“Low Cost Sensors for Real Time Monitoring of Overhead Transmission Lines”

Presented:

U .S. Department of Energy Visualization and Controls Program Peer Review

SBIR Project No.: DE-FG02-05ER 84176

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Washington, DC.
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Project Objective:

The network energy control center is responsible for providing operators with an accurate view of current system conditions.

The object of this project is to develop and bring to commercial readiness a low cost sensor platform for overhead high voltage power systems that provides data for energy control centers to generate accurate system views.

The base platform on which this sensor has been developed is the Power Donut ™ originally developed by Niagara Mohawk Power Company Research Division circa 1985.

Power Donut2 – Original vs. Re-Designed Comparison

Original Power Donut ™ Features

- One 8 bit microprocessor
- Low power custom crystal radio

- Ground station for radio communications
- Medium accuracy temperature sensor

- Required custom installation each location

Re-Designed Power Donut2 ™ Features

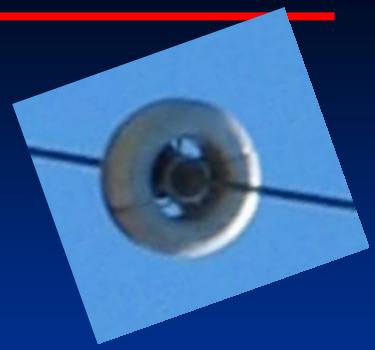
- Two 32 bit microcontroller/processors
- Industry Standard Communications
  - 3G wireless to server/internet
  - 900 MHz and 2.4 GHz spread spectrum radio
  - Bluetooth™ communications
  - Ground station available but not required
- High accuracy expanded range temp sensors

- Standard Design, no customization to install
  - no outages or line disconnects
  - installs in minutes on live wire

New added features

- Inclination monitor for catenary characteristics
- Wave form capture for current and voltage - event recording
- Low cost weather sensor input by Bluetooth ™
- Possibilities for more…..

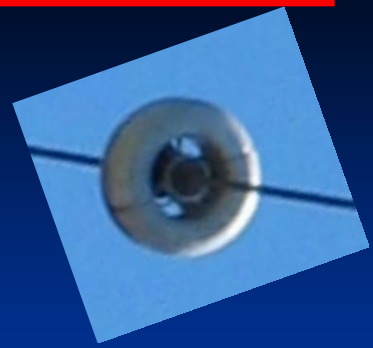
Modern technology, more reliable, added functionality, field proven and more intelligent



Why use the "*original*" Power Donut ™ platform?

An instrumentation product can be evaluated according to four criteria:

1. **<u>Accuracy</u> – the ability to produce suitable results in a "noisy" data environment**
2. **<u>Performance</u> – the ability to deliver these results when needed**
3. **<u>Robustness</u> – the ability to survive in the environment with a minimum of maintenance**
4. **<u>Completeness</u> (degree deployed) - when the benefits exceed the cost wide spread deployment is experienced**

