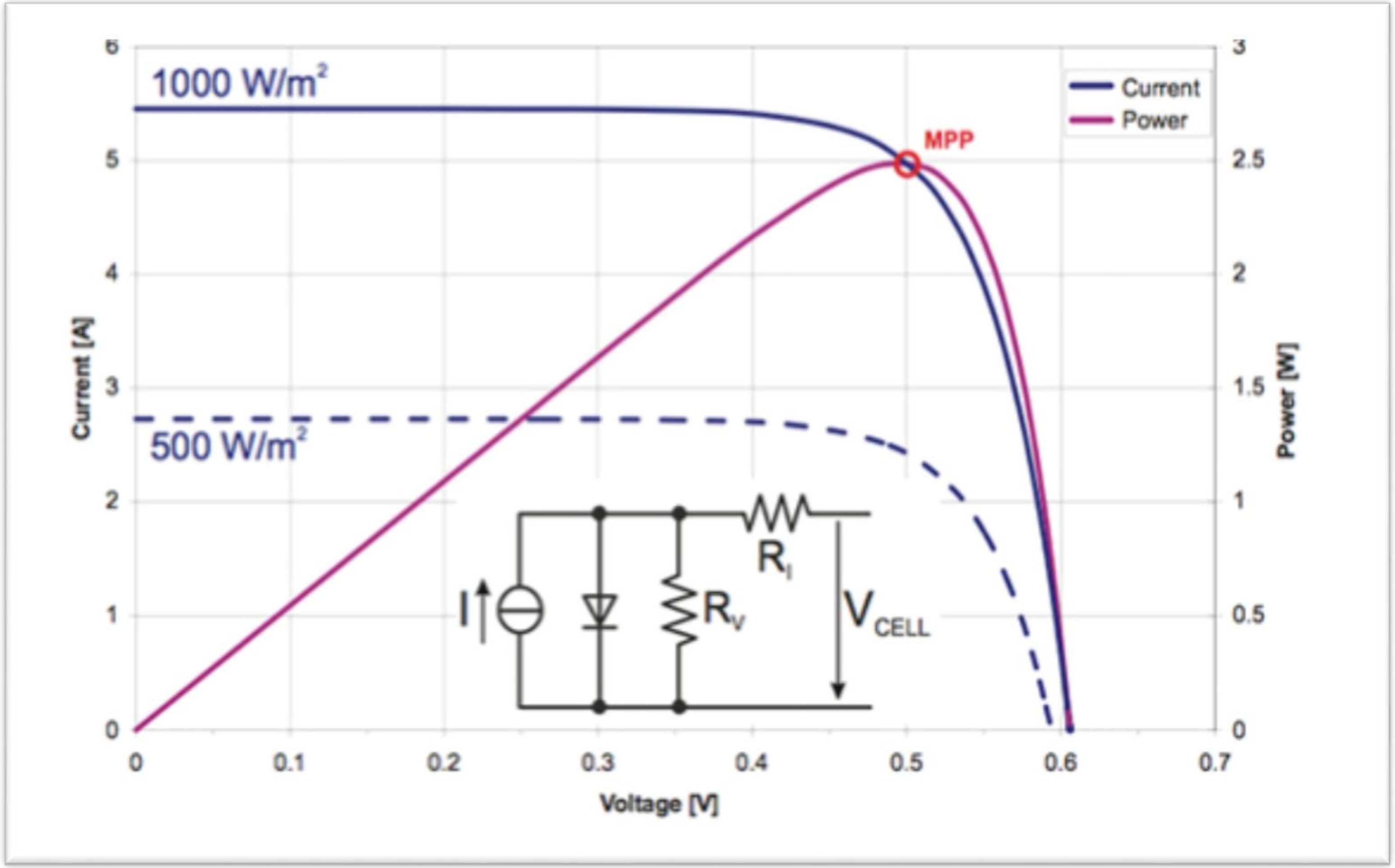
- Off Grid, Existing Solar and Battery System
  - For Now It Is What It Is!
- Loads
  - Remote Computers 75-500 W
  - Experiment Electronics 25-200W
  - System Parameter Telemetry 5W
  - Network GPRS / EDGE to WiFi connection 5W
- Run through 2 days with no sun
- Recharge in 1 day full sun in winter

Work it Backwards

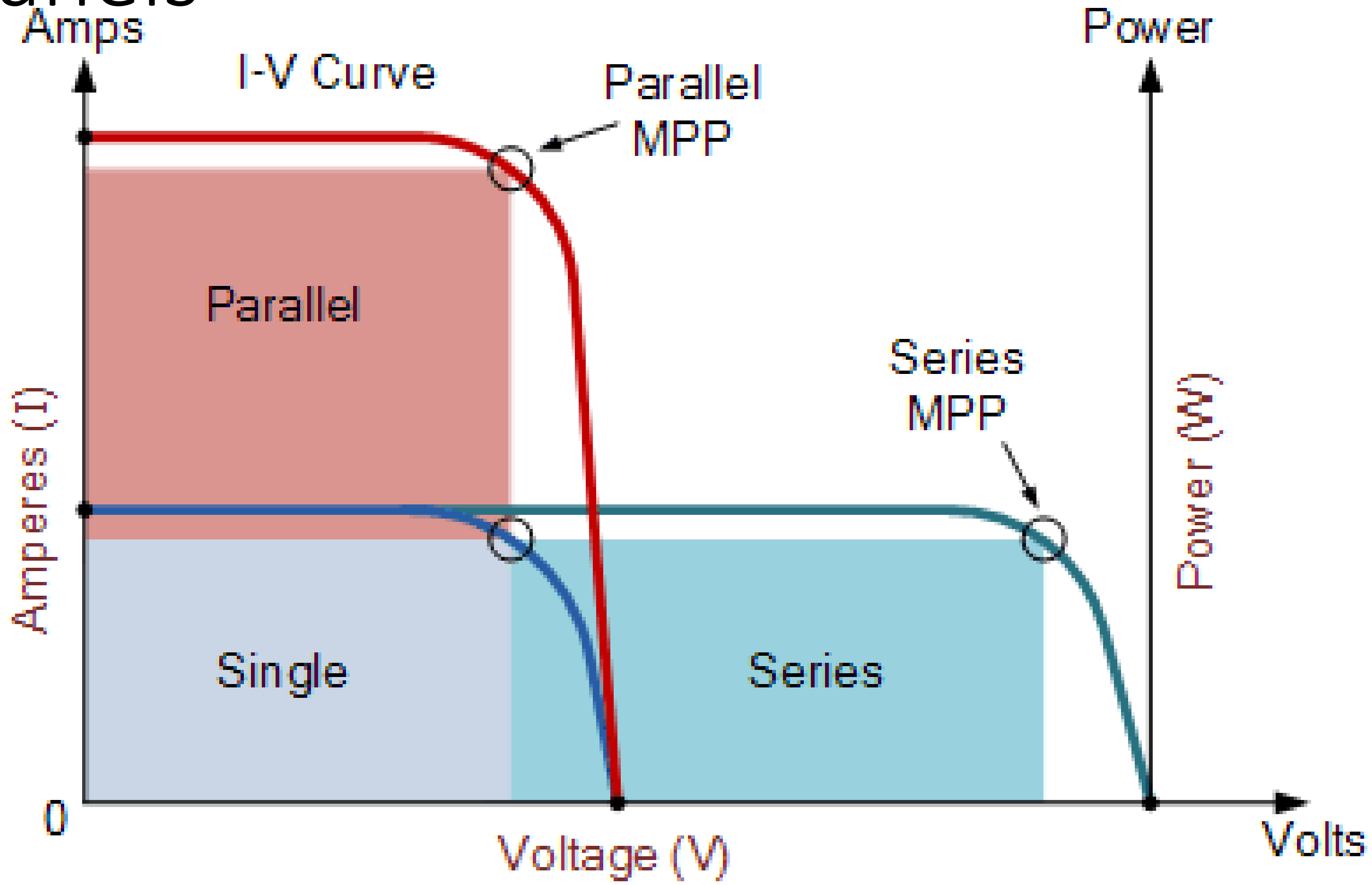
- In most solar sizing analysis the system size is determined starting with the load.
- But we have an existing system. What can we power with it ?
- Determine the system capacity and then the capability to load it.
- From this determine what to add.

