

# Innovative Digital Instrumentation For Geotechnical Monitoring

*Andrew Hyett  
YieldPoint Inc.*

**ME/MO CONFERENCE  
“INNOVATIONS IN MINING”**

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[www.yieldpoint.com](http://www.yieldpoint.com)

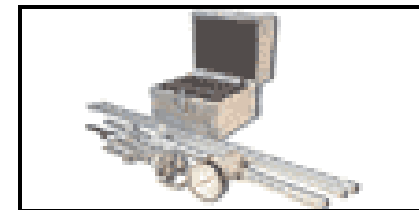
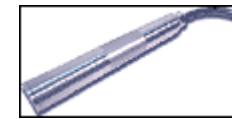
# Conventional Geotechnical Instrumentation



*Load cells*



*Strain Gauges*



*Piezometers*



*Data-loggers*

- Expensive
- Conservative design.
- Retrievable deployment strategies
- Designed for permanent civil structures

# Analog Sensors : Limitations

- High Cost – especially for those products widely used in civil engineering
- Reliability??
  - (i) mV output susceptible to water ingress
  - (ii) potentiometers poor survivability after blasting
- Suspect Sensor Performance in dynamic mining scenarios
  - (i) vulnerable lead-wires. 1 channel /wire
  - (ii) Money spent protecting leadwires
- Esoteric analog data (V, mV, mA, Hz) needs to be converted into real world units

Today, 99% of geotechnical sensors are analog

# The Digital Opportunity

Beyond Geotechnical field over last decade, design of instrumentation affected by two factors:

1. The ongoing revolution in computation and telecommunications
2. Explosion of sensor utilization in the automotive industry

A decade ago state-of-the-art sensing technology was largely confined to government, military and university laboratories. *Today, low mass produced commercial components are the state-of-the-art.*

***More cost effective geotechnical sensors can be built using digital as opposed to analog technology***

# Point 1. Ongoing revolution in computation

## IBM - XT



Speed: 4.77 MHz  
RAM: 64k  
ROM: 64k  
I/O: RS232 +  
Cost: UKP1000-1500

## Micro-Controller (MCU)

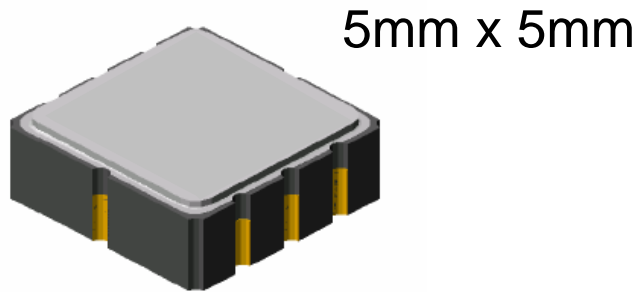
*"Micro-computer on a chip"*



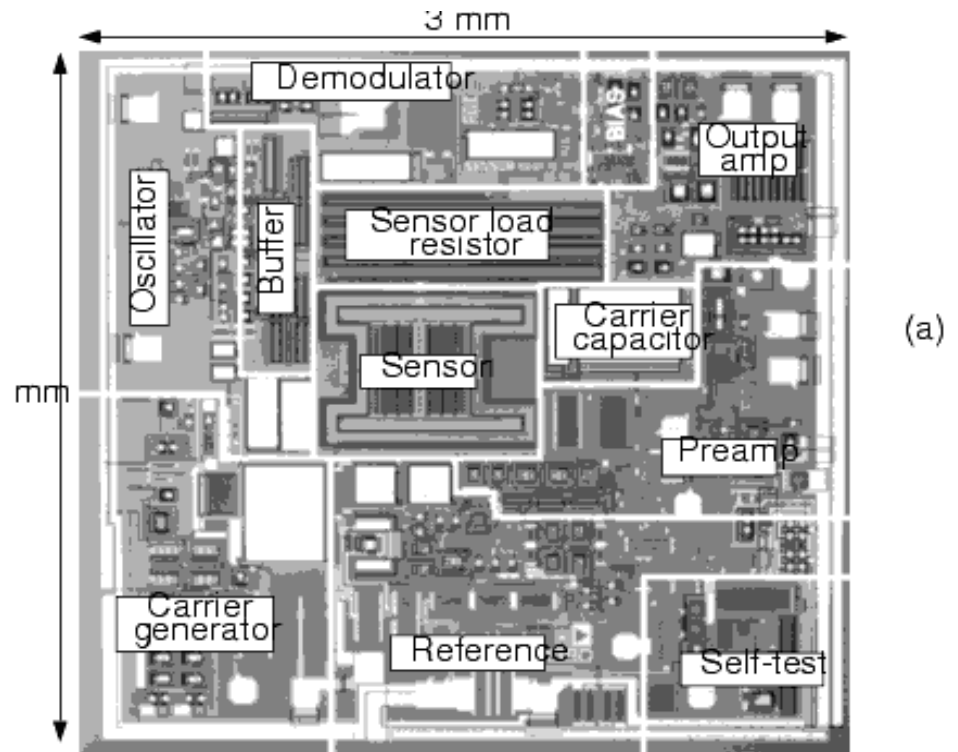
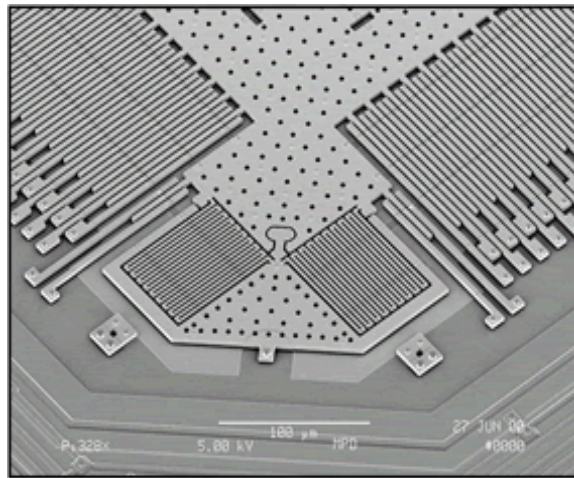
Speed: 20 MHz  
RAM: 1K  
ROM: 8K FLASH  
I/O: UART (RS-232)  
Cost: \$2-5

