Project Glenda – 2002 Status Report

Project Glenda – Purpose

The primary mission of Project Glenda is to provide the capability to rapidly gather previously inaccessible localized microclimate data from altitudes ranging from ground level to 40,000 feet and to return this data for immediate use.

Project Glenda is a reusable sounding rocket delivery system designed to place instrument packages into areas previously considered to be to hazardous or inaccessible using traditional platforms such as balloons, aircraft, helicopters, kites, etc.

Project Glenda – Data Capabilities

Project Glenda has the capability to collect temperature, humidity, barometric pressure, wind speed and other types of environmental data from ground level to 40,000 feet.

Glenda is designed to be launched into thunderstorms, tornados, and other volatile weather environments and to return intact with its collected data.

Project Glenda – Typical Flight Profile

2 – Boost Phase

3 – Deployment Phase

1 – Launch Phase

Note: Propulsion is provided by reloadable /reusable rocket motors giving the capability of rapid turnaround between flights.

4 – Recovery Phase

Project Glenda – Flight Vehicles

Glenda 54mm (2.125”)

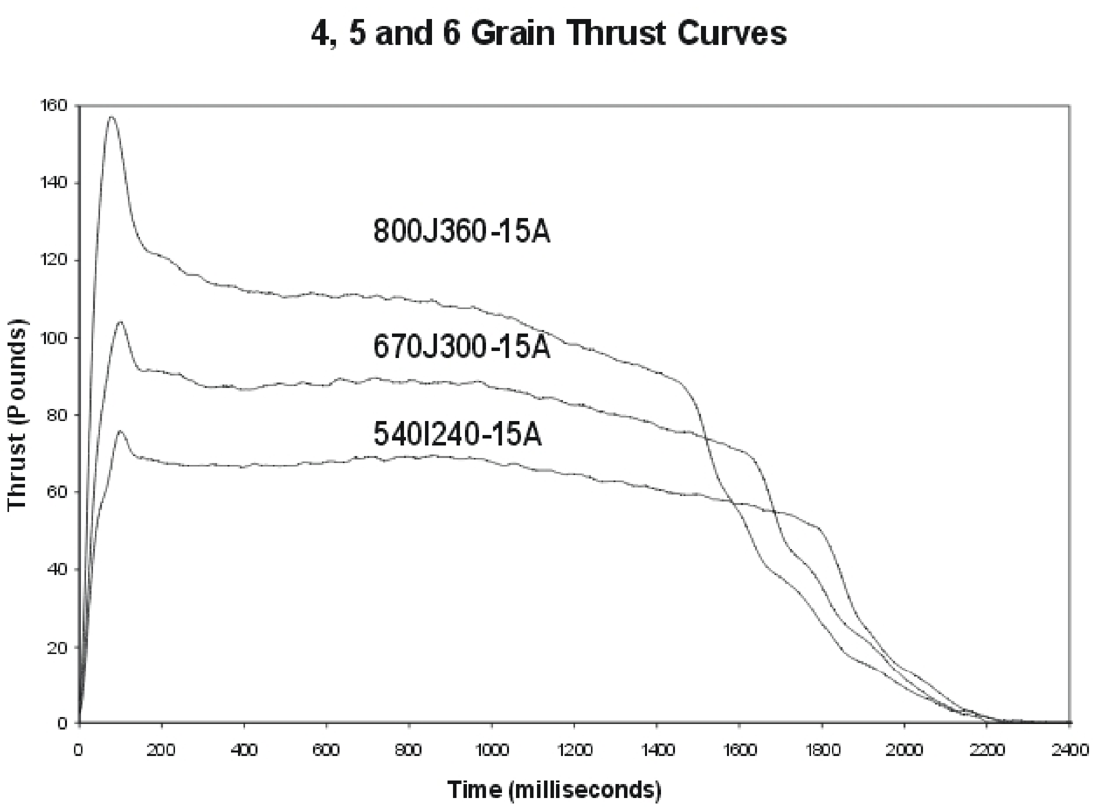
Length: 46”
Diameter: 2.125”
Dry Weight: 1.75 Pounds
Attainable Altitudes: 1,000 feet to 15,000 feet

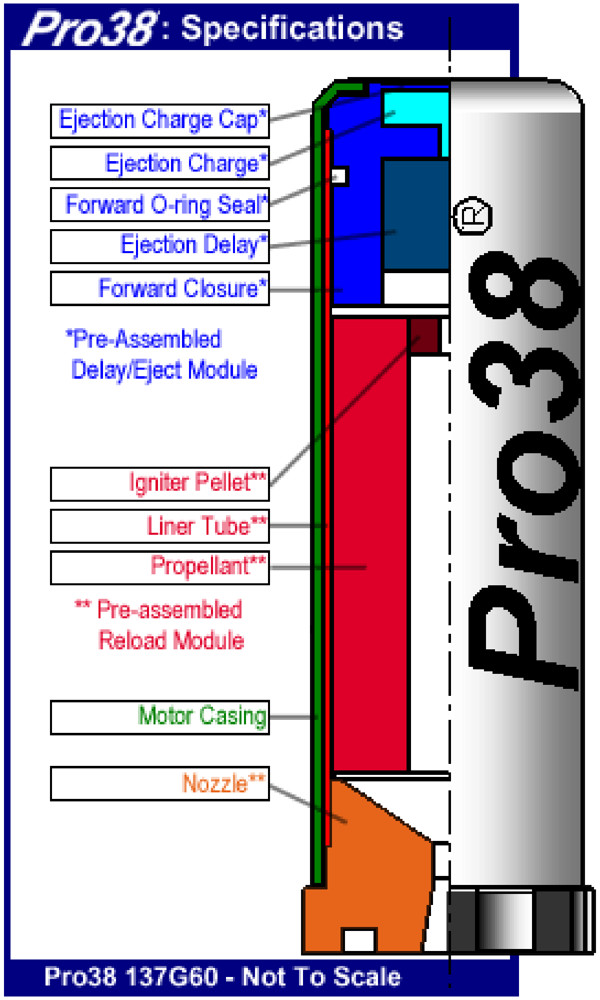
Glenda 98mm (4”)

Length: 63”
Diameter: 4”
Dry Weight: 3.5 Pounds
Attainable Altitudes: 2,000 feet to 40,000 feet

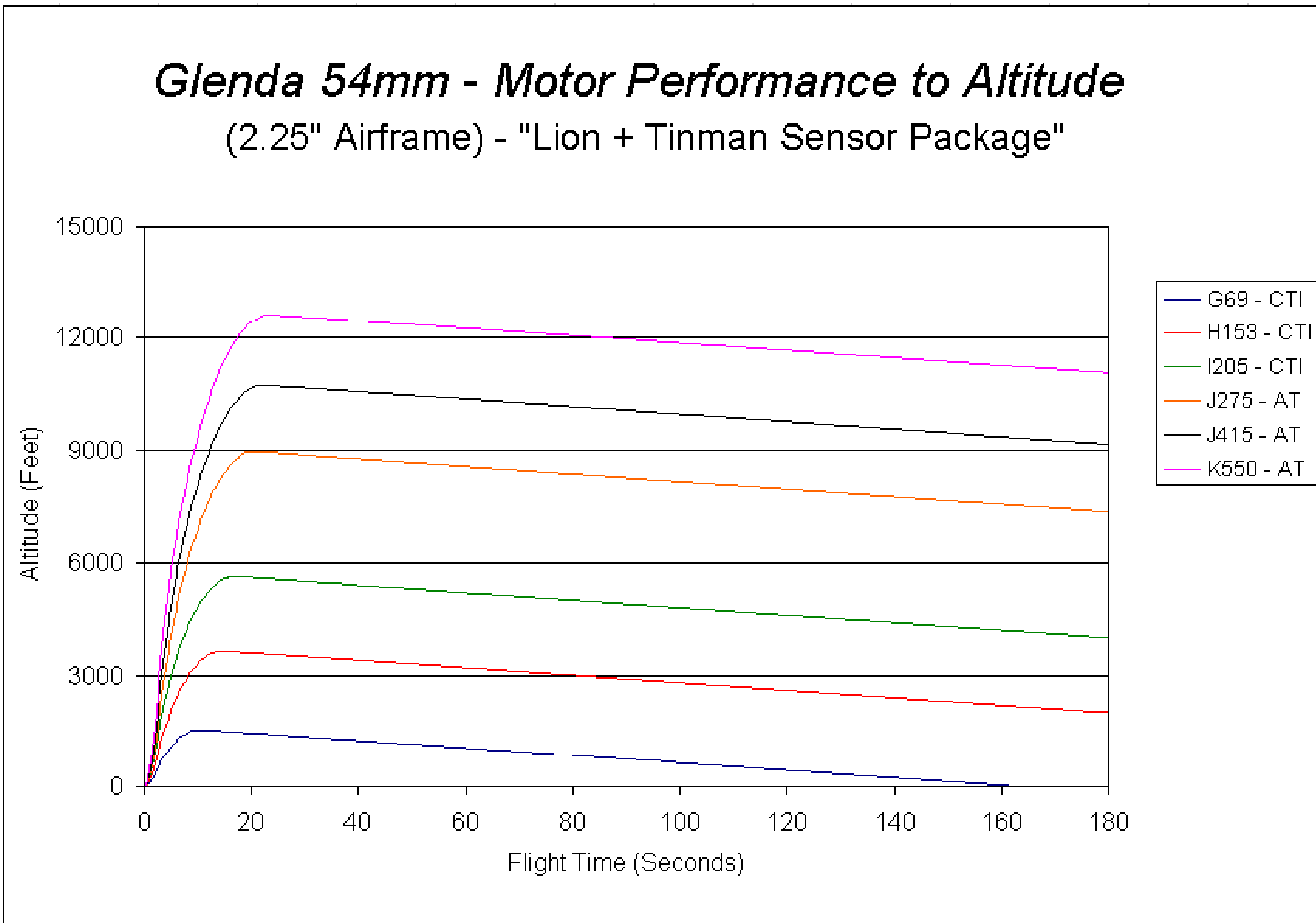
Project Glenda – Propulsion

The Pro38 rocket motor propulsion system is the first commercial thermoplastic propellant-based solid rocket motor and is produced by Cesaroni Technology Inc. of Toronto Canada. The Pro38 is a modular, reloadable solid propellant rocket motor system designed primarily for use in launching small experimental payloads by universities, colleges, research institutes and sport rocketry enthusiasts.





Project Glenda – Performance



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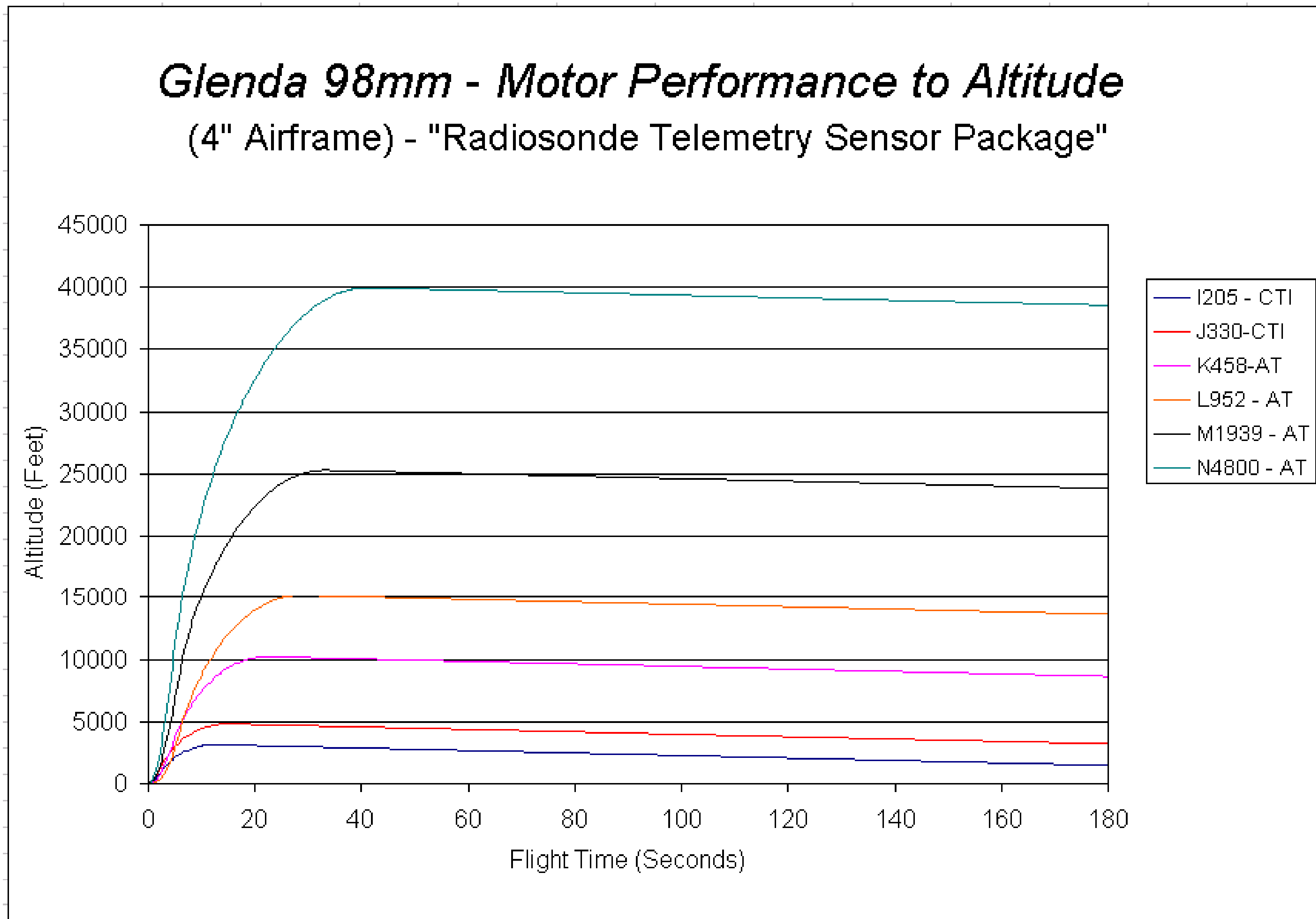


Project Glenda – Data Collection Methods

Project Glenda has two methods of collecting data:

- Dataloggers
- Radiosondes

Project Glenda Payload – Dataloggers

A data logger is an electronic instrument that records measurements over time. Typically, data loggers are small, battery-powered devices that are equipped with a microprocessor, data storage and sensors. Most data loggers utilize software on a personal computer to initiate the logger and view the collected data.

Prior to a Glenda launch, the data logger is connected to a laptop computer. Then, Windows based software is used to select logging parameters (sampling intervals, start time, etc.) and initiate the logger. The logger is then disconnected from the laptop and installed inside the Glenda payload capsule. Upon launch, the logger records each measurement and stores it in memory along with the time and date. Post recovery, the logger is then reconnected to the laptop computer and the software is used again to readout the data and see the measurements as a graph, showing the profile over time. The tabular data can be viewed as well, or exported to a spreadsheet for further manipulation.

Project Glenda Payload – Dataloggers

The Temperature / Relative Humidity datalogger is one of Glenda's primary data collection devices.

Temperature / Relative Humidity Datalogger Specifications:

- Capacity: 7943 measurements total
- User-selectable sampling interval: 0.5 seconds to 9 hours
- Programmable start time/date
- Memory modes: stop when full, wrap-around when full
- Nonvolatile EEPROM memory retains data even if battery fails
- Blinking LED light confirms operation
- User-replaceable battery lasts 1 year
- Battery level indication at launch
- Operating range: -4°F to +158°F (-20°C to +70°C), 0 to 95% relative humidity
- Time accuracy: ±1 minute per week at +68°F (+20°C)
- Size/Weight: 2.4 x 1.9 x 0.8" (68 x 48 x 19 mm)/approx. 1 oz.(29 grams)

Project Glenda Payload – Dataloggers

The Barometric Pressure datalogger functions perfectly in detecting atmospheric anomolies that are generated prior to a thunderstorm or tornado. The rapid response time of Glenda allows data to be interpreted quickly gaining valuable time in the event a severe weather warning is necessary.

<u>Barometric Pressure Datalogger Specifications:</u>

- Pressure range 0.5 to 16 psia
- User-selectable sampling interval: 0.5 seconds to 9 hours
- Two year battery life (user replaceable)
- Nonvolatile EEPROM memory retains data even when the battery has been removed
- Stores up to 1800 measurements
- Safe operating temperature range of -39°C to +75°C, non-condensing
- Small size: 1.8" wide x 1.9" tall x 0.6" thick and 0.9 oz.
- Sampling intervals from 0.5 seconds to 9.0 hours
- Wide variety of pressure/altitude units
- Blinking LED light confirms operation
- Data exportable to spreadsheet programs (Lotus, Excel, etc.)

Project Glenda Payload – Radiosondes

The radiosonde contains instruments capable of making direct measurements of air temperature, humidity and pressure.These observed data are transmitted immediately to the ground station by a radio transmitter located within the instrument package.

The Glenda Project uses converted radiosondes that were previously designed for use with weather balloons. The circuitry and sensors function properly under thrust loads of the Glenda boosters and are compatible with NOAA radiosonde receiver systems.

Viasala Radiosonde in sealed packaging

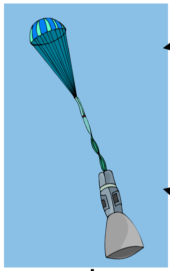
<u>Radiosonde Specifications:</u>

- Pressure range 3mb to 1060mb +/- .1mb
- Operating temperature range of -90°C to +60°C
- Relative Humidity from 0 to 100%
- Sampling Rate of 1.5 seconds for the sensor suite
- Small size: 3.5" wide x 5.8" tall x 2.2" thick and 7.8 oz.

Project Glenda Payload – Radiosondes

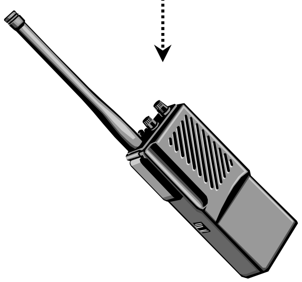
Signal Processing Flow Diagram

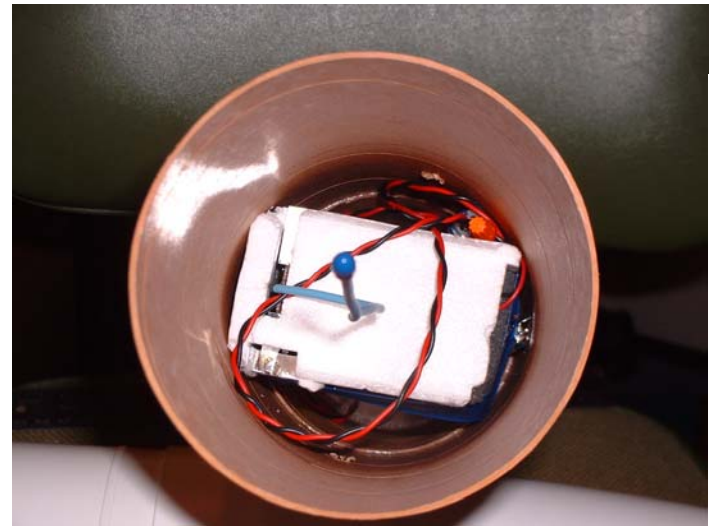
Viasala Radiosonde



- Barometric Pressure Sensor Data
- Temperature Sensor Data
- Relative Humidity Sensor Data

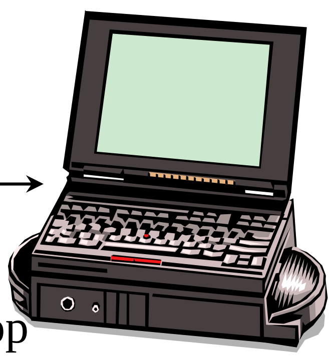
Sensor Data Transmitted to Ground Receiver





Viasala Radiosonde in Glenda 98mm payload capsule

Radiosonde Signal Sample

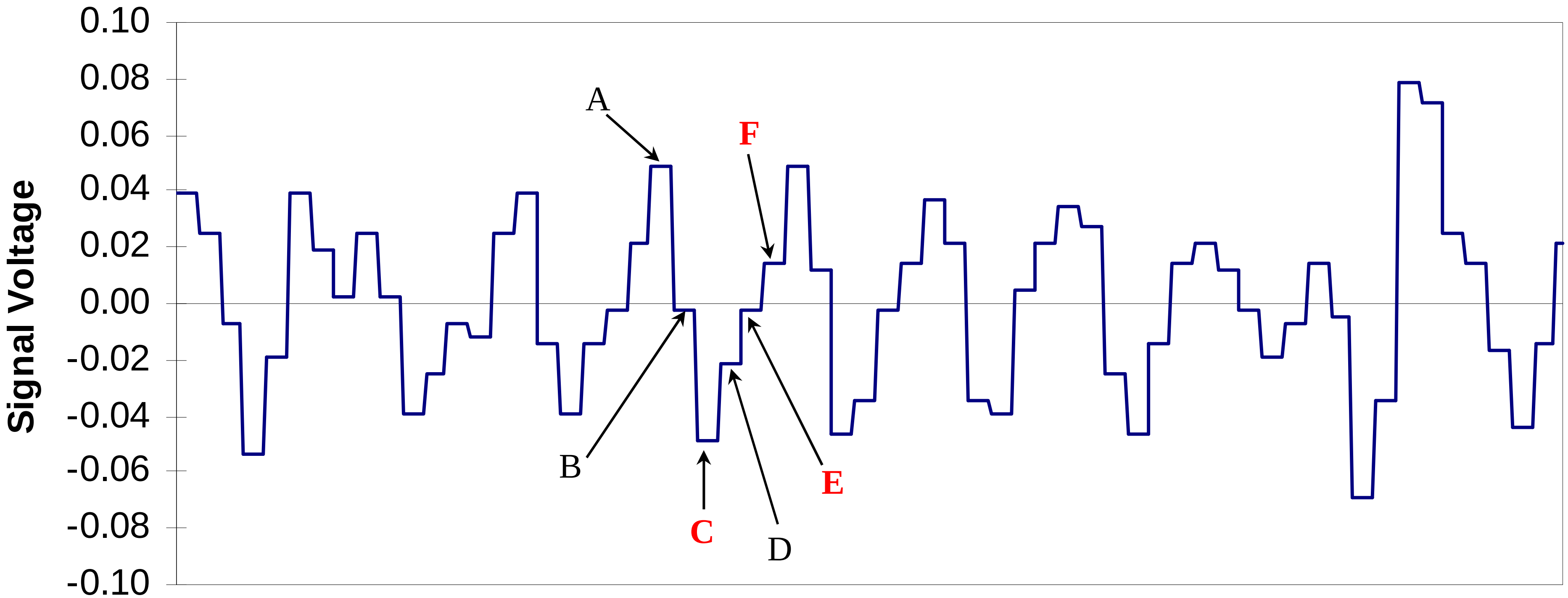


Received Data recorded onto Laptop

Recorded digital signal displayed as WAV file → Digital WAV file converted to Analog data using Fast Fourier Transformation → FFT File opened using Excel To graphically display data

Signal Data represented as voltage curve.

Glenda Radiosonde – Typical Signal Transmission



A – High Calibration Point
B – Temperature of Pressure Sensor
C – Pressure Sensor (millibars)
D – Low Calibration Point
E – Temperature Sensor (Degrees)
F – Relative Humidity Sensor (%)

Note: Each Cycle is 1.5 Seconds

Project Glenda Payload – Tracking Systems

To ensure the recovery of the payloads, Project Glenda has implemented several recovery and tracking aids.

To support short range recovery, a 110 db audio alarm is installed in the payload capsule. The alarm functions independently of the data payload and is activated by its own internal countdown timer. Field tests have shown an effective range of one half mile.

For long range tracking and recovery, a tracking transmitter is installed in the payload capsule. Field tests have indicated a line of sight tracking distance at over three miles.

110 db audio alarm payload location package

Audio Beacon Sound Sample

Payload tracking transmitter

Tracking Transmitter Signal

Project Glenda Payload – Dataloggers

Glenda 54mm Capsule in Flight Configuration

Tracking System Antenna

Datalogger Sensor Port

Here is a typical Glenda payload ready for flight. This capsule contains the tracking locator transmitter, the combination temperature/relative humidity datalogger, and the barometric pressure datalogger. Total payload weight including capsule is less than one pound.

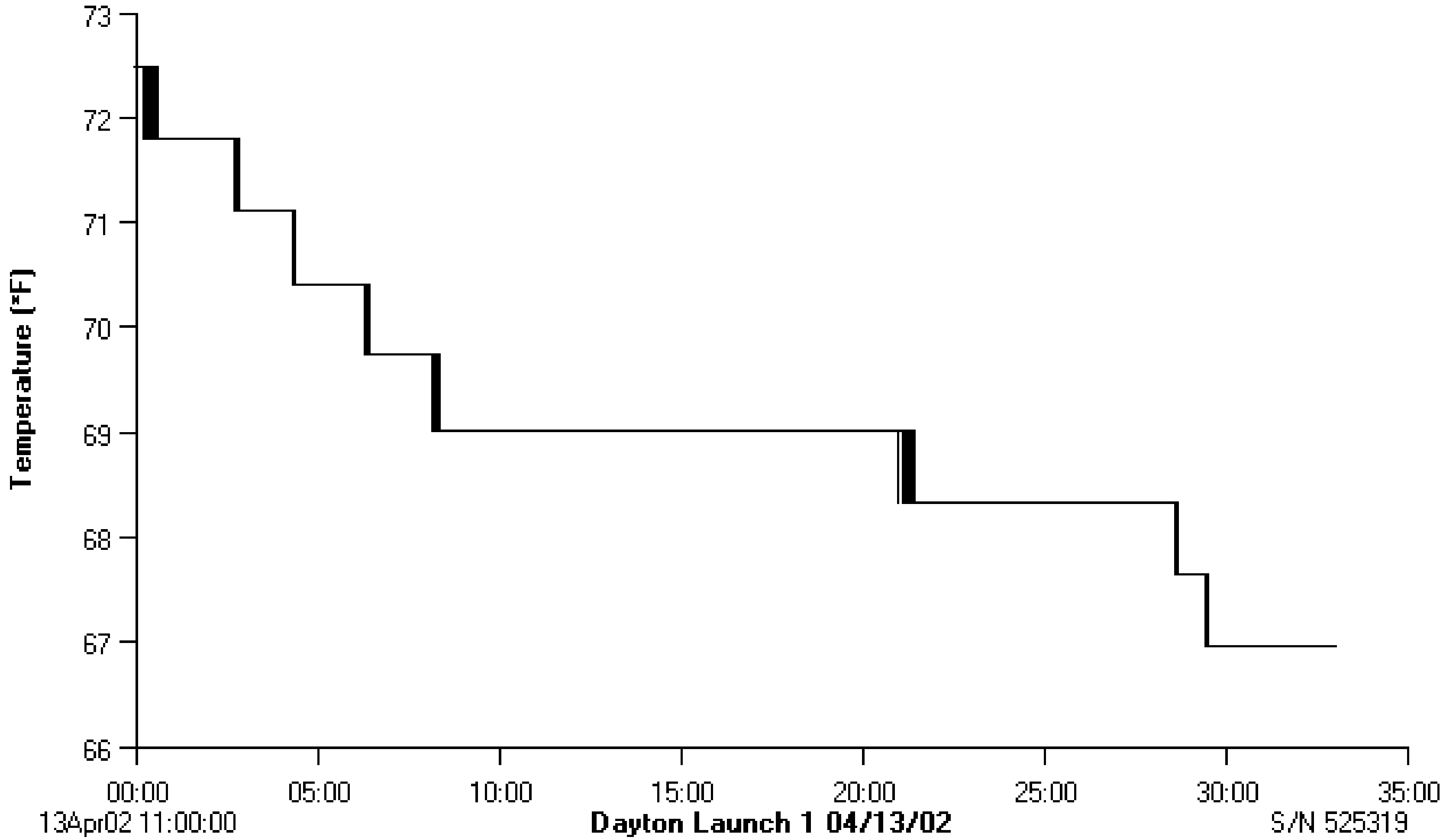
April 13th, 2002 Dayton Washington Flight Success

- The April Dayton launch featured the first flight of Project Glenda's multi-sensor datalogger.
- Temperature and humidity data was collected every ½ second from 11:00 a.m. to 11:33 a.m.
- The datalogger was flown at 11:07:10 a.m. and data is displayed for the first 60 seconds of flight time
- This test flight met the mission criteria of verifying the capability of collecting temperature and humidity data in a "G" loaded environment.

H8 – Datalogger Temperature (Degrees F)

Dayton, WA – 04/13/02

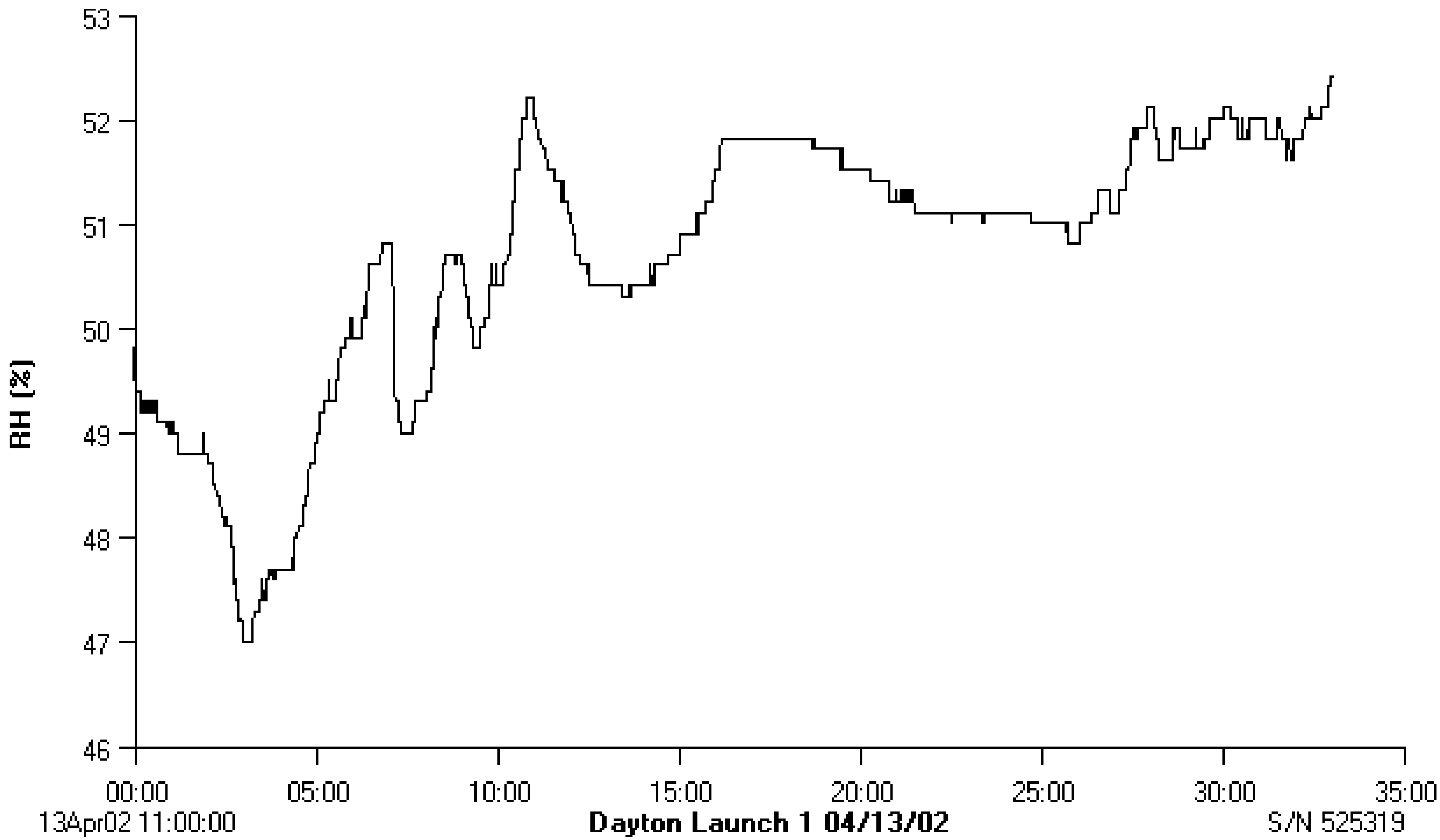
11:00 a.m. to 11:33 a.m.

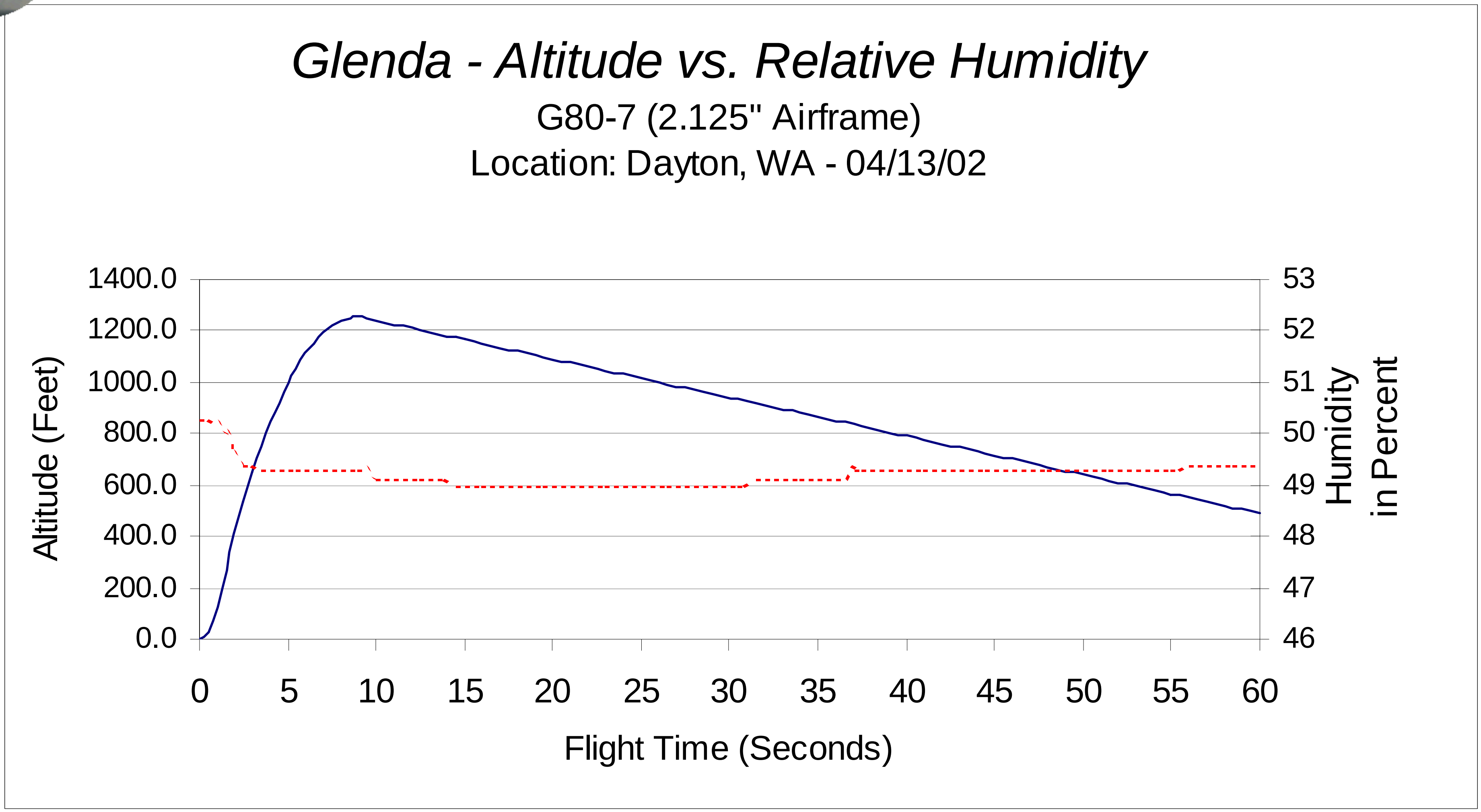


H8 – Datalogger Relative Humidity (%)

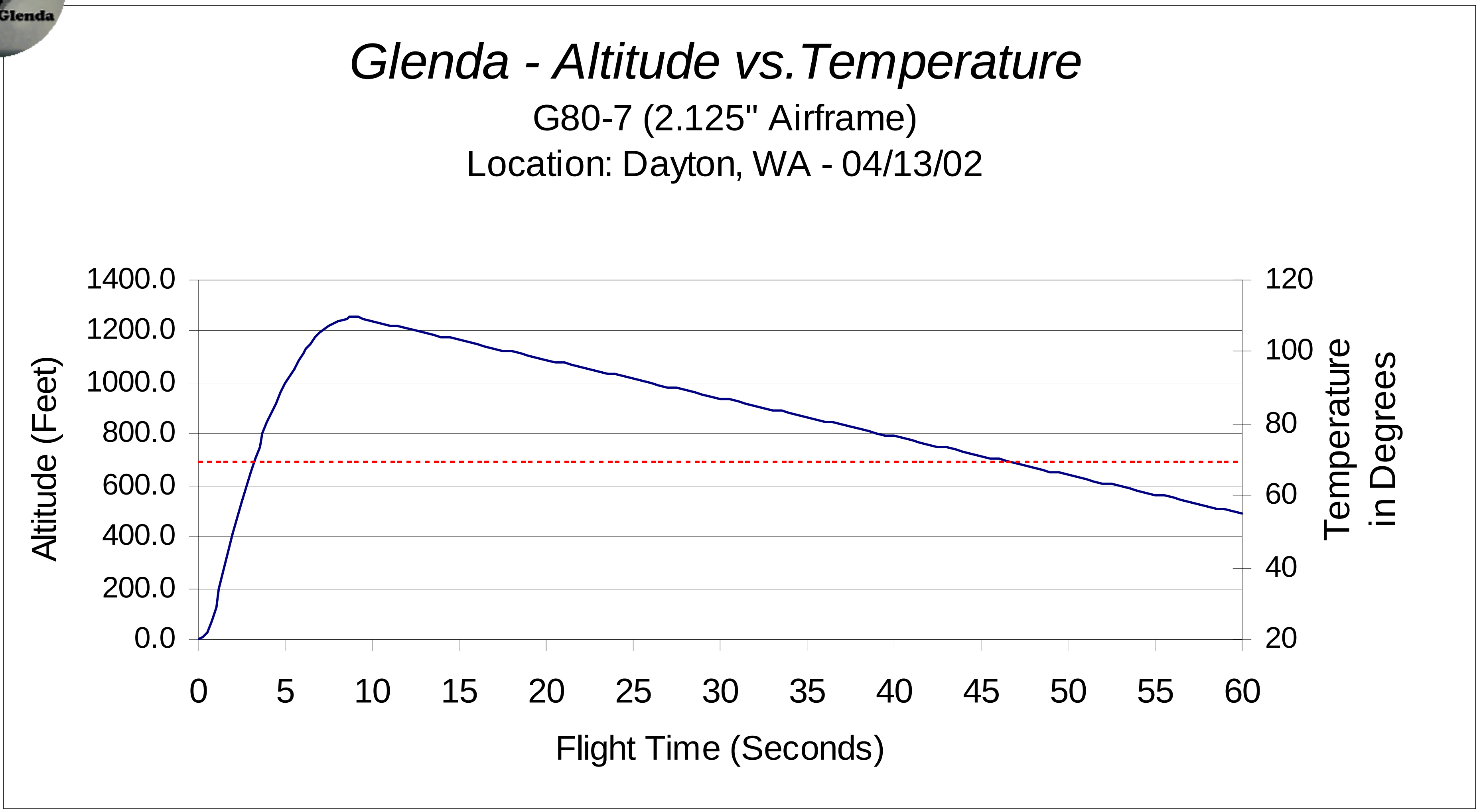
Dayton, WA – 04/13/02

11:00 a.m. to 11:33 a.m.





* Flight time from 11:07:10 am to 11:08:10 a.m.



* Flight time from 11:07:10 am to 11:08:10 a.m.

June 8th, 2002 Dayton Washington Flight Success

- The June Dayton launch featured the second flight of the Temperature / Relative Humidity datalogger. An additional datalogger was kept on the ground to provide a baseline.
- First Flight of the Cesaroni reloadable motor system.
- First Flight of the audio tracking location package.
- First Flight of an integrated payload combining the radiosonde and tracking transmitters.
- Deployed a ground station collecting windspeed, temperature, relative humidity, and pressure every one half hour.
- Second test flight of the radiosonde confirming signal and sensor stability under acceleration loads.

June 8th, 2002 Dayton Washington Flight Tests

- While the flight of the Glenda 54mm booster was a success with the safe recovery of the capsule, the recovery system of the booster requires more work. For the next launch, a more robust recovery system will be installed. The design of the recovery system defaults to the safety of the payload capsule in the event of a recovery system failure, and that mode performed as designed.

June 8th, 2002 Dayton Washington

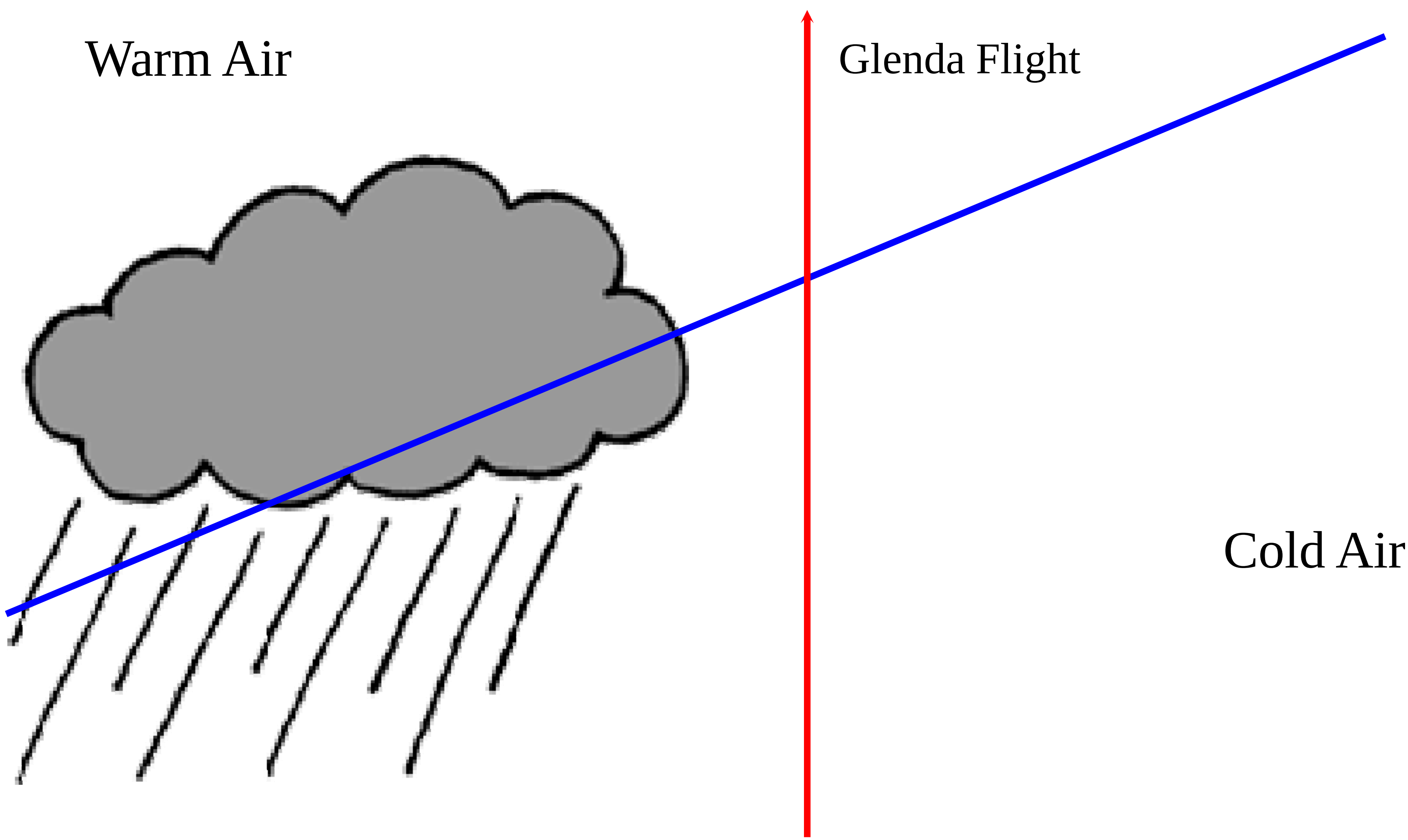
Design Validation Success – Warm Front Successfully Detected

- One of mission goals of Project Glenda is to serve as an early warning system for incoming storms. During the June launch an incoming warm front was detected by the temperature and humidity dataloggers as shown by the warmer air at altitude versus cooler air at ground level. The data was collected within one hour of the incoming storm.

- A warm front is formed when warm air overtakes colder air. Warm air and cold air are of different densities, and they do not mix very well. The warm air, being less dense, rises gradually up the ramp of colder air in front. This forms two layers of an upper warmer air layer, and a cooler lower air layer. As the warm air rises, there comes a point where it can no longer hold its moisture in the form of a vapor. The excess water vapor condenses to form clouds. As the warmer air continues to condense and cool, precipitation results.

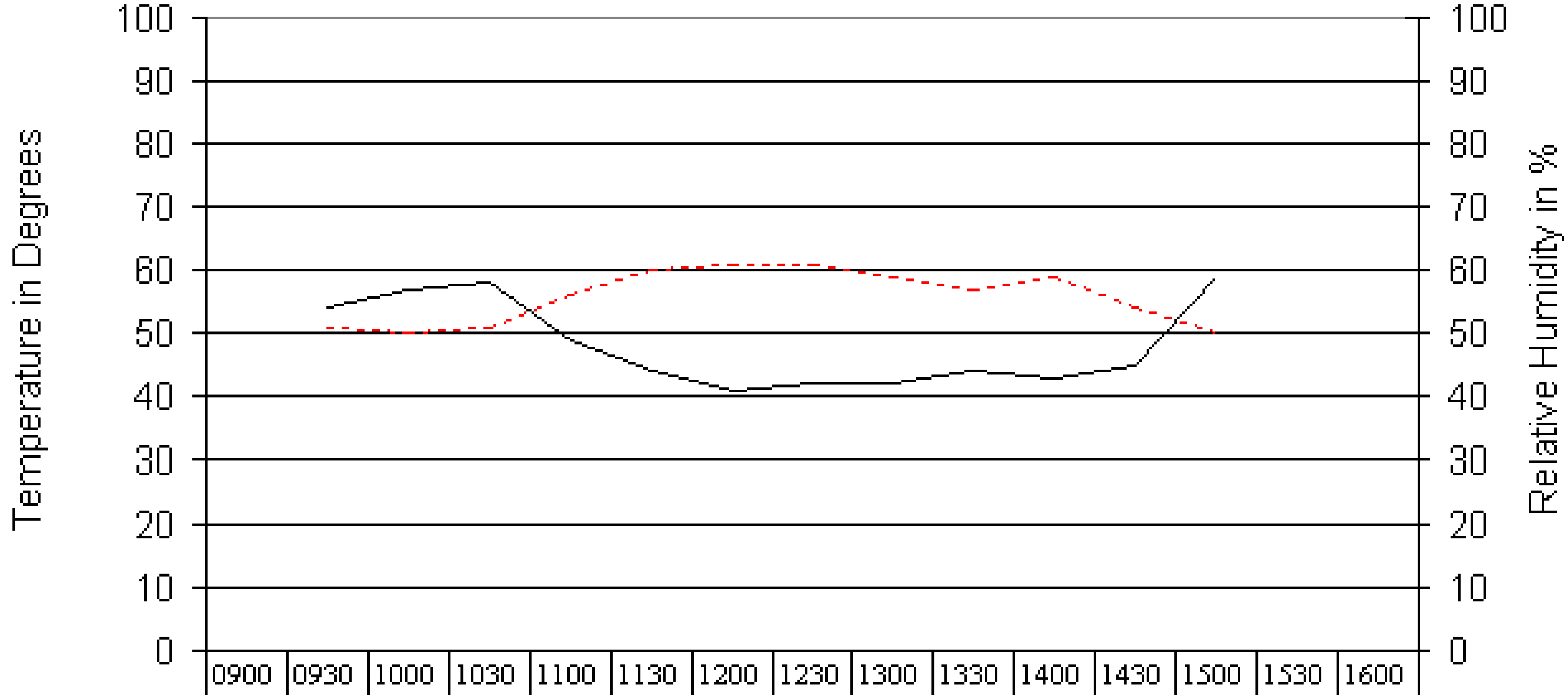
June 8th, 2002 Dayton Washington

Design Validation Success – Warm Front Successfully Detected



Site Analysis - Temperature & Relative Humidity

Dayton WA - "Thunder Bowl Site" - 06/08/02

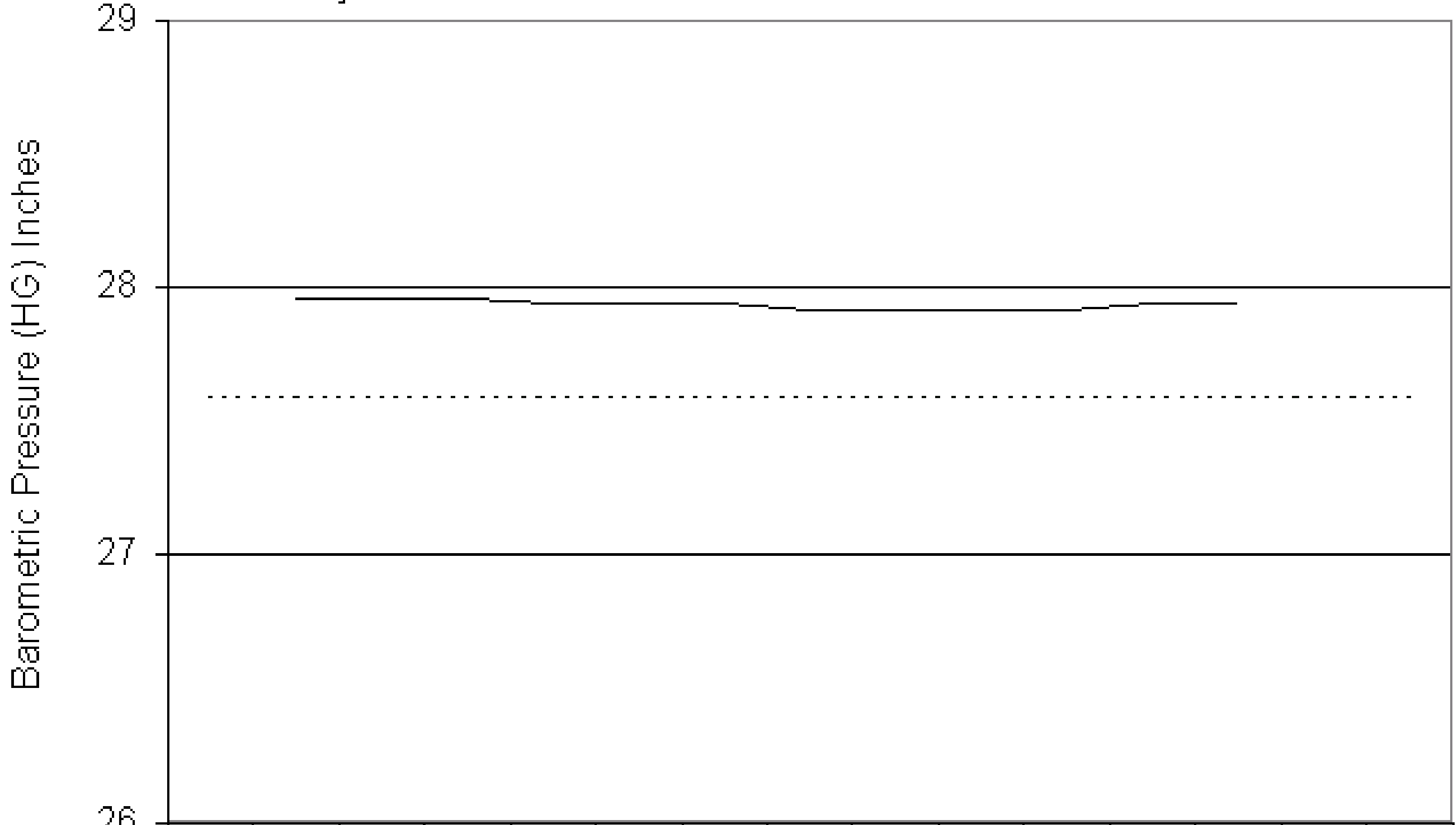


	0900	0930	1000	1030	1100	1130	1200	1230	1300	1330	1400	1430	1500	1530	1600
Site Temperature		51	50	51	56	60	61	61	59	57	59	54	50		
Site Humidity		54	57	58	49	44	41	42	42	44	43	45	59		

Barometric Site Analysis

Compensated for Altitude

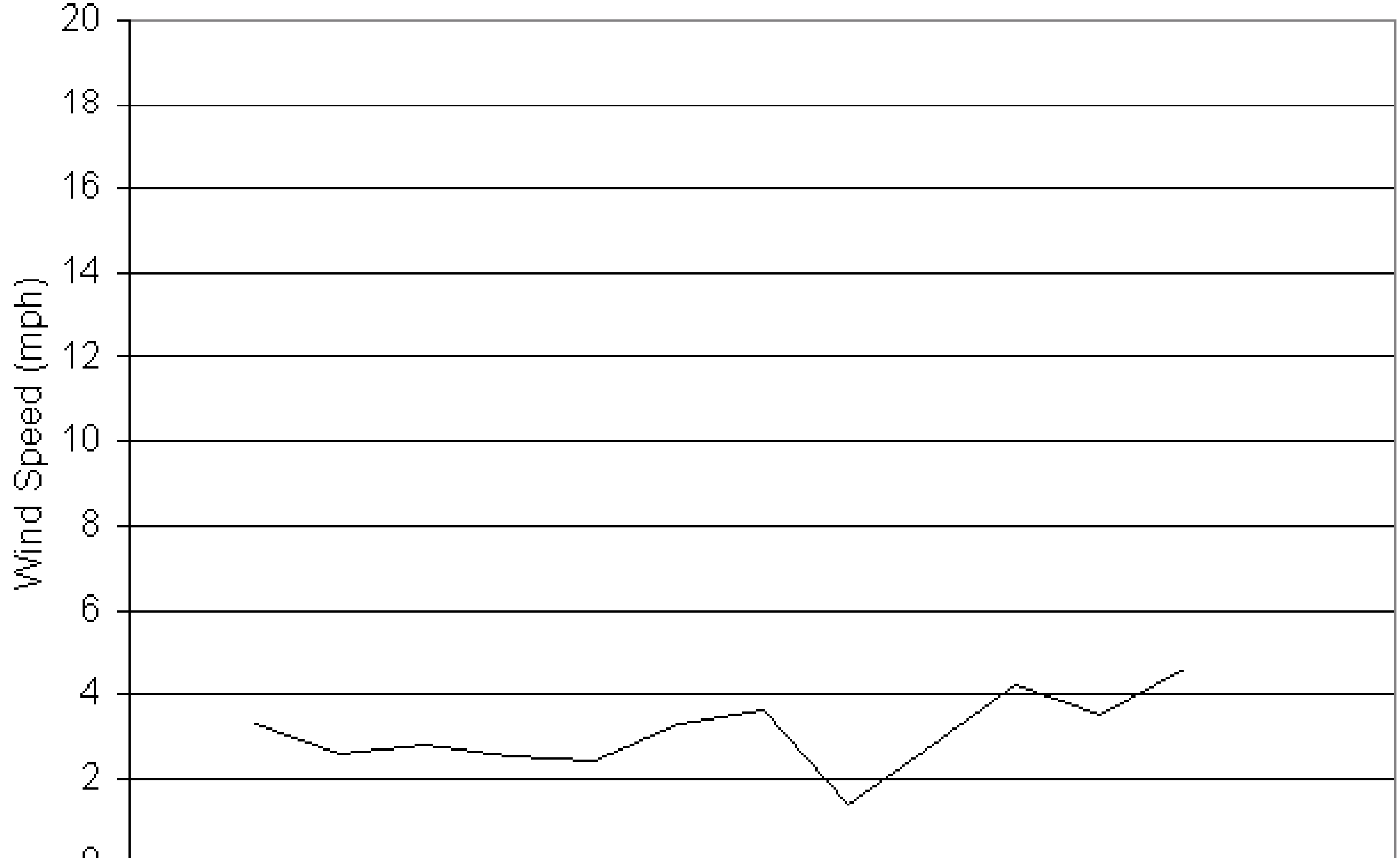
Dayton WA - "Thunder Bowl Site" 06/08/02



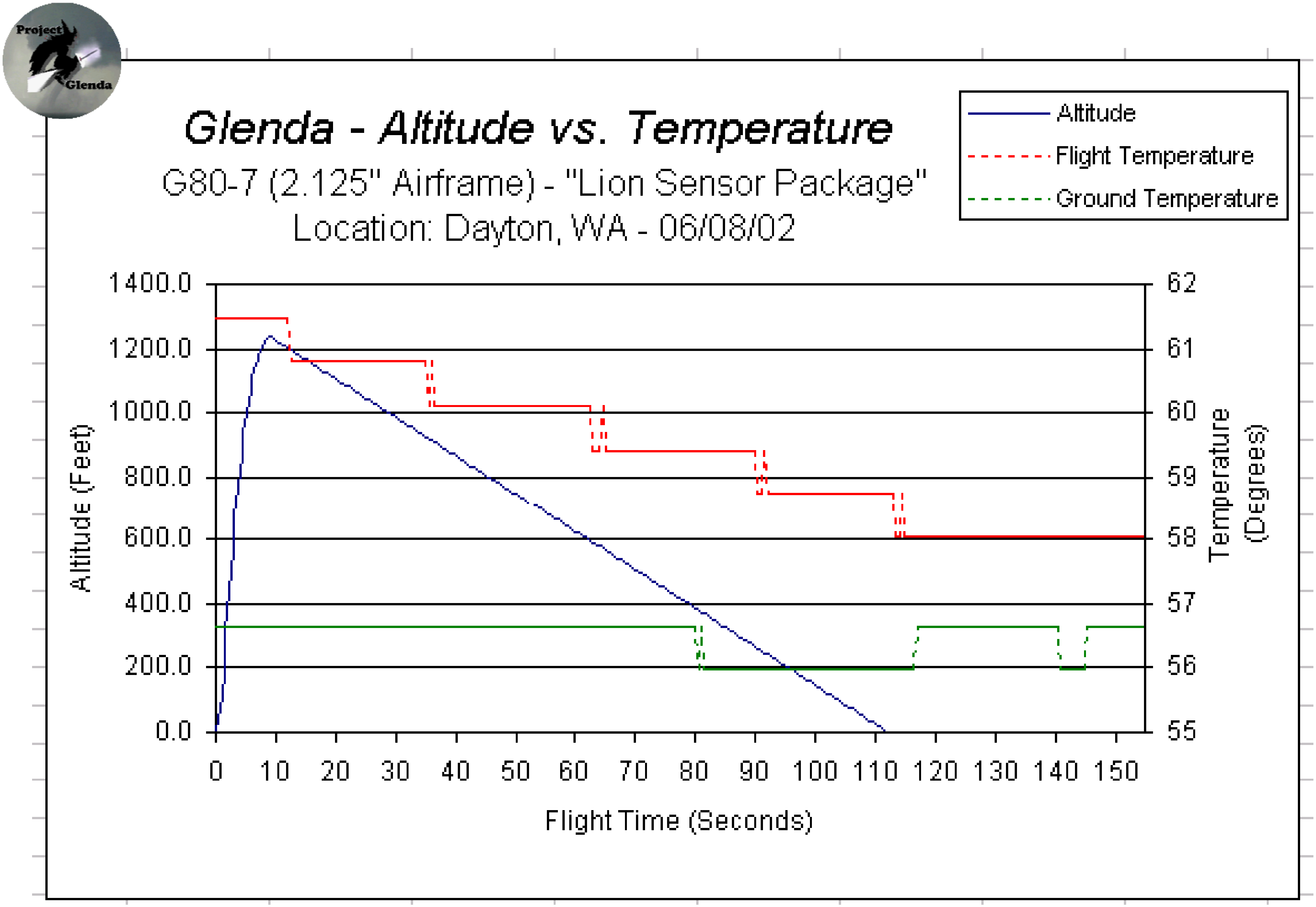
	0900	0930	1000	1030	1100	1130	1200	1230	1300	1330	1400	1430	1500	1530	1600
Site Baro Pressure	27.58	27.58	27.58	27.58	27.58	27.58	27.58	27.58	27.58	27.58	27.58	27.58	27.58	27.58	27.58
Recorded Pressure		27.96	27.96	27.96	27.94	27.94	27.94	27.91	27.91	27.91	27.91	27.94	27.94		

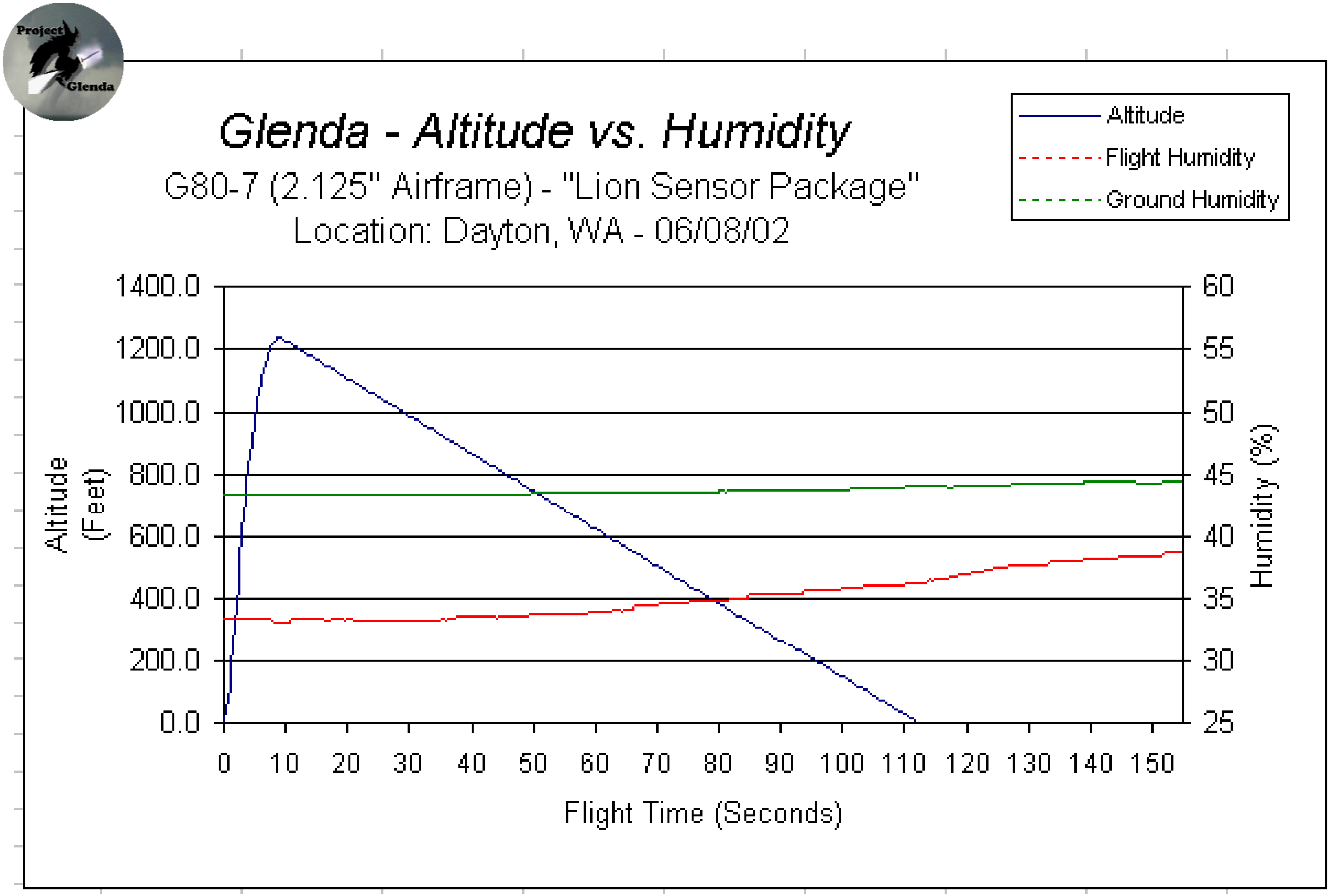
Site Analysis - Wind Speed

Dayton WA - "Thunder Bowl Site" - 06/08/02



	0900	0930	1000	1030	1100	1130	1200	1230	1300	1330	1400	1430	1500	1530	1600
Site Wind Speed		3.3	2.6	2.8	2.5	2.4	3.3	3.6	1.4	2.8	4.2	3.5	4.6		


Glenda - Altitude vs. Temperature
G80-7 (2.125" Airframe) - "Lion Sensor Package"
Location: Dayton, WA - 06/08/02
Altitude
Flight Temperature
Ground Temperature
1400.0
1200.0
1000.0
800.0
600.0
400.0
200.0
0.0
Altitude (Feet)
62
61
60
59
58
57
56
55
Temperature (Degrees)
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150
Flight Time (Seconds)


Project Glenda
Glenda - Altitude vs. Humidity
G80-7 (2.125" Airframe) - "Lion Sensor Package"
Location: Dayton, WA - 06/08/02
Altitude
Flight Humidity
Ground Humidity
Altitude (Feet)
Humidity (%)
Flight Time (Seconds)
1400.0
1200.0
1000.0
800.0
600.0
400.0
200.0
0.0
60
55
50
45
40
35
30
25
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150

September 20th, 2002 Dayton Washington Tests

- Launch of the Glenda 54mm in full flight configuration consisting of dual Temperature/Relative Humidity dataloggers, and the “Fergiesonde” tracking transmitter. The purpose of the flight was to determine any potential discrepancies between the sensors of the two dataloggers. Discrepancies were found to exist and a second flight will be necessary to confirm. The tracking transmitter functioned flawlessly.

- Third flight of the Glenda 98mm with radiosonde payload having full data stream capture. Twenty five seconds of usable data was captured. Data is presently under analysis.

September 20th, 2002 Dayton Washington Tests

- Successful deployment of the Glenda 54mm booster recovery system continues to be a problem. The capsule recovery system performs perfectly. However, the booster mass is over stressing the decelerating shock cord to the point of failure. On this months flight of the Glenda 98mm booster, a dual recovery system was used with a separate recovery system for the booster and a second recovery system for the capsule. Both capsule and booster were undamaged. On the next flight of the Glenda 54mm booster, a dual recovery system will be used.

October 11th, 2002 Dayton Washington Tests

- Second flight of the Glenda 54mm in the triple payload launch configuration consisting of two Temperature/Relative Humidity Dataloggers, and “Fergiesonde” tracking transmitter.

- Both dataloggers were inspected prior to launch and their batteries cushioned against vibration. Post flight, the data was compared between the two dataloggers and no discrepancies were found. The datalogger batteries will now be cushioned on all future flights.

October 11th, 2002 Dayton Washington Tests

- The recovery system on the Glenda 54mm booster failed again. Even in dual system mode, the stresses on the deceleration cord were to excessive for the material. A series of materials tests will be needed prior to the next round of flights. The booster was damaged beyond repair, and a replacement will need to be constructed. Due to the modular nature of the Glenda design, the only major component requiring replacement is the plastic airframe. The fin assembly is undamaged, and will be re-used.

Project Glenda – Next Steps

March 8th, 2003 Dayton Washington Tests

- Launch of the Glenda 54mm in full flight configuration consisting of the Temperature/Relative Humidity Datalogger, Barometric Pressure Datalogger and “Fergiesonde” tracking transmitter.

- Fourth flight of the Glenda 98mm with radiosonde payload having full data stream capture.

- Initiate field testing of enhanced receiver and Yagi antenna for payload tracking system.

- Flight testing of the new Glenda 54mm booster recovery system.

June 14th, 2003 Dayton Washington Tests

- Launch of the Glenda 54mm booster with color video and audio transmission broadcast to a ground station for digital and tape recording.

- Second flight flight of the of the Glenda 54mm in full flight configuration of the Temperature/Relative Humidity Datalogger, Barometric Pressure Datalogger and “Fergiesonde” tracking transmitter.

- Continue field testing of enhanced receiver and Yagi antenna for payload tracking system and expansion of the flight envelope.

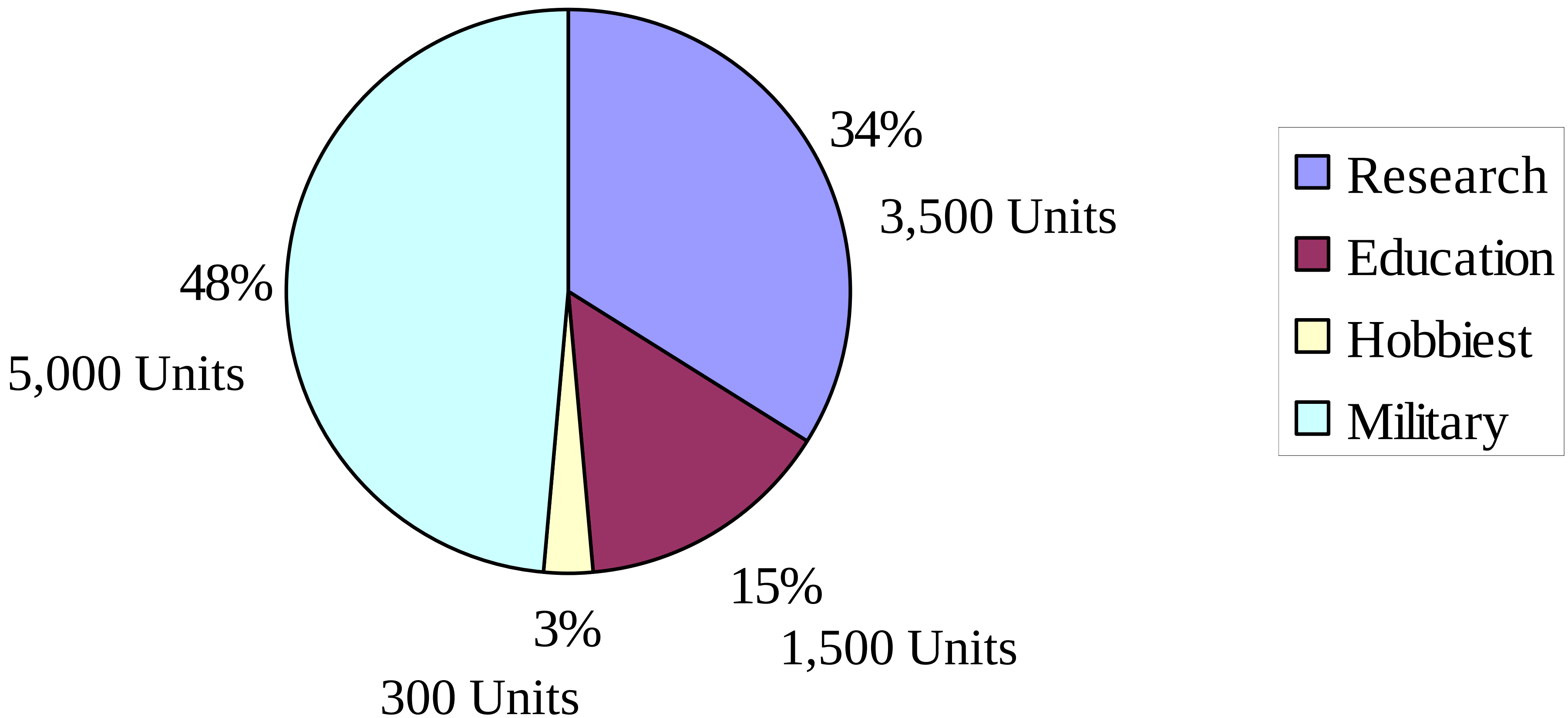
Project Glenda - Advantages

- Portability and Rapid Deployment with "Launch on the Run" capability
- Ease of Use of propellant and vehicle/payload preparation
- Radiosonde compatible with existing weather data collection systems
- Datalogger payload adaptable for external sensors to match user specific applications
- Composite components designed for extreme environments
- On-board locater transmitter allows for rapid recovery
- Off-the-shelf components reduce operating costs and ease repair

Project Glenda - Disadvantages

- Training required for system use, data collection and analysis
- Composite materials not bio-degradable
- Rocket motors are "Hazardous Materials" and are classified as Flammable Solids 4.1, or 1.4c and 1.3c Explosives
- Multiple sensors required to support complex analysis
- Radiosonde requires ground station for data reduction and analysis
- Dataloggers difficult to recover in marine environments

Project Glenda – Projected Market



Project Glenda – Acknowledgements

Team Glenda would like to acknowledge that this project would not be possible without the support of the Blue Mountain Rocketeers, and their Senior Advisor Tim Quigg for allowing us the use of their rocket test range.

Team Glenda would also like to acknowledge our spouses Judy Porter and Jan Pullman for allowing crazy engineers to be part of their lives.

Lastly, Team Glenda would like to acknowledge Matt and Keri Beland for providing sanity checks, photos, food and shelter during our test flights.
You all helped make it possible and put up with our insanities.

Stitch – The Team Glenda Mascot

Glenda Project – Executive Summary - 2004

Glenda Project – Purpose

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The Glenda Project is mix of adaptable ground stations combined with a reusable sounding rocket delivery system designed to place instrument packages into areas previously considered to be to hazardous or inaccessible using traditional platforms such as balloons, aircraft, helicopters, kites, etc.

Glenda Project – Data Capabilities

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Glenda payloads are designed to be launched into thunderstorms, tornados, and other volatile weather environments and to return intact with its collected data.

Glenda Project – Data Collection Methods

Glenda has three methods of collecting data:

- Active Flight Data Collection Systems - Transmitters
- Passive Flight Data Collection Systems – Dataloggers
- Ground Stations

Glenda Project – Typical Flight Vehicles

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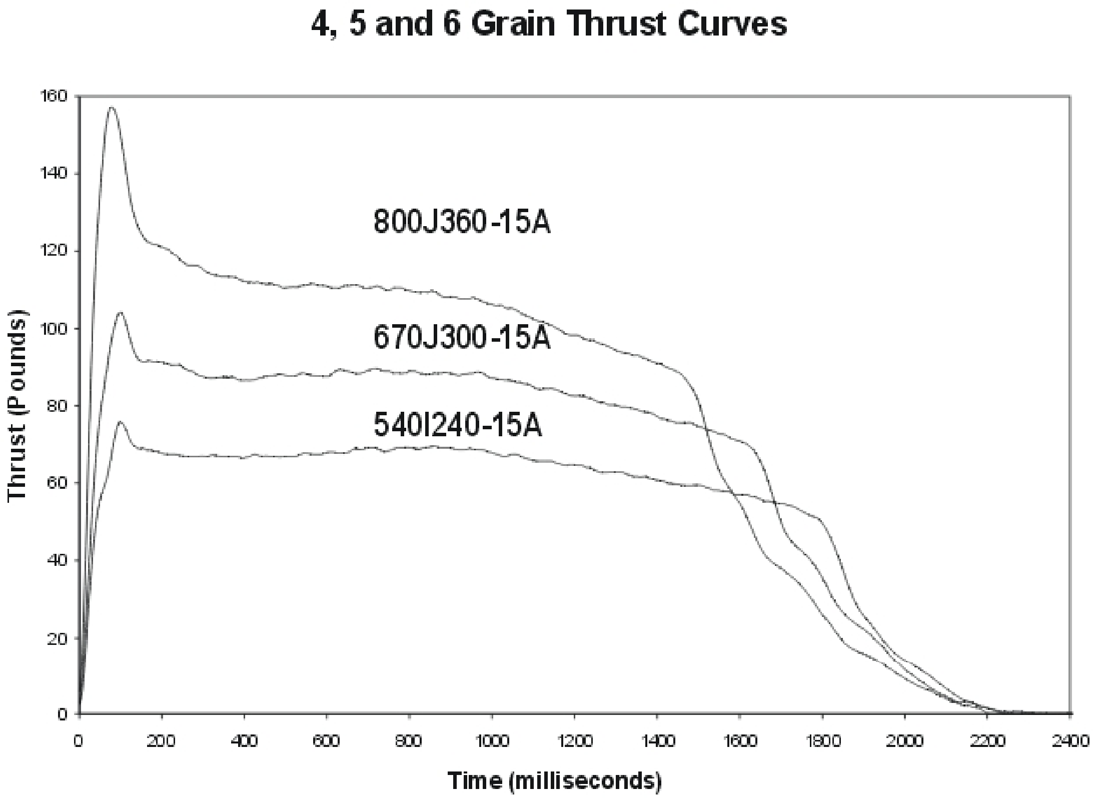
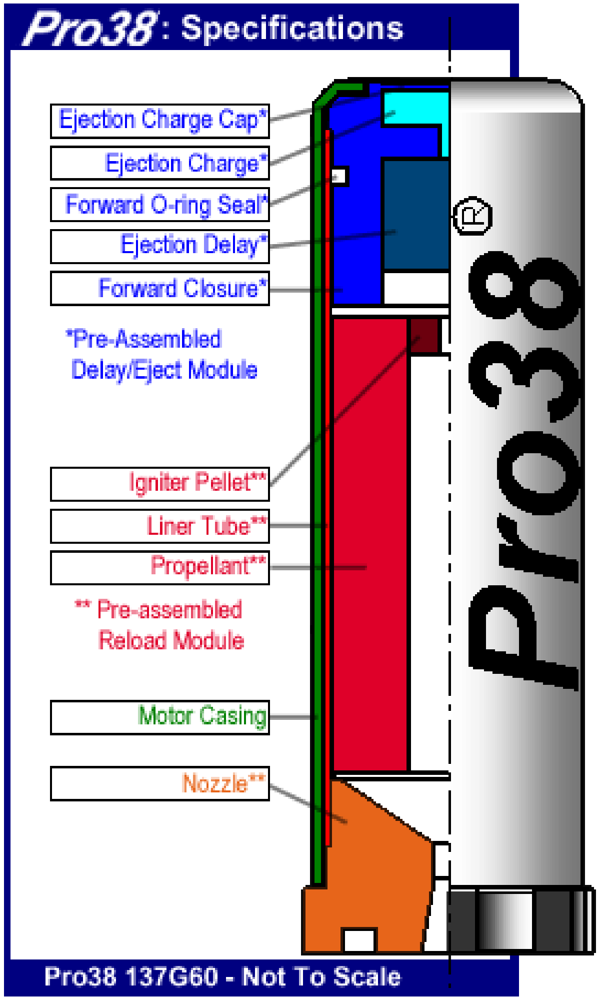
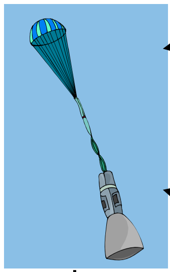


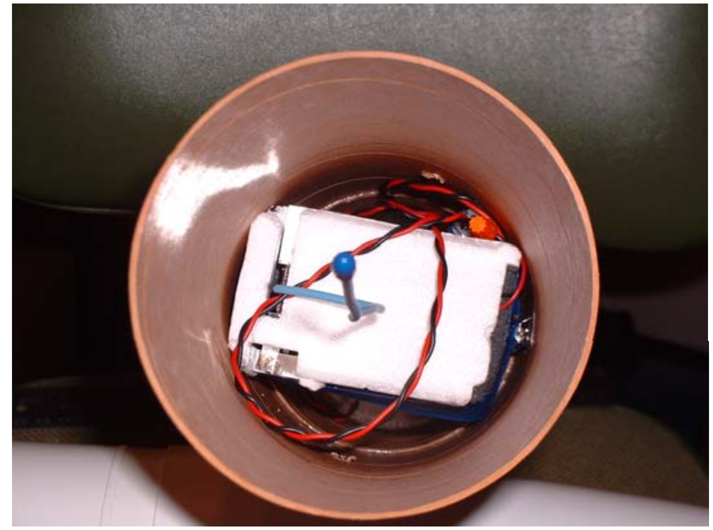


Glenda Project – Active Payloads - Transmitters

Signal Processing Flow Diagram

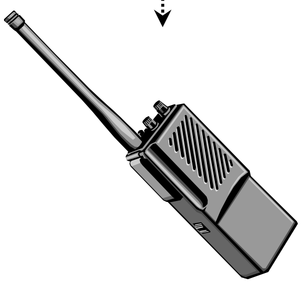


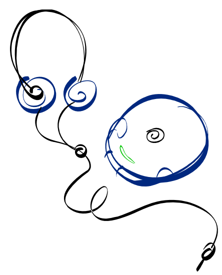
- Barometric Pressure Sensor Data
- Temperature Sensor Data
- Relative Humidity Sensor Data



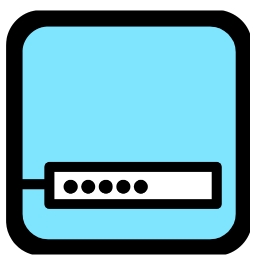
Active Payload cushioned within the flight capsule

Sensor Data Transmitted to Ground Receiver





Data Digitally Recorded



Received Data Decoded

Decoded Data recorded onto Laptop for analysis

Glenda Project – Active Payloads

Ground Station

Digital Recorder

Receiver

Decoder Box

Laptop

Not Shown:

a) Receiver Antenna System

b) Laptop External Power Supply

Flight Vehicle

Payload Capsule

Length: 63”
Diameter: 4”
Dry Weight: 3.5 Pounds
Attainable Altitudes: 2,000 feet to 40,000 feet

Glenda Project - Passive Payloads – Dataloggers

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Glenda Project – Passive Payloads – Dataloggers

Glenda 54mm Capsule in Flight Configuration

Tracking System Antenna

Sensor Port

Here is a typical Glenda payload ready for flight. This capsule contains a tracking locator transmitter, a combination temperature/relative humidity datalogger, and a barometric pressure datalogger. Total payload weight including capsule is less than one pound.

Glenda Project – Ground Station

Digital Chart Recorders

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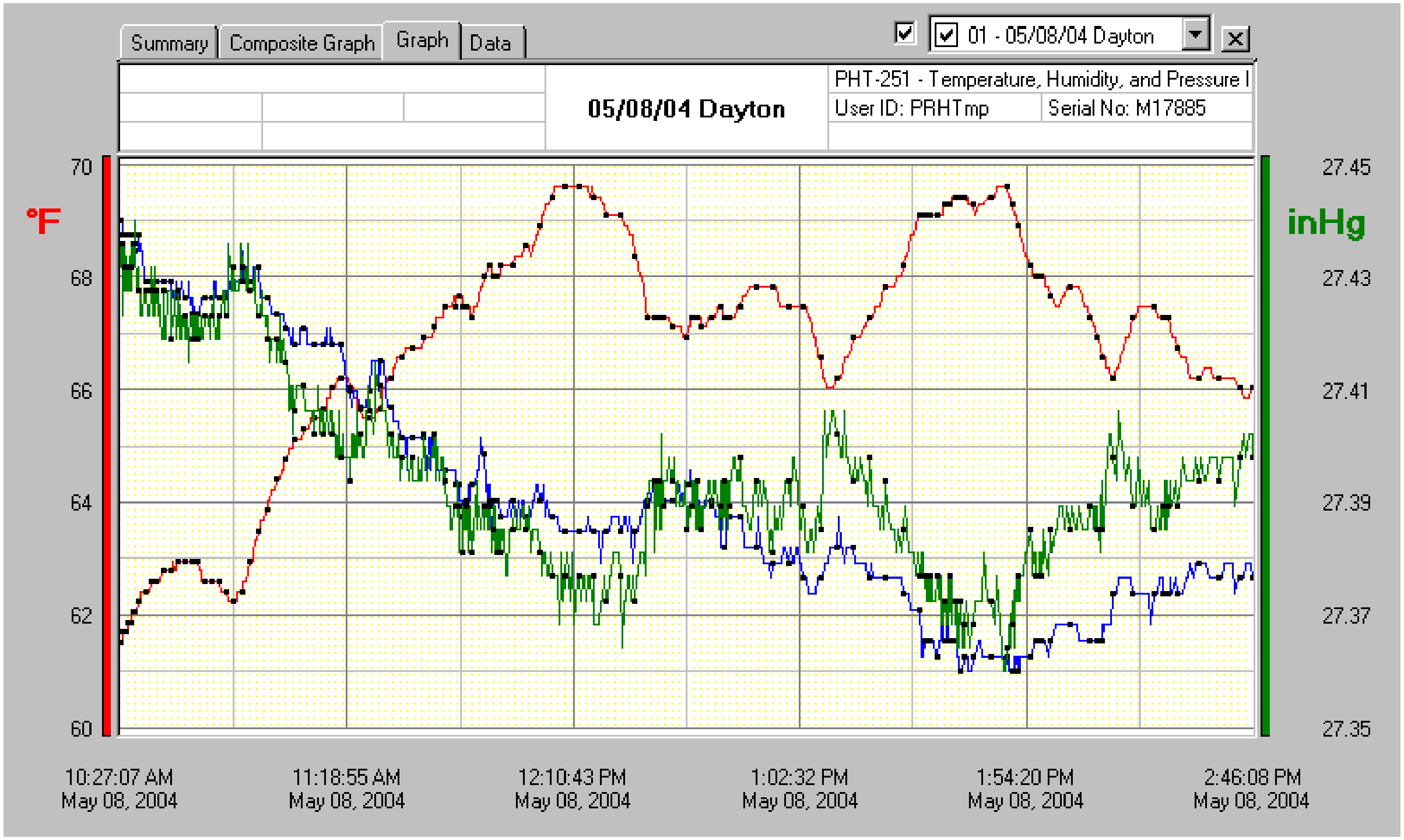
The example below is a digital chart record of temperature, humidity, and barometric pressure at a test site.