Communications Trailer Solar System 1

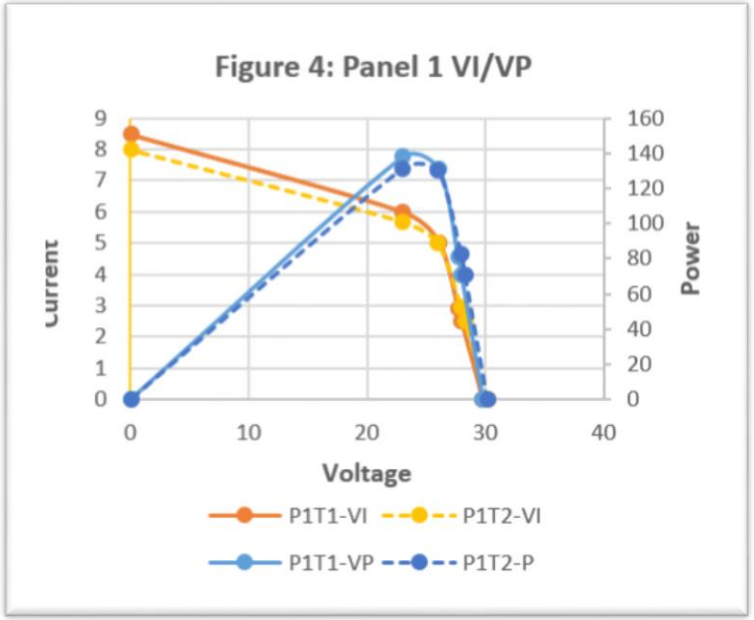
Solar Cell V/I Characteristics

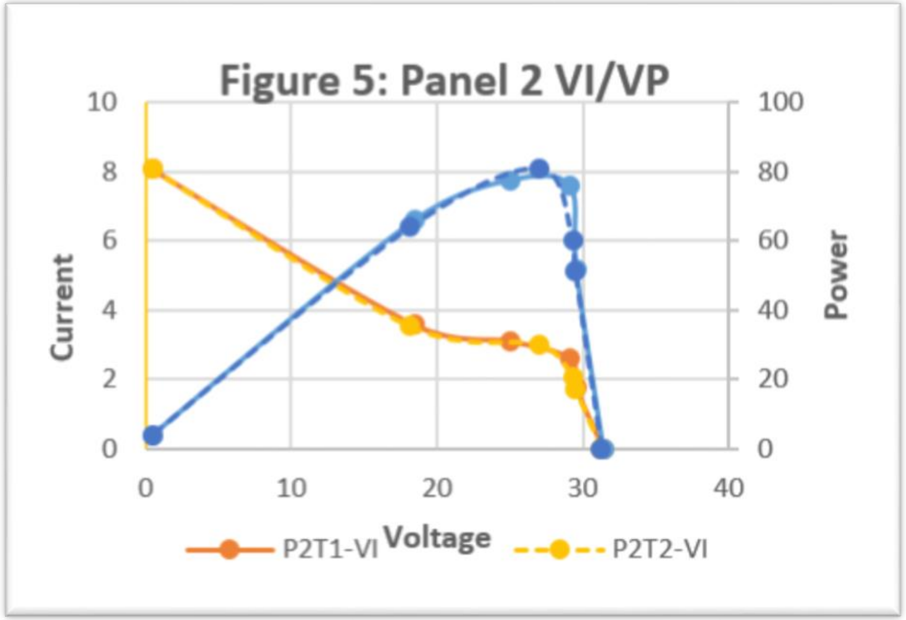


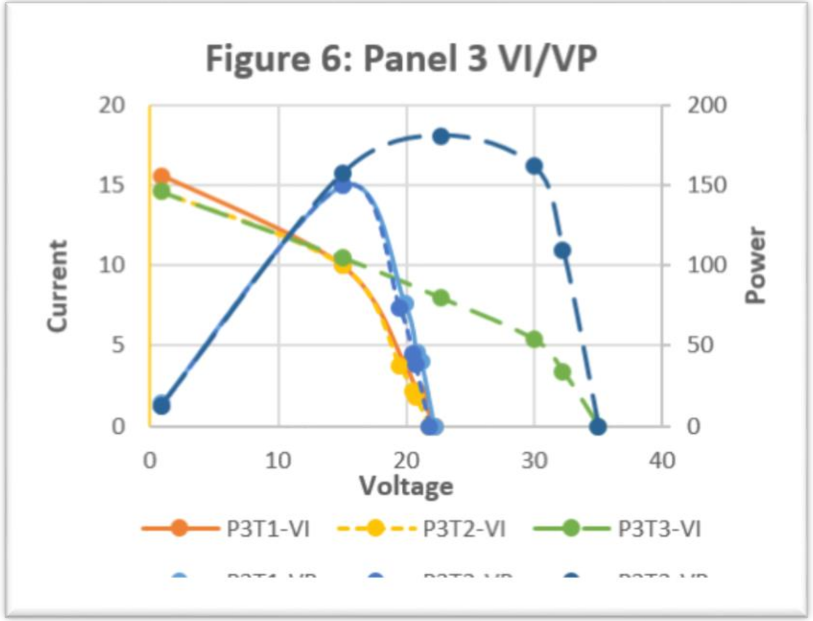
Parallel and Series Cells and Panels



Solar Panel Characteristics







Definitions

- Module performance is generally rated under standard test conditions (STC): irradiance of 1,000 W/m^2, solar spectrum of AM 1.5 and module temperature at 25 °C.
- AM is the Air Mass index and is the relative solar path length through the atmosphere.
- Electrical characteristics include nominal power (P_{MAX}, measured in W), open circuit voltage (V_{OC}), short circuit current (I_{SC}, measured in amperes), maximum power voltage (V_{MPP}), maximum power current (I_{MPP}), peak power, (watt-peak, W_p), and module efficiency (%).

Ref: Wikipedia https://en.wikipedia.org/wiki/Solar_panel

Monthly Averaged Direct Radiation kWh/m^2/day or Colorado

: NASA Atmospheric Science Resource Center, Surface meteorology and Solar Energy, *A renewable energy resource web site* https://eosweb.larc.nasa.gov/cgi-bin/sse/sse.cgi?skip@larc.nasa.gov

Monthly Averaged Direct Normal Radiation (kWh/m^2/day) For Colorado.

	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
Best Winter Tilt 34 deg	4.58	4.99	5.47	5.17	5.1	5.05	4.96	5.05	5.63	5.71	4.79	4.47
Best Summer Tilt 66 deg	3.72	4.43	5.39	5.78	6.24	6.47	6.21	5.87	5.79	5.17	3.98	3.53

Total Energy Calculated from Monthly Averaged Direct Normal Radiation Watt Hours

		jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
Best Winter Tilt 34 deg		4.58	4.99	5.47	5.17	5.10	5.05	4.96	5.05	5.63	5.71	4.79	4.47
Best Summer Tilt 66 deg		3.72	4.43	5.39	5.78	6.24	6.47	6.21	5.87	5.79	5.17	3.98	3.53
Panel Output WATT HOURS/DAY													
Winter Tilt Angle													
Panel 1	138	632	689	755	713	704	697	684	697	777	788	661	617
Panel 2	75	344	374	410	388	383	379	372	379	422	428	359	335
Panel 3	182	834	908	996	941	928	919	903	919	1025	1039	872	814
Panels Total	395												
Average Daily Watt Hours		1809	1971	2161	2042	2015	1995	1959	1995	2224	2255	1892	1766
Winter Tilt Minimum Daily Average Watt Hours	1766												

Loss Calculation Represented as the Input (Array Terminals) to Output (Battery Terminals) Efficiency

Loss Calculation								
Total Panel Output Watts	395.00							
Battery Voltage	13.50							
Max Output Current	29.26							
Wire Gauge	10	6	8	10	12	14	16	18
Wire Resistance Per Foot	0.0010	0.0004	0.0021	0.0010	0.0016	0.0026	0.0041	0.0065
Run Length from Panel to Battery	30.00							
Total Round Trip Resistance	0.06							
Wire Loss in Watts	51.37							
Distribution Net Output watts	343.63							
Charge Controller Efficiency								
PWM	0.75							
MPP	0.95							
Net Output	257.73							
Input to Output Efficiency %	0.65							

Table 2: The Resistance of Various Wires

Diameter			dc Resistance	
AWG	inches	mm	Ohms/ft	Ohms/m
6	0.162	4.1	0.00040	0.00132
8	0.129	3.3	0.00064	0.00210
10	0.102	2.6	0.0010	0.0033
12	0.081	2.1	0.0016	0.0053
14	0.064	1.6	0.0026	0.0084
16	0.051	1.3	0.0041	0.0134
18	0.040	1.0	0.0065	0.0214

Table 3: Loss Calculation Represented as the Input (Array Terminals) to Output (Battery Terminals) Efficiency

Battery Capacity to Load Estimate Based on 50% degradation of Batteries

Battery Capacity			
New Cell capacity- Ahr	**264**	Lap Top Power Watts	**75**
		Hour Run Time on Full	
Float Voltage	**2.25**	Charge	**47.52**
Number of Cells per String	**6**		
Number of parallel Strings	**2**	Desk Top Power Watts	**150**
		Hour Run Time on Full	
String Voltage	**13.5**	Charge	**23.76**
Total New Capacity	**528**		
Yrs Life @25C	**20**		
Cycle Life @25C	**1200**		
Estimated Degradation %	**50**		
Estimated Degraded Capacity Ahr	**264**		
Total Battery Watt Hr Capacity= Ahr X V	**3564**		

Summary, Daily Watt Hour Capacity and Maximum Load for 1 in 3 day Solar Scenario

Winter Tilt Minimum Daily Average Watt Hours		1765.65
Input to Output Efficiency %		0.65
Available input Minimum Daily Watt Hours		1152.03
Tolerable cloudy day plus sunny day to sunny day ratio		3.00
Daily available Watt Hours for load and charge		384.01
Average 24 hr load watts available under this cloudy day scenario		16.00
What is really needed for a 75 watt Load		
Present Computer Load Wattage Estimate for Lap Top		50.00
Present Instrument Load Wattage Estimate		25.00
Total Estimated Load		75.00
Daily Whr requirement for loads = Watts * 24 Hr		1800.00
Assume 2	days of stored reserve = Daily Whr*days reserve	3600.00
Total Battery Watt Hr Capacity= Ahr X V		3564.00
But must replenish this and provide the load in 1 solar day		
Total Whr from Solar = 1 Days Batt Chrg + 3 days Load		5400.00

Conclusions

Table 5 shows a summary of the input energy, the average load capability for the 1 in 3 day solar scenario and then makes the reverse calculation of what is required for our modest 75Watt laptop plus experiment pack load. There is a considerable deficit even with 3 solar panels and 264 Ampere Hours of battery. This would indicate that if we keep the same assumptions we would need to increase the system size by over 4.5 times to be able to keep the 75 watt load running for three days with only one day of sun in December.

There are some caveats to consider:

- Actual battery capacity is unknown without a complete characterization test of the batteries.
- Using new more efficiency solar panels would dramatically improve the solar power output for the same panel area.
- Using a more efficient controller and large hookup wire would reduce loses.

Further Work

- Do a better solar panel characterization with a continuously variable load bank.
- Improve the measurement with a solar flux instrument or radiometer.
- Do a load /time characterization of the batteries.
- Use the NASA data for a location closest to the site.
- Characterize and include the battery charge/discharge loss in the calculation.