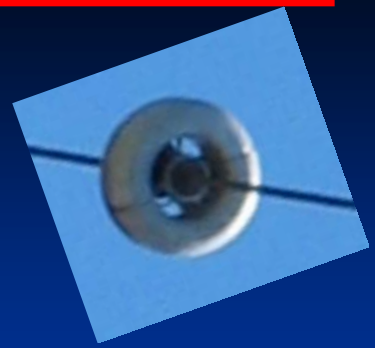


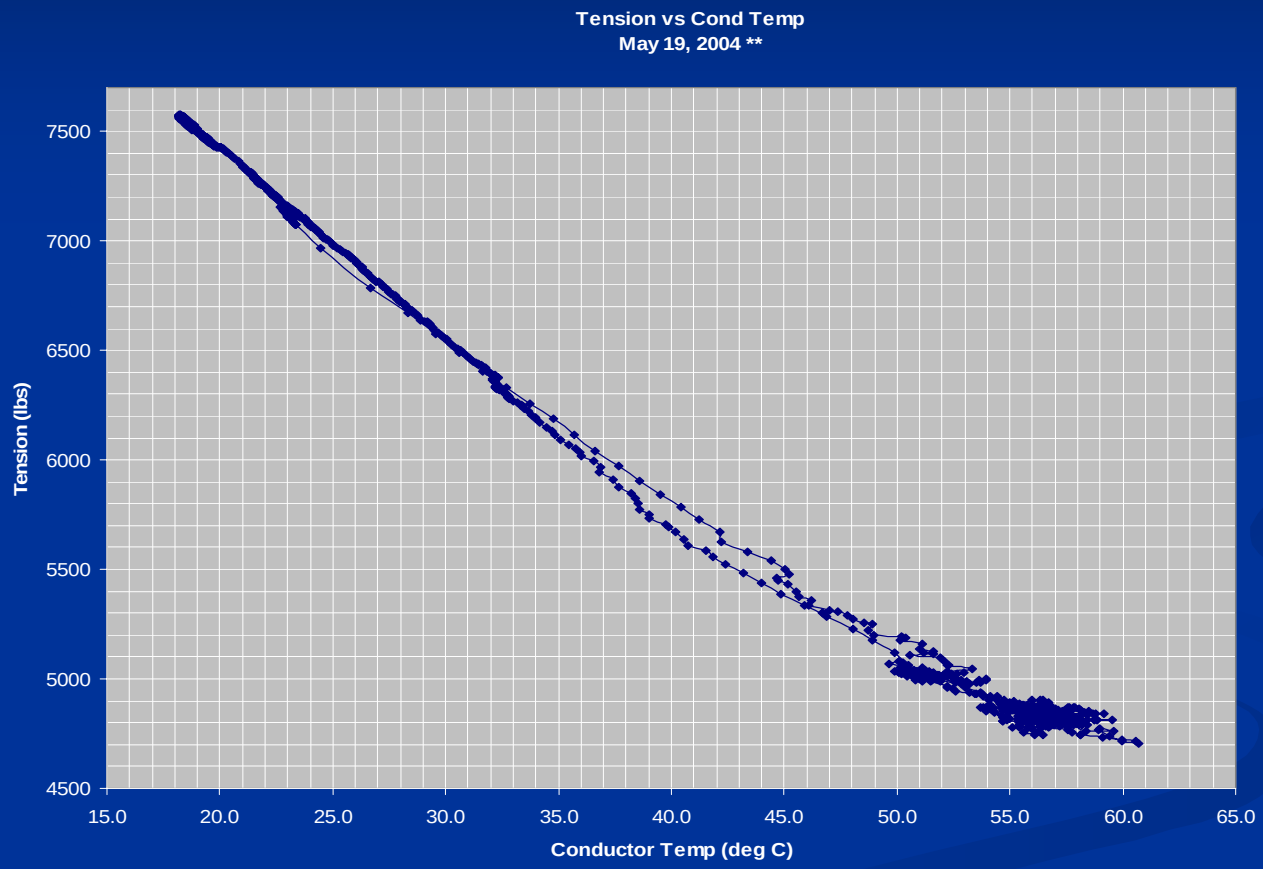
Why use the Power Donut ™ platform?
Accuracy Issues

	1985 Donut	2005 Donut2
Amps measurement	good accuracy	good accuracy *
Voltage	Capacitive	Capacitive *
Temperature	poor accuracy	good accuracy *
Inclination (Sag)	----0----	good accuracy *
Waveform Capture	----0----	Amps & Volts
Solar Radiation	----0----	Bluetooth™ Net
Ambient Temperature	----0----	Bluetooth™ Net
Add on capability	----0----	Considerable
Communications	Modest Availability	> 99.9% (GPRS)

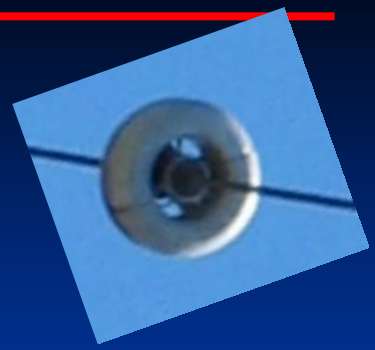
* Digital adaptive filter to extract signal from noise (patent pending)

Why use the Power Donut ™ platform?
Accuracy Issues





Typical Data before digital filter applied
– from literature (ref available) -



Why use the Power Donut ™ platform?
Performance Issues

	1985 Donut	2005 Donut2
Amps measurement	Rogowski Coil	Rogowski Coil
Voltage	Capacitive	Capacitive
Temperature	Thermister	RTD
Inclination (Sag)	----0----	Inclinometer
Waveform Capture	----0----	Amps & Volt
Solar Radiation	----0----	Bluetooth™ Net
Ambient Temperature	----0----	Bluetooth™ Net *
Add on capability	----0----	Considerable **
Communications	Custom Radio	Choices

** Phasor Monitoring Unit feature in development (patent pending)
** Ice detection system in development (patent pending)

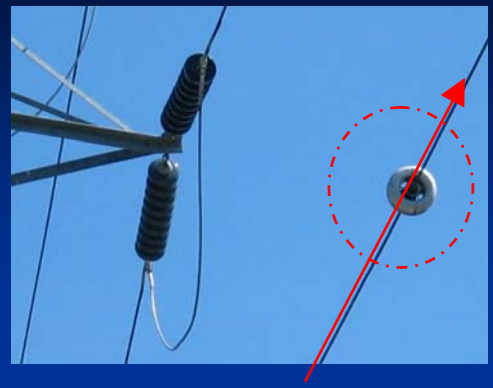
Why use the Power Donut ™ platform?
Robustness Issues