Glenda Project – AN/TMQ-34 Ground Station

In March 2005, the Glenda Project obtained a military ground weather station. This acquisition further enhances the projects ground condition data collection capabilities.

Sensor Module

Computer Module

The TMQ–34 is a military self contained portable weather measuring system that is powered by a rechargeable Ni CAD battery.

The TMQ–34 alphanumerically displays wind speed and direction, peak wind, temperature, dew point, barometric pressure, 3-hour pressure change, and the minimum and maximum temperature.

The entire TMQ–34, including the system case, weighs about 20 pounds. The set contains a computer module with a pressure sensor, and the main sensor module with a red sensor for temperature, a white sensor for humidity, a wind direction compass, and an anemometer to measure wind speed.

The TMQ–34 can operate in temperatures ranging from a low of –59.5°F to 132°F. The TMQ–34 is intended for use in a tactical environment with an operating range of 100 feet below sea level to 10,000 feet above sea level.

Glenda Project – Typical Missions

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April 9, 2005 Columbia County / Dayton, Washington

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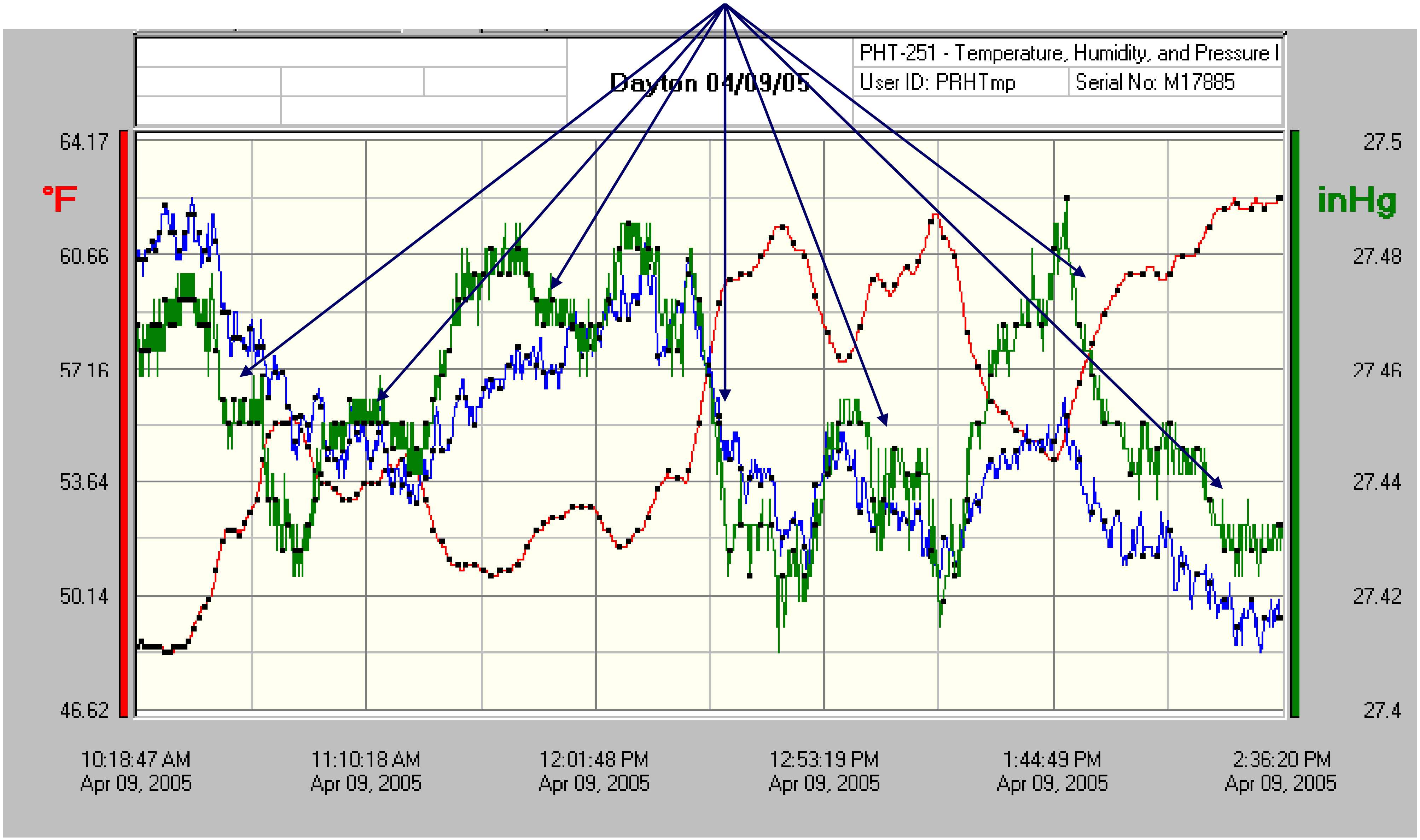
The system performed flawlessly throughout the day and detected the passage of local storm cells and weather fronts as they passed through the area.

The primary focus of the ground station mission is to provide an early warning mechanism to local officials and citizens of approaching hazardous weather systems.

Without viable ground condition data, it is difficult to determine the level of changes in temperature, barometric pressure, and humidity at altitude.

April 9th, 2005 – Dayton, WA - Ground Station Mission

Barometric Pressure Drops which serve as weather system pre-cursor signals



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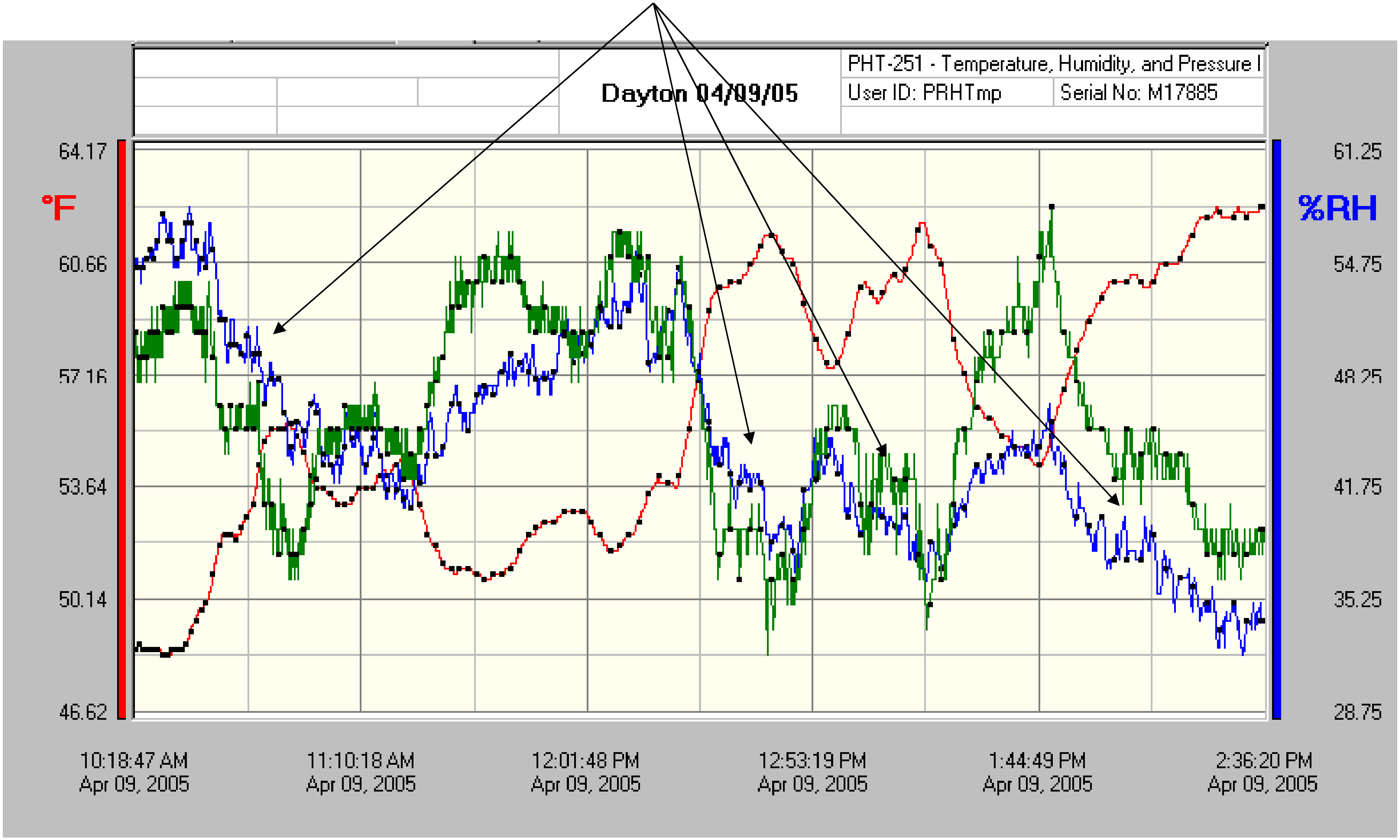
While the Barometric Pressure targets local cells, RH data gives us "Frontal" trends



Sensors detected seven cells based on four local fronts

Glenda Project – Thermal Mapping Mission

September 25, 2004 Columbia County / Dayton, Washington

During September 2004, Glenda performed a thermal mapping mission using the chart recording ground station, and both active and passive payloads.

The purpose of these two flights was to confirm, or refute the existence of a region of thermal activity over a local site called “Lone Tree”.

The first rocket sounding employed the Glenda 98mm booster lofting an active transmitting payload broadcasting temperature, relative humidity and barometric pressure data to the ground station.

The second sounding flight was made using the Glenda 54mm booster carrying a passive payload recording temperature and relative humidity.

Glenda Project – Thermal Mapping Mission

September 25, 2004 Columbia County / Dayton, Washington

At the time of the Glenda flights, the ground temperature was around 80 degrees, with a Relative Humidity around 37-38%. Under the standard atmospheric model, temperature goes down, as does humidity as you increase in altitude.

At the launch site, this was not the case.

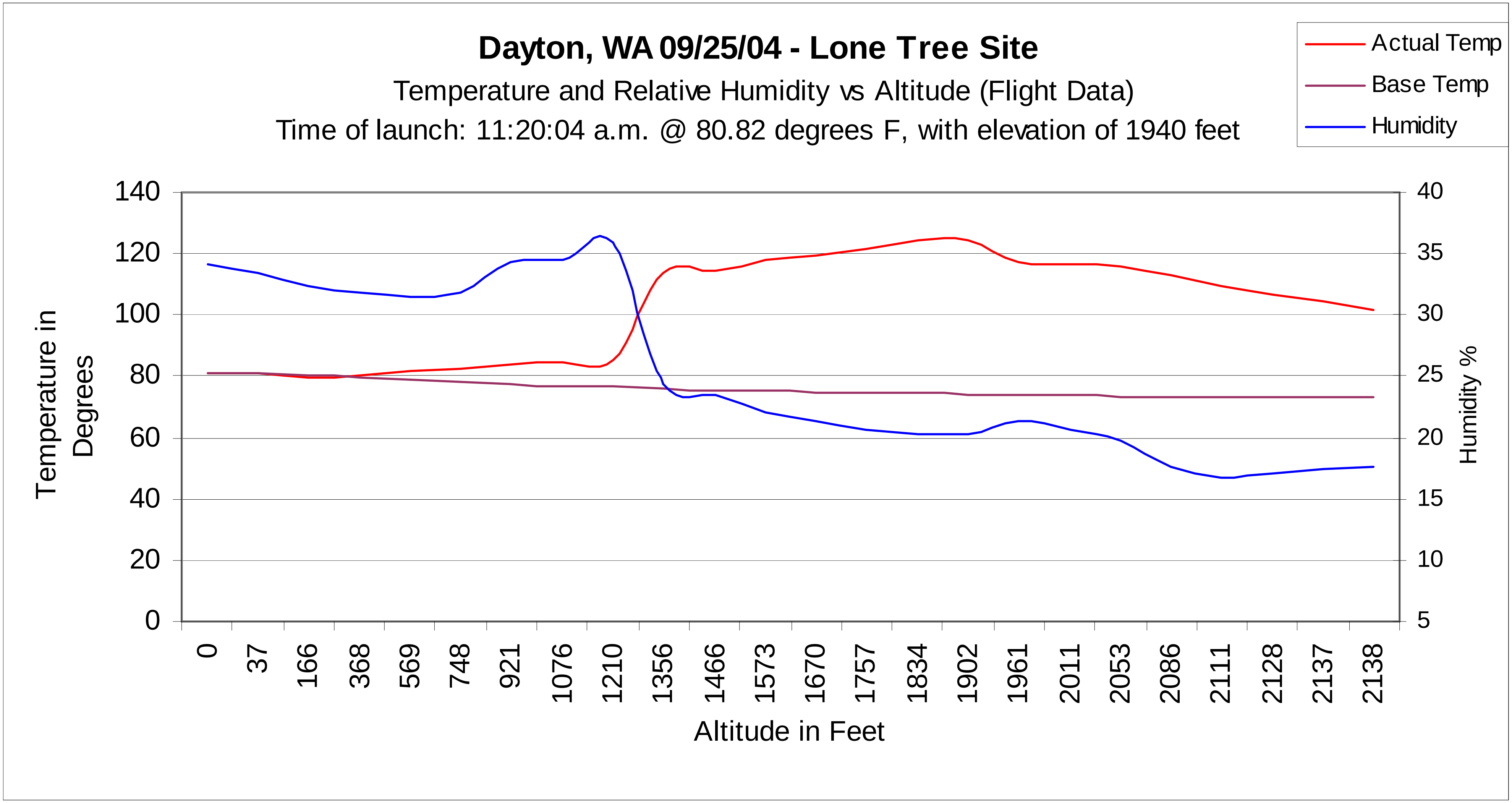
Temperature and humidity stayed relatively constant until 1,300 – 1,400 feet. Then things got interesting. The temperature rose rapidly, and the humidity level dropped. The sensors detected a 500 foot layer of hot, dry air which topped over 124 degrees at 11:00 in the morning. That's a 40+ degree difference from ground conditions. As the sensors penetrated the layer, more "normal" readings were detected.

The data between the two flights supported one another and have provided a body of evidence proving the existence of a thermal layer above the launch site.

The mapping mission was a success and the results are shown on the following slide.

Glenda Project – Thermal Mapping Mission

September 25, 2004 Columbia County / Dayton, Washington



Glenda Project – Next Mission

Expanding the Flight Envelope – “Wall Cloud”

Glenda Project – Next Mission

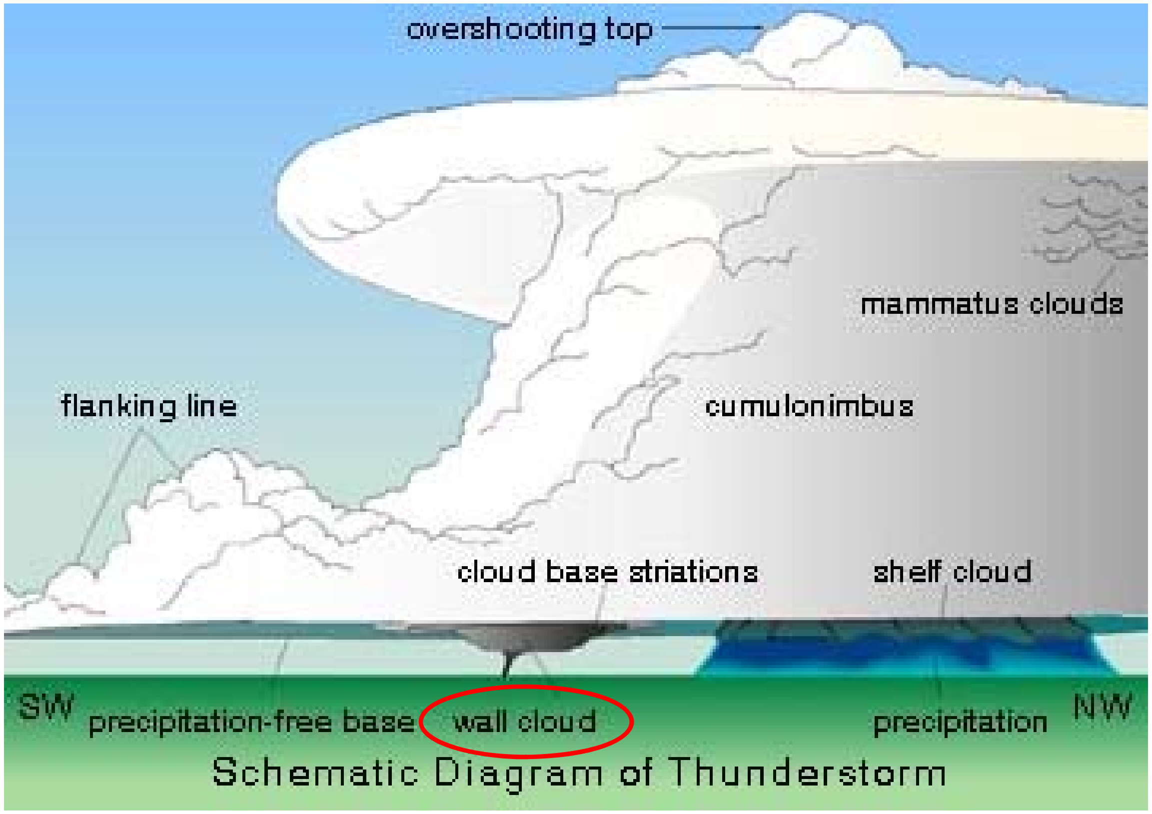
Over the past eight years, the primary goal of the Glenda Project has been to develop payloads capable of collecting data from within thunderstorms, tornados, and other hazardous environments.

With the success of the recent flights, the development phase of the project is now complete.

The next step for Glenda is to initiate the launch of a viable payload into a thunderstorm. Our primary target will be a “Wall Cloud”. Wall Clouds are precursor cloud formations which serve as the breeding ground for tornados.

The base of the Wall Cloud is easily within Glenda range and we can loft a payload deep within the cloud to gather critical data and provide early warning data on possible tornado formation.

Glenda Project – Next Mission



The “Wall Cloud” is only a small portion of a typical thunderstorm. As the Glenda Project matures, More advanced sensors will be deployed to higher altitudes and even more extreme environments.

Glenda is proving itself to be more than capable of collecting data, and returning safely.

Glenda Project – Next Missions

The Glenda Project has additional sensors and ground stations under development which will soon be operational:

- Radiological Detection Systems
- Magnetometer Mapping and EM Detection
- Lightning Detection and Early Warning Systems
- GPS integration to generate payload wind speed and directional data

Glenda Project - Advantages

- Portability and Rapid Deployment with “Launch on the Run” capability
- Ease of Use of propellant and vehicle/payload preparation
- Payload adaptable for external sensors to match user specific applications
- Composite components designed for extreme environments
- On-board locater transmitter allows for rapid recovery
- Off-the-shelf components reduce operating costs and ease repair

Glenda Project - Disadvantages

- Training required for system use, data collection and analysis
- Composite materials not bio-degradable
- Rocket motors are “Hazardous Materials” and are classified as Flammable Solids 4.1, or 1.4c and 1.3c Explosives
- Multiple sensors required to support complex analysis
- Active Payloads require ground stations for data reduction and analysis

In Conclusion

The Glenda Project is a reusable sounding rocket delivery system designed to place instrument packages into areas previously considered to be to hazardous or inaccessible using traditional platforms such as balloons, aircraft, helicopters, kites, etc.

During 2004 and 2005, Glenda completed its first successful mapping missions and is well under way to further extend its flight envelope to even more hazardous environments.

The next series of launches will allow the project to continue to mature, and return even more valuable data.

Our next project milestone is obtaining “Wall Cloud” data and Glenda is up to the task.

Glenda Project – Executive Summary - 2006

Glenda Project – Purpose

The primary mission of the Glenda Project is to provide the capability to rapidly gather previously inaccessible localized microclimate data from altitudes ranging from ground level to 40,000 feet and to return this data for immediate use.

The Glenda Project is mix of adaptable ground stations combined with a reusable sounding rocket delivery system designed to place instrument packages into areas previously considered to be to hazardous or inaccessible using traditional platforms such as balloons, aircraft, helicopters, kites, etc.

Glenda Project – Data Capabilities

The Glenda Project has the capability to collect temperature, humidity, barometric pressure, wind speed and other types of environmental data from ground level to 40,000 feet.

Glenda payloads are designed to be launched into thunderstorms, tornados, and other volatile weather environments and to return intact with its collected data.

Glenda Project – Data Collection Methods

Glenda has three methods of collecting data:

- Active Flight Data Collection Systems - Transmitters
- Passive Flight Data Collection Systems – Dataloggers
- Ground Stations

Glenda Project – Typical Flight Vehicles

Glenda 54mm (2.125")

Length: 46"
Diameter: 2.125"
Dry Weight: 1.75 Pounds
Attainable Altitudes: 1,000 feet to 15,000 feet

Glenda 98mm (4")

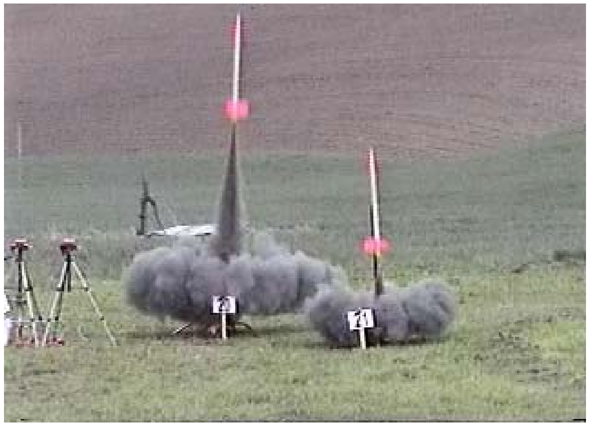
Length: 63"
Diameter: 4"
Dry Weight: 3.5 Pounds
Attainable Altitudes: 2,000 feet to 40,000 feet

Glenda Project – Typical Flight Profile

2 – Boost Phase

3 – Deployment Phase

1 – Launch Phase

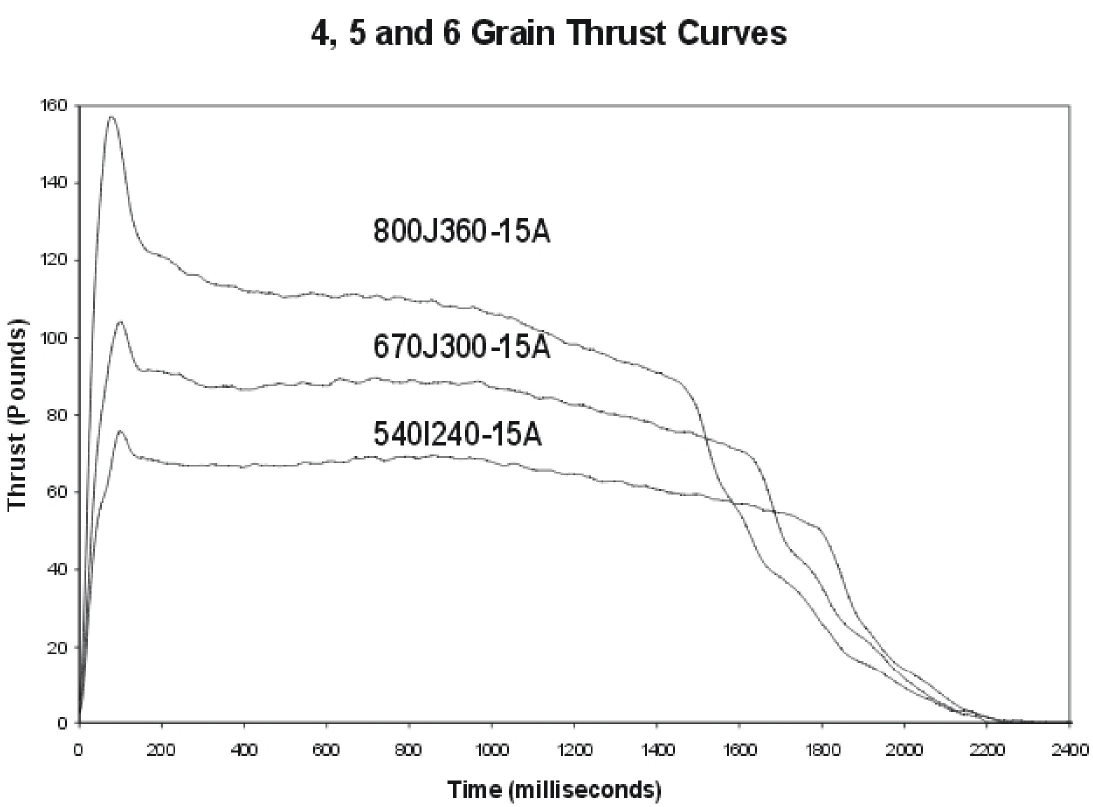


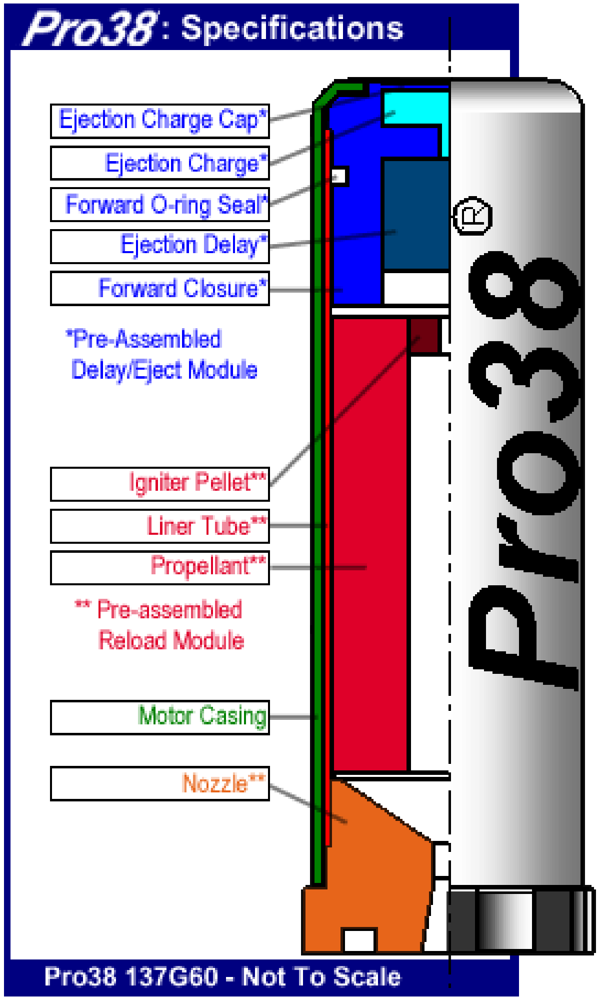
Note: Propulsion is provided by reloadable /reusable rocket motors giving the capability of rapid turnaround between flights.

4 – Recovery Phase

Glenda Project – Propulsion

The Pro38 rocket motor propulsion system is the first commercial thermoplastic propellant-based solid rocket motor and is produced by Cesaroni Technology Inc. of Toronto Canada. The Pro38 is a modular, reloadable solid propellant rocket motor system designed primarily for use in launching small experimental payloads by universities, colleges, research institutes and sport rocketry enthusiasts.



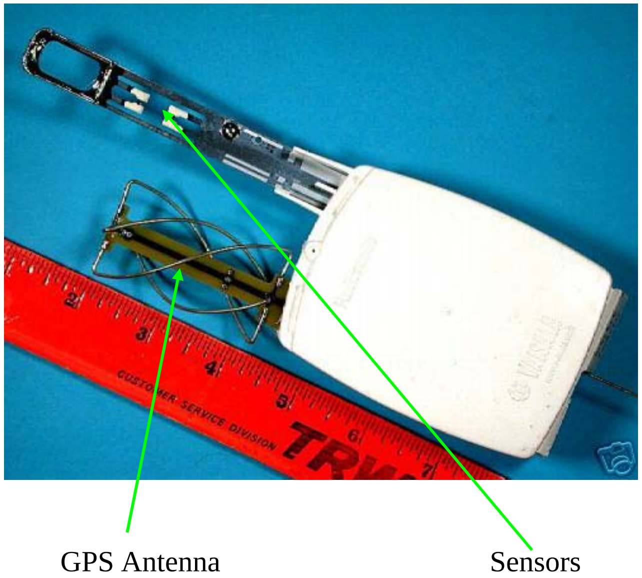


Glenda Project – Active Payloads - Transmitters

Converted Radiosonde Payloads

The Glenda Project uses converted radiosondes that were previously designed for use with weather balloons. The circuitry and sensors function properly under thrust loads of the Glenda boosters and are compatible with NOAA radiosonde receiver systems.

The radiosonde contains instruments capable of making direct measurements of air temperature, humidity and pressure. These observed data are transmitted immediately to the ground station by a radio transmitter located within the instrument package.

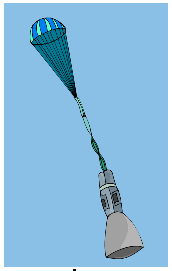


Radiosonde Specifications:

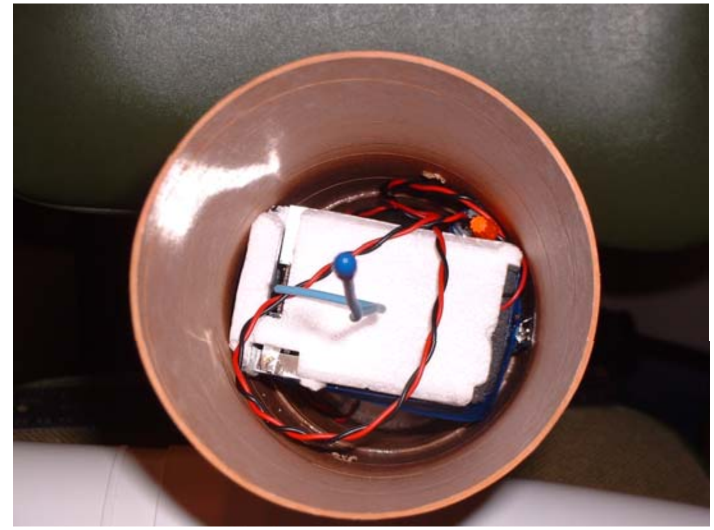
- Pressure range 3mb to 1060mb +/- .1mb
- Operating temperature range of -90°C to +60°C
- Relative Humidity from 0 to 100%
- Sampling Rate of once per second for the sensor suite
- Provides positioning data via GPS for payload location and wind velocity

Glenda Project – Active Payloads - Transmitters

Signal Processing Flow Diagram

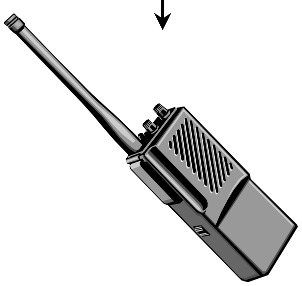


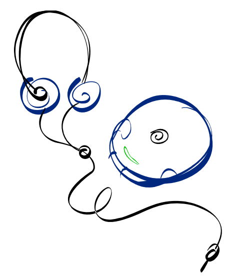
- Barometric Pressure Sensor Data
- Temperature Sensor Data
- Relative Humidity Sensor Data
- GPS - Payload Position Data



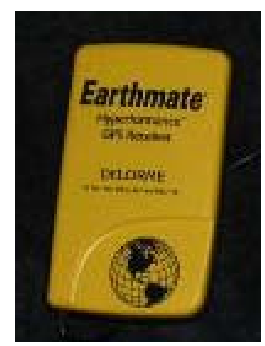
Sensor Data Transmitted to Ground Receiver

Active Payload cushioned within the flight capsule





Sensor Data Digitally Recorded

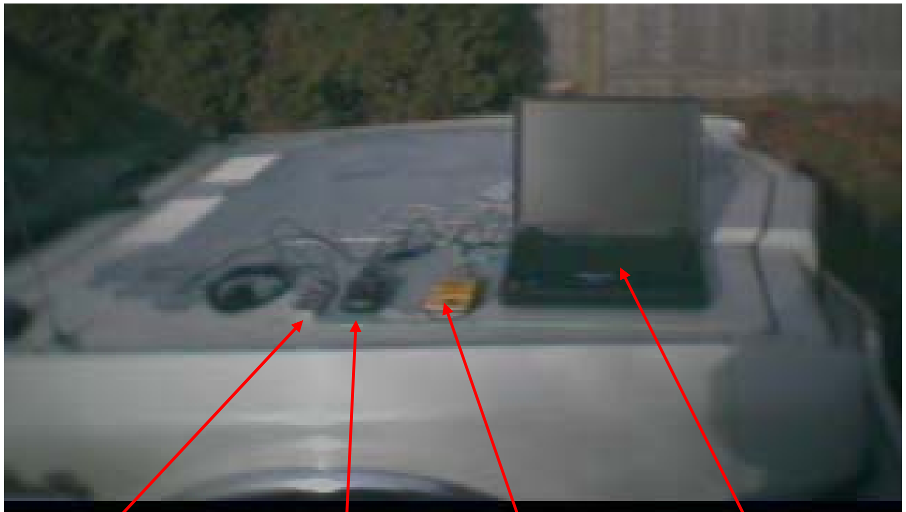


Data recorded into Laptop for analysis

GPS – Ground Station Position Data

Glenda Project – Active Payloads

Ground Station



Digital Recorder

Telemetry Receiver

GPS Receiver

Laptop

Not Shown:

a) Telemetry Receiver Antenna System
b) Laptop External Power Supply

Flight Vehicle

Payload Capsule

Length: 63”
Diameter: 4”
Dry Weight: 3.5 Pounds
Attainable Altitudes: 2,000 feet to 40,000 feet

Glenda Project - Passive Payloads – Dataloggers

A data logger is an electronic instrument that records measurements over time. Typically, data loggers are small, battery-powered devices that are equipped with a microprocessor, data storage and sensors. Most data loggers utilize software on a personal computer to initiate the logger and view the collected data.

Prior to a Glenda launch, the datalogger is connected to a laptop computer. Then, Windows based software is used to select logging parameters (sampling intervals, start time, etc.) and initiate the logger. The logger is then disconnected from the laptop and installed inside the Glenda payload capsule. Upon launch, the logger records each measurement and stores it in memory along with the time and date. Post recovery, the logger is then reconnected to the laptop computer and the software is used again to readout the data and see the measurements as a graph, showing the profile over time. The tabular data can be viewed as well, or exported to a spreadsheet for further manipulation.

Glenda Project – Passive Payloads – Dataloggers

54mm Capsule in Flight Configuration

Tracking System Antenna

Datalogger Sensor Port

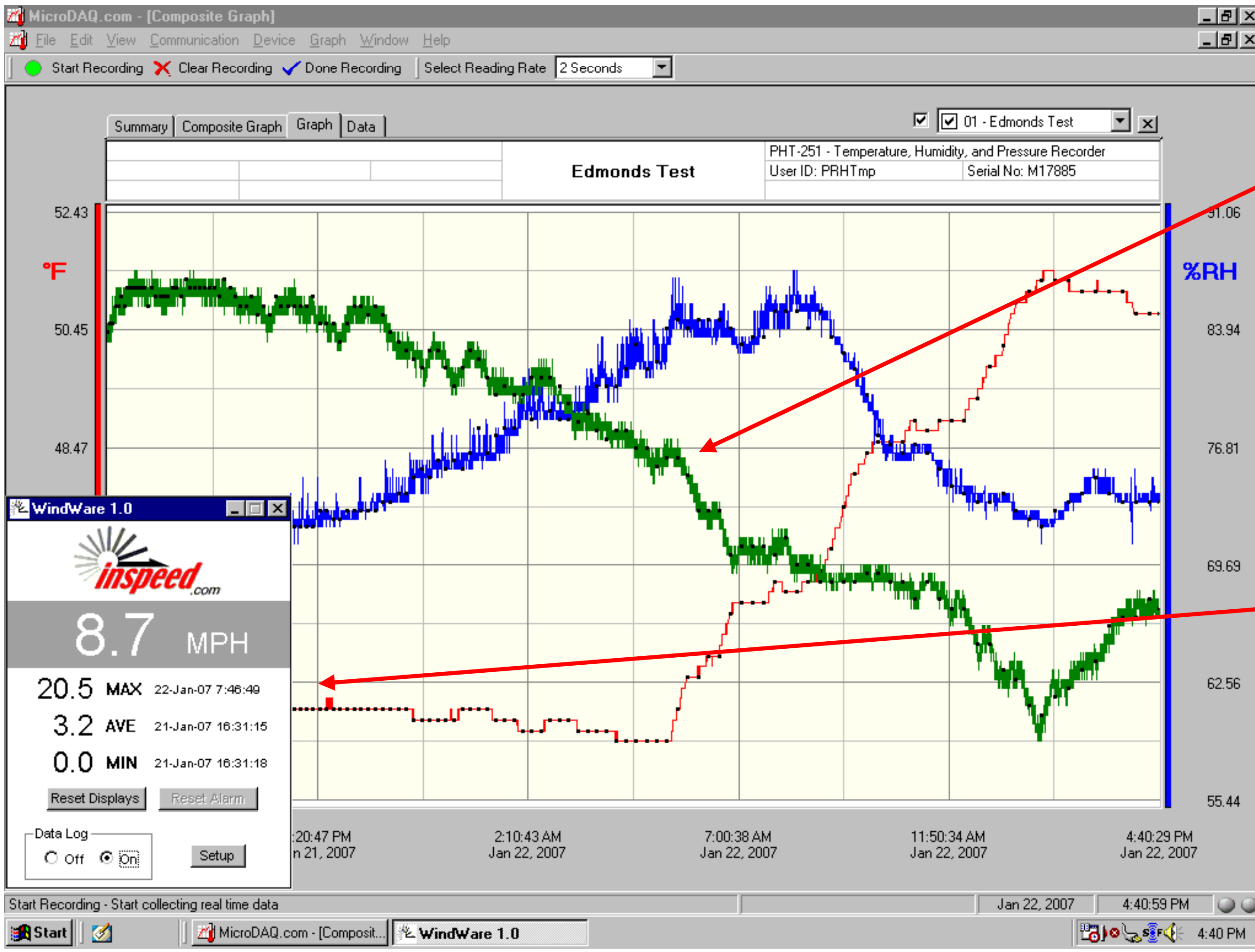
Here is a typical Glenda payload ready for flight. This capsule contains a tracking locator transmitter, a combination temperature/relative humidity datalogger, and a barometric pressure datalogger. Total payload weight including capsule is less than one pound.

Glenda Project – Ground Stations

Digital Chart Recorders

Glenda Project also utilizes sensors combined with ground based laptops to provide a digital based chart record of ground conditions mapped over time.

The example below is a digital chart record of temperature, humidity, barometric pressure and wind speed at a test site.



Pressure, Temperature, & Barometric Pressure data stream using Micro-DAQ software and COM 1 port

Wind Speed data using InSpeed Anemometer and supporting software Using COM 3 port via USB port application adapter

Glenda Project – AN/TMQ-34 Ground Station

In March 2005, the Glenda Project obtained a military ground weather station. This acquisition further enhances the projects ground condition data collection capabilities.

The TMQ–34 is a military self contained portable weather measuring system that is powered by a rechargeable Ni CAD battery.

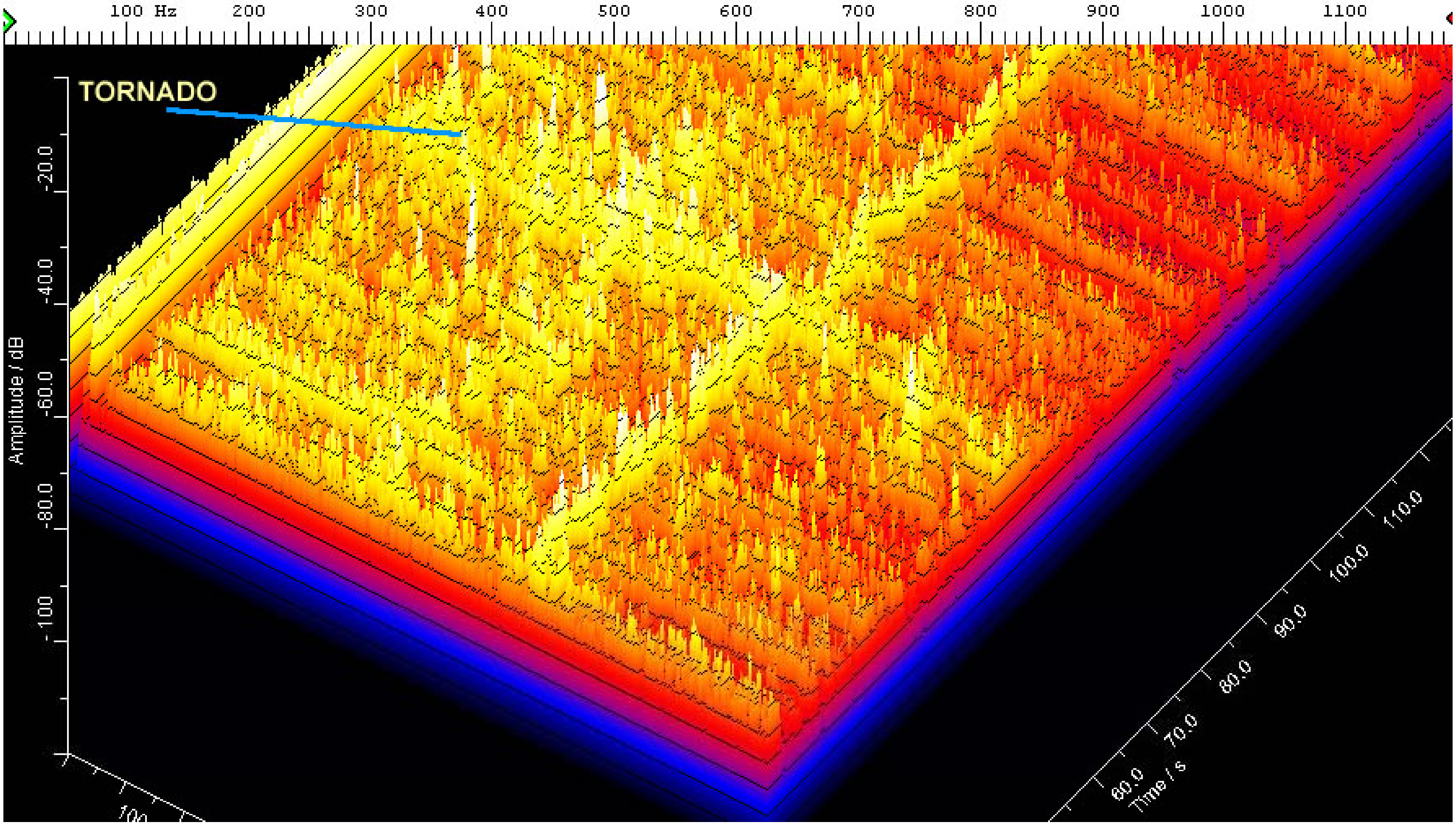
The TMQ–34 alphanumerically displays wind speed and direction, peak wind, temperature, dew point, barometric pressure, 3-hour pressure change, and the minimum and maximum temperature.

The entire TMQ–34, including the system case, weighs about 20 pounds. The set contains a computer module with a pressure sensor, and the main sensor module with a red sensor for temperature, a white sensor for humidity, a wind direction compass, and an anemometer to measure wind speed.

The TMQ–34 can operate in temperatures ranging from a low of –59.5°F to 132°F. The TMQ–34 is intended for use in a tactical environment with an operating range of 100 feet below sea level to 10,000 feet above sea level.

Glenda Project – EMF Spectral Mapping

Combining Glenda computing and sensors allows the capability for advanced analysis and detection. Shown below is a 3D EMF analysis of a tornado based off of a three second data capture. The circular effects of the funnel are easily visible and provide a snap shot of the electrical activity around a tornado.



Glenda Project – Chase Teams

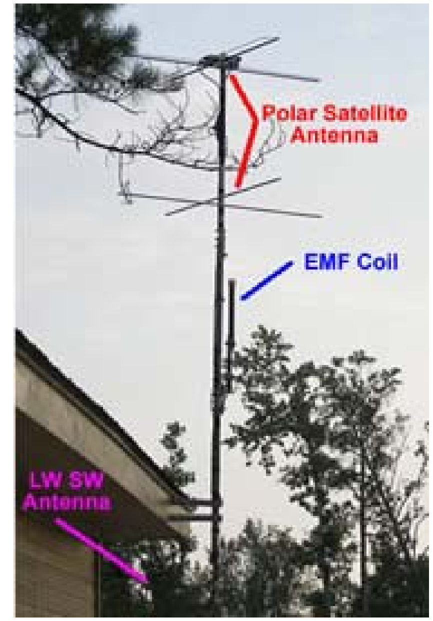
In order to obtain data from dynamic weather phenomena it is necessary to seek out and intercept storms and to launch sensors into the heart of the disturbance, capture the data, and return the data for immediate processing and analysis. Hence the name, Chase Team.

The Chase Teams utilize Jeep Grand Cherokee 4 wheel drive units, equipped with specialized tires and suspension to handle road debris situations and evasive maneuvers while on the go. When storm data is required, the teams immediately equip the jeeps with instrument packages and laptop computers inside the vehicle and attach to the roof, weather instrumentation, satellite dishes, sensors and communication gear. Portable rocket launching stands and weather rockets are loaded into the back of the jeep. Transforming from a standard jeep to a fully operational weather pursuit vehicle takes as little as five minutes.

Glenda Project – Pullman Point Research Facility

The Pullman Point Weather Research Facility is located in Petal, Mississippi, roughly 60 miles north of the Gulf of Mexico.

The Facility houses instrumentation that is a combination of old school analog, as well as, state of the art digital that is exclusive to less than a half dozen operations in the continental United States and the most advanced privately owned instrumentation in Southern Mississippi.



Data is acquired and network backup communication systems are in place with an eight dish satellite antenna array located onsite.

Backed with an onsite super computing cluster and multi mode communication links with the outside world we supply information in live time for the purposes of research and learning. The facility is linked by networks to additional computing clusters in Moses Lake, Washington and server farms in Kelowna, British Columbia, Canada.

Glenda Project – Engineering / Computing

David Davis - Launch Operations Director - Brings decades of experience from engineering work in private industry and United States government in rocket research, and aerospace. Extensive background in electronics, mechanics, communications, computing, and storm chasing. Member of the National Association of Rocketry since 1983, and been involved with hobby related rocketry since the 1960’s.

Robert Pullman - Long Range Sensor Development - Has three decades of experience in communication and the computer industry and his expertise is world renown. His work has enabled governments to formulate policies and legislation in international, national and local forums. He has developed products that are used by universities for seminars, by corporations for internal operations to meet government regulations, by scientists for research work in field and laboratory conditions, by government departments for device operations and maintenance, and by the military for use in battlefield activities.

Glenda Project – Media Communications / Public Relations

As the Glenda Project matured, a definite need became apparent for an individual with media communications skills and public relations.

Tim Quigg brings a unique mix of personal background and professional experience to the Glenda Project. Quigg has over two decades of experience in customer service and media relations. He has been the Assistant Editor of Extreme Rocketry Magazine since 2000, as well as a freelance writer of numerous articles for Sport Rocketry Magazine. He is a current member of the National Association of Rocketry, and is the 2001 recipient of the National Association of Rocketry's President's Award, in recognition of his work with youth in model rocketry on a national level. Quigg is a highly decorated 24-year veteran of law enforcement, and is currently the Senior Communications Officer at a Southeastern Washington State E911 Communications Center.

Glenda Project – Typical Missions

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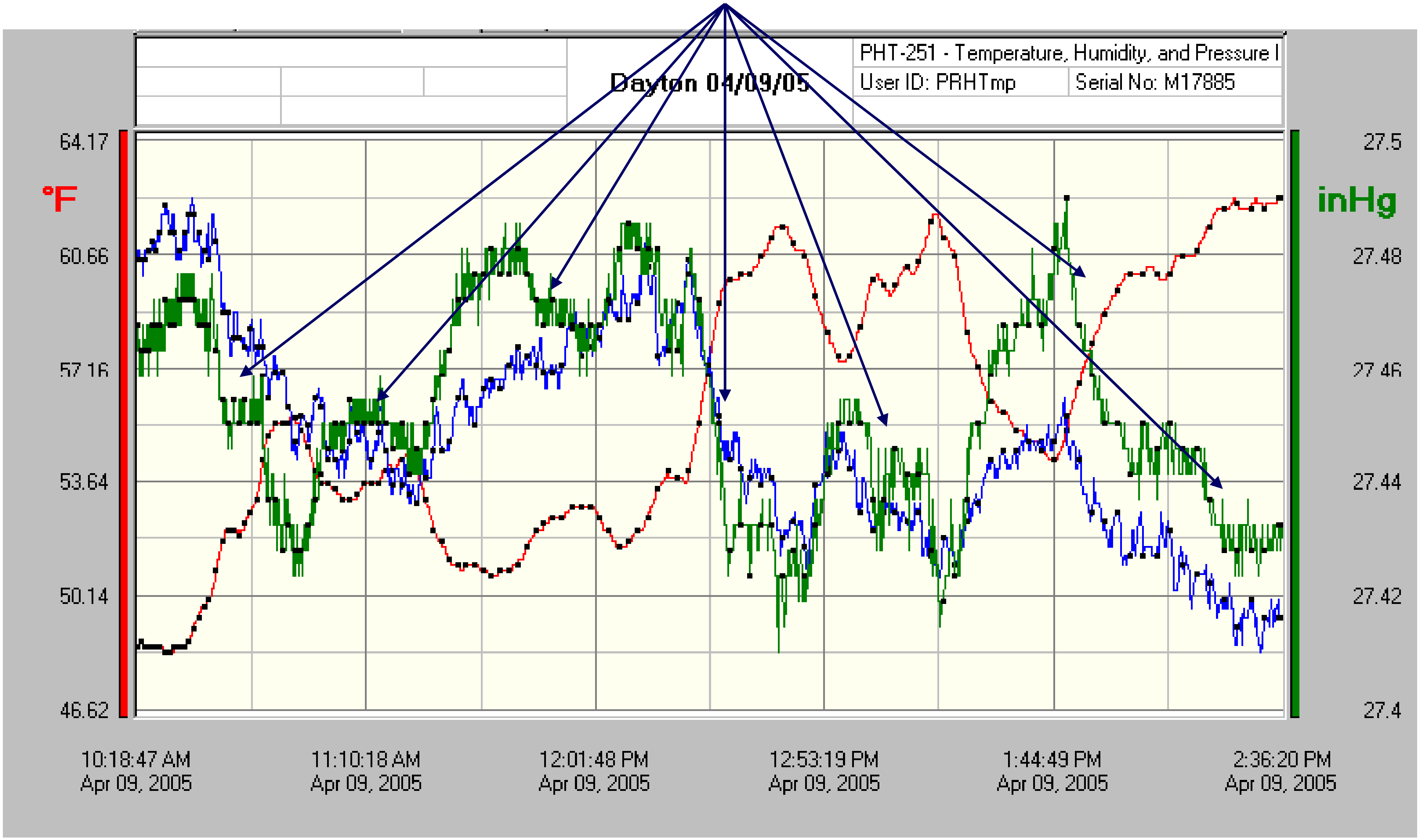

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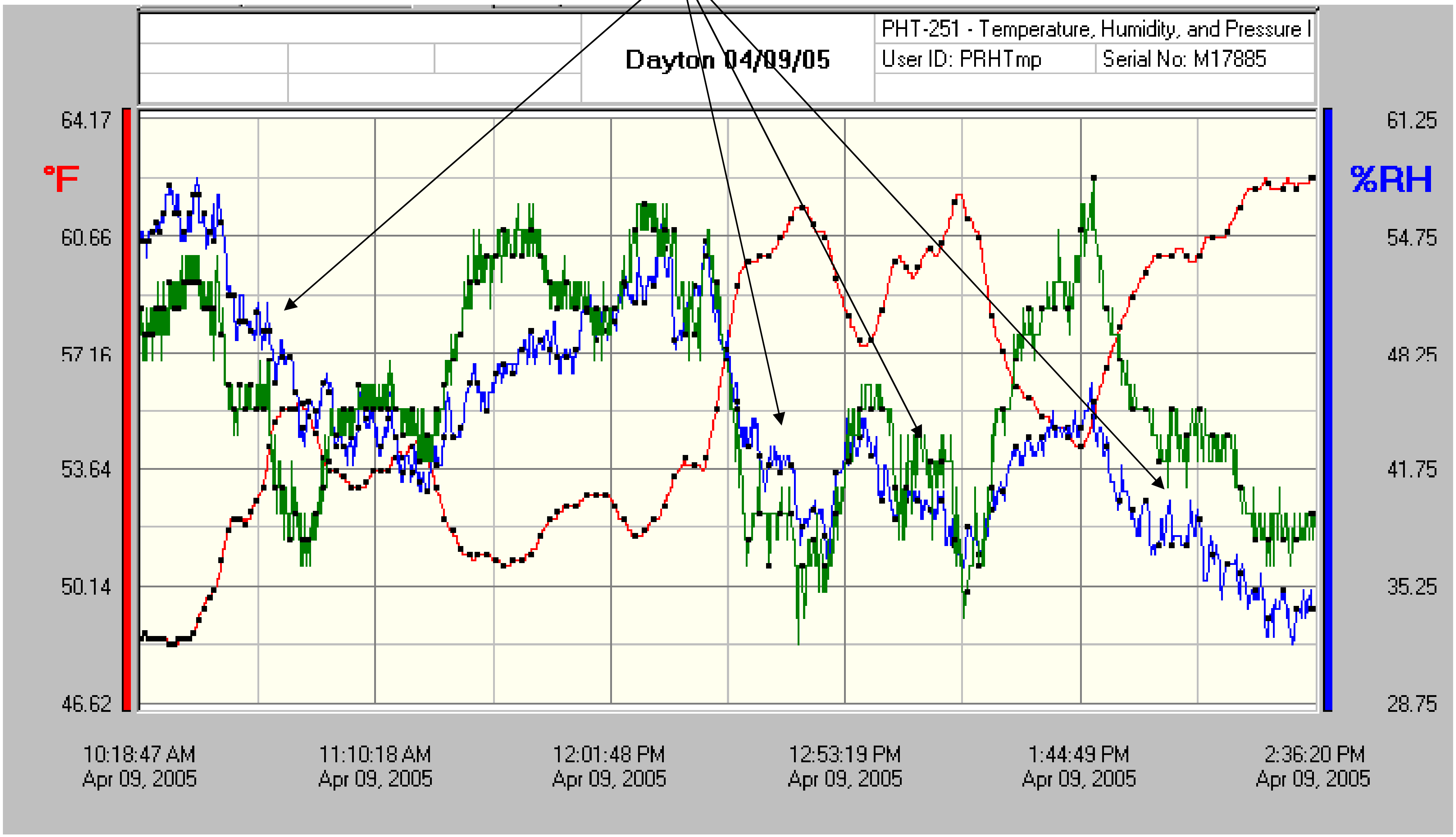

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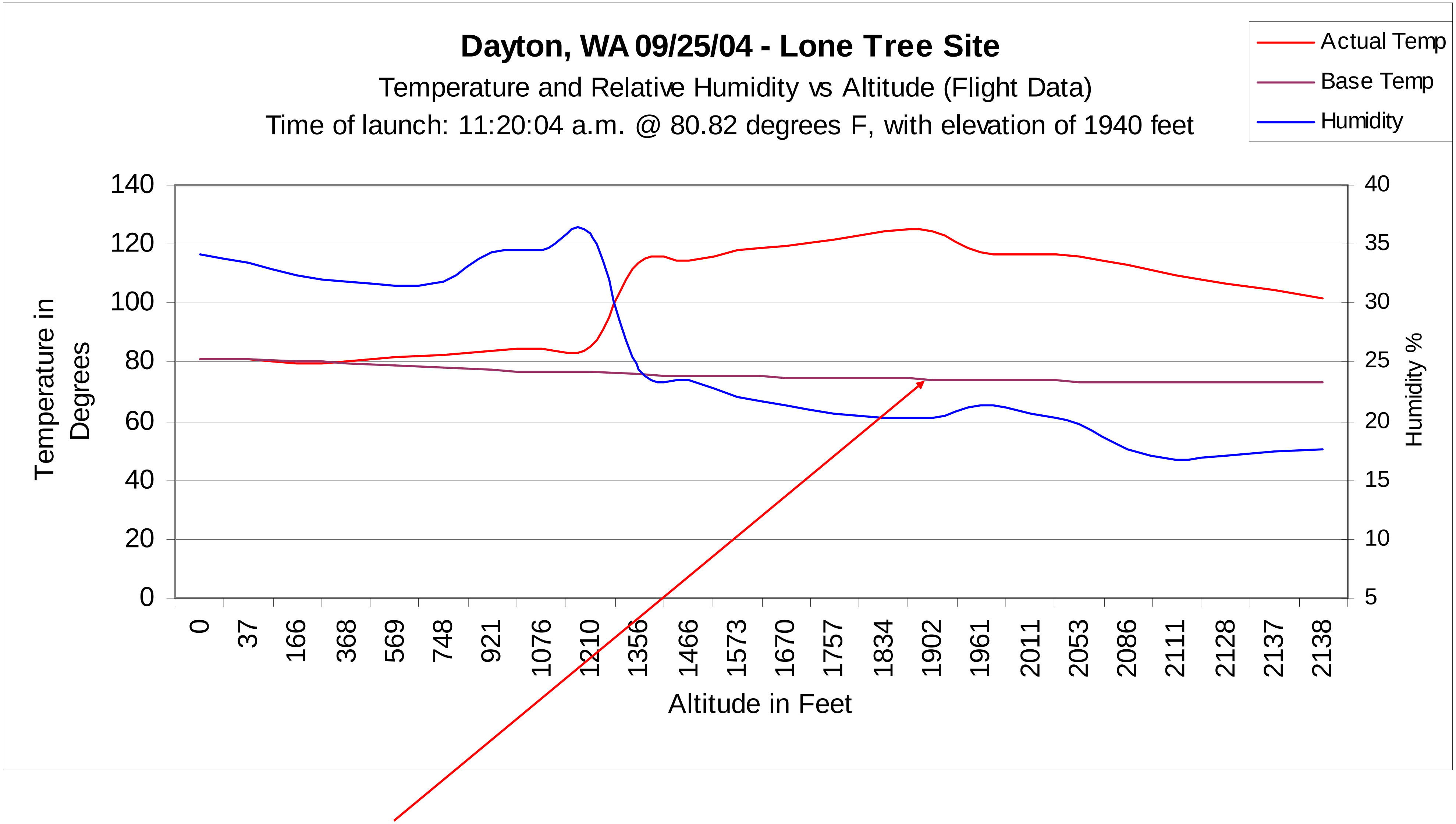

Projected Temperature based on Standard Atmospheric Model – Something definitely out of the ordinary is happening!

Glenda Project – 2006 Accomplishments

Maturing Payloads & Systems – Preparing for the "Wall Cloud" Mapping Mission

Glenda Project – 2006 Accomplishments

- December 2006 - Raid 5 backup facilities on BSD Unix now online with full network live access.

- December 2006 - Upgraded the Active Payloads from analog to digital signal transmission including GPS tracking and wind velocity data.

- September 2006 - Completed design of a video recording payload in order to provide on board video capture of a wall cloud intercept.

- August 2006 - First chase vehicle equipped with ham communication gear.

- June 2006 - Chase team qualified with ham licenses; first chase vehicle equipped with ham communication gear.

- May 2006 - Developed and implemented a multiple channel digital mobile ground station with a one second data capture rate including wind speed, temperature, relative humidity and barometric pressure.

Glenda Project - Advantages

- Portability and Rapid Deployment with "Launch on the Run" capability
- Ease of Use of propellant and vehicle/payload preparation
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In Conclusion

The Glenda Project is a reusable sounding rocket delivery system designed to place instrument packages into areas previously considered to be to hazardous or inaccessible using traditional platforms such as balloons, aircraft, helicopters, kites, etc.

Through 2004 and 2005, Glenda completed its first successful mapping missions and during 2006, the ground station and payloads continued to mature in order to prepare to further extend the flight envelope to even more hazardous environments.

The 2007 series of launches will allow full testing of the GPS tracking and wind velocity capability, and return even more valuable data.

Our next project milestone will be showing the difference between Hollywood “fiction”, and engineering “fact”, by mapping a “Wall Cloud”, or a full tornadic funnel with a full suite of sensors, and Glenda is up to the task.

Glenda Project – Executive Summary - 2008

Glenda Project – Purpose

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Glenda Project – Typical Flight Profile

2 – Boost Phase

3 – Deployment Phase

1 – Launch Phase

Note: Propulsion is provided by reloadable /reusable rocket motors giving the capability of rapid turnaround between flights.

4 – Recovery Phase

Glenda Project – Propulsion

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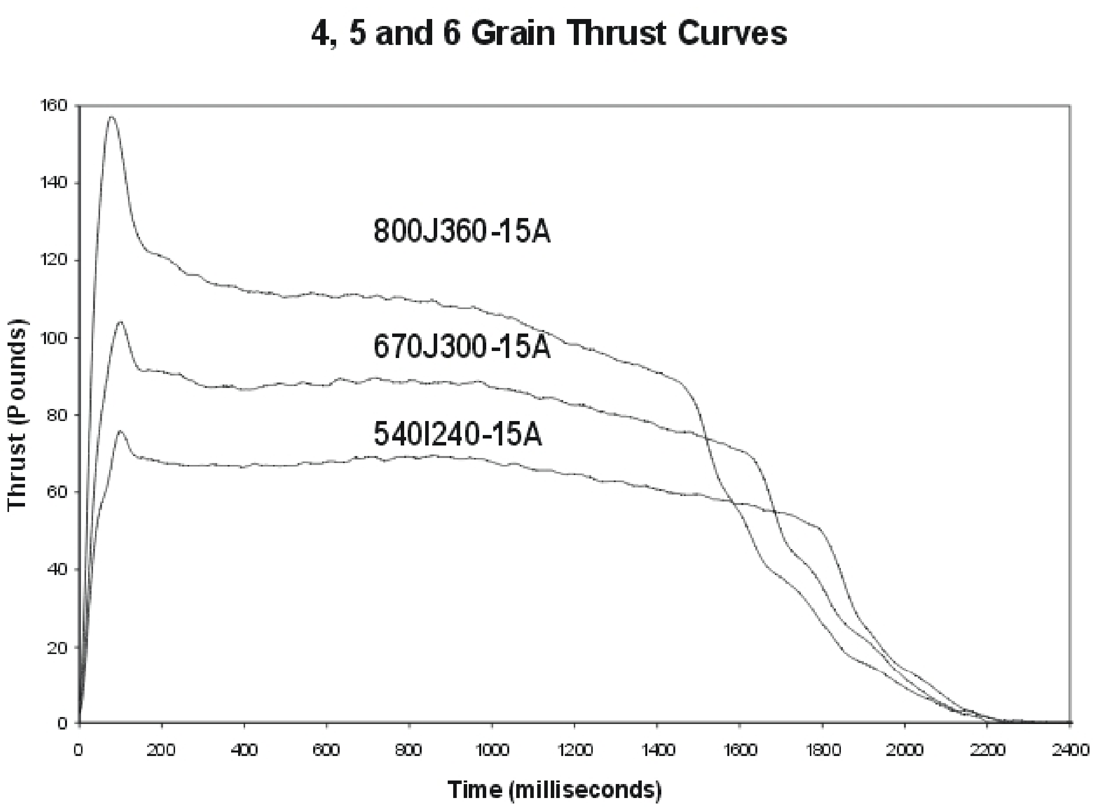

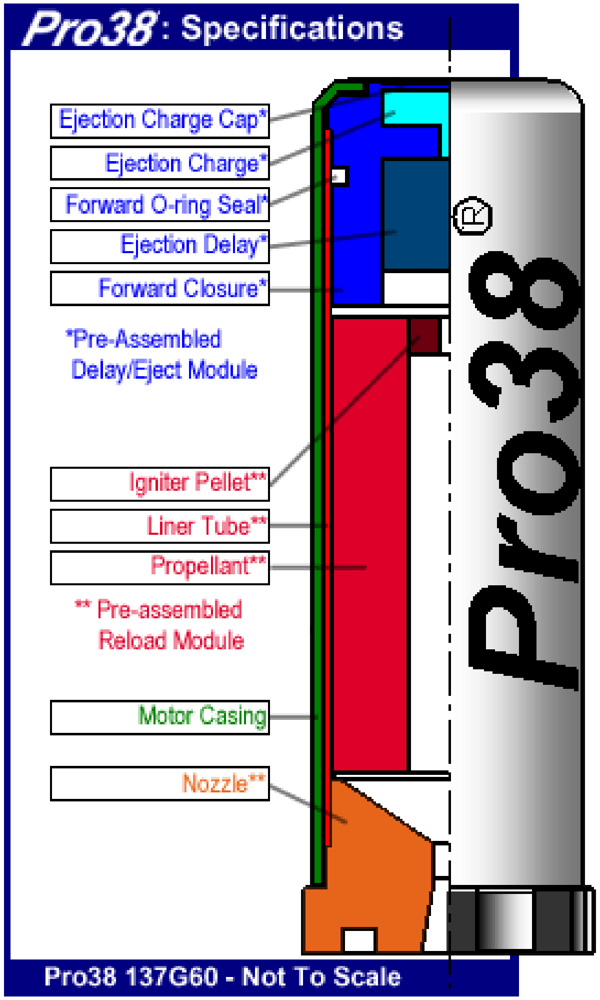

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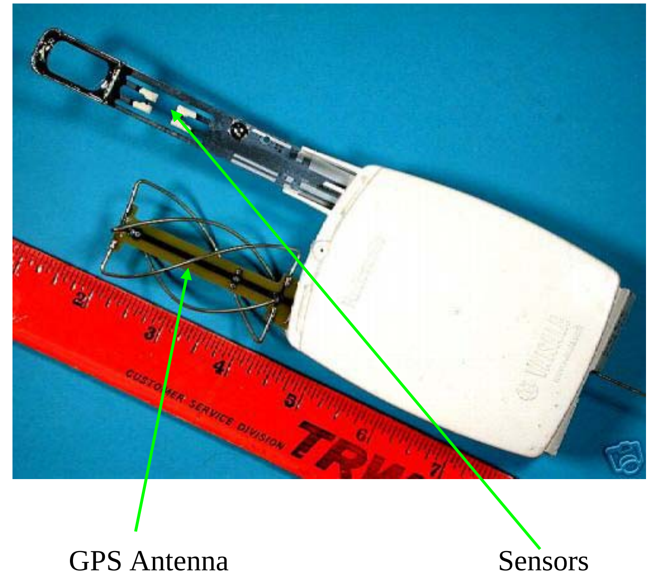
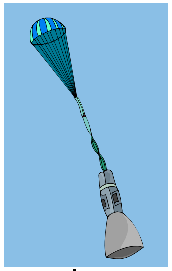


<u>Radiosonde Specifications:</u>

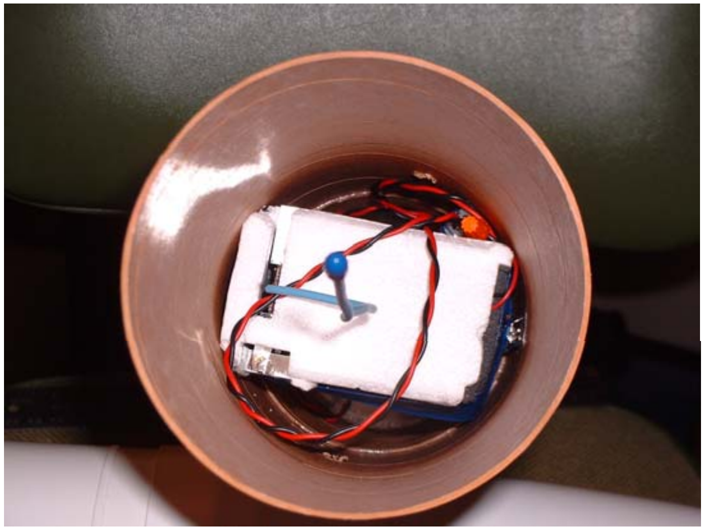
- Pressure range 3mb to 1060mb +/- .1mb
- Operating temperature range of -90°C to +60°C
- Relative Humidity from 0 to 100%
- Sampling Rate of once per second for the sensor suite
- Provides positioning data via GPS for payload location and wind velocity

Glenda Project – Active Payloads - Transmitters

Signal Processing Flow Diagram

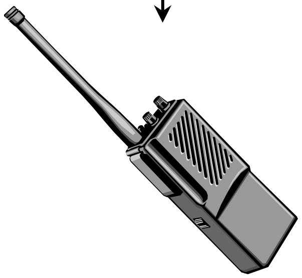


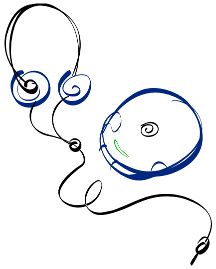
- Barometric Pressure Sensor Data
- Temperature Sensor Data
- Relative Humidity Sensor Data
- GPS - Payload Position Data



Active Payload cushioned within the flight capsule

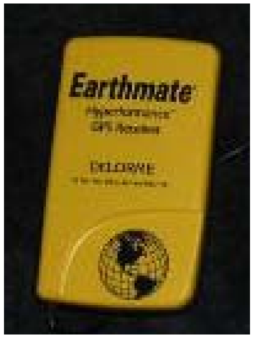
Sensor Data Transmitted to Ground Receiver





Sensor Data Digitally Recorded

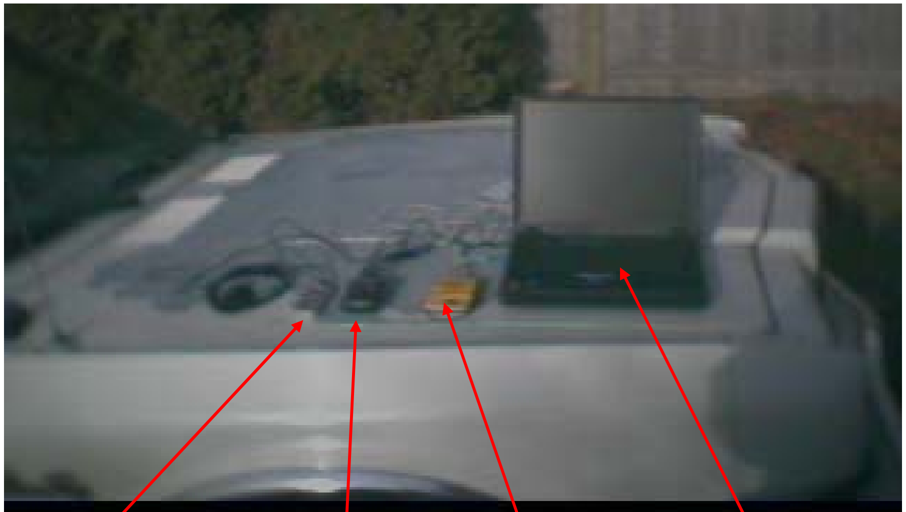
Data recorded into Laptop for analysis



GPS – Ground Station Position Data

Glenda Project – Active Payloads

Ground Station



Digital Recorder

Telemetry Receiver

GPS Receiver

Laptop

Not Shown:

a) Telemetry Receiver Antenna System
b) Laptop External Power Supply

Flight Vehicle

Payload Capsule

Length: 63”
Diameter: 4”
Dry Weight: 3.5 Pounds
Attainable Altitudes: 2,000 feet to 40,000 feet

Glenda Project - Passive Payloads – Dataloggers

A data logger is an electronic instrument that records measurements over time. Typically, data loggers are small, battery-powered devices that are equipped with a microprocessor, data storage and sensors. Most data loggers utilize software on a personal computer to initiate the logger and view the collected data.

Prior to a Glenda launch, the datalogger is connected to a laptop computer. Then, Windows based software is used to select logging parameters (sampling intervals, start time, etc.) and initiate the logger. The logger is then disconnected from the laptop and installed inside the Glenda payload capsule. Upon launch, the logger records each measurement and stores it in memory along with the time and date. Post recovery, the logger is then reconnected to the laptop computer and the software is used again to readout the data and see the measurements as a graph, showing the profile over time. The tabular data can be viewed as well, or exported to a spreadsheet for further manipulation.

Glenda Project – Passive Payloads – Dataloggers

54mm Capsule in Flight Configuration

Tracking System Antenna

Datalogger Sensor Port

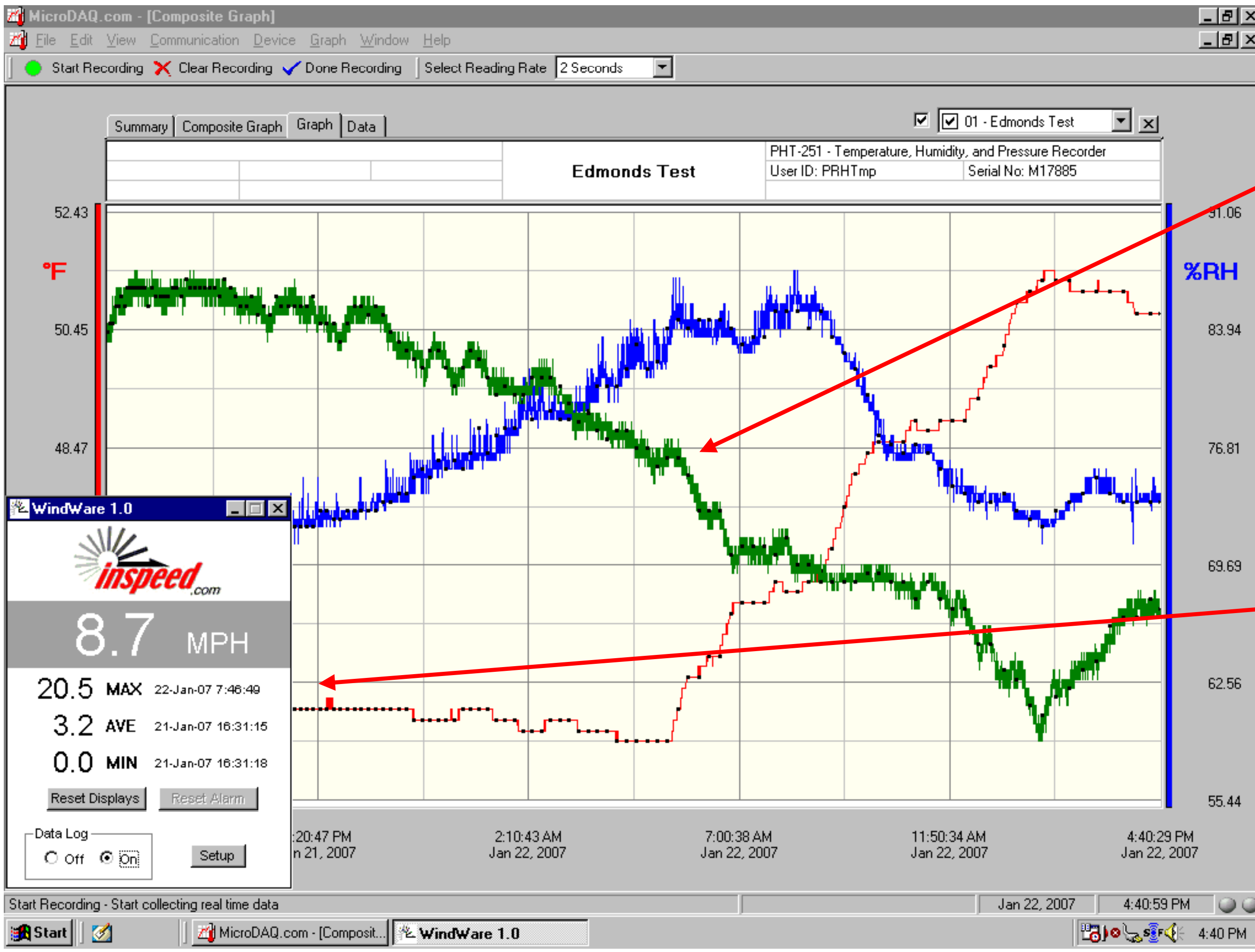
Here is a typical Glenda payload ready for flight. This capsule contains a tracking locator transmitter, a combination temperature/relative humidity datalogger, and a barometric pressure datalogger. Total payload weight including capsule is less than one pound.

Glenda Project – Ground Stations

Digital Chart Recorders

Glenda Project also utilizes sensors combined with ground based laptops to provide a digital based chart record of ground conditions mapped over time.

The example below is a digital chart record of temperature, humidity, barometric pressure and wind speed at a test site.

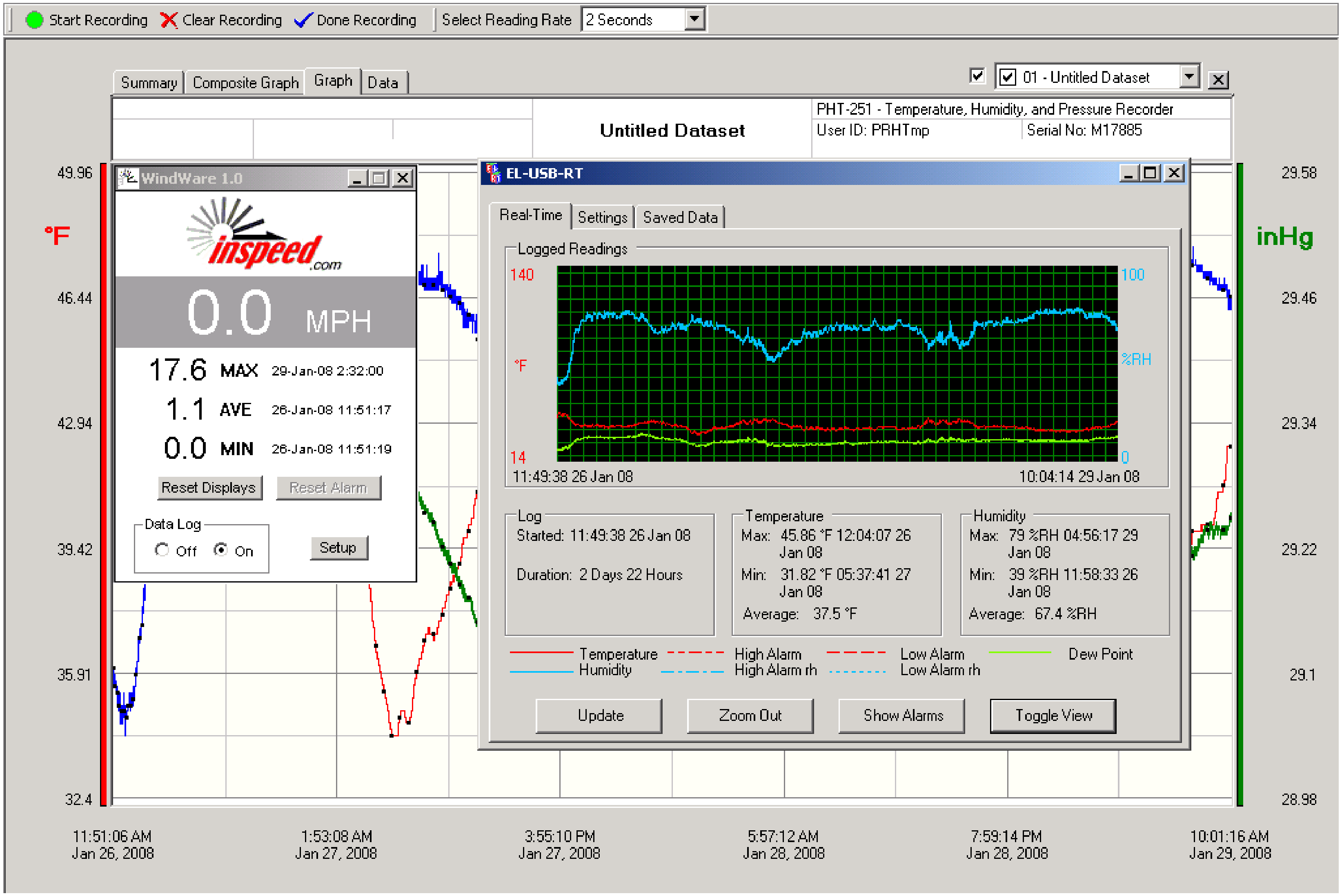


Pressure, Temperature, & Barometric Pressure data stream using Micro-DAQ software and COM 1 port

Wind Speed data using InSpeed Anemometer and supporting software Using COM 3 port via USB port application adapter

Glenda Project – Ground Stations

Digital Chart Recorders - 2008



For 2008, Glenda is now using the Micro-Daq Three channel datalogger, Inspeed anemometer, plus a Lascar Dew Point sensor running on a Thinkpad A20m Pentium III laptop. The Inspeed and Lascar software run in the background collecting data at one second intervals providing wind speed and Dew Point trend data.

Glenda Project – AN/TMQ-34 Ground Station

In March 2005, the Glenda Project obtained a military ground weather station. This acquisition further enhances the projects ground condition data collection capabilities.

The TMQ–34 is a military self contained portable weather measuring system that is powered by a rechargeable Ni CAD battery.

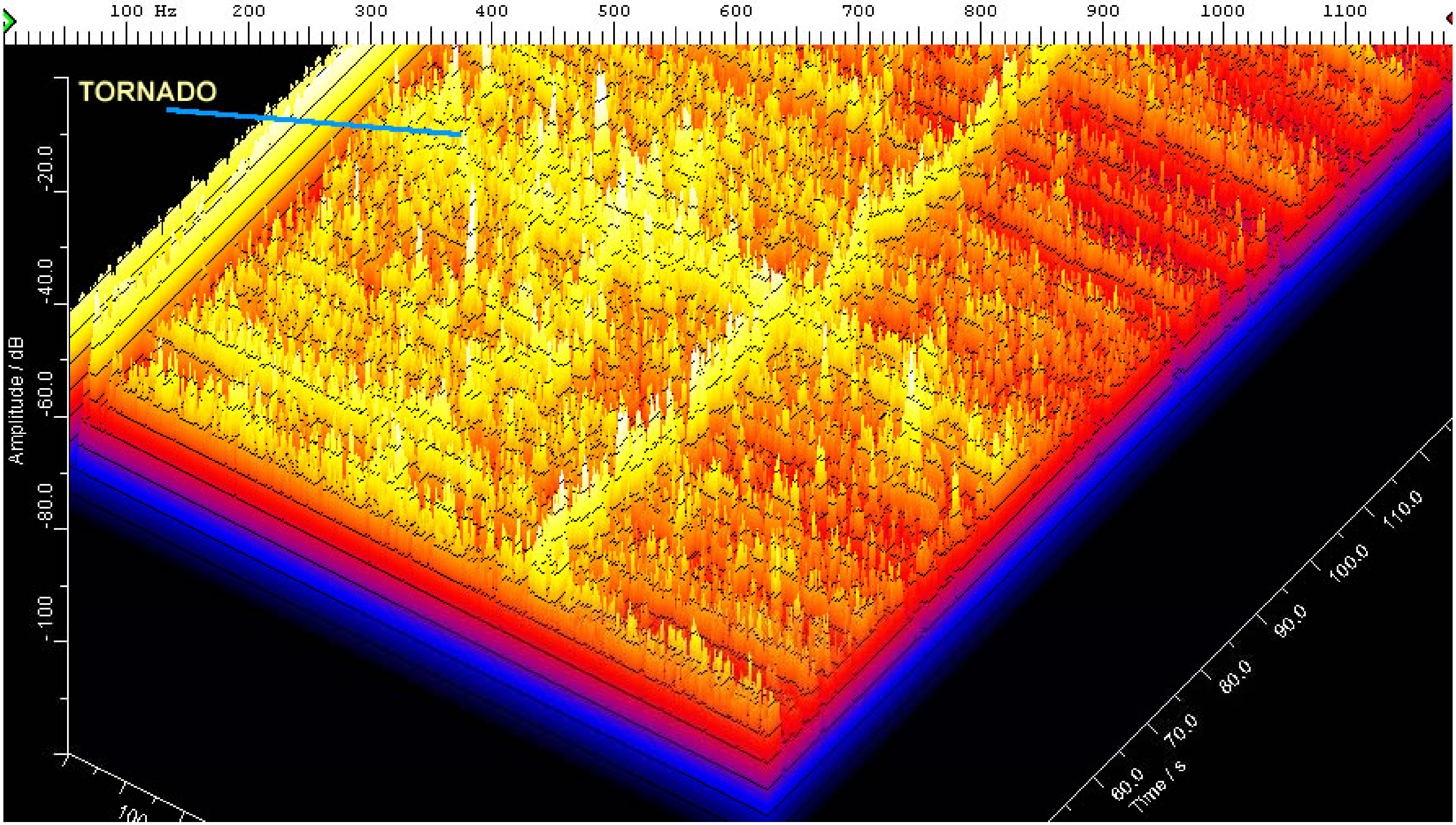
The TMQ–34 alphanumerically displays wind speed and direction, peak wind, temperature, dew point, barometric pressure, 3-hour pressure change, and the minimum and maximum temperature.

The entire TMQ–34, including the system case, weighs about 20 pounds. The set contains a computer module with a pressure sensor, and the main sensor module with a red sensor for temperature, a white sensor for humidity, a wind direction compass, and an anemometer to measure wind speed.

The TMQ–34 can operate in temperatures ranging from a low of –59.5°F to 132°F. The TMQ–34 is intended for use in a tactical environment with an operating range of 100 feet below sea level to 10,000 feet above sea level.

Glenda Project – EMF Spectral Mapping

Combining Glenda computing and sensors allows the capability for advanced analysis and detection. Shown below is a 3D EMF analysis of a tornado based off of a three second data capture. The circular effects of the funnel are easily visible and provide a snap shot of the electrical activity around a tornado.