Plishner Radio Astronomy and Space Science Center
60-Foot Dish Position Indication System Development

David Molter
Deep Space Exploration Society

Glenn Davis
Deep Space Exploration Society

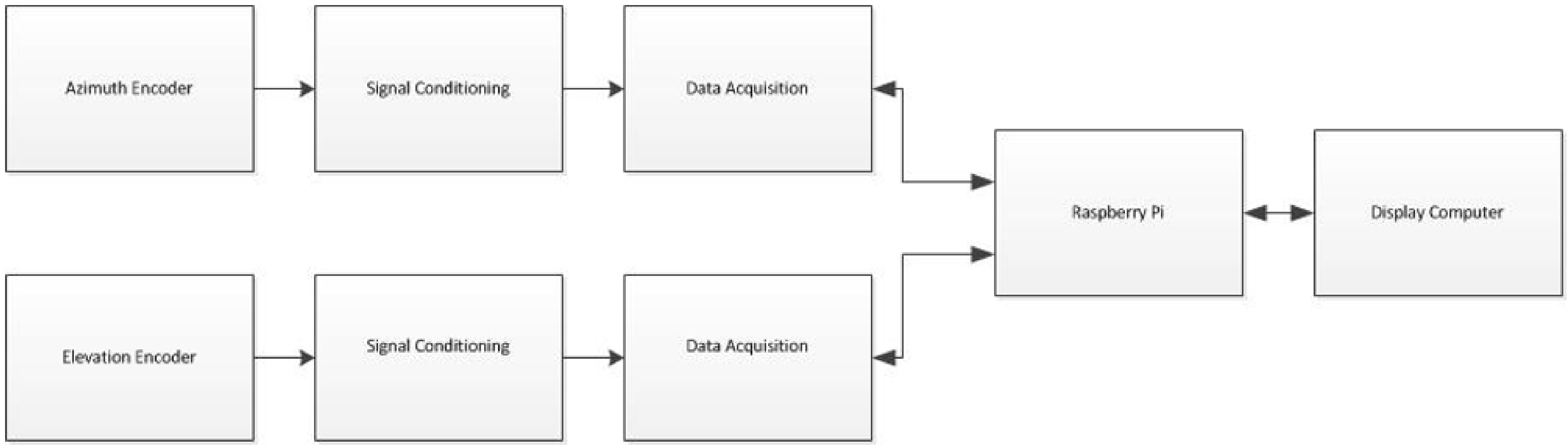
Richard Russel
Deep Space Exploration Society

60 foot Dish

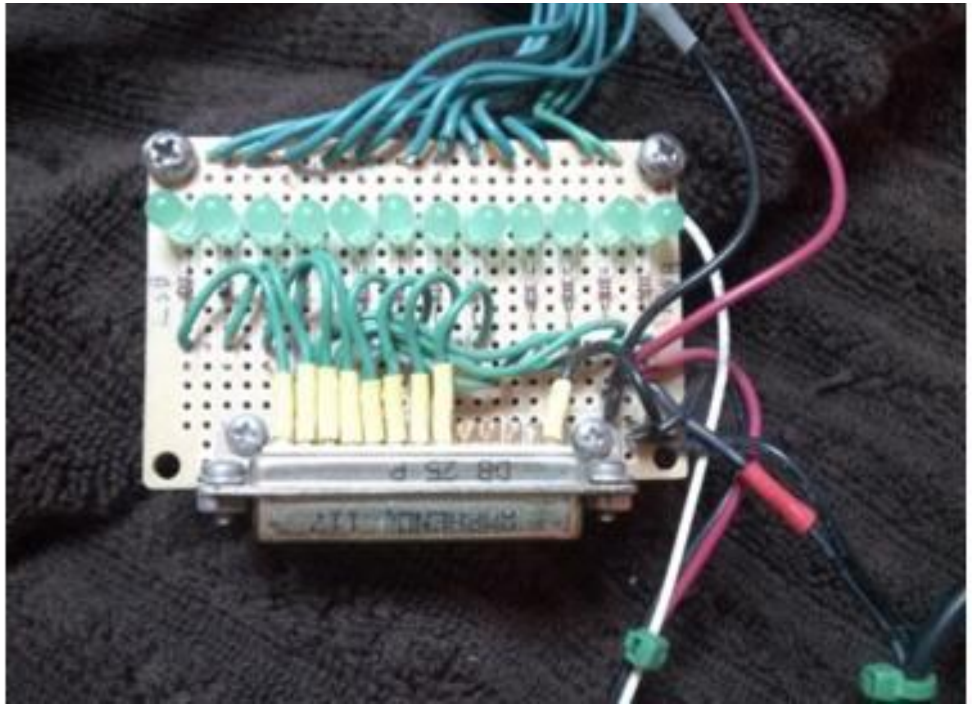
Multiband Feed and Installation Team

Communications Trailer and Equipment Racks

Position Indication System Circuitry Block Diagram



12 Bit Encoder and Signal Conditioning Board



DAQ Board and Rasberry Pi

Figure 10: Rasberry Pi Computer and 2 Line 16 Character Display

Multi-voltage Power Supply

Azimuth Motor Controller and Elevation Variable Frequency Drive

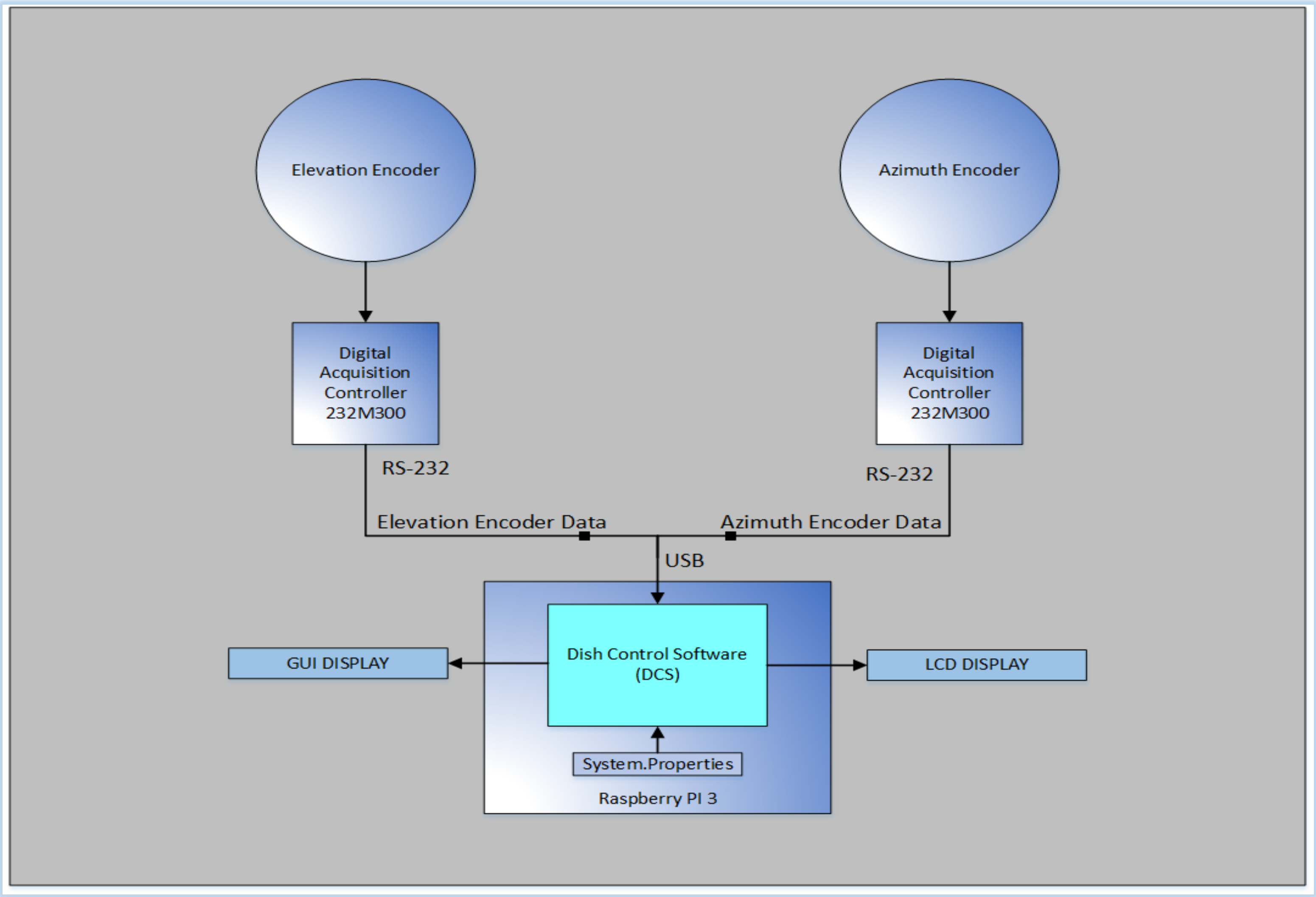
Software Capabilities

1. Provides a software interface to the Antenna Axis Position Encoders.
   - Interface to each Encoder is via an individual serial communication port.
   - Each axis encoder can return a value between 0 – 4095.
   - The DCS interprets the encoder position data to generate Azimuth and Elevation positions.
   - The System.Properties file contains Encoder to Position Mapping constants.

2. Provides a Graphical User Interface (GUI) to display the AZ/EL and encoder position data.
   - Additionally, the GUI displays a calculated RA and DEC position based on the current AZ/EL position, location and time.

3. Provides a 16x2 Character LCD display of the current AZ/EL Position.
   - The LCD display also provides an operator interface to shut down the Raspberry Pi.