	1985 Donut	2005 Donut2
Platform	Very Reliable	Very Reliable
Communications	Reliable	Very Reliable

Why use the Power Donut ™ platform?
Completeness Issues

1985 Donut – one application (DLR) limited deployment

2005 Donut2 – multiple applications; we expect extensive deployment



The cost to deploy an instrument in a utility environment is composed of:

- → Equipment Cost
- → Installation Cost – materials and labor
- → Operating and Maintenance costs

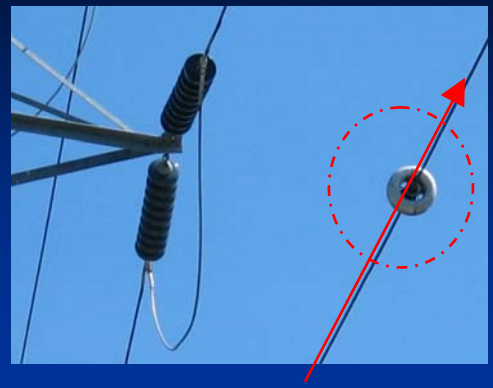
Our objective is to minimize all three, i.e., lifecycle cost.

Explanation:

The original Power Donut ™ has had a 20 year track record of minimal or no maintenance being required for more than 1000 deployed units.

The platform was therefore a good choice.

The cost to deploy an instrument in a utility environment is composed of:



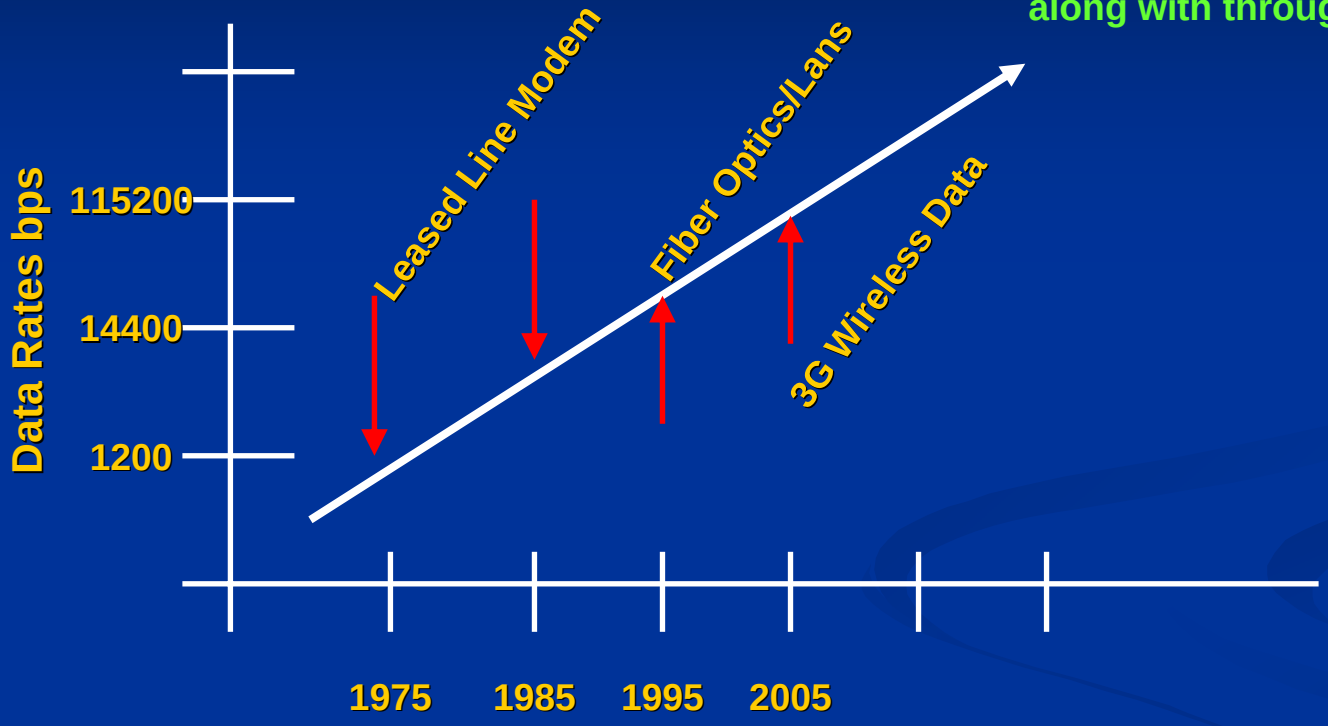
- → Equipment Cost
- → Installation Cost – materials and labor
- → Operating and Maintenance costs

Our objective is to minimize all three, i.e, lifecycle cost.