Glenda Project – "Ranger Intercept" Video Payload

Glenda has developed an operational on-board video capture payload capability in order to compare visual storm characteristics to other collected sensory data.

Video Payload Capsule Attributes:

- 40 Second Video Capture Capability
- 9 Frames per second Capture Rate
- 24 Bit Video Resolution
- Operable in both high and low light conditions
- Parachute Recovery
- Adaptable across multiple Glenda boosters
- Video downloadable in the field to laptop computers

Glenda Project – "Ranger Intercept" Video Payload

May 6th, 2007 – Redmond, WA – A typical flight towards an incoming storm center.

1. Launch

2. Mid - Boost

3. Apogee

4. Descent

5. Landing

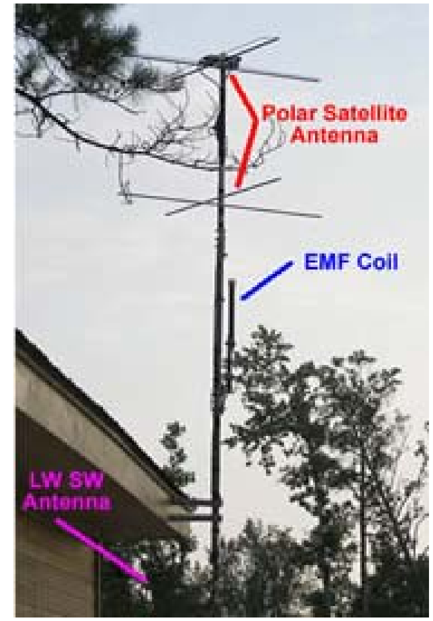
Glenda Project – Chase Teams

In order to obtain data from dynamic weather phenomena it is necessary to seek out and intercept storms and to launch sensors into the heart of the disturbance, capture the data, and return the data for immediate processing and analysis. Hence the name, Chase Team.

The Chase Teams utilize Jeep Grand Cherokee 4 wheel drive units, equipped with specialized tires and suspension to handle road debris situations and evasive maneuvers while on the go. When storm data is required, the teams immediately equip the jeeps with instrument packages and laptop computers inside the vehicle and attach to the roof, weather instrumentation, satellite dishes, sensors and communication gear. Portable rocket launching stands and weather rockets are loaded into the back of the jeep. Transforming from a standard jeep to a fully operational weather pursuit vehicle takes as little as five minutes.

Glenda Project – Pullman Point Research Facility

The Pullman Point Weather Research Facility is located in Petal, Mississippi, roughly 60 miles north of the Gulf of Mexico.



The Facility houses instrumentation that is a combination of old school analog, as well as, state of the art digital that is exclusive to less than a half dozen operations in the continental United States and the most advanced privately owned instrumentation in Southern Mississippi.

Data is acquired and network backup communication systems are in place with an eight dish satellite antenna array located onsite.

Backed with an onsite super computing cluster and multi mode communication links with the outside world we supply information in live time for the purposes of research and learning. The facility is linked by networks to additional computing clusters in Moses Lake, Washington and server farms in Kelowna, British Columbia, Canada.

Glenda Project – Engineering / Computing

David Davis – Edmonds, WA - Launch Operations Director - Brings decades of experience from engineering work in private industry and United States government in rocket research, and aerospace. Extensive background in electronics, mechanics, communications, computing, and storm chasing. Member of the National Association of Rocketry since 1983, and been involved with hobby related rocketry since the 1960's.

Robert Pullman – Petal, MS - Long Range Sensor Development - Has three decades of experience in communication and the computer industry and his expertise is world renown. His work has enabled governments to formulate policies and legislation in international, national and local forums. He has developed products that are used by universities for seminars, by corporations for internal operations to meet government regulations, by scientists for research work in field and laboratory conditions, by government departments for device operations and maintenance, and by the military for use in battlefield activities.

Glenda Project – Media Communications / Public Relations

As the Glenda Project matured, a definite need became apparent for an individual with media communications skills and public relations.

Tim Quigg in Dayton, WA brings a unique mix of personal background and professional experience to the Glenda Project. Quigg has over two decades of experience in customer service and media relations. He has been the Assistant Editor of Extreme Rocketry Magazine since 2000, as well as a freelance writer of numerous articles for Sport Rocketry Magazine. He is a current member of the National Association of Rocketry, and is the 2001 recipient of the National Association of Rocketry's President's Award, in recognition of his work with youth in model rocketry on a national level. Quigg is a highly decorated 24-year veteran of law enforcement, and is currently the Senior Communications Officer at a Southeastern Washington State E911 Communications Center.

Glenda Project – Typical Missions

Glenda Project – Typical Missions

April 9, 2005 Columbia County / Dayton, Washington

Project Glenda utilized the digital chart recording system connected to a laptop computer to collect data of a forecasted dynamic weather system.

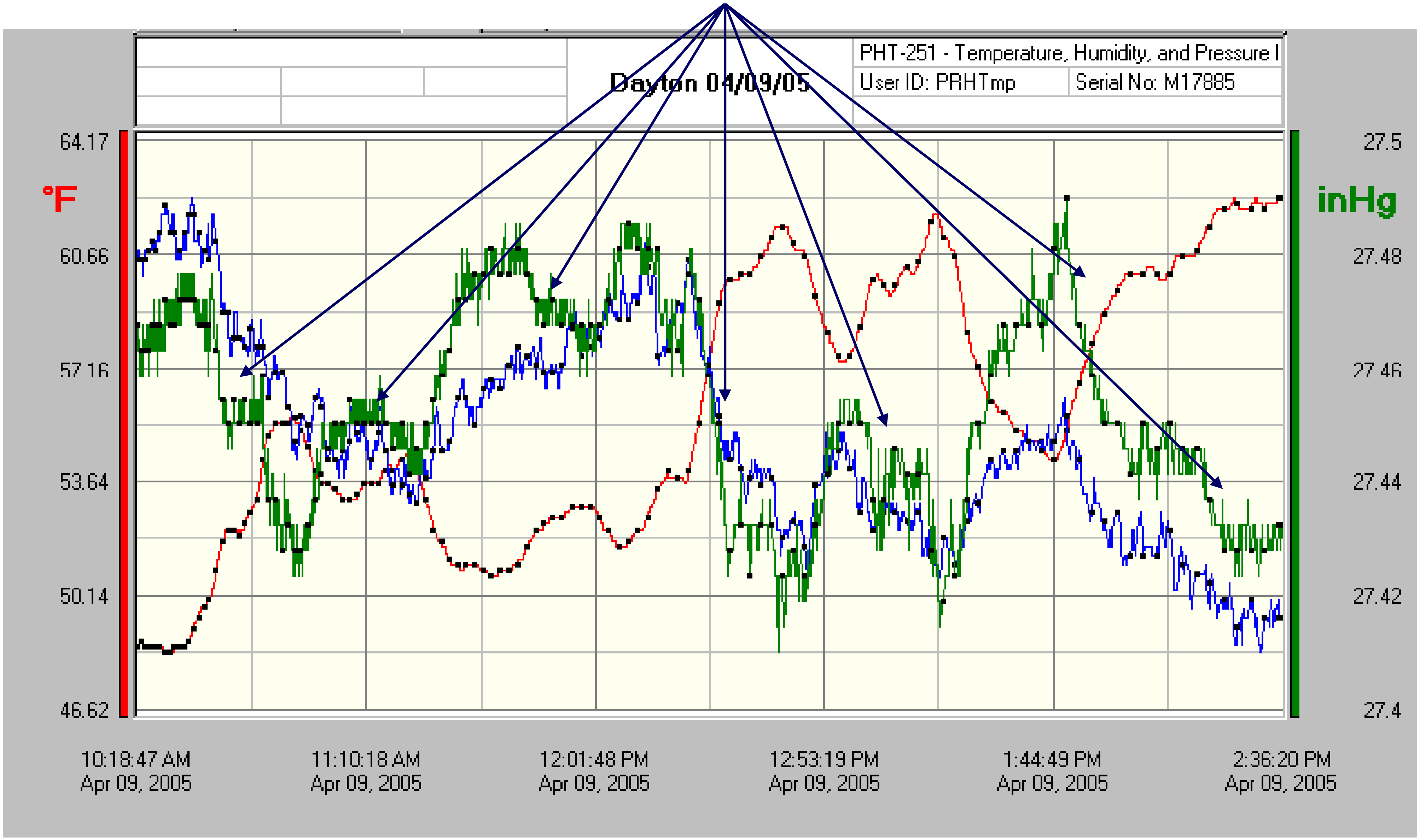
The system performed flawlessly throughout the day and detected the passage of local storm cells and weather fronts as they passed through the area.

The primary focus of the ground station mission is to provide an early warning mechanism to local officials and citizens of approaching hazardous weather systems.

Without viable ground condition data, it is difficult to determine the extent of changes in temperature, barometric pressure, and humidity at altitude.

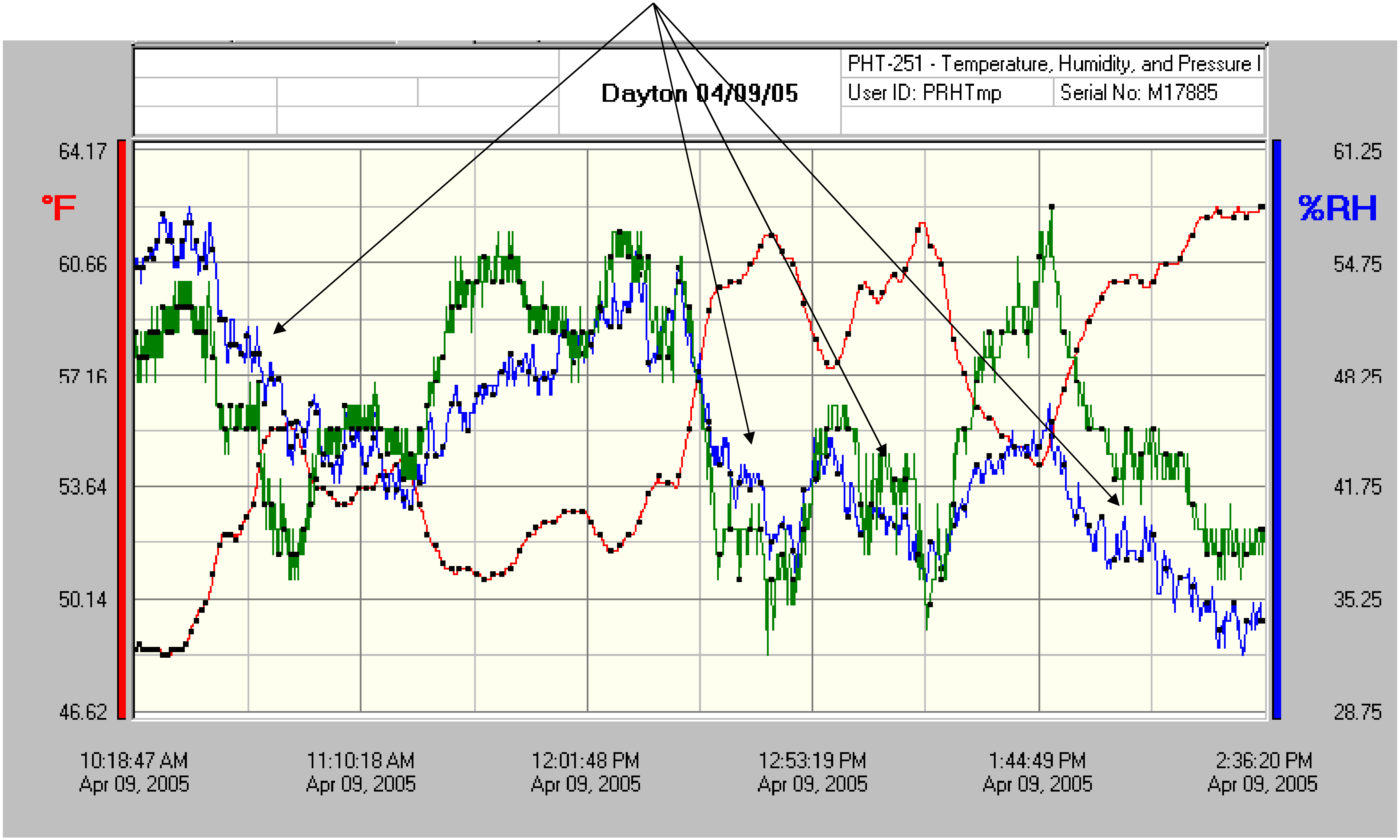
April 9th, 2005 – Dayton, WA - Ground Station Mission

Barometric Pressure Drops which serve as weather system pre-cursor signals



April 9th, 2005 – Dayton, WA - Ground Station Mission

While the Barometric Pressure targets local cells, RH data gives us "Frontal" trends



Sensors detected seven cells based on four local fronts

Glenda Project – Thermal Mapping Mission

September 25, 2004 Columbia County / Dayton, Washington

During September 2004, Glenda performed a thermal mapping mission using the chart recording ground station, and both active and passive payloads.

The purpose of these two flights was to confirm, or refute the existence of a region of thermal activity over a local site called “Lone Tree”.

The first rocket sounding employed the Glenda 98mm booster lofting an active transmitting payload broadcasting temperature, relative humidity and barometric pressure data to the ground station.

The second sounding flight was made using the Glenda 54mm booster carrying a passive payload recording temperature and relative humidity.

Glenda Project – Thermal Mapping Mission

September 25, 2004 Columbia County / Dayton, Washington

At the time of the Glenda flights, the ground temperature was around 80 degrees, with a Relative Humidity around 37-38%. Under the standard atmospheric model, temperature goes down, as does humidity as you increase in altitude.

At “Lone Tree”, this was not the case.

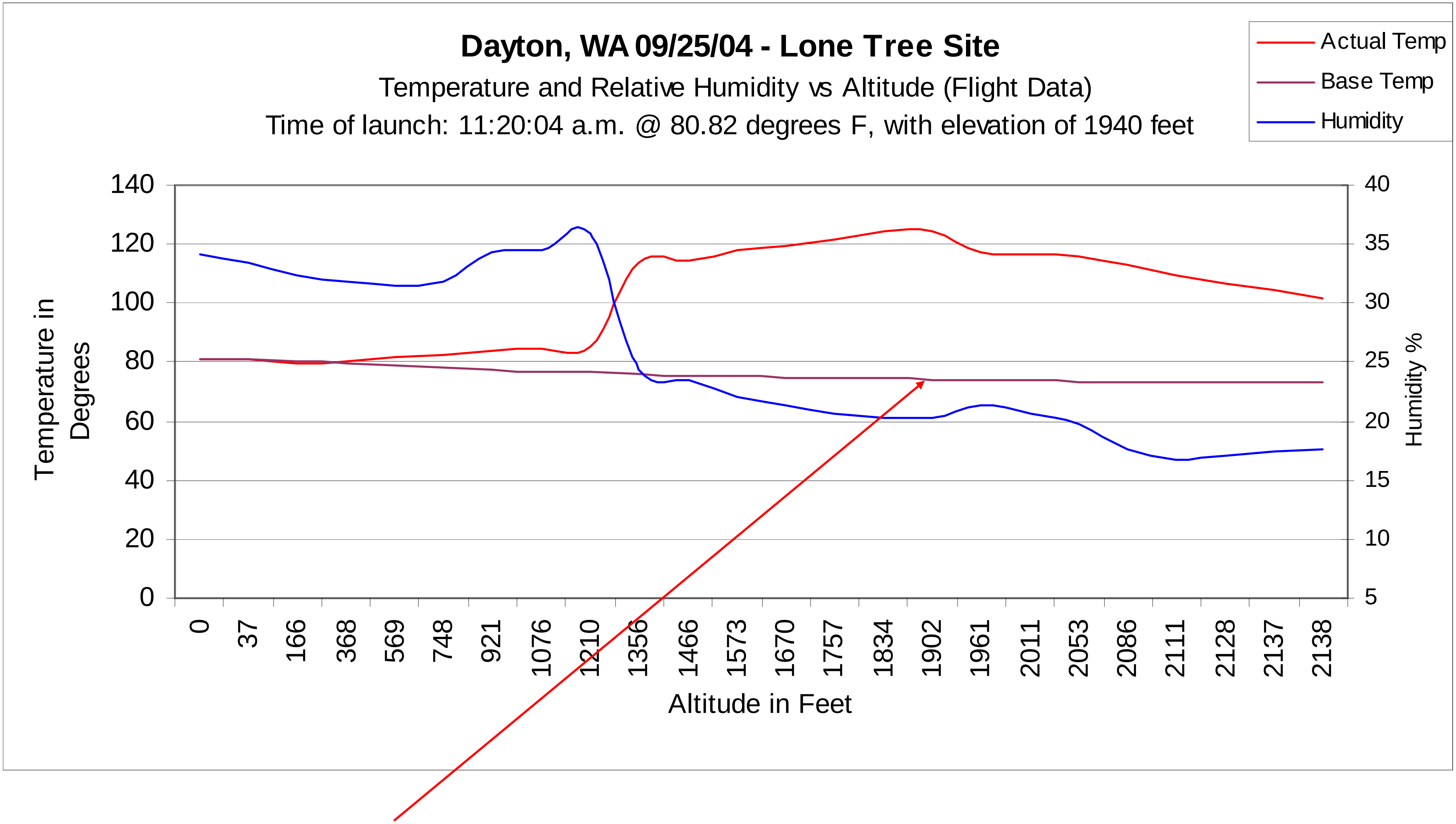
Temperature and humidity stayed relatively constant until 1,300 – 1,400 feet. Then things got interesting. The temperature rose rapidly, and the humidity level dropped. The sensors detected a 500 foot layer of hot, dry air which topped over 124 degrees at 11:00 in the morning. That's a 40+ degree difference from ground conditions. As the sensors penetrated the layer, more "normal" readings were detected.

The data between the two flights supported one another and have provided a body of evidence proving the existence of a thermal layer above the launch site.

The mapping mission was a success and the results are shown on the following slide.

Glenda Project – Thermal Mapping Mission

September 25, 2004 Columbia County / Dayton, Washington



Projected Temperature based on Standard Atmospheric Model – Something definitely out of the ordinary is happening!

Glenda Project – 2006 Accomplishments

Maturing Payloads & Systems – Preparing for the “Wall Cloud” Mapping Mission

Glenda Project – 2006 / 2007 Accomplishments

- October 2007 - Edmonds, WA ground station operational as additional facility for sensor testing.

- May 2007 – The new "Ranger Intercept" research rocket was successfully launched into a storm front and captured live video which was downloaded to a ground station laptop.

- May 2007 – In conjunction with the Blue Mountain Rocketeers, participated in the National Weather Service (Pendleton, OR) open house in celebration of the 200th birthday of the NOAA. There was a great deal of interest in the project, with multiple presentations during the day including overviews of the project, its capabilities, and demonstrating various aspects of the weather payloads and the ground support equipment.

- Feb - June 2007 – Conducted several "Train the Trainer" courses in severe weather and storm spotting for Emergency Management in Mississippi and the Gulf Coast.

- December 2006 - Upgraded the Active Payloads from analog to digital signal transmission including GPS tracking and wind velocity data.

- August 2006 - First chase vehicle equipped with ham communication gear.

- May 2006 - Developed and implemented a multiple channel digital mobile ground station with a one second data capture rate including wind speed, temperature, relative humidity and barometric pressure.

Glenda Project - Advantages

- Portability and Rapid Deployment with "Launch on the Run" capability
- Ease of Use of propellant and vehicle/payload preparation
- Payload adaptable for external sensors to match user specific applications
- Composite components designed for extreme environments
- On-board locater transmitter allows for rapid recovery
- Off-the-shelf components reduce operating costs and ease repair

Glenda Project - Disadvantages

- Training required for system use, data collection and analysis
- Composite materials not bio-degradable
- Rocket motors are “Hazardous Materials” and are classified as Flammable Solids 4.1, or 1.4c and 1.3c Explosives
- Multiple sensors required to support complex analysis
- Active Payloads require ground stations for data reduction and analysis

In Conclusion

The Glenda Project is a reusable sounding rocket delivery system designed to place instrument packages into areas previously considered to be to hazardous or inaccessible using traditional platforms such as balloons, aircraft, helicopters, kites, etc.

Through 2004 and 2005, Glenda completed its first successful mapping missions and during 2006, the ground station and payloads continued to mature in order to prepare to further extend the flight envelope to even more hazardous environments.

2007 brought continued maturing of sensors and first flight of “Ranger Intercept”.

The 2008 series of launches will allow full testing of the GPS tracking and wind velocity capability, and return even more valuable data.

Our next project milestone will be showing the difference between Hollywood “fiction”, and engineering “fact”, by mapping a “Wall Cloud”, or a full tornadic funnel with a full suite of sensors, and Glenda is up to the task.

Glenda Project – Executive Summary - 2009

Glenda Project – Purpose

The primary mission of the Glenda Project is to provide the capability to rapidly gather previously inaccessible localized microclimate data from altitudes ranging from ground level to 20,000 feet and to return this data for immediate use.

The Glenda Project is mix of adaptable ground stations combined with a reusable sounding rocket delivery system designed to place instrument packages into areas previously considered to be to hazardous or inaccessible using traditional platforms such as balloons, aircraft, helicopters, kites, etc.

Glenda Project – Data Capabilities

The Glenda Project has the capability to collect temperature, humidity, barometric pressure, wind speed and other types of environmental data from ground level to 20,000 feet.

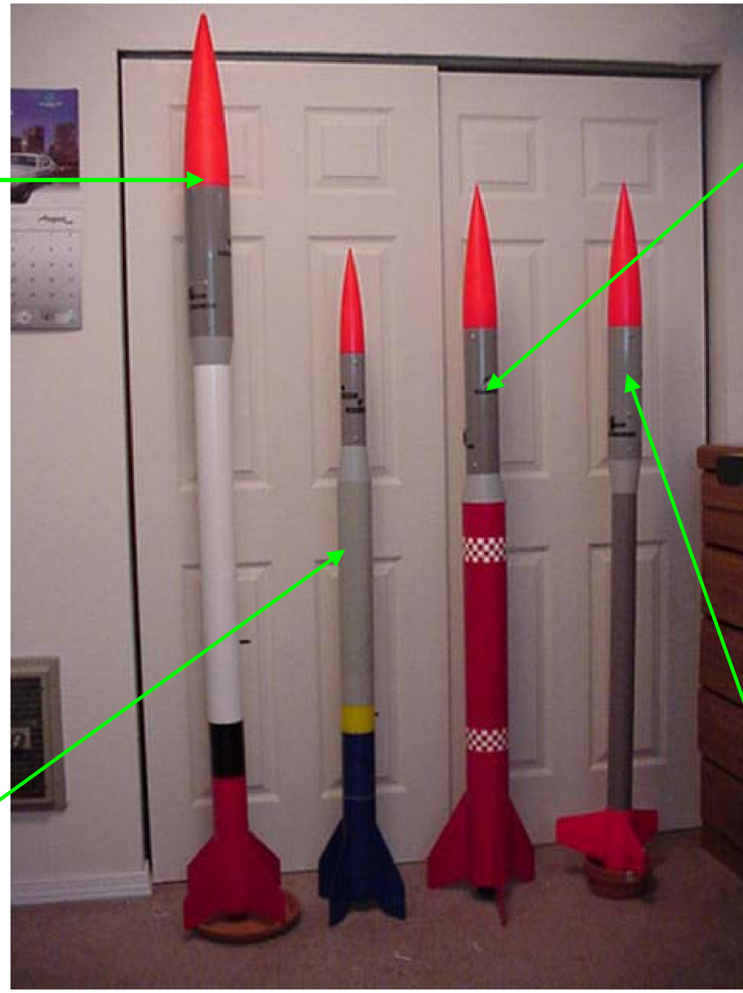
Glenda payloads are designed to be launched into thunderstorms, tornados, and other volatile weather environments and to return intact with its collected data.

Glenda Project – Data Collection Methods

Glenda has three primary methods of collecting data:

- Rocket Launched - Active Flight Data Collection Systems - Transmitters
- Rocket Launched - Passive Flight Data Collection Systems – Dataloggers
- Ground Stations

Glenda Project – Typical Flight Vehicles



7598 Booster

- 3” diameter booster, 4” diameter capsule
- RS80 Radiosonde Payload
- 3,000 to 20,000 ft altitude envelope

9875 Booster

- 4” diameter booster, 3” diameter capsule
- RS92 Digital Radiosonde Payload with GPS
- Temp / RH Datalogger
- 2,000 to 15,000 ft altitude envelope

FAR 101 Booster

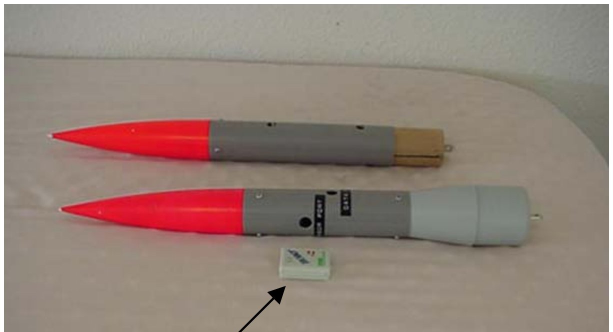
- 3” diameter booster, 2.125” diameter capsule
- Temp / RH Datalogger Payload
- 2,000 foot altitude envelope

5475 Booster

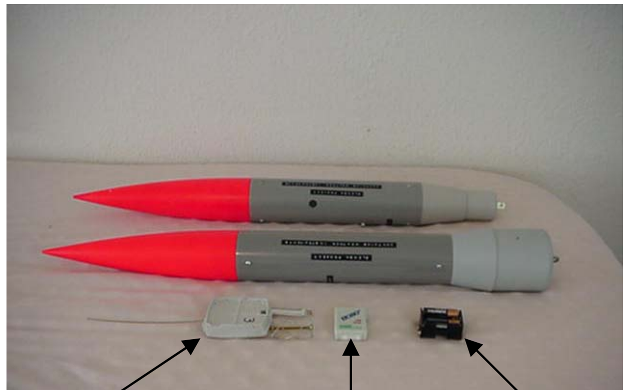
- 2.125” diameter booster, 3” diameter capsule
- RS92 Digital Radiosonde Payload with GPS
- Temp / RH Datalogger
- 2,000 to 15,000 ft altitude envelope

Glenda Project – Typical Flight Payloads

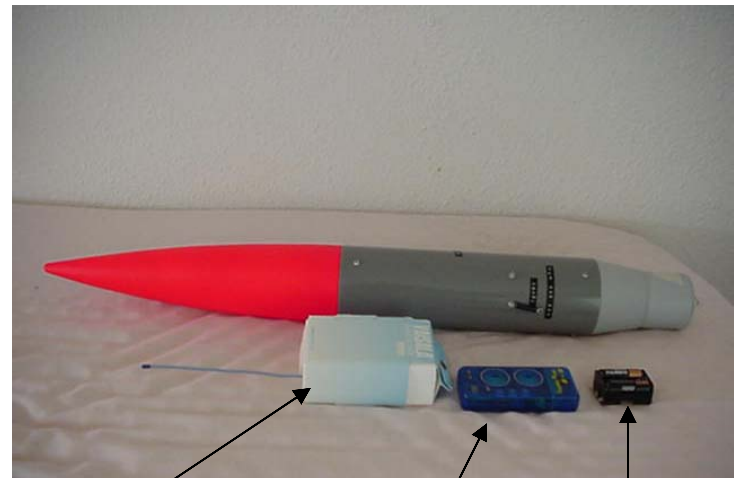
The Glenda project uses several different payload capsule configurations carrying a variety of instrumentation in order to gain weather related information, and other micro-climate data



Datalogger



RS92 Digital Radiosonde Datalogger Battery Pack



RS80 Analog Radiosonde Locator Beacon Battery Pack

54mm (2.125”) Capsules

- Datalogger Payloads
- Measures Temperature & RH values at 1 second intervals.
- Used by 54mm & 75mm boosters.

75mm (3”) Capsules

- Datalogger Payloads
- Measures Temperature & RH values at 1 second intervals.
- RS92 Digital Radiosondes transmitting temperature, RH, barometric pressure, and GPS coordinates.
- Used by 54mm & 98mm boosters.

98mm (4”) Capsule

- RS80 Analog Radiosonde transmitting temperature, RH, and barometric pressure.
- Audio location beacon
- Used by 75mm boosters.

Glenda Project – Typical Flight Profile

2 – Boost Phase

3 – Deployment Phase

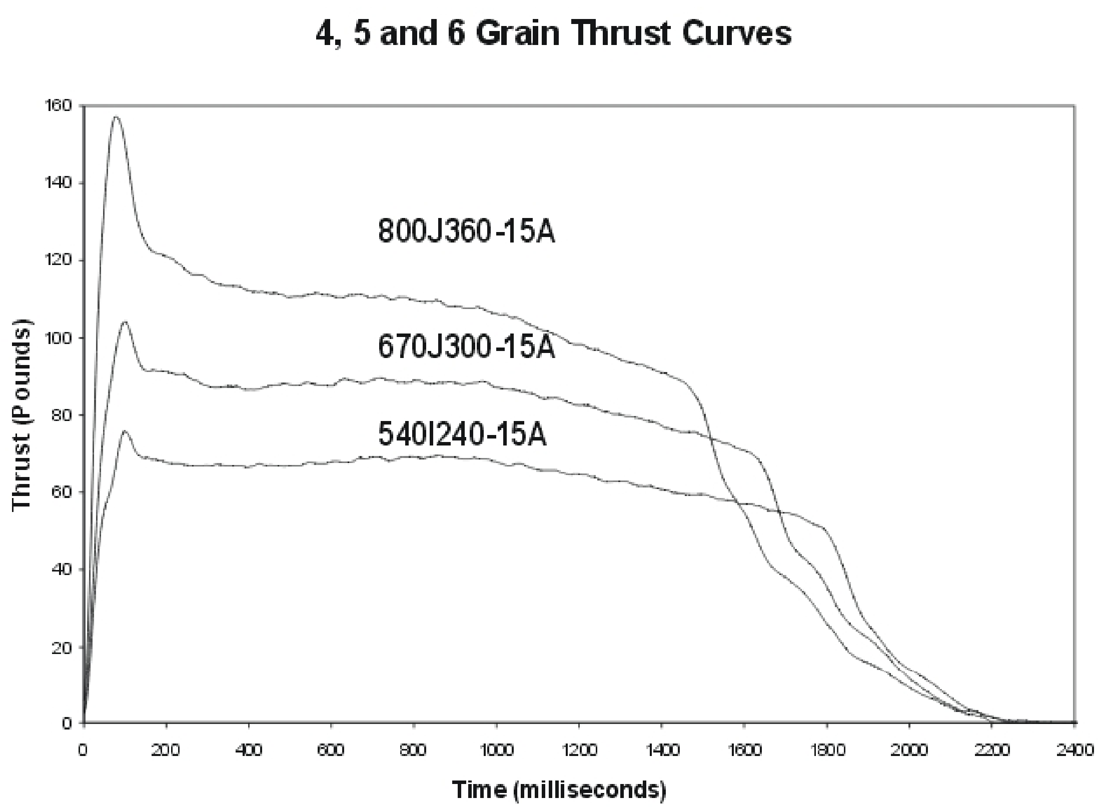
1 – Launch Phase

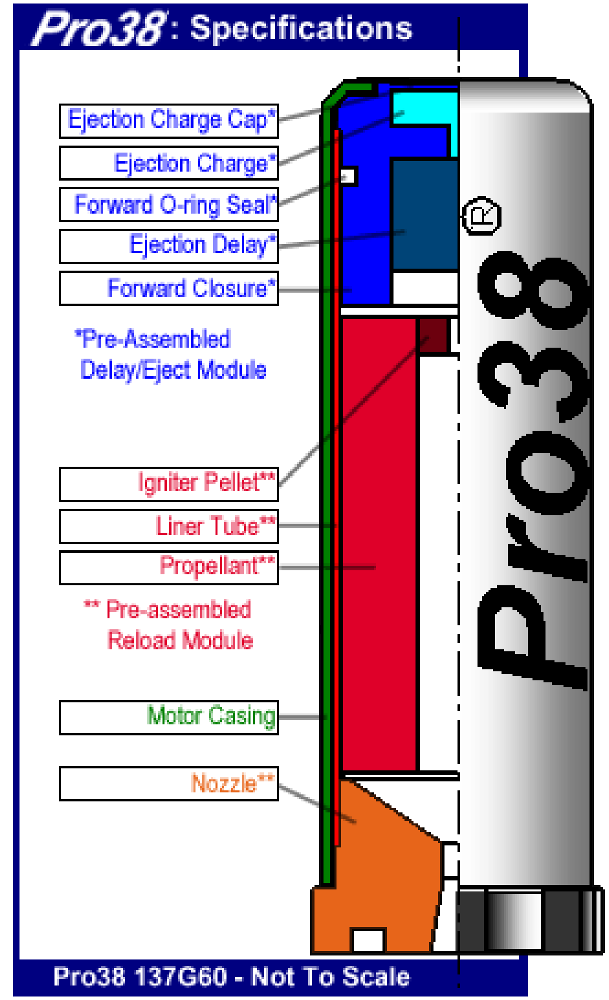
Note: Propulsion is provided by reloadable /reusable rocket motors giving the capability of rapid turnaround between flights.

4 – Recovery Phase

Glenda Project – Propulsion

The Pro38 rocket motor propulsion system is the first commercial thermoplastic propellant-based solid rocket motor and is produced by Cesaroni Technology Inc. of Toronto Canada. The Pro38 is a modular, reloadable solid propellant rocket motor system designed primarily for use in launching small experimental payloads by universities, colleges, research institutes and sport rocketry enthusiasts.





Glenda Project – Active Payloads - Transmitters

Converted Radiosonde Payloads

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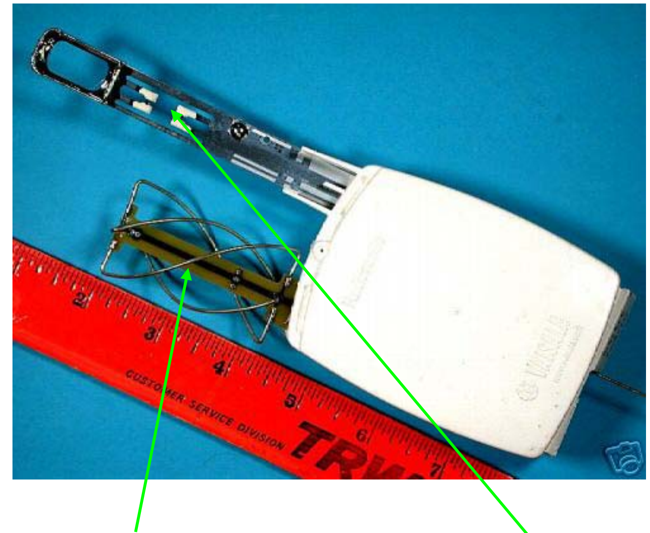

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Vaisala RS92 Radiosonde

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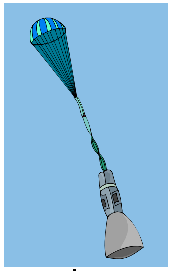
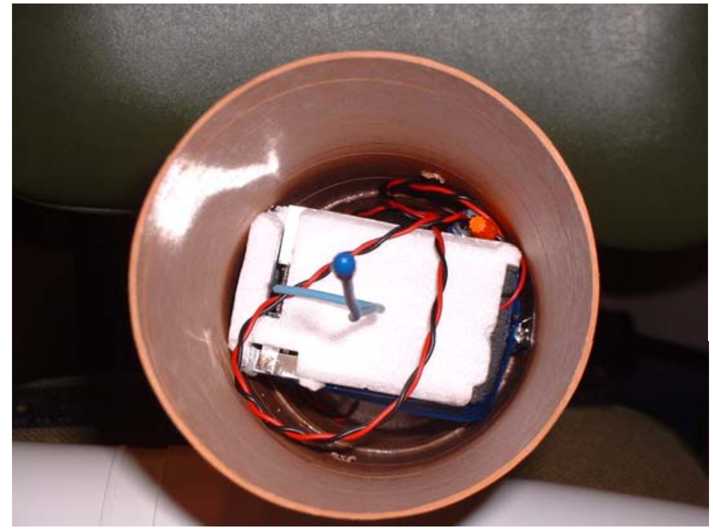
- Relative Humidity from 0 to 100%
- Sampling Rate of once per second for the sensor suite
- Provides positioning data via GPS for payload location and wind velocity

Glenda Project – Active Payloads - Transmitters

Signal Processing Flow Diagram

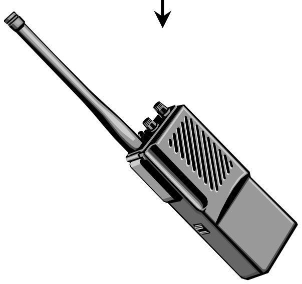


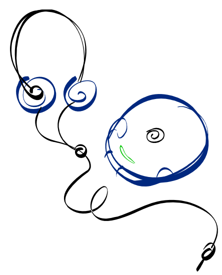
- Barometric Pressure Sensor Data
- Temperature Sensor Data
- Relative Humidity Sensor Data
- GPS - Payload Position Data



Active Payload cushioned within the flight capsule

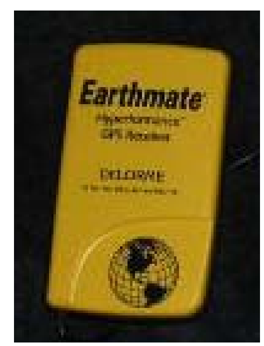
Sensor Data Transmitted to Ground Receiver





Sensor Data Digitally Recorded

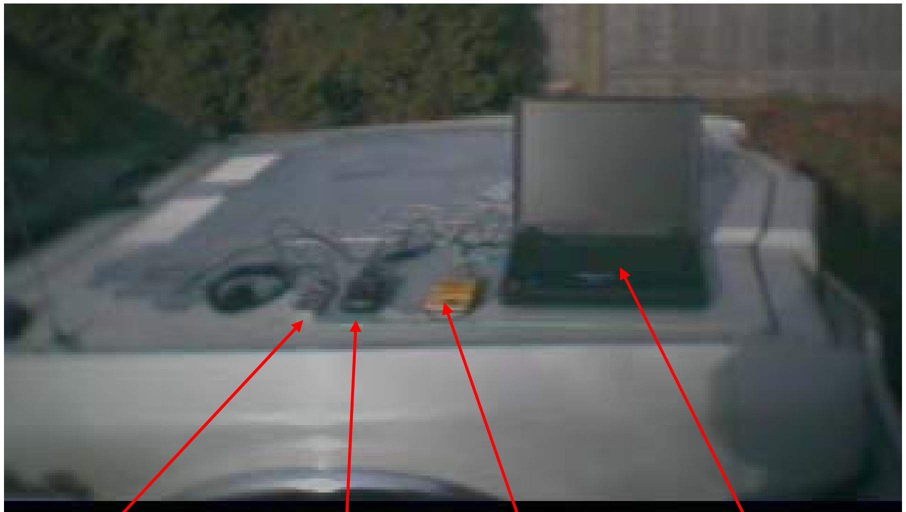
Data recorded into Laptop for analysis



GPS – Ground Station Position Data

Glenda Project – Active Payloads

Ground Station



Digital Recorder

Telemetry Receiver

GPS Receiver

Laptop

Not Shown:

a) Telemetry Receiver Antenna System

b) Laptop External Power Supply

Flight Vehicle

Payload Capsule

Length: 63”

Diameter: 4”

Dry Weight: 3.5 Pounds

Attainable Altitudes: 2,000 feet to 20,000 feet

Glenda Project - Passive Payloads – Dataloggers

A data logger is an electronic instrument that records measurements over time. Typically, data loggers are small, battery-powered devices that are equipped with a microprocessor, data storage and sensors. Most data loggers utilize software on a personal computer to initiate the logger and view the collected data.

Prior to a Glenda launch, the datalogger is connected to a laptop computer. Then, Windows based software is used to select logging parameters (sampling intervals, start time, etc.) and initiate the logger. The logger is then disconnected from the laptop and installed inside the Glenda payload capsule. Upon launch, the logger records each measurement and stores it in memory along with the time and date. Post recovery, the logger is then reconnected to the laptop computer and the software is used again to readout the data and see the measurements as a graph, showing the profile over time. The tabular data can be viewed as well, or exported to a spreadsheet for further manipulation.

Project Glenda Payload – Dataloggers

The Temperature / Relative Humidity datalogger is an example of a typical Glenda data collection device.

Temperature / Relative Humidity Datalogger Specifications:

- Capacity: 7943 measurements total
- User-selectable sampling interval: 0.5 seconds to 9 hours
- Programmable start time/date
- Memory modes: stop when full, wrap-around when full
- Nonvolatile EEPROM memory retains data even if battery fails
- Blinking LED light confirms operation
- User-replaceable battery lasts 1 year
- Battery level indication at launch
- Operating range: -4°F to +158°F (-20°C to +70°C), 0 to 95% relative humidity
- Time accuracy: ±1 minute per week at +68°F (+20°C)
- Size/Weight: 2.4 x 1.9 x 0.8" (68 x 48 x 19 mm)/approx. 1 oz.(29 grams)

Glenda Project – Passive Payloads – Dataloggers

54mm Capsule in Flight Configuration

Tracking System Antenna

Datalogger Sensor Port

Here is a typical Glenda payload ready for flight. This capsule contains a tracking locator transmitter, a combination temperature/relative humidity datalogger, and a barometric pressure datalogger. Total payload weight including capsule is less than one pound.

Additional Payload Tracking Systems

In addition to the GPS tracking capability, and to ensure recovery of the payloads, the Glenda Project has implemented several additional recovery and tracking aids.

To support short range recovery, a 110 db audio alarm can be installed in the payload capsule. The alarm functions independently of the data payload and is activated by its own internal countdown timer. Field tests have shown an effective range of one half mile.

For longer range tracking and recovery, a tracking transmitter is installed in the payload capsule. Field tests have indicated a line of sight tracking distance at over three miles.

110 db audio alarm payload location package

Audio Beacon Sound Sample

Payload tracking transmitter

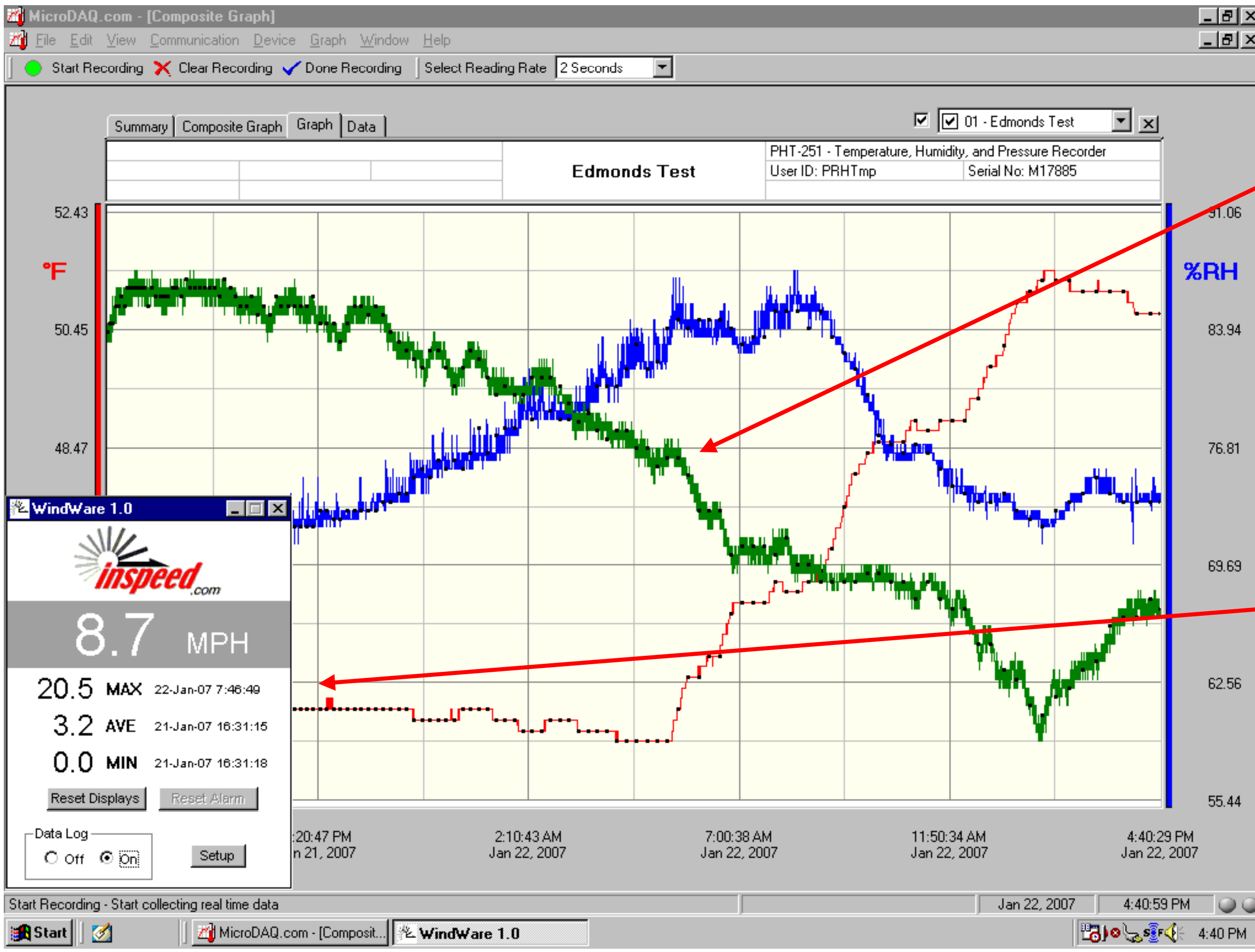
Tracking Transmitter Signal

Glenda Project – Ground Stations

Digital Chart Recorders

Glenda Project also utilizes sensors combined with ground based laptops to provide a digital based chart record of ground conditions mapped over time.

The example below is a digital chart record of temperature, humidity, barometric pressure and wind speed at a test site.

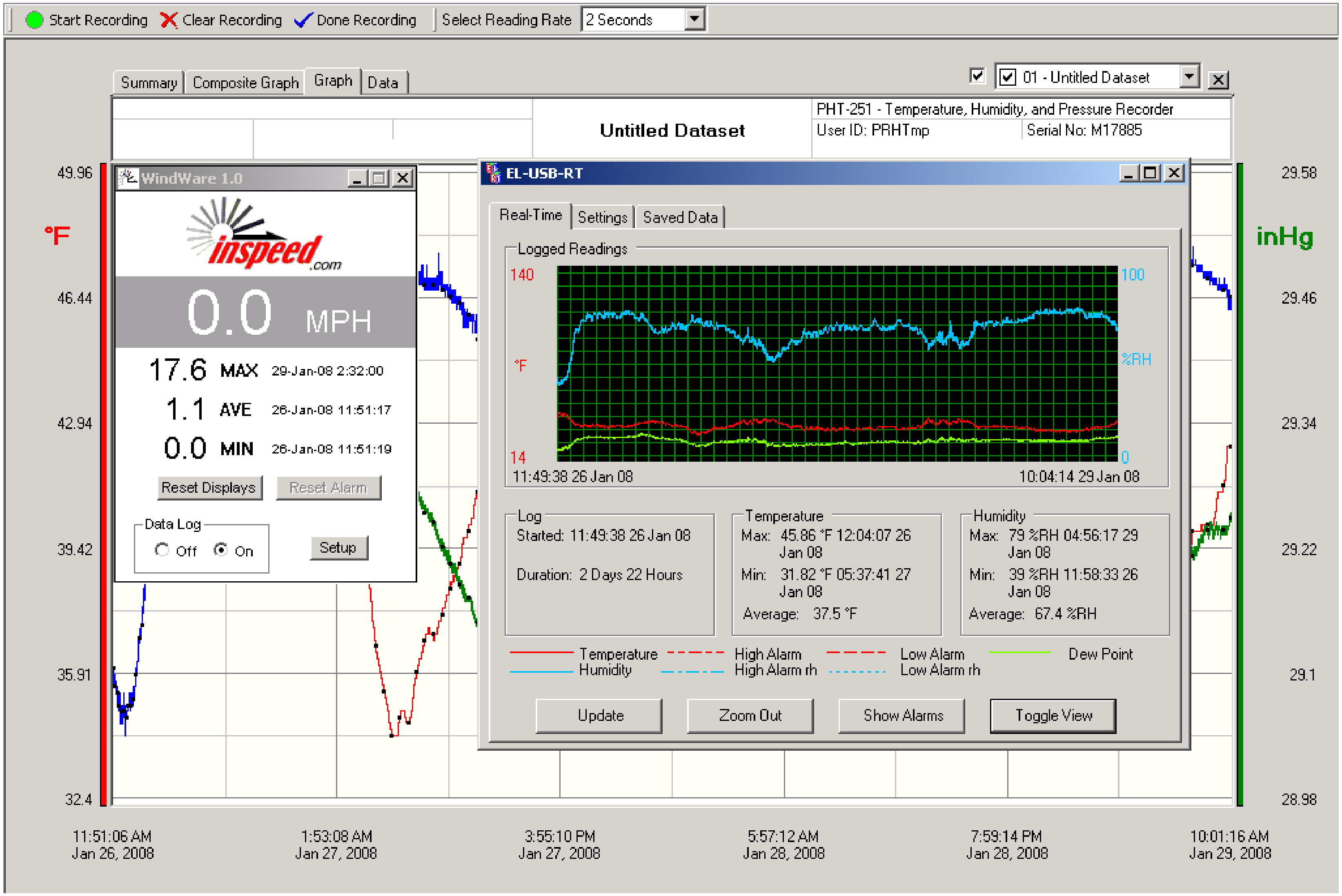


Pressure, Temperature, & Barometric Pressure data stream using Micro-DAQ software and COM 1 port

Wind Speed data using InSpeed Anemometer and supporting software Using COM 3 port via USB port application adapter

Glenda Project – Ground Stations

Digital Chart Recorders - 2008



For 2008, Glenda is now using the Micro-Daq Three channel datalogger, Inspeed anemometer, plus a Lascar Dew Point sensor running on a Thinkpad A20m Pentium III laptop. The Inspeed and Lascar software run in the background collecting data at one second intervals providing wind speed and Dew Point trend data.

Glenda Project – AN/TMQ-34 Ground Station

In March 2005, the Glenda Project obtained a portable military ground weather station. This acquisition further enhances the projects ground condition data collection capabilities.

The TMQ–34 is a military self contained portable weather measuring system that is powered by a rechargeable Ni CAD battery.

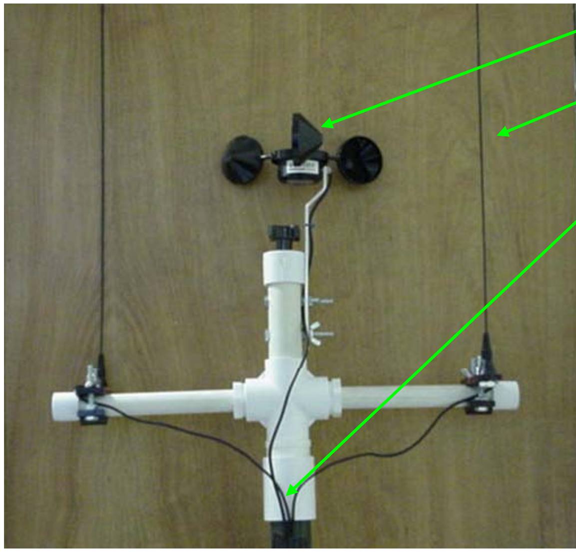
The TMQ–34 alphanumerically displays wind speed and direction, peak wind, temperature, dew point, barometric pressure, 3-hour pressure change, and the minimum and maximum temperature.

The entire TMQ–34, including the system case, weighs about 20 pounds. The set contains a computer module with a pressure sensor, and the main sensor module with a red sensor for temperature, a white sensor for humidity, a wind direction compass, and an anemometer to measure wind speed.

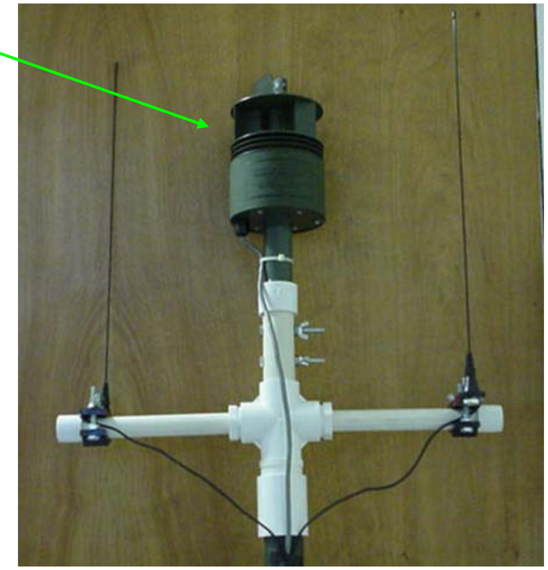
The TMQ–34 can operate in temperatures ranging from a low of –59.5°F to 132°F. The TMQ–34 is intended for use in a tactical environment with an operating range of 100 feet below sea level to 10,000 feet above sea level.

Glenda Mobile Ground Station and Mast System

<u>Removable / Adaptable Mast Sensor Head</u>

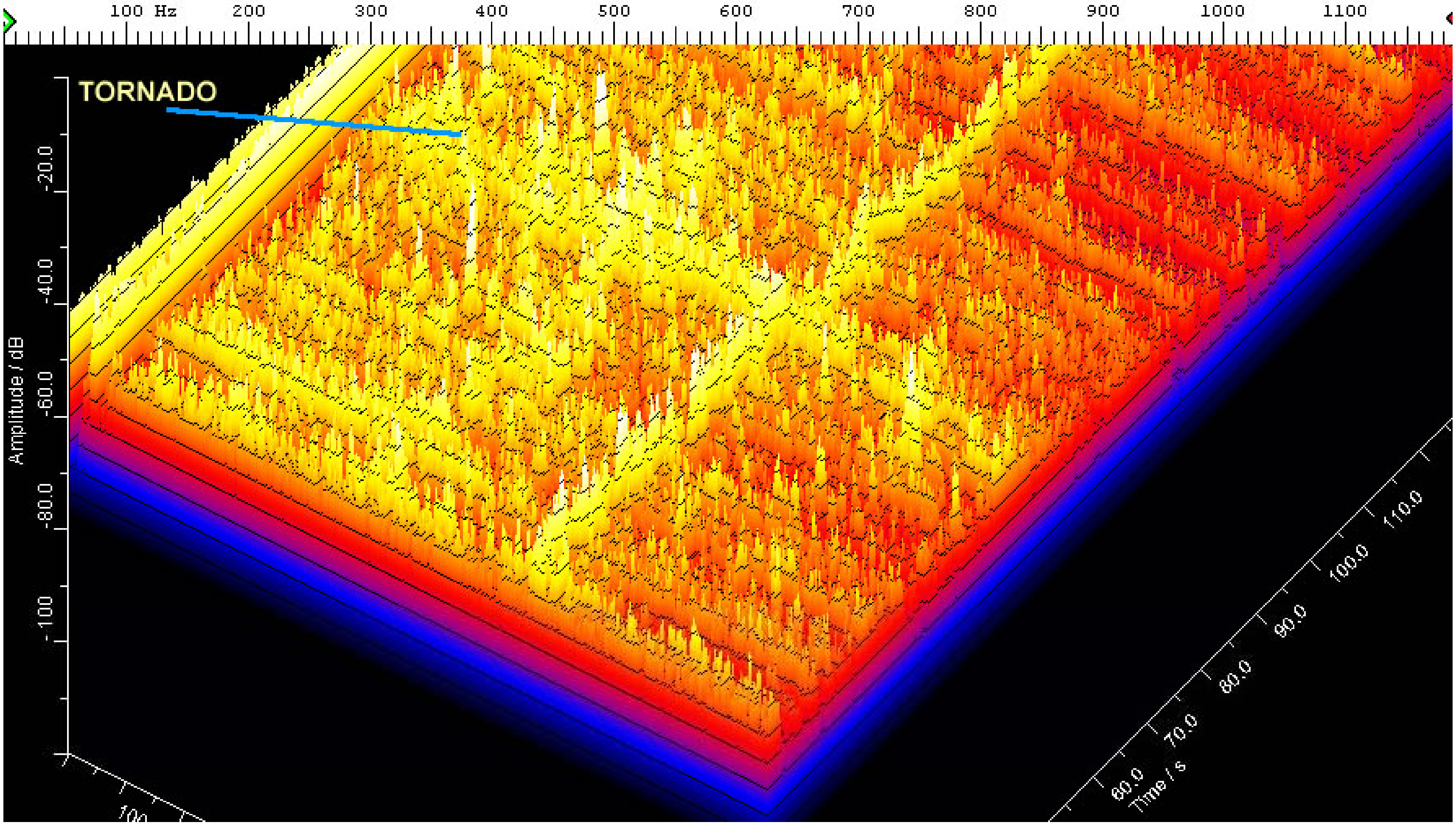


- In-Speed Anemometer / TMQ-34 Sensor
- Two Wide Band Receiver Antennas for Radiosonde telemetry signals.
- Mast System Interface Adapter
- Light weight PVC construction to reduce potential for lightning strike
- Antennas with 1.2 GHz capability allows multiple frequencies and multiple radiosonde reception
- Mast head integrates with man portable mast system



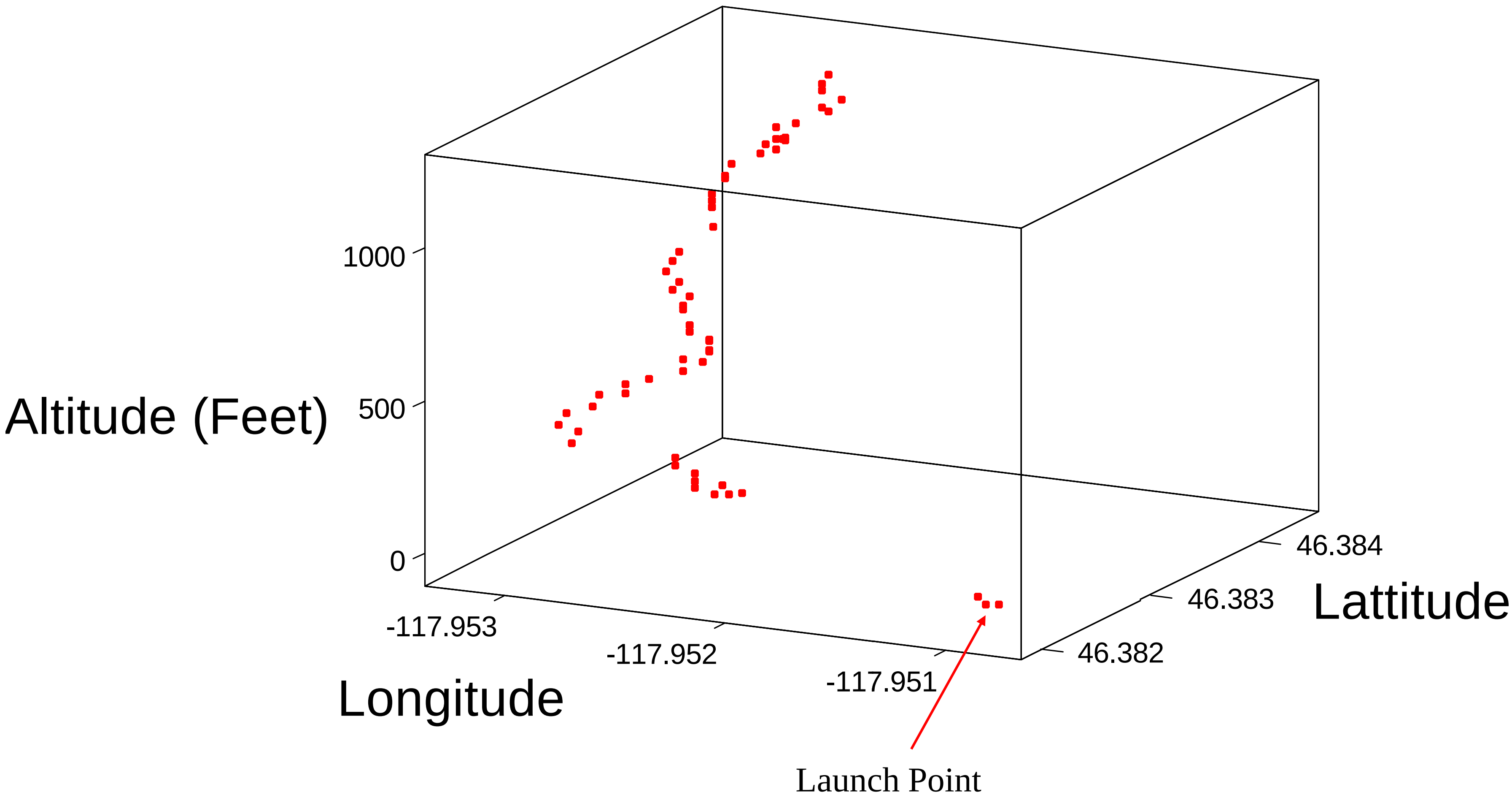
Glenda Project – EMF Spectral Mapping

Combining Glenda computing and sensors allows the capability for advanced analysis and detection. Shown below is a 3D EMF analysis of a tornado based off of a three second data capture. The circular effects of the funnel are easily visible and provide a snap shot of the electrical activity around a tornado.



Glenda Project – Wind Velocity Profiling

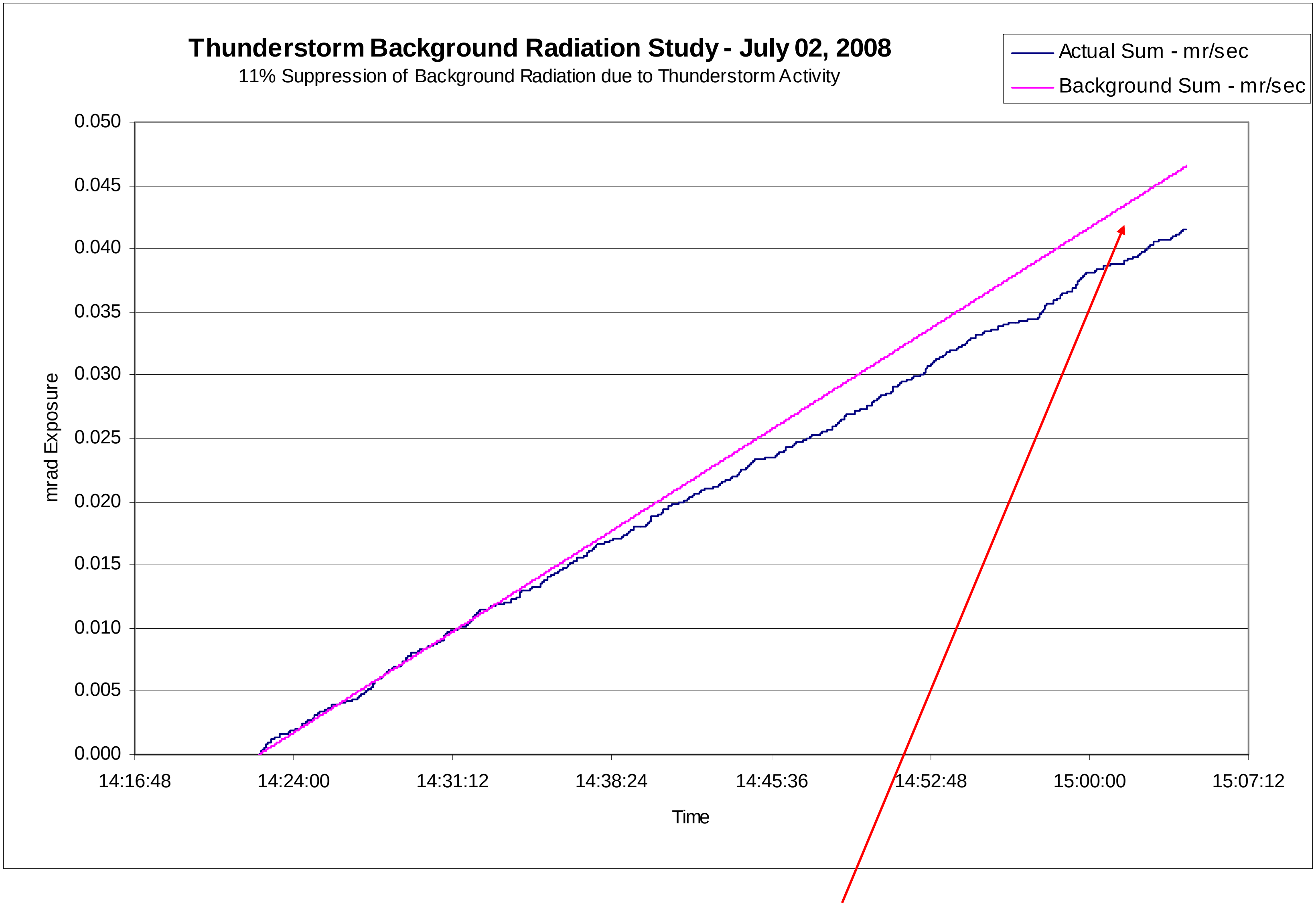
An Active GPS Payload tracks motion of a capsule over a site location in three dimensions



GPS functionality allows capsule tracking plus wind velocity determination capabilities

Glenda Project – Gamma Radiation Studies

Data collection capability of Gamma Ray Radiation during Thunderstorms



During this extensive Thunderstorm, lightning suppressed the “background” gamma radiation count by 11 percent

Glenda Project – "Ranger Intercept" Video Payload

Glenda has developed an operational on-board video capture payload capability in order to compare visual storm characteristics to other collected sensory data.

Video Payload Capsule Attributes:

- 40 Second Video Capture Capability
- 9 Frames per second Capture Rate
- 24 Bit Video Resolution
- Operable in both high and low light conditions
- Parachute Recovery
- Adaptable across multiple Glenda boosters
- Video downloadable in the field to laptop computers

Glenda Project – “Ranger Intercept” Video Payload

May 6th, 2007 – Redmond, WA – A typical flight towards an incoming storm center.

1. Launch

2. Mid - Boost

3. Apogee

4. Descent

5. Landing

Glenda Project – Chase Teams

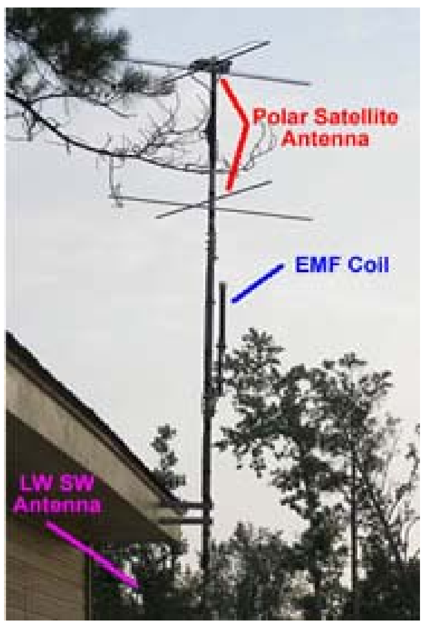
In order to obtain data from dynamic weather phenomena it is necessary to seek out and intercept storms and to launch sensors into the heart of the disturbance, capture the data, and return the data for immediate processing and analysis. Hence the name, Chase Team.

The Chase Teams utilize Jeep Grand Cherokee 4 wheel drive units, equipped with specialized tires and suspension to handle road debris situations and evasive maneuvers while on the go. When storm data is required, the teams immediately equip the jeeps with instrument packages and laptop computers inside the vehicle and attach to the roof, weather instrumentation, satellite dishes, sensors and communication gear. Portable rocket launching stands and weather rockets are loaded into the back of the jeep. Transforming from a standard jeep to a fully operational weather pursuit vehicle takes as little as five minutes.

Glenda Project – Pullman Point Research Facility

The Pullman Point Weather Research Facility is located in Petal, Mississippi, roughly 60 miles north of the Gulf of Mexico.

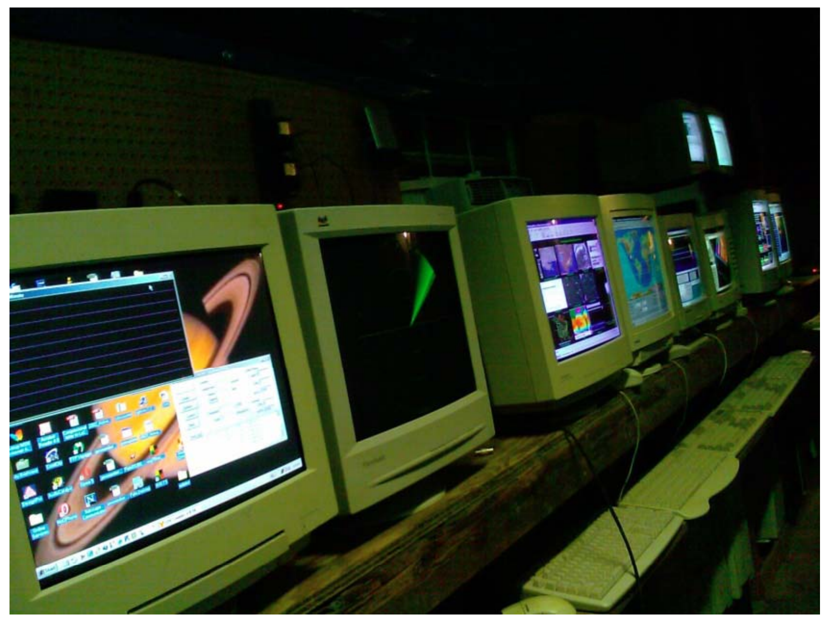
The Facility houses instrumentation that is a combination of old school analog, as well as, state of the art digital that is exclusive to less than a half dozen operations in the continental United States and the most advanced privately owned instrumentation in Southern Mississippi.



Glenda Project – Pullman Point Research Facility

Data is acquired and network backup communication systems are in place with an eight dish satellite antenna array located onsite.

Backed with an onsite super computing cluster and multi mode communication links with the outside world we supply information in live time for the purposes of research and learning. The facility is linked by networks to additional computing clusters in Moses Lake, Washington and server farms in New York, NY



Glenda Project – Engineering / Computing

David Davis – Edmonds, WA - Launch Operations Director - Brings decades of experience from engineering work in private industry and United States government in rocket research, and aerospace. Extensive background in electronics, mechanics, communications, computing, and storm chasing. Member of the National Association of Rocketry since 1983, and been involved with hobby related rocketry since the 1960’s.

Robert Pullman – Petal, MS - Long Range Sensor Development - Has three decades of experience in communication and the computer industry and his expertise is world renown. His work has enabled governments to formulate policies and legislation in international, national and local forums. He has developed products that are used by universities for seminars, by corporations for internal operations to meet government regulations, by scientists for research work in field and laboratory conditions, by government departments for device operations and maintenance, and by the military for use in battlefield activities.

Glenda Project – Media Communications / Public Relations

As the Glenda Project matured, a definite need became apparent for an individual with media communications skills and public relations.

Tim Quigg in Dayton, WA brings a unique mix of personal background and professional experience to the Glenda Project. Quigg has over two decades of experience in customer service and media relations. He has been the Assistant Editor of Extreme Rocketry Magazine since 2000, as well as a freelance writer of numerous articles for Sport Rocketry Magazine. He is a current member of the National Association of Rocketry, and is the 2001 recipient of the National Association of Rocketry's President's Award, in recognition of his work with youth in model rocketry on a national level. Quigg is a highly decorated 24-year veteran of law enforcement, and is currently the Senior Communications Officer at a Southeastern Washington State E911 Communications Center.

Glenda Project – Application - Dayton, WA

"Lone Tree" Launch Site – Microclimate Profiling in Motion

"Lone Tree" Launch Site – Dayton, WA

Glenda Project – Dayton, WA

“Lone Tree” Launch Site – Background

The Blue Mountain Rocketeers (BMR), a youth based rocketry club, initiated launches at the “Lone Tree” site in 2000, and immediately noticed a bizarre behavior that when rockets were flown above 1,500 feet, that during recovery, they were blown by apparent high winds towards the direction of the gravel perimeter road located at the northern edge of the launch site even though ground wind speed was at a minimum.

Prior to BMR’s use of the site, “Lone Tree” was also used as a runway by local crop dusters who also noticed this effect as well and were able to fly with heavier loads of agricultural sprays due to the increased winds at altitude.

The Glenda Project saw this effect as an opportunity to test out various sensors and provide wind velocity mapping data to BMR in support of the National Association of Rocketry (NAR) safety code requirement of assurance of recovery of all high powered rockets within the fields boundaries.

Glenda Project – Thermal Mapping Mission

September 25, 2004 Columbia County / Dayton, Washington

During September 2004, Glenda performed a thermal mapping mission using a chart recording ground station, and both active and passive payloads.

The purpose of these two flights was to confirm, or refute the existence of a region of thermal activity over the "Lone Tree" launch site.

The first rocket sounding employed the Glenda 98mm capsule lofting an active transmitting payload broadcasting temperature, relative humidity and barometric pressure data to the ground station.

The second sounding flight was made using the Glenda 54mm capsule carrying a passive payload recording temperature and relative humidity.

Glenda Project – Thermal Mapping Mission

September 25, 2004 Columbia County / Dayton, Washington

At the time of the Glenda flights, the ground temperature was around 80 degrees, with a Relative Humidity around 37-38%. Under the standard atmospheric model, temperature goes down, as does humidity as you increase in altitude.

At “Lone Tree”, this was not the case.

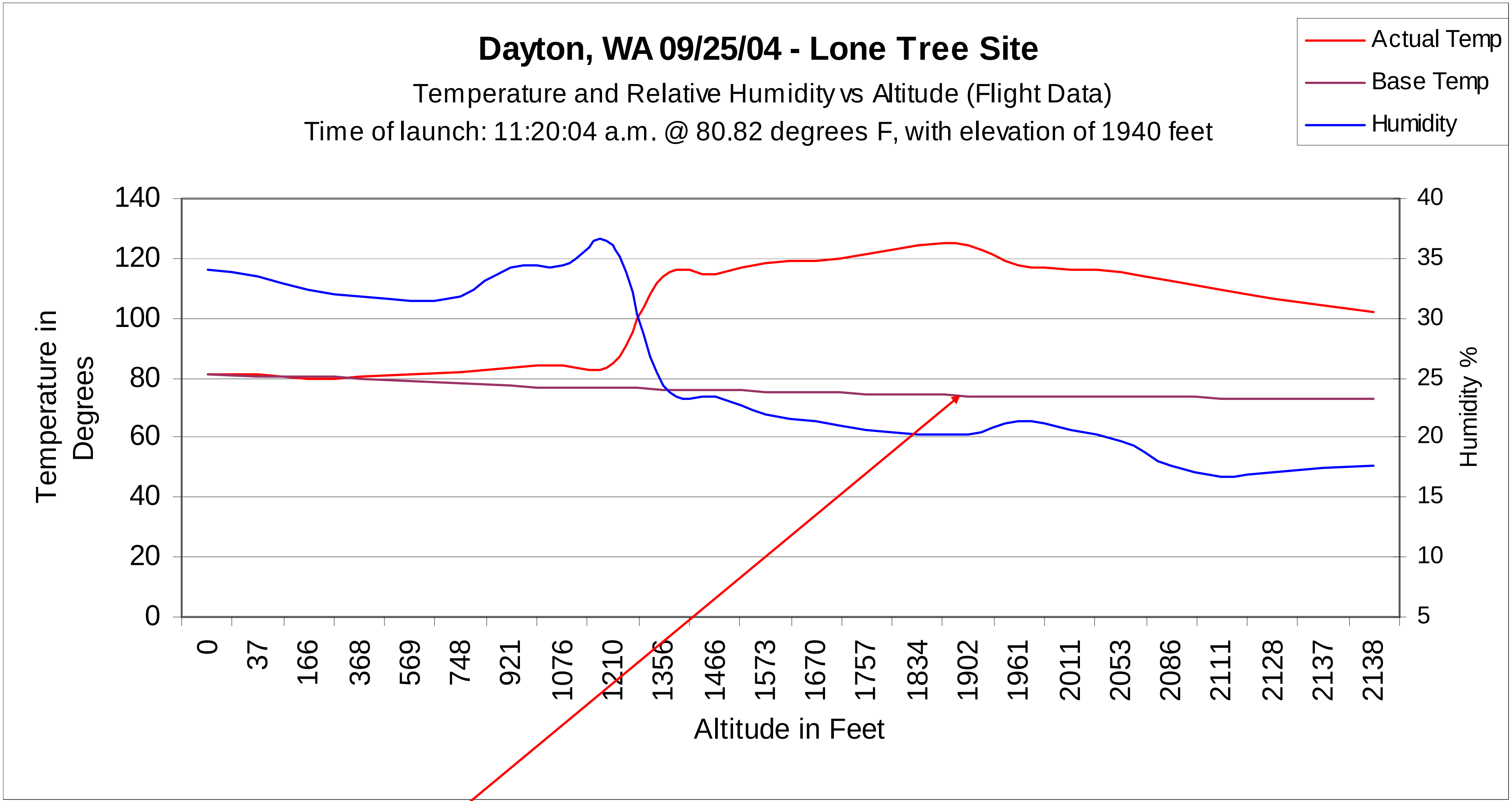
Temperature and humidity stayed relatively constant until 1,300 – 1,400 feet. Then things got interesting. The temperature rose rapidly, and the humidity level dropped. The sensors detected a 500 foot layer of hot, dry air which topped over 124 degrees at 11:00 in the morning. That's a 40+ degree difference from ground conditions. As the sensors penetrated the layer, more "normal" readings were detected.

The data between the two flights supported one another and have provided a body of evidence proving the existence of a thermal layer above the launch site.

The mapping mission was a success and the results are shown on the following slide.

Glenda Project – Thermal Mapping Mission

September 25, 2004 Columbia County / Dayton, Washington



Projected Temperature based on Standard Atmospheric Model – Something definitely out of the ordinary is happening!

Glenda Project – Thermal Mapping Mission

September 14, 2008 Columbia County / Dayton, Washington

Four years later in September 2008, the Glenda Project took this investigation to the next level by flying a hybrid payload containing a GPS transmitter to measure wind velocity, and a datalogger to measure temperature and RH.

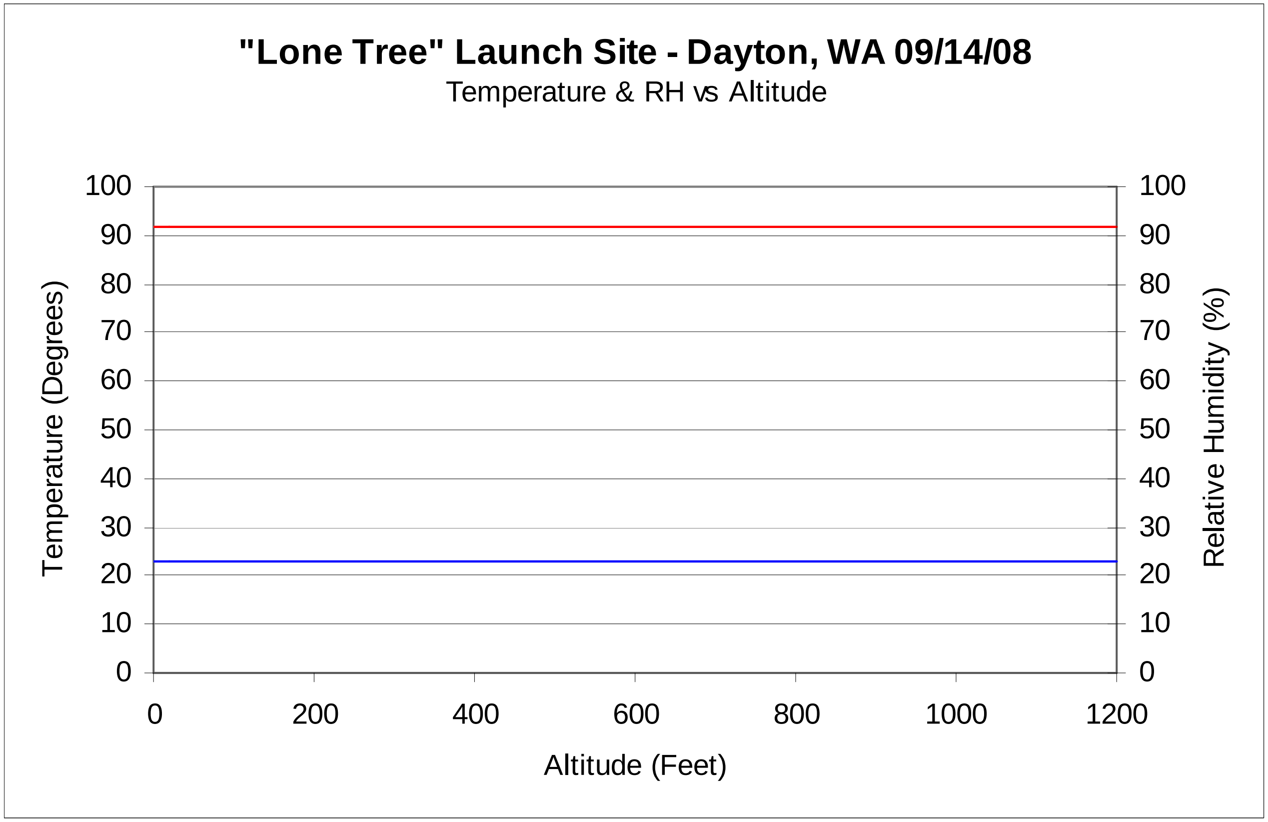
The most significant difference between the 2004 and 2008 flights was in the condition of the launch site. In 2004, the site was sown in Alfalfa and was uncut. In 2008, the site was still in Alfalfa. However, it had been freshly cut and bailed. It was unknown how this would effect the atmospheric conditions above the launch site.

The differences between the temperature vs. altitudes between 2004 and 2008 were striking. In 2008, with the cut field, the air temperatures remained constant through the capsules decent envelope.

The 2008 temperature and RH data vs. altitude chart is shown in the next slide.

Glenda Project – Thermal Mapping Mission

September 14, 2008 Columbia County / Dayton, Washington



Glenda 5475 Booster takes flight

A distinct difference between a cut and an uncut field on air temperature and humidity!

Glenda Project – Wind Velocity Profiling

September 14, 2008 Columbia County / Dayton, Washington

This "cut" condition effected the wind velocity vs. altitude as well.

An area of calm air existed between 1,200 feet when wind velocity measurement commenced, and 800 feet when changes to wind speed and direction occurred.

The advantage of GPS capsule positioning is that the Glenda capsule can rapidly detect changes aloft, transmit them to the ground station, then map these changes in multiple dimensions.

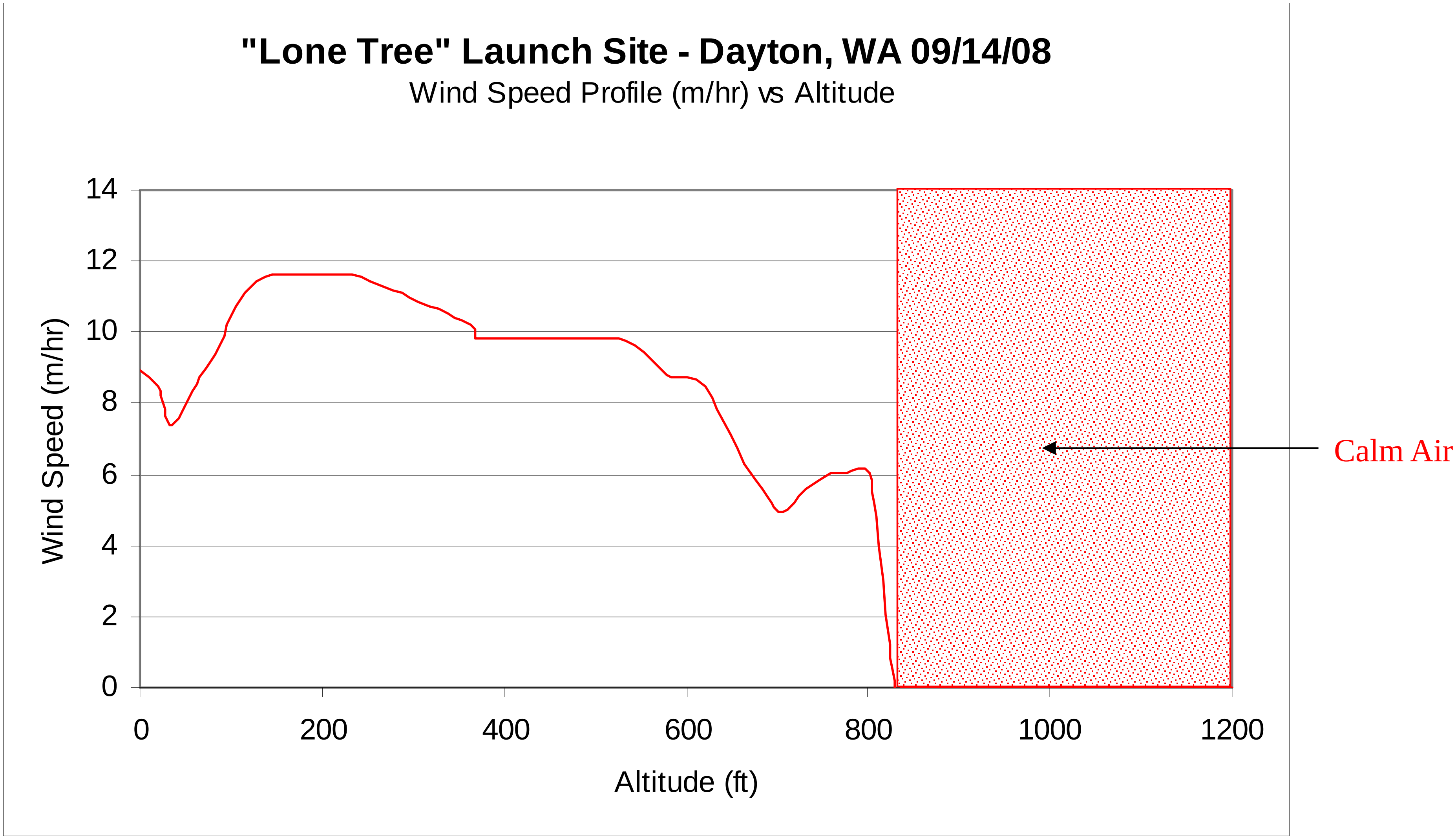
Wind velocity and capsule positioning are shown in the following two charts.