Hardware/Software Block Diagram

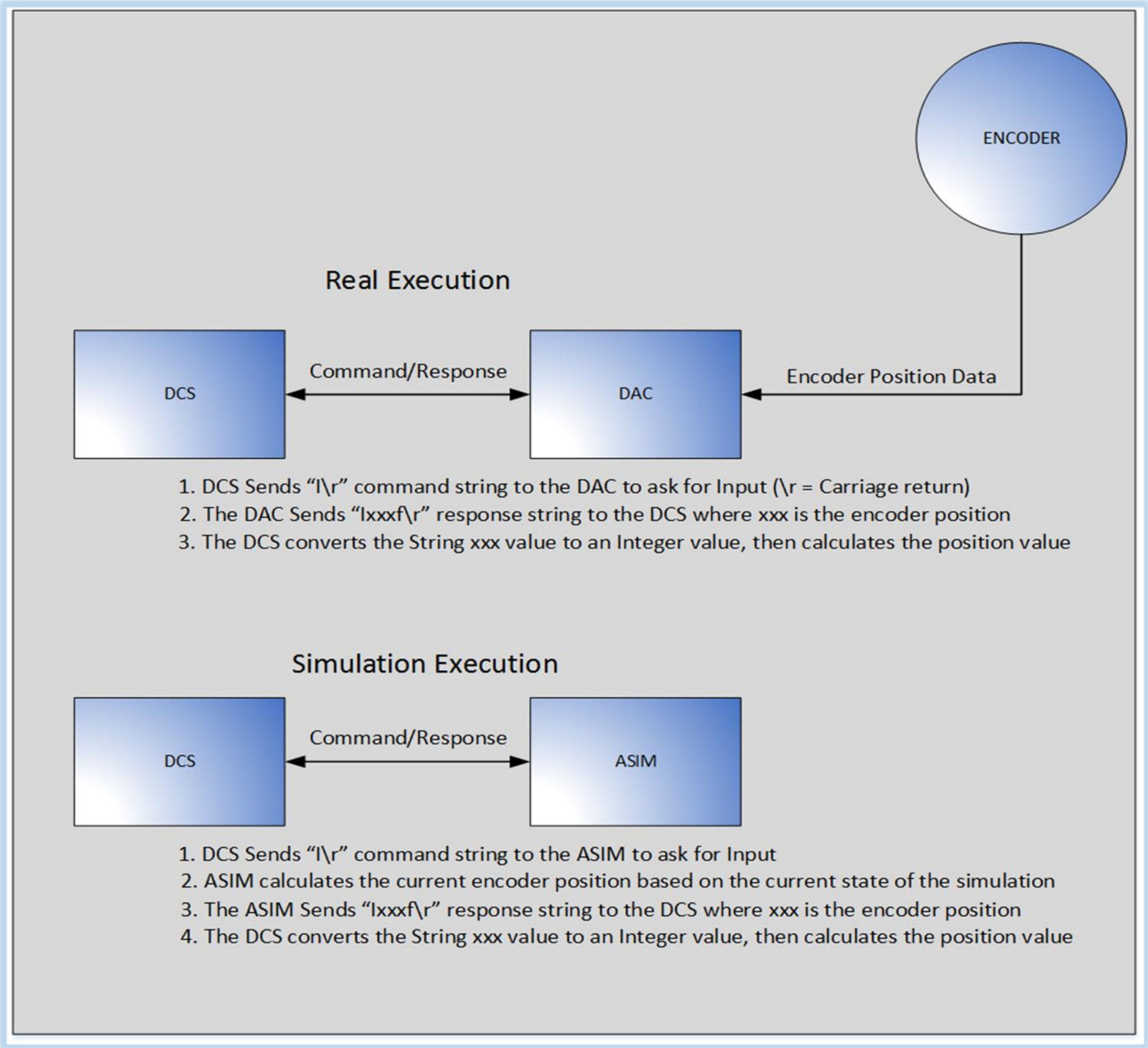


Rasberry Pi 3

Raspberry Pi 3 Model B

Raspberry Pi 3 with LCD Display

Real vs. Simulation Block Diagram



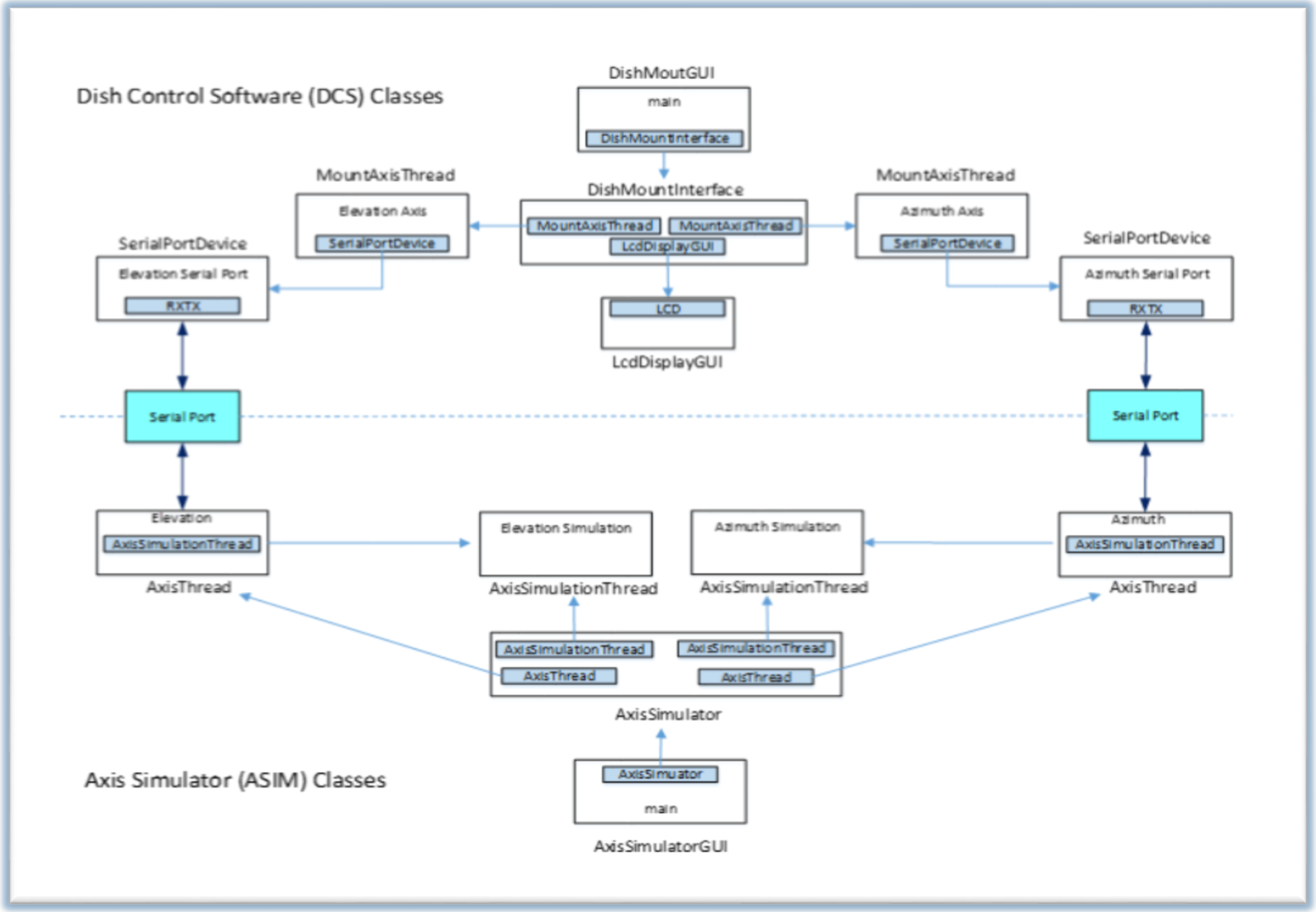
DCS Software Classes

- **DishMountGUI** – System “main”. Builds and displays the DCS GUI then starts the main processing threads (DishMountInterface).
- **DishMountInterface** – Starts up the LCD Display and the Azimuth and Elevation processing threads then queries each axis thread every 250 ms to update the DCS GUI position data.
- **MountAxisThread** – A thread for each axis. This thread commands the DAC, via the serial port, for encoder position data, it then reads the position data from the serial port. The encoder position data is then converted to an AZ or EL Position. The encoder position and AZ/EL position are saved internally for display processing. The AZ/EL position data is converted to Ra/Dec for display.
- **SerialPortDevice** – A class for each serial port. This class manages the initialization and the software interface to a serial port (read/write). The system has two serial ports, one for each DAC/Encoder.
- **LcdDisplayGUI** – This manages the initialization and the software interface to display position data on the 2 Line LCD Display.

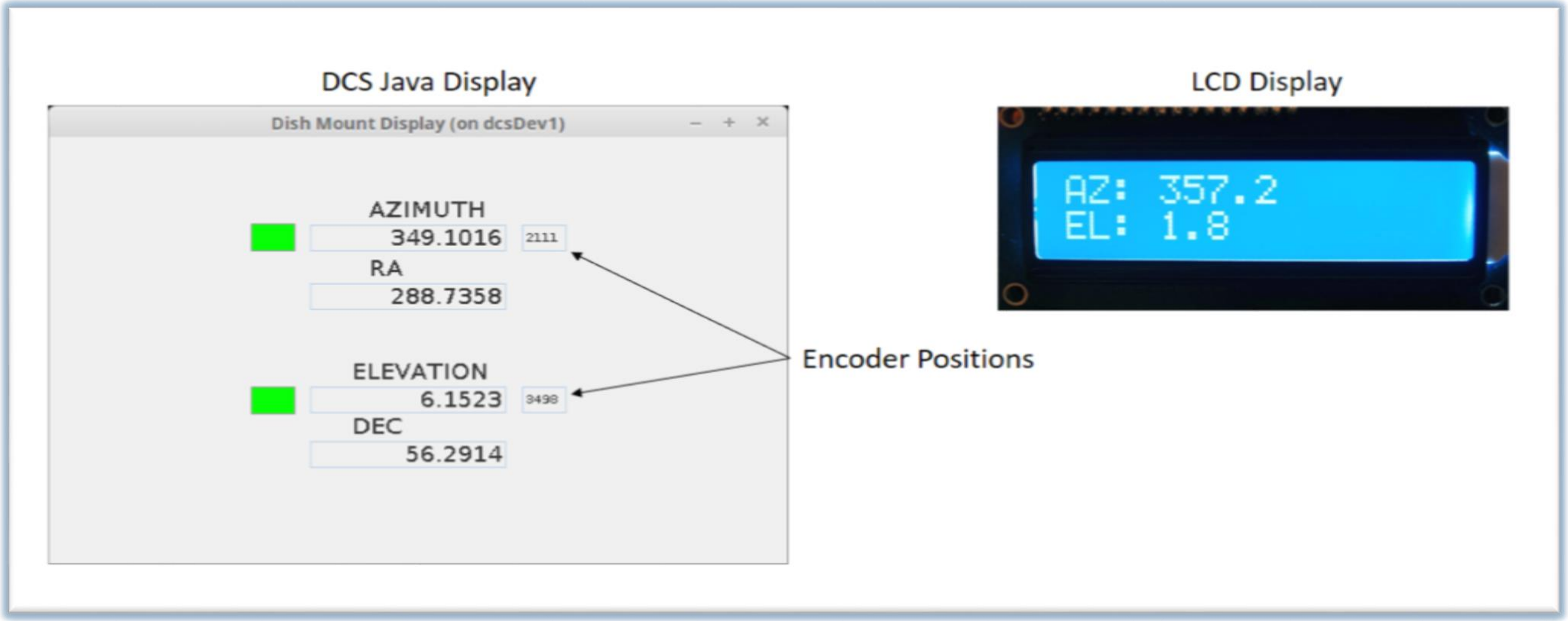
ASIM Software Classes

- **AxisSimulatorGUI** – System “main”. Builds and displays the ASIM GUI then starts the main processing threads (AxisSimulator).
- **AxisSimulator** – This class manages the startup of the two axis simulation threads (AxisSimulationThread) and the startup of the two axis threads (AxisThread).
- **AxisSimulationThread** – This class contains a thread that models an Axis (encoder) position and movement. There is a AxisSimulationThread object for each axis. Axis movement is simulated based on movement commands initiated from the ASIM display.
- **AxisThread** – This class contains a thread that interfaces with an Axis serial port. It accepts “I” commands from the DCS and uses it’s associated AxisSimulationThread object to respond with the current encoder position data. The response is in the form “Ixxxf\r” where xxx is the “hex” encoder position.