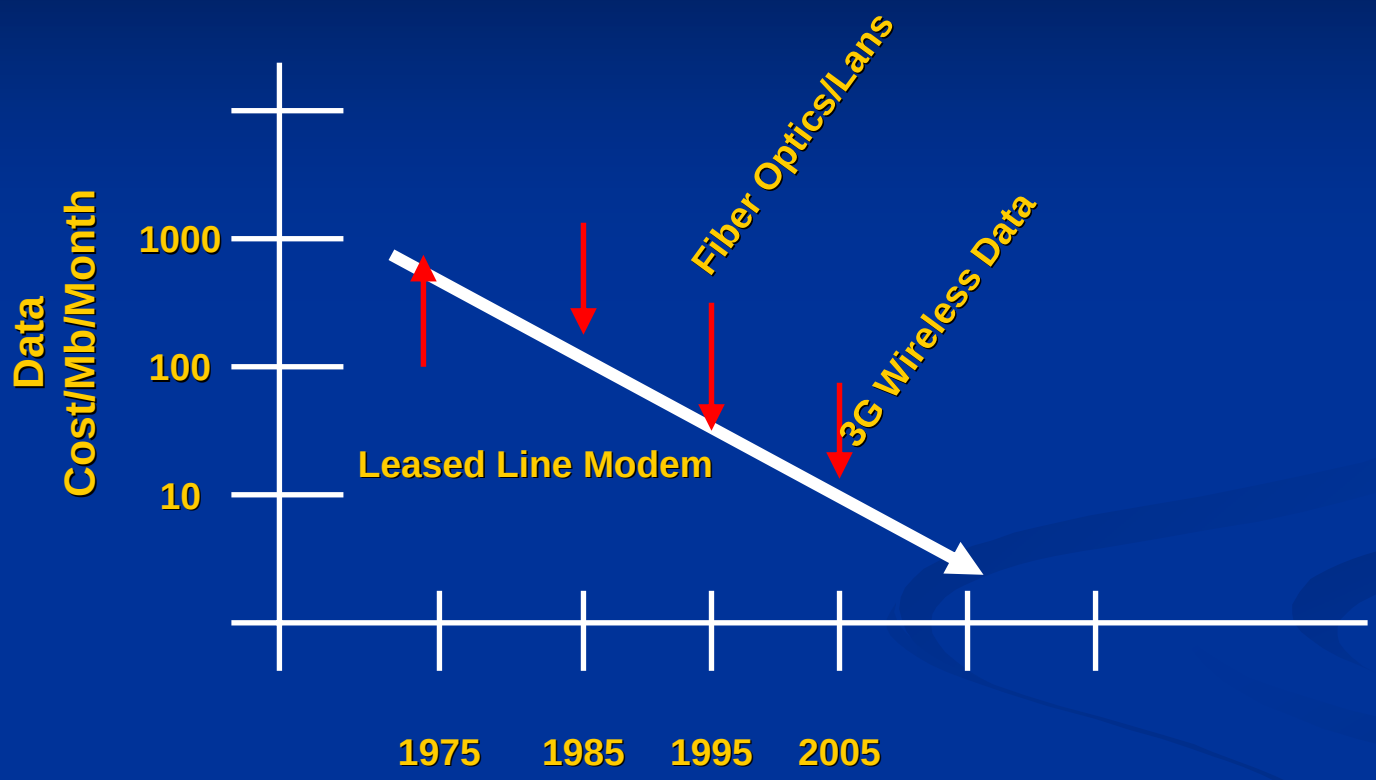
Explanation:

- ***Installation cost** is minimal – no outage is required*
- *Installation security (vandalism) is assured –it is high above ground level*
- ***Equipment Cost** is relative –lifecycle cost is easier to quantify*