Glenda 75mm Capsule

Glenda 54mm Booster

Glenda Project – Wind Velocity Profiling

September 14, 2008 Columbia County / Dayton, Washington

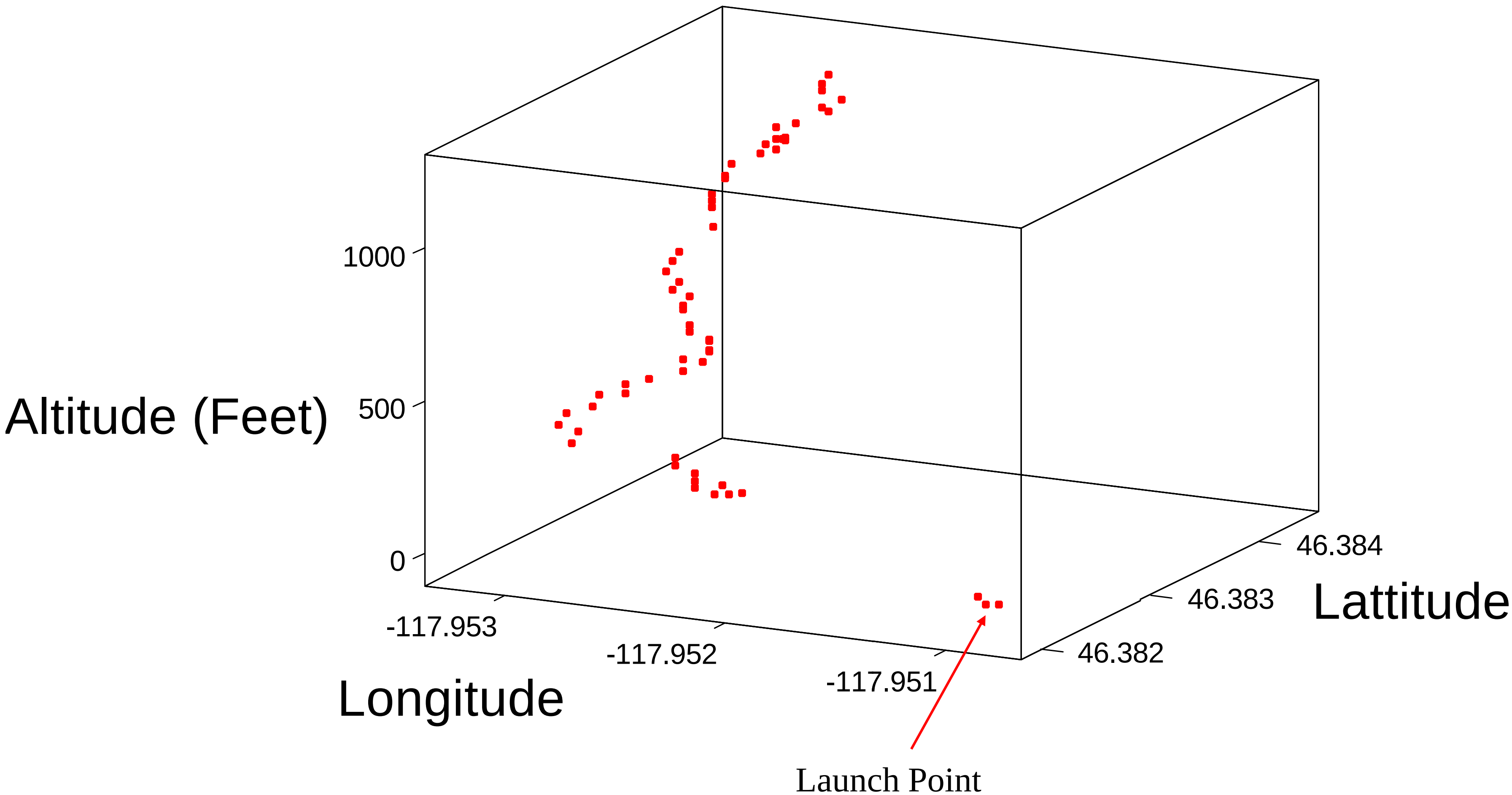


Insignificant wind speed from 800 to 1,200 feet

Glenda Project – Wind Velocity Profiling

September 14, 2008 Columbia County / Dayton, Washington

Active GPS Payload tracks motion of the capsule over the launch site in three dimensions



GPS functionality allows capsule tracking plus wind velocity determination capabilities

Glenda Project – Dayton, WA

"Lone Tree" Launch Site – Preliminary Findings

- A cut Alfalfa field has a significant positive impact on reducing air temperatures and wind speeds above the launch site.

- As air temperatures are reduced above the launch site, updrafts and turbulence are reduced as well, reducing the possibility of vehicle recovery outside of the field perimeter creating a safer launch environment.

- It is recommended that BMR have the alfalfa cut prior to launch operations in order to mitigate the evaporative effects of the alfalfa creating the increased temperature inversions and the associated wind speeds.

- Additional hybrid payload flights containing both dataloggers and GPS be made in order to study the effects various temperature ranges and field conditions have on the thicknesses, wind velocities and temperatures of the inversion layers above the launch site.

Glenda Project – Accomplishments

Maturing Payloads & Systems – Preparing for the "Wall Cloud" Mapping Mission

Glenda Project – 2007 / 2008 Accomplishments

- July 2008 – Deployed Gamma Ray sensor and determined that Thunderstorms suppressed "background" radiation counts.

- September 2008 – First Flight of the GPS Wind Velocity payload which allows 3D mapping capability of storm systems

- October 2007 - Edmonds, WA ground station operational as additional facility for sensor testing.

- May 2007 – The new "Ranger Intercept" research rocket was successfully launched into a storm front and captured live video which was downloaded to a ground station laptop.

- May 2007 – In conjunction with the Blue Mountain Rocketeers, participated in the National Weather Service (Pendleton, OR) open house in celebration of the 200th birthday of the NOAA. There was a great deal of interest in the project, with multiple presentations during the day including overviews of the project, its capabilities, and demonstrating various aspects of the weather payloads and the ground support equipment.

- Feb - June 2007 – Conducted several "Train the Trainer" courses in severe weather and storm spotting for Emergency Management in Mississippi and the Gulf Coast.

Accomplishments and Operational Capabilities

- EMF detection in 2D with a 500 mile range; plus EMF detection in 3D with the ability to catch the electronic signature of a tornado.

- Magnetic and electrical monitoring system - the only private one in Mississippi (only 6 commercial units in the country)

- Holder of Patent Number 60/903,881 - Multi-Dimensional Data Models for Tornado Prediction

- Local and regional weather information going out on the internet, full weather data on APRS over the air over the southeast of the country.

- Multiple chase vehicles that can do full weather analysis, soil analysis, and radiation measurement

- Mobile and stationary ground stations that can conduct weather measurements and monitor radiation levels.

- Weather Sounding Rocket payload launch capability with multiple sensors.

- Full satellite and weather data reception and analysis, with licensed radio operators and facilities that can communicate around the world; weather forecasts available on servers, and radio gateways that run 24 hours a day, 7 days a week non-stop - at no charge to the end users. The information is used by Emergency management crews in 5 Mississippi counties, as well as multiple radio and television stations and Fortune 500 companies.

Glenda Project - Advantages

- Portability and Rapid Deployment with “Launch on the Run” capability
- Ease of Use of propellant and vehicle/payload preparation
- Payload adaptable for external sensors to match user specific applications
- Composite components designed for extreme environments
- On-board locater transmitter allows for rapid recovery
- Off-the-shelf components reduce operating costs and ease repair

Glenda Project - Disadvantages

- Training required for system use, data collection and analysis
- Composite materials are not bio-degradable
- Rocket motors are “Hazardous Materials” and are classified as Flammable Solids 4.1, or 1.4c and 1.3c Explosives
- Multiple sensors required to support complex analysis
- Active Payloads require ground stations for ground condition baseline data collection, data reduction and analysis

Glenda Project - Available

The Glenda Project has reached the level of maturity where we can offer portions for sale to end users based on their mission requirements.

Due to the nature of today's political environment, anyone expressing interest in a Glenda system should be capable of passing a federal background check because of the propellant system used in our boosters. Without having the appropriate permits, we cannot help you with your request. However, we can help guide you through the permitting process and other regulations which govern the use of Glenda systems.

The Glenda Project is constantly testing new sensors and new attributes. Let us know of your mission and budget requirements and we can help you develop the optimal design approach at the best value for your investment.

In Conclusion

The Glenda Project is a reusable sounding rocket delivery system designed to place instrument packages into areas previously considered to be to hazardous or inaccessible using traditional platforms such as balloons, aircraft, helicopters, kites, etc.

Through 2004 and 2005, Glenda completed its first successful mapping missions and during 2006, the ground station and payloads continued to mature in order to prepare to further extend the flight envelope to even more hazardous environments.

2007 brought continued maturing of sensors and first flight of “Ranger Intercept”.

The 2008 series of launches allowed full testing of the GPS tracking and wind velocity capability, and returned even more valuable data.

The operational Glenda Project shows the differences between Hollywood “fiction”, and engineering “fact”, from mapping local environments to a full tornadic funnel with a suite of sensors. Glenda is up to the task.

Glenda Project – Executive Summary - 2010

Glenda Project – Purpose

The primary mission of the Glenda Project is to provide the capability to rapidly gather previously inaccessible localized microclimate data from altitudes ranging from ground level to 20,000 feet and to return this data for immediate use.

The Glenda Project is mix of adaptable ground stations combined with a reusable sounding rocket delivery system designed to place instrument packages into areas previously considered to be to hazardous or inaccessible using traditional platforms such as balloons, aircraft, helicopters, kites, etc.

Glenda Project – Data Capabilities

The Glenda Project has the capability to collect temperature, humidity, barometric pressure, wind speed and other types of environmental data from ground level to 20,000 feet.

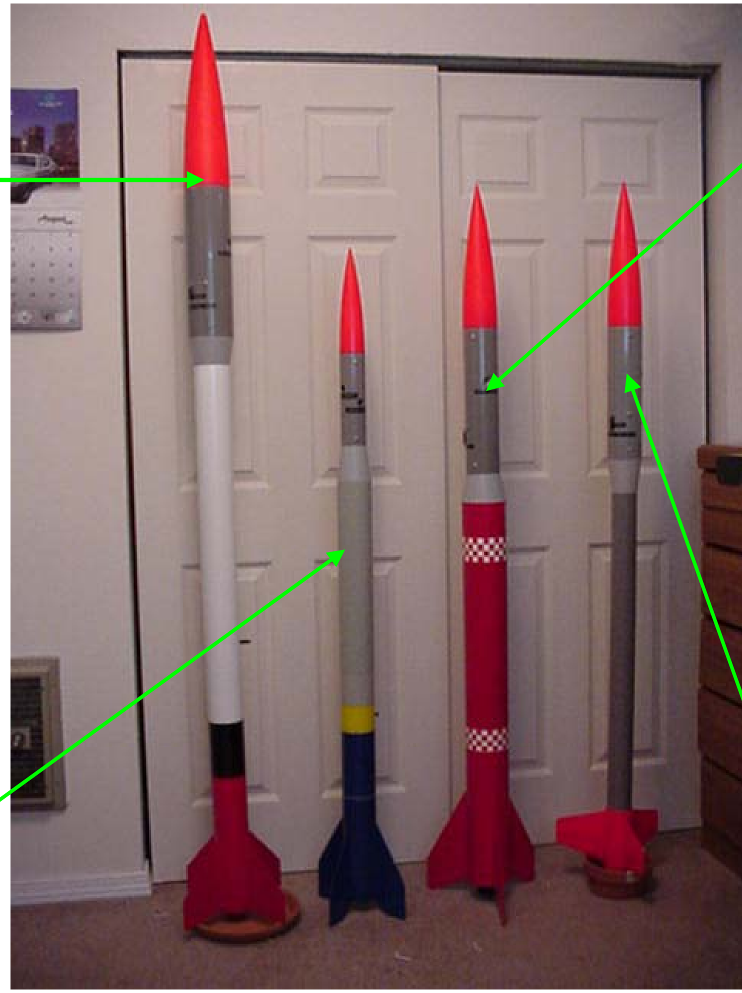
Glenda payloads are designed to be launched into thunderstorms, tornados, and other volatile weather environments and to return intact with its collected data.

Glenda Project – Data Collection Methods

Glenda has three primary methods of collecting data:

- Rocket Launched - Active Flight Data Collection Systems - Transmitters
- Rocket Launched - Passive Flight Data Collection Systems – Dataloggers
- Ground Stations

Glenda Project – Typical Flight Vehicles



7598 Booster

- 3” diameter booster, 4” diameter capsule
- RS80 Radiosonde Payload
- 3,000 to 20,000 ft altitude envelope

9875 Booster

- 4” diameter booster, 3” diameter capsule
- RS92 Digital Radiosonde Payload with GPS
- Temp / RH Datalogger
- 2,000 to 15,000 ft altitude envelope

FAR 101 Booster

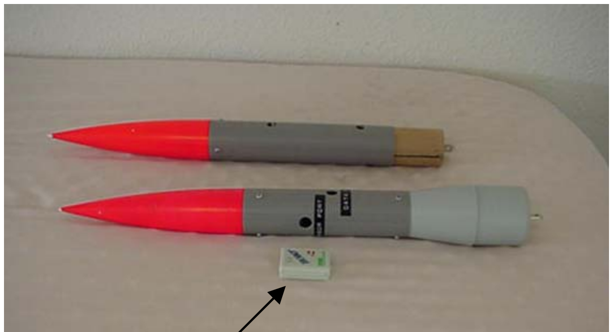
- 3” diameter booster, 2.125” diameter capsule
- Temp / RH Datalogger Payload
- 2,000 foot altitude envelope

5475 Booster

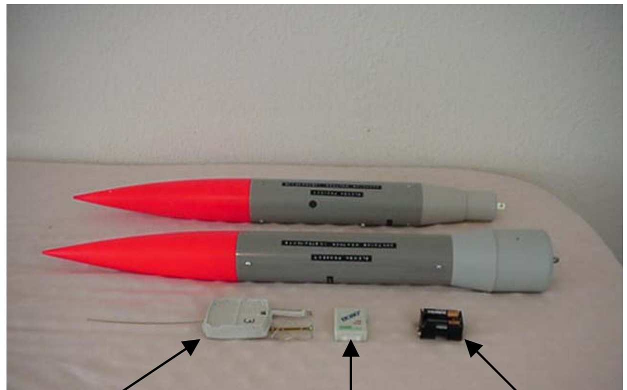
- 2.125” diameter booster, 3” diameter capsule
- RS92 Digital Radiosonde Payload with GPS
- Temp / RH Datalogger
- 2,000 to 15,000 ft altitude envelope

Glenda Project – Typical Flight Payloads

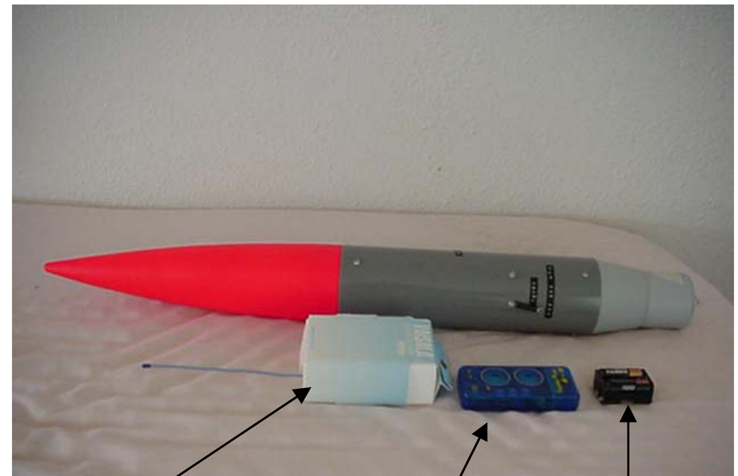
The Glenda project uses several different payload capsule configurations carrying a variety of instrumentation in order to gain weather related information, and other micro-climate data



Datalogger



RS92 Digital Radiosonde Datalogger Battery Pack



RS80 Analog Radiosonde Locator Beacon Battery Pack

54mm (2.125") Capsules

- Datalogger Payloads
- Measures Temperature & RH values at 1 second intervals.
- Used by 54mm & 75mm boosters.

75mm (3") Capsules

- Datalogger Payloads
- Measures Temperature & RH values at 1 second intervals.
- RS92 Digital Radiosondes transmitting temperature, RH, barometric pressure, and GPS coordinates.
- Used by 54mm & 98mm boosters.

98mm (4") Capsule

- RS80 Analog Radiosonde transmitting temperature, RH, and barometric pressure.
- Audio location beacon
- Used by 75mm boosters.

Glenda Project – Typical Flight Profile

2 – Boost Phase

3 – Deployment Phase

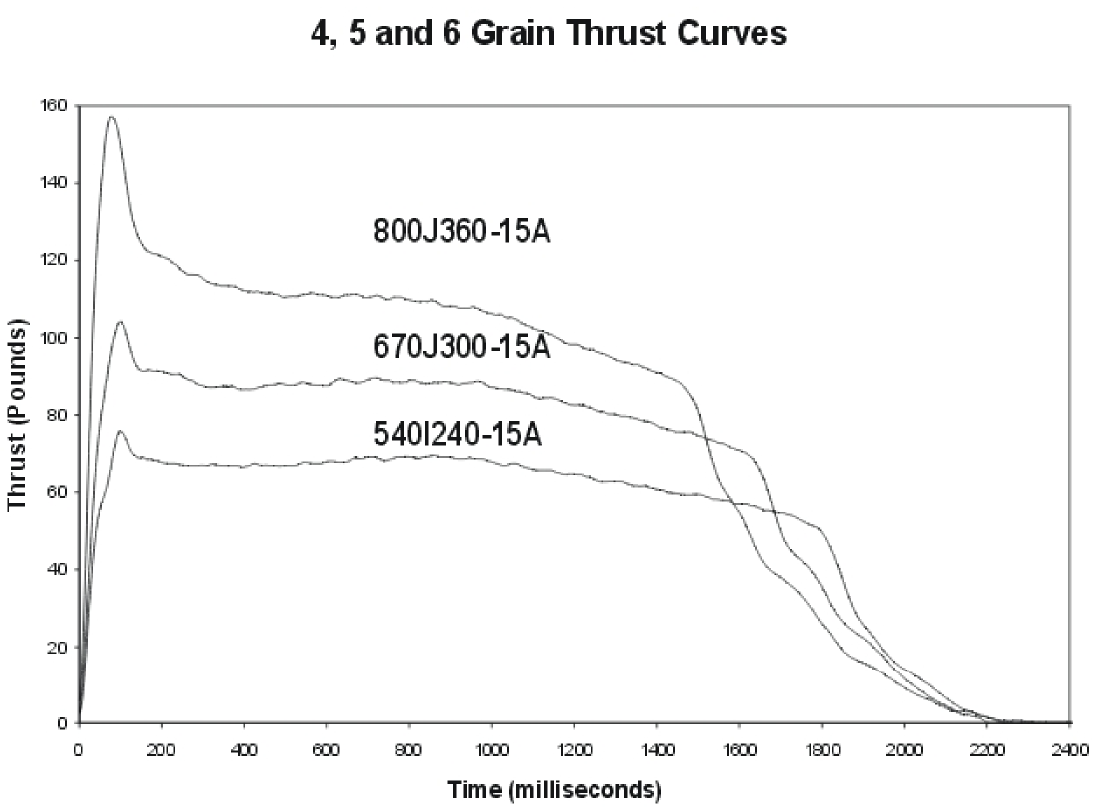
1 – Launch Phase

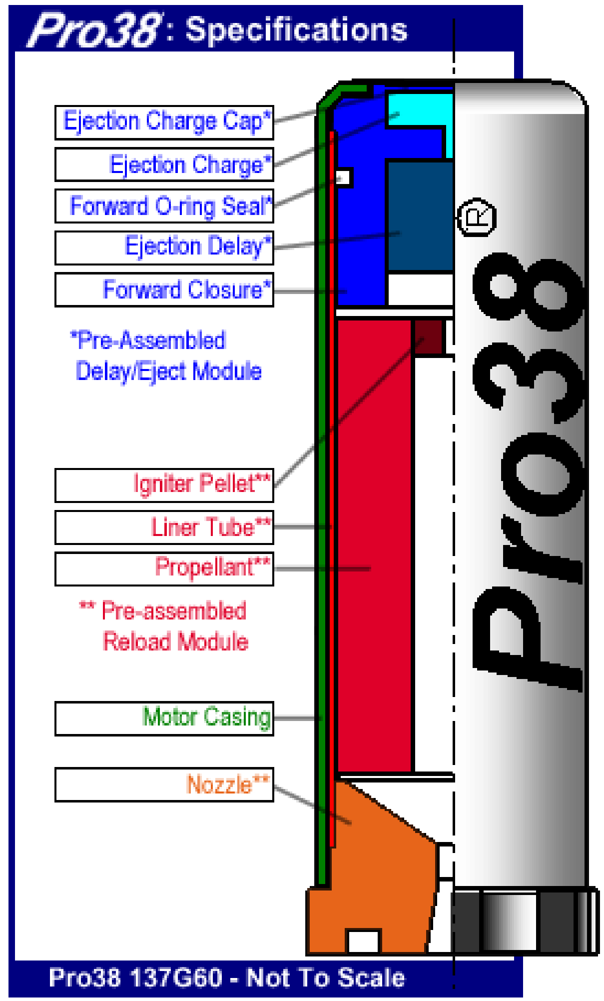
Note: Propulsion is provided by reloadable /reusable rocket motors giving the capability of rapid turnaround between flights.

4 – Recovery Phase

Glenda Project – Propulsion

The Pro38 rocket motor propulsion system is the first commercial thermoplastic propellant-based solid rocket motor and is produced by Cesaroni Technology Inc. of Toronto Canada. The Pro38 is a modular, reloadable solid propellant rocket motor system designed primarily for use in launching small experimental payloads by universities, colleges, research institutes and sport rocketry enthusiasts.

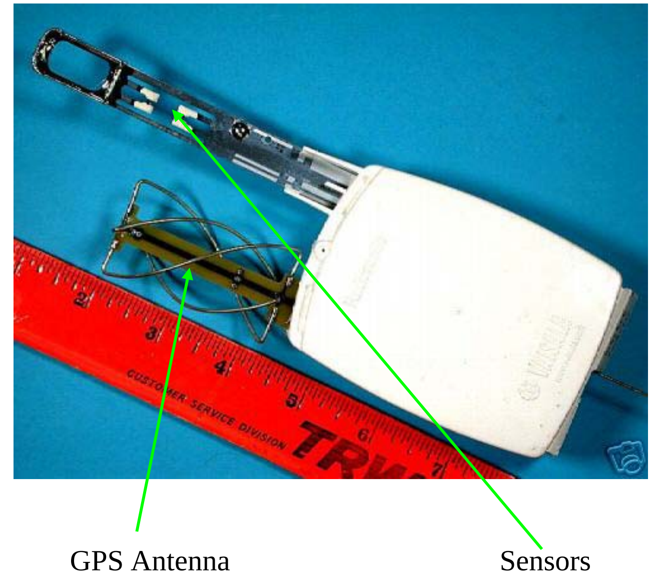




Glenda Project – Active Payloads - Transmitters

Converted Radiosonde Payloads

The Glenda Project uses converted radiosondes that were previously designed for use with weather balloons. The circuitry and sensors function properly under thrust loads of the Glenda boosters and are compatible with NOAA radiosonde receiver systems.



The radiosonde contains instruments capable of making direct measurements of air temperature, humidity and pressure. These observed data are transmitted immediately to the ground station by a radio transmitter located within the instrument package.

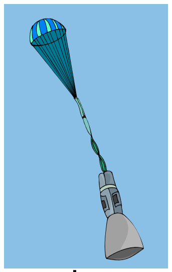

Vaisala RS92 Radiosonde

Radiosonde Specifications:

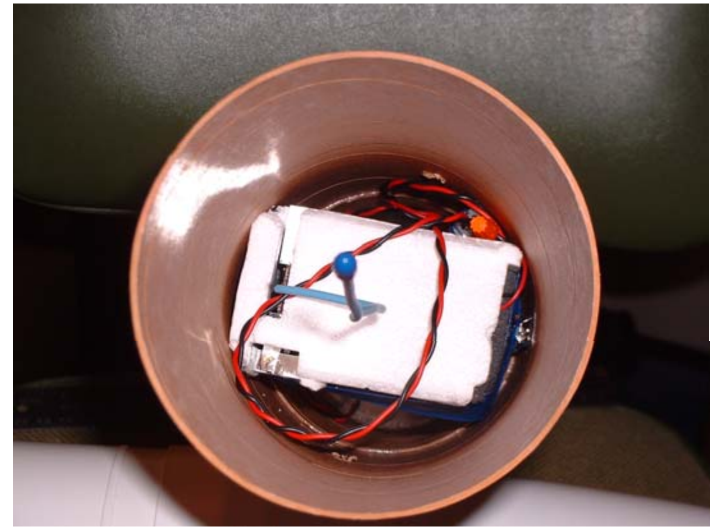
- Pressure range 3mb to 1060mb +/- .1mb
- Operating temperature range of -90°C to +60°C
- Relative Humidity from 0 to 100%
- Sampling Rate of once per second for the sensor suite
- Provides positioning data via GPS for payload location and wind velocity

Glenda Project – Active Payloads - Transmitters

Signal Processing Flow Diagram

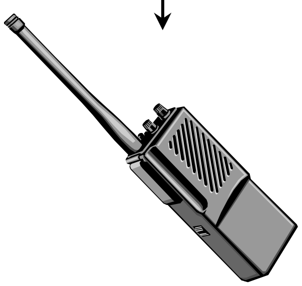


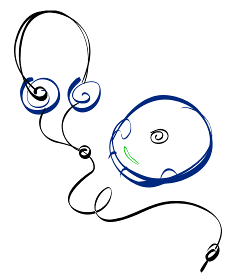
- Barometric Pressure Sensor Data
- Temperature Sensor Data
- Relative Humidity Sensor Data
- GPS - Payload Position Data



Active Payload cushioned within the flight capsule

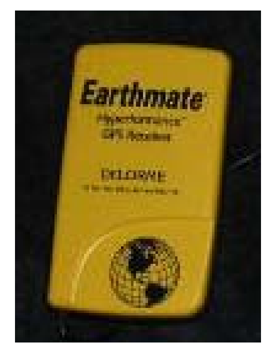
Sensor Data Transmitted to Ground Receiver





Sensor Data Digitally Recorded

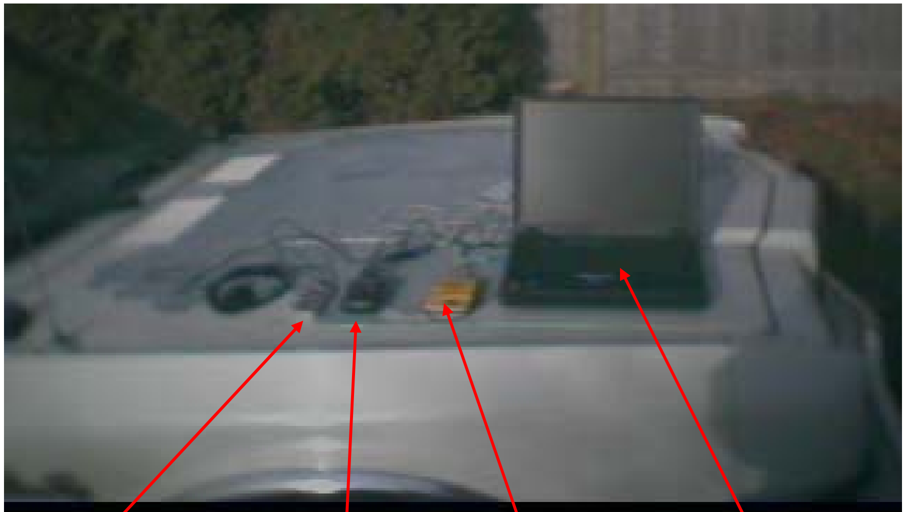
Data recorded into Laptop for analysis



GPS – Ground Station Position Data

Glenda Project – Active Payloads

Ground Station



Digital Recorder

Telemetry Receiver

GPS Receiver

Laptop

Not Shown:

a) Telemetry Receiver Antenna System
b) Laptop External Power Supply

Flight Vehicle

Payload Capsule

Length: 63”
Diameter: 4”
Dry Weight: 3.5 Pounds
Attainable Altitudes: 2,000 feet to 20,000 feet

Glenda Project - Passive Payloads – Dataloggers

A data logger is an electronic instrument that records measurements over time. Typically, data loggers are small, battery-powered devices that are equipped with a microprocessor, data storage and sensors. Most data loggers utilize software on a personal computer to initiate the logger and view the collected data.

Prior to a Glenda launch, the datalogger is connected to a laptop computer. Then, Windows based software is used to select logging parameters (sampling intervals, start time, etc.) and initiate the logger. The logger is then disconnected from the laptop and installed inside the Glenda payload capsule. Upon launch, the logger records each measurement and stores it in memory along with the time and date. Post recovery, the logger is then reconnected to the laptop computer and the software is used again to readout the data and see the measurements as a graph, showing the profile over time. The tabular data can be viewed as well, or exported to a spreadsheet for further manipulation.

Project Glenda Payload – Dataloggers

The Temperature / Relative Humidity datalogger is an example of a typical Glenda data collection device.

<u>Temperature / Relative Humidity Datalogger Specifications:</u>

- Capacity: 7943 measurements total
- User-selectable sampling interval: 0.5 seconds to 9 hours
- Programmable start time/date
- Memory modes: stop when full, wrap-around when full
- Nonvolatile EEPROM memory retains data even if battery fails
- Blinking LED light confirms operation
- User-replaceable battery lasts 1 year
- Battery level indication at launch
- Operating range: -4°F to +158°F (-20°C to +70°C), 0 to 95% relative humidity
- Time accuracy: ±1 minute per week at +68°F (+20°C)
- Size/Weight: 2.4 x 1.9 x 0.8" (68 x 48 x 19 mm)/approx. 1 oz.(29 grams)

Glenda Project – Passive Payloads – Dataloggers

54mm Capsule in Flight Configuration

Here is a typical Glenda payload ready for flight. This capsule contains a tracking locator transmitter, a combination temperature/relative humidity datalogger, and a barometric pressure datalogger. Total payload weight including capsule is less than one pound.

Tracking System Antenna

Datalogger Sensor Port

Additional Payload Tracking Systems

In addition to the GPS tracking capability, and to ensure recovery of the payloads, the Glenda Project has implemented several additional recovery and tracking aids.

To support short range recovery, a 110 db audio alarm can be installed in the payload capsule. The alarm functions independently of the data payload and is activated by its own internal countdown timer. Field tests have shown an effective range of one half mile.

For longer range tracking and recovery, a tracking transmitter is installed in the payload capsule. Field tests have indicated a line of sight tracking distance at over three miles.

110 db audio alarm payload location package

Audio Beacon Sound Sample

Payload tracking transmitter

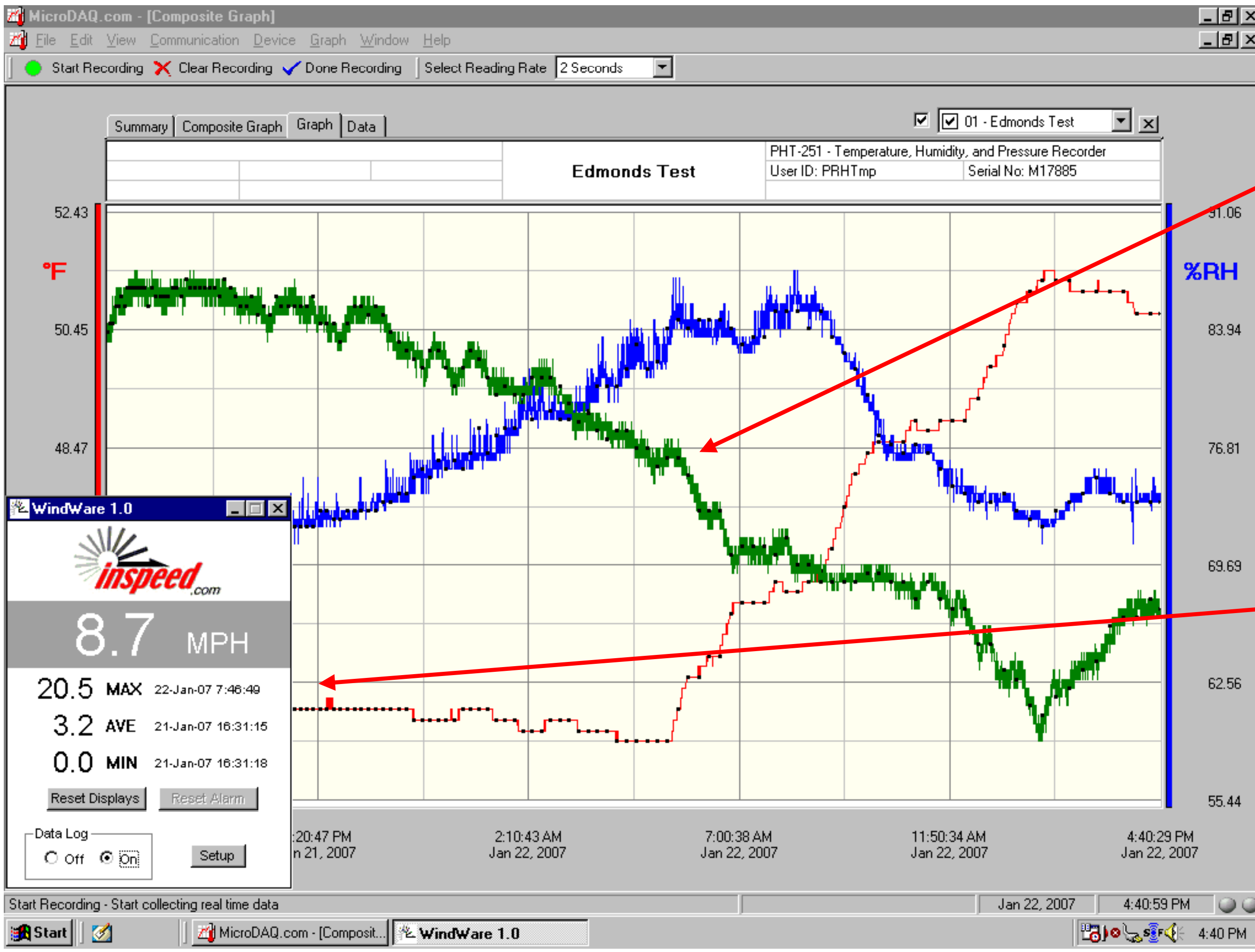
Tracking Transmitter Signal

Glenda Project – Ground Stations

Digital Chart Recorders

Glenda Project also utilizes sensors combined with ground based laptops to provide a digital based chart record of ground baseline conditions mapped over time.

The basic example below is a digital chart record of temperature, humidity, barometric pressure and wind speed at a test site.

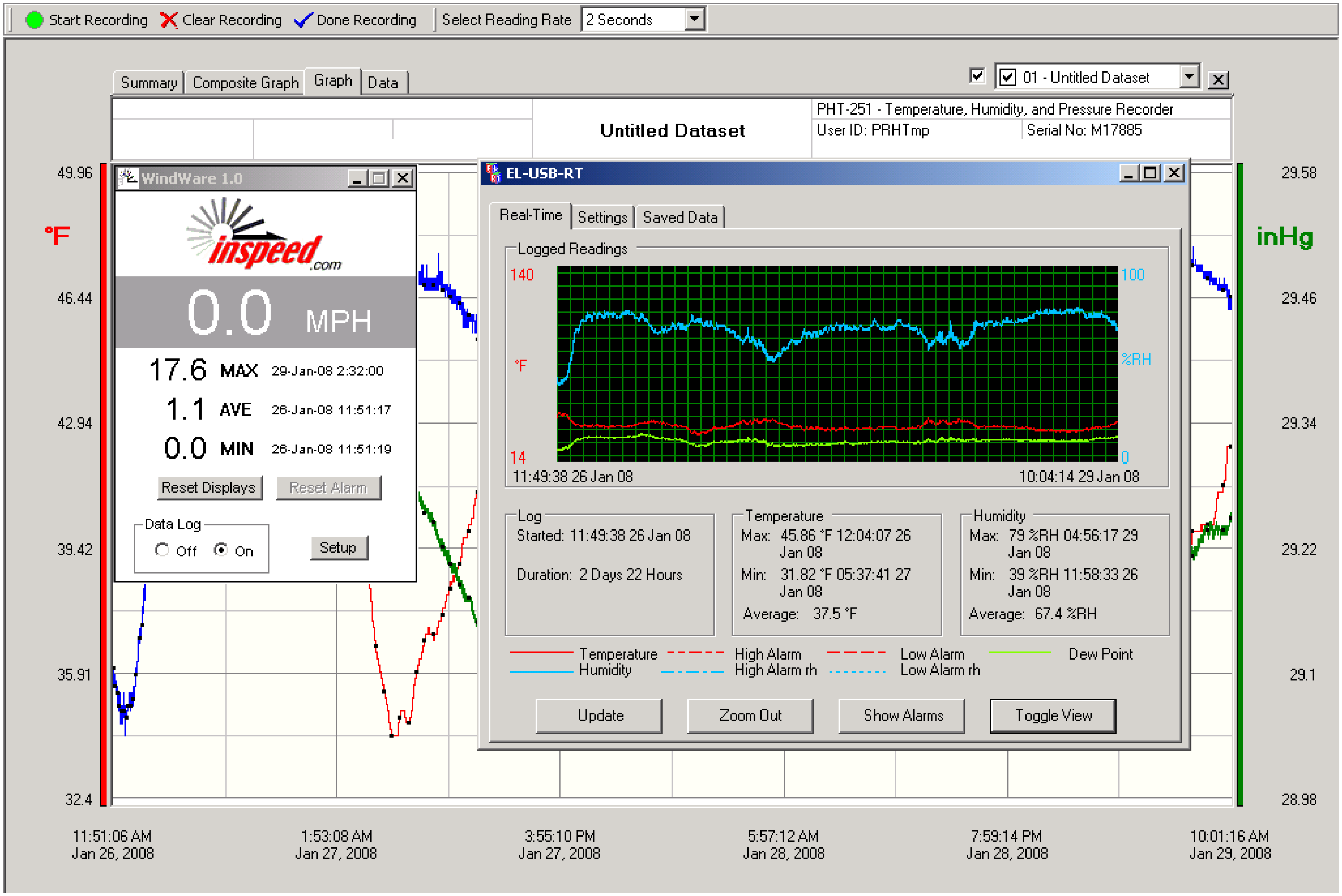


Pressure, Temperature, & Barometric Pressure data stream using Micro-DAQ software and COM 1 port

Wind Speed data using InSpeed Anemometer and supporting software Using COM 3 port via USB port application adapter

Glenda Project – Ground Stations

Digital Chart Recorders - Evolution



Glenda can also use the Micro-Daq Three channel datalogger, Inspeed anemometer, plus a Lascar Dew Point sensor running on a Thinkpad A20m Pentium III laptop. The Inspeed and Lascar software run in the background collecting data at one second intervals providing wind speed and Dew Point trend data.

Project Glenda – Ground Station Maturity

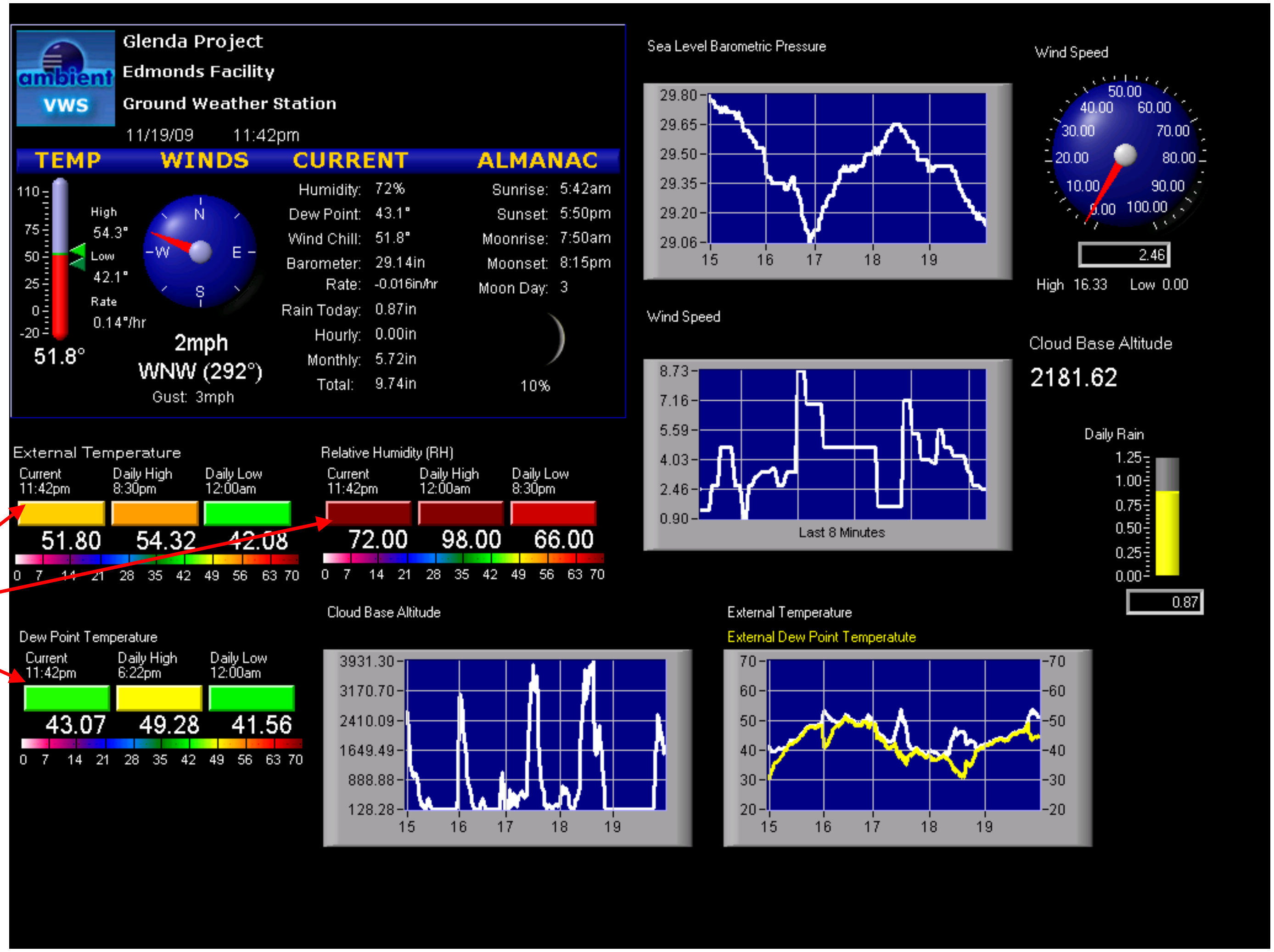
Oregon Scientific WMR100 – Mobile Application

- Wind Direction Sensor
- Anemometer
- Combination Temperature and Relative Humidity Sensor
- Rain Gauge
- Mobile Mast Interface
- Barometric Pressure Sensor internally enclosed in base station.

The Oregon Scientific WMR 100 is a wireless multi sensor weather station and when combined with the Glenda mobile mast system provides a potent combination of world class sensors and portability.

Project Glenda – Ground Station Maturity

VMR 100 Ground Station using Ambient VWS Software

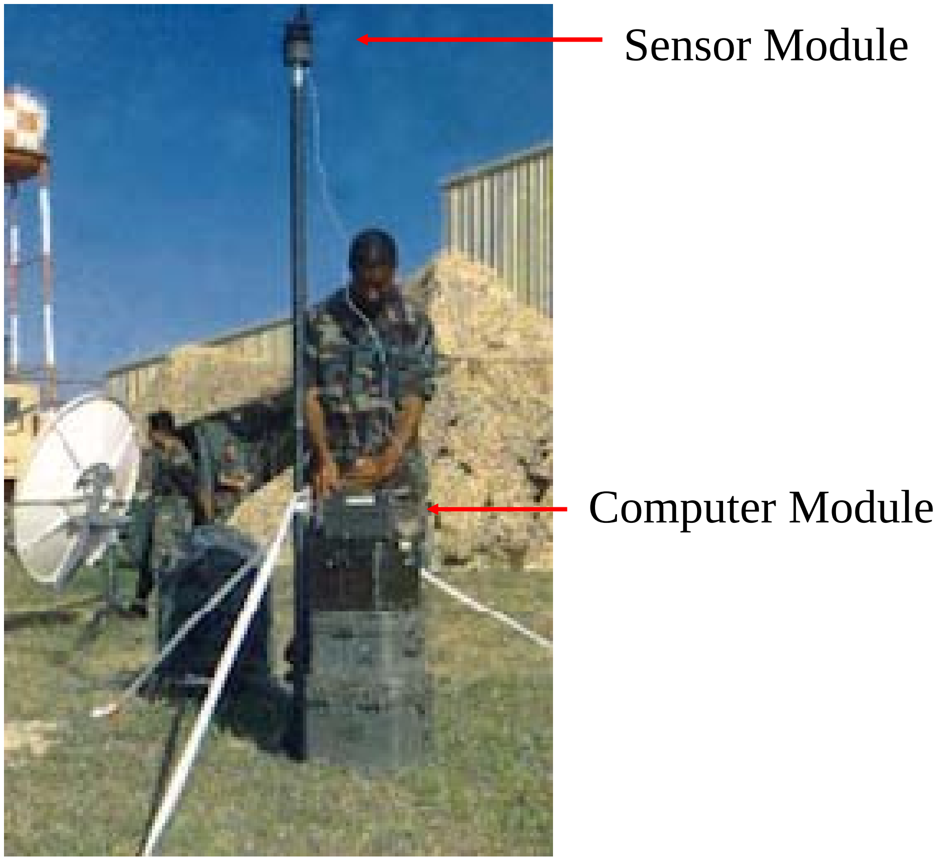


Severe Weather Precursors:
When the three indicated boxes display red at the same time, severe weather is highly Probable.

By connecting the VMR 100 to a Pentium III laptop, the raw data can be collected, processed and displayed using the Ambient Virtual Weather Station (VWS) software. Critical variables can now be displayed and recorded combined with severe weather precursors on key attributes.

Glenda Project – AN/TMQ-34 Ground Station

Glenda also has an operational portable military ground weather station. This acquisition further enhances the projects ground condition data collection capabilities.



The TMQ–34 is a military self contained portable weather measuring system that is powered by a rechargeable Ni CAD battery.

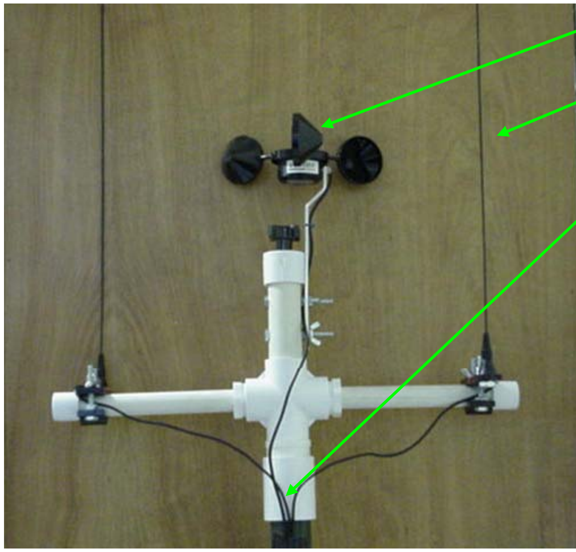
The TMQ–34 alphanumerically displays wind speed and direction, peak wind, temperature, dew point, barometric pressure, 3-hour pressure change, and the minimum and maximum temperature.

The entire TMQ–34, including the system case, weighs about 20 pounds. The set contains a computer module with a pressure sensor, and the main sensor module with a red sensor for temperature, a white sensor for humidity, a wind direction compass, and an anemometer to measure wind speed.

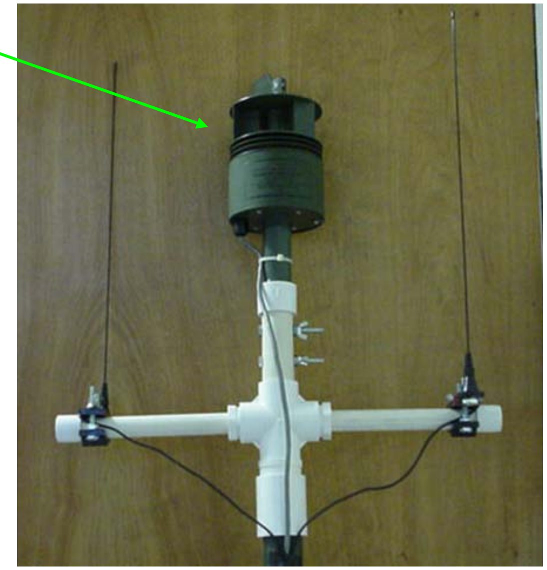
The TMQ–34 can operate in temperatures ranging from a low of –59.5°F to 132°F. The TMQ–34 is intended for use in a tactical environment with an operating range of 100 feet below sea level to 10,000 feet above sea level.

Glenda Mobile Ground Station and Mast System

<u>Removable / Adaptable Mast Sensor Head</u>

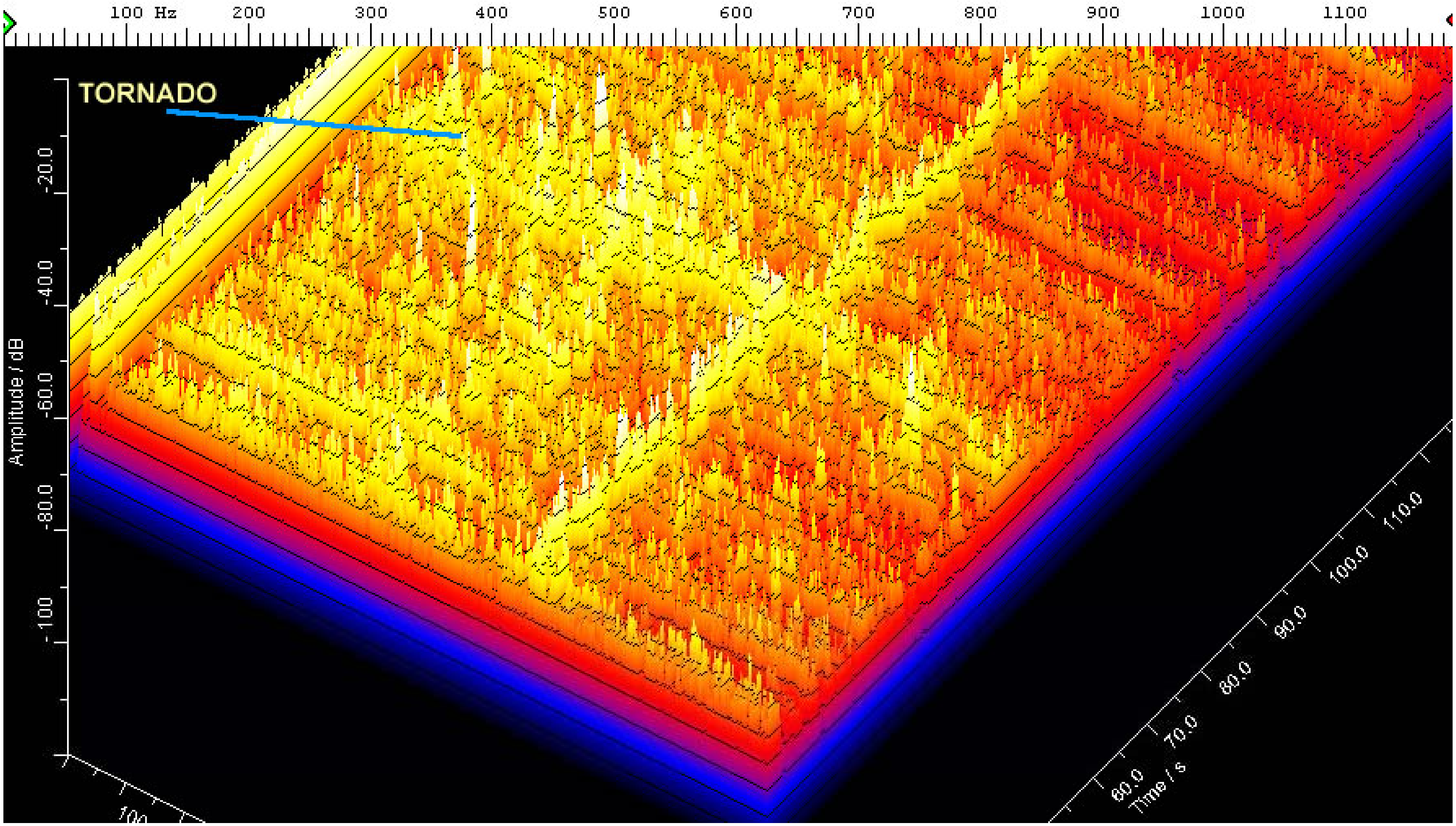


- In-Speed Anemometer / TMQ-34 Sensor
- Two Wide Band Receiver Antennas for Radiosonde telemetry signals.
- Mast System Interface Adapter
- Light weight PVC construction to reduce potential for lightning strike
- Antennas with 1.2 GHz capability allows multiple frequencies and multiple radiosonde reception
- Mast head integrates with man portable mast system



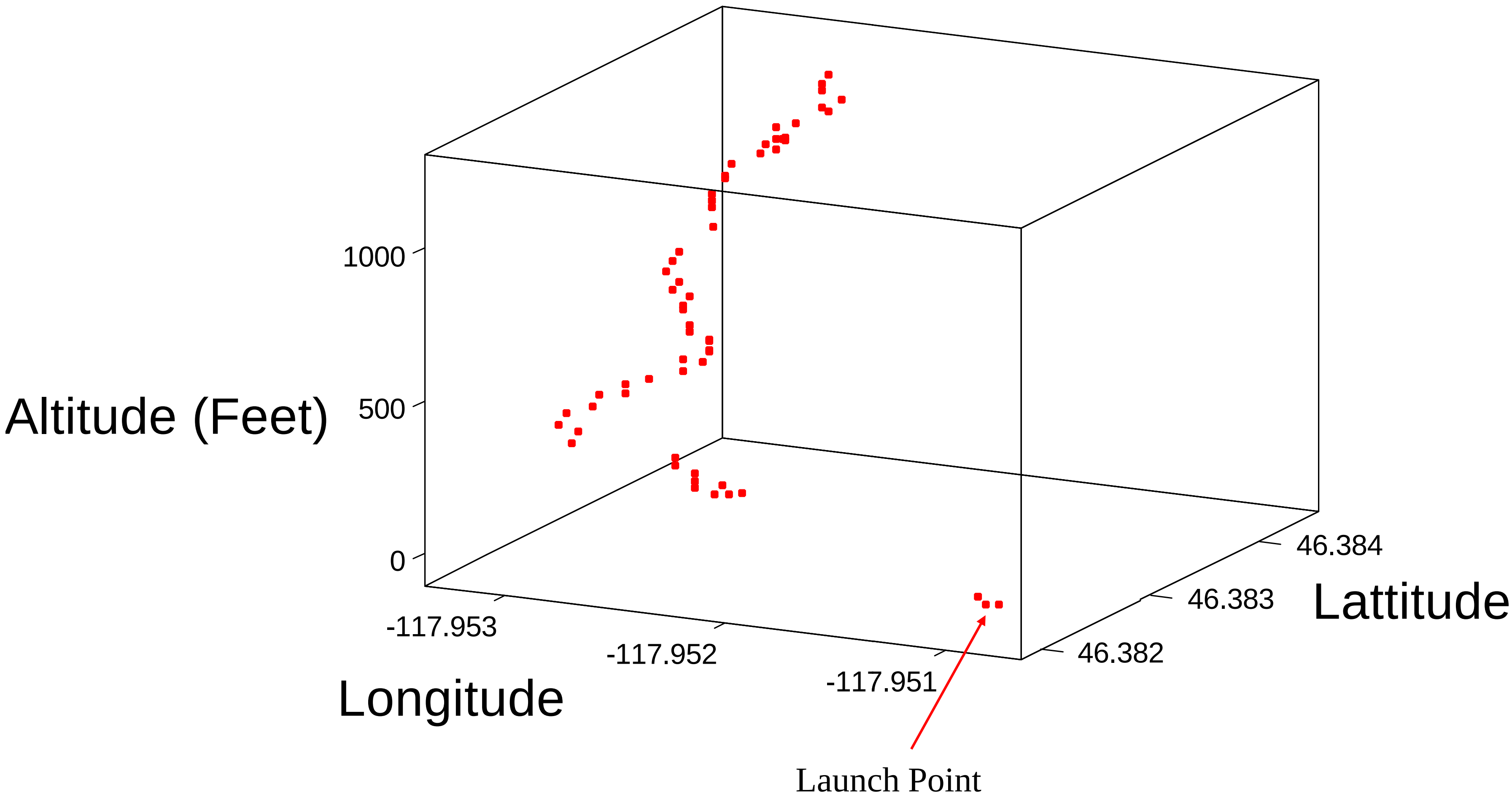
Glenda Project – EMF Spectral Mapping

Combining Glenda computing and sensors allows the capability for advanced analysis and detection. Shown below is a 3D EMF analysis of a tornado based off of a three second data capture. The circular effects of the funnel are easily visible and provide a snap shot of the electrical activity around a tornado.



Glenda Project – Wind Velocity Profiling

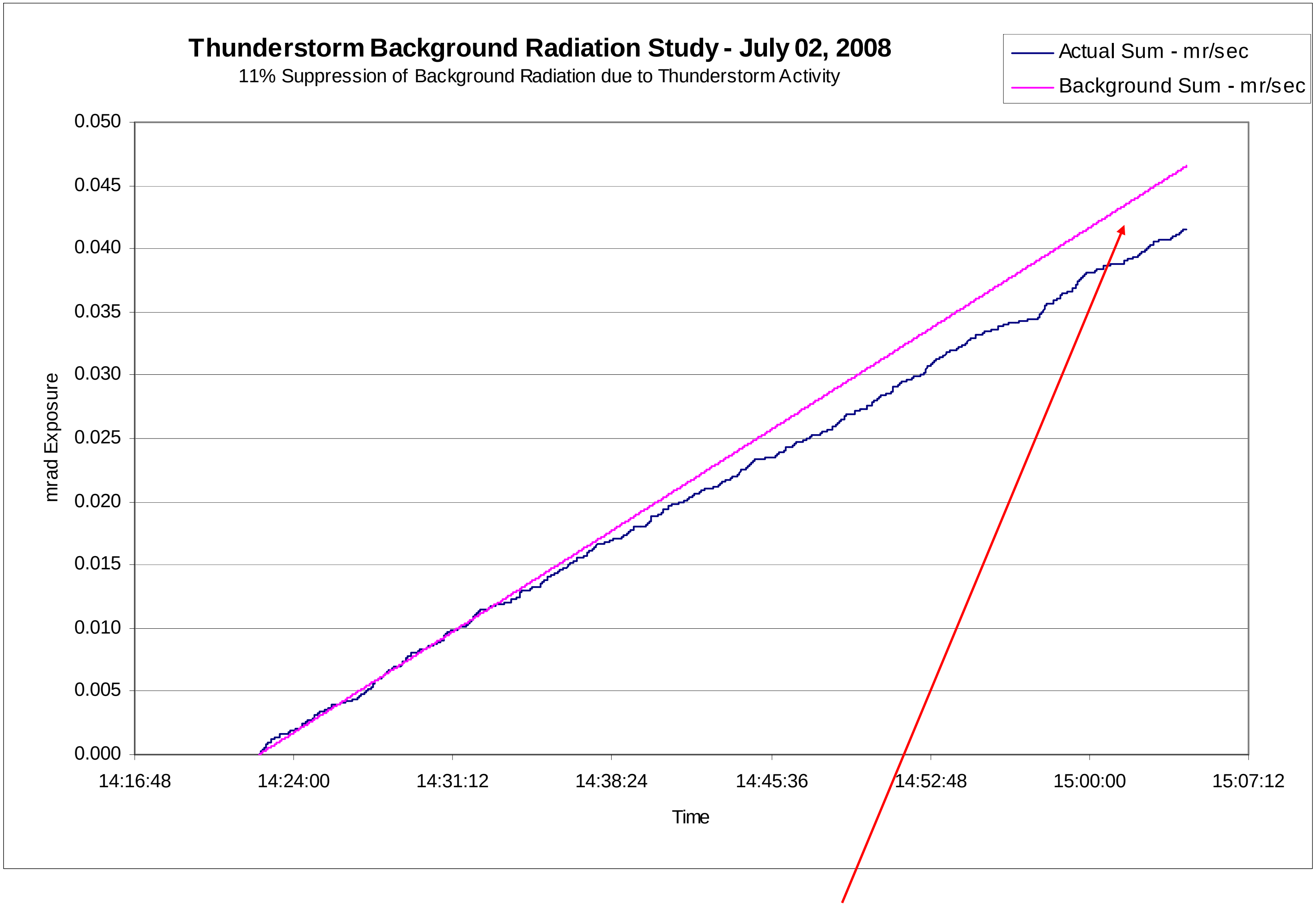
An Active GPS Payload tracks motion of a capsule over a site location in three dimensions



GPS functionality allows capsule tracking plus wind velocity determination capabilities

Glenda Project – Gamma Radiation Studies

Data collection capability of Gamma Ray Radiation during Thunderstorms



During this extensive Thunderstorm, lightning suppressed the “background” gamma radiation count by 11 percent

Glenda Project – "Ranger Intercept" Video Payload

Glenda has developed an operational on-board video capture payload capability in order to compare visual storm characteristics to other collected sensory data.

<u>Video Payload Capsule Attributes:</u>

- 40 Second Video Capture Capability
- 9 Frames per second Capture Rate
- 24 Bit Video Resolution
- Operable in both high and low light conditions
- Parachute Recovery
- Adaptable across multiple Glenda boosters
- Video downloadable in the field to laptop computers

Glenda Project – “Ranger Intercept” Video Payload

May 6th, 2007 – Redmond, WA – A typical flight towards an incoming storm center.

1. Launch

2. Mid - Boost

3. Apogee

4. Descent

5. Landing

Glenda Project – Chase Teams

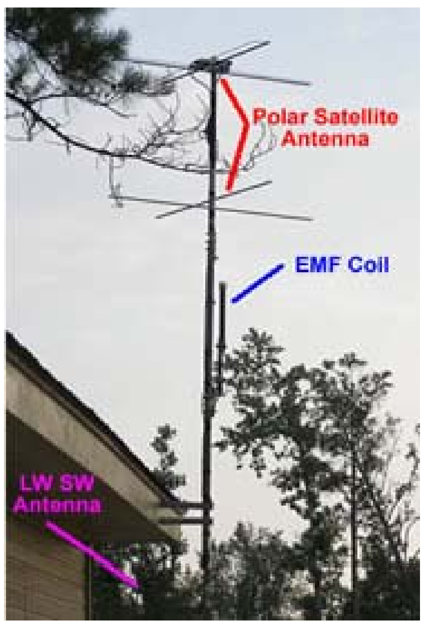
In order to obtain data from dynamic weather phenomena it is necessary to seek out and intercept storms and to launch sensors into the heart of the disturbance, capture the data, and return the data for immediate processing and analysis. Hence the name, Chase Team.

The Chase Teams utilize Jeep Grand Cherokee 4 wheel drive units, equipped with specialized tires and suspension to handle road debris situations and evasive maneuvers while on the go. When storm data is required, the teams immediately equip the jeeps with instrument packages and laptop computers inside the vehicle and attach to the roof, weather instrumentation, satellite dishes, sensors and communication gear. Portable rocket launching stands and weather rockets are loaded into the back of the jeep. Transforming from a standard jeep to a fully operational weather pursuit vehicle takes as little as five minutes.

Glenda Project – Pullman Point Research Facility

The Pullman Point Weather Research Facility is located in Petal, Mississippi, roughly 60 miles north of the Gulf of Mexico.

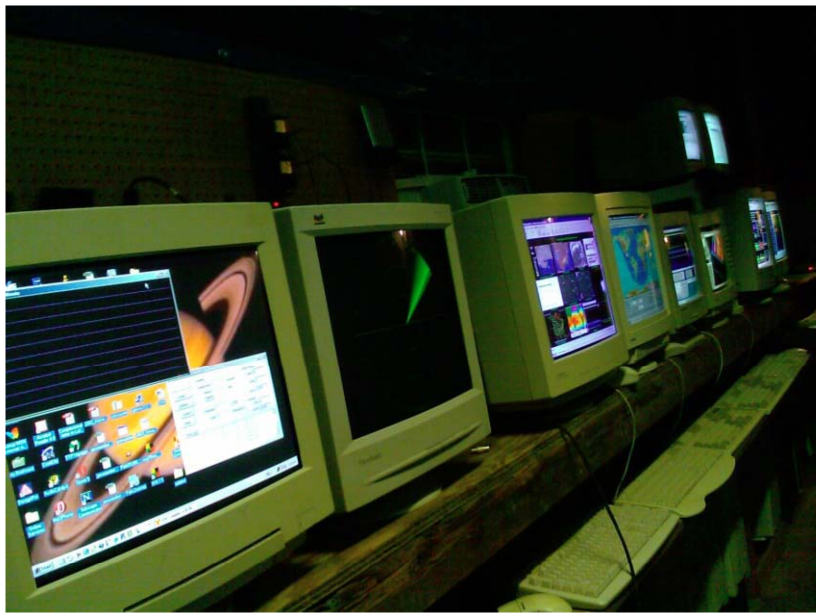
The Facility houses instrumentation that is a combination of old school analog, as well as, state of the art digital that is exclusive to less than a half dozen operations in the continental United States and the most advanced privately owned instrumentation in Southern Mississippi.



Glenda Project – Pullman Point Research Facility

Data is acquired and network backup communication systems are in place with an eight dish satellite antenna array located onsite.

Backed with an onsite super computing cluster and multi mode communication links with the outside world we supply information in live time for the purposes of research and learning. The facility is linked by networks to additional computing clusters in Moses Lake, Washington and server farms in New York, NY



Glenda Project – Engineering / Computing

David Davis – Edmonds, WA - Launch Operations Director - Brings decades of experience from engineering work in private industry and United States government in rocket research, and aerospace. Extensive background in electronics, mechanics, communications, computing, and storm chasing. Member of the National Association of Rocketry since 1983, and been involved with hobby related rocketry since the 1960's.

Robert Pullman – Petal, MS - Long Range Sensor Development - Has three decades of experience in communication and the computer industry and his expertise is world renown. His work has enabled governments to formulate policies and legislation in international, national and local forums. He has developed products that are used by universities for seminars, by corporations for internal operations to meet government regulations, by scientists for research work in field and laboratory conditions, by government departments for device operations and maintenance, and by the military for use in battlefield activities.

Glenda Project – Media Communications / Public Relations

As the Glenda Project matured, a definite need became apparent for an individual with media communications skills and public relations.

Tim Quigg in Dayton, WA brings a unique mix of personal background and professional experience to the Glenda Project. Quigg has over two decades of experience in customer service and media relations. He has been the Assistant Editor of Extreme Rocketry Magazine since 2000, as well as a freelance writer of numerous articles for Sport Rocketry Magazine. He is a current member of the National Association of Rocketry, and is the 2001 recipient of the National Association of Rocketry’s President’s Award, in recognition of his work with youth in model rocketry on a national level. Quigg is a highly decorated 24-year veteran of law enforcement, and is currently the Senior Communications Officer at a Southeastern Washington State E911 Communications Center.

Glenda Project – Application - Dayton, WA
“Lone Tree” Launch Site – Microclimate Profiling in Motion

“Lone Tree” Launch Site – Dayton, WA

Glenda Project – Dayton, WA

"Lone Tree" Launch Site – Background

The Blue Mountain Rocketeers (BMR), a youth based rocketry club, initiated launches at the "Lone Tree" site in 2000, and immediately noticed a bizarre behavior that when rockets were flown above 1,500 feet, that during recovery, they were blown by apparent high winds towards the direction of the gravel perimeter road located at the northern edge of the launch site even though ground wind speed was at a minimum.

Prior to BMR's use of the site, "Lone Tree" was also used as a runway by local crop dusters who also noticed this effect as well and were able to fly with heavier loads of agricultural sprays due to the increased winds at altitude.

The Glenda Project saw this effect as an opportunity to test out various sensors and provide wind velocity mapping data to BMR in support of the National Association of Rocketry (NAR) safety code requirement of assurance of recovery of all high powered rockets within the fields boundaries.

Glenda Project – Thermal Mapping Mission

September 25, 2004 Columbia County / Dayton, Washington

During September 2004, Glenda performed a thermal mapping mission using a chart recording ground station, and both active and passive payloads.

The purpose of these two flights was to confirm, or refute the existence of a region of thermal activity over the "Lone Tree" launch site.

The first rocket sounding employed the Glenda 98mm capsule lofting an active transmitting payload broadcasting temperature, relative humidity and barometric pressure data to the ground station.

The second sounding flight was made using the Glenda 54mm capsule carrying a passive payload recording temperature and relative humidity.

Glenda Project – Thermal Mapping Mission

September 25, 2004 Columbia County / Dayton, Washington

At the time of the Glenda flights, the ground temperature was around 80 degrees, with a Relative Humidity around 37-38%. Under the standard atmospheric model, temperature goes down, as does humidity as you increase in altitude.

At “Lone Tree”, this was not the case.

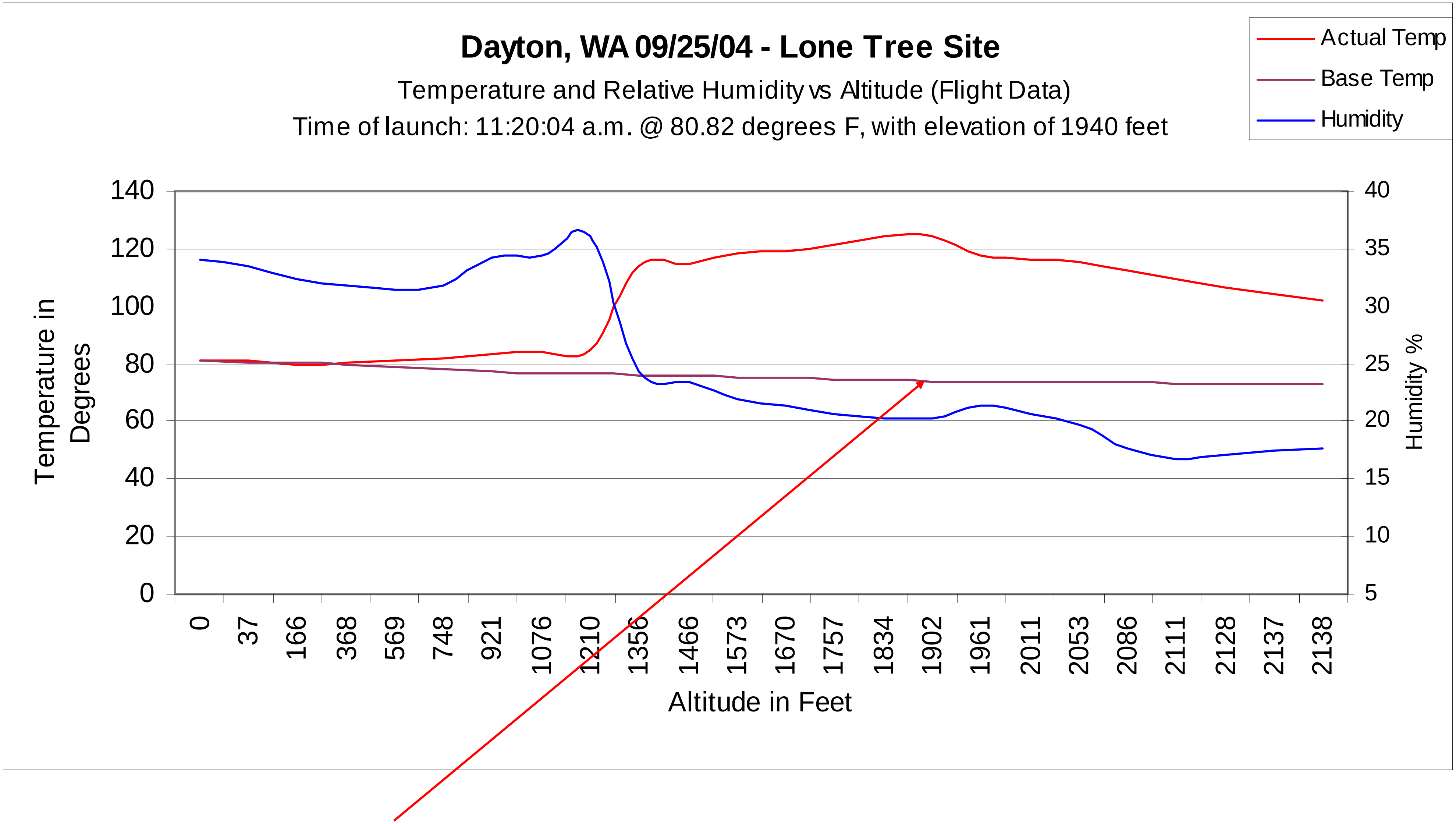
Temperature and humidity stayed relatively constant until 1,300 – 1,400 feet. Then things got interesting. The temperature rose rapidly, and the humidity level dropped. The sensors detected a 500 foot layer of hot, dry air which topped over 124 degrees at 11:00 in the morning. That's a 40+ degree difference from ground conditions. As the sensors penetrated the layer, more "normal" readings were detected.

The data between the two flights supported one another and have provided a body of evidence proving the existence of a thermal layer above the launch site.

The mapping mission was a success and the results are shown on the following slide.

Glenda Project – Thermal Mapping Mission

September 25, 2004 Columbia County / Dayton, Washington



Projected Temperature based on Standard Atmospheric Model – Something definitely out of the ordinary is happening!

Glenda Project – Thermal Mapping Mission

September 14, 2008 Columbia County / Dayton, Washington

Four years later in September 2008, the Glenda Project took this investigation to the next level by flying a hybrid payload containing a GPS transmitter to measure wind velocity, and a datalogger to measure temperature and RH.

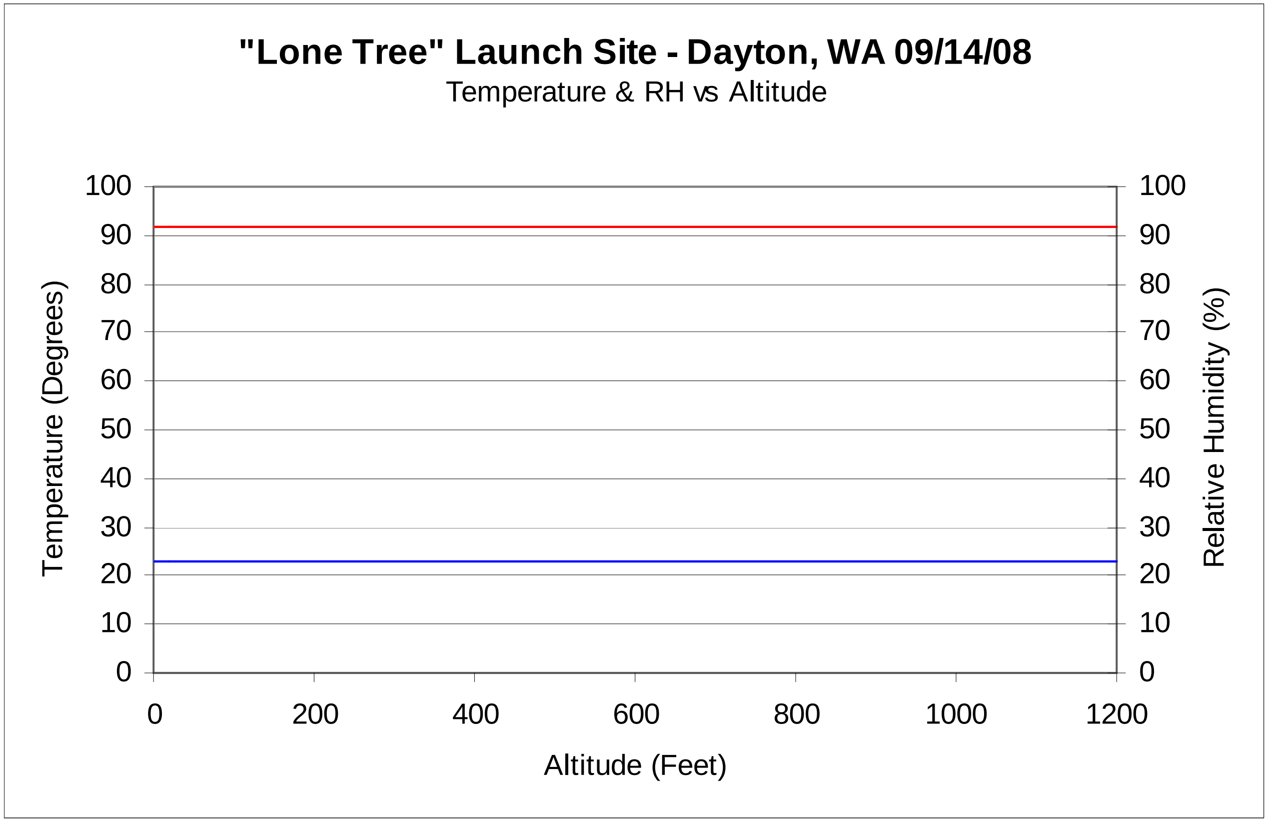
The most significant difference between the 2004 and 2008 flights was in the condition of the launch site. In 2004, the site was sown in Alfalfa and was uncut. In 2008, the site was still in Alfalfa. However, it had been freshly cut and bailed. It was unknown how this would effect the atmospheric conditions above the launch site.

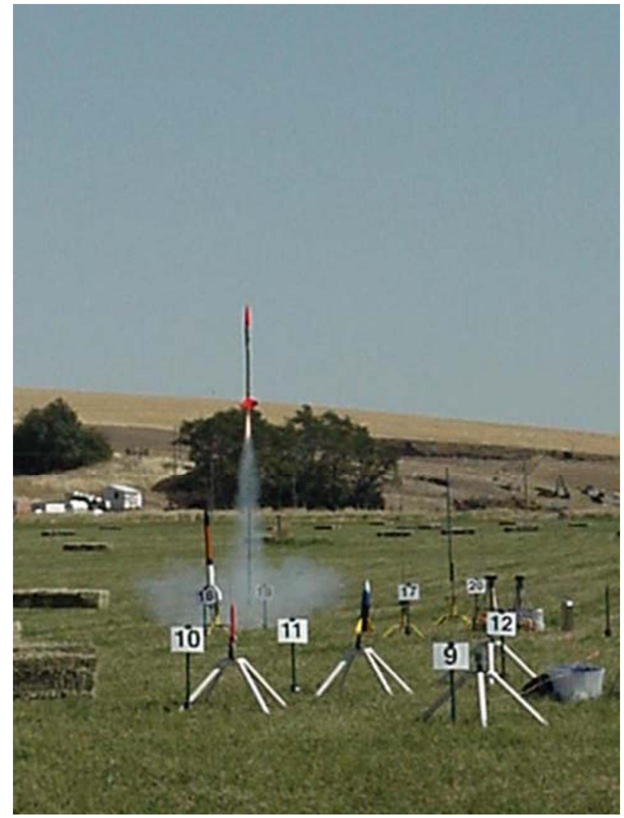
The differences between the temperature vs. altitudes between 2004 and 2008 were striking. In 2008, with the cut field, the air temperatures remained constant through the capsules decent envelope.

The 2008 temperature and RH data vs. altitude chart is shown in the next slide.

Glenda Project – Thermal Mapping Mission

September 14, 2008 Columbia County / Dayton, Washington





Glenda 5475 Booster takes flight

A distinct difference between a cut and an uncut field on air temperature and humidity!

Glenda Project – Wind Velocity Profiling

September 14, 2008 Columbia County / Dayton, Washington

This “cut” condition effected the wind velocity vs. altitude as well.

An area of calm air existed between 1,200 feet when wind velocity measurement commenced, and 800 feet when changes to wind speed and direction occurred.

The advantage of GPS capsule positioning is that the Glenda capsule can rapidly detect changes aloft, transmit them to the ground station, then map these changes in multiple dimensions.

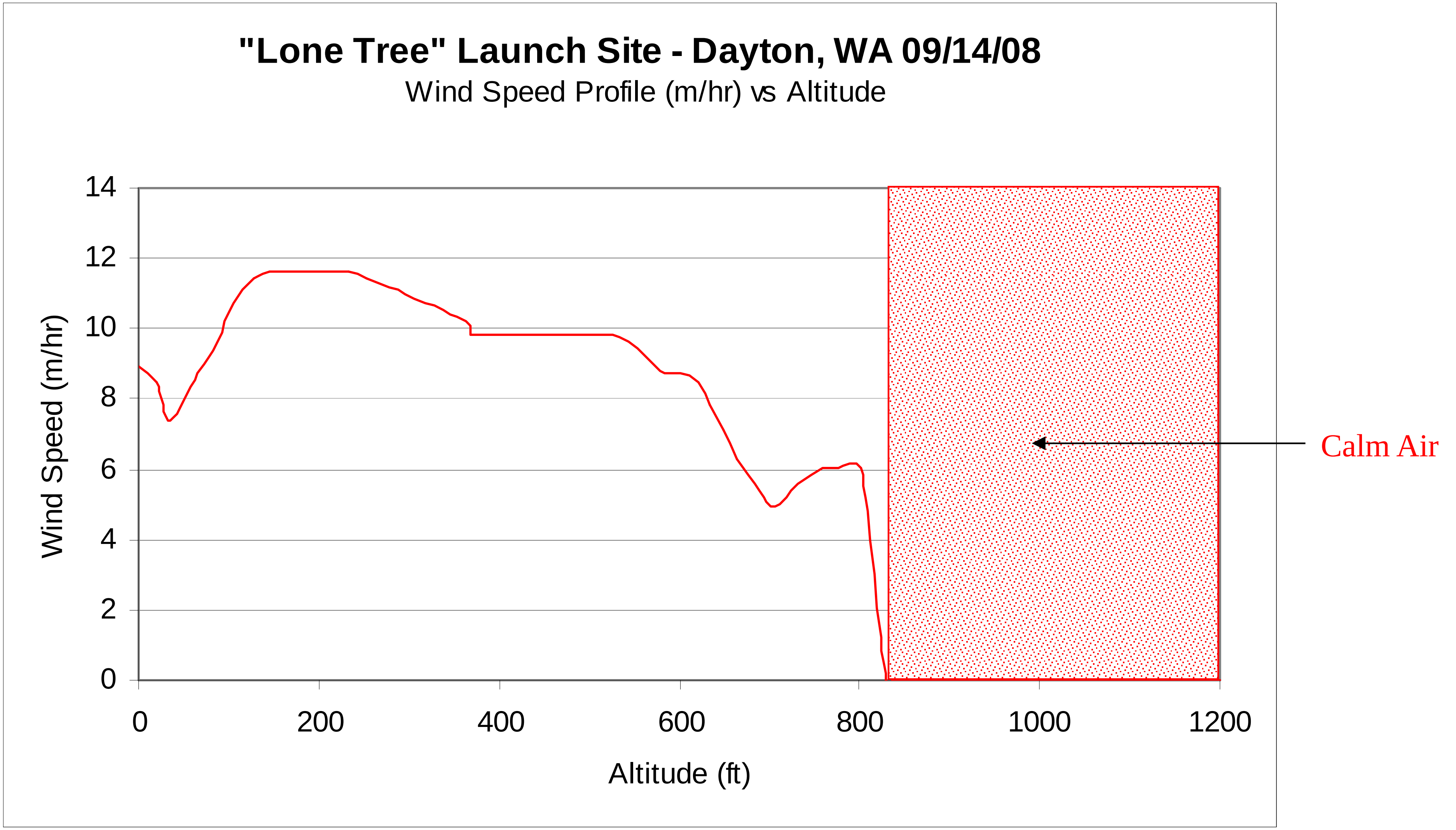
Wind velocity and capsule positioning are shown in the following two charts.