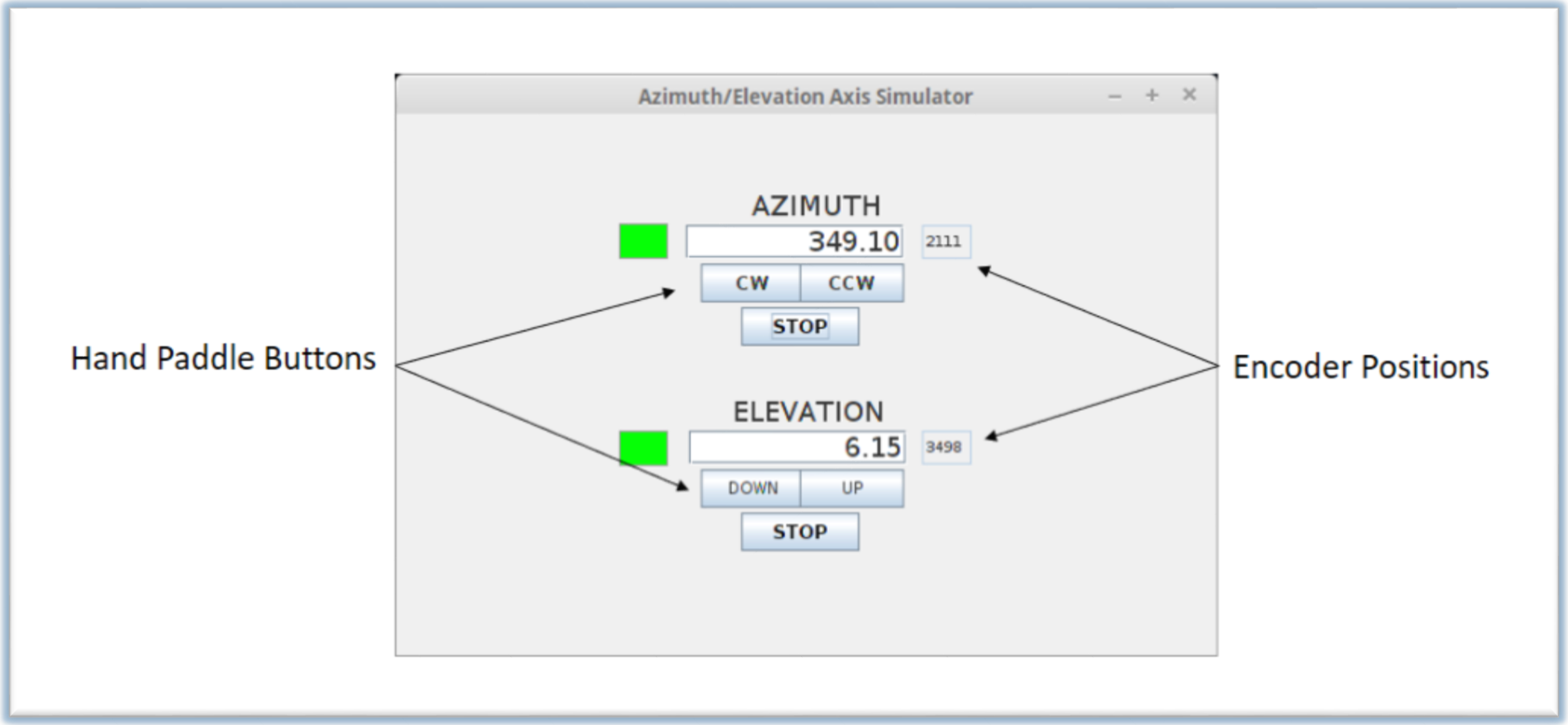
JAVA Software Classes



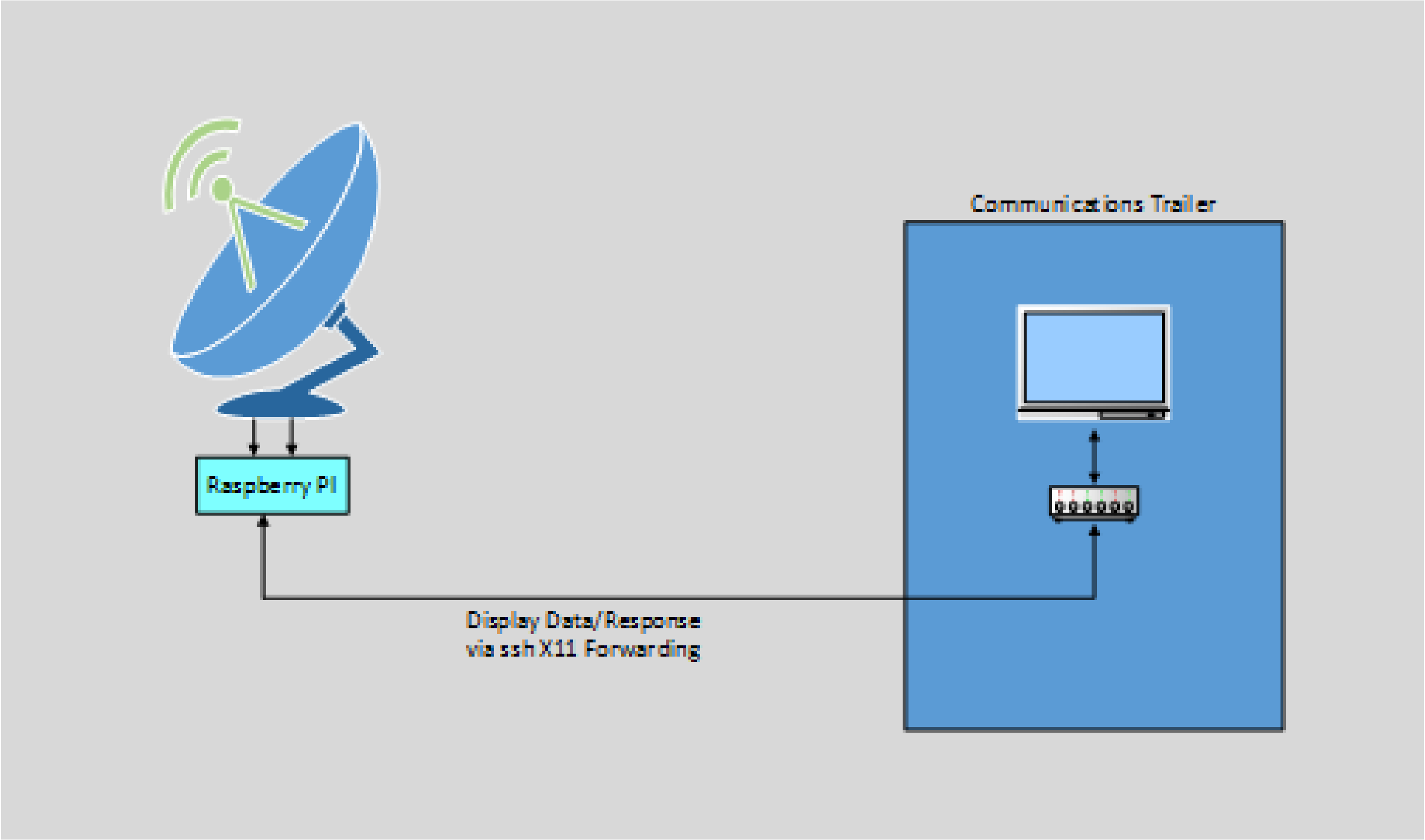
DCS JAVA and LCD Displays



ASIM Display



DCS Network


Communications Trailer
Raspberry PI
Display Data/Response
via ssh X11 Forwarding

DCS Testing

- The DCS software testing was completed in three phases:

  a. **Developmental Testing -** The initial developmental testing was completed using the mount hardware in a stand-alone environment. The Encoder was "hand" turned which changed the illumination of 12 LED's located on the Signal Conditioner Board. The LED display was used to verify the encoder position data reported by the Java software.

  b. **Initial Site Integration** – The Raspberry Pi/DCS software was connected to the azimuth and elevation encoders and the mount was slewed to known fixed azimuth and elevation positions. Results were captured and a zero point for each axis was calculated and stored in the DCS system.properties file.

  c. **Beacon Testing -** When the Dish's Feedhorn hardware became available, known radio beacons were identified and their site azimuth positions were calculated. The Dish was slewed to each of the positions and a radio receiver was used to establish and verify their reception (at their expected frequencies). The displayed azimuth position was compared to their calculated position. In each case the reported azimuth position and the calculated positions were within 1 degree of each other.

Software Future Development

1. Separate the GUI software from Axis Interface software.
    a. Allows the GUI software to run from any device with communication to the Raspberry PI via TCP/IP.
    b. Allows the use of more accurate time to be used in position calculations. The Raspberry PI does not have a Real-Time Clock (RTC) so the calculation of AZ/EL and RA/DEC will be completed on a client system that has more accurate time.
2. Add Additional Display Capabilities.
    a. Graphical Display showing the current Axis Position in RA/DEC space.
    b. Pulldowns with lists of known radio source objects.
    c. Operator control of the Raspberry PI in the Pedestal. Remote reboot and shutdown capabilities.
3. Create standalone tools to support observing, data collection and system testing.

Long term modifications will include commanding and real-time tracking of the antenna via software hardware control algorithms.