System Reliability and availability is improving along with throughput



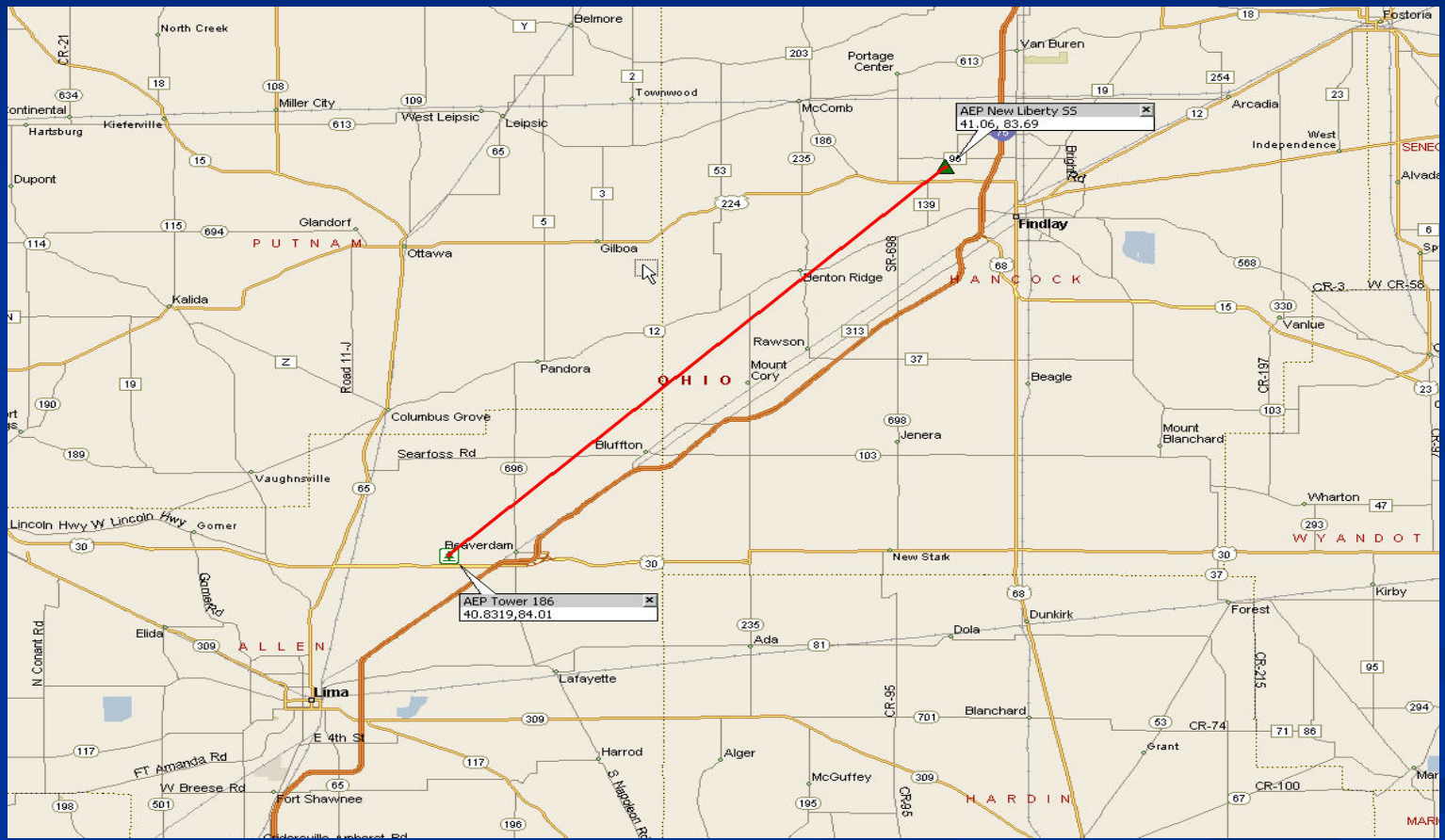
Utility Data Communications Technology has evolved over the past 30 years



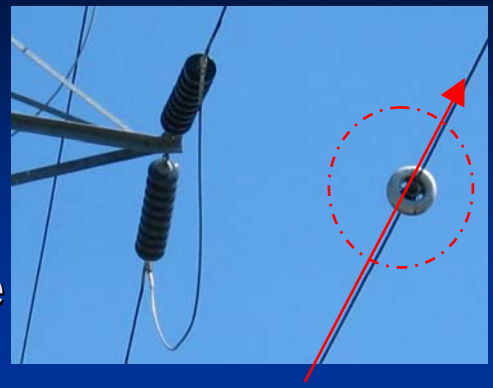
Cost of Utility Data Communications has decreased over the past 30 years