*"Embedded Systems"*

# POINT 2: Transducers in Automobiles

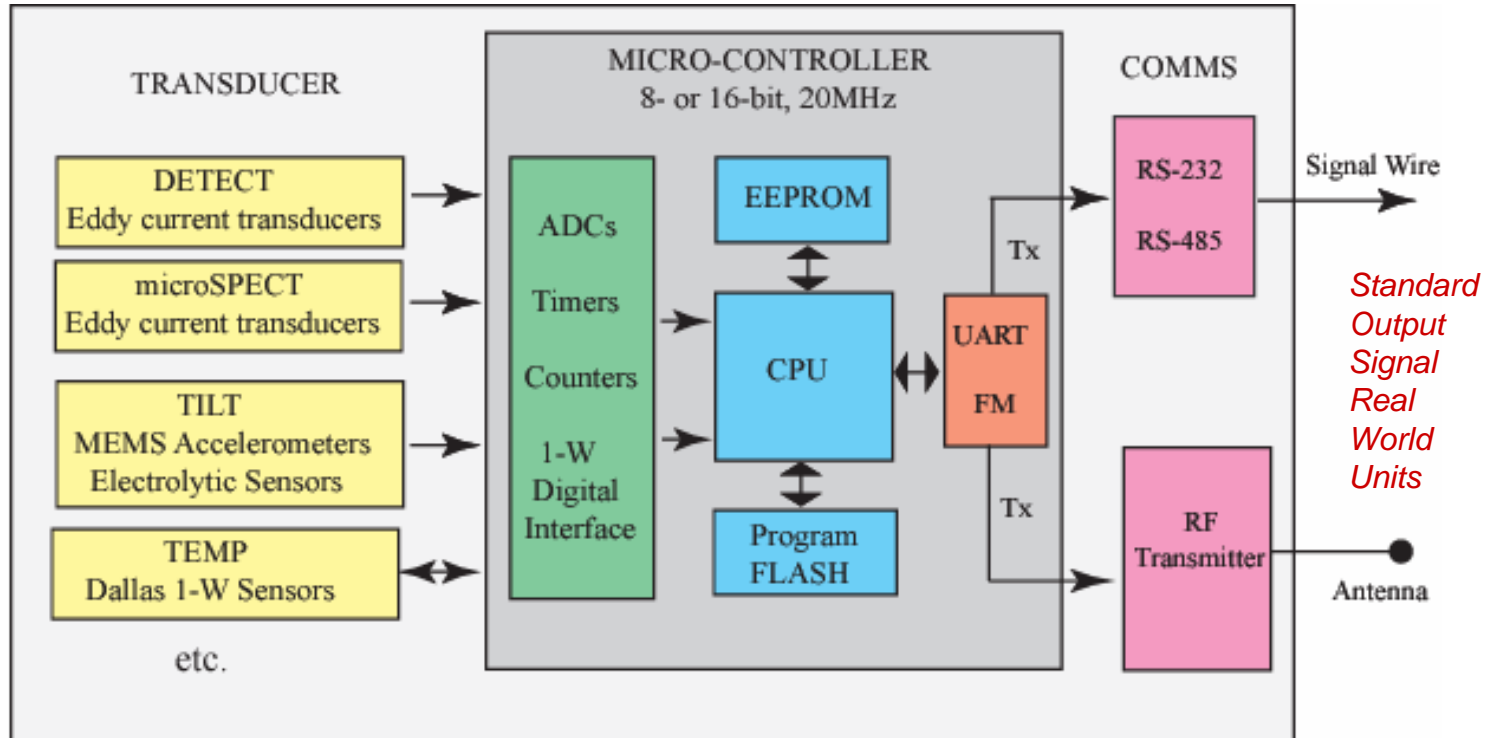
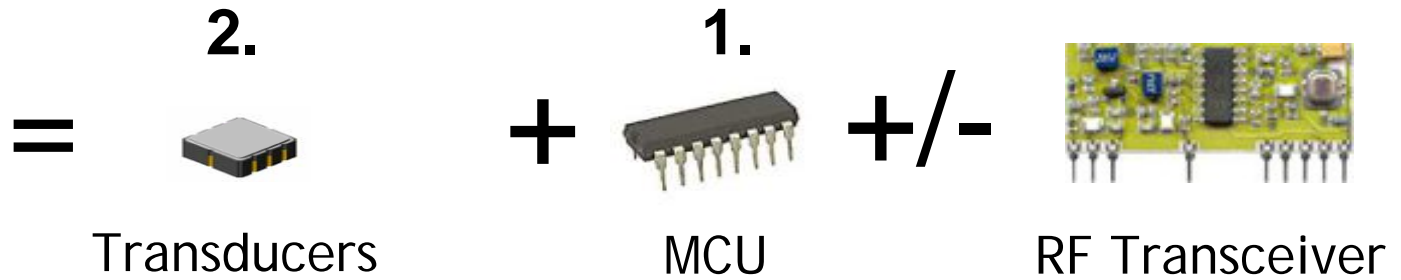