Plishner Radio Astronomy and Space Science Center

The Use of Statistical Process Control to Improve the Detection of Extraterrestrial Radio Sources

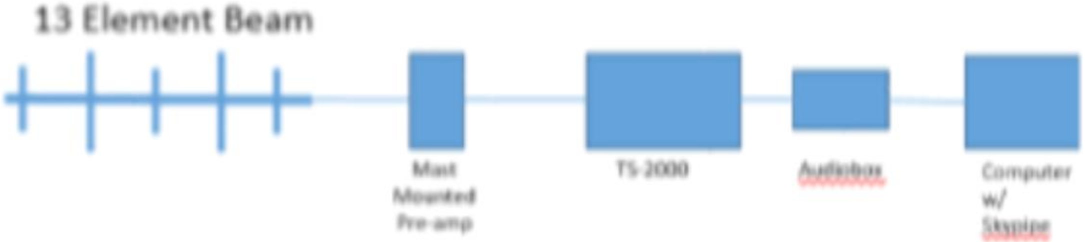
Richard Russel

Deep Space Exploration Society

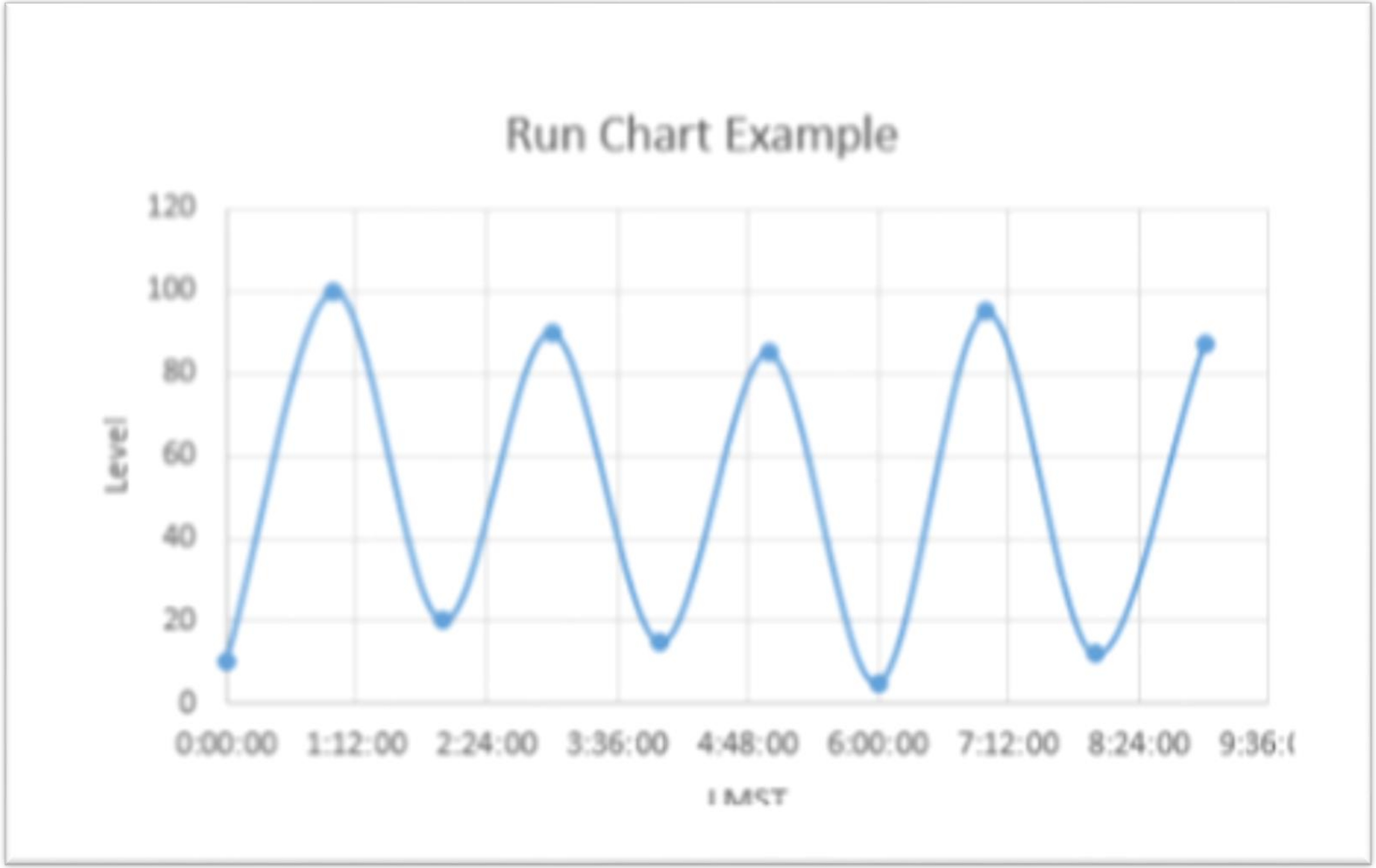
Statistical Process Control

Statistical Process Control (SPC) provides tools to achieve process and stability to improve capability through the reduction of variability.

Prototype Setup



Run Chart Example



Control Chart Example

LMST	Data
0:00:00	10
1:00:00	100
2:00:00	20
3:00:00	90
4:00:00	15
After Process Change	
5:00:00	50
6:00:00	30
7:00:00	55
8:00:00	40
9:00:00	35

Before Process Chan	Value 1	Value 2	Time-Low	Time - Max
Mean	47	47	0:00:00	4:00:00
Standard Deviation	44.1	44.1		
Upper Control Limit	91.1	91.1	0:00:00	4:00:00
Lower Control Limit	2.9	2.9	0:00:00	4:00:00

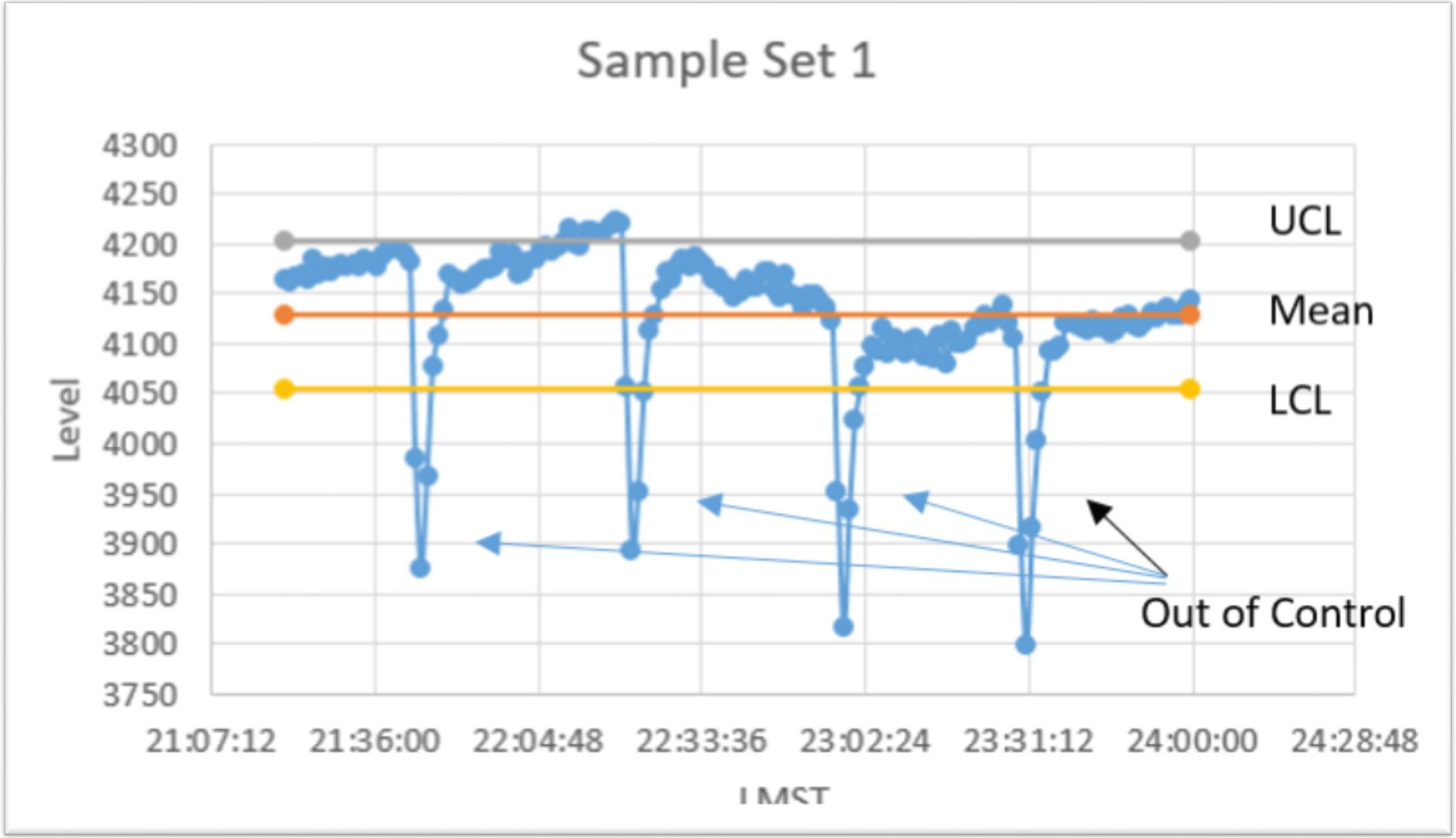
After Process Change	Value 1	Value 2	Time-Low	Time - Max
Mean	42	42	5:00:00	9:00:00
Standard Deviation	10.4	10.4		
Upper Control Limit	52.4	52.4	5:00:00	9:00:00
Lower Control Limit	31.6	31.6	5:00:00	9:00:00

Control Chart Rules

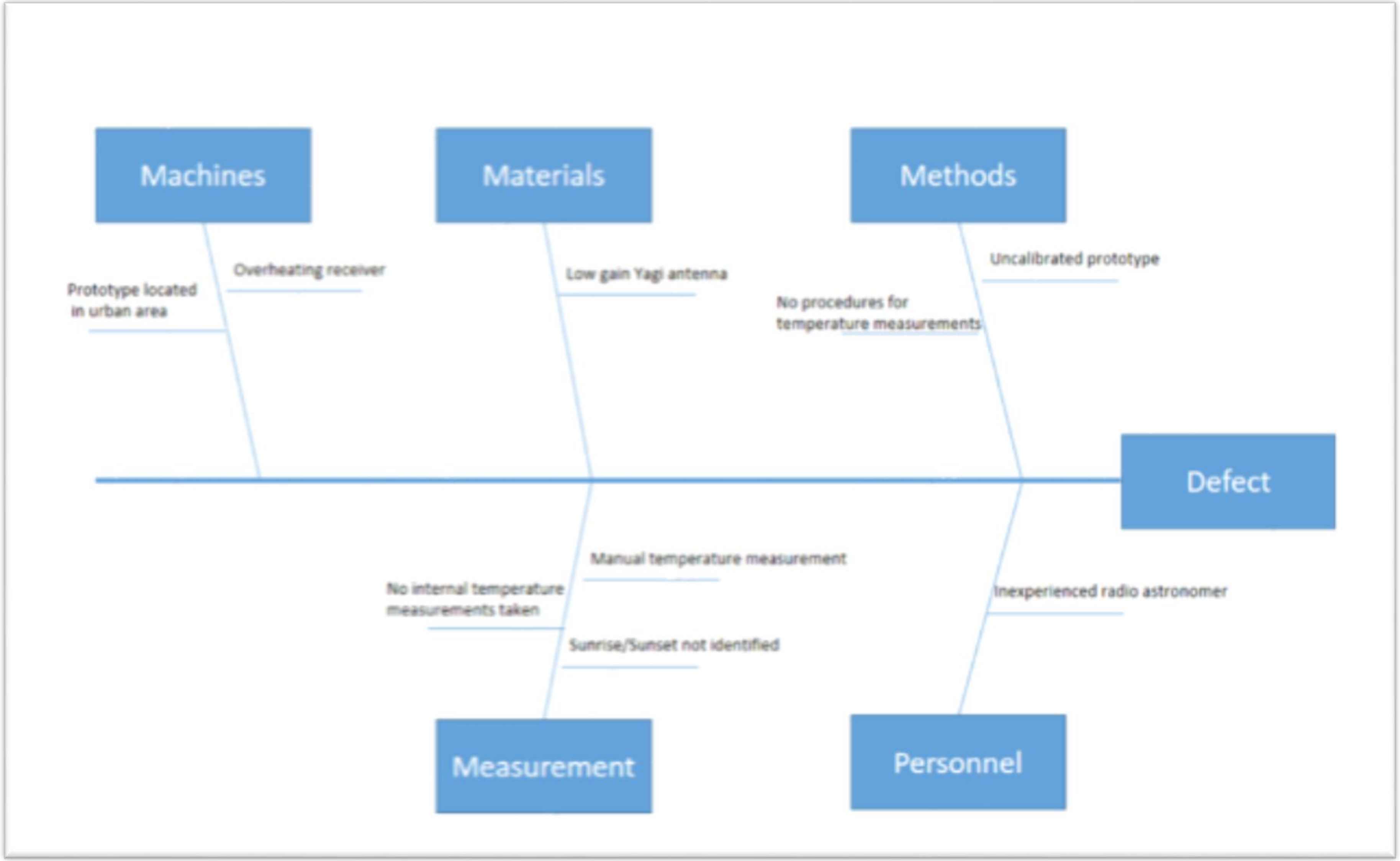
- 1 or more points outside of control limits
- Four of five consecutive points beyond the one segment limit
- A run of eight consecutive points on one side of the center line
- Six points in a row steadily increasing or decreasing
- An unusual or nonrandom pattern in the data