A Project Field Location is ongoing near Findlay, Ohio

Sponsored by American Electric Power

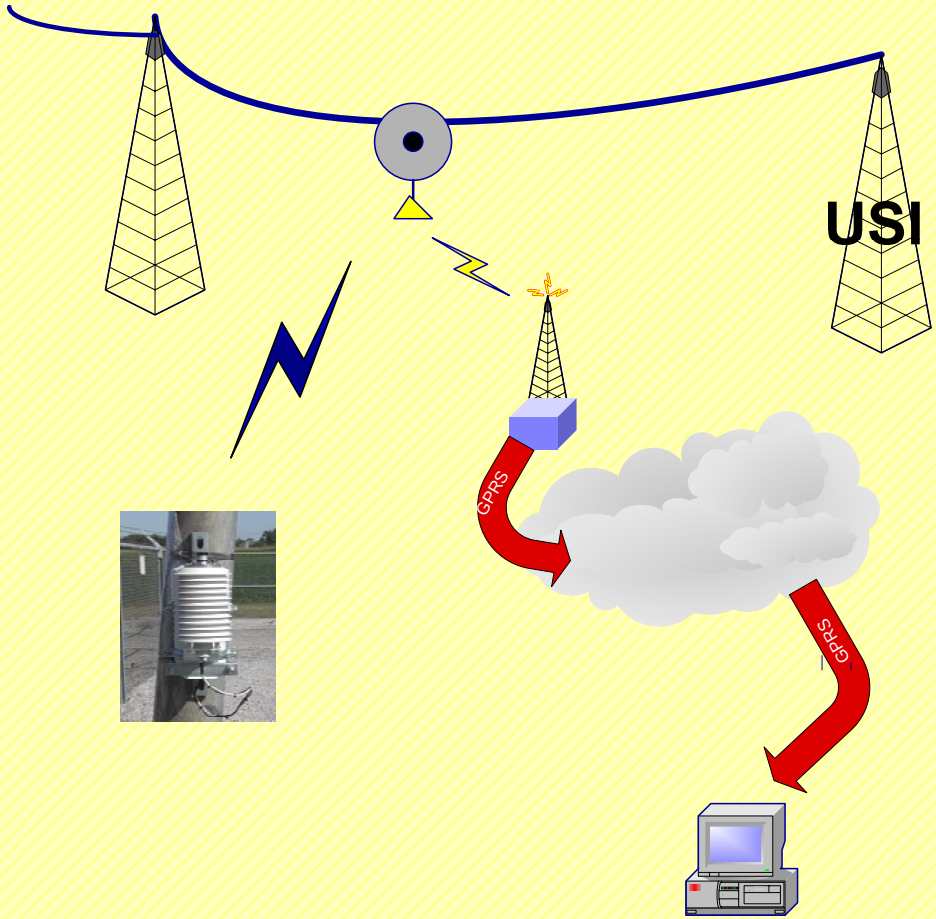


AEP Field Installation Experience:

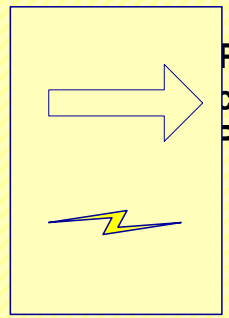


1. The Power Donut2s were powered from the energized electric conductors - requiring no external wired connections.
2. Installation effort proved to be minimal (video available).
3. GPRS Wireless data communications activated immediately on installation. No further integration work was required.
4. A new weather station product took less than 20 minutes to install.
5. Data is integrated with the Donut via a Bluetooth™ wireless connection.

USI Power Donut2 High Voltag
Monitoring Syster



Power Donut2



PRS
cations
P, MO

Transmission Tower

GSM Cell

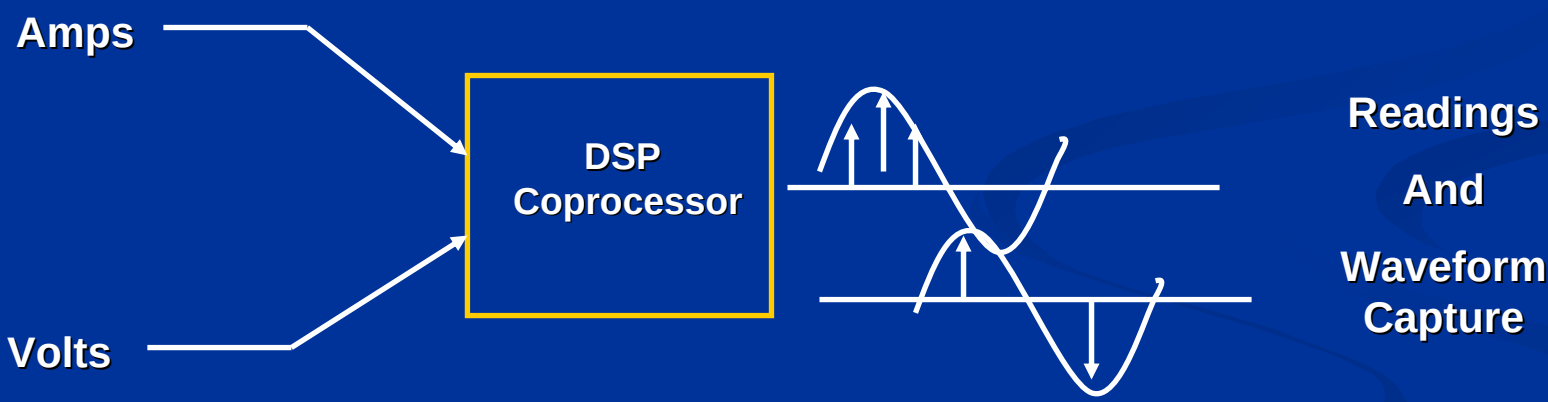
What is a Low Cost Sensor?

The cost function is dependant on how the data is used.