Glenda 75mm Capsule

Glenda 54mm Booster

Glenda Project – Wind Velocity Profiling

September 14, 2008 Columbia County / Dayton, Washington

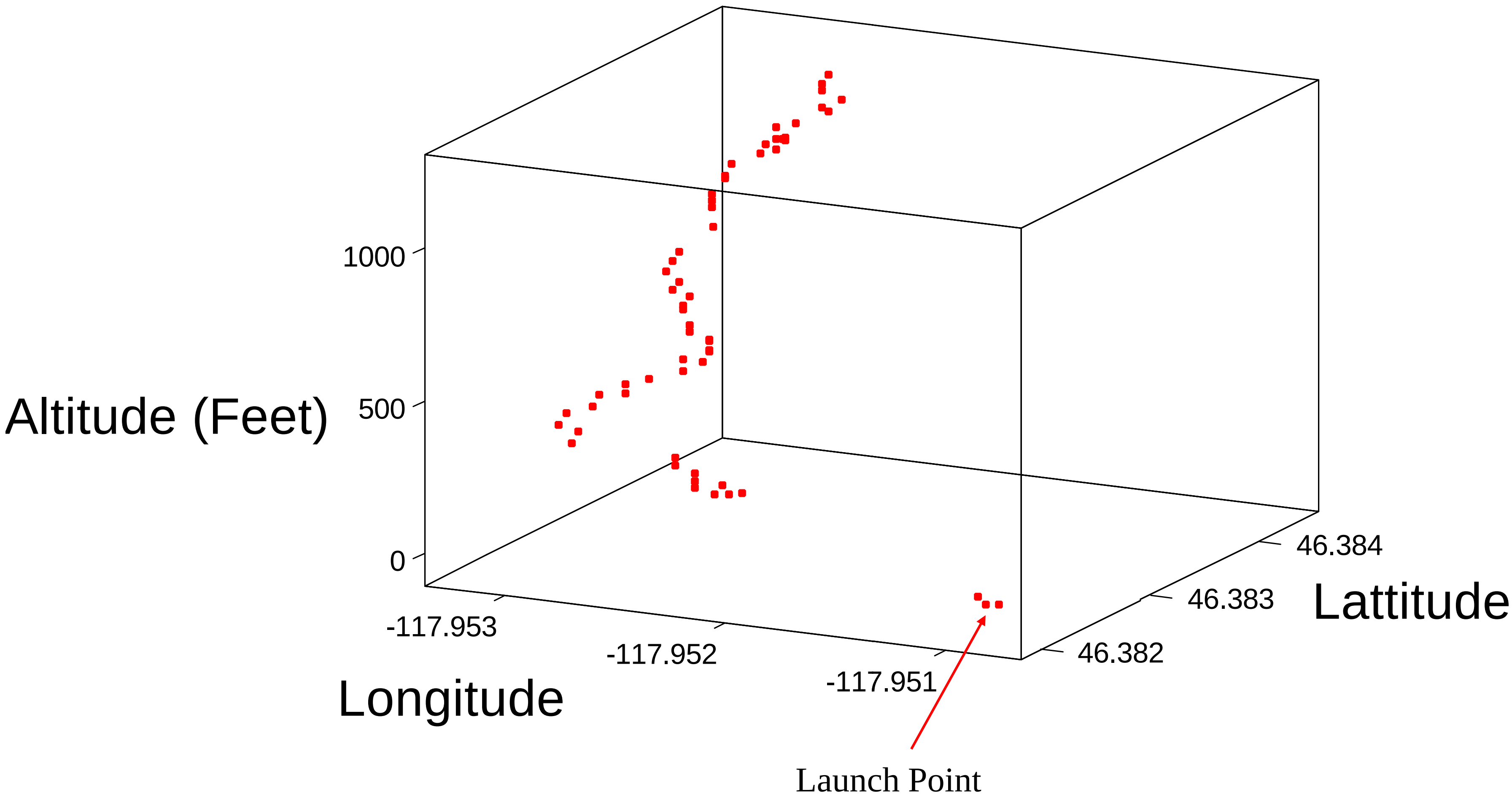


Insignificant wind speed from 800 to 1,200 feet

Glenda Project – Wind Velocity Profiling

September 14, 2008 Columbia County / Dayton, Washington

Active GPS Payload tracks motion of the capsule over the launch site in three dimensions



GPS functionality allows capsule tracking plus wind velocity determination capabilities

Glenda Project – Updraft Profiling

September 12, 2009 Columbia County / Dayton, Washington

In September 2009, a verification flight was made to confirm the temperature and humidity conditions.

Temperature and humidity, again remained constant. Therefore a temperature inversion was not occurring.

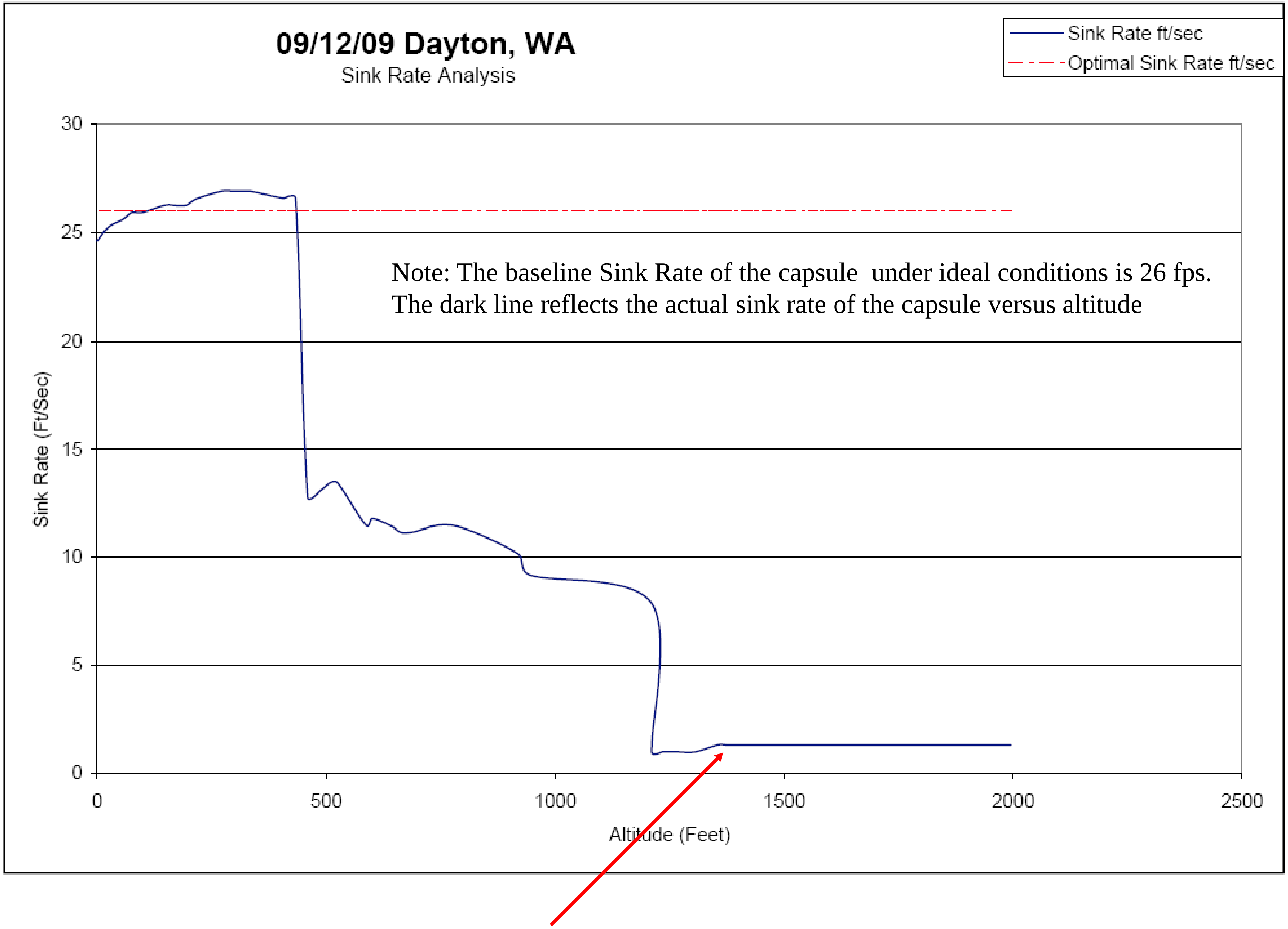
While the 2008 flight focused on vertical and horizontal drift, the 2009 flight included a more detailed vertical analysis. An additional characteristic was mapped during this flight. That of capsule sink rate. The purpose of this was to determine the existence up updrafts due to thermal inversions, or local terrain.

The results were astounding. Above 1,200 feet, a close to 25 feet per second updraft was recorded. All driven by local geography and micro-climate.

The following slide displays this updraft profile.

Glenda Project – Sink Rate Profiling

September 12, 2009 Columbia County / Dayton, Washington



Note the close to 25 feet per second updrafts above 1,200 feet

Glenda Project – Dayton, WA

"Lone Tree" Launch Site – Findings to Date

- A cut Alfalfa field has a significant positive impact on reducing air temperatures and wind speeds above the launch site.

- It is recommended that BMR have the alfalfa cut prior to launch operations in order to mitigate the evaporative effects of the alfalfa creating the increased temperature inversions and the associated wind speeds.

- The extensive detected updrafts have a profound effect on the recovery trajectory of models launched at the "Lone Tree" site if their altitude exceeds 1,200 feet.

- Additional flights, to higher altitudes containing both dataloggers and GPS be made in order to study the effects ground conditions have on the thicknesses of the updraft layers, their wind velocities, temperatures, and humidities.

Glenda Project – Accomplishments

Maturing Payloads & Systems – Preparing for the “Wall Cloud” Mapping Mission

Glenda Project – 2007 / 2009 Accomplishments

- September 2009 – Incorporated Sink Rate profiling into the GPS capsule data analysis.

- July 2008 – Deployed Gamma Ray sensor and determined that Thunderstorms suppressed "background" radiation counts.

- September 2008 – First Flight of the GPS Wind Velocity payload which allows 3D mapping capability of storm systems

- October 2007 - Edmonds, WA ground station operational as additional facility for sensor testing.

- May 2007 – The new "Ranger Intercept" research rocket was successfully launched into a storm front and captured live video which was downloaded to a ground station laptop.

- May 2007 – In conjunction with the Blue Mountain Rocketeers, participated in the National Weather Service (Pendleton, OR) open house in celebration of the 200th birthday of the NOAA. There was a great deal of interest in the project, with multiple presentations during the day including overviews of the project, its capabilities, and demonstrating various aspects of the weather payloads and the ground support equipment.

Accomplishments and Operational Capabilities

- EMF detection in 2D with a 500 mile range; plus EMF detection in 3D with the ability to catch the electronic signature of a tornado.

- Magnetic and electrical monitoring system - the only private one in Mississippi (only 6 commercial units in the country)

- Holder of Patent Number 60/903,881 - Multi-Dimensional Data Models for Tornado Prediction

- Local and regional weather information going out on the internet, full weather data on APRS over the air over the southeast of the country.

- Multiple chase vehicles that can do full weather analysis, soil analysis, and radiation measurement

- Mobile and stationary ground stations that can conduct weather measurements and monitor radiation levels.

- Weather Sounding Rocket payload launch capability with multiple sensors.

- Full satellite and weather data reception and analysis, with licensed radio operators and facilities that can communicate around the world; weather forecasts available on servers, and radio gateways that run 24 hours a day, 7 days a week non-stop - at no charge to the end users. The information is used by Emergency management crews in 5 Mississippi counties, as well as multiple radio and television stations and Fortune 500 companies.

Glenda Project - Advantages

- Portability and Rapid Deployment with “Launch on the Run” capability
- Ease of Use of propellant and vehicle/payload preparation
- Payload adaptable for external sensors to match user specific applications
- Composite components designed for extreme environments
- On-board locater transmitter allows for rapid recovery
- Off-the-shelf components reduce operating costs and ease repair

Glenda Project - Disadvantages

- Training required for system use, data collection and analysis
- Composite materials are not bio-degradable
- Rocket motors are "Hazardous Materials" and are classified as Flammable Solids 4.1
- Multiple sensors required to support complex analysis
- Active Payloads require ground stations for ground condition baseline data collection, data reduction and analysis

Glenda Project - Available

The Glenda Project has reached the level of maturity where we can offer portions for sale to end users based on their mission requirements.

Due to the nature of today's political environment, anyone expressing interest in a Glenda system should be capable of passing a federal background check because of the propellant system used in our boosters. Without having the appropriate permits, we cannot help you with your request. However, we can help guide you through the permitting process and other regulations which govern the use of Glenda systems.

The Glenda Project is constantly testing new sensors and new attributes. Let us know of your mission and budget requirements and we can help you develop the optimal design approach at the best value for your investment.

In Conclusion

The Glenda Project is a reusable sounding rocket delivery system designed to place instrument packages into areas previously considered to be to hazardous or inaccessible using traditional platforms such as balloons, aircraft, helicopters, kites, etc.

Through 2004 and 2005, Glenda completed its first successful mapping missions and during 2006, the ground station and payloads continued to mature in order to prepare to further extend the flight envelope to even more hazardous environments.

2007 brought continued maturing of sensors and first flight of “Ranger Intercept”.

The 2008 and 2009 series of launches allowed full testing of the GPS tracking and wind velocity and sink rate capability, and returned even more valuable data.

The operational Glenda Project shows the differences between Hollywood “fiction”, and engineering “fact”, from mapping local environments to a full tornadic funnel with a suite of sensors. Glenda is up to the task.

Glenda Project – Executive Summary - 2011

Glenda Project – Purpose

The primary mission of the Glenda Project is to provide the capability to rapidly gather previously inaccessible localized microclimate data from altitudes ranging from ground level to 20,000 feet and to return this data for immediate use.

The Glenda Project is mix of adaptable ground stations combined with a reusable sounding rocket delivery system designed to place instrument packages into areas previously considered to be to hazardous or inaccessible using traditional platforms such as balloons, aircraft, helicopters, kites, etc.

Glenda Project – Data Capabilities

The Glenda Project has the capability to collect temperature, humidity, barometric pressure, wind speed and other types of environmental data from ground level to 20,000 feet.

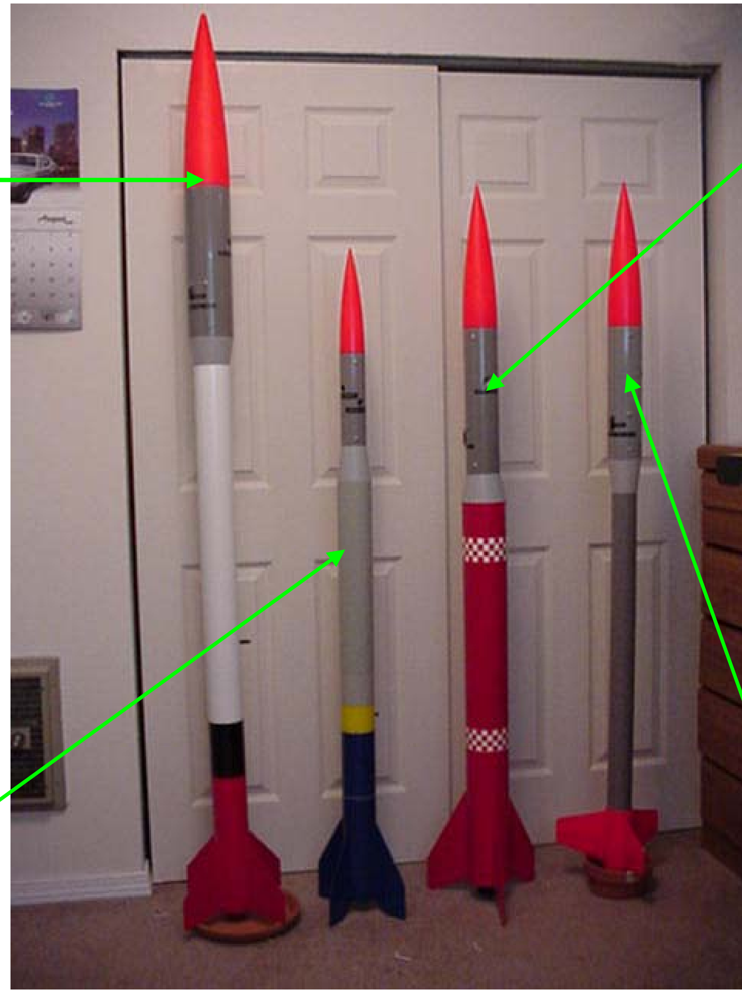
Glenda payloads are designed to be launched into thunderstorms, tornados, and other volatile weather environments and to return intact with its collected data.

Glenda Project – Data Collection Methods

Glenda has three primary methods of collecting data:

- Rocket Launched - Active Flight Data Collection Systems - Transmitters
- Rocket Launched - Passive Flight Data Collection Systems – Dataloggers
- Ground Stations

Glenda Project – Typical Flight Vehicles



7598 Booster
- 3” diameter booster, 4” diameter capsule
- RS80 Radiosonde Payload
- 3,000 to 20,000 ft altitude envelope

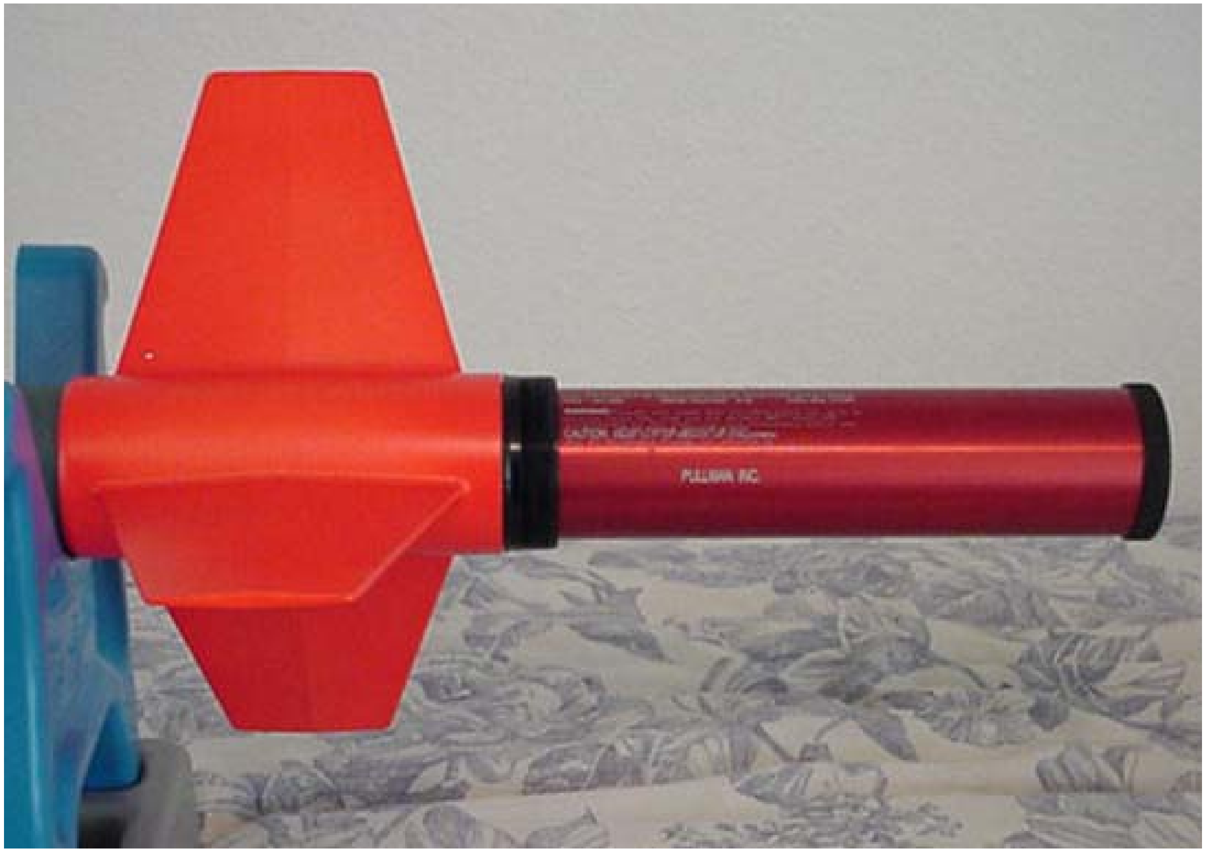
9875 Booster
- 4” diameter booster, 3” diameter capsule
- RS92 Digital Radiosonde Payload with GPS
- Temp / RH Datalogger
- 2,000 to 15,000 ft altitude envelope

FAR 101 Booster
- 3” diameter booster, 2.125” diameter capsule
- Temp / RH Datalogger Payload
- 2,000 foot altitude envelope

5475 “Standard” Booster
- 2.125” diameter booster, 3” diameter capsule
- RS92 Digital Radiosonde Payload with GPS
- Temp / RH Datalogger
- 2,000 to 15,000 ft altitude envelope

Glenda Project – 5475 HV Booster

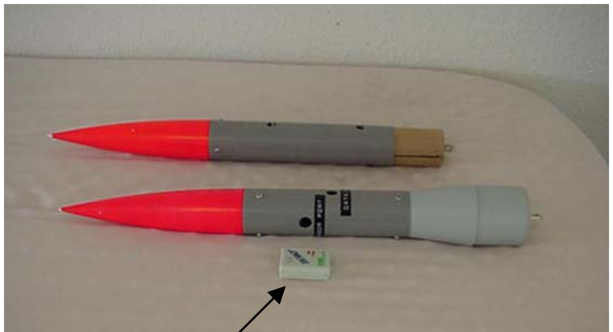
Comparison between the 5475 “Conventional” Booster and the 5475 HV Booster



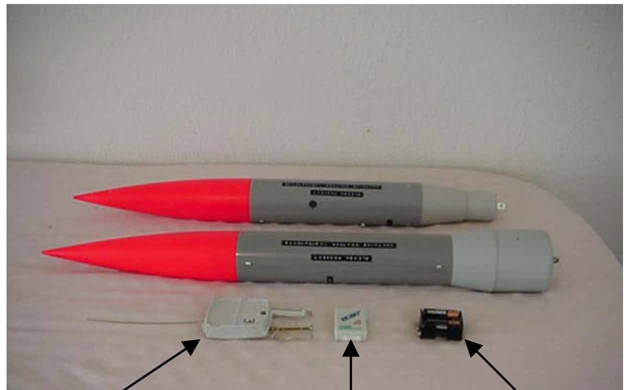
- 54mm motor vs. 38mm motor
- Adaptable altitude performance based on mission requirements from 2,000 to 20,000 feet
- Blue Tube heavy duty airframe with bonded motor retainer to support higher velocities
- Longer airframe to support larger “L” class motors
- Longer Payload capsule for increased payload capacity.

Glenda Project – Typical Flight Payloads

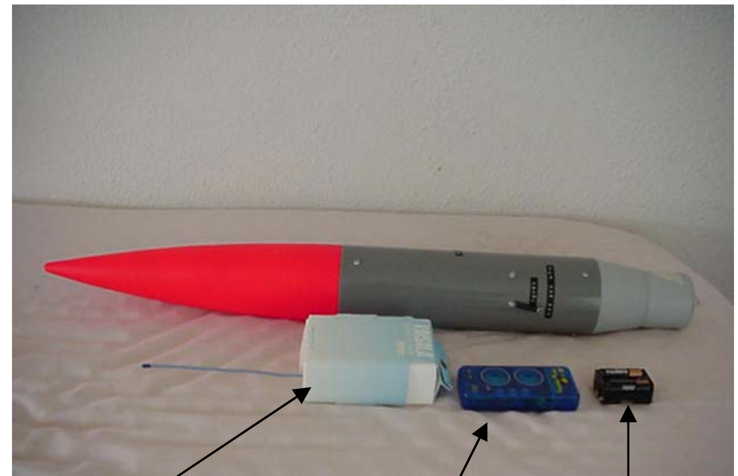
The Glenda project uses several different payload capsule configurations carrying a variety of instrumentation in order to gain weather related information, and other micro-climate data



Datalogger



RS92 Digital Radiosonde   Datalogger   Battery Pack



RS80 Analog Radiosonde   Locator Beacon   Battery Pack

54mm (2.125”) Capsules

- Datalogger Payloads
- Measures Temperature & RH values at 1 second intervals.
- Used by 54mm & 75mm boosters.

75mm (3”) Capsules

- Datalogger Payloads
- Measures Temperature & RH values at 1 second intervals.
- RS92 Digital Radiosondes transmitting temperature, RH, barometric pressure, and GPS coordinates.
- Used by 54mm & 98mm boosters.

98mm (4”) Capsule

- RS80 Analog Radiosonde transmitting temperature, RH, and barometric pressure.
- Audio location beacon
- Used by 75mm boosters.

Glenda Project – Typical Flight Profile

2 – Boost Phase

3 – Deployment Phase

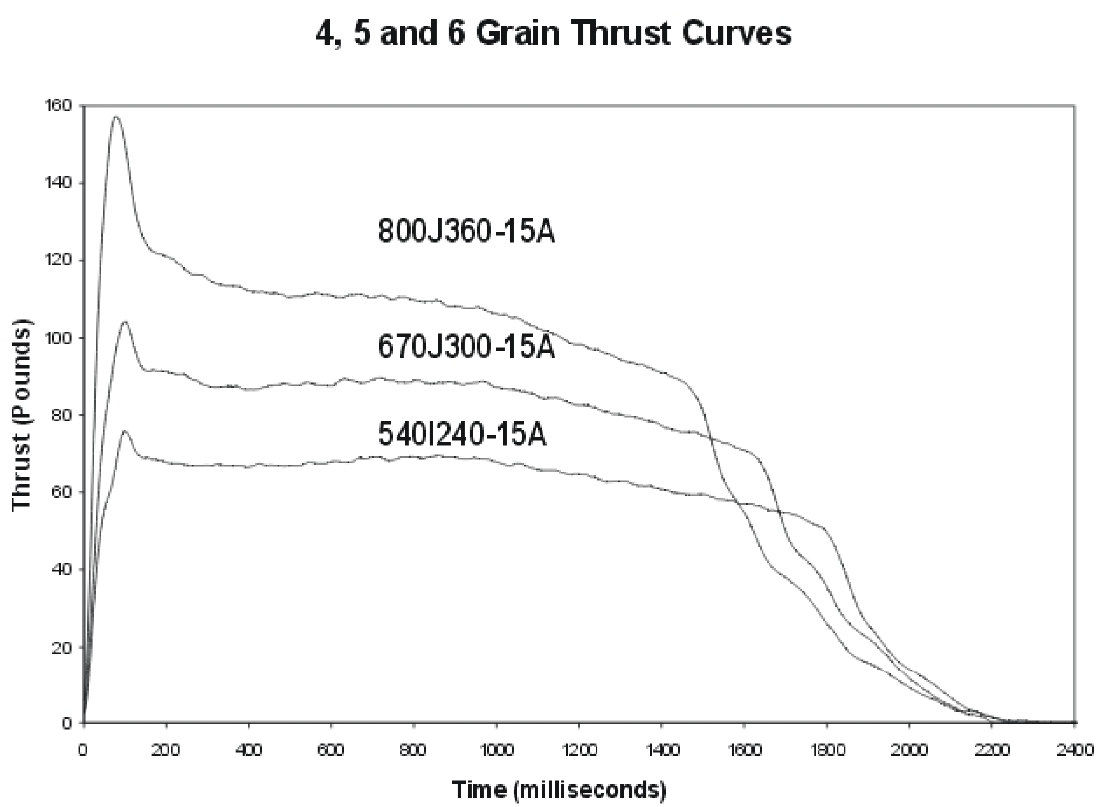
1 – Launch Phase

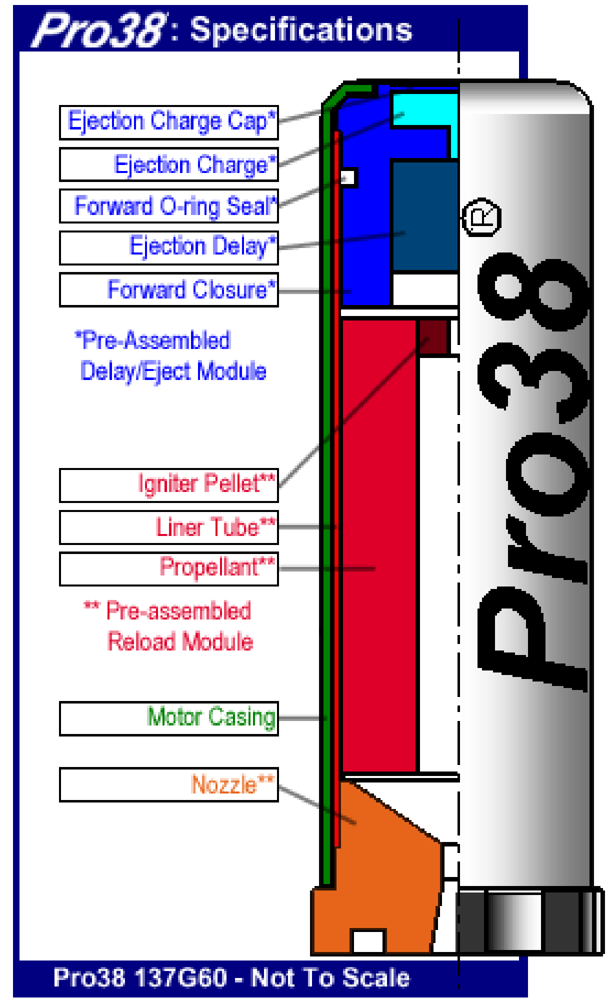
Note: Propulsion is provided by reloadable /reusable rocket motors giving the capability of rapid turnaround between flights.

4 – Recovery Phase

Glenda Project – Propulsion

The Pro38 / Pro54 rocket motor propulsion system is the first commercial thermoplastic propellant-based solid rocket motor and is produced by Cesaroni Technology Inc. of Toronto Canada. The Pro38 / Pro 54 is a modular, reloadable Solid propellant rocket motor system designed primarily for use in launching small experimental payloads by universities, colleges, research institutes and sport rocketry enthusiasts.

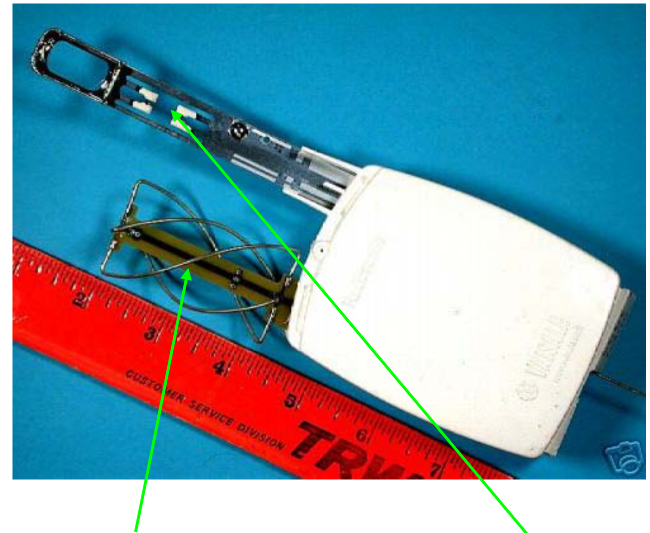




Glenda Project – Active Payloads - Transmitters

Converted Radiosonde Payloads

The Glenda Project uses converted radiosondes that are designed primarily for use with weather balloons. The circuitry and sensors function properly under thrust loads of the Glenda boosters and are compatible with NOAA radiosonde receiver systems.



The radiosonde contains instruments capable of making direct measurements of air temperature, humidity and pressure. These observed data are transmitted immediately to the ground station by a radio transmitter located within the instrument package.

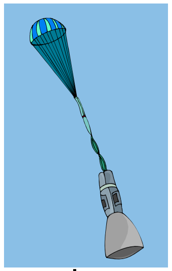
Vaisala RS92 Radiosonde

Radiosonde Specifications:

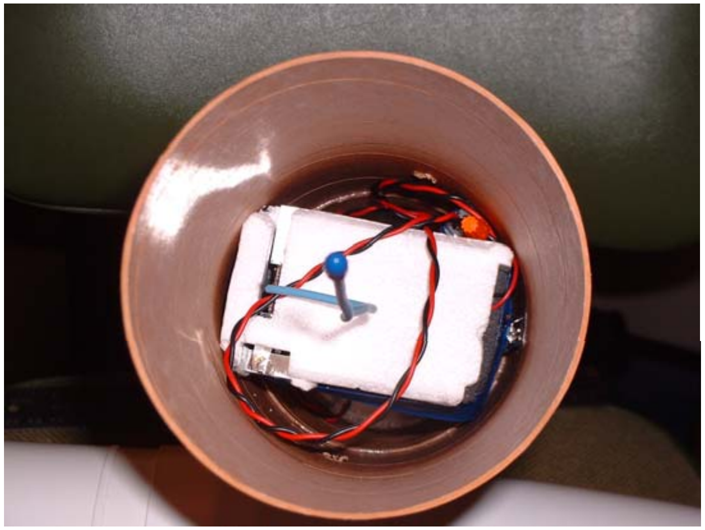
- Pressure range 3mb to 1060mb +/- .1mb
- Operating temperature range of -90°C to +60°C
- Relative Humidity from 0 to 100%
- Sampling Rate of once per second for the sensor suite
- Provides positioning data via GPS for payload location and wind velocity

Glenda Project – Active Payloads - Transmitters

Signal Processing Flow Diagram

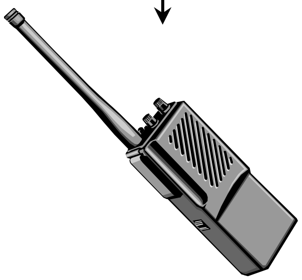


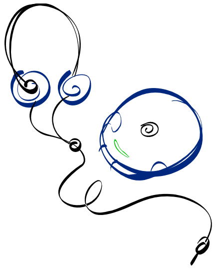
- Barometric Pressure Sensor Data
- Temperature Sensor Data
- Relative Humidity Sensor Data
- GPS - Payload Position Data



Active Payload cushioned within the flight capsule

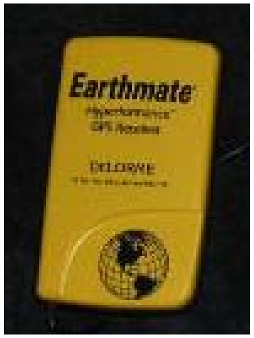
Sensor Data Transmitted to Ground Receiver





Sensor Data Digitally Recorded

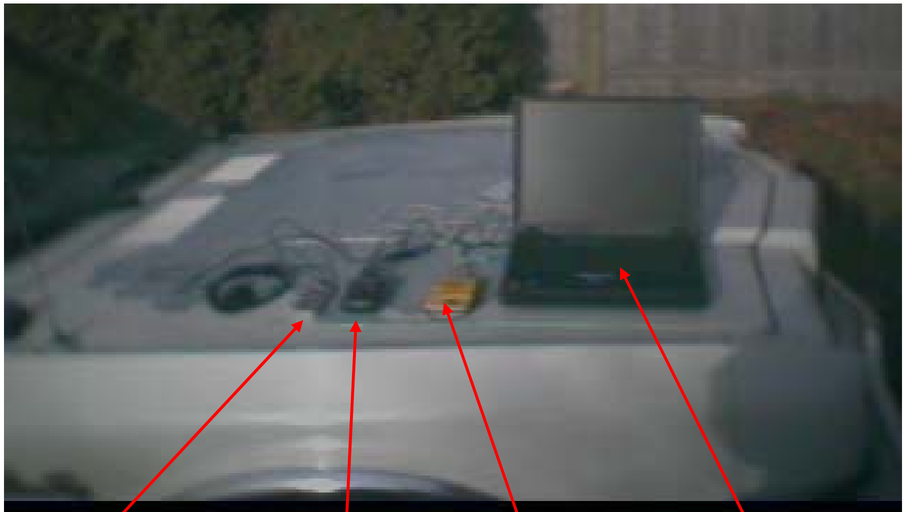
Data recorded into Laptop for analysis



GPS – Ground Station Position Data

Glenda Project – Active Payloads

Ground Station



Digital Recorder

Telemetry Receiver

GPS Receiver

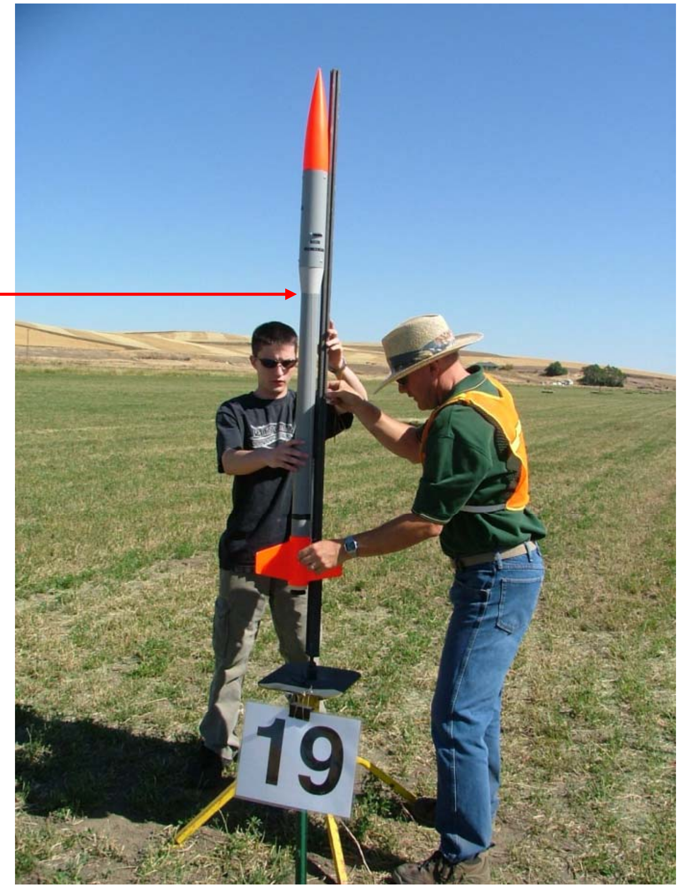
Laptop

Not Shown:

a) Telemetry Receiver Antenna System
b) Laptop External Power Supply

Flight Vehicle

Payload Capsule



Length: 63”
Diameter: 4”
Dry Weight: 3.5 Pounds
Attainable Altitudes: 2,000 feet to 20,000 feet

Glenda Project - Passive Payloads – Dataloggers

A data logger is an electronic instrument that records measurements over time. Typically, data loggers are small, battery-powered devices that are equipped with a microprocessor, data storage and sensors. Most data loggers utilize software on a personal computer to initiate the logger and view the collected data.

Prior to a Glenda launch, the datalogger is connected to a laptop computer. Then, Windows based software is used to select logging parameters (sampling intervals, start time, etc.) and initiate the logger. The logger is then disconnected from the laptop and installed inside the Glenda payload capsule. Upon launch, the logger records each measurement and stores it in memory along with the time and date. Post recovery, the logger is then reconnected to the laptop computer and the software is used again to readout the data and see the measurements as a graph, showing the profile over time. The tabular data can be viewed as well, or exported to a spreadsheet for further manipulation.

Project Glenda Payload – Dataloggers

The Temperature / Relative Humidity datalogger is an example of a typical Glenda data collection device.

Temperature / Relative Humidity Datalogger Specifications:

- Capacity: 7943 measurements total
- User-selectable sampling interval: 0.5 seconds to 9 hours
- Programmable start time/date
- Memory modes: stop when full, wrap-around when full
- Nonvolatile EEPROM memory retains data even if battery fails
- Blinking LED light confirms operation
- User-replaceable battery lasts 1 year
- Battery level indication at launch
- Operating range: -4°F to +158°F (-20°C to +70°C), 0 to 95% relative humidity
- Time accuracy: ±1 minute per week at +68°F (+20°C)
- Size/Weight: 2.4 x 1.9 x 0.8" (68 x 48 x 19 mm)/approx. 1 oz.(29 grams)

Glenda Project – Passive Payloads – Dataloggers

54mm Capsule in Flight Configuration

Here is a typical Glenda payload ready for flight. This capsule contains a tracking locator transmitter, a combination temperature/relative humidity datalogger, and a barometric pressure datalogger. Total payload weight including capsule is less than one pound.

Tracking System Antenna

Datalogger Sensor Port

Additional Payload Tracking Systems

In addition to the GPS tracking capability, and to ensure recovery of the payloads, the Glenda Project has implemented several additional recovery and tracking aids.

110 db audio alarm payload location package

Audio Beacon Sound Sample

To support short range recovery, a 110 db audio alarm can be installed in the payload capsule. The alarm functions independently of the data payload and is activated by its own internal countdown timer. Field tests have shown an effective range of one half mile.

Payload tracking transmitter

Tracking Transmitter Signal

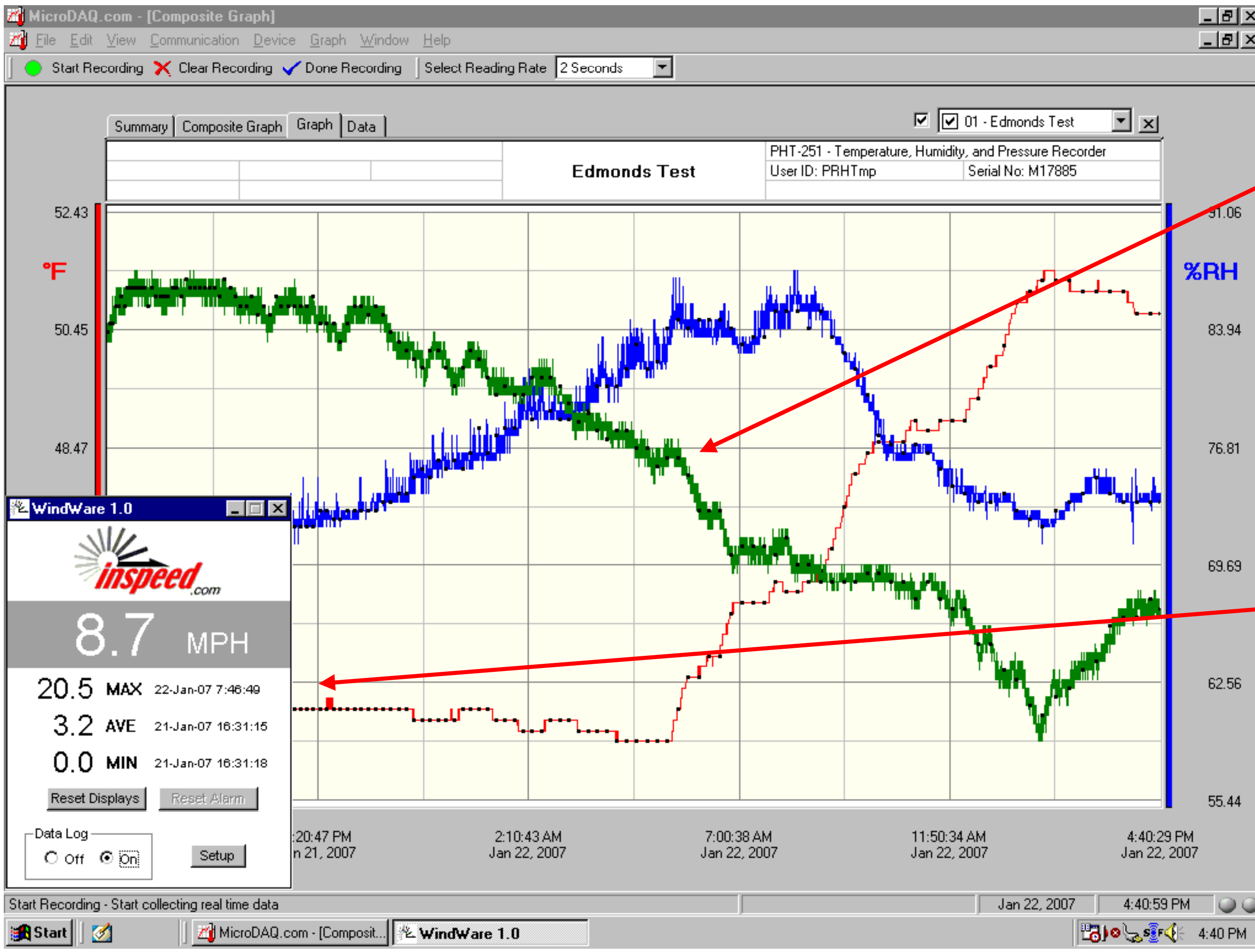
For longer range tracking and recovery, a tracking transmitter is installed in the payload capsule. Field tests have indicated a line of sight tracking distance at over three miles.

Glenda Project – Ground Stations

Digital Chart Recorders

Glenda Project also utilizes sensors combined with ground based laptops to provide a digital based chart record of ground baseline conditions mapped over time.

The basic example below is a digital chart record of temperature, humidity, barometric pressure and wind speed at a test site.

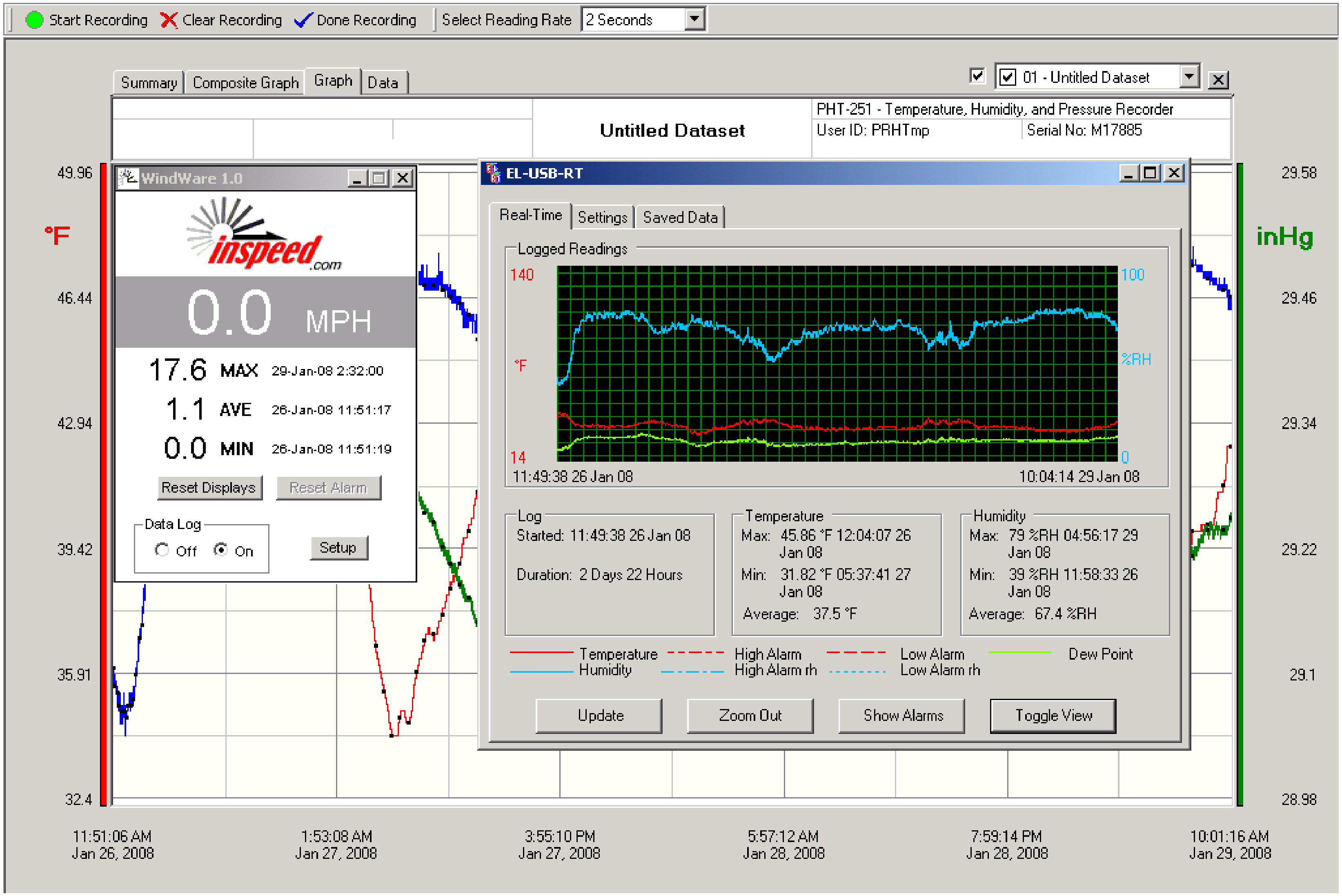


Pressure, Temperature, & Barometric Pressure data stream using Micro-DAQ software and COM 1 port

Wind Speed data using InSpeed Anemometer and supporting software Using COM 3 port via USB port application adapter

Glenda Project – Ground Stations

Digital Chart Recorders - Evolution



Glenda can also use the Micro-Daq Three channel datalogger, Inspeed anemometer, plus a Lascar Dew Point sensor running on a Thinkpad A20m Pentium III laptop. The Inspeed and Lascar software run in the background collecting data at one second intervals providing wind speed and Dew Point trend data.

Project Glenda – Ground Station Maturity

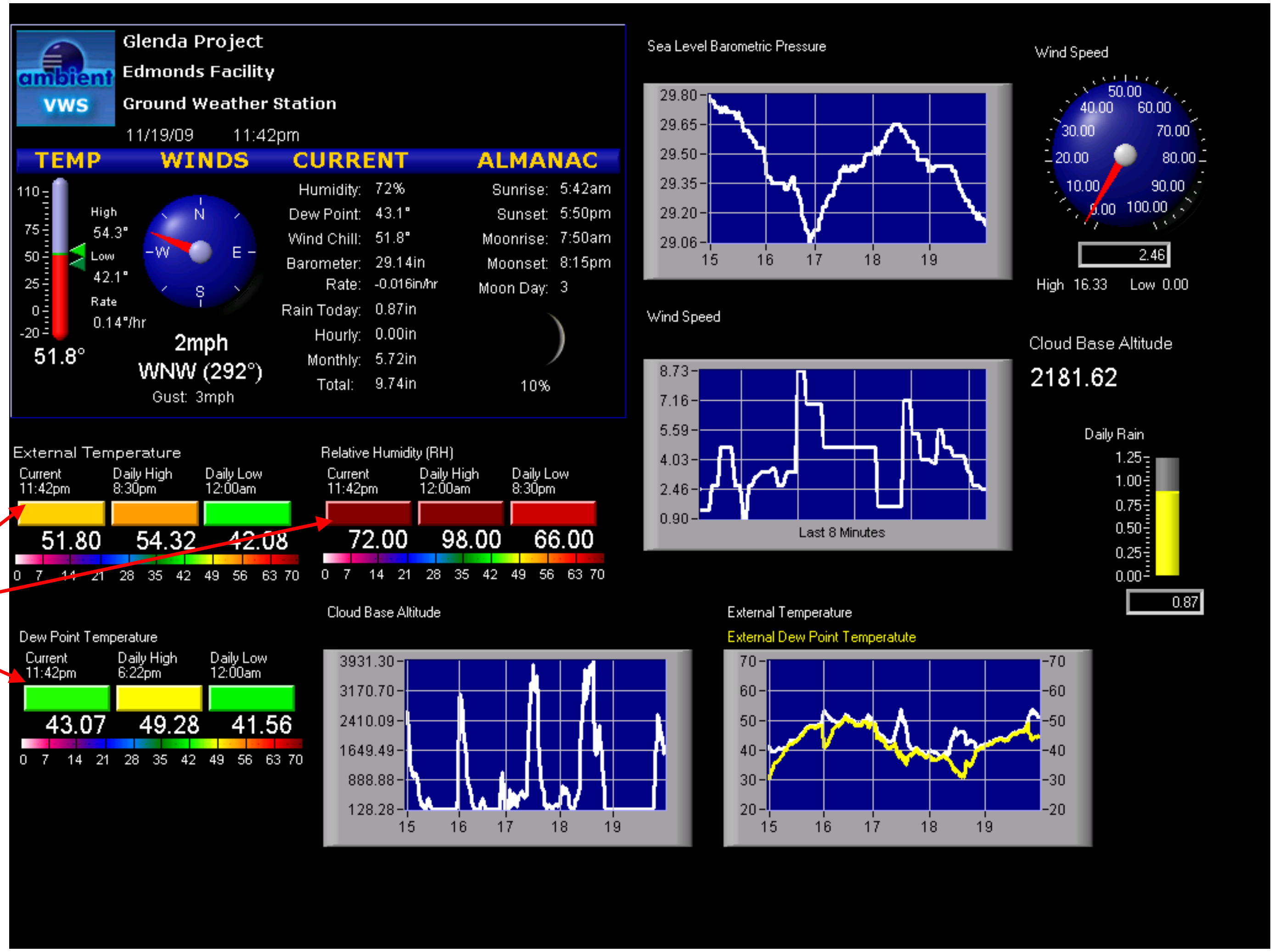
Oregon Scientific WMR100 – Mobile Application

- Wind Direction Sensor
- Anemometer
- Combination Temperature and Relative Humidity Sensor
- Rain Gauge
- Mobile Mast Interface
- Barometric Pressure Sensor internally enclosed in base station.

The Oregon Scientific WMR 100 is a wireless multi sensor weather station and when combined with the Glenda mobile mast system provides a potent combination of world class sensors and portability.

Project Glenda – Ground Station Maturity

VMR 100 Ground Station using Ambient VWS Software



Severe Weather Precursors:
When the three indicated boxes display red at the same time, severe weather is highly Probable.

By connecting the VMR 100 to a Pentium III laptop, the raw data can be collected, processed and displayed using the Ambient Virtual Weather Station (VWS) software. Critical variables can now be displayed and recorded combined with severe weather precursors on key attributes.

Glenda Project – AN/TMQ-34 Ground Station

Glenda also has an operational portable military ground weather station. This acquisition further enhances the projects ground condition data collection capabilities.

The TMQ–34 is a military self contained portable weather measuring system that is powered by a rechargeable Ni CAD battery.

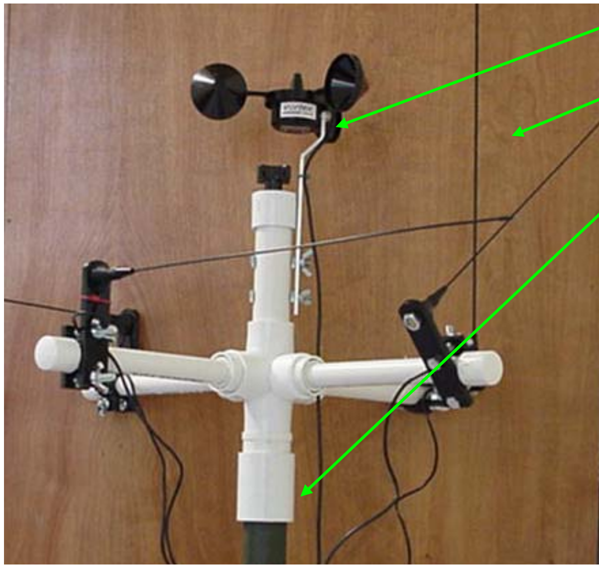
The TMQ–34 alphanumerically displays wind speed and direction, peak wind, temperature, dew point, barometric pressure, 3-hour pressure change, and the minimum and maximum temperature.

The entire TMQ–34, including the system case, weighs about 20 pounds. The set contains a computer module with a pressure sensor, and the main sensor module with a red sensor for temperature, a white sensor for humidity, a wind direction compass, and an anemometer to measure wind speed.

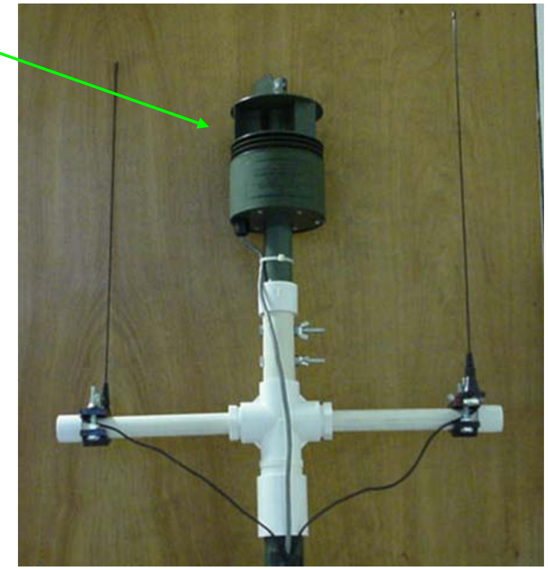
The TMQ–34 can operate in temperatures ranging from a low of –59.5°F to 132°F. The TMQ–34 is intended for use in a tactical environment with an operating range of 100 feet below sea level to 10,000 feet above sea level.

Glenda Mobile Ground Station and Mast System

<u>Removable / Adaptable Mast Sensor Head</u>

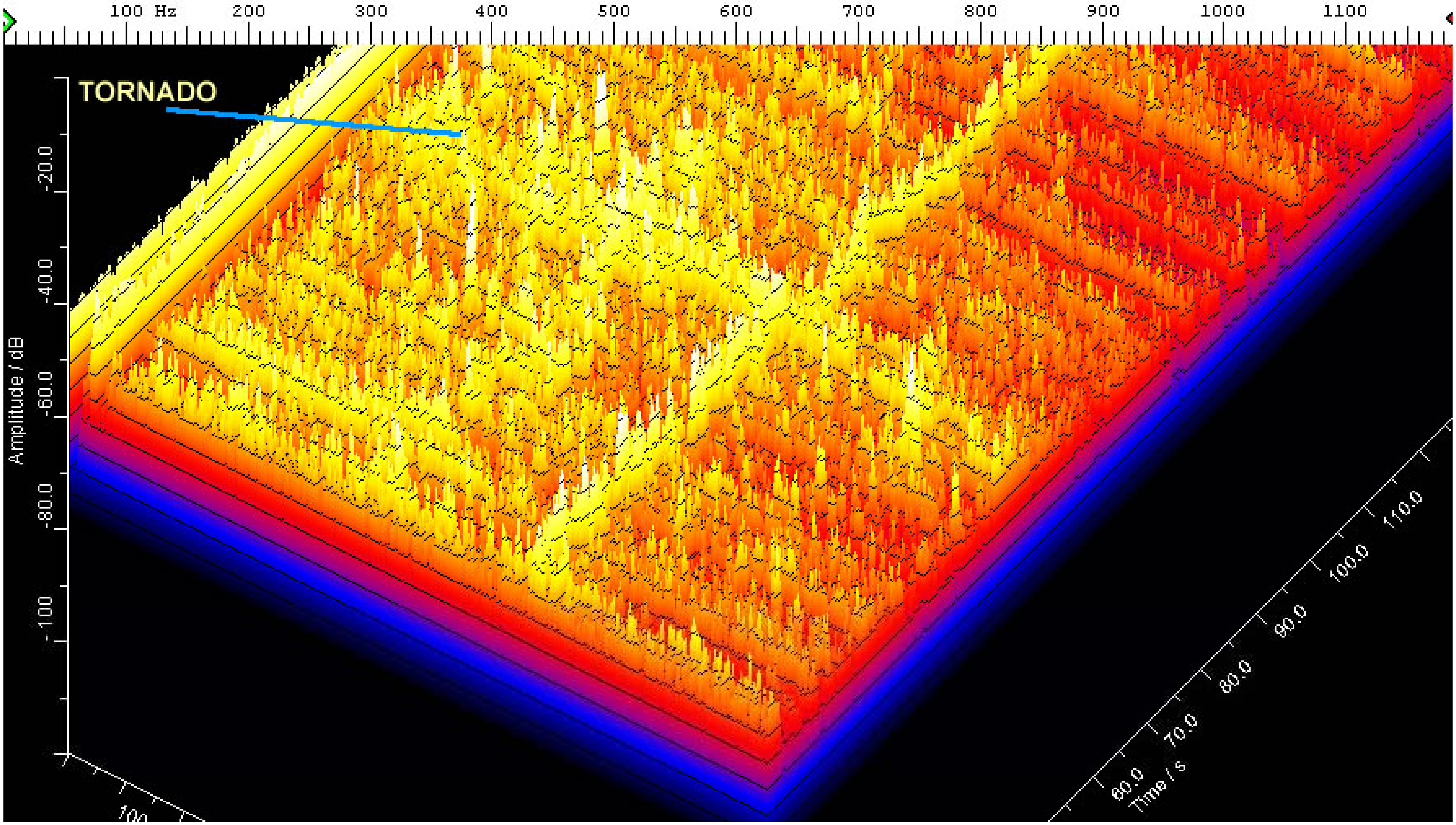


- In-Speed Anemometer / TMQ-34 Sensor
- Two / Four Wide Band Receiver Antennas for Radiosonde telemetry signals.
- Mast System Interface Adapter
- Light weight PVC construction to reduce potential for lightning strike
- Antennas with 1.2 GHz capability allows multiple frequencies and multiple radiosonde reception
- Mast head integrates with man portable mast system



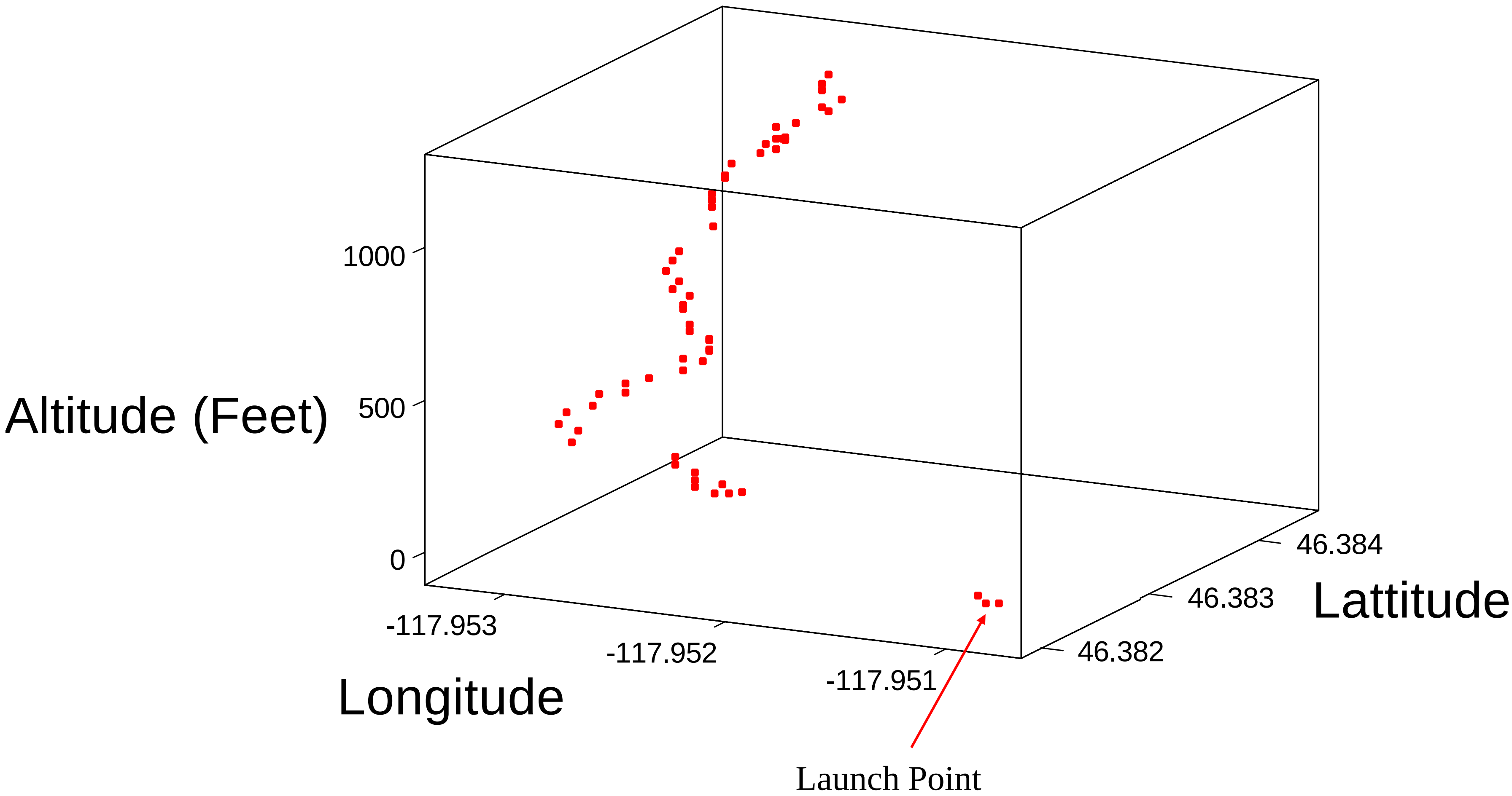
Glenda Project – EMF Spectral Mapping

Combining Glenda computing and sensors allows the capability for advanced analysis and detection. Shown below is a 3D EMF analysis of a tornado based off of a three second data capture. The circular effects of the funnel are easily visible and provide a snap shot of the electrical activity around a tornado.



Glenda Project – Wind Velocity Profiling

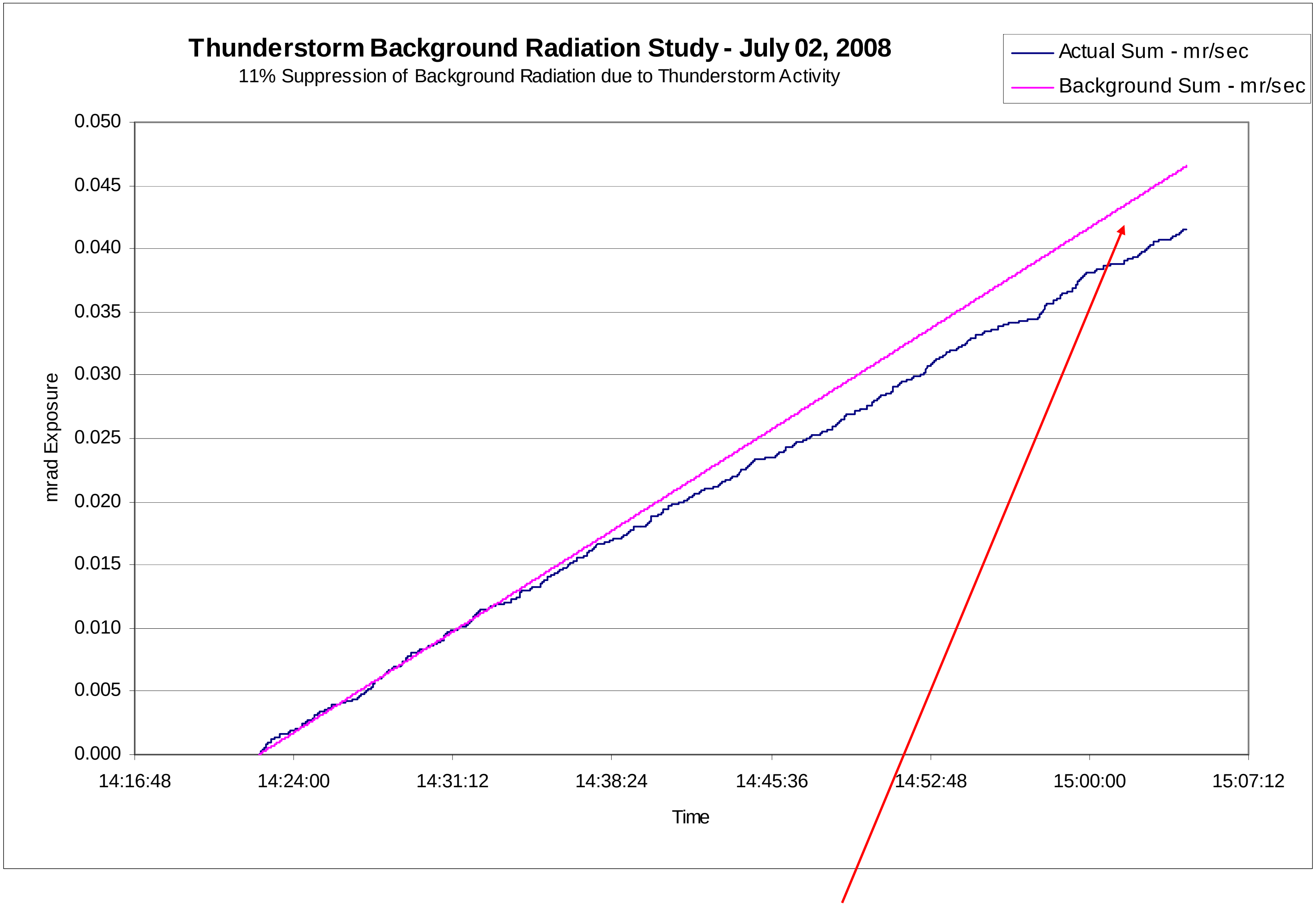
An Active GPS Payload tracks motion of a capsule over a site location in three dimensions



GPS functionality allows capsule tracking plus wind velocity determination capabilities

Glenda Project – Gamma Radiation Studies

Data collection capability of Gamma Ray Radiation during Thunderstorms



During this extensive Thunderstorm, lightning suppressed the “background” gamma radiation count by 11 percent

Glenda Project – "Ranger Intercept" Video Payload

Glenda has developed an operational on-board video capture payload capability in order to compare visual storm characteristics to other collected sensory data.

Video Payload Capsule Attributes:

- 40 Second Video Capture Capability
- 9 Frames per second Capture Rate
- 24 Bit Video Resolution
- Operable in both high and low light conditions
- Parachute Recovery
- Adaptable across multiple Glenda boosters
- Video downloadable in the field to laptop computers

Glenda Project – “Ranger Intercept” Video Payload

May 6th, 2007 – Redmond, WA – A typical flight towards an incoming storm center.

1. Launch

2. Mid - Boost

3. Apogee

4. Descent

5. Landing

Glenda Project – Chase Teams

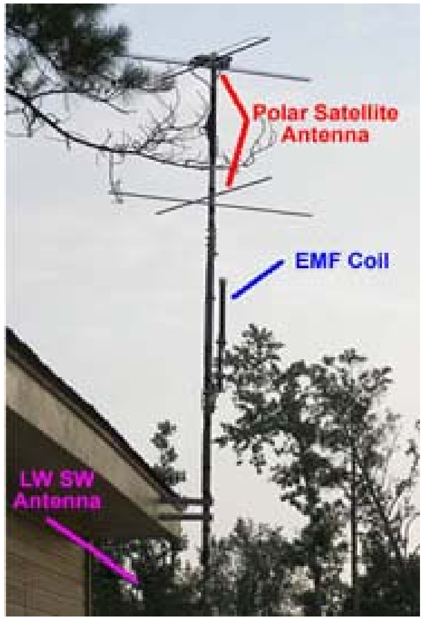
In order to obtain data from dynamic weather phenomena it is necessary to seek out and intercept storms and to launch sensors into the heart of the disturbance, capture the data, and return the data for immediate processing and analysis. Hence the name, Chase Team.

The Chase Teams utilize Jeep Grand Cherokee 4 wheel drive units, equipped with specialized tires and suspension to handle road debris situations and evasive maneuvers while on the go. When storm data is required, the teams immediately equip the jeeps with instrument packages and laptop computers inside the vehicle and attach to the roof, weather instrumentation, satellite dishes, sensors and communication gear. Portable rocket launching stands and weather rockets are loaded into the back of the jeep. Transforming from a standard jeep to a fully operational weather pursuit vehicle takes as little as five minutes.

Glenda Project – Pullman Point Research Facility

The Pullman Point Weather Research Facility is located in Petal, Mississippi, roughly 60 miles north of the Gulf of Mexico.

The Facility houses instrumentation that is a combination of old school analog, as well as, state of the art digital that is exclusive to less than a half dozen operations in the continental United States and the most advanced privately owned instrumentation in Southern Mississippi.



Glenda Project – Pullman Point Research Facility

Data is acquired and network backup communication systems are in place with an eight dish satellite antenna array located onsite.

Backed with an onsite super computing cluster and multi mode communication links with the outside world we supply information in live time for the purposes of research and learning. The facility is linked by networks and hardened server farms in New York, NY

Glenda Project – Engineering / Computing

David Davis – Edmonds, WA - Launch Operations Director - Brings decades of experience from engineering work in private industry and United States government in rocket research, and aerospace. Extensive background in electronics, mechanics, communications, computing, and storm chasing. Member of the National Association of Rocketry since 1983, and been involved with hobby related rocketry since the 1960's.

Robert Pullman – Petal, MS - Long Range Sensor Development - Has three decades of experience in communication and the computer industry and his expertise is world renown. His work has enabled governments to formulate policies and legislation in international, national and local forums. He has developed products that are used by universities for seminars, by corporations for internal operations to meet government regulations, by scientists for research work in field and laboratory conditions, by government departments for device operations and maintenance, and by the military for use in battlefield activities.

Glenda Project – Media Communications / Public Relations

As the Glenda Project matured, a definite need became apparent for an individual with media communications skills and public relations.

Tim Quigg in Dayton, WA brings a unique mix of personal background and professional experience to the Glenda Project. Quigg has over two decades of experience in customer service and media relations. He has been the Assistant Editor of Extreme Rocketry Magazine since 2000, as well as a freelance writer of numerous articles for Sport Rocketry Magazine. He is a current member of the National Association of Rocketry, and is the 2001 recipient of the National Association of Rocketry’s President’s Award, in recognition of his work with youth in model rocketry on a national level. Quigg is a highly decorated 24-year veteran of law enforcement, and is currently the Senior Communications Officer at a Southeastern Washington State E911 Communications Center.

Glenda Project – Application - Dayton, WA

“Lone Tree” Launch Site – Microclimate Profiling in Motion

“Lone Tree” Launch Site – Dayton, WA

Glenda Project – Dayton, WA

“Lone Tree” Launch Site – Background

The Blue Mountain Rocketeers (BMR), club, initiated launches at the “Lone Tree” site in 2000, and immediately noticed a bizarre behavior that when rockets were flown above 1,500 feet, that during recovery, they were blown by apparent high winds towards the direction of the gravel perimeter road located at the northern edge of the launch site even though ground wind speed was at a minimum.

Prior to BMR’s use of the site, “Lone Tree” was also used as a runway by local crop dusters who also noticed this effect as well and were able to fly with heavier loads of agricultural sprays due to the increased updrafts at altitude.

The Glenda Project saw this effect as an opportunity to test out various sensors and provide wind velocity mapping data to BMR in support of the National Association of Rocketry (NAR) safety code requirement of assurance of recovery of all high powered rockets within the fields boundaries.

Glenda Project – Thermal Mapping Mission

September 25, 2004 Columbia County / Dayton, Washington

During September 2004, Glenda performed a thermal mapping mission using a chart recording ground station, and both active and passive payloads.

The purpose of these two flights was to confirm, or refute the existence of a region of thermal activity over the “Lone Tree” launch site.

The first rocket sounding employed the Glenda 98mm capsule lofting an active transmitting payload broadcasting temperature, relative humidity and barometric pressure data to the ground station.

The second sounding flight was made using the Glenda 54mm capsule carrying a passive payload recording temperature and relative humidity.

Glenda Project – Thermal Mapping Mission

September 25, 2004 Columbia County / Dayton, Washington

At the time of the Glenda flights, the ground temperature was around 80 degrees, with a Relative Humidity around 37-38%. Under the standard atmospheric model, temperature goes down, as does humidity as you increase in altitude.

At “Lone Tree”, this was not the case.

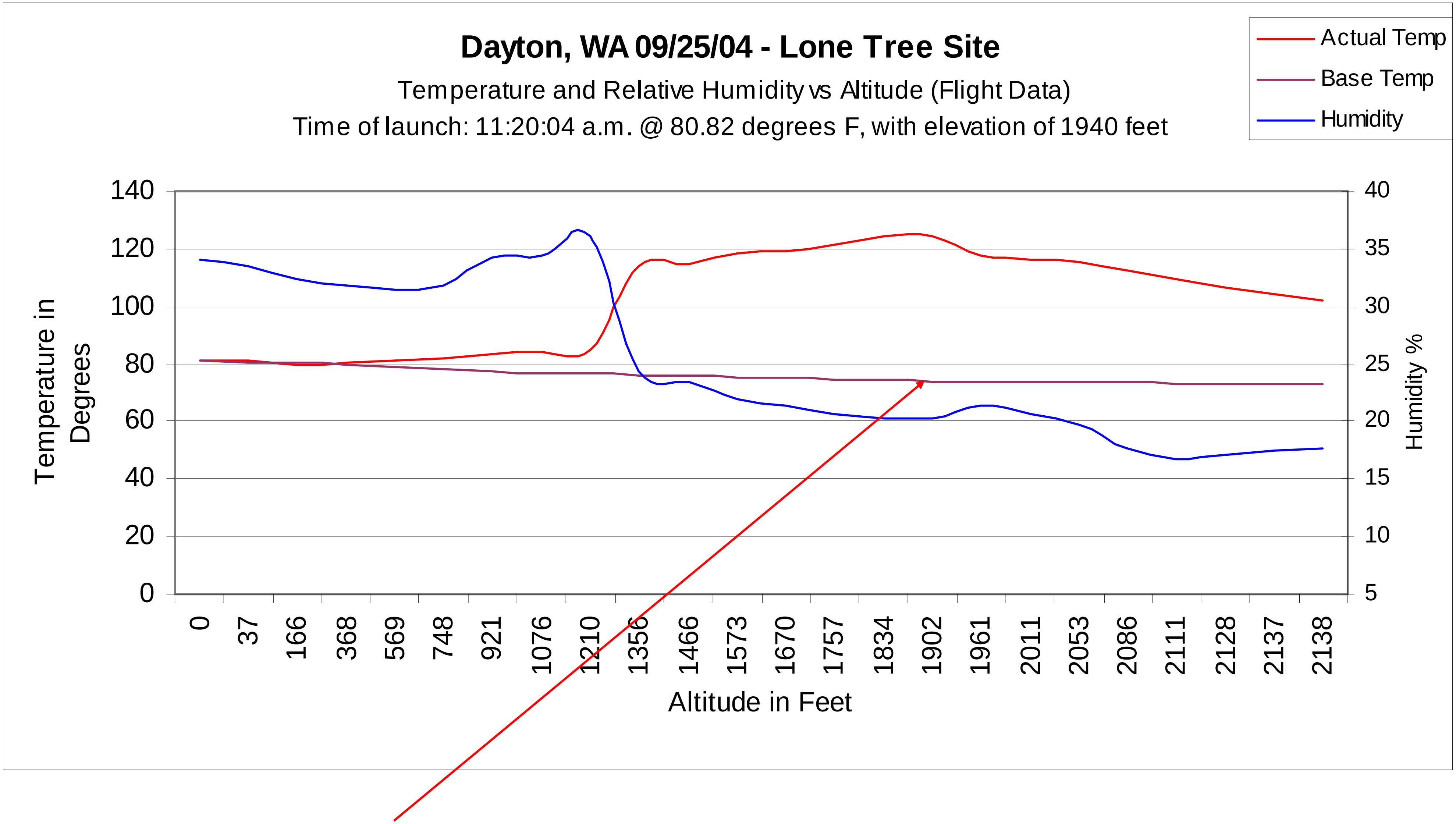
Temperature and humidity stayed relatively constant until 1,300 – 1,400 feet. Then things got interesting. The temperature rose rapidly, and the humidity level dropped. The sensors detected a 500 foot layer of hot, dry air which topped over 124 degrees at 11:00 in the morning. That's a 40+ degree difference from ground conditions. As the sensors penetrated the layer, more "normal" readings were detected.

The data between the two flights supported one another and have provided a body of evidence proving the existence of a thermal layer above the launch site.

The mapping mission was a success and the results are shown on the following slide.

Glenda Project – Thermal Mapping Mission

September 25, 2004 Columbia County / Dayton, Washington



Projected Temperature based on Standard Atmospheric Model – Something definitely out of the ordinary is happening!

Glenda Project – Thermal Mapping Mission

September 14, 2008 Columbia County / Dayton, Washington

Four years later in September 2008, the Glenda Project took this investigation to the next level by flying a hybrid payload containing a GPS transmitter to measure wind velocity, and a datalogger to measure temperature and RH.

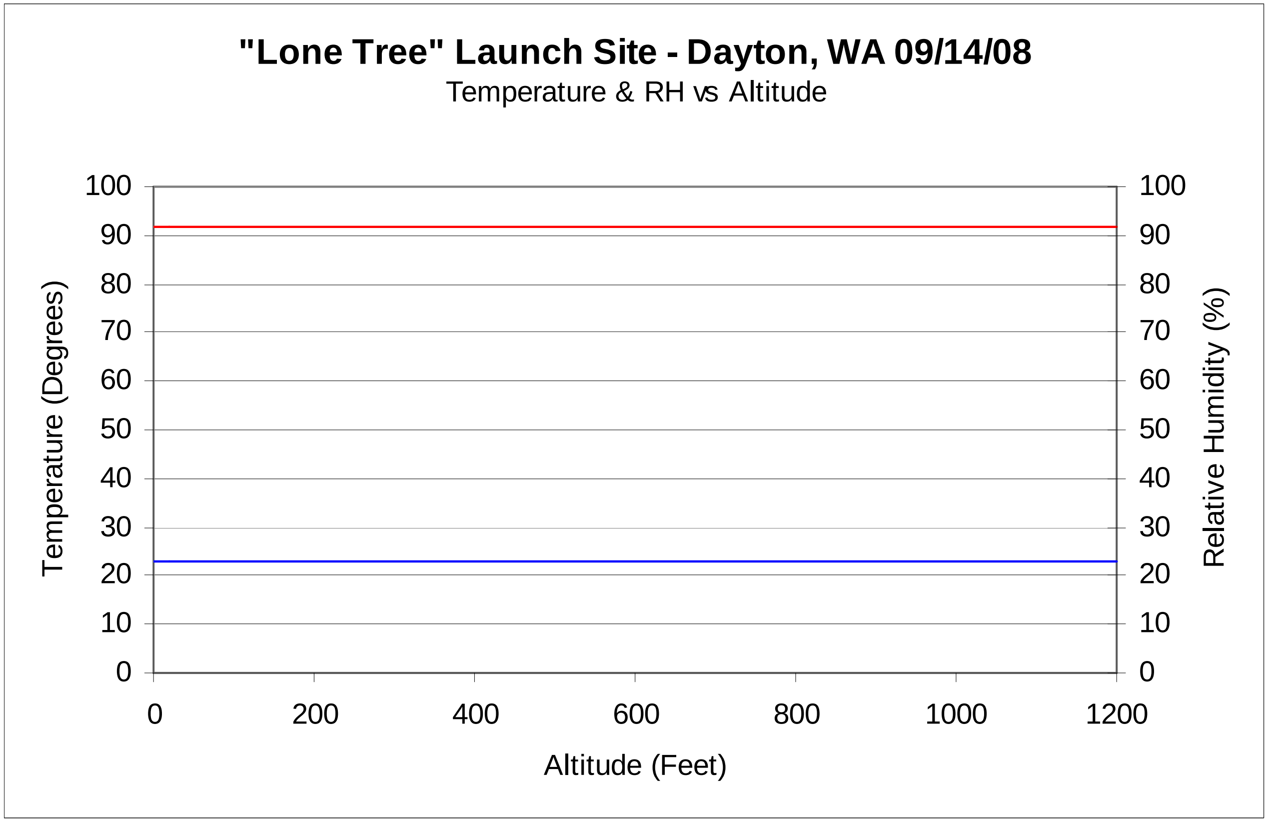
The most significant difference between the 2004 and 2008 flights was in the condition of the launch site. In 2004, the site was sown in Alfalfa and was uncut. In 2008, the site was still in Alfalfa. However, it had been freshly cut and bailed. It was unknown how this would effect the atmospheric conditions above the launch site.

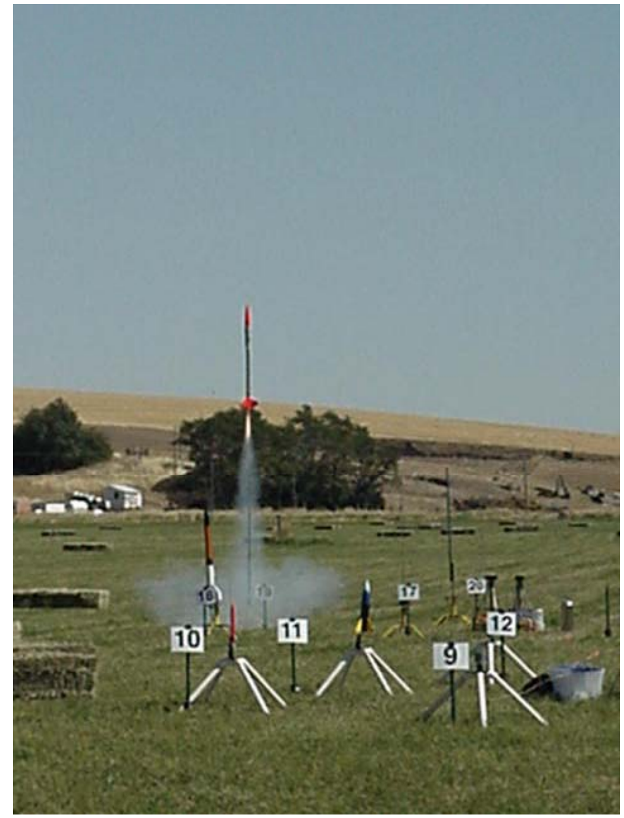
The differences between the temperature vs. altitudes between 2004 and 2008 were striking. In 2008, with the cut field, the air temperatures remained constant through the capsules decent envelope.

The 2008 temperature and RH data vs. altitude chart is shown in the next slide.

Glenda Project – Thermal Mapping Mission

September 14, 2008 Columbia County / Dayton, Washington





Glenda 5475 Booster takes flight

A distinct difference between a cut and an uncut field on air temperature and humidity!

Glenda Project – Updraft Profiling

September 12, 2009 Columbia County / Dayton, Washington

In September 2009, a verification flight was made to confirm the temperature and humidity conditions.

Temperature and humidity, again remained constant. Therefore a temperature inversion was not occurring.