The assumption for the prototype is that the majority of the data received would be background noise caused by the environmental temperature variations of the antenna, preamp and receiver.

50 Ohm Test – Sample Set 1



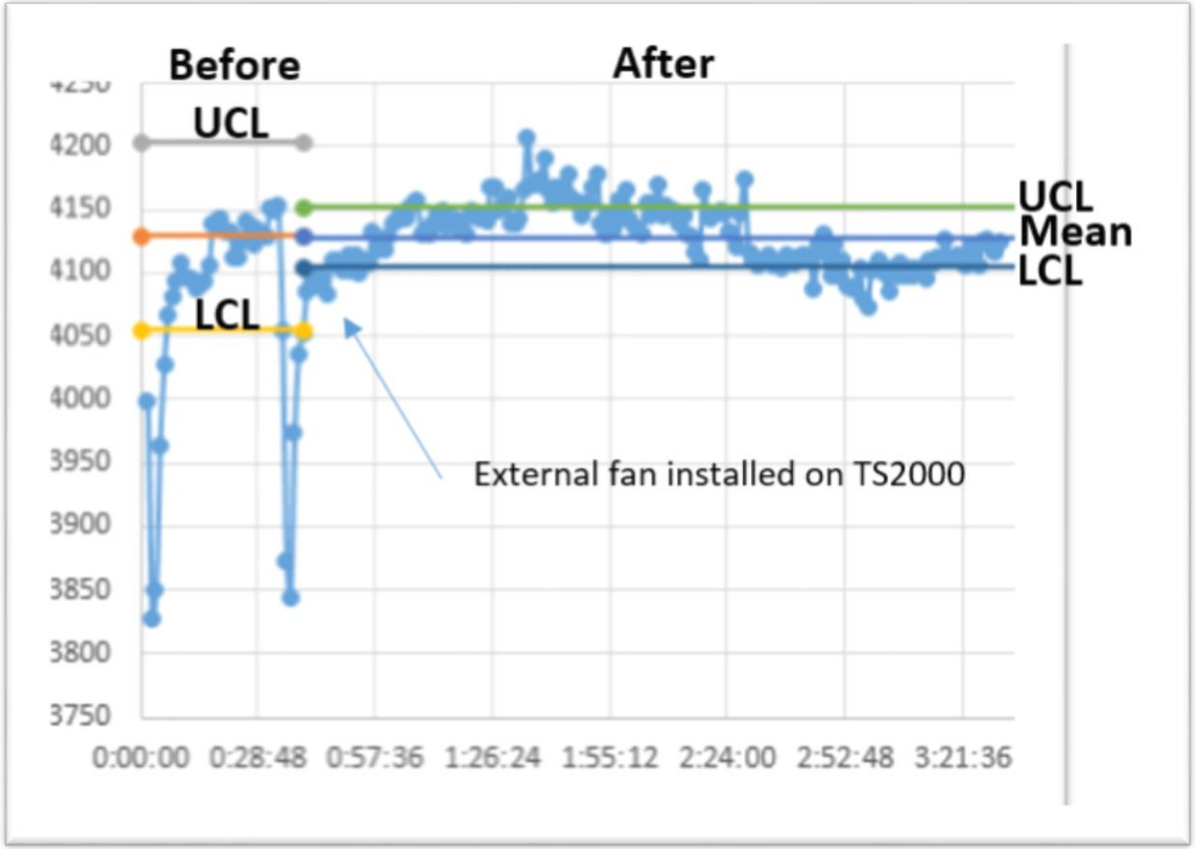
Cause and Effect Diagram



Ranking Cause and Corrective Actions

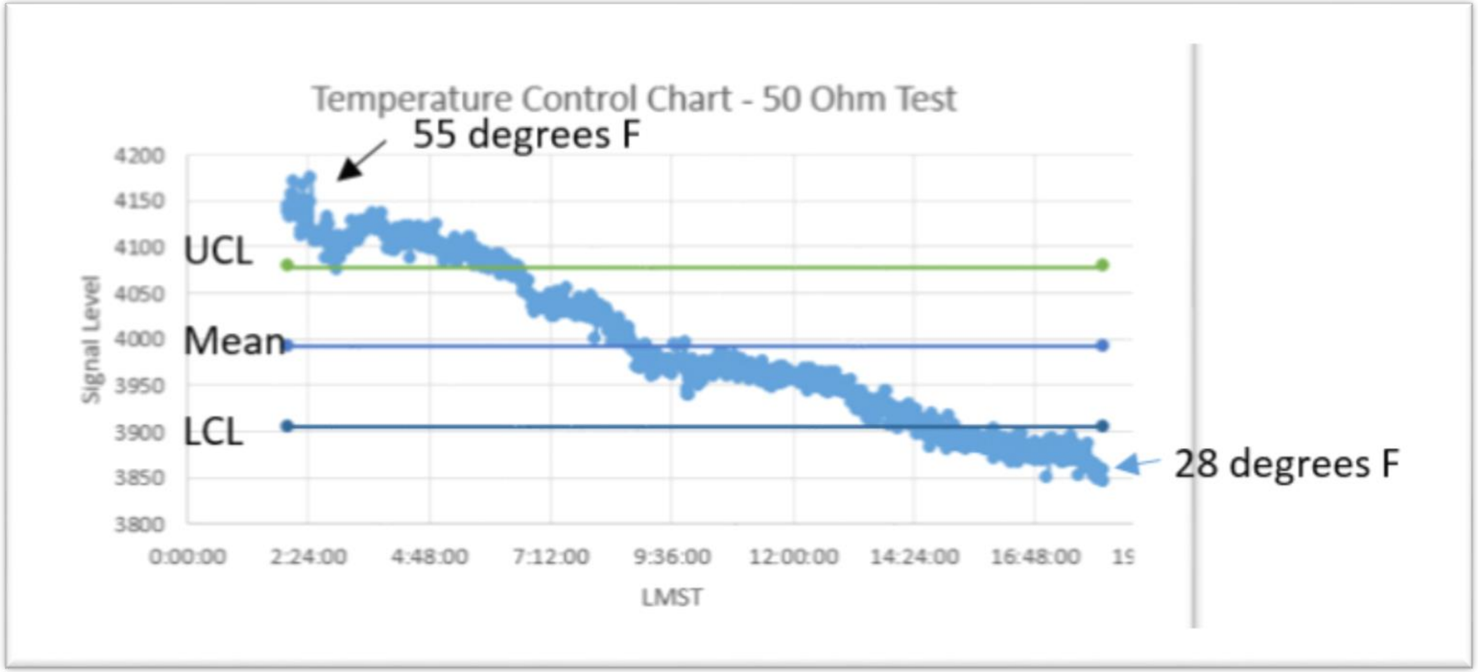
Rank	Cause	Corrective Action
1	Receiver overheating	Add external fan
2	Manual Temperature measurements	Add weather station with automatic data collection
3	Sunrise/Sunset not documented	Add step in procedures

Before and After Corrective Action



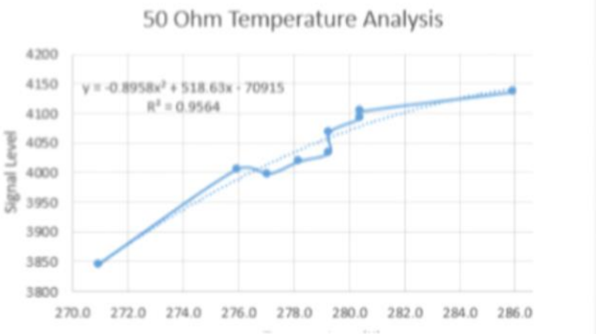
Sample Set 2				
arameter	Level-Start	Level-End	LMST-Start	LMST-End
ld Mean	4129	4129	0:00:00	0:40:0
ld Stdev	74			
ld UCL (Mean+stdev	4203	4203	0:00:00	0:40:0
ld LCL (Mean-Stdev)	4054	4054	0:00:00	0:40:0
arameter	Level-Start	Level-End	LMST-Start	LMST-End
lew Mean	4128	4128	0:40:00	4:00:0
lew Stdev	24			
lew UCL (Mean+stde	4151	4151	0:40:00	4:00:0
lew LCL (Mean-Stde	4104	4104	0:40:00	4:00:0