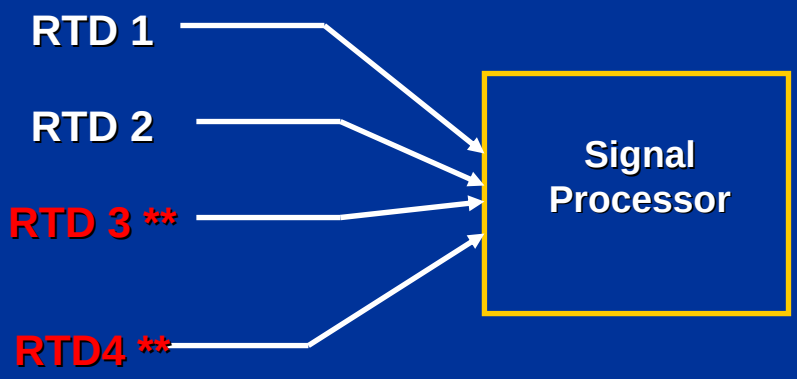
- **What may be high cost for one application may be low cost for another**

- **USi's strategy for the Power Donut2 is to provide many functions and therefore spread the cost per function across several applications**

Discussion of New Functions of the New Power Donut2 Product



Discussion of New Functions of the New Power Donut2 Product

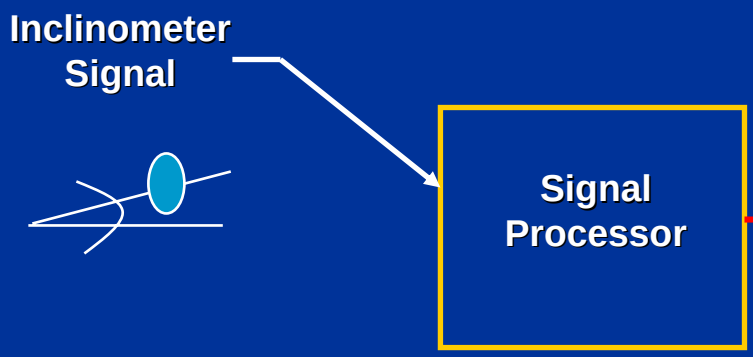


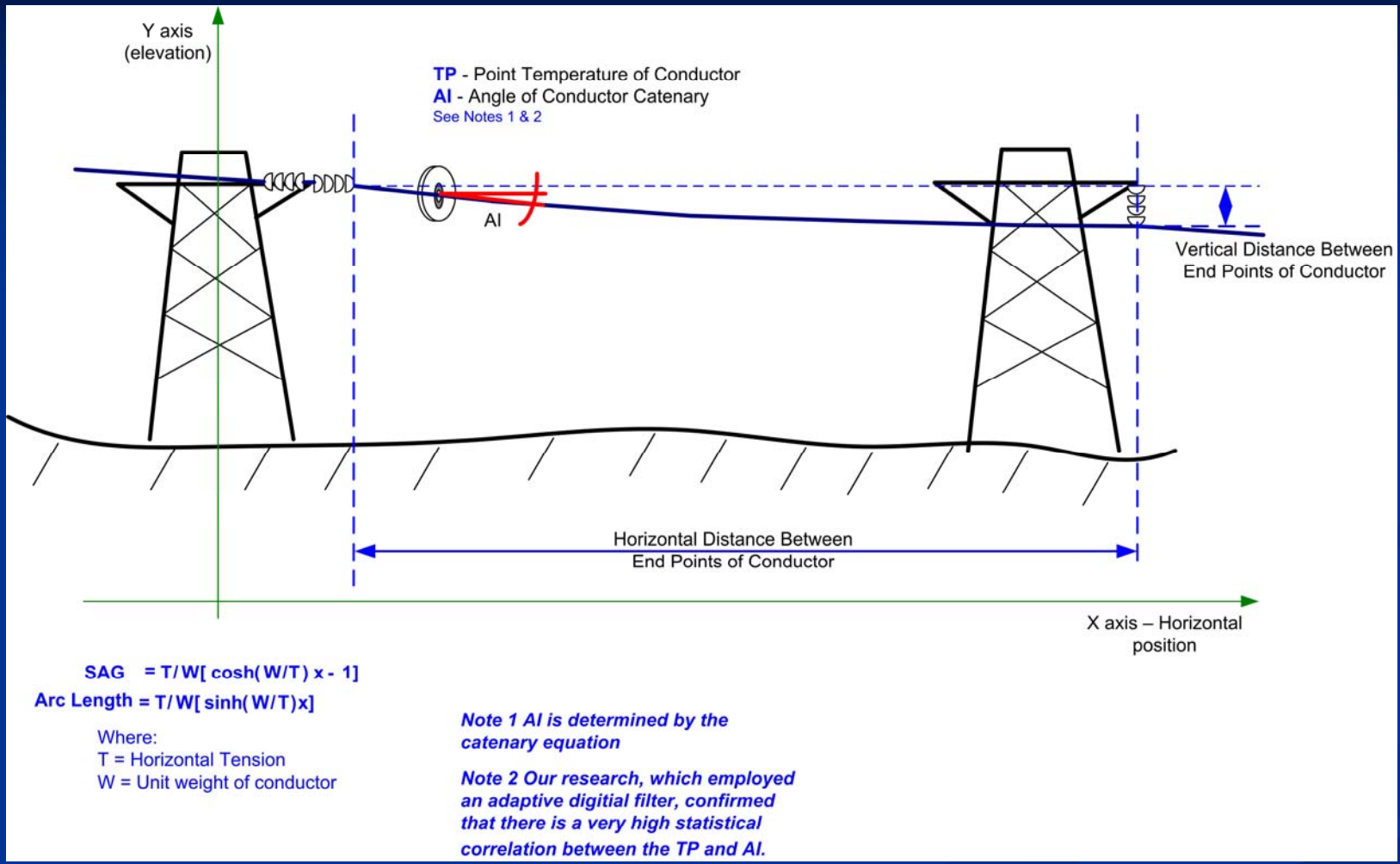
Temperature

-50 to +250 C

** Existing on board Expansion – external RTD for Splice Monitor

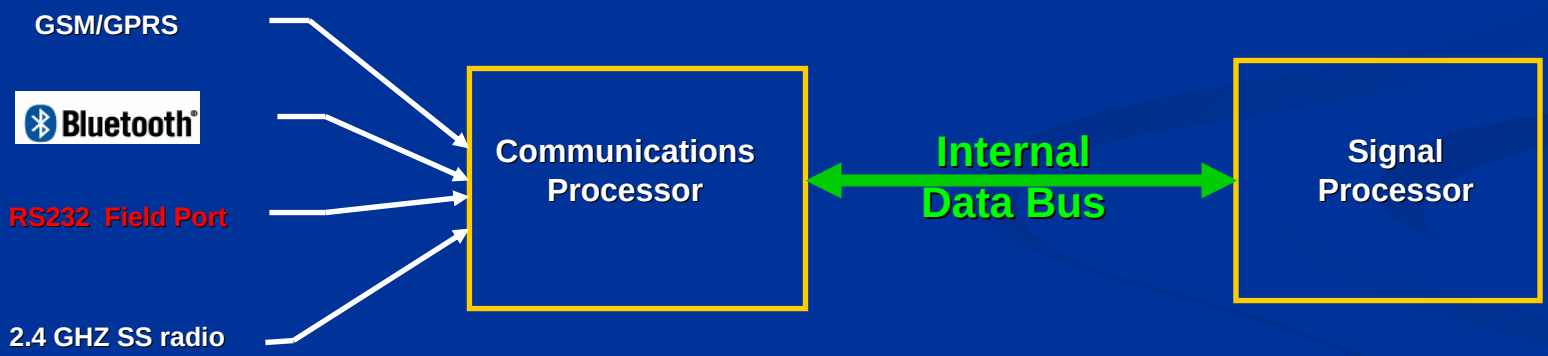
Discussion of New Functions of the New Power Donut2 Product





Catenary System Characteristics

Discussion of New Functions of the New Power Donut2 Product



Discussion of New Functions of the New Power Donut2 Product

This device is therefore an instrument platform, not simply a measuring instrument.

Current field trial applications include:

- **Dynamic Ratings**
- **Sag- Clearance - Temperature monitoring (See slide showing graphic of catenary system)**
- **Waveform/ Event Capture for system security monitoring**

Discussion of New Functions of the New Power Donut2 Product

New applications to be developed include:

- Integration of GPS time stamps
- Phasor Monitoring Unit using the donut waveform capture capability
- Splice temperature monitor
- Ice Build Up detection
- Forecast ratings

Continue drive to achieve ultimate accuracy for all measurements.

How Does USi accomplish these results? – A Proven Project Management Track Record

USi has been providing products and services to the electric power delivery marketplace for over 30 years.

Our staff consists mainly of technical professionals, many recognized as industry experts in the areas of electric power transmission.

How Does USi accomplish these results? – A Strong Project Management Track Record

USi leverages this unique technical capability with a number of manufacturing and technical specialist subcontractors allowing USi to:

- **Provide A/E Services for underground transmission systems**
- **Provide UG Cable and OH conductor ratings analysis software (such as USAMP)**
- **Provide System Integration - Dynamic Real Time Rating systems for OH and UG T&D systems including HMI/ Communications/ Sensors/ Algorithms/ Operating Systems**
- **Design/Build/Maintain UG transmission cable Pressurization and Cooling Plants with integrated control systems**
- **Design/Manufacture specialty accessories for high voltage cable industry including splices and terminations**
- **Research and Develop new Power Donut2 product**

How can we make the Power Donut2 Instrument a Low Cost product?

USi, with the assistance of a contract manufacturer, is completely redesigning the manufacturing process for the Power Donut2.

The new process will be suitable for high volume production and will result in lower costs of production.

Time for Questions……..

Thank You

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