University of Puerto Rico at Mayagüez
Electrical and Computer Engineering Department

# PROJECT PRESENTATION

# WATER MONITORING SYSTEM UNDER EXTREME ENVIRONMENTAL CONDITIONS (MOSYS)

Engineering Solutions Group
Misael Pérez
José Peguero
Ricardo L. Rivera

May 15, 2009

# OUTLINE

- Project Background
- Proposed Solution
- Design
  - Hardware
  - Software
- Results
- Budget Analysis
- Conclusions
- Lessons Learned
- Future Work
- References

# PROJECT BACKGROUND

- Aquaculture of the Sea Monkeys
- Multidisciplinary research
- Multi-sectorial partnership
- Market Overview
- Cabo Rojo's Salt Flats National Refuge

# PROBLEM STATEMENT

- Jose Vargas' words:
  - "Can you implement a water monitoring system that can survive this harsh environment???"
  - "Can you build it???"
  - And the answer was…

# Problem Statement

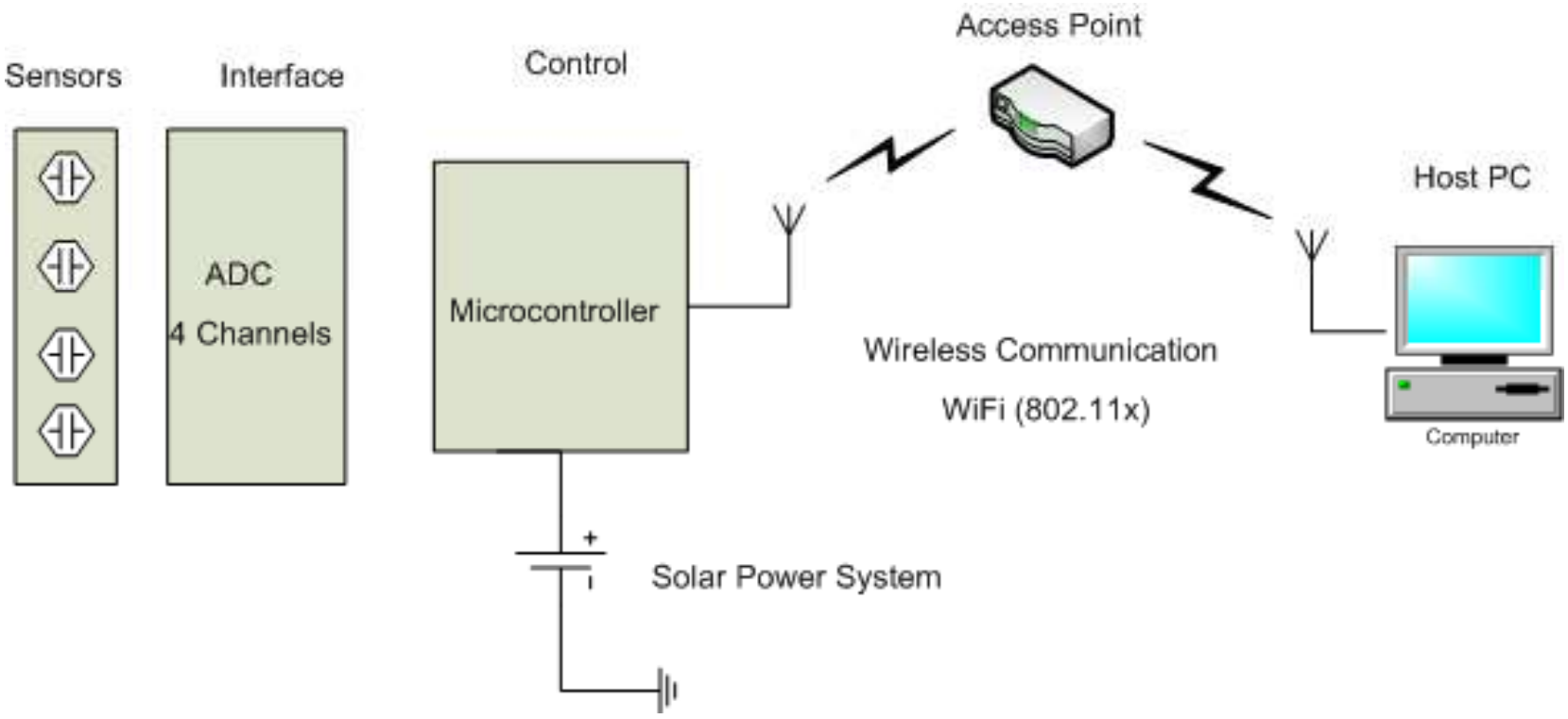
- Engineering Solutions Group words:
  - "YES, WE CAN!!!"