\$10-25 (in Qty)



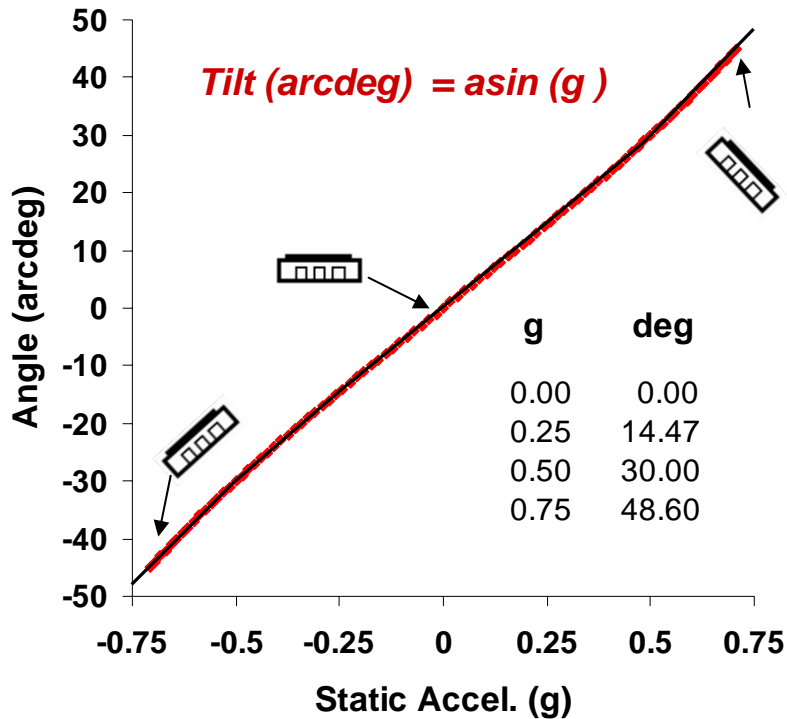
MEMS +/- 1.3g Accelerometer

# Digital Sensors Architecture



# MCU Tasks: Conversion + Filtering

## 1. Units conversion:



## 2. Digital Signal Processing (DSP):

*Take 10,000 readings over 2s period and average*

- Reduce noise floor*
- Increase effective resolution*

## 3. Output Signal

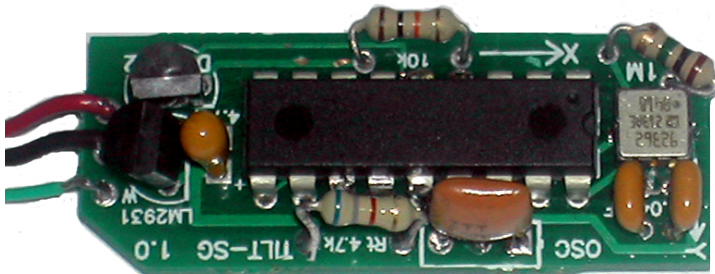
*Transmit Standard Digital Output Signal*



# TILT (Tilt, Inclination, and Leveling Technology)

Static Application:

Dual Axis TILT-SG sensor



- Sill Mat monitoring
- Crown pillars
- Brow monitoring
- Roof monitoring

*Range +/- 30 arcdeg. Res. 0.01arcdeg*

Dynamic Application:

Biggest Opportunity: Seismic monitoring over mine communications system. Low cost Digital wireless micro-seismic Systems (5kHz bandwidth)

# DETECT - Digital Extensometer Technology using Eddy Current Transducers

*Measurement of movement around underground excavations is the most fundamental indicator of instability.*