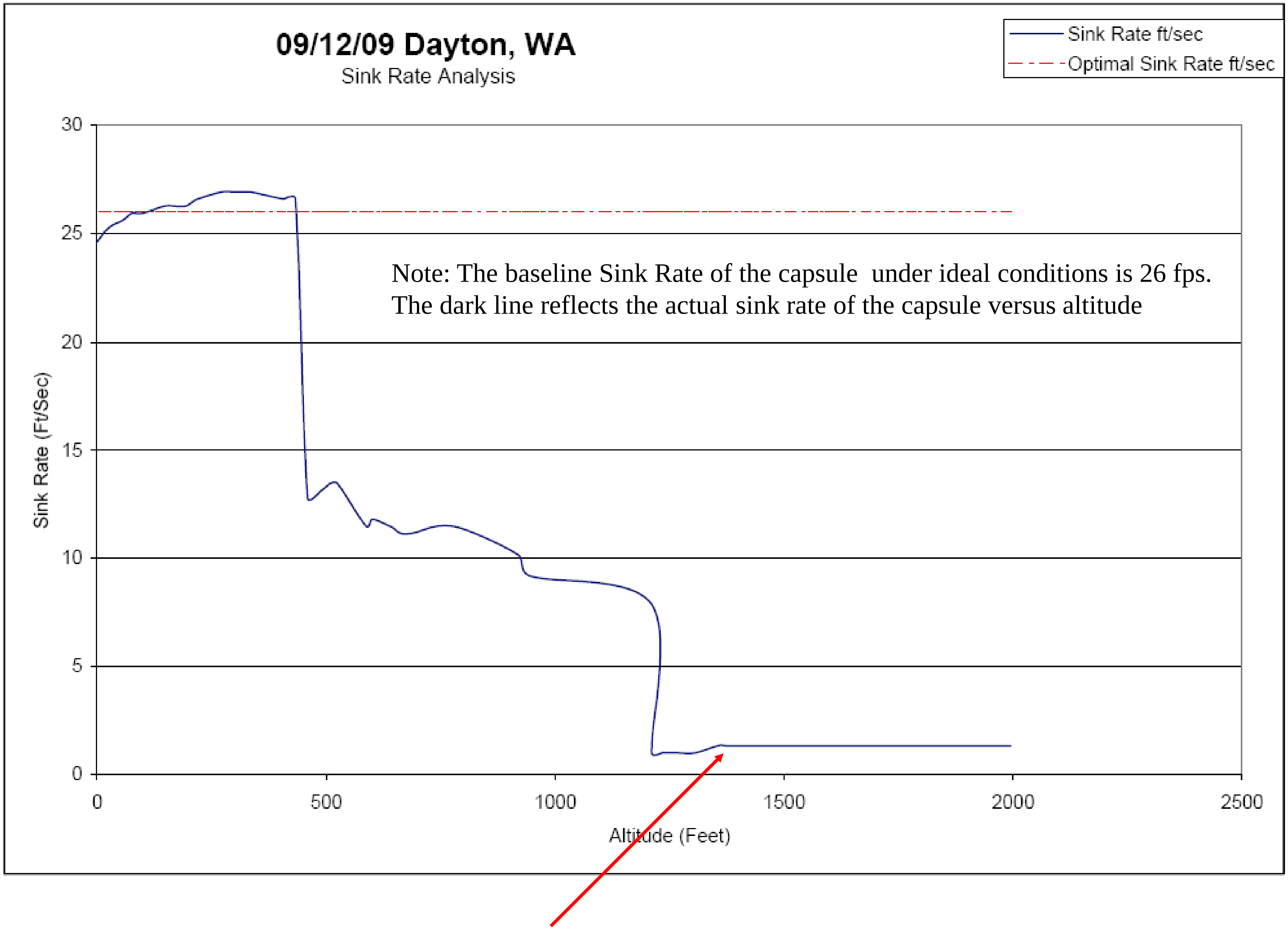
While the 2008 flight focused on temperature and humidity, the 2009 flight included a more detailed vertical analysis. An additional characteristic was mapped during this flight. That of capsule sink rate. The purpose of this was to determine the existence up updrafts due to thermal inversions, or local terrain.

The results were astounding. Above 1,200 feet, a close to 25 feet per second updraft was recorded. All driven by local geography and micro-climate.

The following slide displays this updraft profile.

Glenda Project – Sink Rate Profiling

September 12, 2009 Columbia County / Dayton, Washington



Note the close to 25 feet per second updrafts above 1,200 feet

Glenda Project – September 2010

Columbia County / Dayton, Washington

For September 2010, our goals were to build on the flights from 2008 and 2009. Three flights were planned with altitudes of 2,500 feet to 4,000 feet. All would have multi-channel telemetry including the important 4D GPS (latitude, longitude, altitude, & motion) which was tested in 2008 / 2009.

The purpose of these flights will be to determine the boundaries and strength of the updraft layer above the "Lone Tree" launch site.

Flights would be made at different times of the day from early morning to mid afternoon in order to capture different flight profiles over different ground temperature conditions.

The boosters for these flights are shown on the following slide.

Glenda Project – September 2010 Flight Vehicles

9875 Booster
- 4" diameter booster, 3" diameter capsule
- RS92 Digital Radiosonde Payload with GPS
- Temp / RH Datalogger
- I211 Aerotech Motor – 2,800 foot altitude

5475 - HV Booster
- 2.125" diameter booster, 3" diameter capsule
- RS92 Digital Radiosonde Payload with GPS
- I218 CTI 54mm motor with 4,000 foot altitude

5475 Booster
- 2.125" diameter booster, 3" diameter capsule
- RS92 Digital Radiosonde Payload with GPS
- Temp / RH Datalogger
- I170 motor - 3,000 foot altitude

Glenda Project – September 2010 - Actual

While we had a really good plan, nature threw us, literally, a curve. A series of fast moving storm systems moved through the Columbia county area with rains on Friday and Saturday nights. The cloud base kept moving up and down through out the day on Saturday, and a decision was made to scrub the 5475HV flight as its altitude would exceed the cloud base.

The 9875 booster flew first on its I211 motor. The GPS board starting going erratic on the launch pad. However, not sufficiently enough to scrub the launch. During boost, the GPS board totally failed and at separation, only temperature and RH data was recorded by the onboard datalogger. While this data was solid, without altitude data to compare it against, it was basically useless.

After this in flight failure, a decision was made to swap out the new 4D capsule from the 5475-HV booster and fly it on the 5475 "Standard" booster powered by a CTI I170. The new capsule was designed to handle the higher accelleration loads and would survive the boost of the "I" motor.

The flight of the 5475 was picture perfect. However, nature then threw us a curve. Right at separation, the capsule hit a major updraft and wind shear and was accidentally "ingested" by a passing storm cloud. The capsule was spun around horizontally, breaking GPS lock. However, all other sensors continued to function. After several seconds, the capsule was ejected from the cloud and re-achieved GPS lock at 2,000 feet. Both capsule and booster landed over ½ mile down range and was successfully recovered. It was not our intent to penetrate the cloud base. However, nature had other plans.

The following series of slides displays the data collected during the flight, plus from the groundstation.

Glenda Project – Updraft / Wind Velocity Profiling

September 18, 2010 Columbia County / Dayton, Washington

The optimal sink rate of a Glenda capsule is 26 feet per second. Mathematically, this translates to -26 fps, as negative values indicate that the capsule is moving down, while positive values mean that the capsule is moving up.

At separation at 2,700 feet, the capsule was caught up in a nearly 80 feet per second updraft. This translates to over 100 miles per hour, a significant updraft event!

This updraft, tumbled the capsule, resulting in only partial signal reception with the groundstation. The capsule eventually re-stabilized at 2,000 feet where GPS lock was re-acquired and was nominal to recovery.

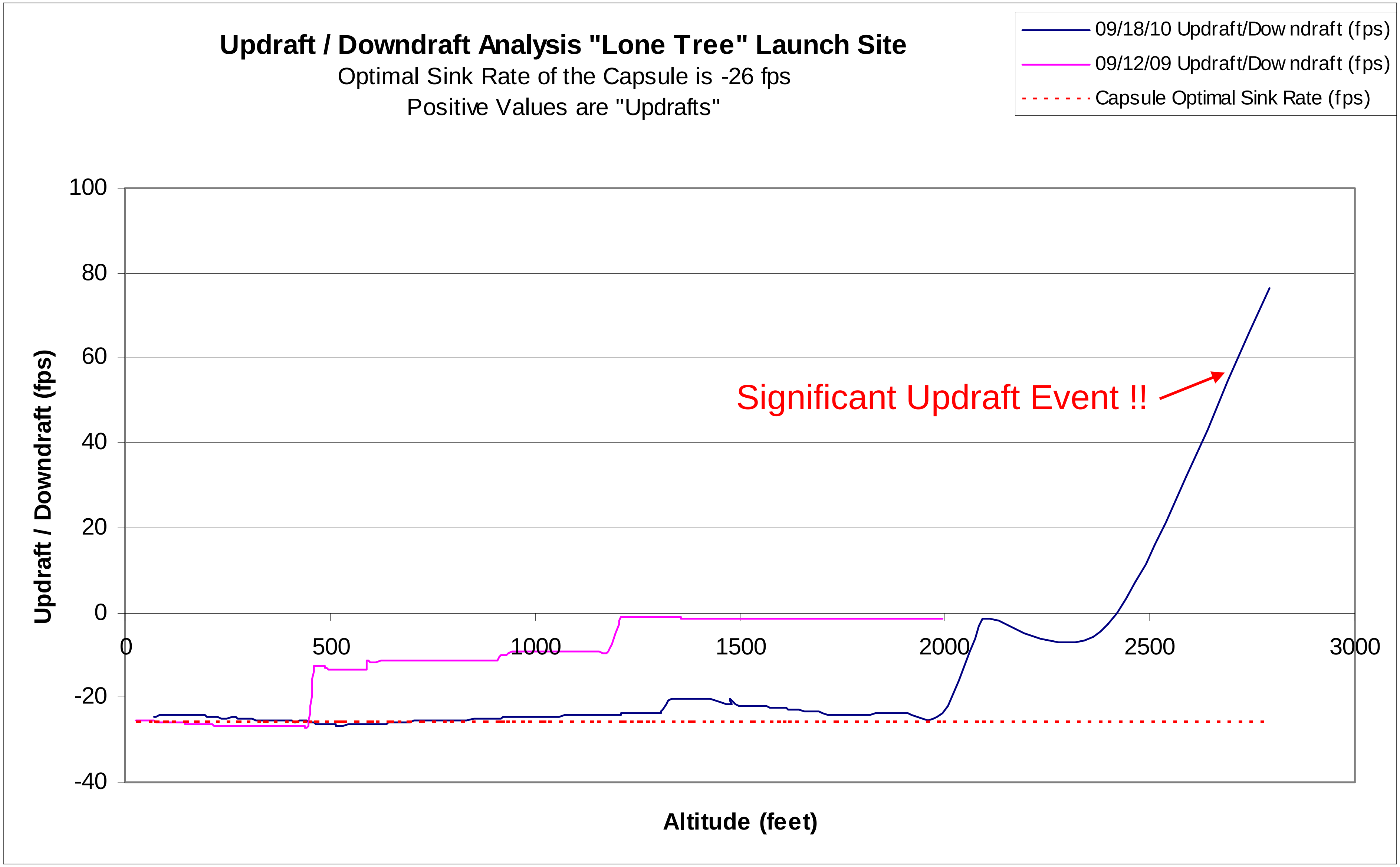
The updrafts finally reached “normal” levels at around 1,200 feet where the flight proceeded under nominal conditions.

One of the major advantages of the Glenda system is its ability to measure wind speed at various altitudes. This launch gave the system a real work out when the capsule hit the combination updraft and wind shear in the altitudes from 2,700 to 2,000 feet.

Wind speeds of just over 90 miles per hour were detected at the 2,000 foot altitude, while another layer of close to 30 miles per hour was detected at the 250 foot level.

Glenda Project – Updraft Profiling

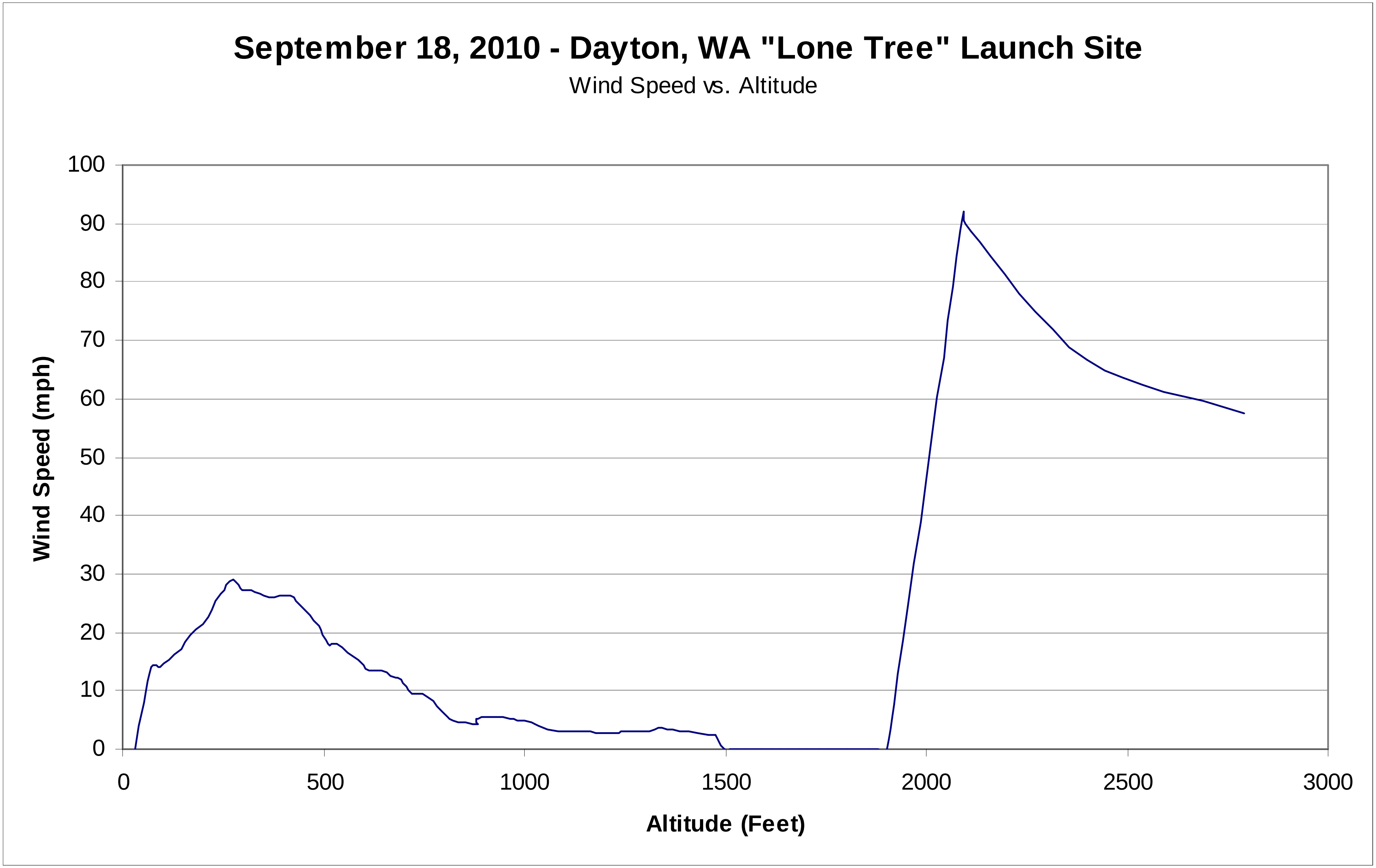
September 18, 2010 Columbia County / Dayton, Washington



Note: The September 2009 Updraft data is included as topical reference

Glenda Project – Wind Velocity Profiling

September 18, 2010 Columbia County / Dayton, Washington



While the winds at ground level reflected nominal conditions, the winds aloft were brutal!

Glenda Project – 4D GPS Positioning

September 18, 2010 Columbia County / Dayton, Washington

One of the improvements made prior to this series of launches was to modify the groundstation antenna system in order to receive signals in two planes. In the past, we used a dual antenna system, with both antennas oriented in the vertical direction. The intent was to increase signal coverage. However, it did not address the basic issue that the capsule did not stay in the vertical orientation for the entire flight. At apogee, the capsule went horizontal, and we lost signal. By aligning one of the antennas along the horizontal plane, it was hoped that signal quality would be improved.

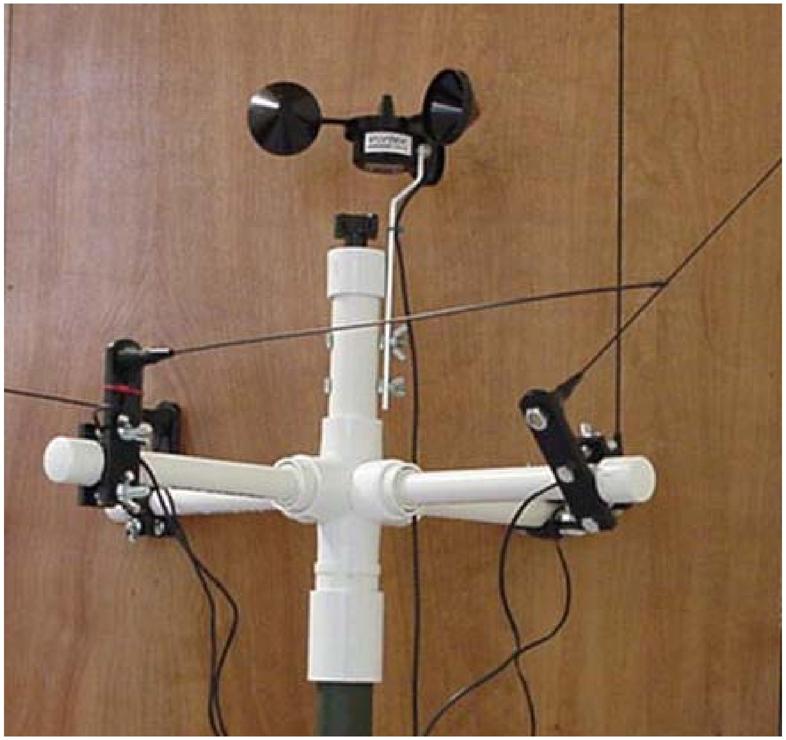
Data quality significantly improved with this flight. However, nature exposed a weakness to this approach. While our “dual” plane antenna system addressed, vertical to horizontal, it did not address changes within the horizontal plane! When the capsule was “ingested” in the updraft / wind shear, the capsule was spun horizontally loosing signal!

The 4D GPS system (Latitude, Longitude, Altitude, plus motion) transmitted excellent data, when not being spun around and in our antenna systems “blind spots”.

For next season, we’ll be deploying a “Quad Plane” antenna system which will solve this signal reception problem.

Nature sometimes presents us with situations which drives improvements which will make our data collection and signal reception even better.

Glenda Mobile Quad Plane Antenna



The September 2010 launch revealed a weakness in our ability to receive signals from a Glenda capsule in one of the horizontal planes. This drove the creation of a "Quad Plane" antenna which now covers all possible capsule orientations and will be available in support of the 2011 launches.

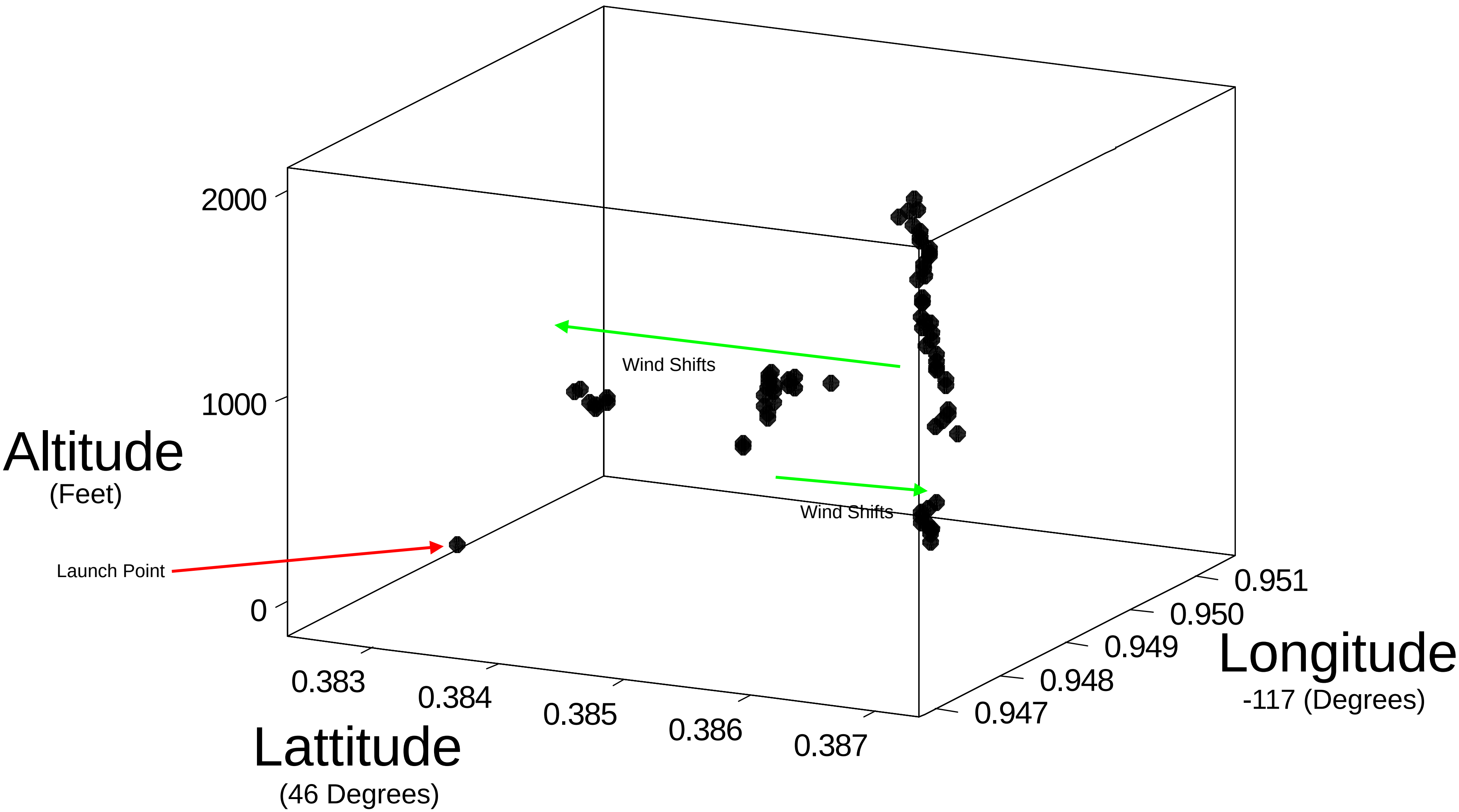
<u>Adaptable Antenna Mast Sensor Head</u>

- In-Speed Anemometer / TMQ-34 Sensor (dual use)
- Four Wide Band Receiver Antennas for Radiosonde telemetry signals to cover each potential plane of capsule orientation.
- Mast System Interface Adapter
- Light weight PVC construction to reduce potential for lightning strike
- Antennas with 1.2 GHz capability allows multiple frequencies and multiple radiosonde reception
- Mast head integrates with portable mast system

Previous "Dual Plane" antenna design

Glenda Project – 4D GPS Positioning

September 18, 2010 Columbia County / Dayton, Washington



Note: The changing wind shifts as the capsule descends.

Glenda Project – Temperature Profiling

September 18, 2010 Columbia County / Dayton, Washington

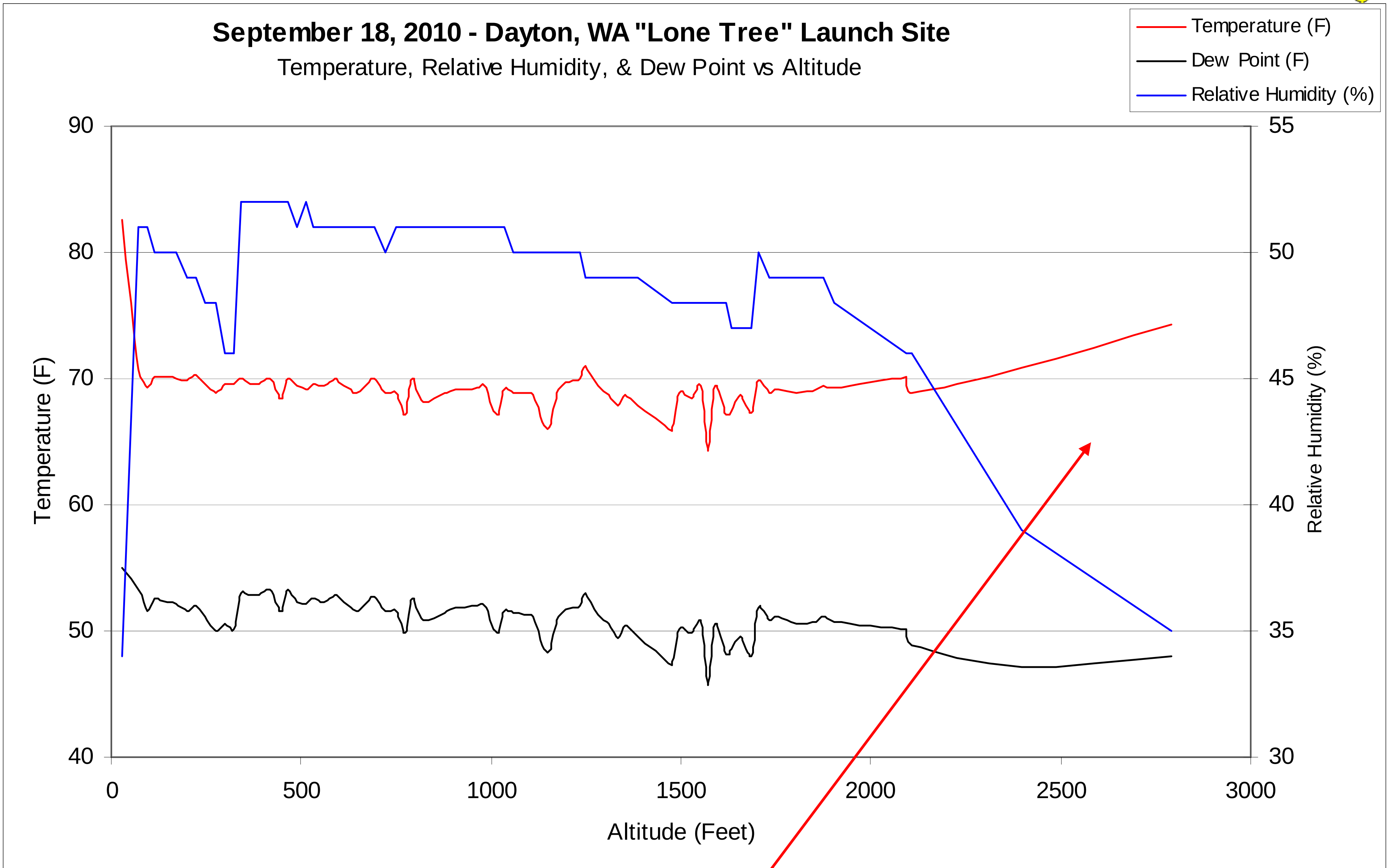
On previous Glenda flights, we've used onboard dataloggers to collect temperature and relative humidity data. This system resulted in additional pre-flight preparation to initiate the datalogger, plus the post flight downloading time and post processing. This datalogger data, combined with the transmitted positioning data, allowed us to "profile" temperature and relative humidity data versus altitude. One of our goals with Glenda is to present data in real time, in order to make real time decisions.

At the September launch, the set of flights used a datalogger system on the 9875 flight and a fully transmitted data suite of temperature and relative humidity sensors for the 5475 flight. The purpose of this was to ensure data collection in the event the transmitted data suite failed during flight. The exact opposite happened. The 9875 flight, with its proven reliable electronics, had an on-board failure of its data transmission system, while the 5475 flight with its untested system performed flawlessly. The major advantage of this new system is that pre flight preparation is greatly simplified. All that is needed is the basic "power on" and the on-board electronics does the rest. We will be transitioning to this new data transmission suite on future flights.

The "Lone Tree" site is a unique microclimate where temperature rises, rather than falls with altitude, and the inverse with relative humidity. The onboard sensors detected the updraft / wind shear was at a higher temperature and lower humidity than at lower altitudes. The exact opposite as to what should be expected.

Glenda Project – Temperature Profiling

September 18, 2010 Columbia County / Dayton, Washington



Note the environmental shift while the capsule is in the updraft / wind shear

Glenda Project – Groundstation Data

September 18, 2010 Columbia County / Dayton, Washington

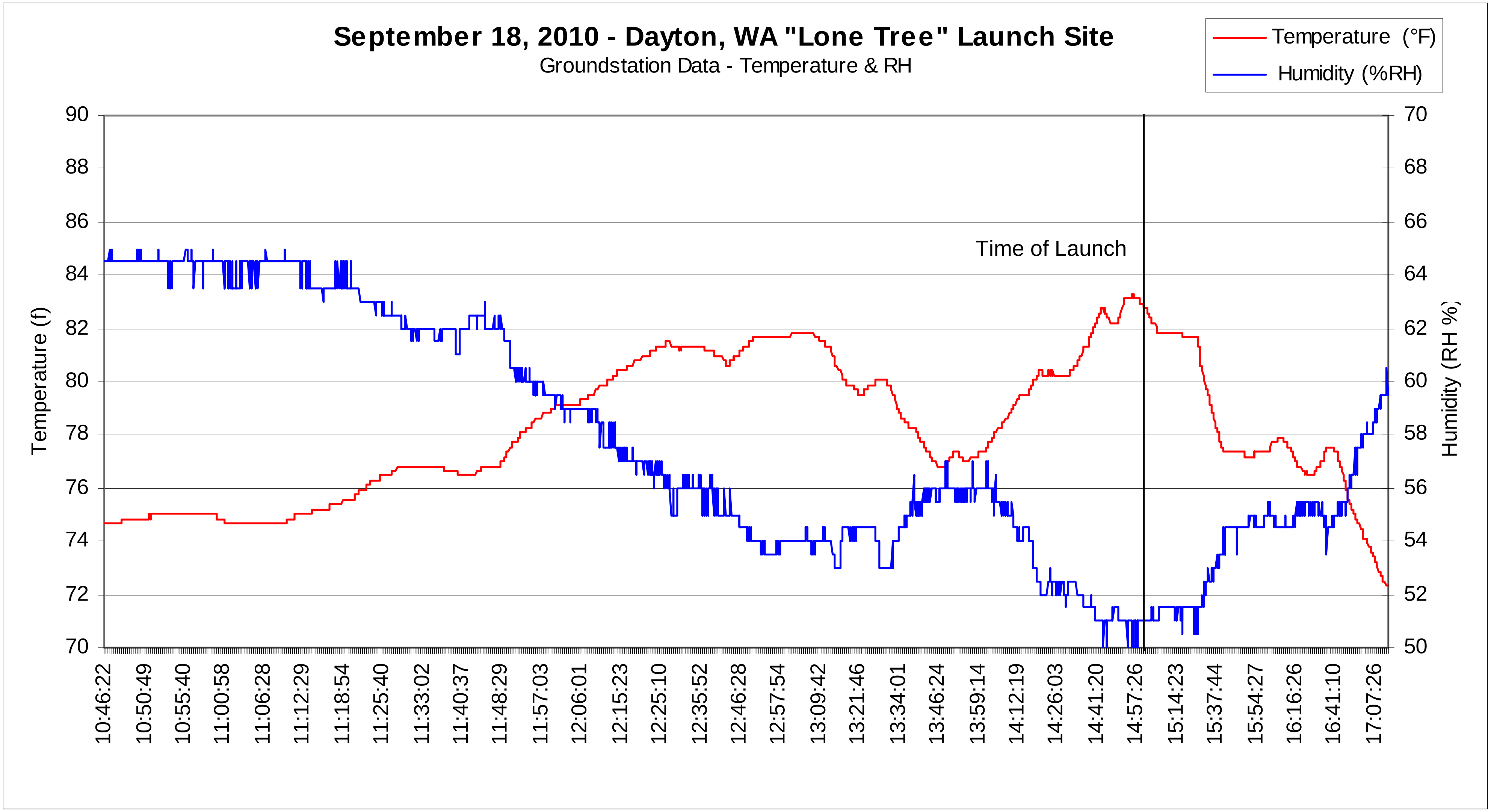
For this launch, we deployed our “traditional” groundstation suite of instruments, as we wanted a digital record of the data, rather than “snap shots” provided by our TMQ-34, or our other “stand alone” sensors. An improvement in our USB-Serial hub allowed us to collect data from all of the necessary ground sensors without disrupting the signal reception and processing of the data being received from the capsule.

The time of the 5475 flight was in the 3:00 pm local time frame. So we were able to synchronize the transmitted data from the capsule with the recorded data from the groundstation.

Based on the recorded groundstation data, we were definitely between storm systems, and per the Launch Director, Saturday night was the first time floatation devices were issued at a BMR launch. The incoming rain and winds severely curtailed Sunday’s activities.

Glenda Project – Groundstation Data

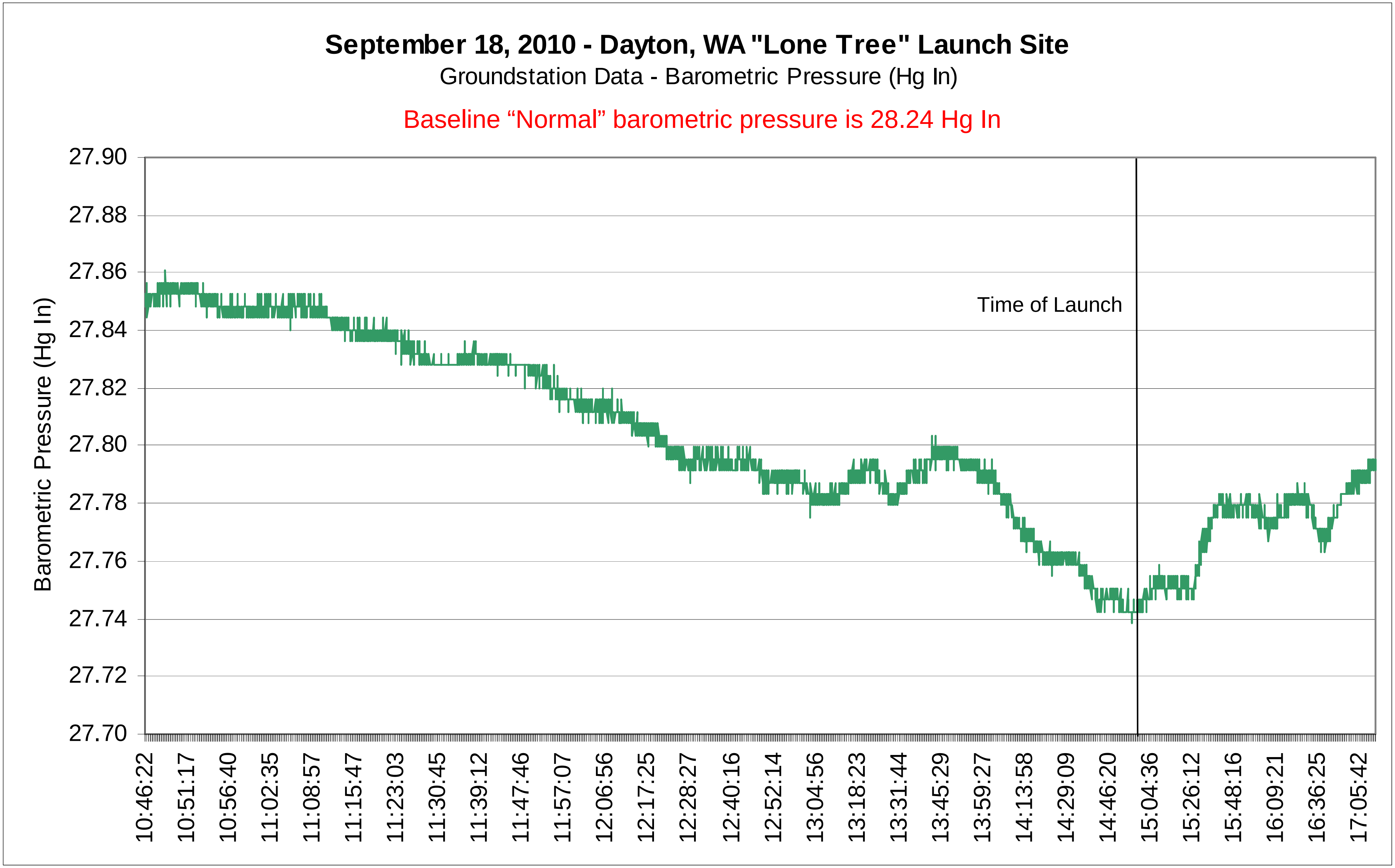
September 18, 2010 Columbia County / Dayton, Washington



Temperature and Relative Humidity fluctuated during the data as the storm system approached

Glenda Project – Groundstation Data

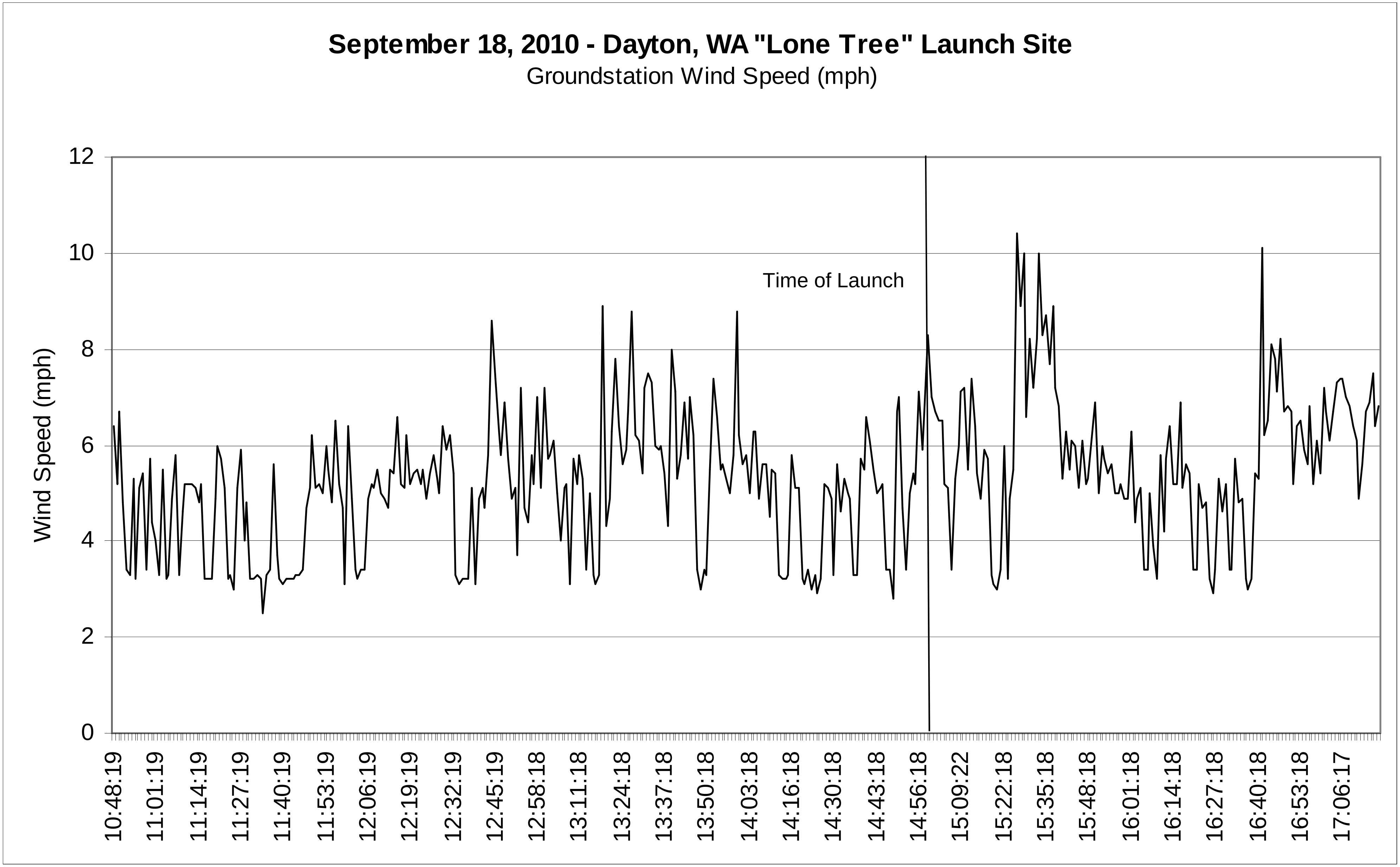
September 18, 2010 Columbia County / Dayton, Washington



Barometric pressure was falling prior to launch

Glenda Project – Groundstation Data

September 18, 2010 Columbia County / Dayton, Washington



Glenda Project – September 2010 – In Conclusion

The Glenda Project continues to grow, and develop. The September 2010 launch featured the first flights of "I" level motors, a full sensor suite, and an integrated groundstation.

Problems continue to be resolved as we extend the flight envelope. Data quality continues to improve and become more reliable.

For 2011, we'll deploy the new "Quad Plane" antenna, a new 98mm booster with 54mm motor capability, and upgraded capsules designed for higher accelleration loads.

Flights will continue in 2011 with the focus being to the map the thermal layer above the "Lone Tree" launch site with the intent to develop a prediction model for updraft conditions.

The Glenda Project would also like to thank the members of BMR for their continued support in our efforts. You all help in so many ways making this all possible.

Glenda Project – Accomplishments

Maturing Payloads & Systems – Preparing for the "Wall Cloud" Mapping Mission

Glenda Project – 2008 / 2010 Accomplishments

- July 2008 – Deployed Gamma Ray sensor and determined that Thunderstorms suppressed "background" radiation counts.

- September 2008 – First Flight of the GPS Wind Velocity payload which allows 3D mapping capability of storm systems

- September 2009 – Incorporated Sink Rate profiling into the GPS capsule data analysis.

- September 2009 – First flight of "4D" payload. (Lattitude, Longitude, Elevation, & motion)

- September 2009 – Collected updraft and downdraft data from the "4D" payload in real time.

- September 2010 – Deployed new "High Velocity" booster and capsule to further expand the flight envelope.

- September 2010 – "4D" payload achieved first cloud "ingestion" collecting valuable updraft and downdraft data plus wind shear velocities.

Accomplishments and Operational Capabilities

- EMF detection in 2D with a 500 mile range; plus EMF detection in 3D with the ability to catch the electronic signature of a tornado.

- Magnetic and electrical monitoring system - the only private one in Mississippi (only 6 commercial units in the country)

- Holder of Patent Number 60/903,881 - Multi-Dimensional Data Models for Tornado Prediction

- Local and regional weather information going out on the internet, full weather data on APRS over the air over the southeast of the country.

- Multiple chase vehicles that can do full weather analysis, soil analysis, and radiation measurement

- Mobile and stationary ground stations that can conduct weather measurements and monitor radiation levels.

- Weather Sounding Rocket payload launch capability with multiple sensors.

- Full satellite and weather data reception and analysis, with licensed radio operators and facilities that can communicate around the world; weather forecasts available on servers, and radio gateways that run 24 hours a day, 7 days a week non-stop - at no charge to the end users. The information is used by Emergency management crews in 5 Mississippi counties, as well as multiple radio and television stations and Fortune 500 companies.

Glenda Project - Advantages

- Portability and Rapid Deployment with “Launch on the Run” capability
- Ease of Use of propellant and vehicle/payload preparation
- Payload adaptable for external sensors to match user specific applications
- Composite components designed for extreme environments
- On-board locater transmitter allows for rapid recovery
- Off-the-shelf components reduce operating costs and ease repair

Glenda Project - Disadvantages

- Training required for system use, data collection and analysis
- Composite materials are not bio-degradable
- Rocket motors are “Hazardous Materials” and are classified as Flammable Solids 4.1
- Multiple sensors required to support complex analysis
- Active Payloads require ground stations for ground condition baseline data collection, data reduction and analysis

Glenda Project - Available

The Glenda Project has reached the level of maturity where we can offer portions for sale to end users based on their mission requirements.

Due to the nature of today's political environment, anyone expressing interest in a Glenda system should be capable of passing a federal background check because of the propellant system used in our boosters. Without having the appropriate permits, we cannot help you with your request. However, we can help guide you through the permitting process and other regulations which govern the use of Glenda systems.

The Glenda Project is constantly testing new sensors and new attributes. Let us know of your mission and budget requirements and we can help you develop the optimal design approach at the best value for your investment.

In Conclusion

The Glenda Project is a reusable sounding rocket delivery system designed to place instrument packages into areas previously considered to be to hazardous or inaccessible using traditional platforms such as balloons, aircraft, helicopters, kites, etc.

Through 2004 and 2005, Glenda completed its first successful mapping missions and during 2006, the ground station and payloads continued to mature in order to prepare to further extend the flight envelope to even more hazardous environments.

2007 brought continued maturing of sensors and first flight of “Ranger Intercept”.

The 2008 through 2010 series of launches allowed full testing of the GPS tracking and wind velocity and sink rate capability, and returned even more valuable data.

The operational Glenda Project shows the differences between Hollywood “fiction”, and engineering “fact”, from mapping local environments to a full tornadic funnel with a suite of sensors. Glenda is up to the task.

Glenda Project – Executive Summary - 2012

Glenda Project – Purpose

The primary mission of the Glenda Project is to provide the capability to rapidly gather previously inaccessible localized microclimate data from altitudes ranging from ground level to 20,000 feet and to return this data for immediate use.

The Glenda Project is mix of adaptable ground stations combined with a reusable sounding rocket delivery system designed to place instrument packages into areas previously considered to be to hazardous or inaccessible using traditional platforms such as balloons, aircraft, helicopters, kites, etc.

Glenda Project – Data Capabilities

The Glenda Project has the capability to collect temperature, humidity, barometric pressure, wind speed and other types of environmental data from ground level to 20,000 feet.

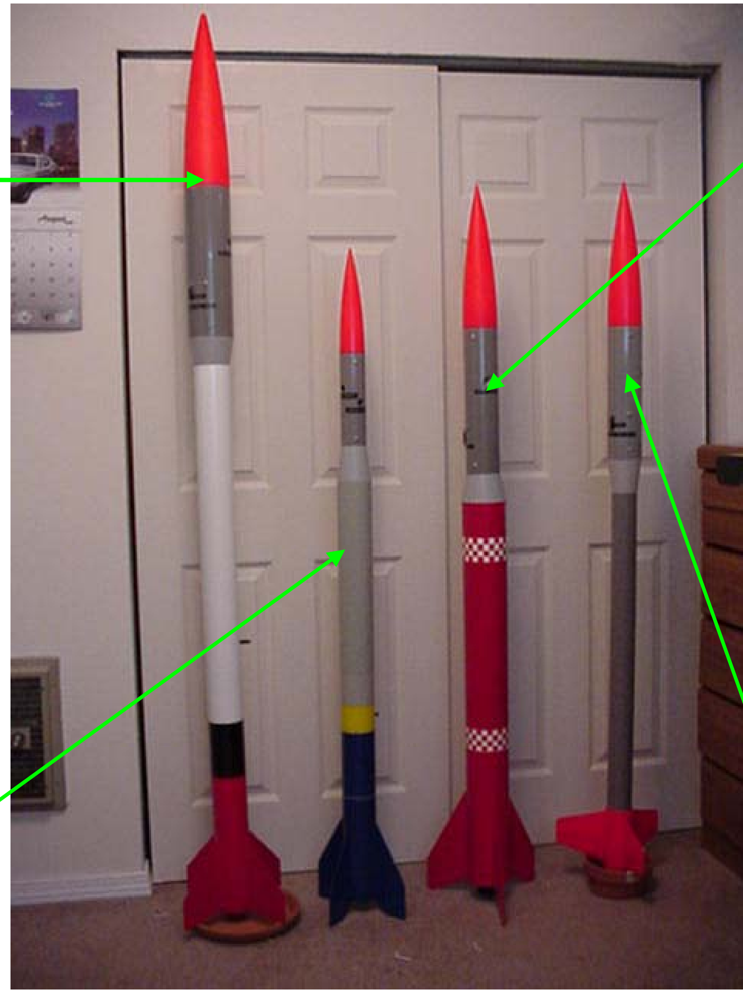
Glenda payloads are designed to be launched into thunderstorms, tornados, and other volatile weather environments and to return intact with its collected data.

Glenda Project – Data Collection Methods

Glenda has three primary methods of collecting data:

- Rocket Launched - Active Flight Data Collection Systems - Transmitters
- Rocket Launched - Passive Flight Data Collection Systems – Dataloggers
- Ground Stations

Glenda Project – Typical Flight Vehicles



<u>7598 Booster</u>
- 3” diameter booster, 4” diameter capsule
- RS80 Radiosonde Payload
- 3,000 to 20,000 ft altitude envelope

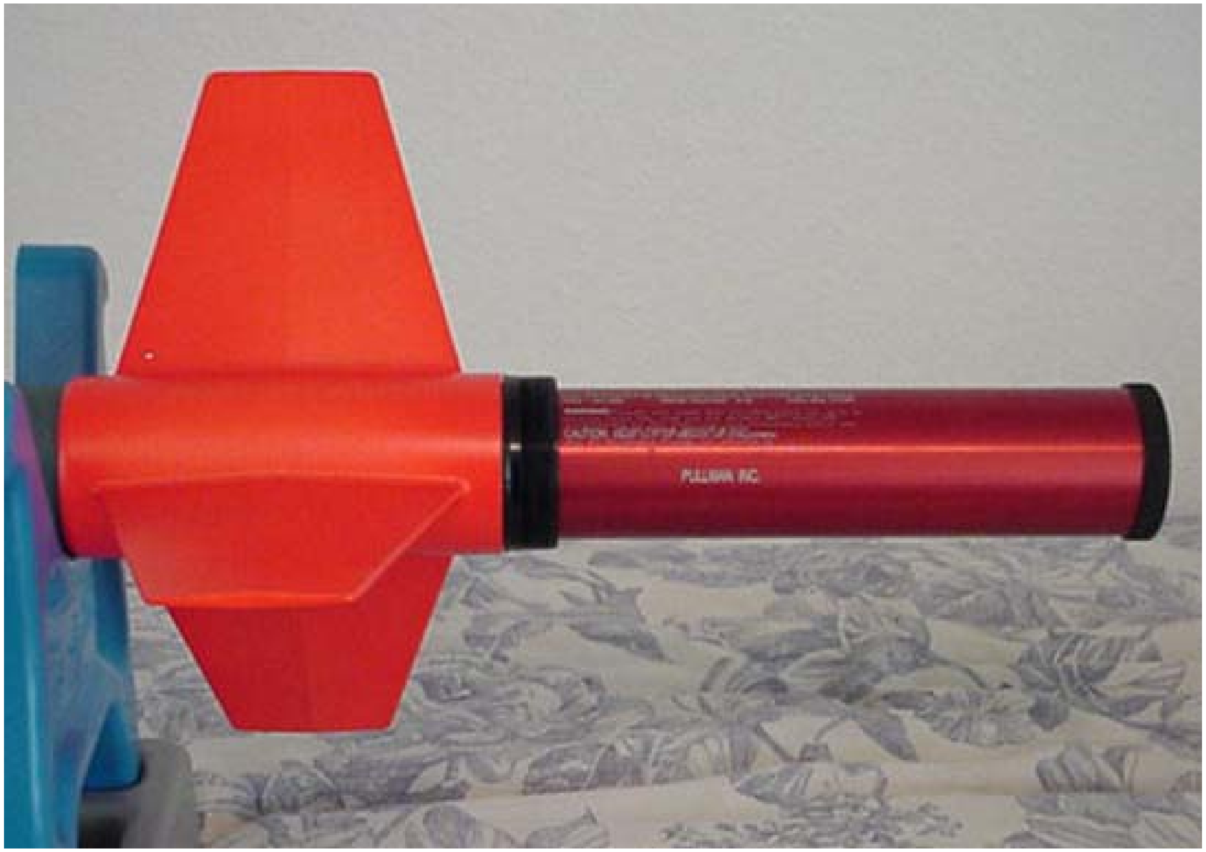
<u>FAR 101 Booster</u>
- 3” diameter booster, 2.125” diameter capsule
- Temp / RH Datalogger Payload
- 2,000 foot altitude envelope

<u>9875 Booster</u>
- 4” diameter booster, 3” diameter capsule
- RS92 Digital Radiosonde Payload with GPS
- Temp / RH Datalogger
- 2,000 to 15,000 ft altitude envelope

<u>5475 “Standard” Booster</u>
- 2.125” diameter booster, 3” diameter capsule
- RS92 Digital Radiosonde Payload with GPS
- Temp / RH Datalogger
- 2,000 to 15,000 ft altitude envelope

Glenda Project – 5475 High Velocity (HV) Booster

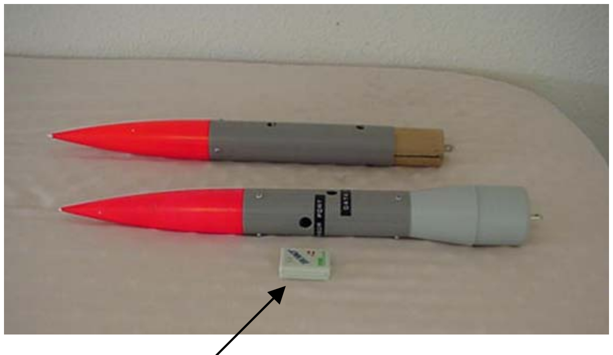
Comparison between the 5475 “Conventional” Booster and the 5475 HV Booster



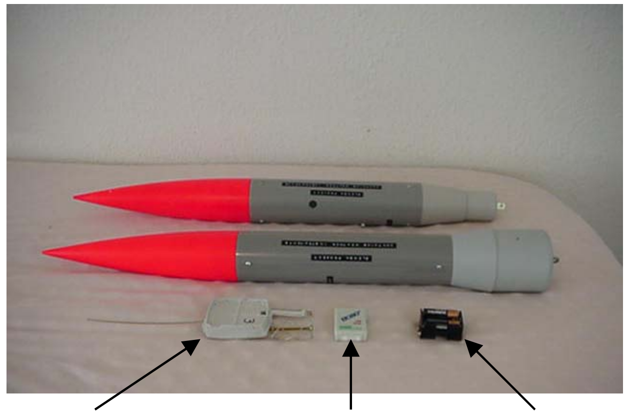
- 54mm motor vs. 38mm motor
- Adaptable altitude performance based on mission requirements from 2,000 to 20,000 feet
- Blue Tube heavy duty airframe with bonded motor retainer to support higher velocities
- Longer airframe to support larger “L” class motors
- Longer Payload capsule for increased payload capacity.

Glenda Project – Typical Flight Payloads

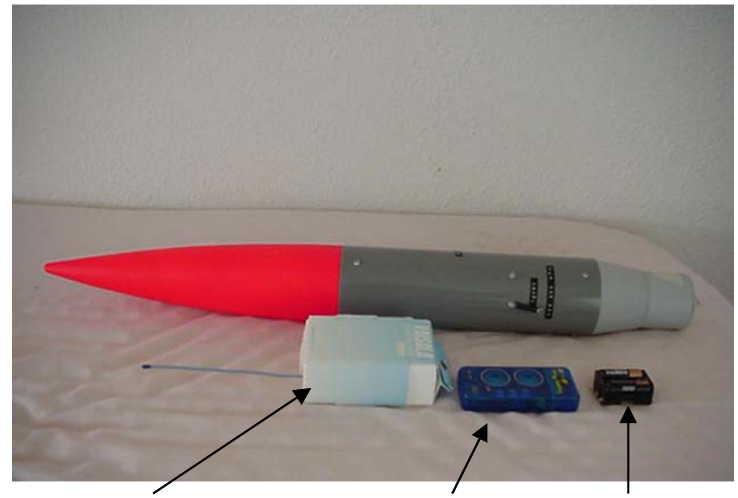
The Glenda project uses several different payload capsule configurations carrying a variety of instrumentation in order to gain weather related information, and other micro-climate data



Datalogger



RS92 Digital Radiosonde Datalogger Battery Pack



RS80 Analog Radiosonde Locator Beacon Battery Pack

54mm (2.125”) Capsules

- Datalogger Payloads
- Measures Temperature & RH values at 1 second intervals.
- Used by 54mm & 75mm boosters.

75mm (3”) Capsules

- Datalogger Payloads
- Measures Temperature & RH values at 1 second intervals.
- RS92 Digital Radiosondes transmitting temperature, RH, barometric pressure, and GPS coordinates.
- Used by 54mm & 98mm boosters.

98mm (4”) Capsule

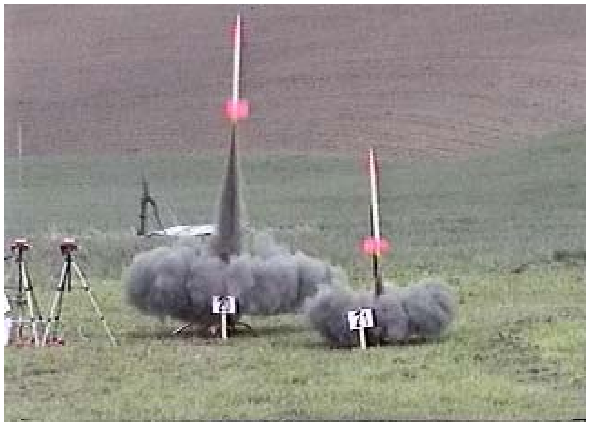
- RS80 Analog Radiosonde transmitting temperature, RH, and barometric pressure.
- Audio location beacon
- Used by 75mm boosters.

Glenda Project – Typical Flight Profile

2 – Boost Phase

3 – Deployment Phase

1 – Launch Phase

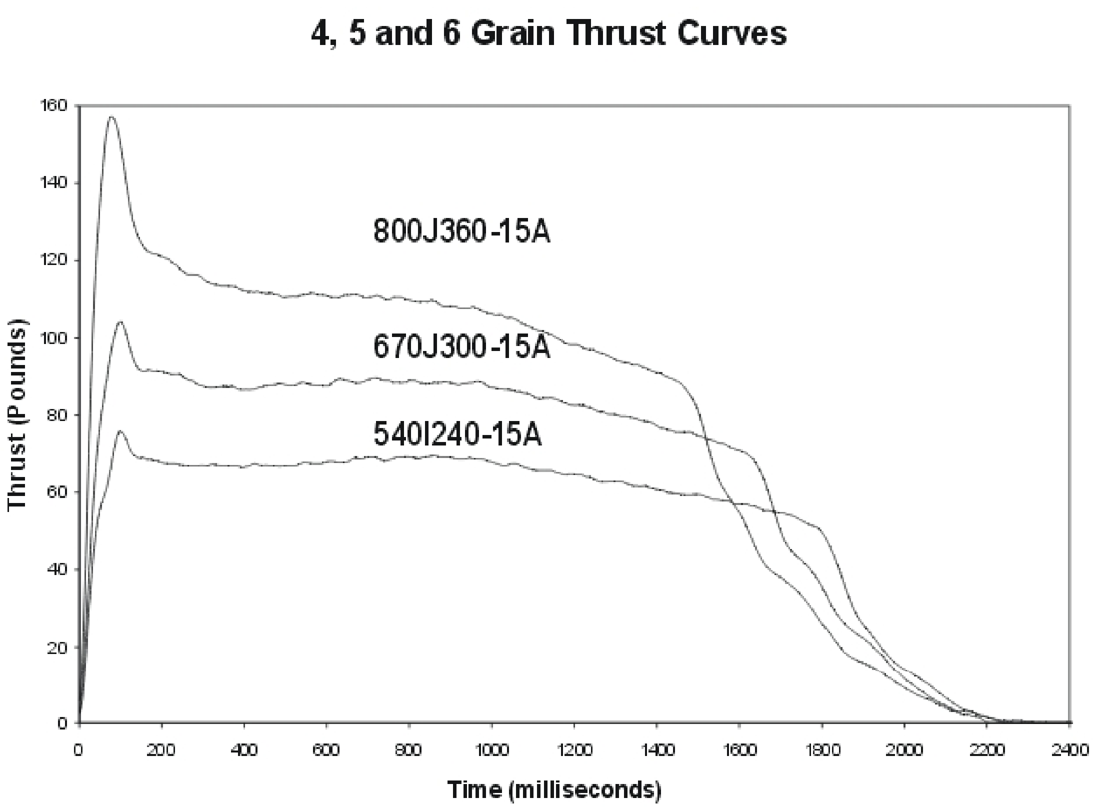


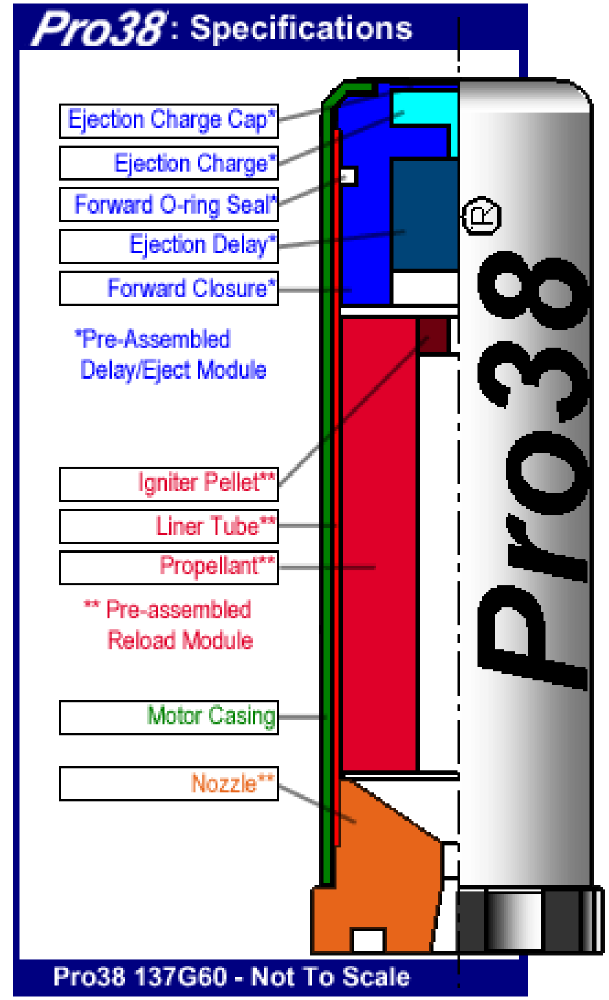
Note: Propulsion is provided by reloadable /reusable rocket motors giving the capability of rapid turnaround between flights.

4 – Recovery Phase

Glenda Project – Propulsion

The Pro38 / Pro54 rocket motor propulsion system is the first commercial thermoplastic propellant-based solid rocket motor and is produced by Cesaroni Technology Inc. of Toronto Canada. The Pro38 / Pro 54 is a modular, reloadable Solid propellant rocket motor system designed primarily for use in launching small experimental payloads by universities, colleges, research institutes and sport rocketry enthusiasts.



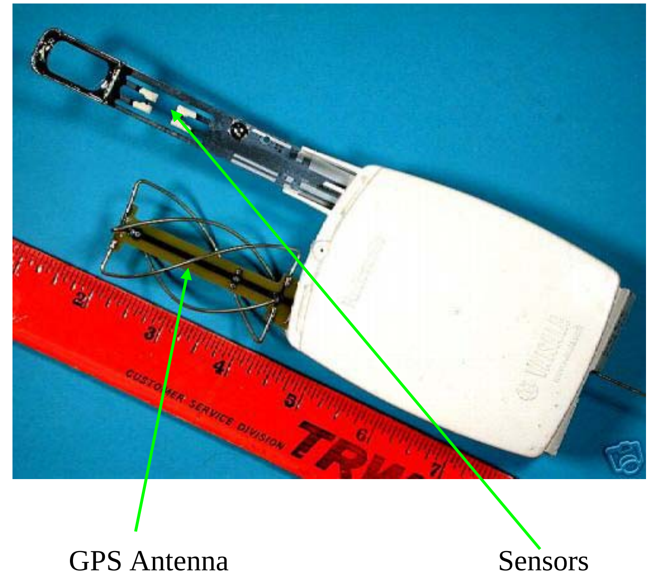


Glenda Project – Active Payloads - Transmitters

Converted Radiosonde Payloads

The Glenda Project uses converted radiosondes that are designed primarily for use with weather balloons. The circuitry and sensors function properly under thrust loads of the Glenda boosters and are compatible with NOAA radiosonde receiver systems.

The radiosonde contains instruments capable of making direct measurements of air temperature, humidity and pressure. These observed data are transmitted immediately to the ground station by a radio transmitter located within the instrument package.



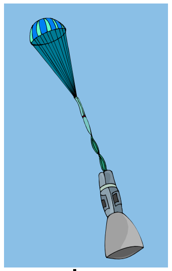
Vaisala RS92 Radiosonde

Radiosonde Specifications:

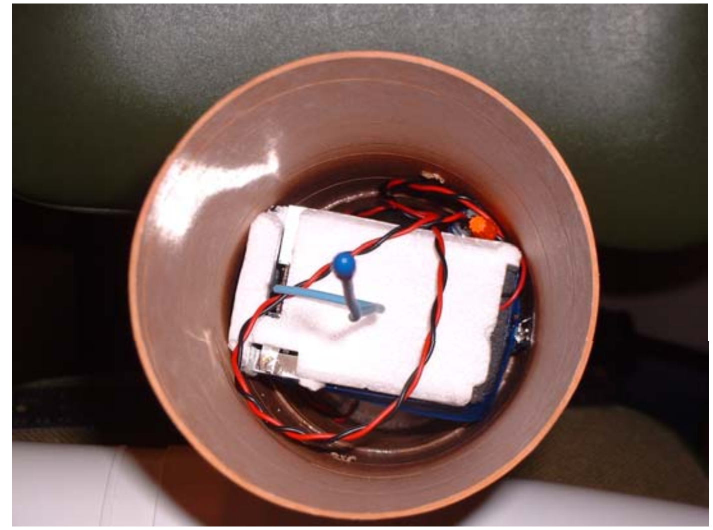
- Pressure range 3mb to 1060mb +/- .1mb
- Operating temperature range of -90°C to +60°C
- Relative Humidity from 0 to 100%
- Sampling Rate of once per second for the sensor suite
- Provides positioning data via GPS for payload location and wind velocity

Glenda Project – Active Payloads - Transmitters

Signal Processing Flow Diagram

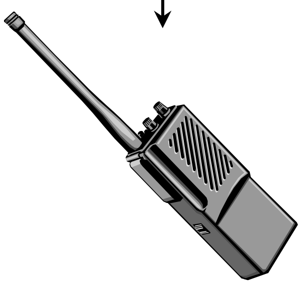


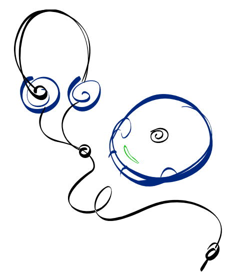
- Barometric Pressure Sensor Data
- Temperature Sensor Data
- Relative Humidity Sensor Data
- GPS - Payload Position Data



Active Payload cushioned within the flight capsule

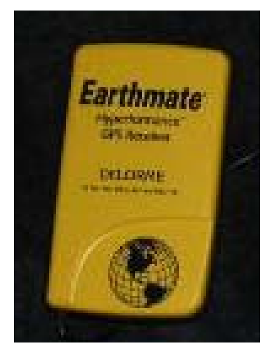
Sensor Data Transmitted to Ground Receiver





Sensor Data Digitally Recorded

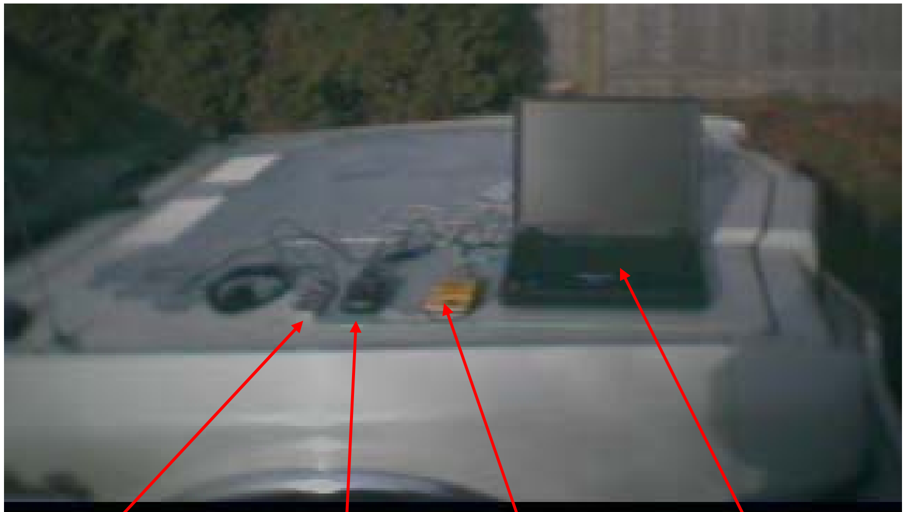
Data recorded into Laptop for analysis



GPS – Ground Station Position Data

Glenda Project – Active Payloads

Ground Station



Digital Recorder

Telemetry Receiver

GPS Receiver

Laptop

Not Shown:

a) Telemetry Receiver Antenna System
b) Laptop External Power Supply

Flight Vehicle

Payload Capsule

Length: 65”
Diameter: 3”
Dry Weight: 3.5 Pounds
Attainable Altitudes: 2,000 feet to 20,000 feet

Glenda Project - Passive Payloads – Dataloggers

A data logger is an electronic instrument that records measurements over time. Typically, data loggers are small, battery-powered devices that are equipped with a microprocessor, data storage and sensors. Most data loggers utilize software on a personal computer to initiate the logger and view the collected data.

Prior to a Glenda launch, the datalogger is connected to a laptop computer. Then, Windows based software is used to select logging parameters (sampling intervals, start time, etc.) and initiate the logger. The logger is then disconnected from the laptop and installed inside the Glenda payload capsule. Upon launch, the logger records each measurement and stores it in memory along with the time and date. Post recovery, the logger is then reconnected to the laptop computer and the software is used again to readout the data and see the measurements as a graph, showing the profile over time. The tabular data can be viewed as well, or exported to a spreadsheet for further manipulation.

Project Glenda Payload – Dataloggers

The Temperature / Relative Humidity datalogger is an example of a typical Glenda data collection device.

Temperature / Relative Humidity Datalogger Specifications:

- Capacity: 7943 measurements total
- User-selectable sampling interval: 0.5 seconds to 9 hours
- Programmable start time/date
- Memory modes: stop when full, wrap-around when full
- Nonvolatile EEPROM memory retains data even if battery fails
- Blinking LED light confirms operation
- User-replaceable battery lasts 1 year
- Battery level indication at launch
- Operating range: -4°F to +158°F (-20°C to +70°C), 0 to 95% relative humidity
- Time accuracy: ±1 minute per week at +68°F (+20°C)
- Size/Weight: 2.4 x 1.9 x 0.8" (68 x 48 x 19 mm)/approx. 1 oz.(29 grams)

MicroLite Temperature Datalogger

The MicroLite USB Datalogger is a small electronic device for monitoring and recording temperature. Manufactured to stringent IP68 standards, the MicroLite logger is dustproof and is only 4.3” long and 1” thick. The data logger features a three digit LCD display, direct USB connection, wide temperature range, high accuracy and large sample memory. Data can be displayed on the small numeric screen or downloaded to the MicroLab Lite software via the USB 2.0 connector.

Datalogger Specifications:

- Internal Temp Sensor: -40°C to 80°C Thermal Conductor enabling a fast sensor response time
- Sampling Resolution A/D Resolution: 16Bit 0.1°C
- Data Storage Capacity: 16,000 Samples
- Sampling Rate: 1 per second to 1 per 2 Hours
- Battery: Replaceable 3V Lithium Battery - CR2032
- Battery Life: 2 Years at 1 second Sampling Rate
- Dimensions: 11cm x 3.9cm x 2.6cm (4.3" x 1.5" x 1.0")
- Weight: 45.5 grams (1.6oz)
- Software: MicroLab Lite for Windows
- Standard Compliance: IP68, NEMA6 (30 Minutes for 0.5 meter Depth) CE, FCC

Holux M-241 GPS Datalogger

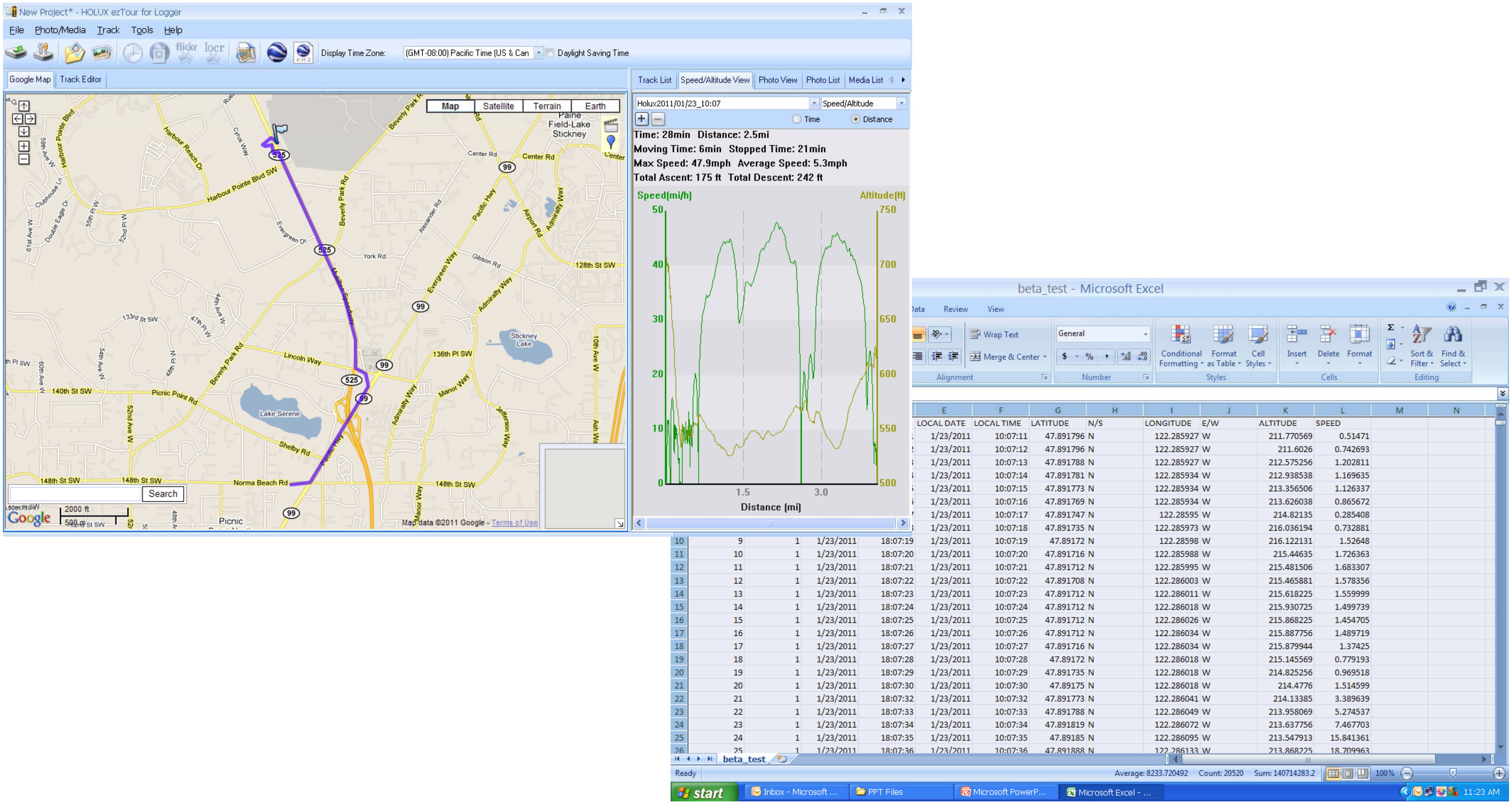
The M-241 is a high performance GPS datalogger. Capable memory size to record up to 130,000 positions, including longitude, latitude, time, and altitude.

Datalogger Specifications:

- 32 parallel satellite searching channels
- Receiver: L1m 1575.42 MHz
- Adjustable sampling rates from 1 second +
- Satellite signal reception sensitivity: -159dbm
- Position: +/- 2.2 meters Horizontal
- Powered by a standard AA battery with 12 hour life cycle
- Size/Weight: 1.26 x 1.18 x 2.93" (32.1 x 30 x 74.5 mm)/approx. 2.5 oz.(71 grams)
- Time to reposition: < 0.1 second average
- Time to boot: 36 seconds (cold), 1 sec (hot)
- Maximum Acceleration: 4G
- Maximum Altitude: 60,000 feet (18,000 m)

Holux M-241 GPS Datalogger Software

System software applies recorded data through the Google earth application to produce path maps, plus altitude and velocity charts. Data is downloadable in both *.html, and *.csv formats for external data manipulation.



Glenda Project – Passive Payloads – Dataloggers

54mm Capsule in Flight Configuration

Tracking System Antenna

Datalogger Sensor Port

Here is a typical Glenda payload ready for flight. This capsule contains a tracking locator transmitter, a combination temperature/relative humidity datalogger, and a barometric pressure datalogger. Total payload weight including capsule is less than one pound.

Additional Payload Tracking Systems

In addition to the GPS tracking capability, and to ensure recovery of the payloads, the Glenda Project has implemented several additional recovery and tracking aids.

To support short range recovery, a 110 db audio alarm can be installed in the payload capsule. The alarm functions independently of the data payload and is activated by its own internal countdown timer. Field tests have shown an effective range of one half mile.

For longer range tracking and recovery, a tracking transmitter is installed in the payload capsule. Field tests have indicated a line of sight tracking distance at over three miles.

110 db audio alarm payload location package

Audio Beacon Sound Sample

Payload tracking transmitter

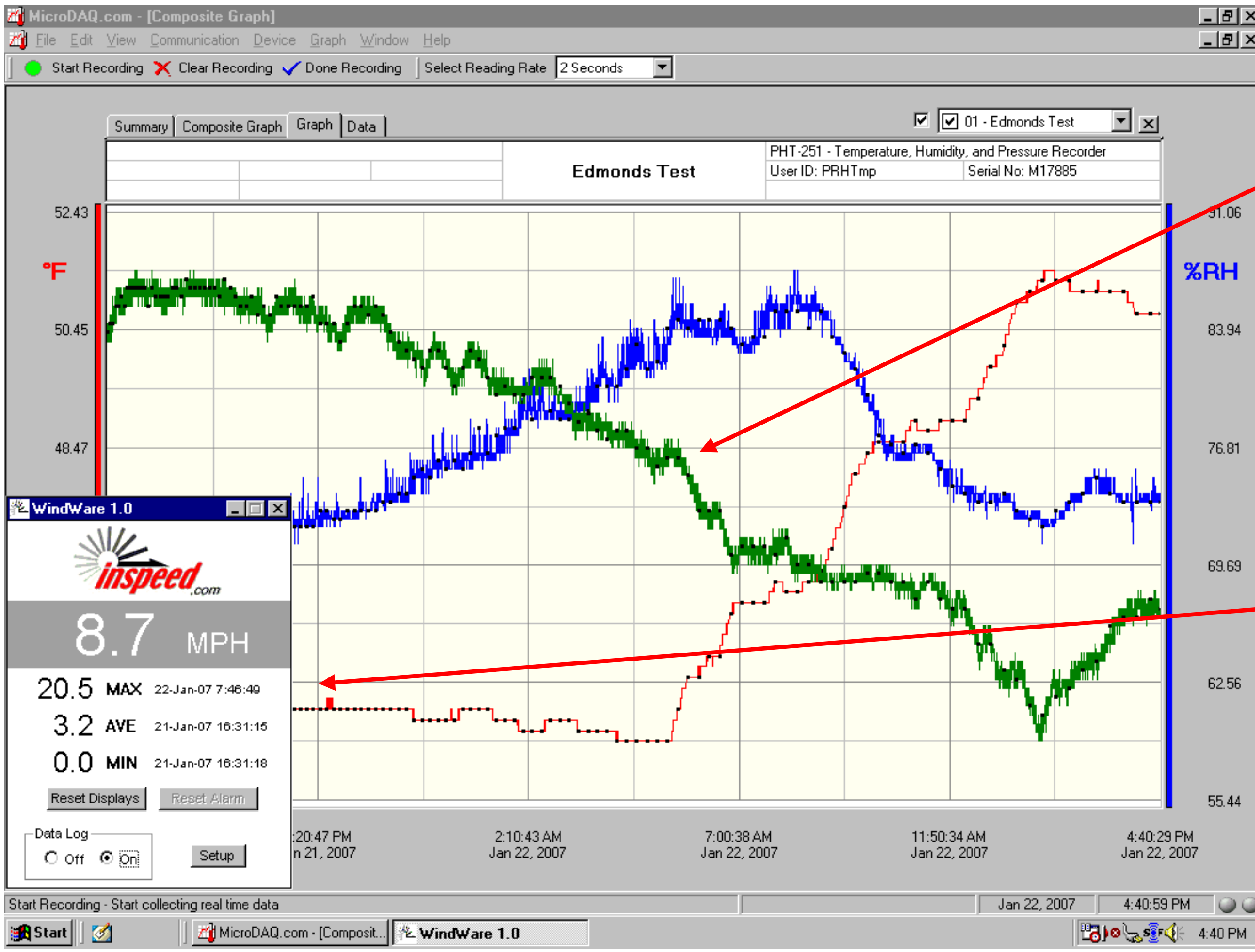
Tracking Transmitter Signal

Glenda Project – Ground Stations

Digital Chart Recorders

Glenda Project also utilizes sensors combined with ground based laptops to provide a digital based chart record of ground baseline conditions mapped over time.

The basic example below is a digital chart record of temperature, humidity, barometric pressure and wind speed at a test site.

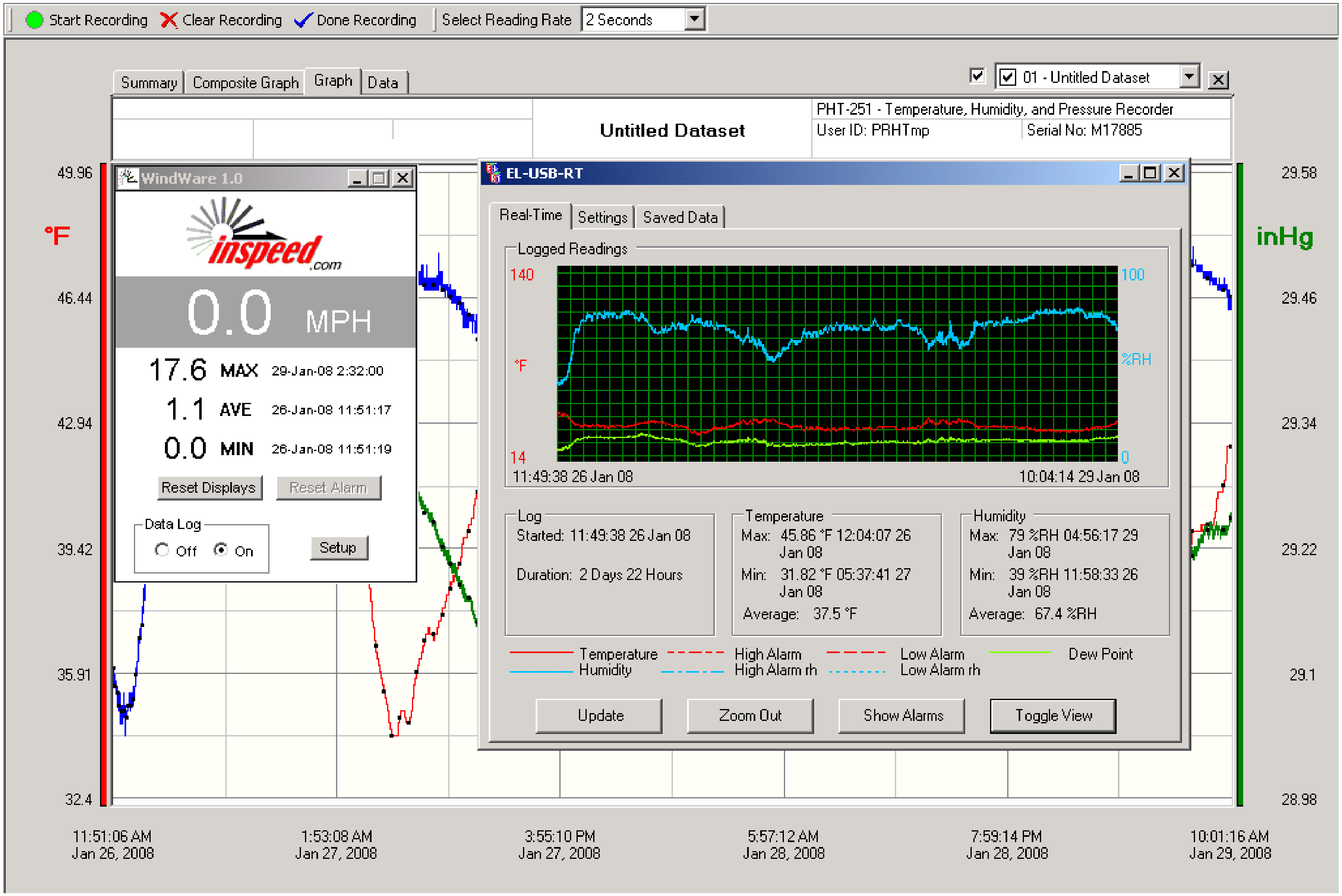


Pressure, Temperature, & Barometric Pressure data stream using Micro-DAQ software and COM 1 port

Wind Speed data using InSpeed Anemometer and supporting software Using COM 3 port via USB port application adapter

Glenda Project – Ground Stations

Digital Chart Recorders - Evolution



Glenda can also use the Micro-Daq Three channel datalogger, Inspeed anemometer, plus a Lascar Dew Point sensor running on a Thinkpad A20m Pentium III laptop. The Inspeed and Lascar software run in the background collecting data at one second intervals providing wind speed and Dew Point trend data.

Glenda Project – AN/TMQ-34 Ground Station

Glenda also has an operational portable military ground weather station. This acquisition further enhances the projects ground condition data collection capabilities.