Control Chart – Temperature Test
50 Ohm Resistor

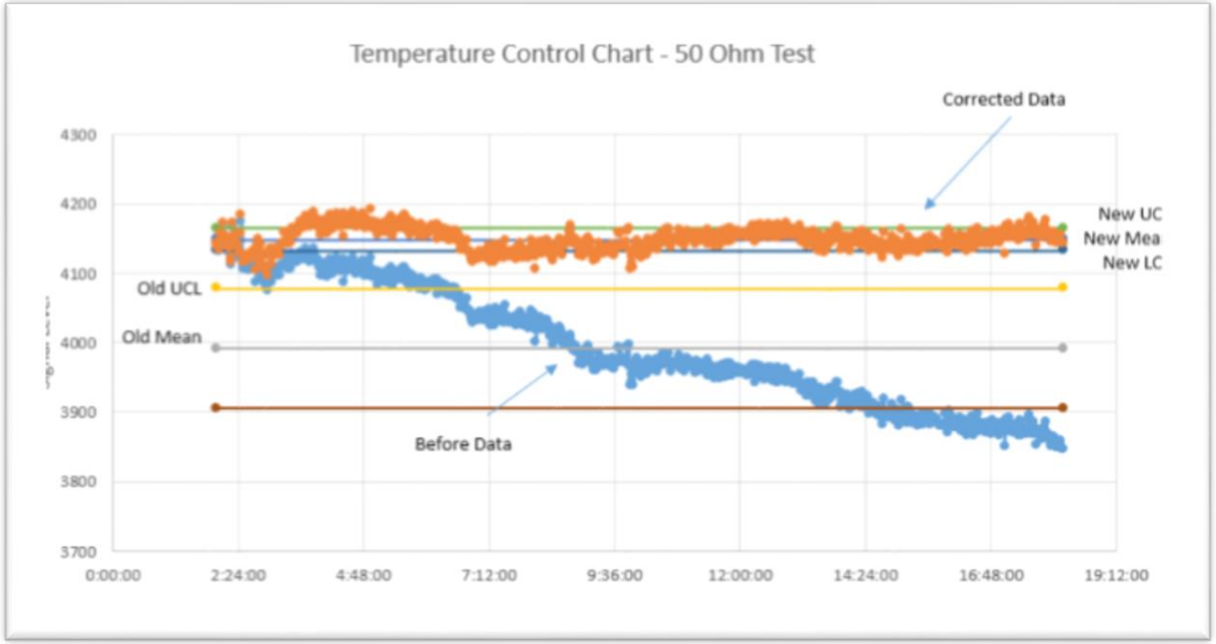


Temperature Variation Analysis				
Parameter	Level-Start	Level-End	LMST-Start	LMST-End
Mean	3991	3991	2:00:00	18:11:00
Stdev	86			
UCL (Mean+stdev)	4078	4078	2:00:00	18:11:00
LCL (Mean-Stdev)	3905	3905	2:00:00	18:11:00

MST	Temp (F)	Temp (K)	Level
2:02:00	55	285.9	4136
4:04:00	45	280.4	4103
5:47:00	45	280.4	4091
6:34:00	43	279.3	4068
7:13:00	43	279.3	4033
8:04:00	41	278.2	4018
8:36:00	39	277.0	3997
8:46:00	37	275.9	4005
18:11:00	28	270.9	3845



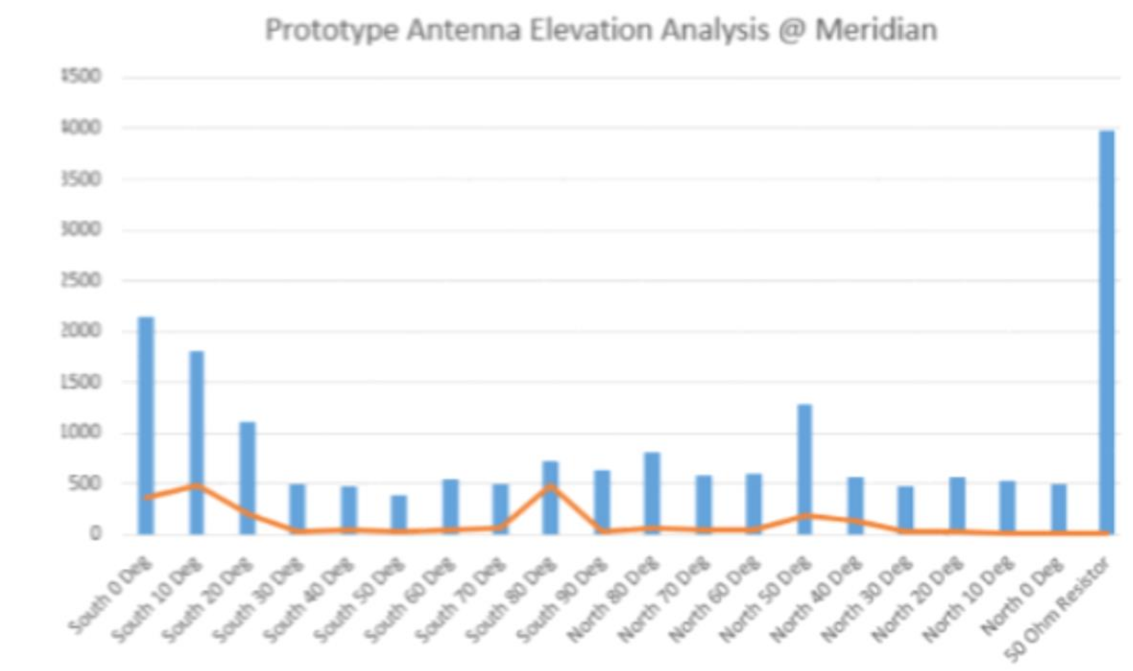
Temperature Test – Before and After Corrective Action



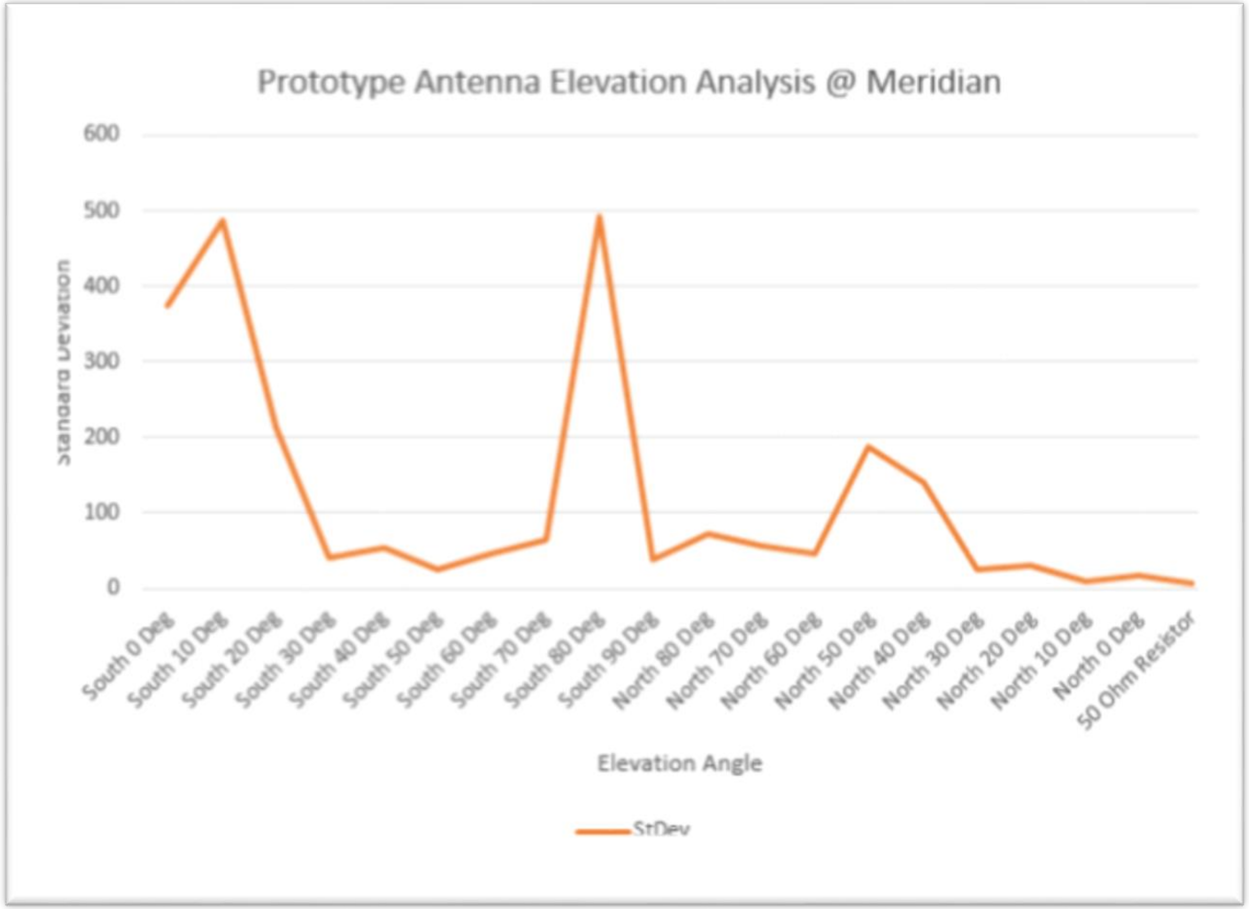
Temperature Variation Analysis				
Parameter	Level-Start	Level-End	LMST-Star	LMST-End
Old Mean	3991	3991	2:00:00	18:11:00
Old Stdev	86			
Old UCL (Mean+stdev)	4078	4078	2:00:00	18:11:00
Old LCL (Mean-Stdev)	3905	3905	2:00:00	18:11:00
Parameter	Level-Start	Level-End	LMST-Star	LMST-End
Corrected Mean	4148	4148	2:00:00	18:11:00
Corrected Stdev	16			
Corrected UCL (Mean+stdev)	4164	4164	2:00:00	18:11:00
Corrected LCL (Mean-Stdev)	4133	4133	2:00:00	18:11:00

Antenna Signal Level vs. Elevation

Elevation	Mean	StDev
South 0 Deg	2139	374
South 10 Deg	1810	488
South 20 Deg	1104	214
South 30 Deg	496	40
South 40 Deg	486	55
South 50 Deg	388	26
South 60 Deg	558	46
South 70 Deg	490	66
South 80 Deg	722	492
South 90 Deg	640	38
North 80 Deg	809	72
North 70 Deg	579	56
North 60 Deg	608	47
North 50 Deg	1293	187
North 40 Deg	560	141
North 30 Deg	471	25
North 20 Deg	560	30
North 10 Deg	527	11
North 0 Deg	496	18
50 Ohm Resistor	3980	8



Prototype Antenna Elevation Analysis @ Meridian



Lessons Learned

The lessons learned from the above SPC analysis shows that the best configuration to conduct a drift scan on the prototype antenna includes:

- The receiver fan causes data spikes in signal level - External fan on receiver to maintain temperature
- External temperature variation is a significant factor – limit observations to a steady state temperature
- Elevation angle has a significant effect on the signal levels – only take data at low mean and σ as noted

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Questions?