**DETECT-GMM**

*<40% price of Pot. GMM*



**DETECT-6EX**

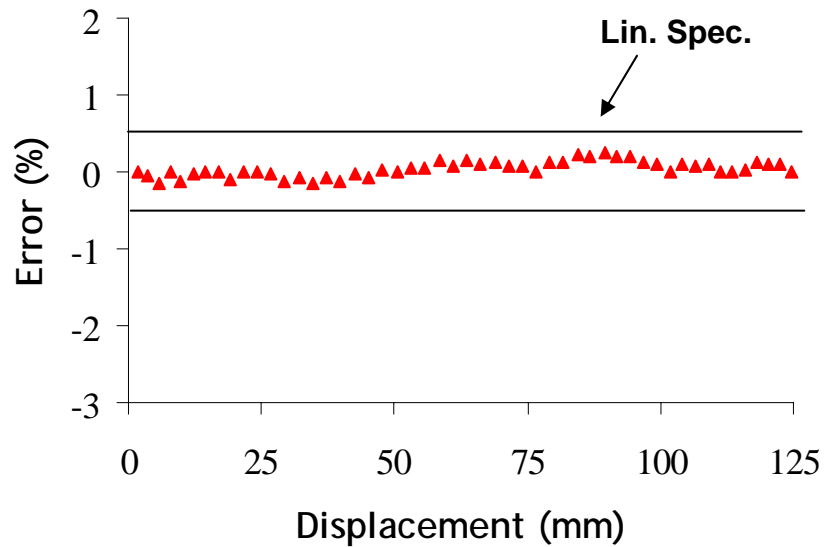
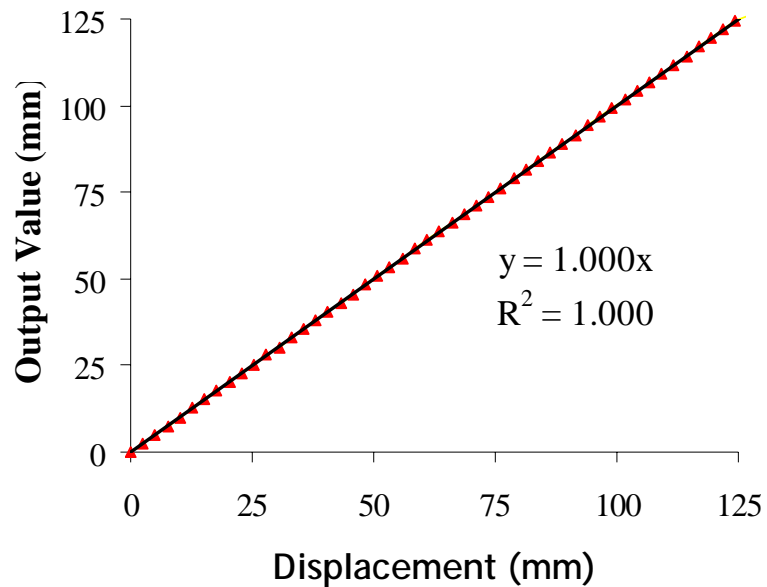
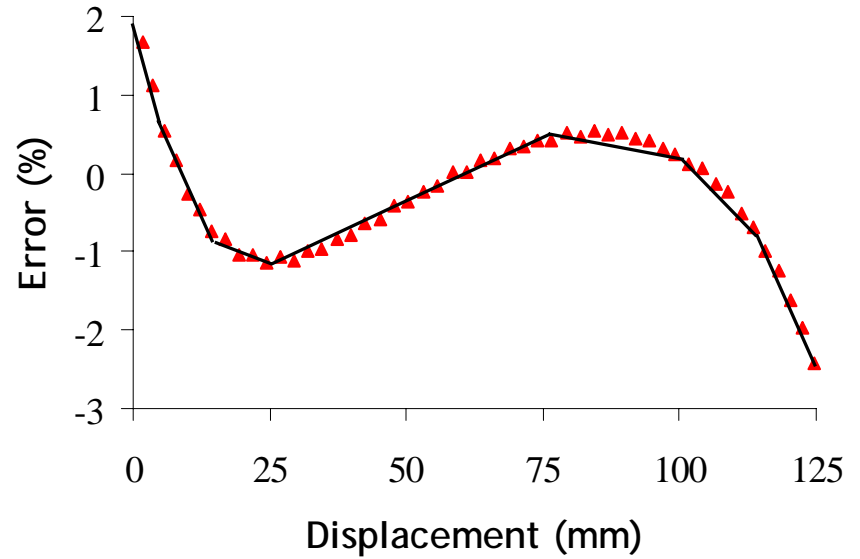
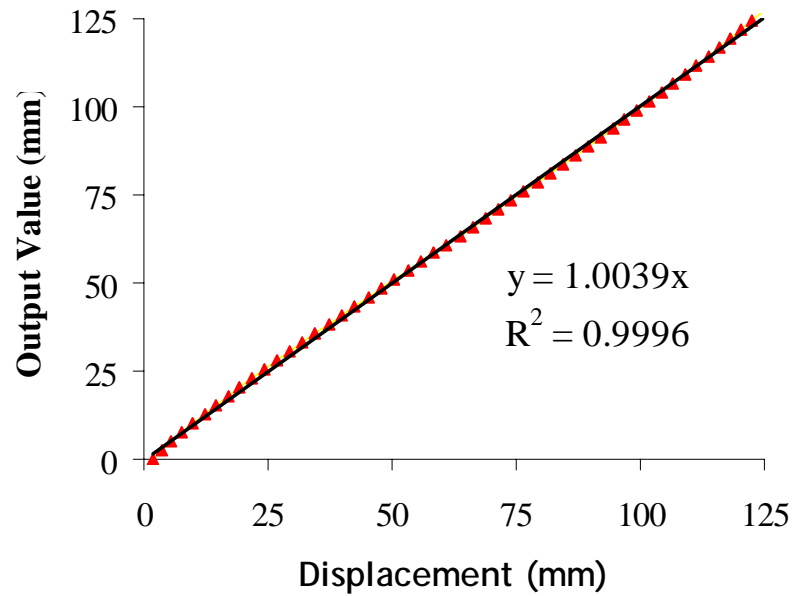
*<50% price of SMART MPBX*