The TMQ–34 is a military self contained portable weather measuring system that is powered by a rechargeable Ni CAD battery.

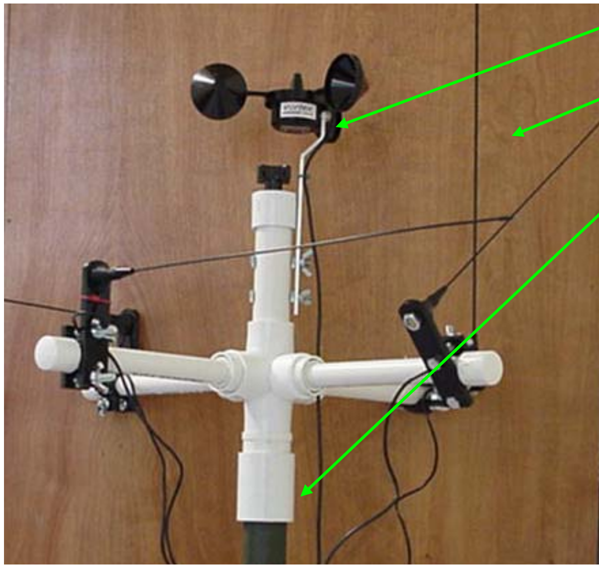
The TMQ–34 alphanumerically displays wind speed and direction, peak wind, temperature, dew point, barometric pressure, 3-hour pressure change, and the minimum and maximum temperature.

The entire TMQ–34, including the system case, weighs about 20 pounds. The set contains a computer module with a pressure sensor, and the main sensor module with a red sensor for temperature, a white sensor for humidity, a wind direction compass, and an anemometer to measure wind speed.

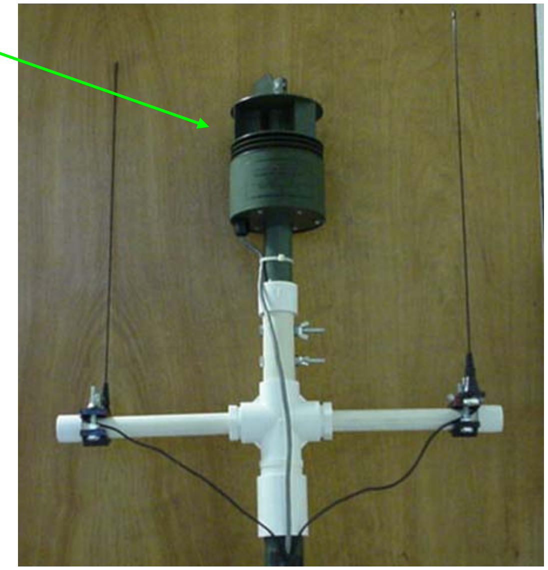
The TMQ–34 can operate in temperatures ranging from a low of –59.5°F to 132°F. The TMQ–34 is intended for use in a tactical environment with an operating range of 100 feet below sea level to 10,000 feet above sea level.

Glenda Mobile Ground Station and Mast System

<u>Removable / Adaptable Mast Sensor Head</u>

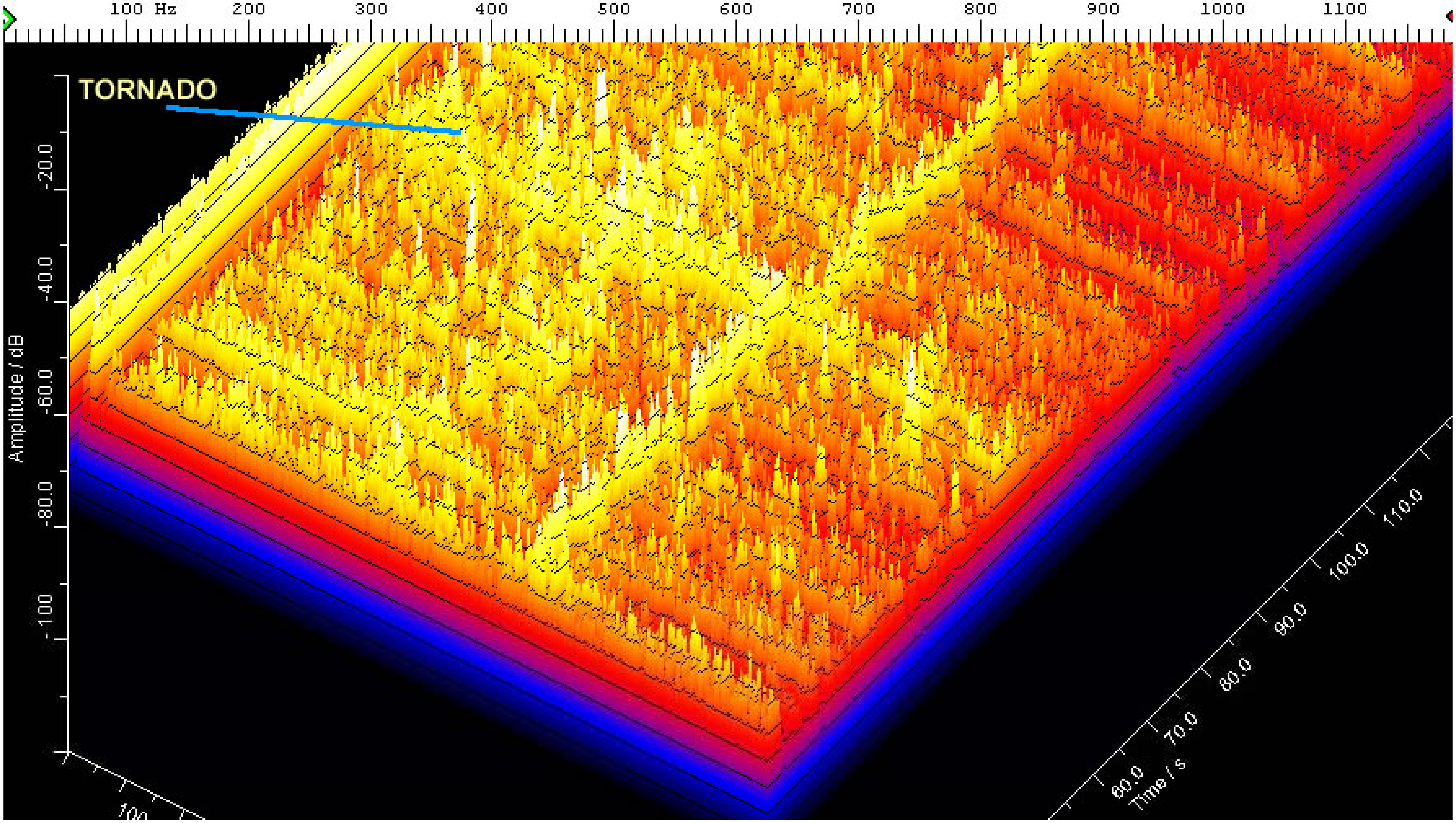


- In-Speed Anemometer / TMQ-34 Sensor
- Two / Four Wide Band Receiver Antennas for Radiosonde telemetry signals.
- Mast System Interface Adapter
- Light weight PVC construction to reduce potential for lightning strike
- Antennas with 1.2 GHz capability allows multiple frequencies and multiple radiosonde reception
- Mast head integrates with man portable mast system



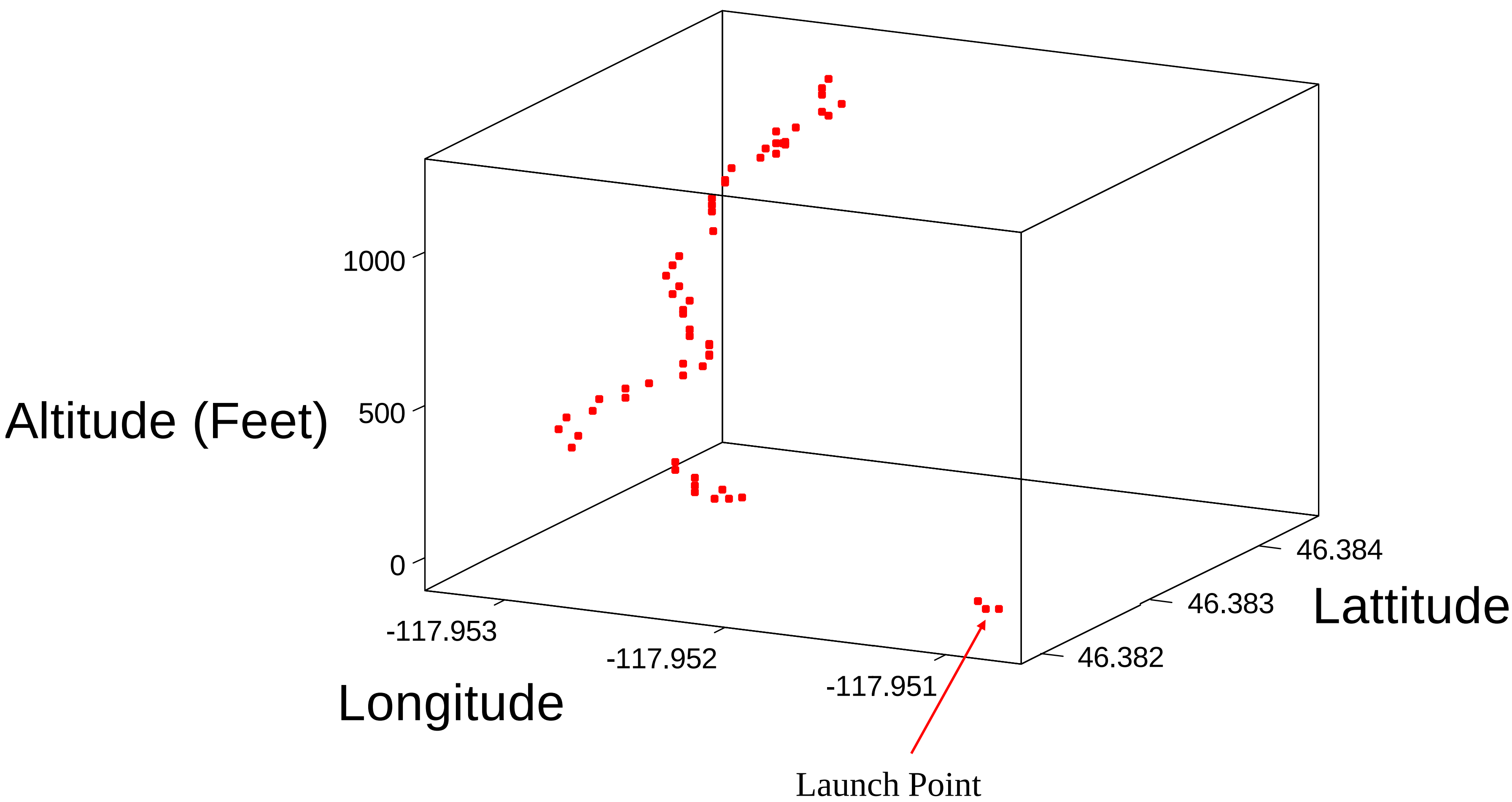
Glenda Project – EMF Spectral Mapping

Combining Glenda computing and sensors allows the capability for advanced analysis and detection. Shown below is a 3D EMF analysis of a tornado based off of a three second data capture. The circular effects of the funnel are easily visible and provide a snap shot of the electrical activity around a tornado.



Glenda Project – Wind Velocity Profiling

An Active GPS Payload tracks motion of a capsule over a site location in three dimensions



GPS functionality allows capsule tracking plus wind velocity determination capabilities

Glenda Project – Terrain Mapping

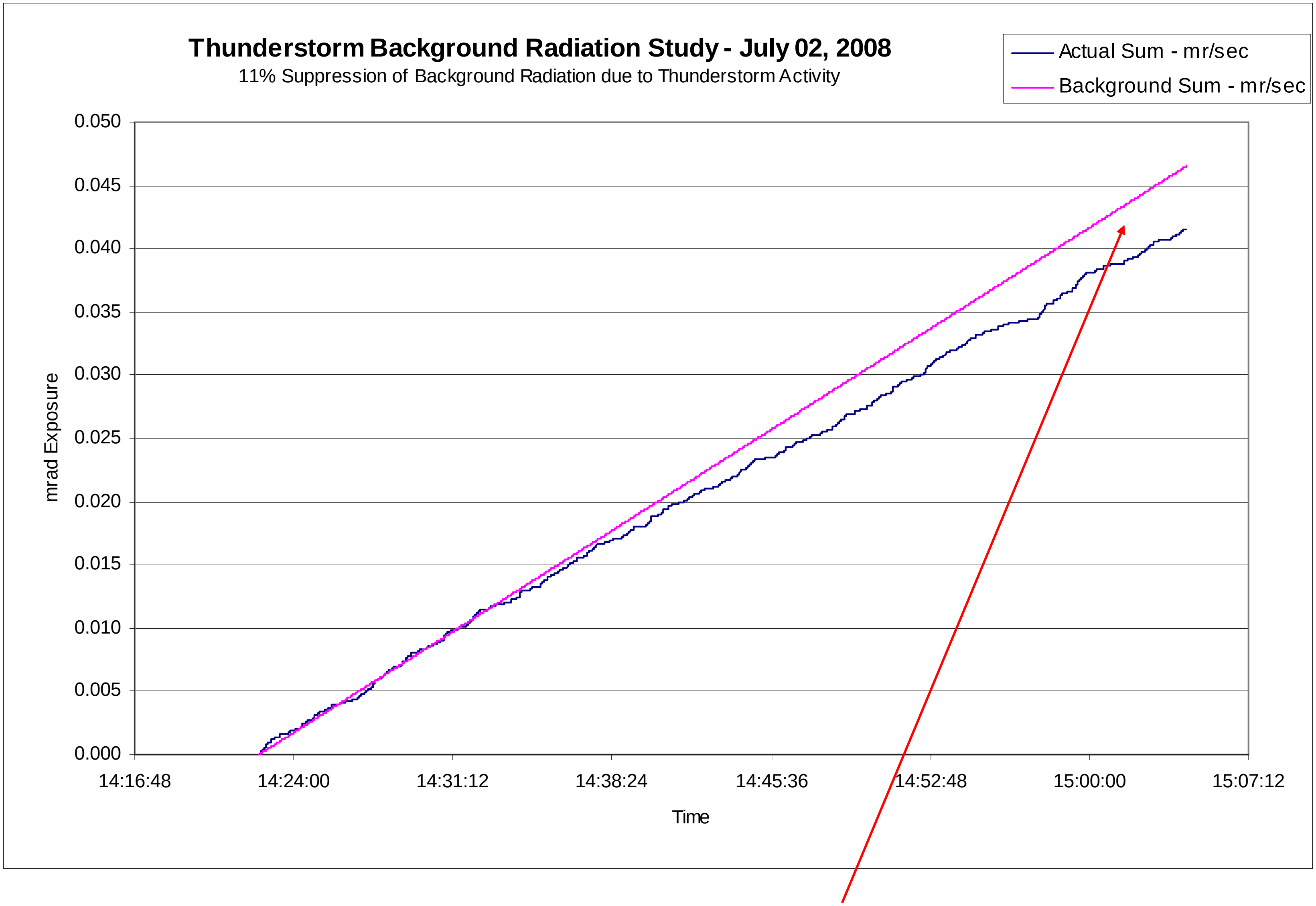
October 1st
7554 Booster – Aerotech I211
Apogee: 2,354

GPS functionality allows telemetry data to map wind currents over local terrain.

An Active GPS Payload tracks motion of a capsule over a site location in three dimensions

Glenda Project – Gamma Radiation Studies

Data collection capability of Gamma Ray Radiation during Thunderstorms



During this extensive Thunderstorm, lightning suppressed the “background” gamma radiation count by 11 percent

Glenda Project – “Ranger Intercept” Video Payload

Glenda has developed an operational on-board video capture payload capability in order to compare visual storm characteristics to other collected sensory data.

<u>Video Payload Capsule Attributes:</u>

- 40 Second Video Capture Capability
- 9 Frames per second Capture Rate
- 24 Bit Video Resolution
- Operable in both high and low light conditions
- Parachute Recovery
- Adaptable across multiple Glenda boosters
- Video downloadable in the field to laptop computers

Glenda Project – "Ranger Intercept" Video Payload

May 6th, 2007 – Redmond, WA – A typical flight towards an incoming storm center.

1. Launch

2. Mid - Boost

3. Apogee

4. Descent

5. Landing

Glenda Project – Chase Teams

In order to obtain data from dynamic weather phenomena it is necessary to seek out and intercept storms and to launch sensors into the heart of the disturbance, capture the data, and return the data for immediate processing and analysis. Hence the name, Chase Team.

The Chase Teams utilize Jeep Grand Cherokee 4 wheel drive units, equipped with specialized tires and suspension to handle road debris situations and evasive maneuvers while on the go. When storm data is required, the teams immediately equip the jeeps with instrument packages and laptop computers inside the vehicle and attach to the roof, weather instrumentation, satellite dishes, sensors and communication gear. Portable rocket launching stands and weather rockets are loaded into the back of the jeep. Transforming from a standard jeep to a fully operational weather pursuit vehicle takes as little as five minutes.

Glenda Project – Chase Teams

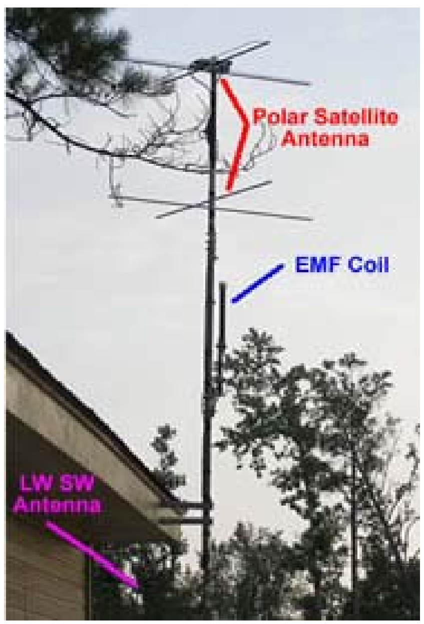
Mobile Mesonet Ground Stations

Chase Team vehicles have the capability to collect multiple data sets in real time, and transmit them either between vehicles, back to a central location, or to the local Ham radio watch network. All vehicles have GPS, mobile internet connections, laptops, and multi-band communications systems.

Glenda Project – Pullman Point Research Facility

The Pullman Point Weather Research Facility is located in Petal, Mississippi, roughly 60 miles north of the Gulf of Mexico.

The Facility houses instrumentation that is a combination of old school analog, as well as, state of the art digital that is exclusive to less than a half dozen operations in the continental United States and the most advanced privately owned instrumentation in Southern Mississippi.



Glenda Project – Pullman Point Research Facility

Data is acquired and network backup communication systems are in place with an eight dish satellite antenna array located onsite.

Backed with an onsite super computing cluster and multi mode communication links with the outside world we supply information in live time for the purposes of research and learning. The facility is linked by networks and hardened server farms in New York, NY

Glenda Project – Engineering / Computing

David Davis – Edmonds, WA - Launch Operations Director - Brings decades of experience from engineering work in private industry and United States government in rocket research, and aerospace. Extensive background in electronics, mechanics, communications, computing, and storm chasing. Member of the National Association of Rocketry since 1983, and been involved with hobby related rocketry since the 1960's.

Robert Pullman – Petal, MS - Long Range Sensor Development - Has three decades of experience in communication and the computer industry and his expertise is world renown. His work has enabled governments to formulate policies and legislation in international, national and local forums. He has developed products that are used by universities for seminars, by corporations for internal operations to meet government regulations, by scientists for research work in field and laboratory conditions, by government departments for device operations and maintenance, and by the military for use in battlefield activities.

Glenda Project – Media Communications / Public Relations

As the Glenda Project matured, a definite need became apparent for an individual with media communications skills and public relations.

Tim Quigg in Dayton, WA brings a unique mix of personal background and professional experience to the Glenda Project. Quigg has over two decades of experience in customer service and media relations. He is the former Assistant Editor of Extreme Rocketry Magazine (2000 to 2007), as well as a freelance writer of numerous articles for Sport Rocketry Magazine. He is a current member of the National Association of Rocketry, and is the 2001 recipient of the National Association of Rocketry’s President’s Award, in recognition of his work with youth in model rocketry on a national level. He has also written a book on the topic of high power rocketry; "A Guide to Level One Certification" currently published by ARA Press. Quigg is a highly decorated 30-year veteran of law enforcement, and is currently the supervisor at a Southeastern Washington State E911 Communications Center.

Glenda Project – Thunderstorm Intercept

"Lone Tree" Launch Site – Dayton, WA - May 14th, 2011

Approaching Thunderstorm

“Lone Tree” Launch Site – May 14th, 2011

The purpose of our Glenda Flights at the “Lone Tree” launch site are essentially two fold. The first is to test out new sensors and instrumentation, and second to develop a data set in support of a prediction model so that members of the Blue Mountain Rocketeers (BMR) could predict the brutal updraft conditions that often exist at this site. This model would allow modelers to hold a safer launch as that larger vehicles would now stay within the boundaries of the launch site.

The Glenda flight plan for the May 2011 launch consisted of two flights. The first, was to be the flight of our new Holux GPS 4D datalogger system, and the second, the first flight of our 54mm High Velocity booster. Well, nature threw us another curve. As we were preparing the Holux datalogger payload for flight, a line of thunderstorms moved through the area. The mission plan then changed to “Thunderstorm Intercept” to see what data could be captured. Based on the success of the September 2010 launch, we knew that the capsule could withstand the environment. The flight was major success and the data is presented in the following slides.

“Lone Tree” Launch Site – May 14th, 2011

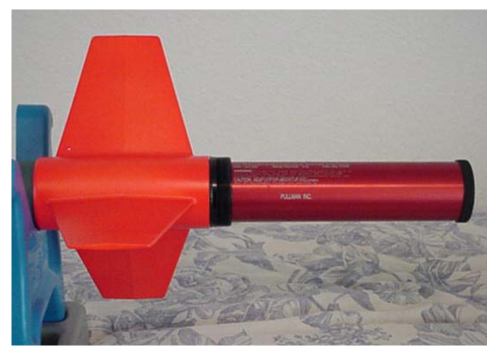
Booster Flight Plan

7554 - 75mm Booster / 54mm Capsule

- 3” diameter booster, 2.125” diameter capsule
- Holux M-241 and MicroLite datalogger payloads
- Optimal capsule sink rate of 20 feet per second
- Aerotech I211-M motor for a 3,000 foot altitude

5475 - HV Booster

- 2.125” diameter booster, 3” diameter capsule
- RS92 Digital Radiosonde Payload with GPS
- I218 CTI 54mm motor with 4,000 foot altitude



“Lone Tree” Launch Site – May 14th, 2011

The one flight that was made at the May BMR launch contained a dual datalogger payload. The first was a Holux M-241GPS 4D datalogger which would capture lattitude, longititude, elevation, plus motion (ie 4 Dimensions, or 4D) at one second intervals. The second payload was a MicroLite USB Temperature datalogger also sampling at one second intervals to gather temperature data above the launch site.

Both payloads performed remarkably well and handled the flight loads without a problem. The GPS payload also gave us the opportunity to test out our cellular internet system. Terrain was against us for this one and we were never able to obtain a solid enough signal to support effective communications. Something to work on for the future.

Holux M-241 GPS & MicroLite Dataloggers

The following slides show the data collected by the Holux and MicroLite dataloggers during the May flight. While the ground track and velocity data displayed by the supplied Holux software is interesting, it does not provide the visibility that the data is capable of displaying.

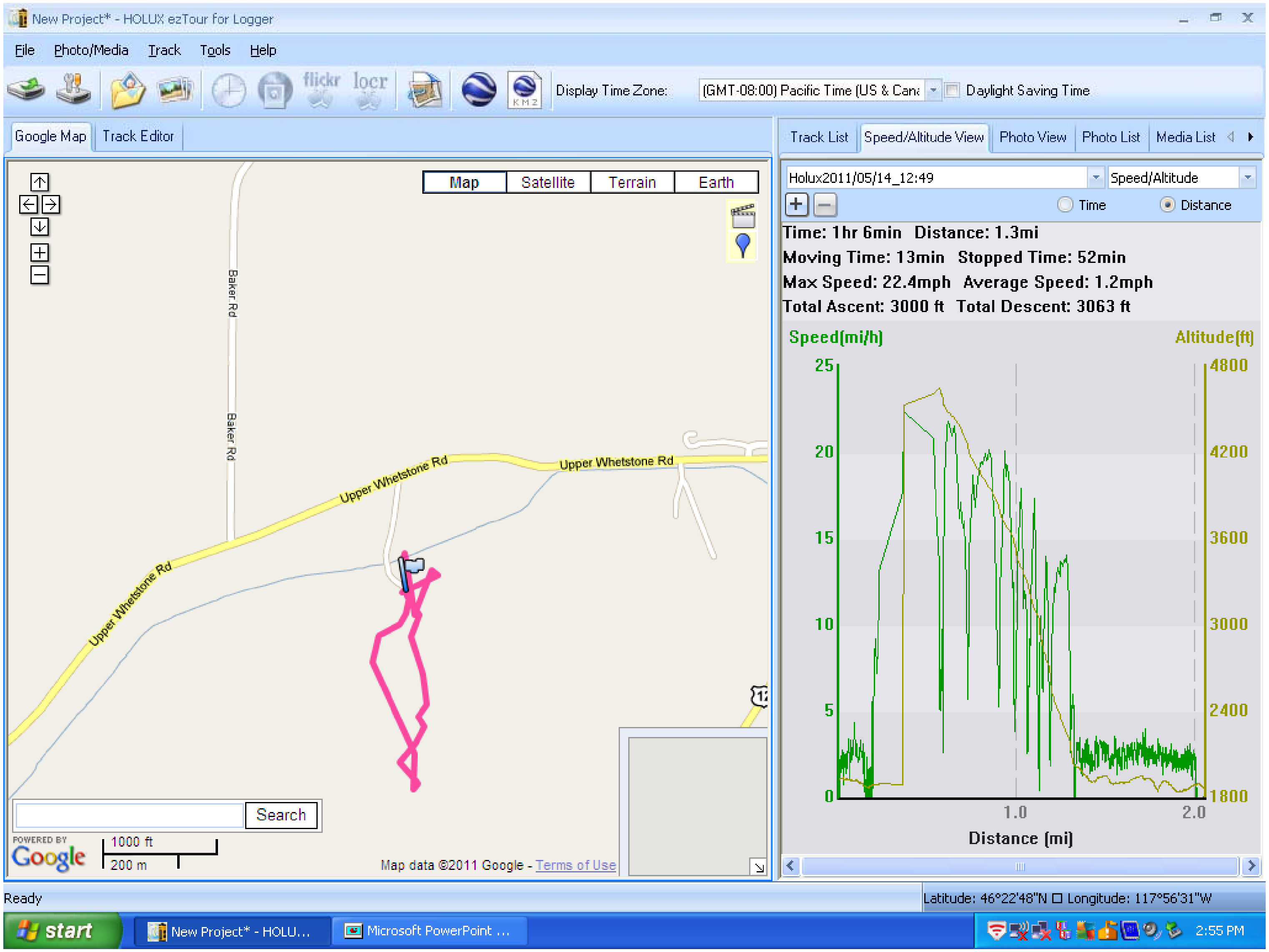
Our Glenda 4D mapping software allows the data to be shown in its true fidelity displaying the motion of the capsule as it descends.

However, the raw data captured by the dataloggers now allows us solid wind velocity And updraft / downdraft data to build a more effective prediction model.

With the MicroLite Temperature datalogger and GPS datalogger running in parallel using matching sampling rates, a viable temperature data model could now be made.

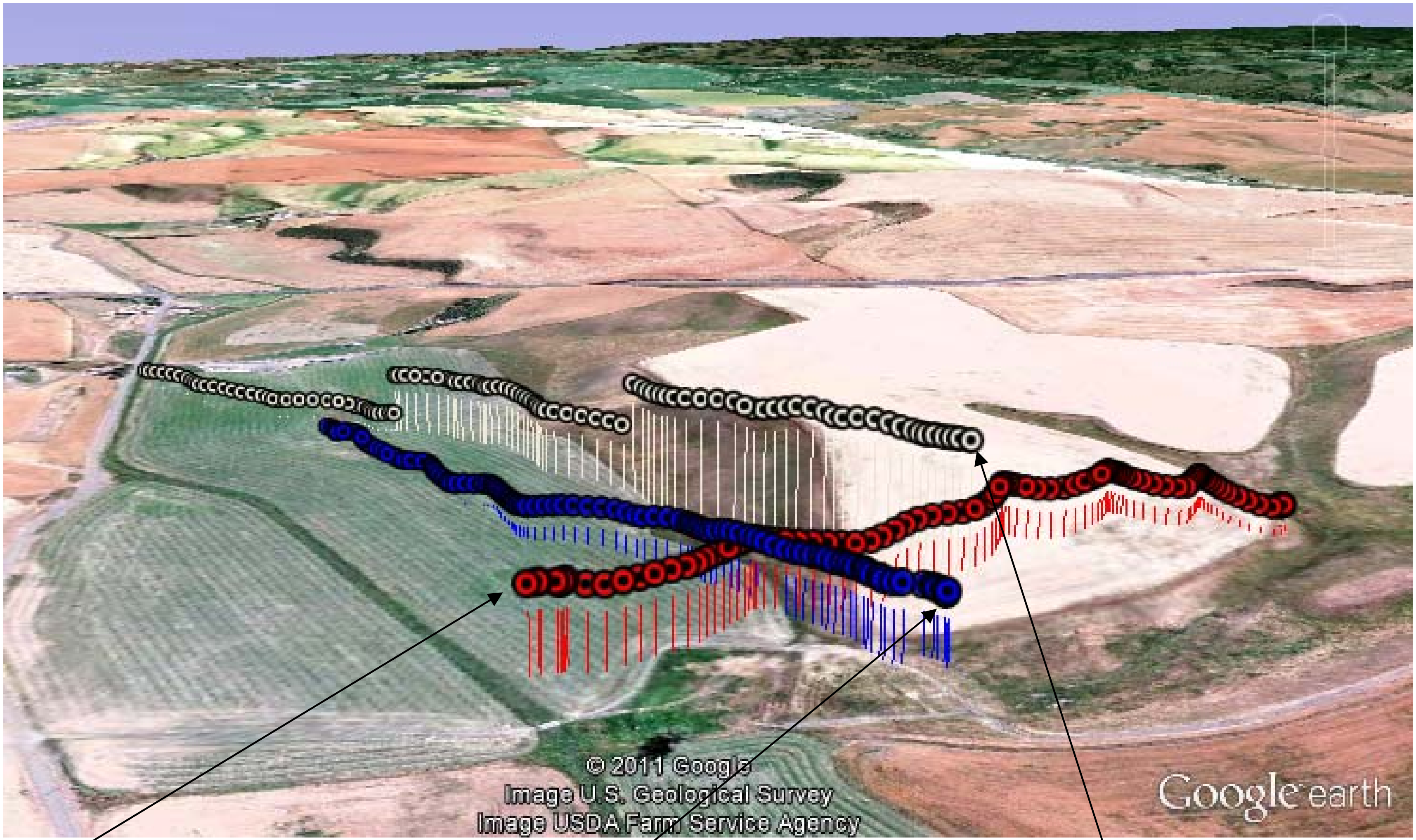
“Lone Tree” Launch Site – May 14th, 2011

Holux M-241 GPS Datalogger - Groundtrack



“Lone Tree” Launch Site – 2011 Test Flights

May 14th, June 11th, and October 1st Recovery Trajectories



May 14th
7554 Booster – Aerotech I211
“Thunderstorm Intercept”
Apogee: 2,706 Feet
Ground Level Wind Speed: 4.5 mph

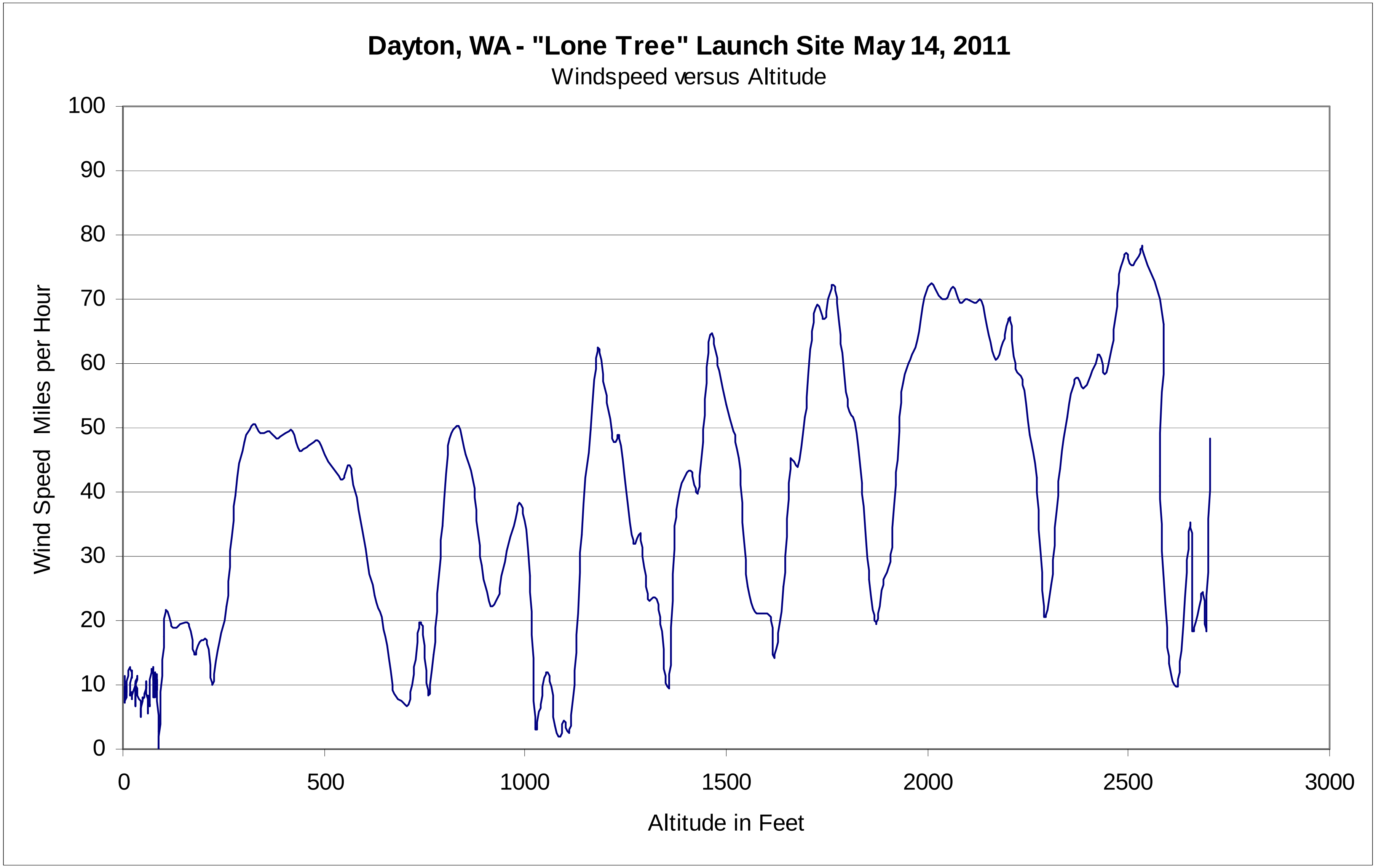
June 11th
9875 Booster – CTI I170
Apogee: 2,211 Feet
Ground Level Wind Speed: 10 mph

October 1st
7554 Booster – Aerotech I211
Apogee: 2,354
Ground Level Wind Speed: 14.5 mph

Note: The “Thunderstorm Intercept” Flight is 90 degrees from the normal Trajectory

“Lone Tree” Launch Site – May 14th, 2011

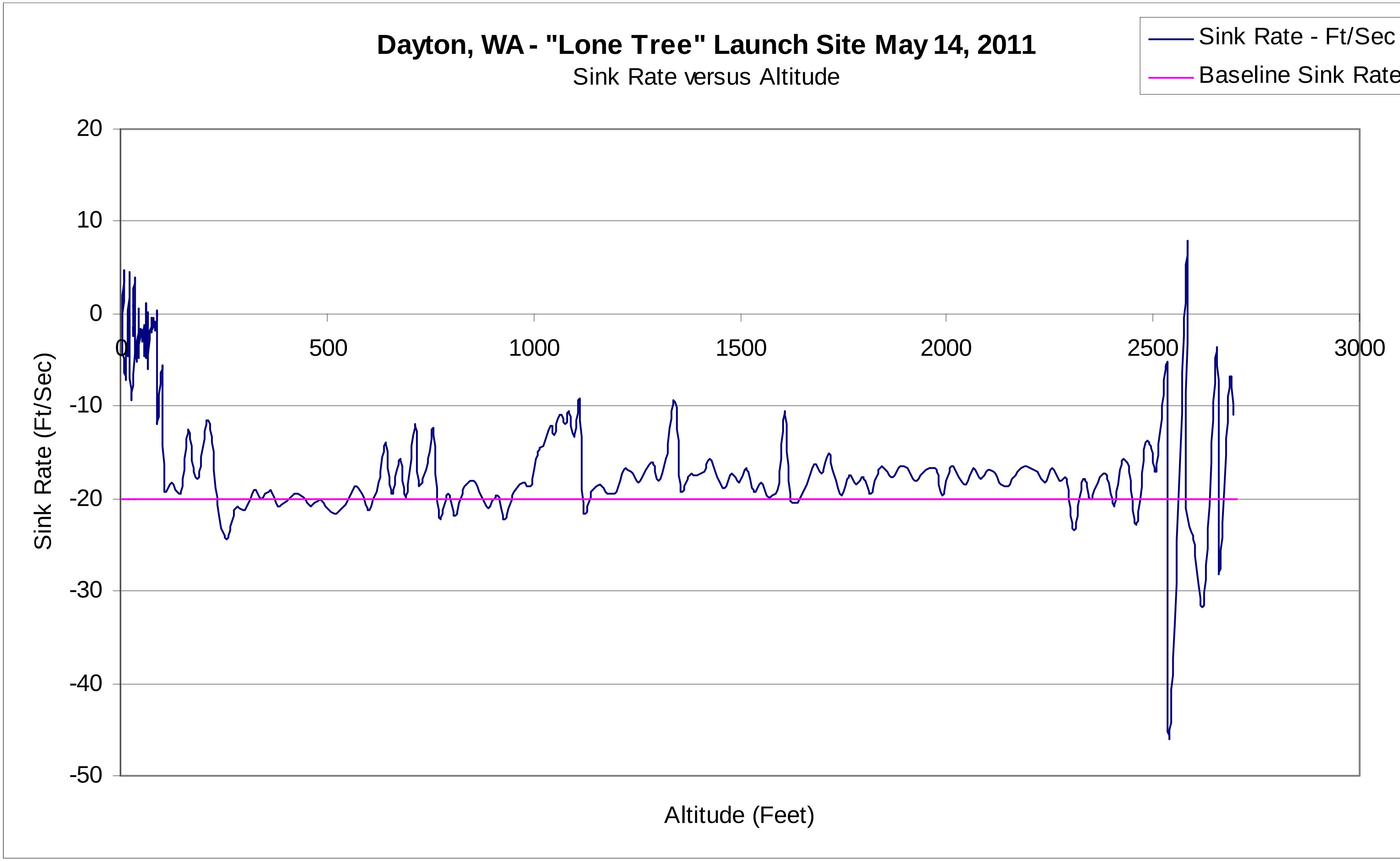
Wind Speed versus Altitude



Note: Wind Speed is increasing with Altitude and the “calm” wind speed near ground level

“Lone Tree” Launch Site – May 14th, 2011

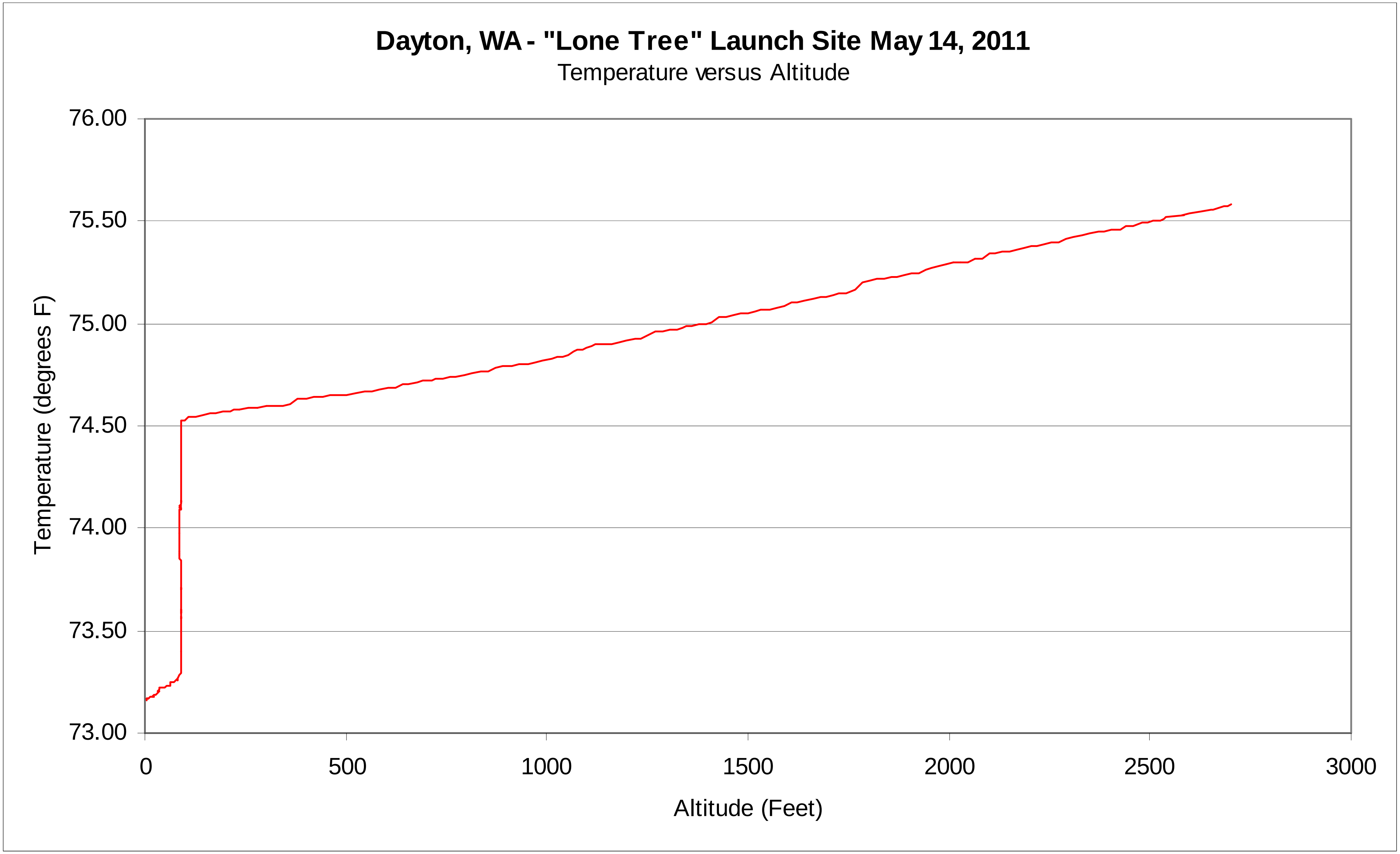
Sink Rate versus Altitude



Note: The “Baseline” Sink Rate of the capsule is 20 feet per second (-20)
There are significant Updrafts and Downdrafts due to the approaching thunderstorm

“Lone Tree” Launch Site – May 14th, 2011

Temperature versus Altitude



Note: Under the “standard” atmospheric model, temperature decreases with altitude

“Lone Tree” Launch Site – May 14th, 2011

Groundstation Data

Our groundstation continues to perform above expectations recording data at one second, and 1.5 second intervals.

The falling barometric pressure indicated the approach of the coming thunderstorm.

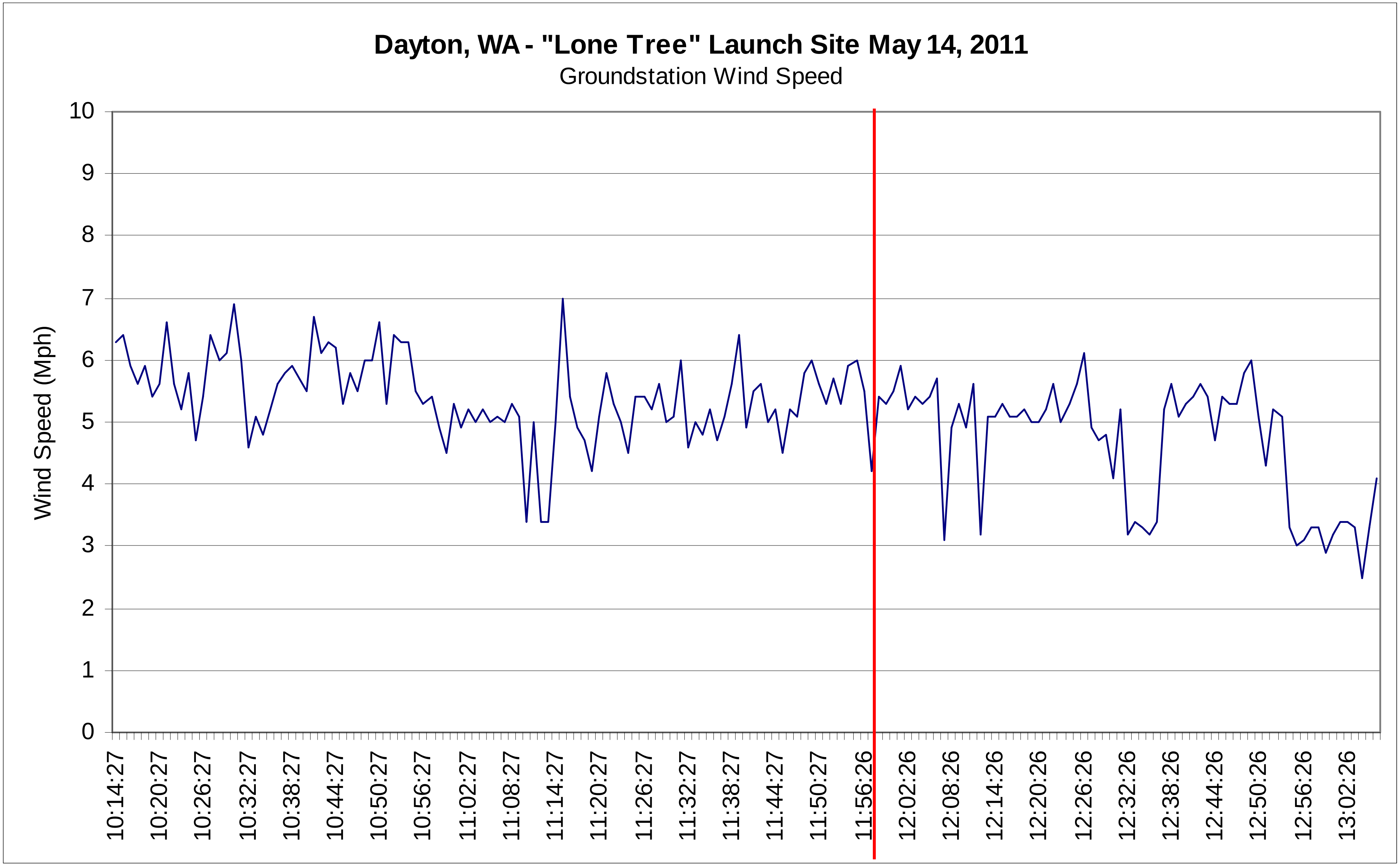
The increasing humidity reflected the coming rains.

Ground wind speed remained relatively constant even though winds aloft were increasing rapidly. A few hours later the ground wind speed became excessive.

The ability of the payloads to detect winds aloft serve as a pre-cursor for events later at ground level.

“Lone Tree” Launch Site – May 14th, 2011

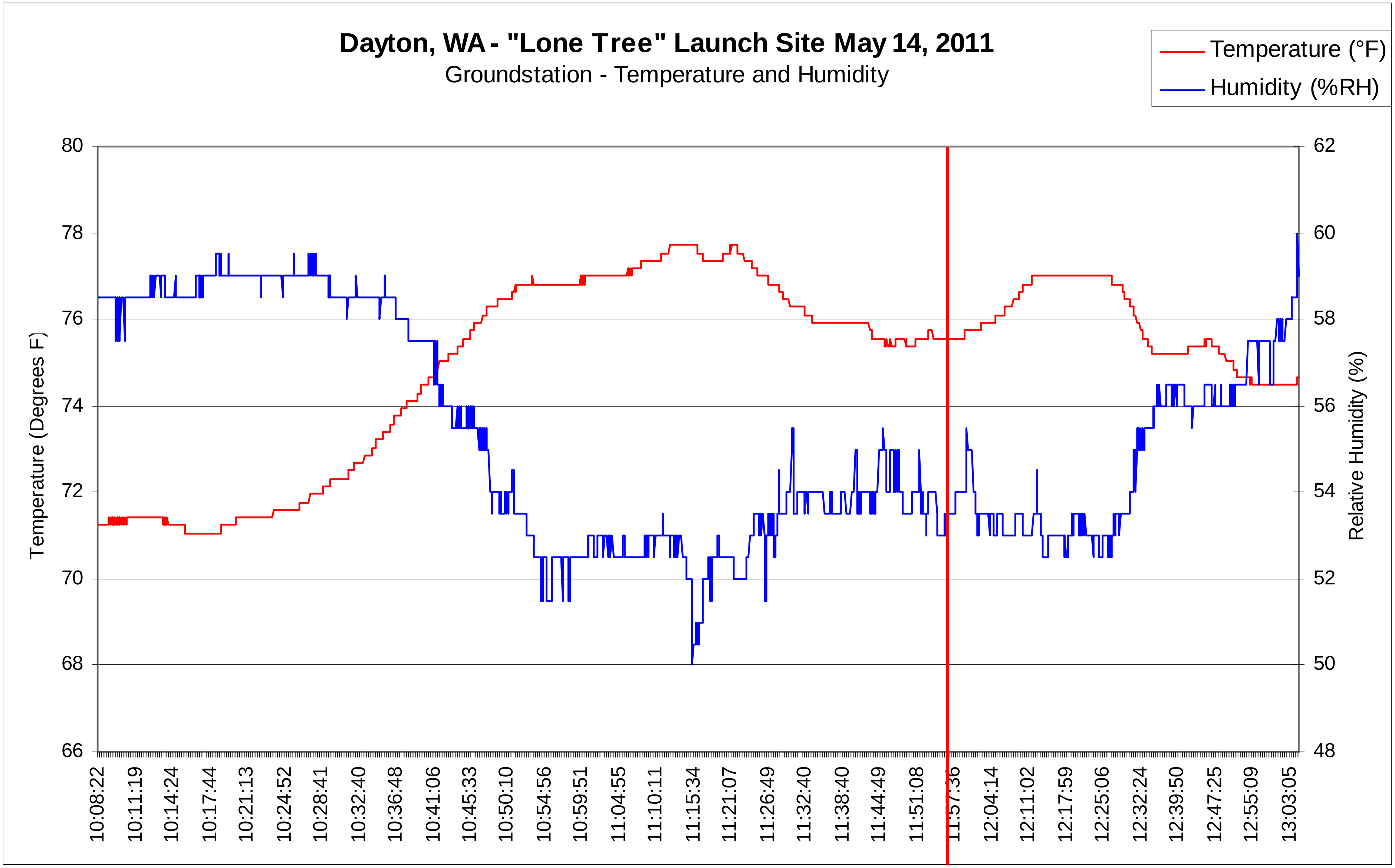
Groundstation Wind Speed



Launch Time 11:57 am

“Lone Tree” Launch Site – May 14th, 2011

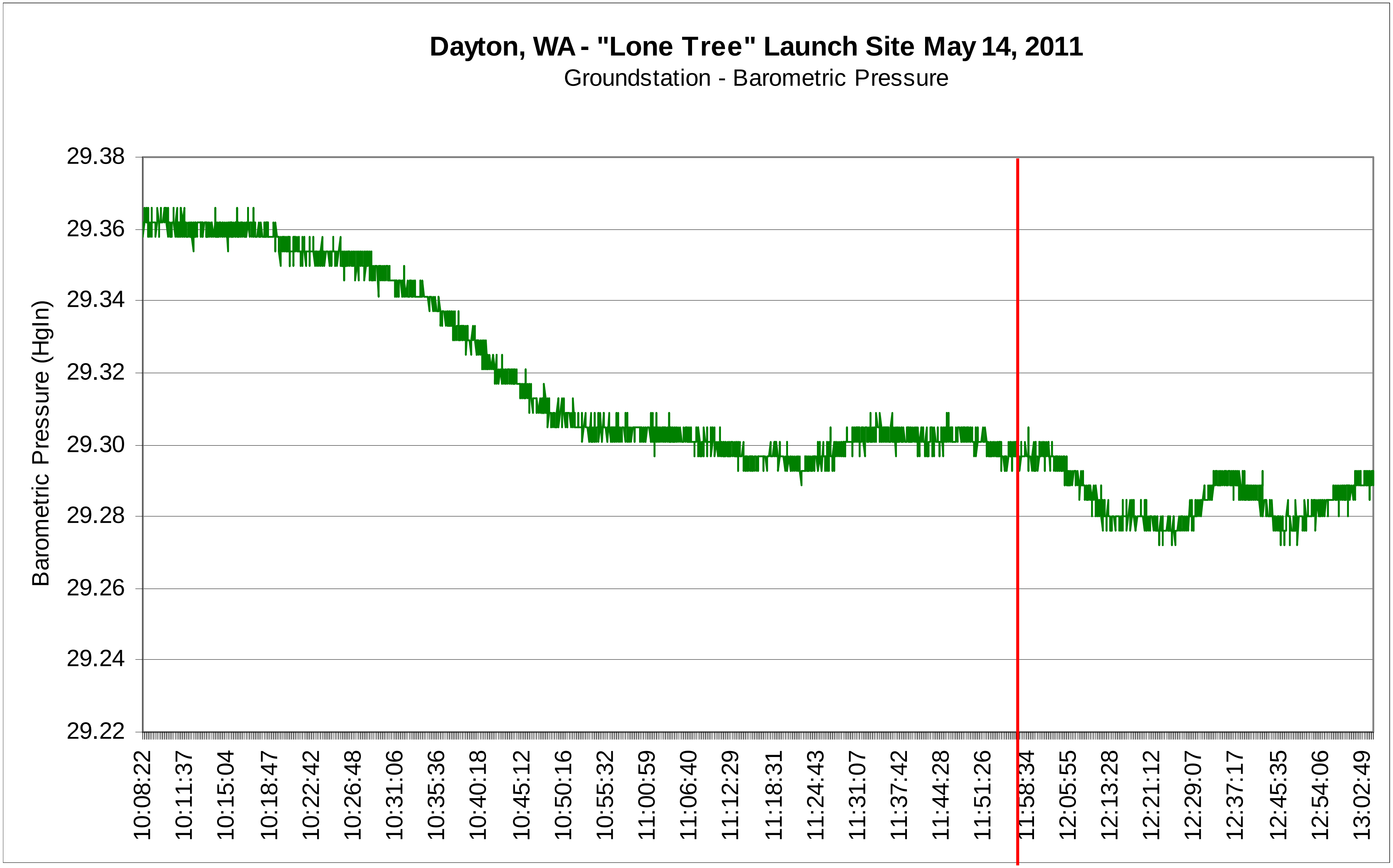
Groundstation Temperature and Relative Humidity



Launch Time 11:57 am

“Lone Tree” Launch Site – May 14th, 2011

Groundstation Barometric Pressure



Launch Time 11:57 am

In Conclusion

The Glenda Project is a reusable sounding rocket delivery system designed to place instrument packages into areas previously considered to be to hazardous or inaccessible using traditional platforms such as balloons, aircraft, helicopters, kites, etc.

At the May 2011 launch, the Glenda Project achieved one of our primary goals of intercepting a severe weather system, collecting usable data, and returning safely.

For 2012, our goal is to complete the differential RS92 Radiosonde GPS tracking and data collection system. This will allow us to chase / capture the radiosonde capsules, displaying the payload and chase vehicle positions simultaneously while also capturing wind speed, temperature, and Relative Humidity data in real time.

The operational Glenda Project shows the differences between Hollywood “fiction”, and engineering “fact”, from mapping local environments to a full tornadic funnel with a suite of sensors. Glenda is up to the task.

Glenda Project – Executive Summary - 2013

Glenda Project – Purpose

The primary mission of the Glenda Project is to provide the capability to rapidly gather previously inaccessible localized microclimate data from altitudes ranging from ground level to 20,000 feet and to return this data for immediate use.

The Glenda Project is mix of adaptable ground stations combined with a reusable sounding rocket delivery system designed to place instrument packages into areas previously considered to be to hazardous or inaccessible using traditional platforms such as balloons, aircraft, helicopters, kites, etc.

Glenda Project – Data Capabilities

The Glenda Project has the capability to collect temperature, humidity, barometric pressure, wind speed and other types of environmental data from ground level to 20,000 feet.

Glenda payloads are designed to be launched into thunderstorms, tornados, and other volatile weather environments and to return intact with its collected data.

Glenda Project – Engineering / Computing / Remote Sensing

David Davis – Edmonds, WA – Engineering - Brings decades of experience from engineering work in private industry and United States government in rocket research, and aerospace. Extensive background in electronics, mechanics, communications, computing, and storm spotting. Member of the National Association of Rocketry since 1983, and been involved with hobby related rocketry since the 1960's.

Robert Pullman – Ponchatoula, LA - Remote Sensing - Has three decades of experience in communication and the computer industry and his expertise is world renown. His work has enabled governments to formulate policies and legislation in international, national and local forums. He has developed products that are used by universities for seminars, by corporations for internal operations to meet government regulations, by scientists for research work in field and laboratory conditions, by government departments for device operations and maintenance, and by the military for use in battlefield activities.

Glenda Project – Media Communications / Public Relations

Tim Quigg in Dayton, WA brings a unique mix of personal background and professional experience to the Glenda Project. Quigg has over two decades of experience in customer service and media relations. He is the former Assistant Editor of Extreme Rocketry Magazine (2000 to 2007), as well as a freelance writer of numerous articles for Sport Rocketry Magazine. He is a current member of the National Association of Rocketry, and is the 2001 recipient of the National Association of Rocketry's President's Award, in recognition of his work with youth in model rocketry on a national level. He has also written a book on the topic of high power rocketry; "A Guide to Level One Certification" currently published by ARA Press. Quigg is a highly decorated 30-year veteran of law enforcement, and is currently the supervisor at a Southeastern Washington State E911 Communications Center.

CERTIFIED SKYWARN SPOTTER

Glenda Project – Columbia County, WA - Intercept Teams

John Quigg in Dayton, WA, brings to the project a mix of skills ranging from high tech computing, to storm spotting field abilities. As the head of our field operations Intercept Team, John plans the missions, deploys the field assets, and collects the data. A SKYWARN trained storm spotter, and a master behind the camera, John continues to bring back amazing photos, and video from the field on our continuing storm intercept operations.

CERTIFIED
SKYWARN
SPOTTER

Glenda Project – Typical Flight Vehicles

9875 Booster

- 4” diameter booster, 3” diameter capsule
- RS92 Digital Radiosonde Active Payload with GPS
- GPS, and Temperature dual data logger payload
- 2,000 to 20,000 ft altitude envelope

5475 Booster

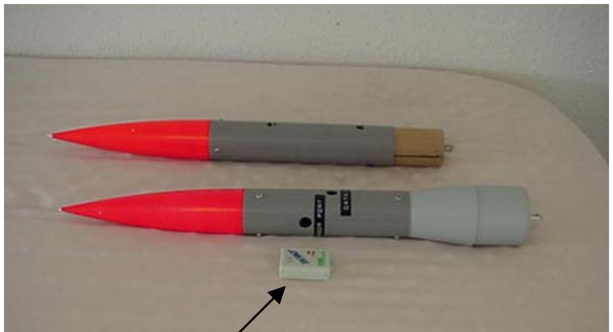
- 2.125” diameter booster, 3” diameter capsule
- RS92 Digital Radiosonde Active Payload with GPS
- GPS, and Temperature dual data logger payload
- 2,000 to 15,000 ft altitude envelope

FAR 101 Booster

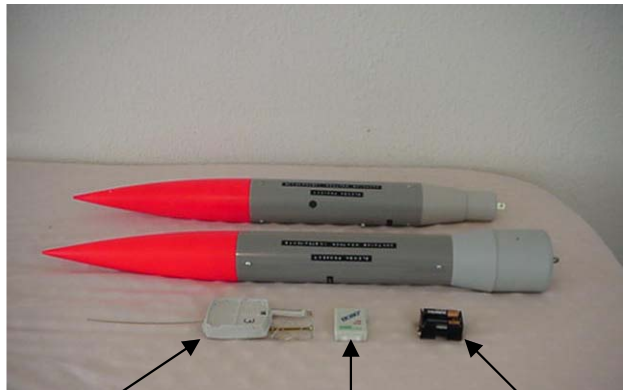
- 3” diameter booster, 2.125” diameter capsule
- GPS, and Temperature dual data logger Payload
- 2,500 foot altitude envelope
- Exempt from FAA Waiver Constraints

Glenda Project – Typical Flight Payloads

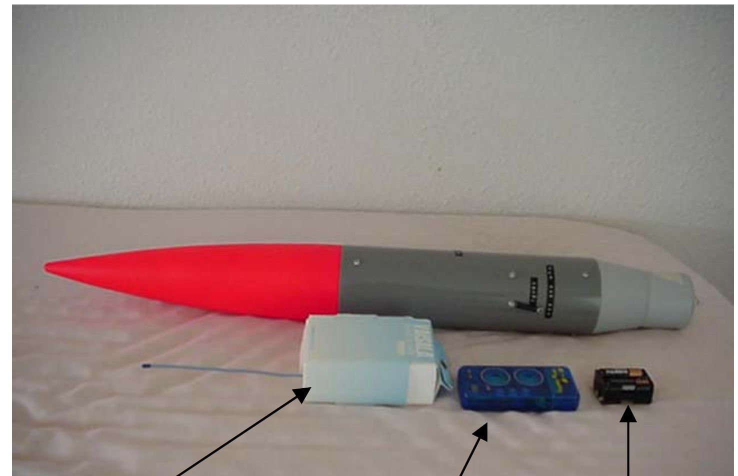
The Glenda project uses several different payload capsule configurations carrying a variety of instrumentation in order to gain weather related information, and other micro-climate data



Datalogger



RS92 Digital Radiosonde   Datalogger   Battery Pack



RS80 Analog Radiosonde   Locator Beacon   Battery Pack

54mm (2.125") Capsules

- Datalogger Payloads
- Measures Temperature & RH values at 1 second intervals.
- Used by 54mm & 75mm boosters.

75mm (3") Capsules

- Datalogger Payloads
- Measures Temperature & RH values at 1 second intervals.
- RS92 Digital Radiosondes transmitting temperature, RH, barometric pressure, and GPS coordinates.
- Used by 54mm & 98mm boosters.

98mm (4") Capsule

- RS80 Analog Radiosonde transmitting temperature, RH, and barometric pressure.
- Audio location beacon
- Used by 75mm boosters.

Glenda Project – Typical Flight Profile

2 – Intercept Phase

3 – Data Collection Phase

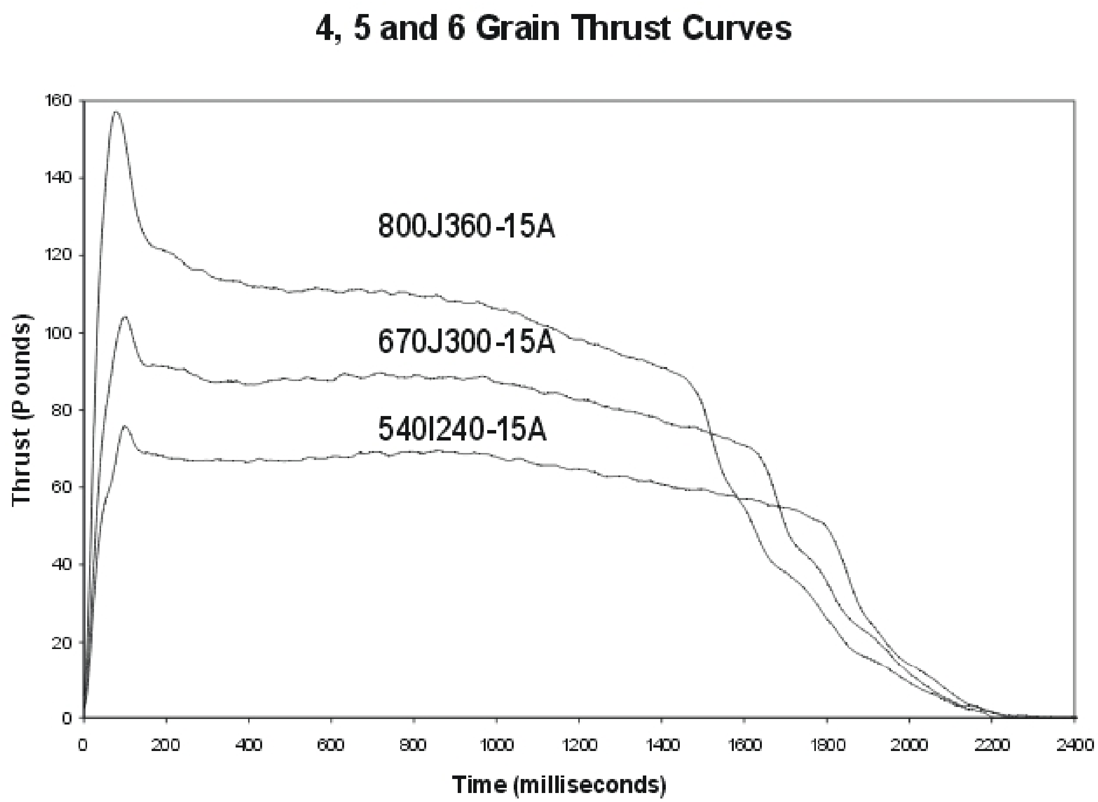
4 – Recovery Phase

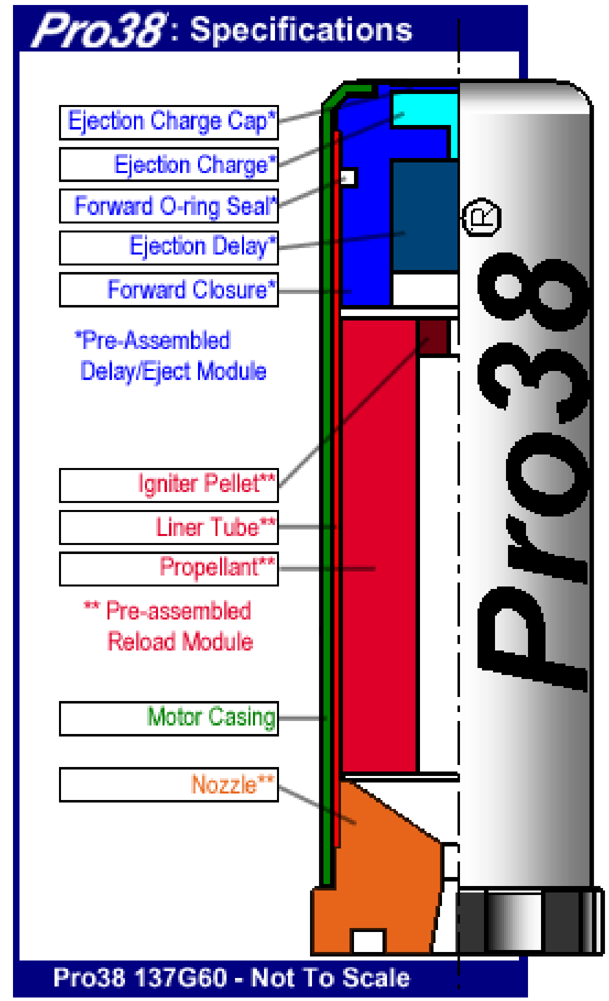
1 – Launch Phase

Note: Propulsion is provided by reloadable /reusable rocket motors giving the capability of rapid turnaround between flights.

Glenda Project – Propulsion

The Pro38 / Pro54 rocket motor propulsion system is the first commercial thermoplastic propellant-based solid rocket motor and is produced by Cesaroni Technology Inc. of Toronto Canada. The Pro38 / Pro 54 is a modular, reloadable Solid propellant rocket motor system designed primarily for use in launching small experimental payloads by universities, colleges, research institutes and sport rocketry enthusiasts.





Glenda Project – Data Collection Methods

Glenda has three primary methods of collecting data:

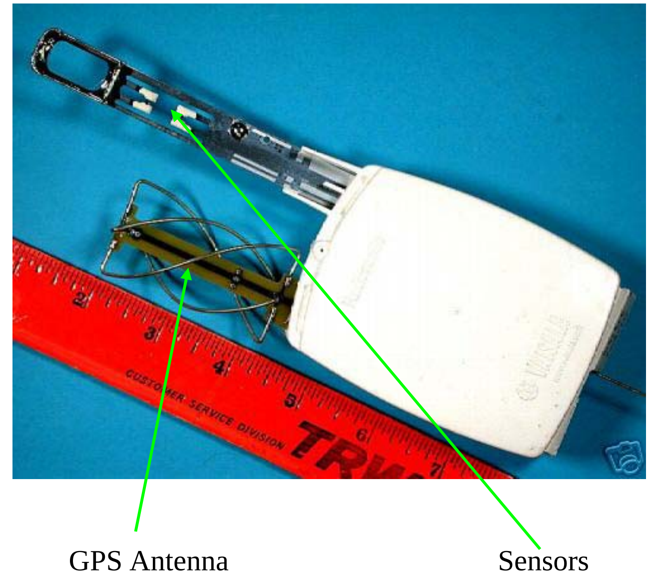
- Rocket Launched - Active Flight Data Collection Systems - Transmitters
- Rocket Launched - Passive Flight Data Collection Systems – Dataloggers
- Ground Stations

Glenda Project – Active Payloads - Transmitters

Converted Radiosonde Payloads

The Glenda Project uses converted radiosondes that are designed primarily for use with weather balloons. The circuitry and sensors function properly under thrust loads of the Glenda boosters and are compatible with NOAA radiosonde receiver systems.

The radiosonde contains instruments capable of making direct measurements of air temperature, humidity and pressure. These observed data are transmitted immediately to the ground station by a radio transmitter located within the instrument package.



Vaisala RS92 Radiosonde

Radiosonde Specifications:

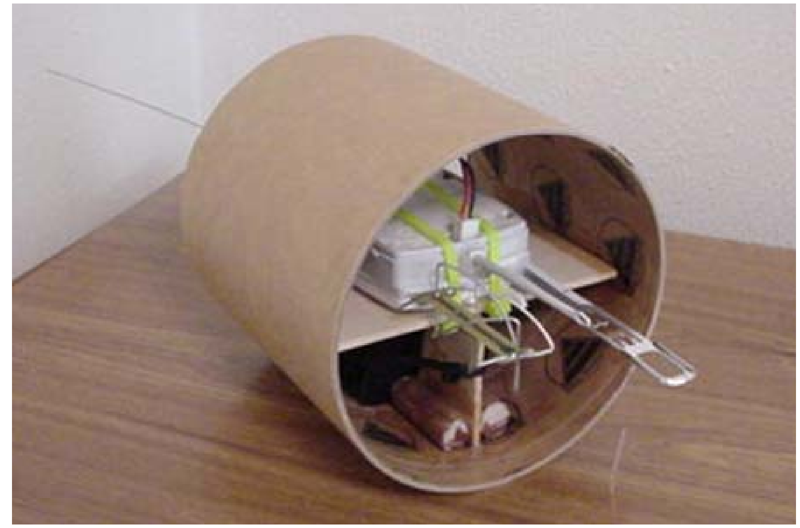
- Pressure range 3mb to 1060mb +/- .1mb
- Operating temperature range of -90°C to +60°C
- Relative Humidity from 0 to 100%
- Sampling Rate of once per second for the sensor suite
- Provides positioning data via GPS for payload location and wind velocity

Glenda Project – Active Payloads - Transmitters

Data Acquisition Flow Diagram

Sensor Data Transmitted from Capsule

- Barometric Pressure Sensor Data
- Temperature Sensor Data
- Relative Humidity Sensor Data
- GPS - Payload Position Data



Active Payload cushioned within the flight capsule

Ground Receiver and Antenna System

Data recorded into Laptop and graphically displayed

GPS – Ground Station / Chase Vehicle Position Data

Glenda Project – Active Payloads - Application

Mobile Ground Station / Intercept Vehicle

Isolated Laptop Power Supply

Telemetry Receiver

Cellular Modem w/ internet connection

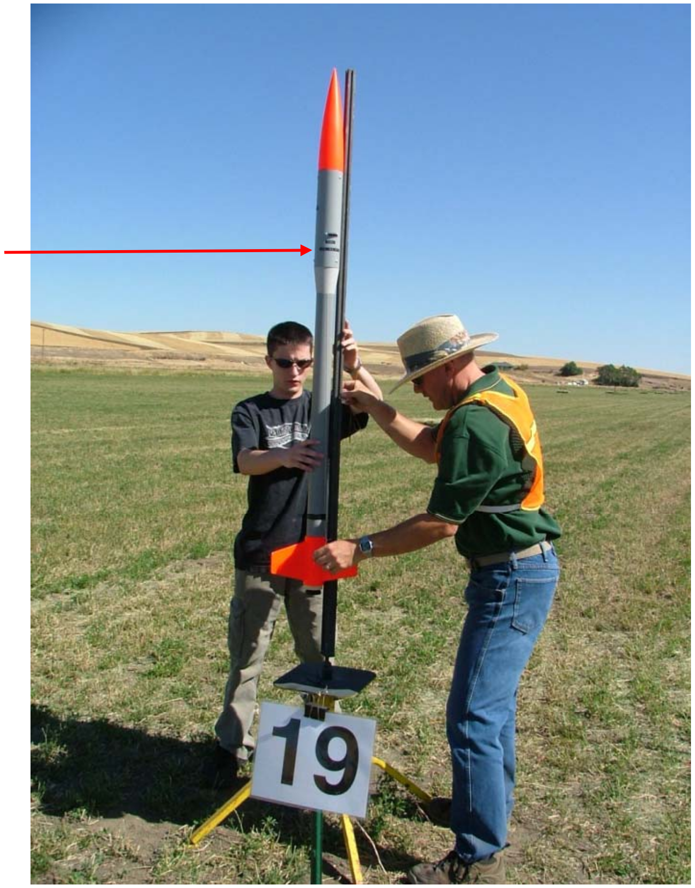
Laptop

Not Shown:

a) External Telemetry Receiver Antenna
b) External GPS Antenna
c) External Cellular Modem Antenna

Flight Vehicle

Payload Capsule

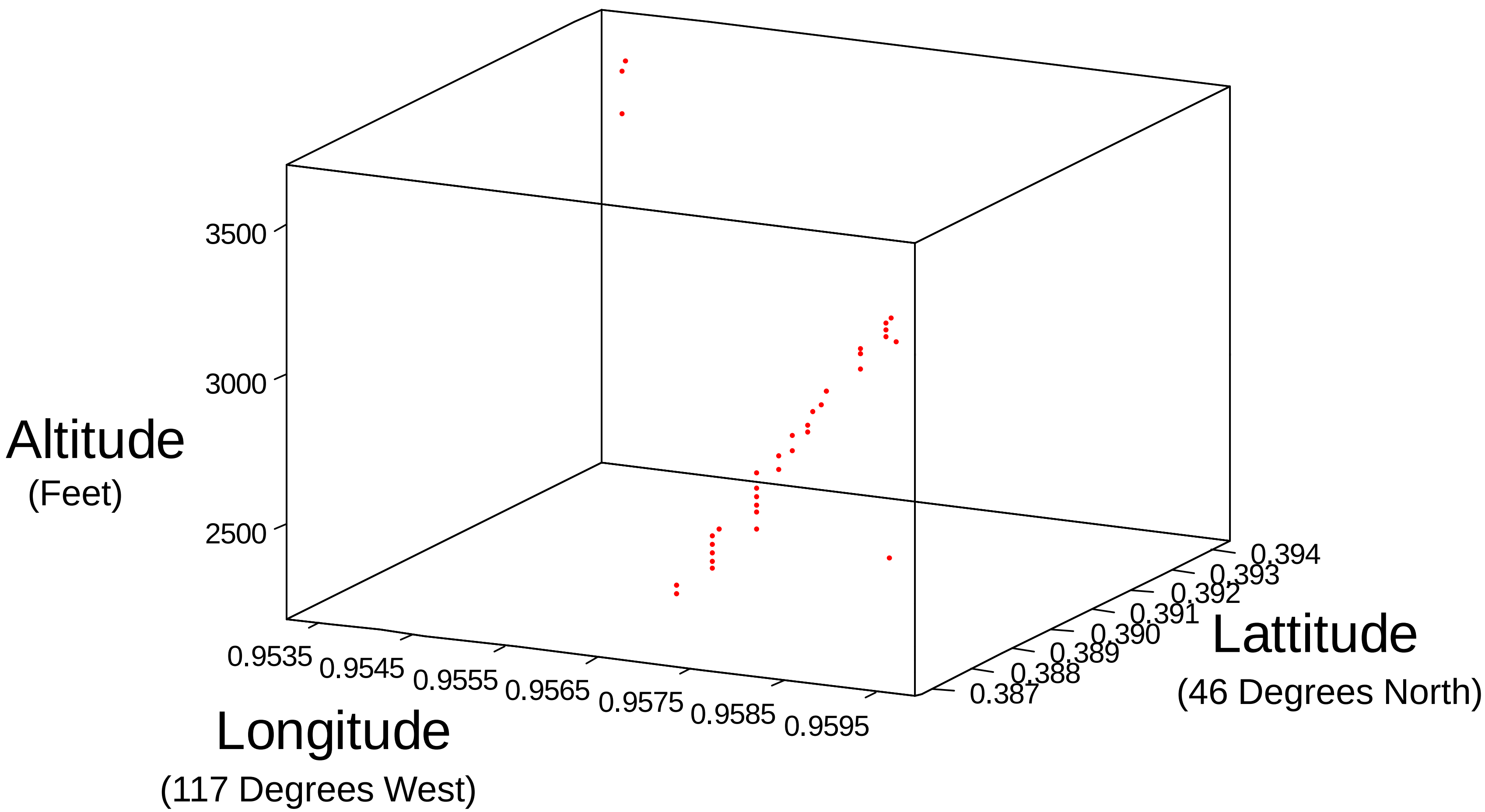


Length: 65”
Diameter: 3”
Dry Weight: 3.5 Pounds
Attainable Altitudes: 2,000 feet to 20,000 feet

Glenda Project – Active Payloads - Application

"Lone Tree" Launch Site – June 11th, 2011

Lattitude / Longitude / Altitude / Motion

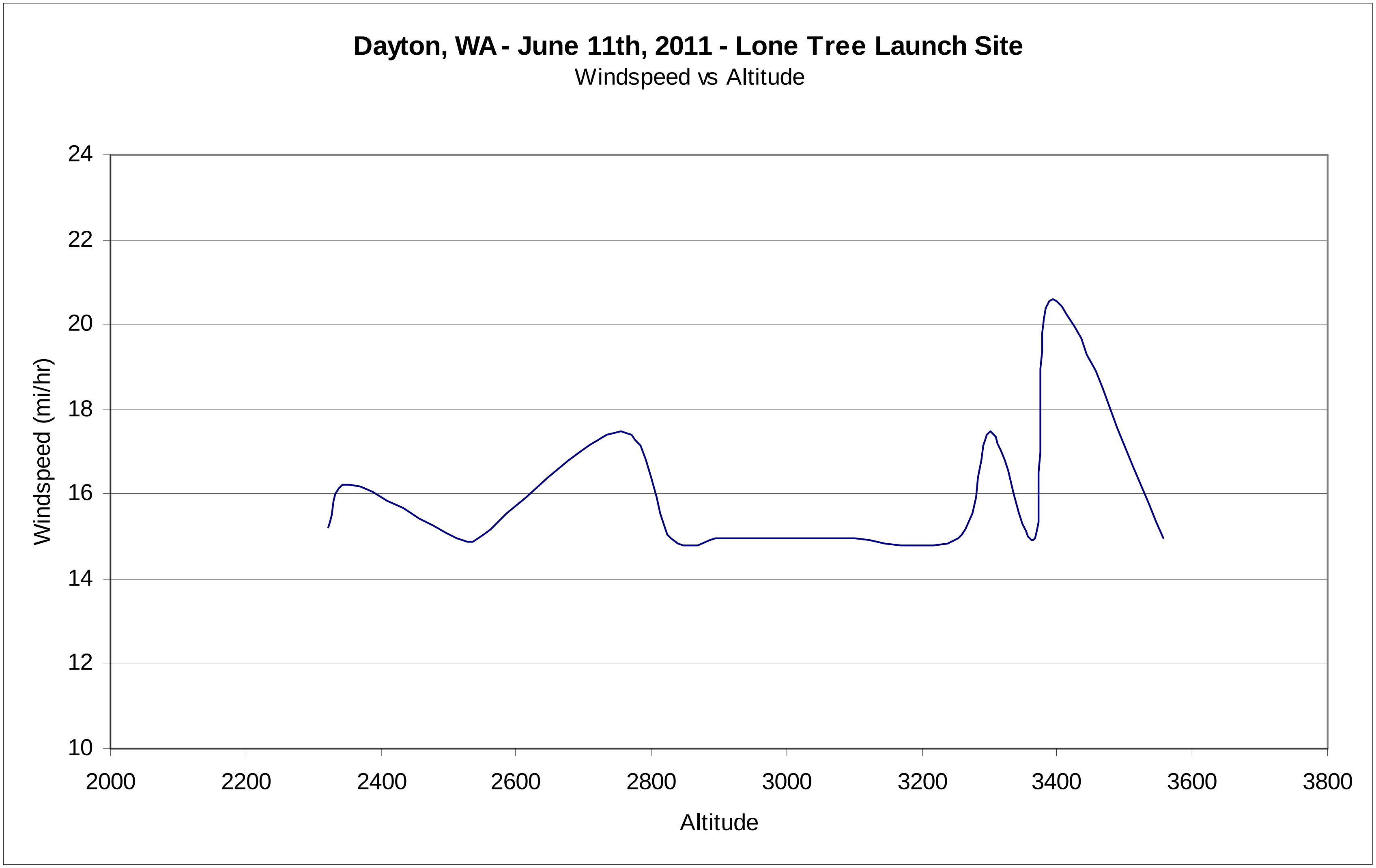


Note: After an initial shift at altitude, due to the winds aloft, recovery was nominal

Glenda Project – Active Payloads - Application

Wind Speed vs. Altitude

“Lone Tree” Launch Site – June 11th, 2011

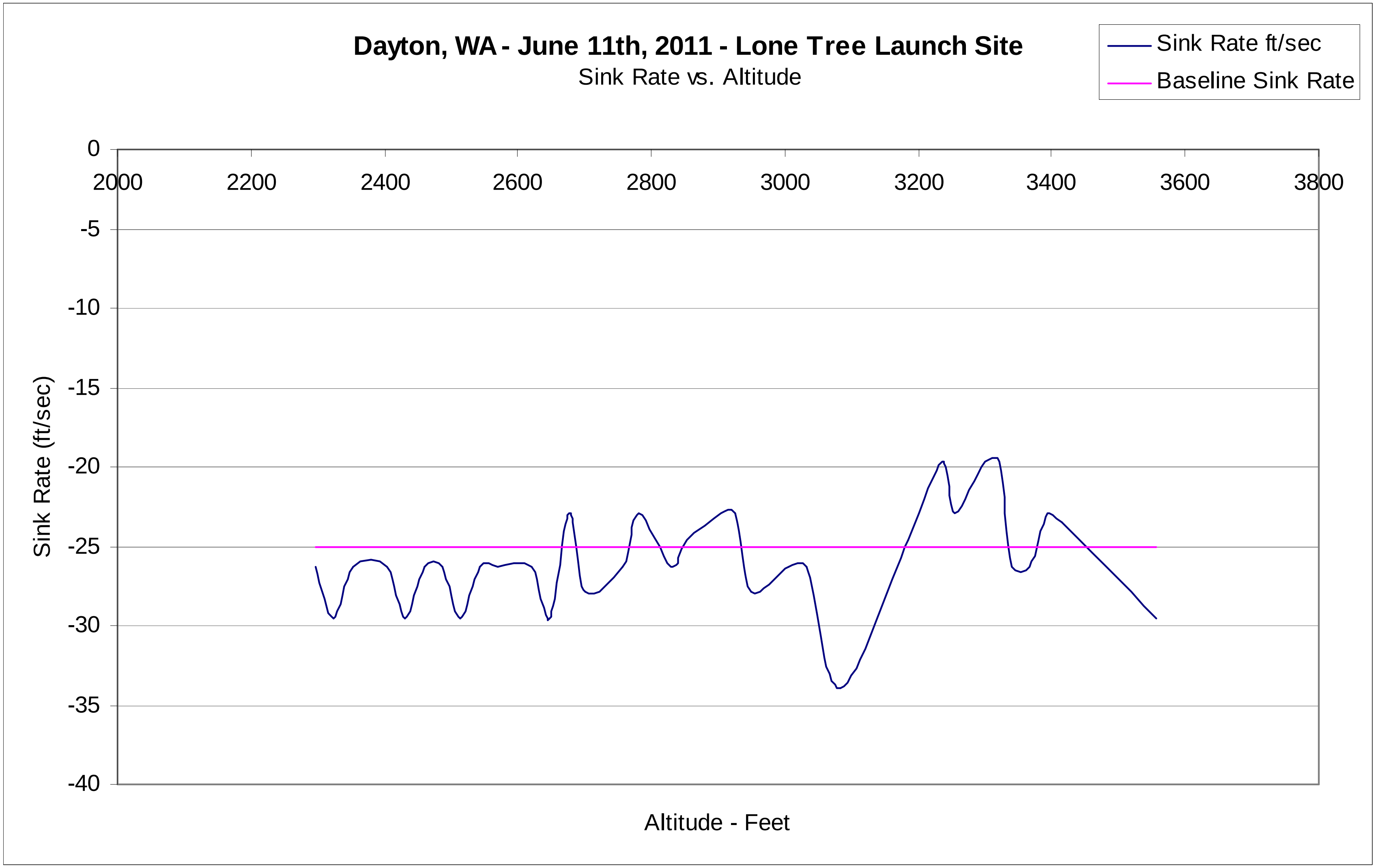


Note: Windspeed values remained relatively consistent during the flight

Glenda Project – Active Payloads - Application

Sink Rate vs Altitude

“Lone Tree” Launch Site – June 11th, 2011



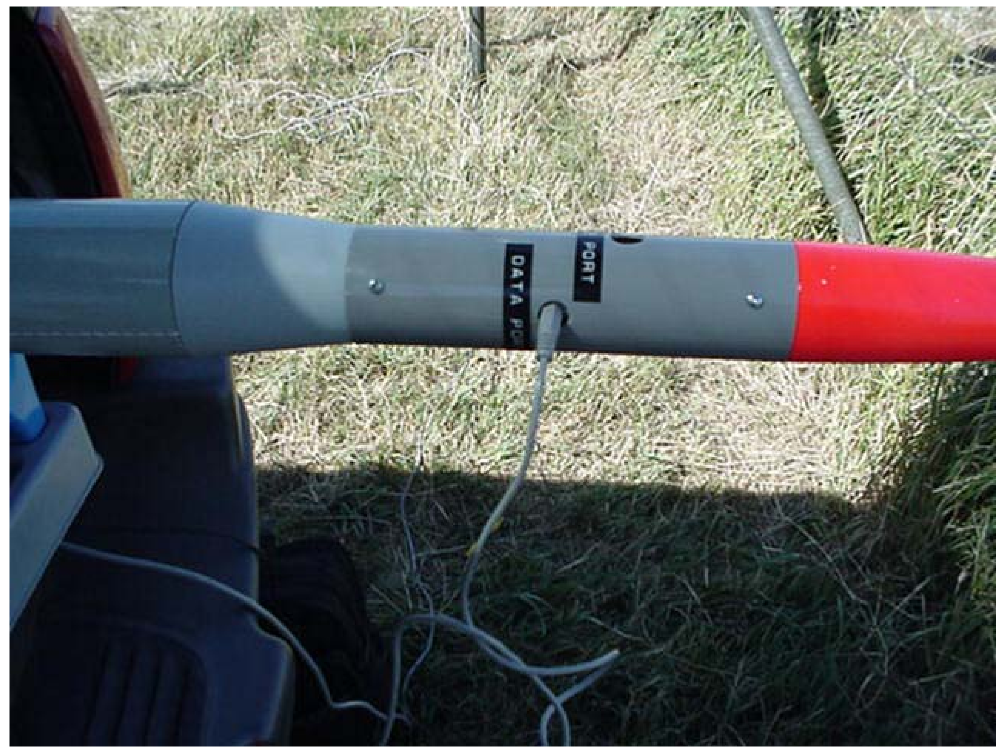
Note: The baseline capsule sink rate was 25 feet per second (-25 fps) and was able to continue to detect updrafts and downdrafts. No consistent pattern was detected.