**DETECT-CABLE**

*Patents Pending*

# MCU Task: 3. Linearity Correction

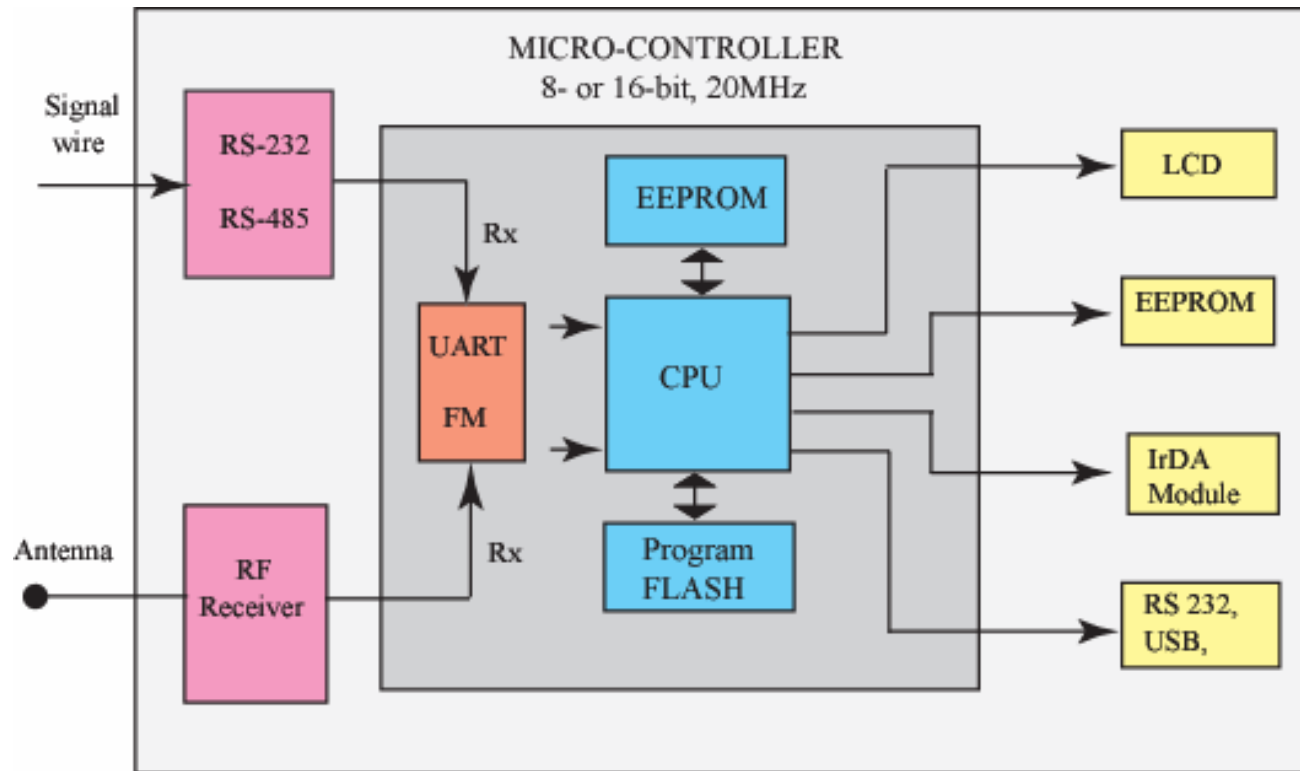


# 7 Reasons Why Digital Sensors are Better

1. Improved Accuracy (i.e. Linearity)
2. Improved Reliability (e.g. non-contact)
3. Output in Real World Units. All digital sensors have standard readout signal.
4. Output signal includes SensorID+ SensorType
5. Many channels on a single wire.
6. Simplified Low-cost Peripherals (e.g.Dataloggers)
7. Simplified Data Transmission(ESG Seismic System, MRS leaky feeder, EI-Equip leaky feeder)
8. Simpler Data Management

# Peripheral Devices

*Peripheral devices communicate with digital sensors and display, store or transmit data*



## PRODUCTS



MIU



SLUG



SensorSync



PC,  
SCADA  
PLC

# SLUG – Sensor Logger for UnderGround

## Key Points:

### Simple:

Parse data to memory

### No Configuration:

*Recognizes sensor type*

*Plug 'n Play*

### Low power consumption:

*100 days at 1rdg/hr*

*½ year at 1 rdg/day*

### Low Cost:

*20% (i.e. 80% less) cost analog data-loggers*

SLUG



SLUG 4



# DESTINY

Digitally Enabled Sensor Transducer +  
Instrumentation Network by Yieldpoint

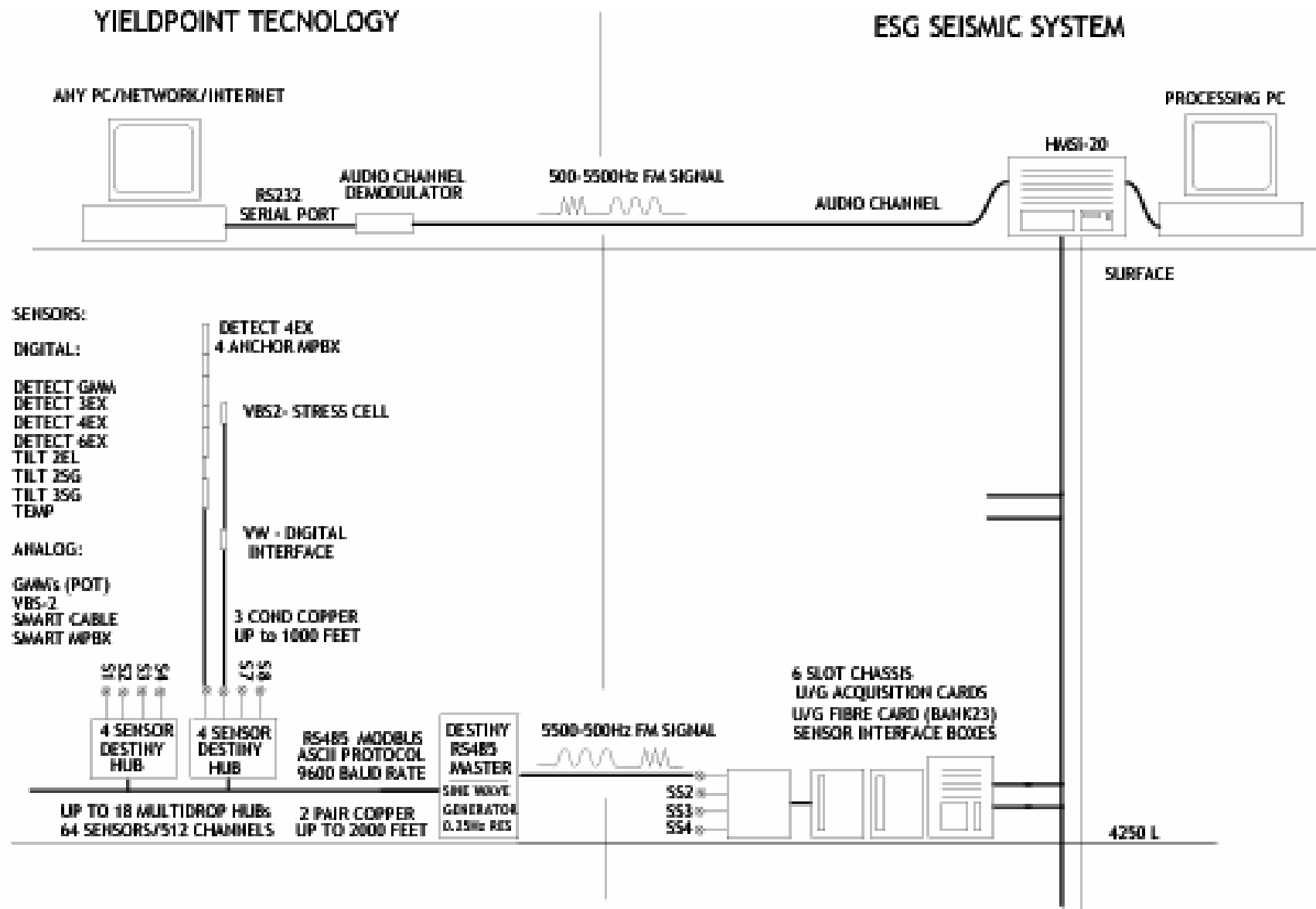
Network sensors + Interface with existing mine communications Infrastructure

## DESTINY RF SLAVE

- 10 RF channels between 433 and 434MHz
- Open Air Range of 200m
- 9600 baud rate
- Wired version: mulidrop RS485 enabled
- Modbus ASCII Protocol
- Ethernet Option also available

*Cost Effective: compared with \$1000's  
spent protecting lead-wires*





*64 Sensors/512 Channels of Conventional Instrumentation over 1 seismic channel*



# Data Management: MineScape

## ***DATA IS ALREADY IN REAL WORLD UNITS***

- No need for transformations, temperature compensation
- Feed data directly into structured Database
- Monitor Trends in the data and compare with alert thresholds
- When alarms triggered e-mail alerts
- FTP offending data to internet server (HTML + XML)
- Data viewed by technicians, engineers, consultants

# MineScape: DataBase (not Spreadsheet) Oriented

1. Identification 2. Installation 3. Readings 4. Temporal Plot 5. Rate Plot 6. Spatial Plot 7. Destruction 8. Peripherals

**Instrument ID: MINEID-04037110**

**Select Sensor:**

MINEID- 0403 71 10

Family: DETECT

Model: 6EX

Type: 71

◀ ▶ ▶\* ✕ ID

Previous Next Add New Delete Enter ID

**Filter Installed Sensors:**

Do Not Show Destroyed Sensors


Filter By Level: 5544

Filter By Location:

Filter By Install Date: Start Date: End Date:

# of Instruments: 1

▼



Filter database by Date, Level and/or Location

# MineScape: 2. Installation

1. Identification 2. Installation 3. Readings 4. Temporal Plot 5. Rate Plot 6. Spatial Plot 7. Destruction 8. Peripherals

**Instrument ID: MINEID-04037110**

**Installation Location + Date:**

Level:

Location:

Borehole:

Install Date:

Installed By:   Metric Units

**Node/Anchor Configuration:**

# 1:	<input type="text" value="10.0"/> m	# 6:	<input type="text" value="1.0"/> m
# 2:	<input type="text" value="8.0"/> m	# 7:	<input type="text" value="N/A"/>
# 3:	<input type="text" value="6.0"/> m	# 8:	<input type="text" value="N/A"/>
# 4:	<input type="text" value="4.0"/> m	# 9:	<input type="text" value="N/A"/>
# 5:	<input type="text" value="2.0"/> m	# 10:	<input type="text" value="N/A"/>

Head at collar of hole

*IMPORTANT: #1 > #2 > #3... etc.*

**Purpose:**

**Notes:**

Installation Level eg 5436 NUM

# MineScope: 3. Readings

- 1. Identification
- 2. Installation
- 3. Readings
- 4. Temporal Plot
- 5. Rate Plot
- 6. Spatial Plot
- 7. Destruction
- 8. Peripherals

Instrument ID: MINEID-04037110

Reading ID: 0403711001/06/200411:22  
Reading Date: 01-Jun-04  Plot Temporal/Rate  
Reading Time: 11:22  Plot Spatial  
Temperature: 14.3 deg C

10.0 m	21.4	mm	1.0 m	10.7	mm
8.0 m	19.7	mm	N/A m.		
6.0 m	13.0	mm	N/A m.		
4.0 m	11.7	mm	N/A m.		
2.0 m	11.3	mm	N/A m.		