Glenda Project - Passive Payloads – Data Loggers

A data logger is an electronic instrument that records measurements over time. Typically, data loggers are small, battery-powered devices that are equipped with a microprocessor, data storage and sensors. Most data loggers utilize software on a personal computer to initiate the logger and view the collected data.

Prior to a Glenda launch, the data logger is connected to a laptop computer. Then, systems software is used to select logging parameters (sampling intervals, start time, etc.) and initiate the logger. The logger is then disconnected from the laptop and installed inside the Glenda payload capsule. Upon launch, the logger records each measurement and stores it in memory along with the time and date.

Post recovery, the logger is then reconnected to the laptop computer and the software is used again to readout the data and see the measurements as a graph, showing the profile over time. The tabular data can be viewed as well, or exported to a spreadsheet for further manipulation.



Holux M-241 GPS Data Logger

The M-241 is a high performance GPS data logger. Capable memory size to record up to 130,000 positions, including latitude, longitude, time, velocity, and altitude.

<u>Data logger Specifications:</u>

- 32 parallel satellite searching channels
- Receiver: L1m 1575.42 MHz
- Adjustable sampling rates from 1 second +
- Satellite signal reception sensitivity: -159dbm
- Position: +/- 2.2 meters Horizontal
- Powered by a standard AA battery with 12 hour life cycle
- Size/Weight: 1.26 x 1.18 x 2.93" (32.1 x 30 x 74.5 mm)/approx. 2.5 oz.(71 grams)
- Time to reposition: < 0.1 second average
- Time to boot: 36 seconds (cold), 1 sec (hot)
- Maximum Acceleration: 4G
- Maximum Altitude: 60,000 feet (18,000 m)

MicroLite Temperature Datalogger

The MicroLite USB Datalogger is a small electronic device for monitoring and recording temperature. Manufactured to stringent IP68 standards, the MicroLite logger is dustproof and is only 4.3” long and 1” thick. The data logger features a three digit LCD display, direct USB connection, wide temperature range, high accuracy and large sample memory. Data can be displayed on the small numeric screen or downloaded to the MicroLab Lite software via the USB 2.0 connector.

Datalogger Specifications:

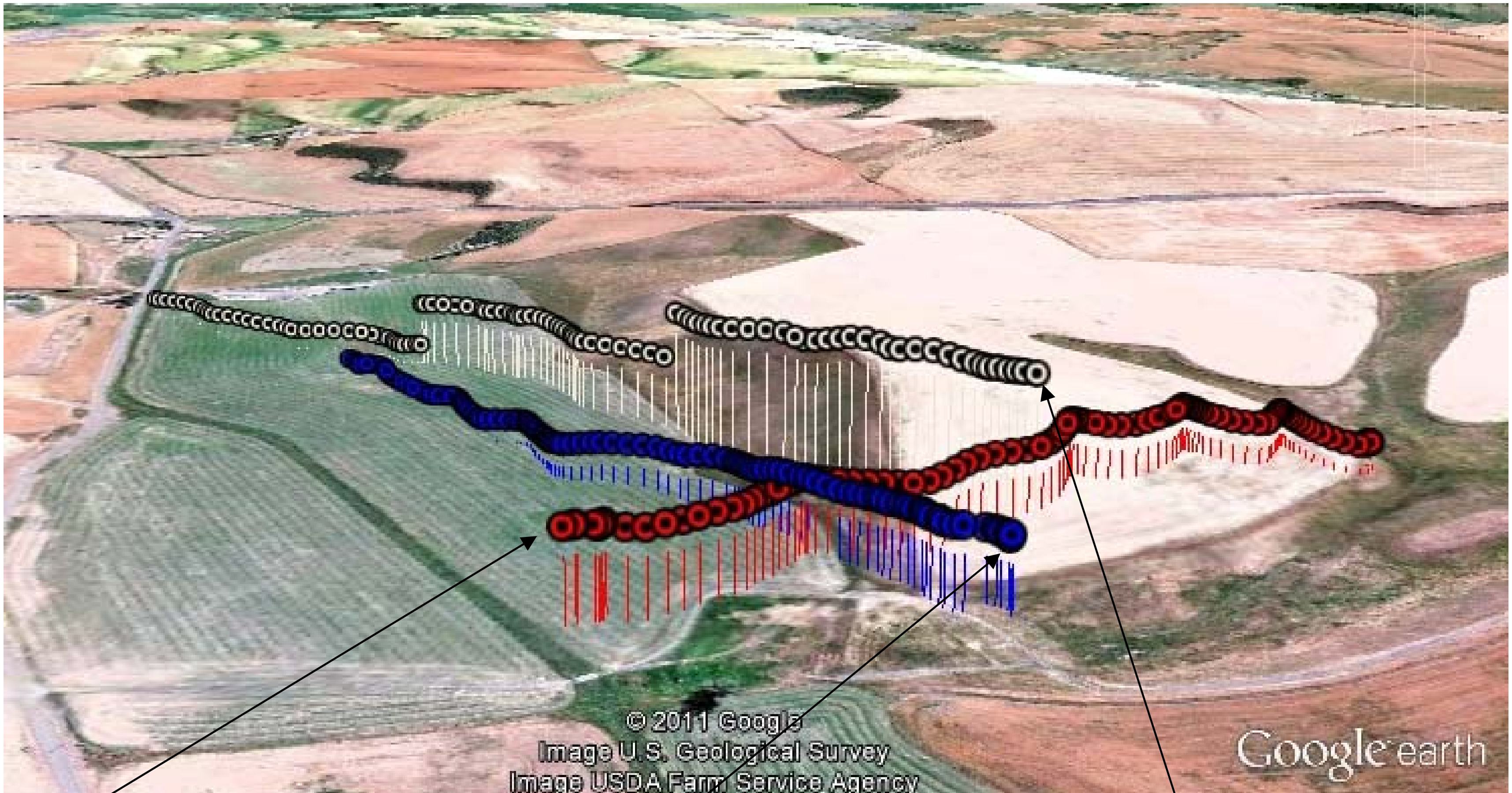
- Internal Temp Sensor: -40°C to 80°C Thermal Conductor enabling a fast sensor response time
- Sampling Resolution A/D Resolution: 16Bit 0.1°C
- Data Storage Capacity: 16,000 Samples
- Sampling Rate: 1 per second to 1 per 2 Hours
- Battery: Replaceable 3V Lithium Battery - CR2032
- Battery Life: 2 Years at 1 second Sampling Rate
- Dimensions: 11cm x 3.9cm x 2.6cm (4.3" x 1.5" x 1.0")
- Weight: 45.5 grams (1.6oz)
- Software: MicroLab Lite for Windows
- Standard Compliance: IP68, NEMA6 (30 Minutes for 0.5 meter Depth) CE, FCC

Glenda Project - Passive Payloads – Application

GPS Data Logging

4D wind current mapping over local terrain.

(4D is latitude, longitude, elevation and velocity)



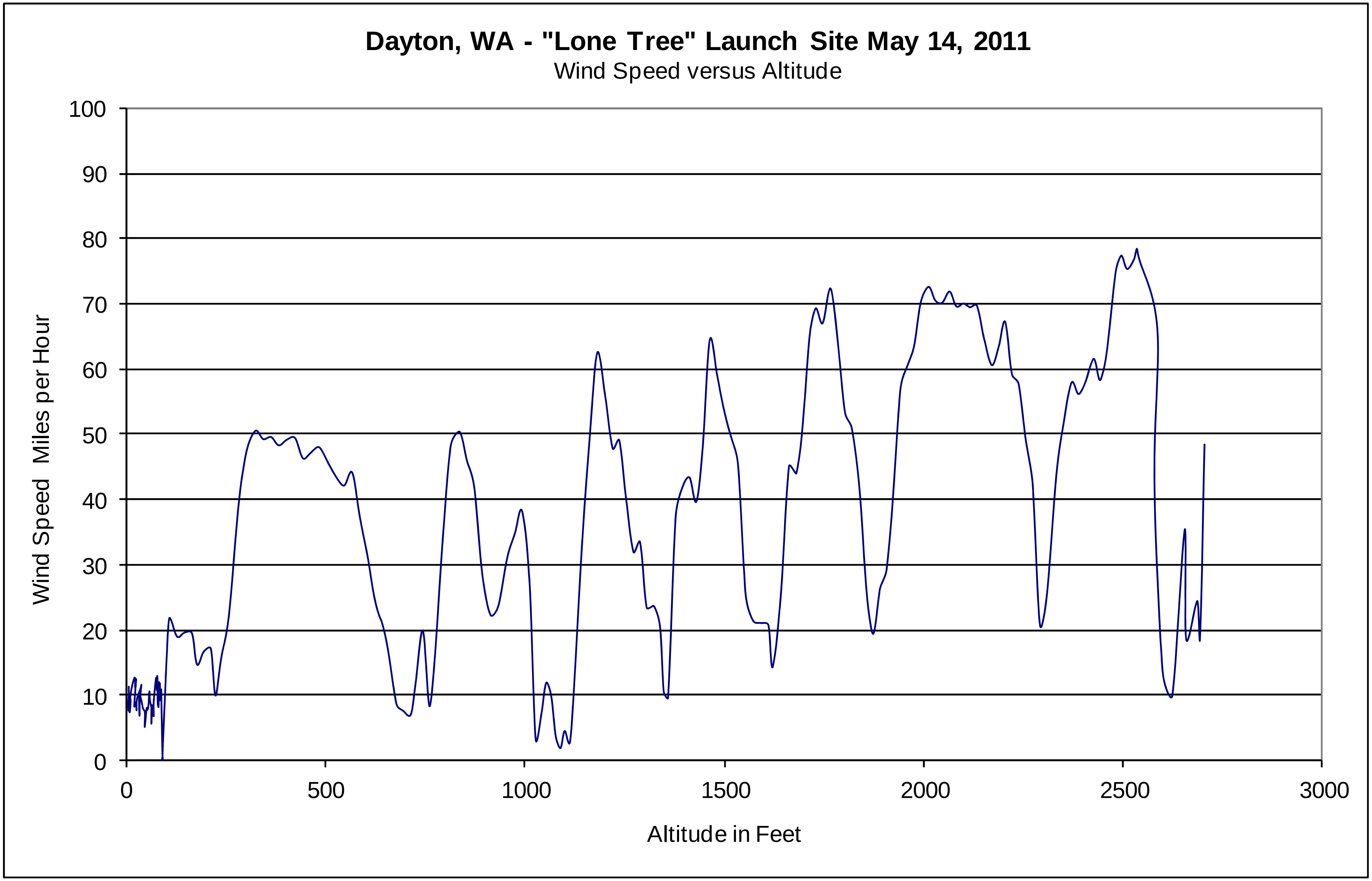
May 14th
7554 Booster – Aerotech I211
"Thunderstorm Intercept"
Apogee: 2,706 Feet
Ground Level Wind Speed: 4.5 mph

June 11th
9875 Booster – CTI I170
Apogee: 2,211 Feet
Ground Level Wind Speed: 10 mph

October 1st
7554 Booster – Aerotech I211
Apogee: 2,354
Ground Level Wind Speed: 14.5 mph

Glenda Project - Passive Payloads – Application

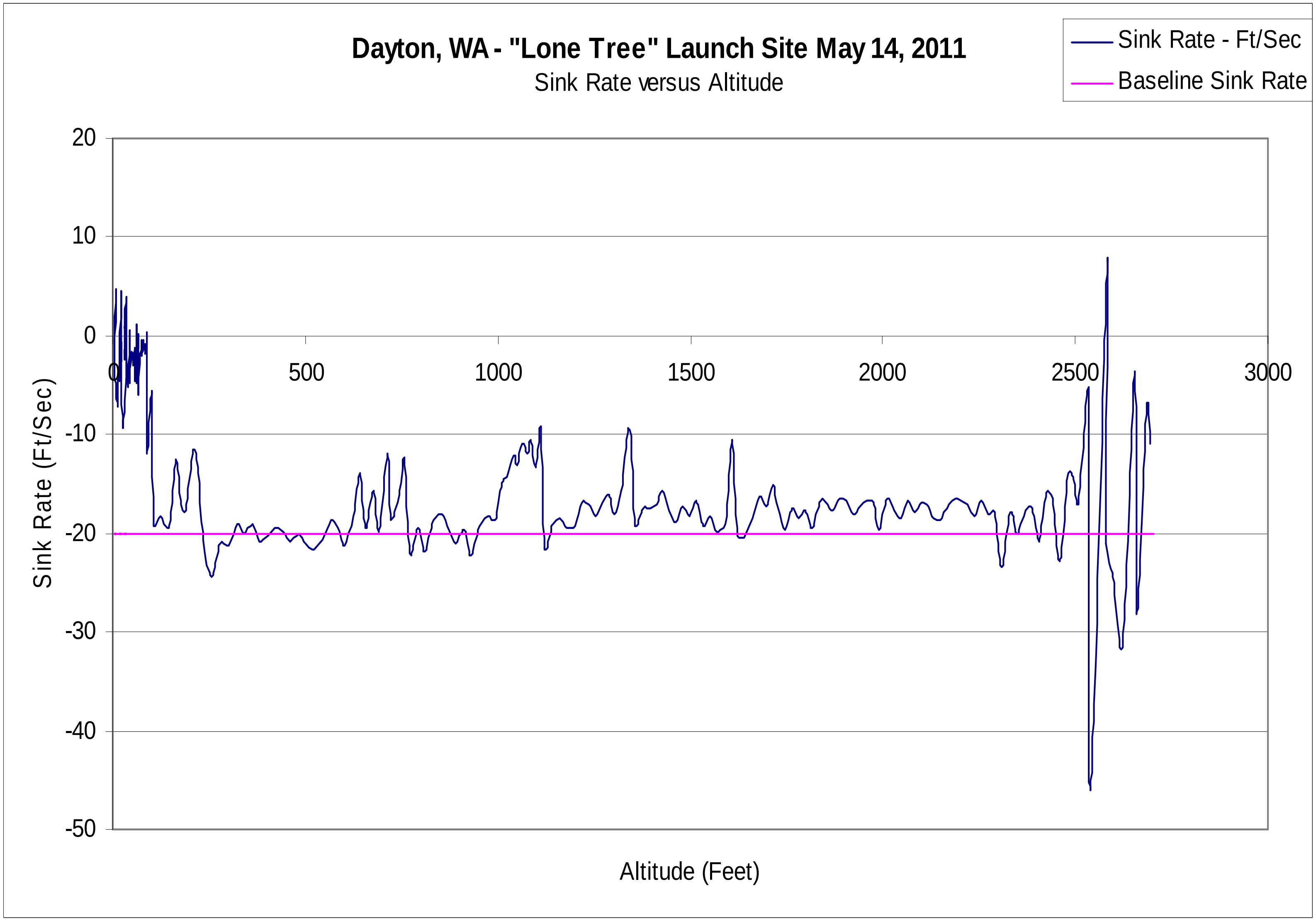
GPS Data Logger – Wind Speed vs Altitude
“Lone Tree” Launch Site – May 14th, 2011



Note: Wind Speed is increasing with Altitude

Glenda Project - Passive Payloads – Application

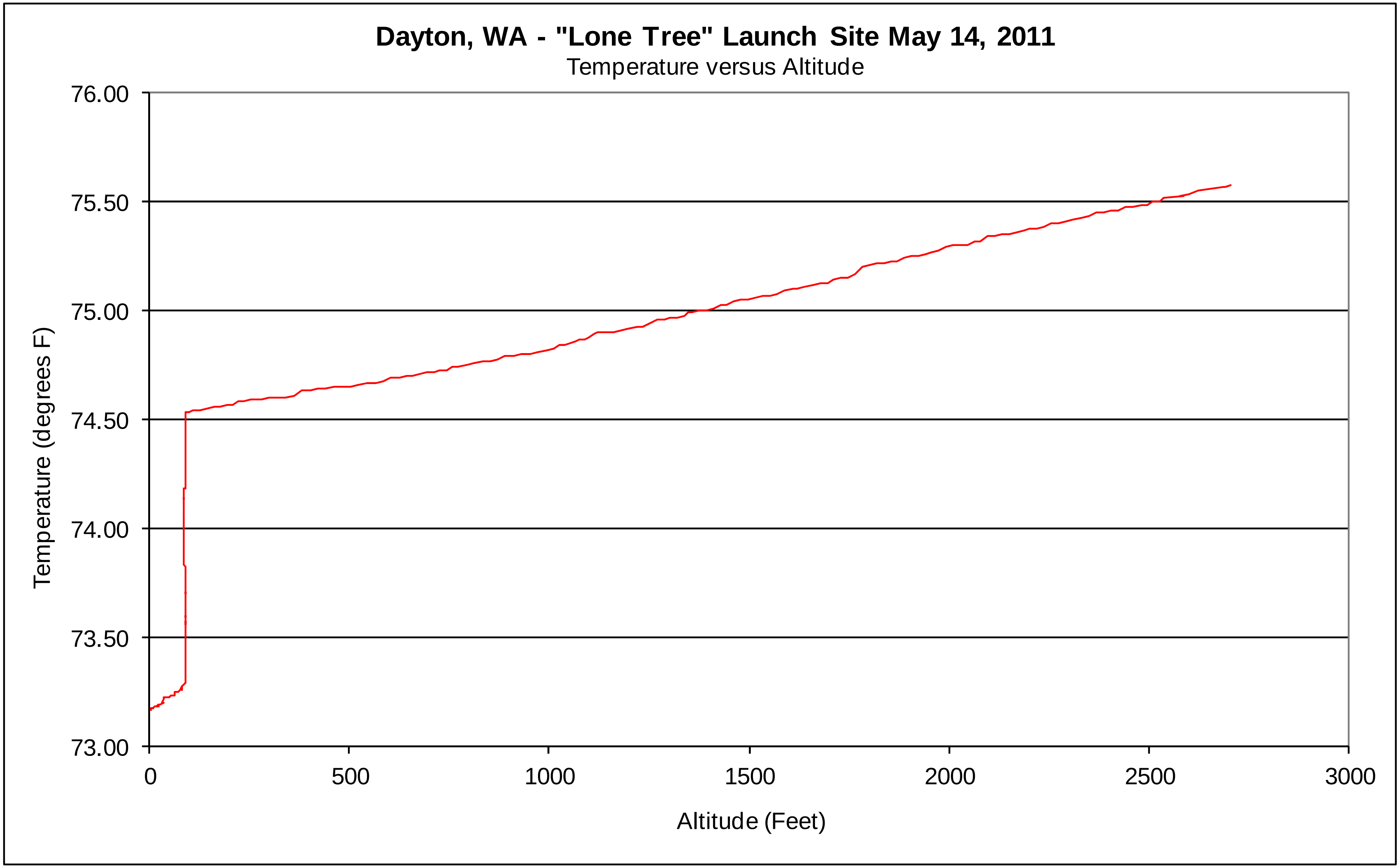
GPS Data Logger – Sink Rate vs Altitude
“Lone Tree” Launch Site – May 14th, 2011



Note: The “Baseline” Sink Rate of the capsule is 20 feet per second (-20)
There are significant Updrafts and Downdrafts due to the approaching thunderstorm

Glenda Project - Passive Payloads – Application

Temperature / GPS Data Logger – Temperature vs Altitude
“Lone Tree” Launch Site – May 14th, 2011



Glenda Project – Ground Stations

The Glenda Project has found that, over time, without knowing ground level weather conditions, there is no effective baseline to measure from as we launch instrument packages into severe weather systems.

This acknowledgement has driven the development of several different types of mobile ground station where their usage can be adapted based on our mission and data requirements.

Some typical examples:

a) Digital Chart Recorders

b) Recording Anemometers

c) TMQ-34 Mobile Military system

d) Coastal Environmental WeatherPak 400 Wireless ground station

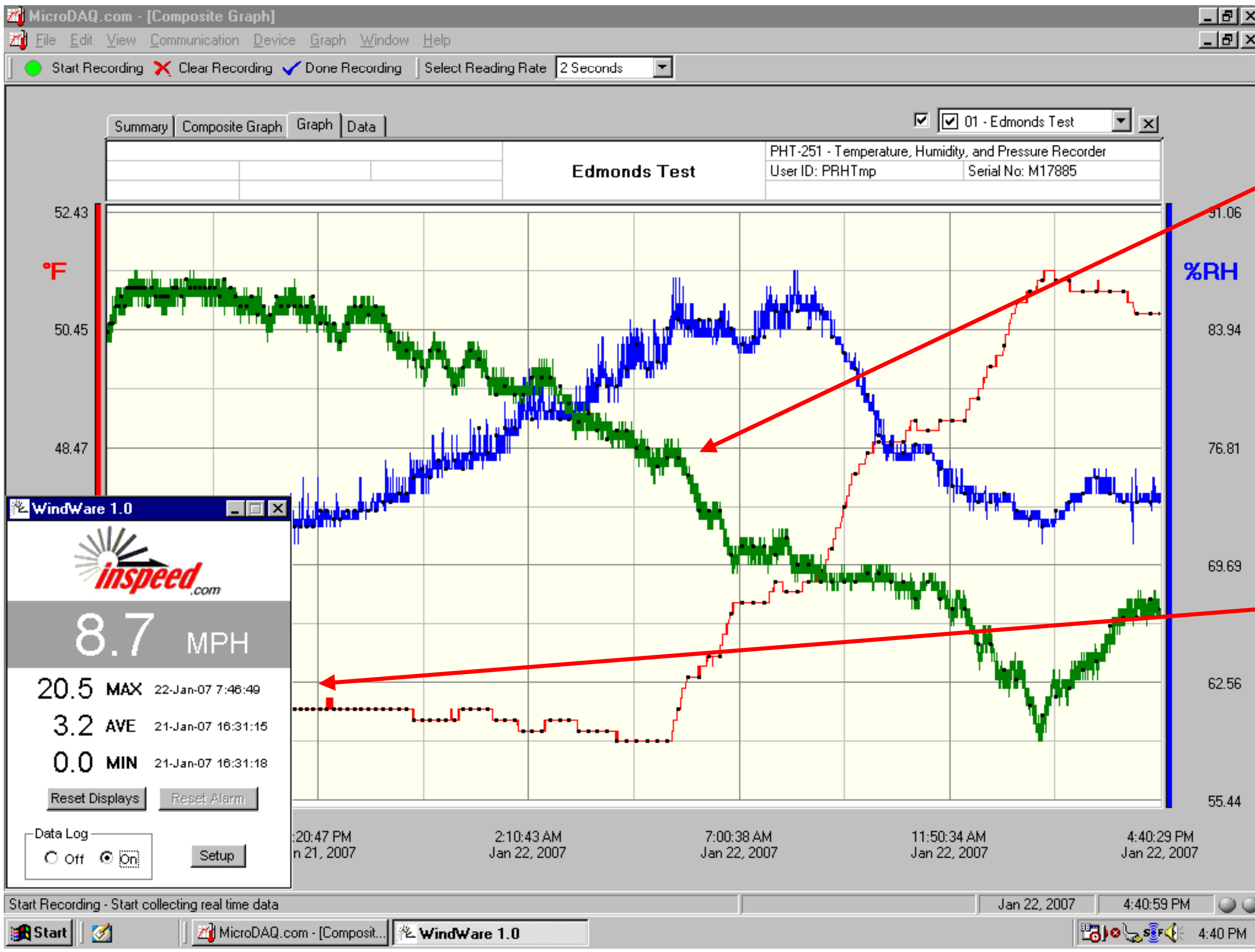
e) Mobile Mesonet ground stations

Glenda Project – Ground Stations

Digital Chart Recorders

Glenda Project utilizes sensors combined with ground based laptops to provide a digital based chart record of ground baseline conditions mapped over time.

The basic example below is a digital chart record of temperature, humidity, barometric pressure and wind speed at a test site.



Pressure, Temperature, & Barometric Pressure data stream using Micro-DAQ software and COM 1 port

Wind Speed data using InSpeed Anemometer and supporting software Using COM 3 port via USB port application adapter

Glenda Project – AN/TMQ-34 Ground Station

Glenda also has an operational portable military weather station. This acquisition further enhances the projects ground condition data collection capabilities.

Sensor Module

Computer Module

The TMQ–34 is a military self contained portable weather measuring system that is powered by a rechargeable Ni CAD battery.

The TMQ–34 alphanumerically displays wind speed and direction, peak wind, temperature, dew point, barometric pressure, 3-hour pressure change, and the minimum and maximum temperature.

The entire TMQ–34, including the system case, weighs about 20 pounds. The set contains a computer module with a pressure sensor, and the main sensor module with a red sensor for temperature, a white sensor for humidity, a wind direction compass, and an anemometer to measure wind speed.

The TMQ–34 can operate in temperatures ranging from a low of –59.5°F to 132°F. The TMQ–34 is intended for use in a tactical environment with an operating range of 100 feet below sea level to 10,000 feet above sea level.

Glenda Project – WeatherPak 400 Ground Station

Coastal Environmental Wireless HazMat Weather Station

The Glenda Project has been able to obtain a Coastal Environmental WeatherPak 400 TRx2 mobile wireless weather station.

Some of its numerous features are:

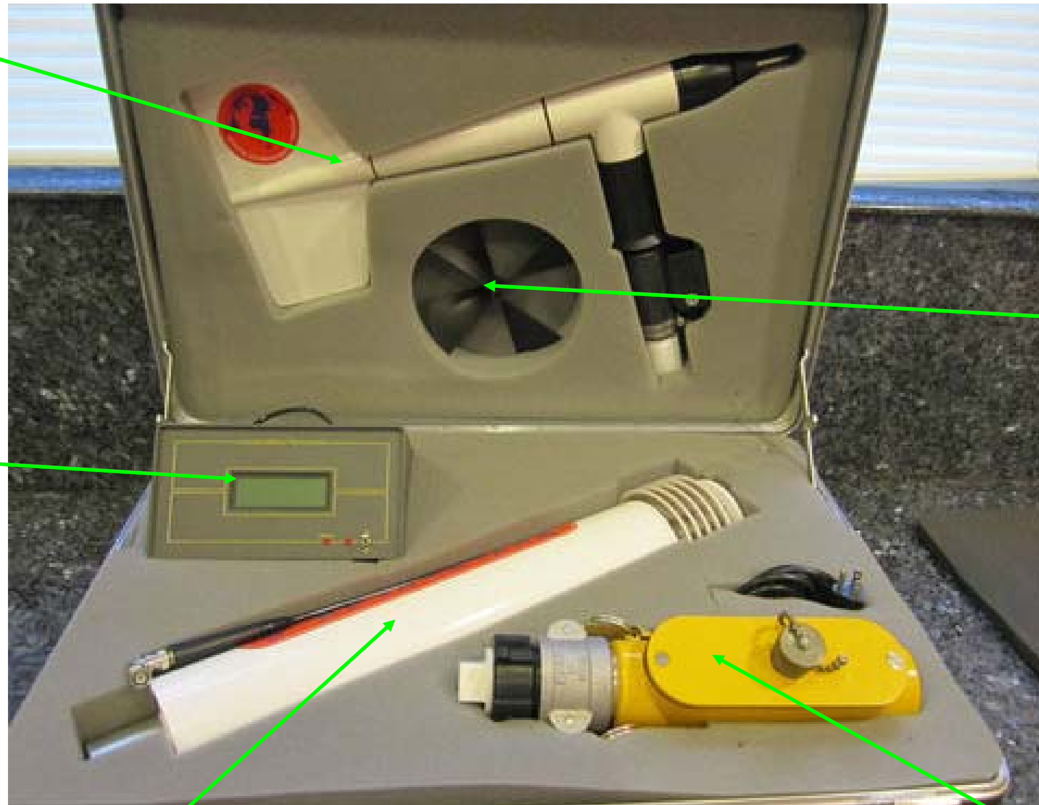
- Wireless radio data Telemetry with a 5 mile range
- Self aligning Fluxgate Compass
- Complete sensor suite to record Temperature, Relative Humidity, Barometric Pressure, Wind Speed, and Wind Direction.
- Weighs less than 10 pounds and is deployable in less than 60 seconds
- Highly portable with its own transit case
- Serial data interface to support data logging and display
- Alternate Power Sources from 120VAC to 12 VDC
- "Stand Alone" capability without requiring a computing interface
- Tested and designed for HazMat and severe environments
- Capability to measure "Sigma Theta" to determine atmospheric instability

Glenda Project – WeatherPak 400 Ground Station

Coastal Environmental Wireless HazMat Weather Station

System Components

Anemometer / Wind Direction Sensor



Anemometer Propeller

Telemetry Receiver Display

Sensor Suite Unit containing Temperature, Relative Humidity, Barometric Pressure and Telemetry Radio transmitter

Power Distribution Junction Box

Glenda Project – WeatherPak 400 Ground Station

Sigma Theta Overview

One of the datasets collected by the Weatherpak 400 is called “Sigma Theta” and is a measurement of Atmospheric Stability.

Atmospheric Stability can be defined as the resistance of the atmosphere to vertical motion. Vertical motion is directly correlated to different types of weather systems and their severity. Atmospheric vertical motion can be either ascending, or descending and are commonly called updrafts, or downdrafts.

Often under calm conditions, and especially over flat terrain, heated air parcels do not rise immediately. They have inertia and remain on the surface until some disturbance permits cooler surrounding air to flow in beneath and provide the needed buoyancy. This disturbance is the trigger for atmospheric in-stability.

Thunderstorms with strong updrafts and downdrafts develop when the atmosphere is unstable and contains sufficient heat, and moisture.

As air rises, it cools and serves as an indicator of atmospheric stability. The term for the rate of this cooling is called the “Adiabatic Lapse Rate”, and is the traditional method for determining atmospheric stability.

In mountainous terrain, temperature and humidity measurements taken at mountaintop and valley-bottom ground stations provide reasonable estimates of the lapse rate and moisture conditions in the air layer between the two levels.

Adiabatic Lapse Rates (under “baseline” conditions):
Dry: 5.5 degrees F decrease per 1,000 feet elevation increase.
Moist: 3 degrees F decrease per 1,000 feet elevation increase.

A large decrease in temperature with height indicates an unstable condition which promotes up and down wind currents. A small decrease with height indicates a stable condition which inhibits vertical motion. Where the temperature increases with height, through an inversion, the atmosphere is extremely stable. (ie capping)

Lapse rate data is typically collected using balloon carried radiosondes, or rocket launched capsules, as the data is not attainable using conventional ground stations.

Glenda Project – WeatherPak 400 Ground Station

Sigma Theta Overview

"Sigma Theta" (ST) is a compound term with its origins coming from both the Statistical / Mathematic community and the Physical Sciences.

The term "Sigma" comes from the Statistical community and is a mathematical term used to define the concept / process called "standard deviation". Standard Deviation is a process used to explain the amount of variability within a data set with the higher the deviation, the higher the level of variability within the data set.

"Theta" comes from the Physical Sciences / Weather community as the term defining the angle of wind direction.

"Sigma Theta" translated means the amount of variability of the changes in wind direction within a dataset.

Robert Yamartino developed the "standard" ST model back in the 1980's and it has been adopted by the HazMat / EPA community as their preferred model for measuring atmospheric stability using ground based sensors and is based off of the following equations:

Step 1: Compute the average sine of wind direction, the average cosine, and epsilon

$$S = \frac{1}{N} \sum_{i=1}^{N} \sin \theta_i \qquad C = \frac{1}{N} \sum_{i=1}^{N} \cos \theta_i \qquad \varepsilon = \sqrt{1-(S^2 + C^2)}$$

Step 2: Compute sigma theta as the arcsine of epsilon, and apply a correction factor

$$\sigma_\theta = \arcsin(\varepsilon) \left[1 + \left(\frac{2}{\sqrt{3}} - 1 \right) \varepsilon^3 \right]$$

Glenda Project – WeatherPak 400 Ground Station

Sigma Theta Overview

Frank Pasquill took the next step, and determined levels of Sigma Theta for differing degrees of atmospheric stability. He created a seven tiered system from “A” to “G”, where Class “G” reflects the most stable atmospheric condition, to Class “A” which reflects the highest level of atmospheric in-stability.

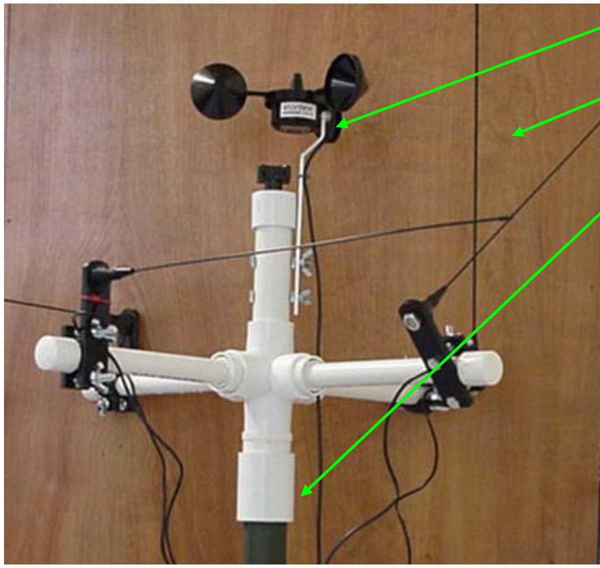
His results are shown in the table below:

Stability Class		Description	Definition
1	A	Extremely Unstable	$22.5 \leq \sigma_\theta$
2	B	Moderately Unstable	$17.5 \leq \sigma_\theta < 22.5$
3	C	Slightly Unstable	$12.5 \leq \sigma_\theta < 17.5$
4	D	Neutral	$7.5 \leq \sigma_\theta < 12.5$
5	E	Slightly Stable	$3.8 \leq \sigma_\theta < 7.5$
6	F	Moderately Stable	$2.1 \leq \sigma_\theta < 3.8$
7	G	Extremely Stable	$\sigma_\theta < 2.1$

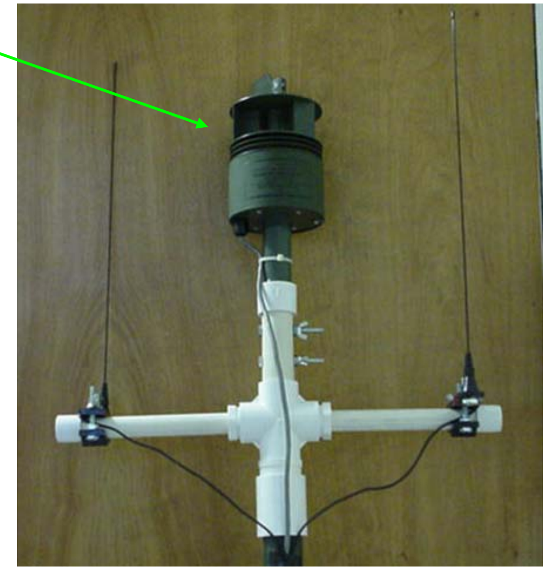
Based on this Stability Class table, we can now make determinations of atmospheric stability based on ground station data and not have to rely on balloon launched radiosondes, or rocket launched payloads.

Glenda Mobile Ground Station Mast System

Removable / Adaptable Mast Sensor Head

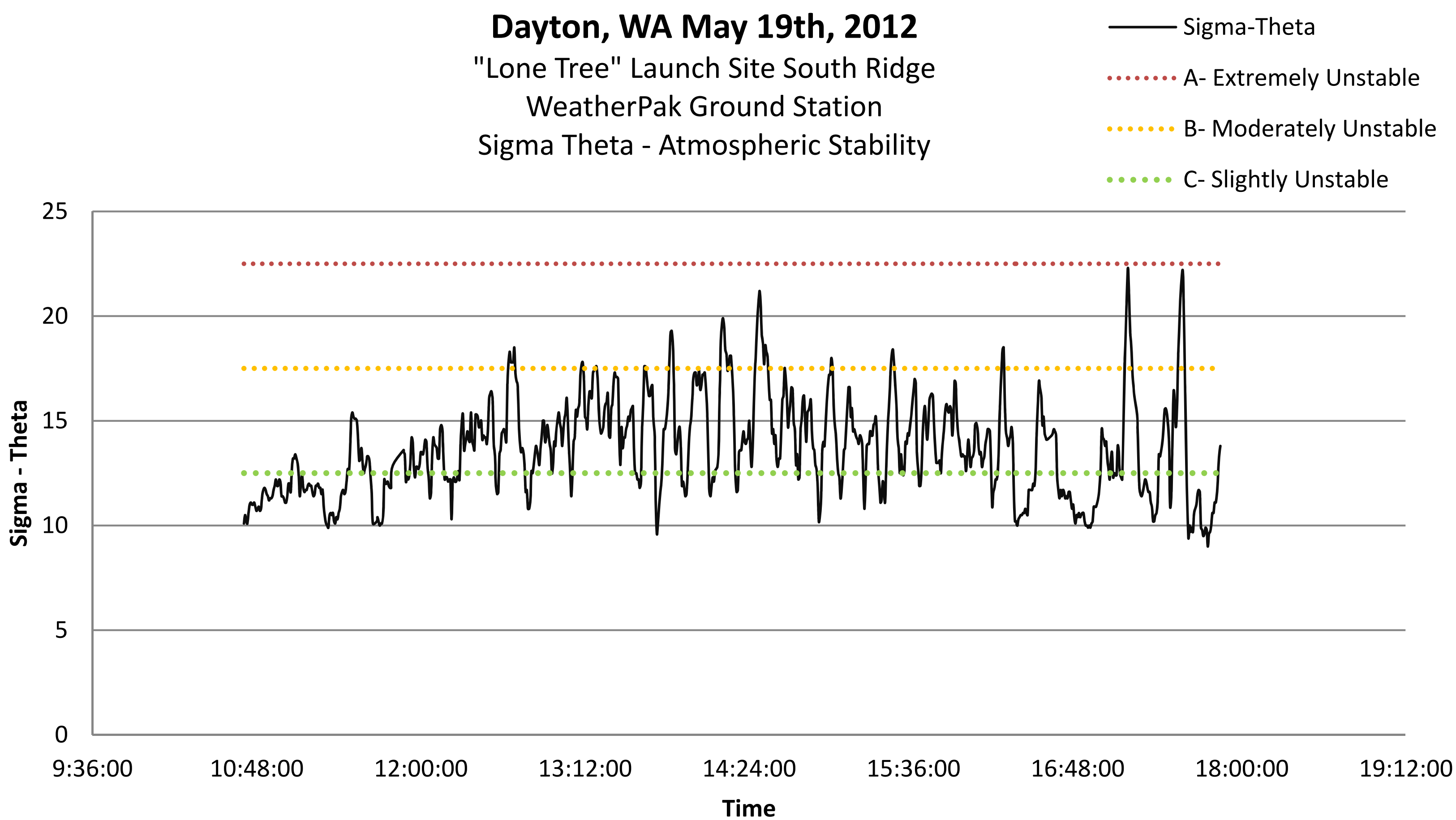


- In-Speed Anemometer / TMQ-34 Sensor
- Two / Four Wide Band Receiver Antennas for Radiosonde telemetry signals.
- Mast System Interface Adapter
- Light weight PVC / Fiberglass construction to reduce potential for lightning strike
- Antennas with 1.2 GHz capability allows multiple frequencies and multiple radiosonde reception
- Mast head integrates with man portable mast system



Glenda Project – Ground Station - Application

WeatherPak 400- Sigma Theta



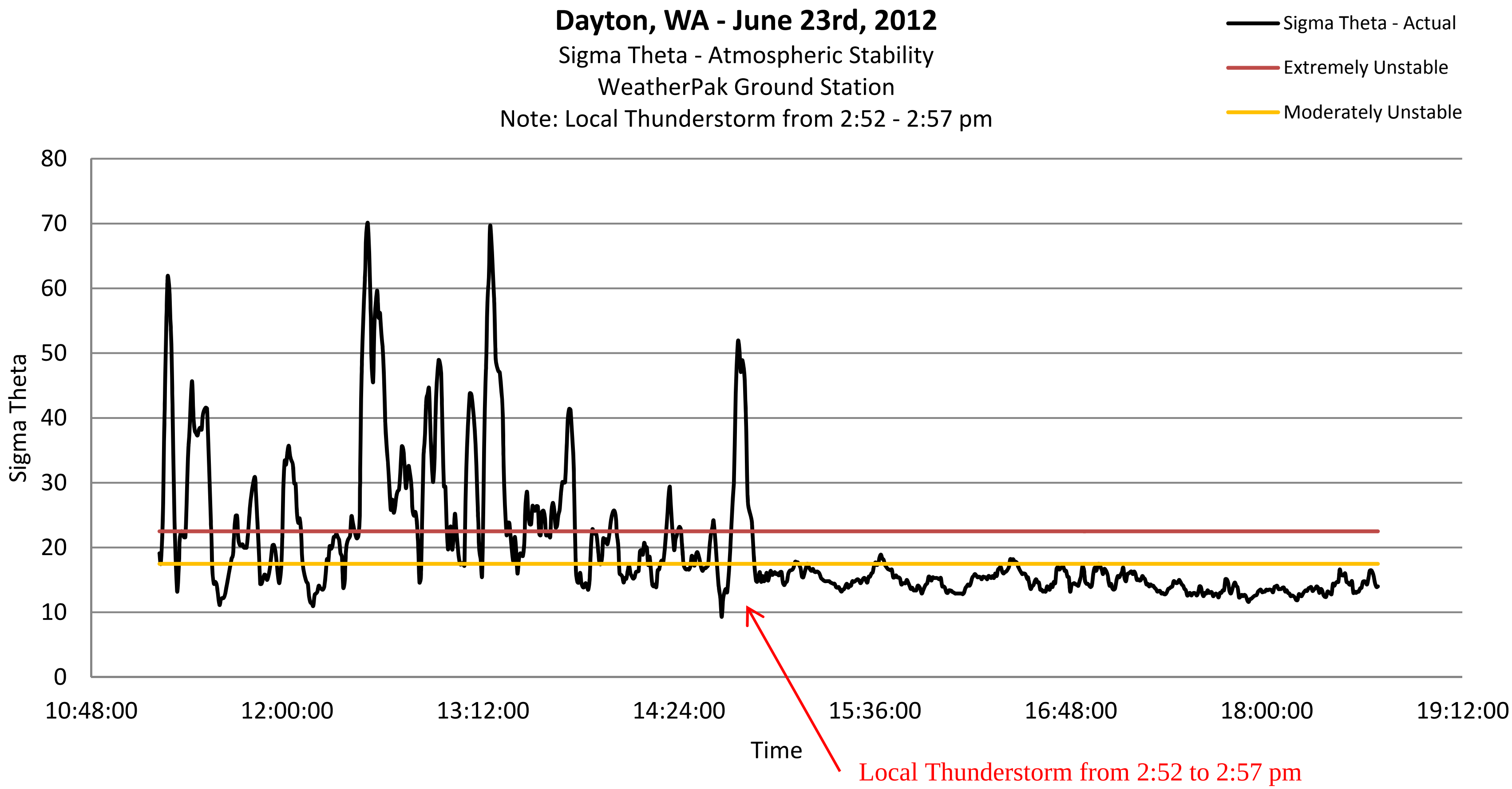
Note that the bulk of the ST data falls in the "Slightly Unstable" range with several points falling into the "Moderately Unstable" band. This implies that atmosphere instability is occurring. However, not severe.

Note also, that atmospheric instability is independent from wind speed as you can have strong winds in a stable atmosphere and calm winds in an unstable atmosphere.

Sigma Theta provides us a tool to measure atmospheric stability using ground based sensors in a mobile environment without the need for lapse rate data and its supporting infrastructure requirements.

Glenda Project – Ground Station - Application

WeatherPak 400- Sigma Theta



On June 23rd, the WeatherPak 400 was deployed on the south ridgeline above the BMR "Lone Tree" launch site.

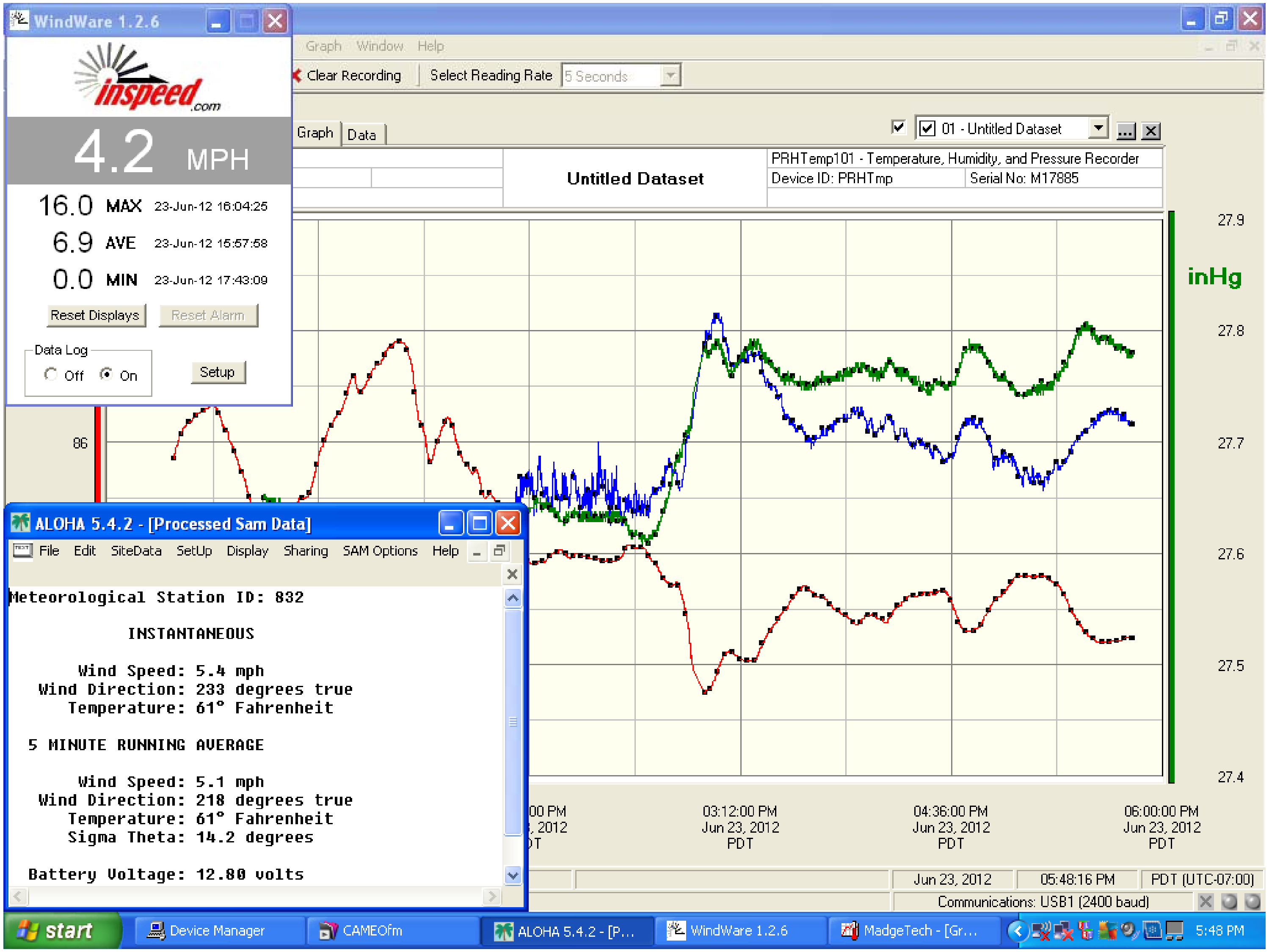
Sigma Theta values reflected "Extremely Unstable" conditions until the passage of a local thunderstorm from 2:52 to 2:57 pm where the Sigma Theta values returned to normal limits.

A case can now be made that Sigma Theta values can be used as a severe weather pre-cursor, and continued deployment opportunities are expected.

Glenda Project – Ground Station - Application

Dual Ground Station Deployment

Dayton, WA – June 23rd, 2012

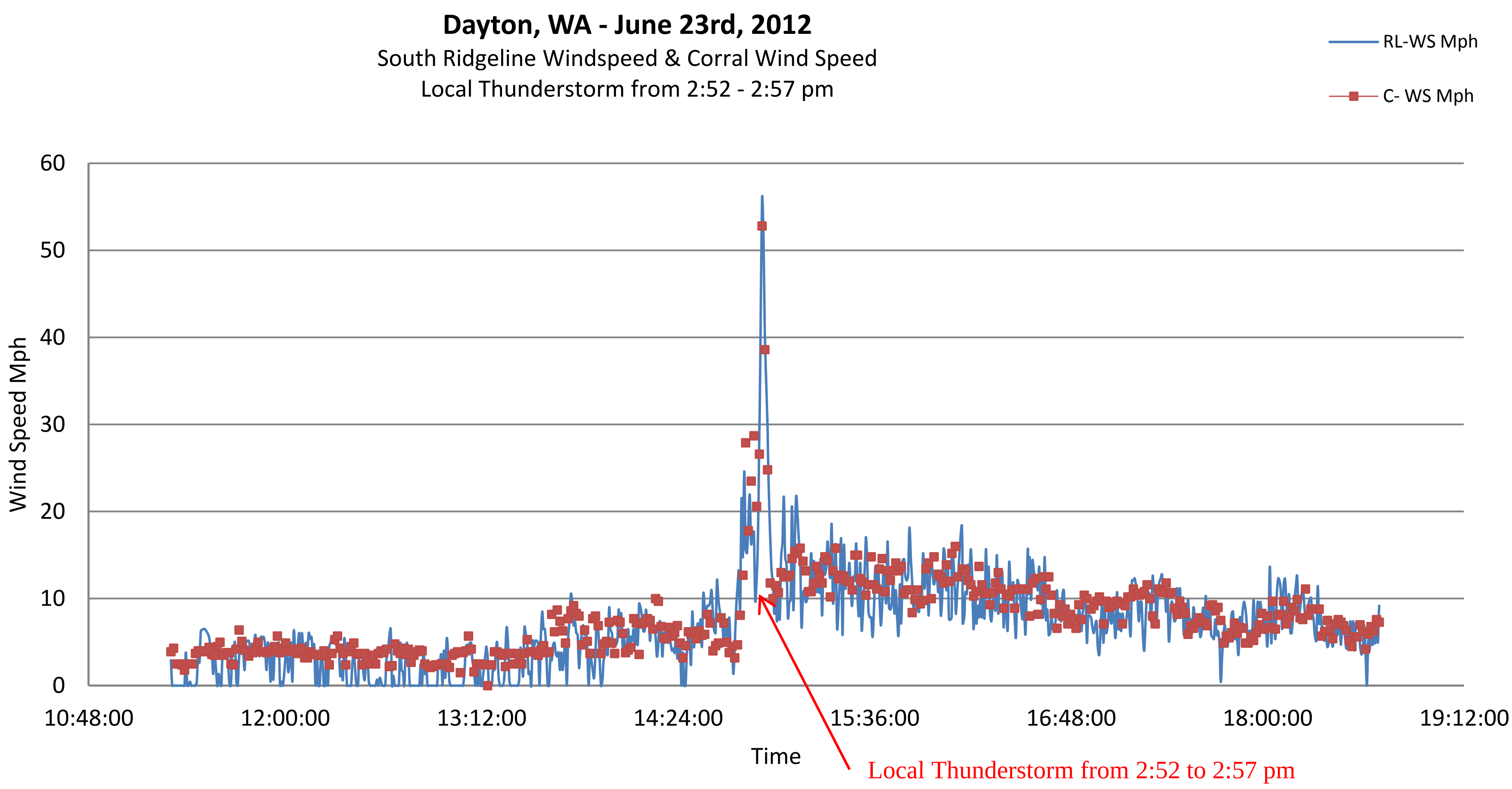


Data from both the wireless and mobile ground stations were displayed side by side on a common interface for seamless integration.

Glenda Project – Ground Station - Application

Dual Ground Station Deployment

Dayton, WA – June 23rd, 2012

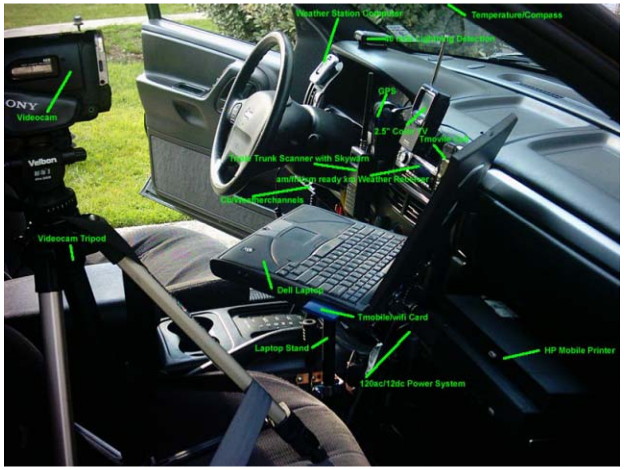


On June 23rd, our first dual deployment accoured as a thunder storm passed over two ground stations simultaneously with one station the wireless WeatherPak and the second, our hard wired mobile station.

Glenda Project – Intercept Teams

In order to obtain data from dynamic weather phenomena it is necessary to seek out and intercept storms and to launch sensors into the heart of the disturbance, capture the data, and return the data for immediate processing and analysis. Hence the name, Intercept Team.

The Intercept Teams utilize Jeep Grand Cherokee 4 wheel drive units, and other heavy duty trucks, equipped with specialized tires and suspension to handle road debris situations and evasive maneuvers while on the go. When storm data is required, the teams immediately equip the vehicles with instrument packages and laptop computers inside the vehicle and attach to the roof, weather instrumentation, satellite dishes, sensors and communication gear. Portable rocket launching stands and weather rockets are loaded into the back of the jeep. Transforming from a ordinary vehicle to a fully operational weather pursuit vehicle takes as little as five minutes.



Glenda Project – Intercept Teams

Mobile Mesonet Ground Station Vehicles

Intercept Team vehicles can feed information directly over the web to Acurite and Weather Underground fully automatically. Vehicles are equipped with full weather station sensors and forecasting ability, weather warning radios, a short wave wefax system, wifi connectivity both local and cellular, and 20 meter and 2 meter transmission systems which allows communications between team vehicles and Emergency Management and First responders . Vehicles have the capability of independent operation with either an onboard generator and / or back-up 12 VDC battery systems.

Glenda Project – Intercept Teams

Columbia County – Dayton, WA

In 2012, the Columbia County / Dayton, WA Intercept Team became the "eyes" for Emergency Management and First Responders in severe weather situations.

Approaching Storms for Intercepts

Glenda Project – Intercept Teams

Columbia County – Dayton, WA

The Dayton storm team made significant advances in 2012 in the areas of micro-climate research and coordination with regional emergency management resources.

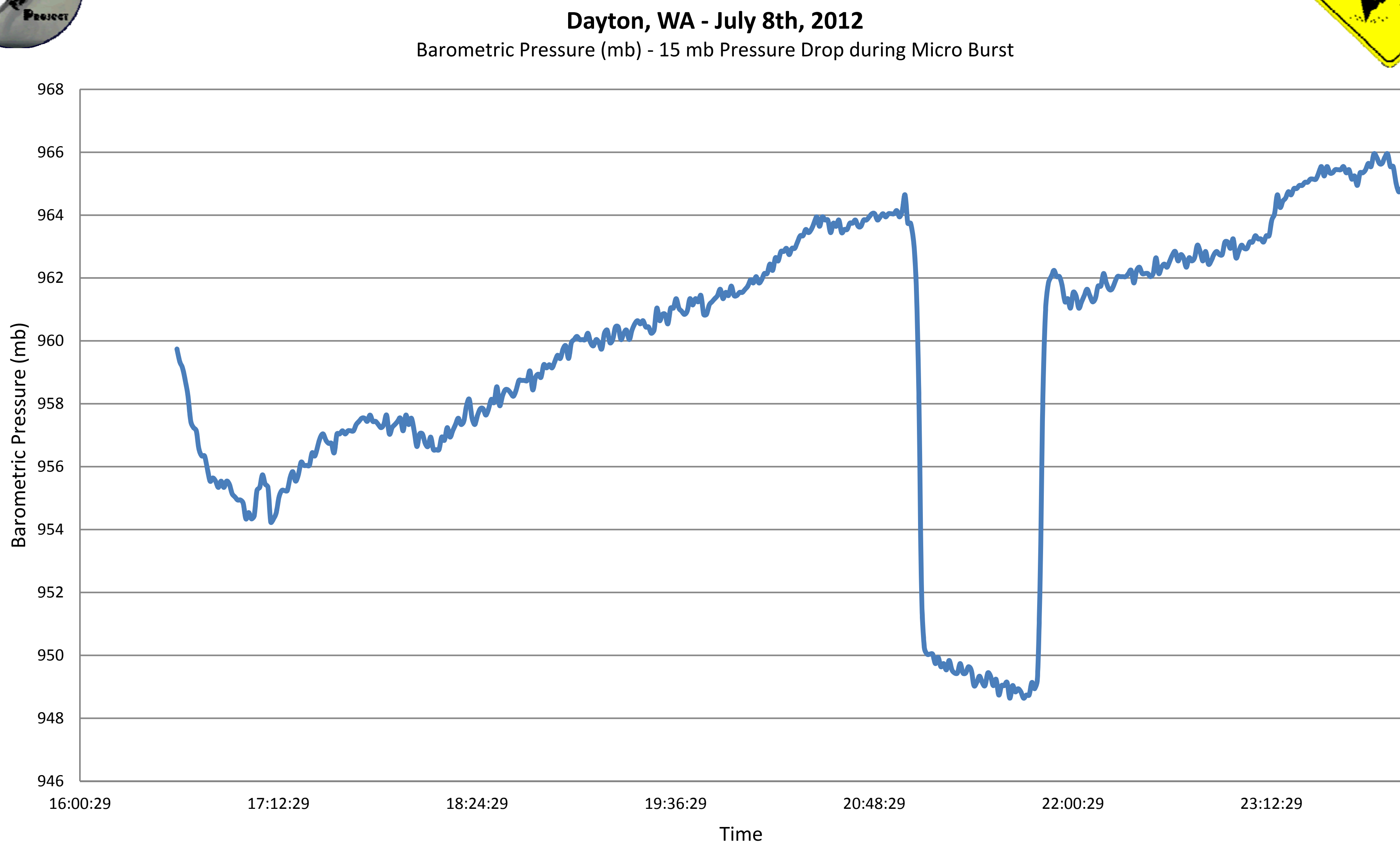
The year started out with significant upgrades to data collection and analysis hardware. Extech RHT50 data loggers were deployed this year. These compact data loggers record barometric pressure, temperature and humidity at rates of up to one minute intervals, recording over 10,000 data points for later download and analysis. Two such data loggers are now in operation; one that records at the team's base of operations in Dayton, while the other travels with the team recording the team's movements in relation to the micro-climate they are in. Team member safety has been enhanced through the use of StrikeAlert II lightning detectors, which monitor electromagnetic field densities and can detect approaching lightning strikes up to 40 miles away. In addition to a hand-held Kestral wind meter, a vehicle-mounted Vortex anemometer has also been deployed this year.

Real-time Doppler radar has been incorporated into the storm team's expanded list of tools this year as well. Using the Doppler radar coupled with the on-board Holux GPS navigation system, the team can pinpoint their exact location in relation to storm systems, providing them the best possible opportunity to position themselves in relation to storm system movements to obtain the best possible data. Unlike other storm "chase" teams, this capability allows the Dayton Intercept Team to concentrate less on chasing storms, and more on positioning themselves to intercept storms.

Glenda Project – Intercept Teams - Applications

Between the months of April and August of 2012, the Dayton storm team intercepted five major storm fronts that traveled through southeastern Washington State.   One storm on July 8th, 2012 created a micro-burst over the north residential area of the town of Dayton, which was recorded on the team's on-board data loggers. Responding to the affected area, the team was able to assist with and coordinate emergency services response. They coordinated storm debris removal to assist with the response of fire, ambulance and law enforcement units, the evacuation of an elderly person trapped in their residence by storm debris, and assisted with crowd control until power was restored by the power company hours later. All information and storm observations were relayed by the Dayton storm team in real time to the Pendleton National Weather Service and to the local Emergency Management office which resulted in local and regional severe weather alerts being issued.

Glenda Project – Intercept Teams - Applications



The Columbia County / Dayton, WA Intercept Team achieved a successful intercept of a microburst thunderstorm and recorded a 16 mb pressure drop during the event.

Glenda Project – Intercept Teams - Applications

As a result of the team's response to the July 8th, storm emergency, subsequent meetings were held with local emergency services. The Dayton storm team has been requested to assist regional emergency services in future storm events. The team has now been equipped with a BK digital radio system that operates over narrow band microwave in the 155 mhz range. This system allows them direct radio communications to regional law, fire, ambulance and emergency management field units as well as the regional 9-1-1 public safety communications center. The team's integrated real time Doppler and GPS capabilities have allowed them the opportunity to coordinate with local and regional fire departments during lightning storms to aid in the staging of fire assets to suppress lightning strike fires.

Additionally, the team has also been asked to provide storm preparedness presentations to the public through local 9-1-1 Public Education Programs and through venues such as National Night Out. The team was also the recipient of an equipment grant from the United States National Forest Service in the form of a complete Olympus OM-2S 35mm camera set complete with multiple lenses to be used for the purpose of documenting storm structures and lightning.

Glenda Project – Intercept Teams – Payload Tracking

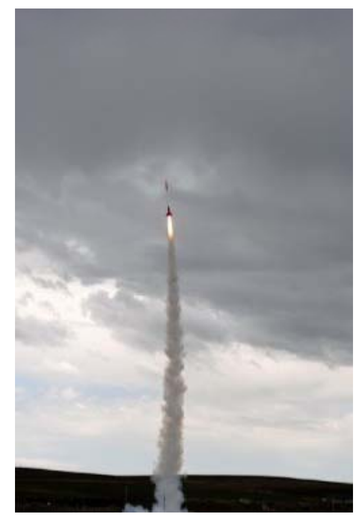
GPS – Payload Tracking System Operational

When capsules are launched into severe weather systems, one of the primary challenges, is their return.

Glenda now has the capability to track capsule positions using GPS in real time combined with real time display of the “intercept” vehicles position using “non-internet / non-cellular” driven GPS positioning.

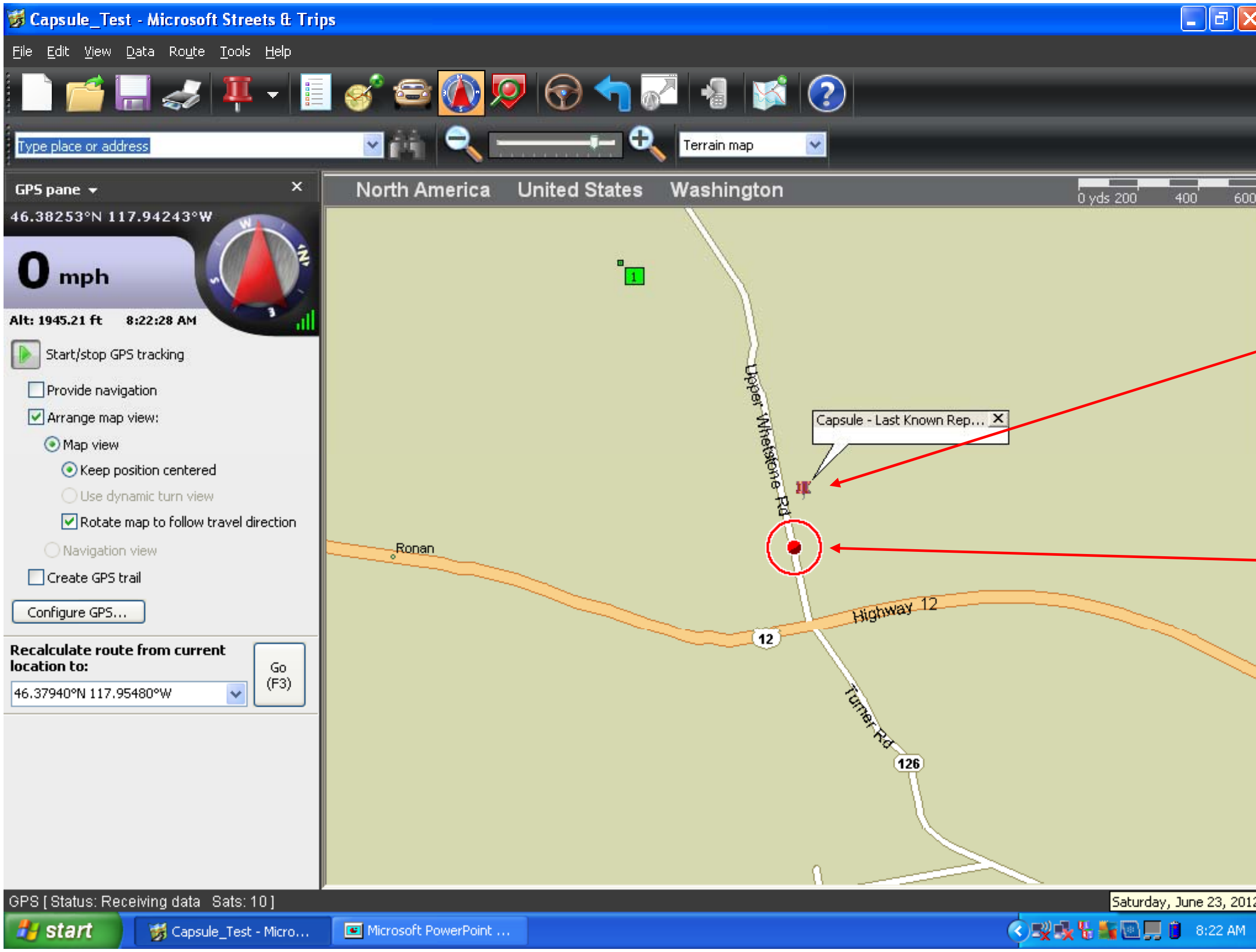
The capsule transmits its GPS position to the intercept vehicle, while that vehicle integrates its own position in relation to the moving capsule in real time.

This capability allows real time deployment capture and rapid return to flight for multiple intercepts with the same storm system.



Glenda Project – Intercept Teams - Applications

GPS – Payload Tracking System Operational
Dayton, WA – June 23rd, 2012



Capsule Position

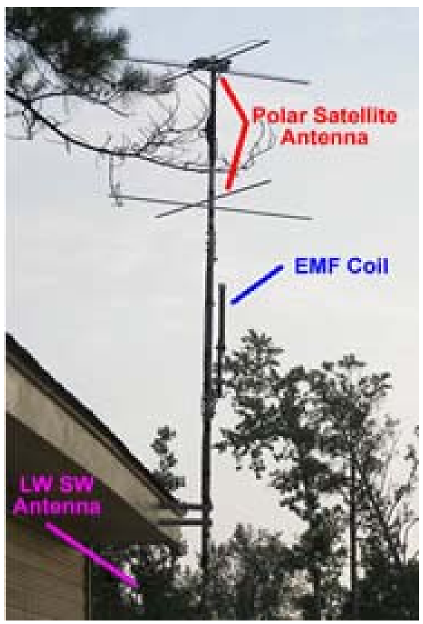
Intercept Vehicle Position

GPS positioning data from both the payload capsule and the intercept vehicle can now be displayed on a common screen in real time allowing for rapid intercepts and near real time return to flight.

Glenda Project – Remote Sensing
Bayou Canada Research Facility

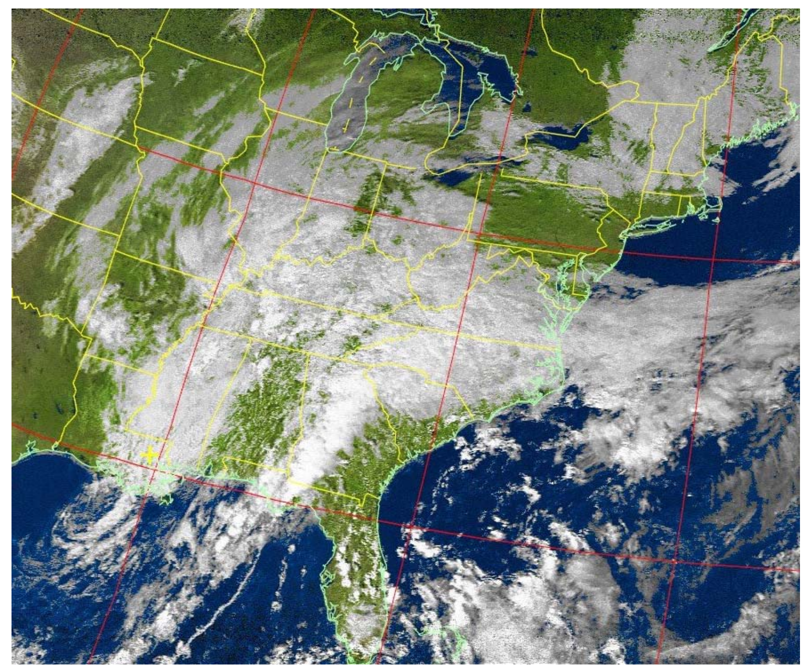
The Bayou Canada Weather Research Facility is located in Ponchatoula, Louisiana, roughly 60 miles north of the Gulf of Mexico.

Bayou Canada feeds out weather data in regular intervals as quickly as every two seconds depending on the need for data and weather conditions. We post real time data including radiation and EMF on our website, as well using both web and over the air radio transmissions. We feed directly to: NOAA and the National Weather Service, APRS via ham radio station KE5JJC both over the web and over 2 meter ham frequencies, Citizens Weather Observation Program, Hamweather, PRSWeather, WeatherBUG, and Weather Underground / The Weather Channel.



Glenda Project – Remote Sensing
Bayou Canada Research Facility

Weather information is fed automatically into various computer processing centers as well as the National Weather Services. Because our information is sent at much shorter intervals than most typical airport weather stations, the analysis of our data is quicker and affects the decisions and warning announcements issued by the National Weather Service. Because we can provide both mobile and base visuals, additional information can be sent to the National Weather Service via cell phone or ham radio transmissions. The NWS monitors particular ham radio frequencies for reports in major weather situations. The National Weather Service will issue watches and warnings both over the air (weather stations and public networks) and over the web based on the information that we and additional stations send them. The NWS is of course the official source for Emergency Management Centers.



Glenda Project – Successful Move to Louisiana

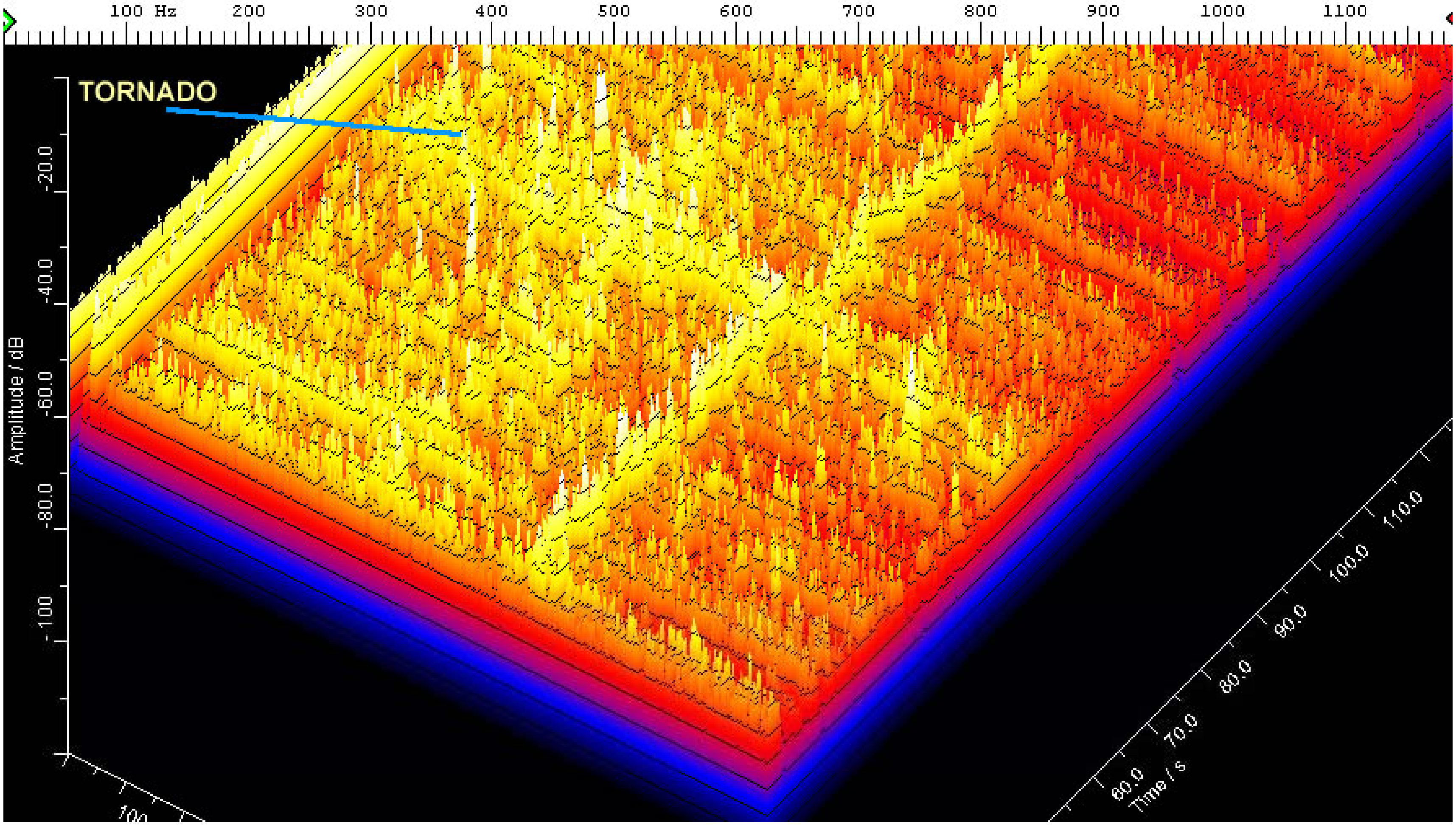
In 2012, the Glenda Project successfully moved from its base in Petal, Mississippi to Pontchatoula, Louisiana.

Service and functionality continue to improve at our new facility while still pursuing field applications and work with both Louisiana and Mississippi first responders and emergency management.

Glenda Project – Remote Sensing – Application

EM Field Mapping

Combining Glenda computing and sensors allows the capability for advanced analysis and detection. Shown below is a 3D Electromagnetic Field (EMF) analysis of a tornado based off of a three second data capture. The circular effects of the funnel are easily visible and provide a snap shot of the electrical activity around a tornado.

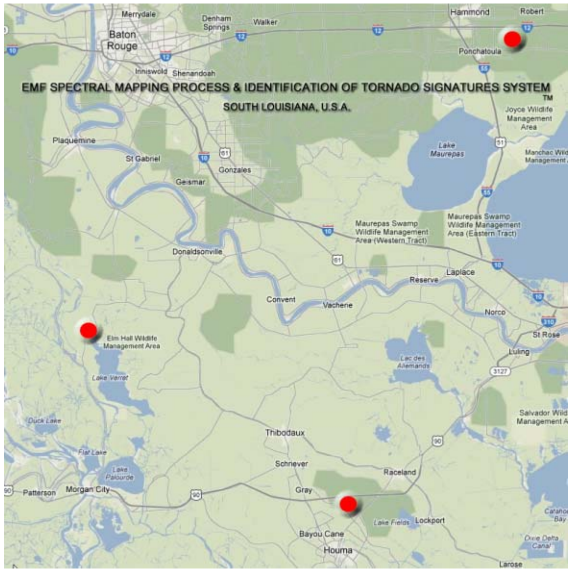


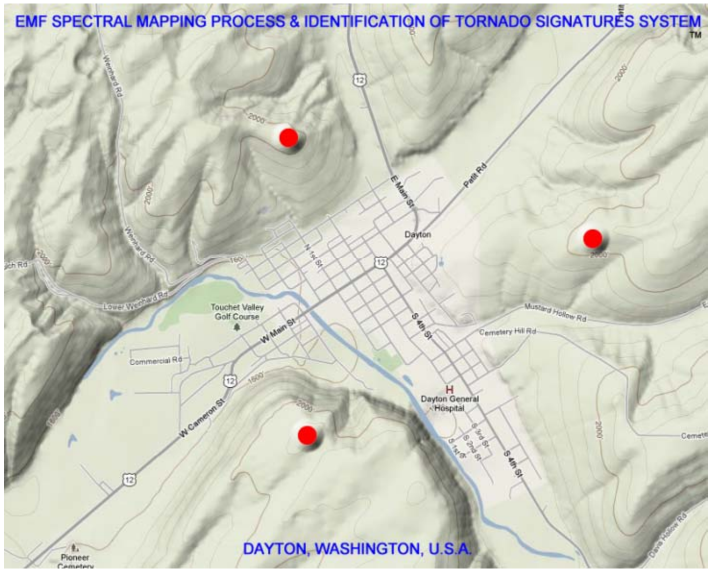
Glenda Project – Remote Sensing – Application

Electro Magnetic Field Mapping and Identification of Tornadic Signatures

Pullman Geosciences Research Foundation has developed an Electro Magnetic Field Spectral Mapping Process and Identification of Tornado Signatures System. The system uses an integrated network of automatic direction finder (ADF) instrumentation that automatically and continuously displays the bearings of energy disturbances in the atmosphere. Using a standard triangulation methodology and an advanced interlinked computer network for data analysis 3D models of the atmosphere can be built reproducing the real time conditions. The system has the ability to identify and track single item energy disturbances and forecast the path across the terrain. This allows the ability to track for example the signature of a tornado as it crosses land similar to weather radar.

The first complete integrated computer network with sensors is under construction with Beta testing of the system starting in Spring 2013.

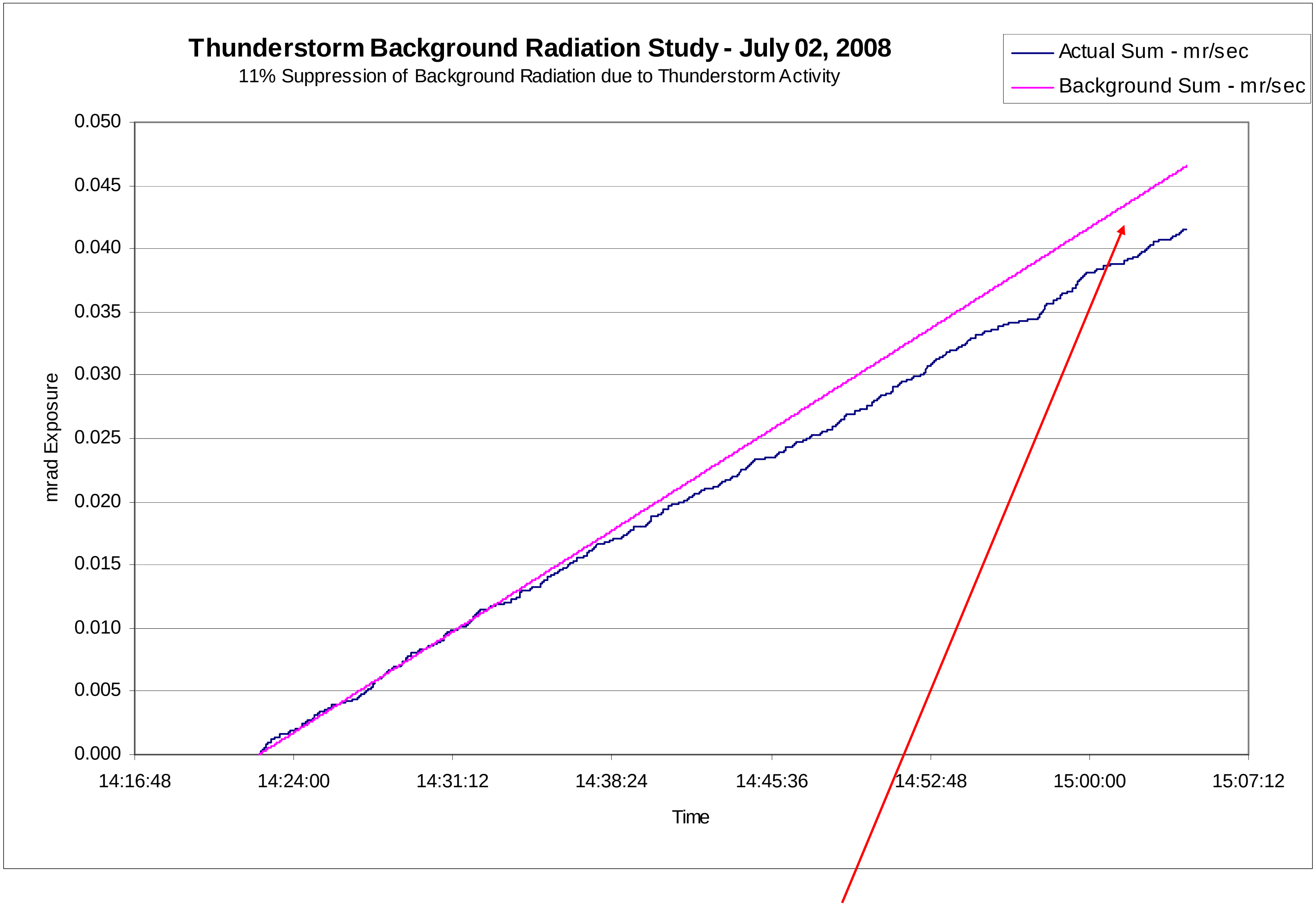




Glenda Project – Remote Sensing – Application

Gamma Radiation Studies

Data collection capability of Gamma Ray Radiation during Thunderstorms



During this extensive Thunderstorm, lightning suppressed the “background” gamma radiation count by 11 percent

In Conclusion

The Glenda Project is a highly mobile data collection system designed to place instrument packages into areas previously considered to be to hazardous or inaccessible using traditional platforms such as balloons, aircraft, helicopters, kites, etc.

The operational Glenda Project shows the differences between Hollywood “fiction”, “Reality Television” publicity stunts, and engineering “fact”, from mapping local environments to a full tornadic funnel with a suite of sensors.

In 2012, we achieved multiple storm intercepts, deployed a wireless long range ground station with Sigma Theta capability and built on sustaining relationships with emergency managers and first responders.

For 2013, we’re developing a balloon deployment capability for applications where booster launches are not feasible and continue to develop the flight envelop of our sensors and ground stations. The Glenda Project is up to the task.