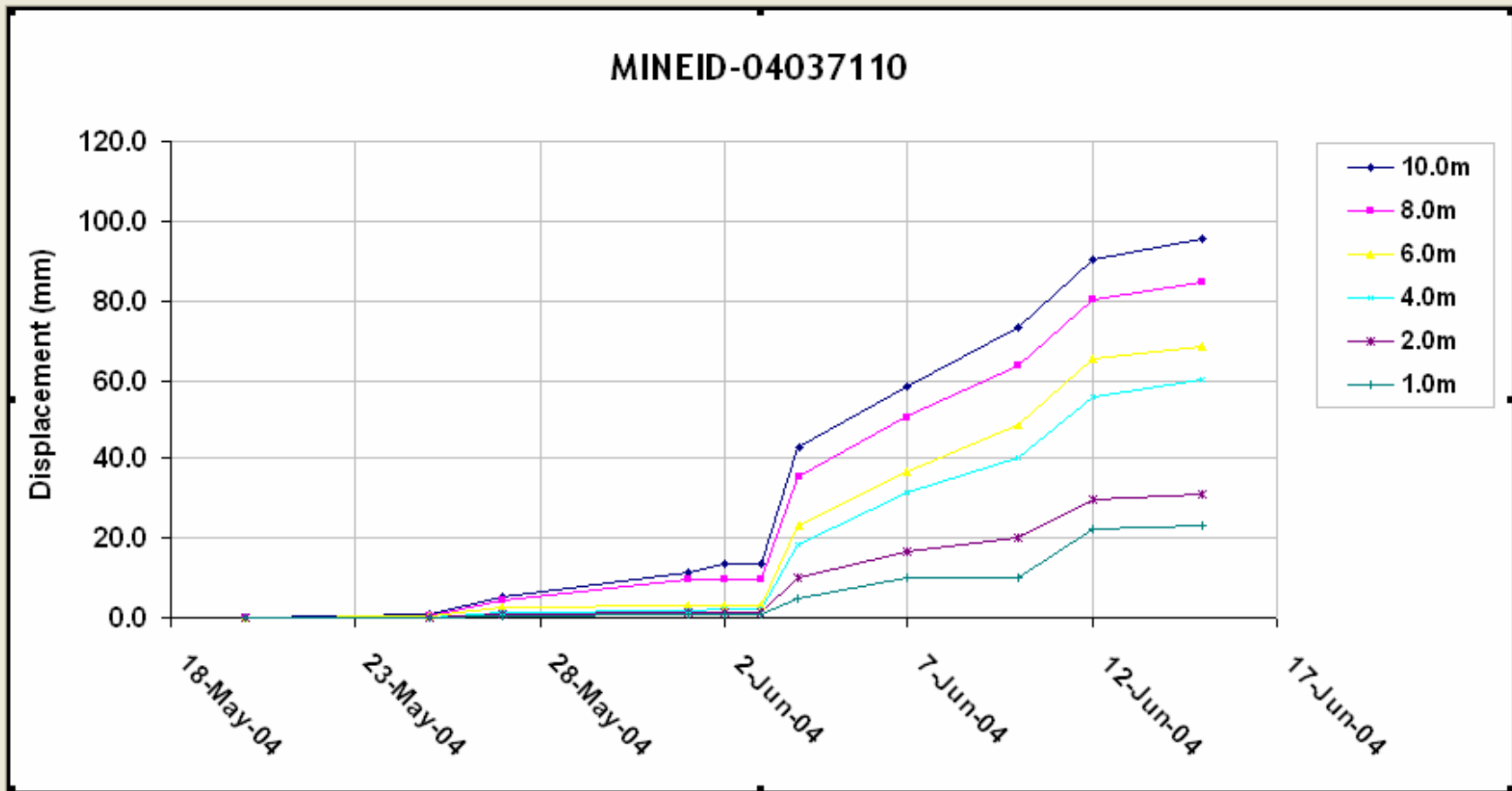
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## Datasheet View:

-  Datasheet
-  Report

# MineScape 4. Temporal Plot

- 1. Identification
- 2. Installation
- 3. Readings
- 4. Temporal Plot
- 5. Rate Plot
- 6. Spatial Plot
- 7. Destruction
- 8. Peripherals



Temp (C)



# MineScape: 8. Peripherals

1. Identification 2. Installation 3. Readings 4. Temporal Plot 5. Rate Plot 6. Spatial Plot 7. Destruction 8. Peripherals

**SLUG Datalogger:**

**STEP 1: Select Serial Port**  
COM1

**STEP 2: Enter a Date/Time**  
Start (Connect) Date +Time:  
Finish (Disconnect) Date + Time :  
13-Oct-04 13:34

**STEP 3: Select Action**  
Extract SLUG Data Erase SLUG Data Configure SLUG

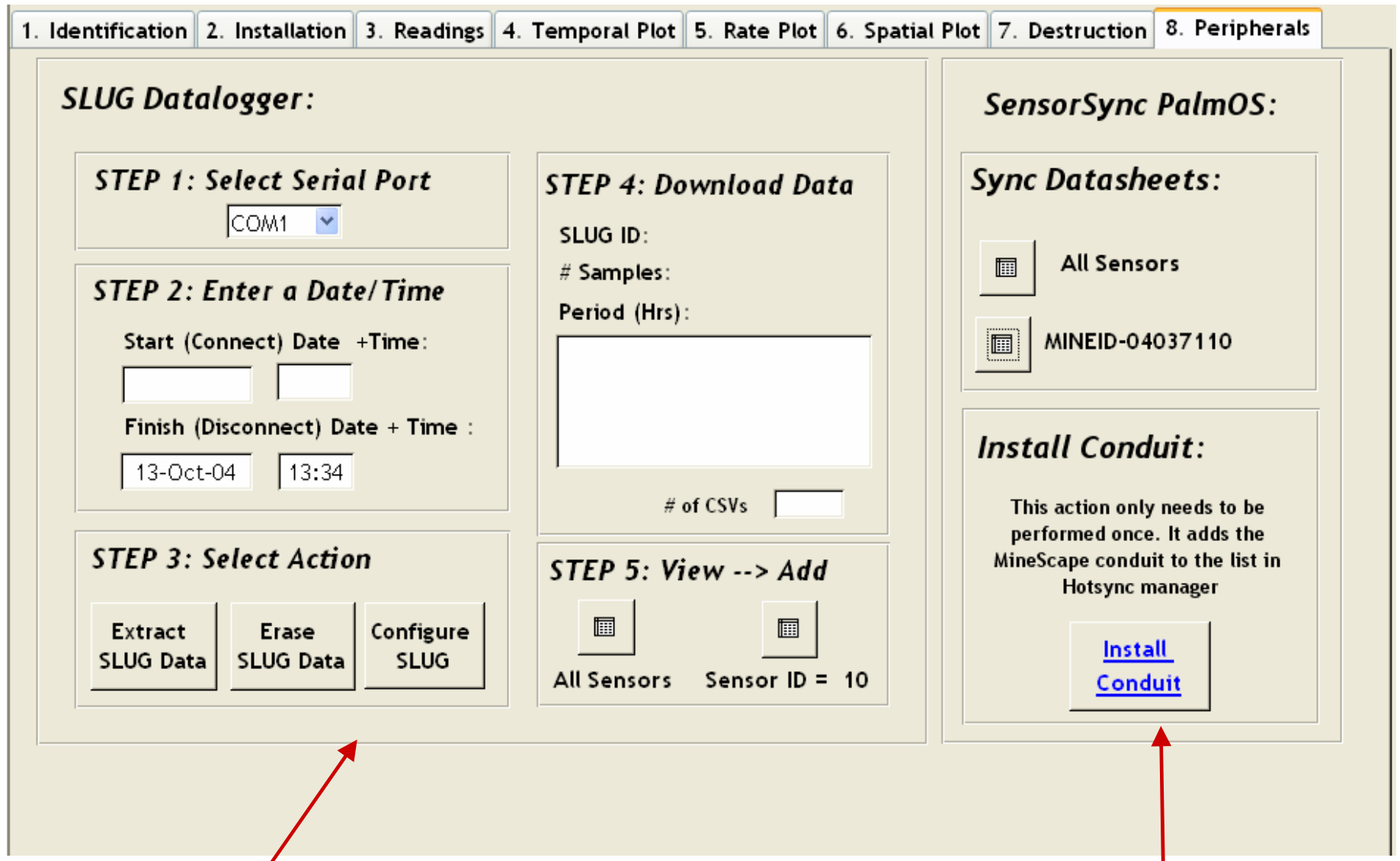
**STEP 4: Download Data**  
SLUG ID:  
# Samples:  
Period (Hrs):  
# of CSVs

**STEP 5: View --> Add**  
All Sensors Sensor ID = 10

**SensorSync PalmOS:**

**Sync Datasheets:**  
All Sensors  
MINEID-04037110

**Install Conduit:**  
This action only needs to be performed once. It adds the MineScape conduit to the list in Hotsync manager  
[Install Conduit](#)



**SLUG Interface**

**SensorSync - PalmOS**

# MinesCAPE: Configure Slug?

1. Identification 2. Installation 3. Readings 4. Temporal Plot 5. Rate Plot 6. Spatial Plot 7. Destruction 8. Peripherals

**SLUG Datalogger:**

**STEP 1: Select Serial Port**  
COM1

**STEP 2: Enter a Date/Time**  
Start (Connect) Date +Time:  
Finish (Disconnect) Date + Time :  
13-Oct-04 13:34

**STEP 3: Select Action**  
Extract SLUG Data Erase SLUG Data **Configure SLUG**

**Configure SLUG**  
Period (hrs) 1 hour  
1 hour  
2 hours  
3 hours  
4 hours  
6 hours  
8 hours  
12 hours  
24 hours  
OK

# of CSVs

**STEP 5: View --> Add**  
All Sensors Sensor ID = 10

**SensorSync PalmOS:**

**Sync Datasheets:**  
All Sensors  
MINEID-04037110

**Install Conduit:**  
This action only needs to be performed once. It adds the MineScape conduit to the list in Hotsync manager  
[Install Conduit](#)

# DIGITAL GEOTECHNICAL SENSORS WITHIN THE DIGITAL MINE

- Digital sensors are typical 40-60% less expensive than analog sensors with even bigger savings in overall cost.
- Low cost peripheral devices integrate geotechnical sensors into the digital mine
- Data transmission over leaky feeder (MRS, EI Equip) or MAN (ethernet) is routine. E-mail alerts+ data uploaded to internet.
- Data integrated with ESG seismic system
- YieldPoint seeks mining operations to demonstrate **Case Studies** for this new exciting technology.