# Proposed Solution

- We proposed…
  - A system that manages information wirelessly for up to 4 analog sensors.
  - An application that would let the user see all the data collected
- They agreed…



# General Design



# HARDWARE – TECHNICAL DETAILS

- Supports 4 analog sensors at any time.
- Supports 1 digital sensor with frequency interface.
- Communicates using IEEE 802.11b with range up to 100 meters.
- Can sample up to 144 times per day for each sensor.
- Capable of storing up to 3000 samples.
- Uses an MSP430f149 microcontroller.
- Solar powered.



# Testing the Design

- The system was tested by connecting different sensors to the available ports.
- Two analog sensors were used
  - Temperature
  - Relative Humidity
- An interface was developed for a conductivity sensor
  - Conductivity sensors are expensive!
- One digital sensor was used
  - A special port was added for this sensor

# Hardware – Analog Sensors

- Temperature sensor
  - Uses a stainless steel probe to measure temperature of a fluid.
  - Linear current output with range from 0˚C to 120˚C.

- Relative Humidity
  - 0 - 3.3 volts linear output.
  - 0 volts corresponds to 0% relative humidity.
  - 3.3 volts corresponds to 100% relative humidity.

# Hardware – Analog Sensors

- Conductivity Sensor
  - Needs an AC power supply.
  - Responds with a DC current.
  - The current needs to be amplified to be used with the system.

# HARDWARE – DIGITAL SENSOR

- Light intensity sensor
  - Converts a light intensity reading into a frequency reading.
  - The number of pulses given by the sensor are measured throughout one second to get the frequency.
  - The pulses are measured throughout a second to get an average reading. It is equivalent to reading the sensor output multiple times

# HARDWARE – WI-FI MODULE

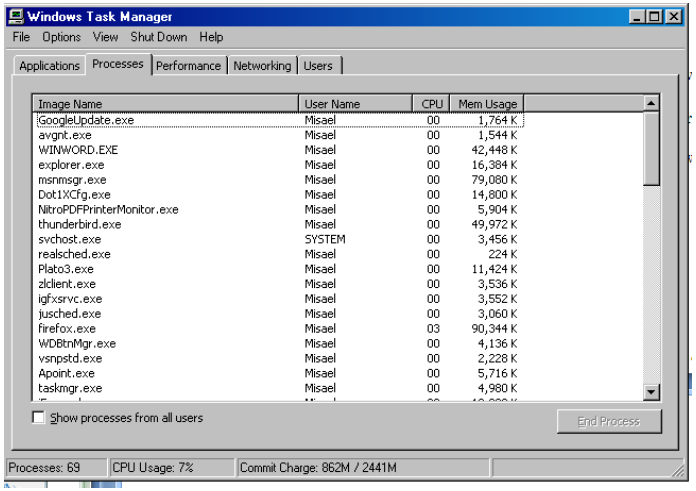
- Wi-Fi Module
  - Communication is provided using a Wifly
  - The microcontroller connects to the module using the UART protocol.
  - TCP/IP Protocol

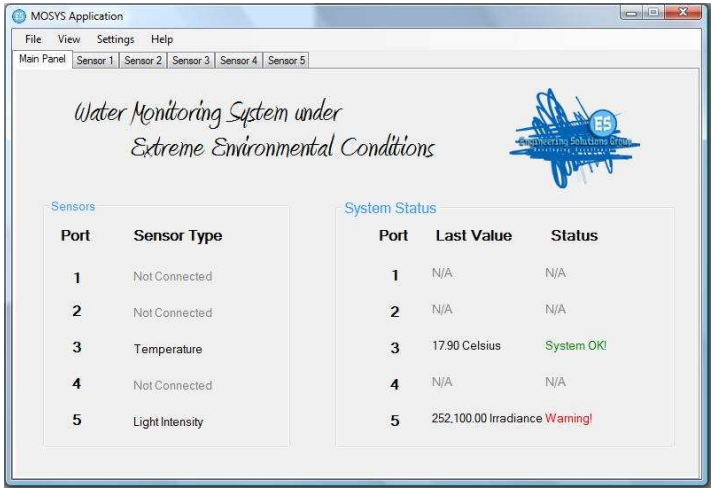
# BUT, WHAT IS HARDWARE WITHOUT SOFTWARE

YOU ARE RIGHT…. NOTHING, USELESS….

# SOFTWARE

- The Mosys software consists of two main components.
  - Windows Service – In charge of retrieving the data from the device.
  - Graphical User Interface – This is where the user manipulates the data.



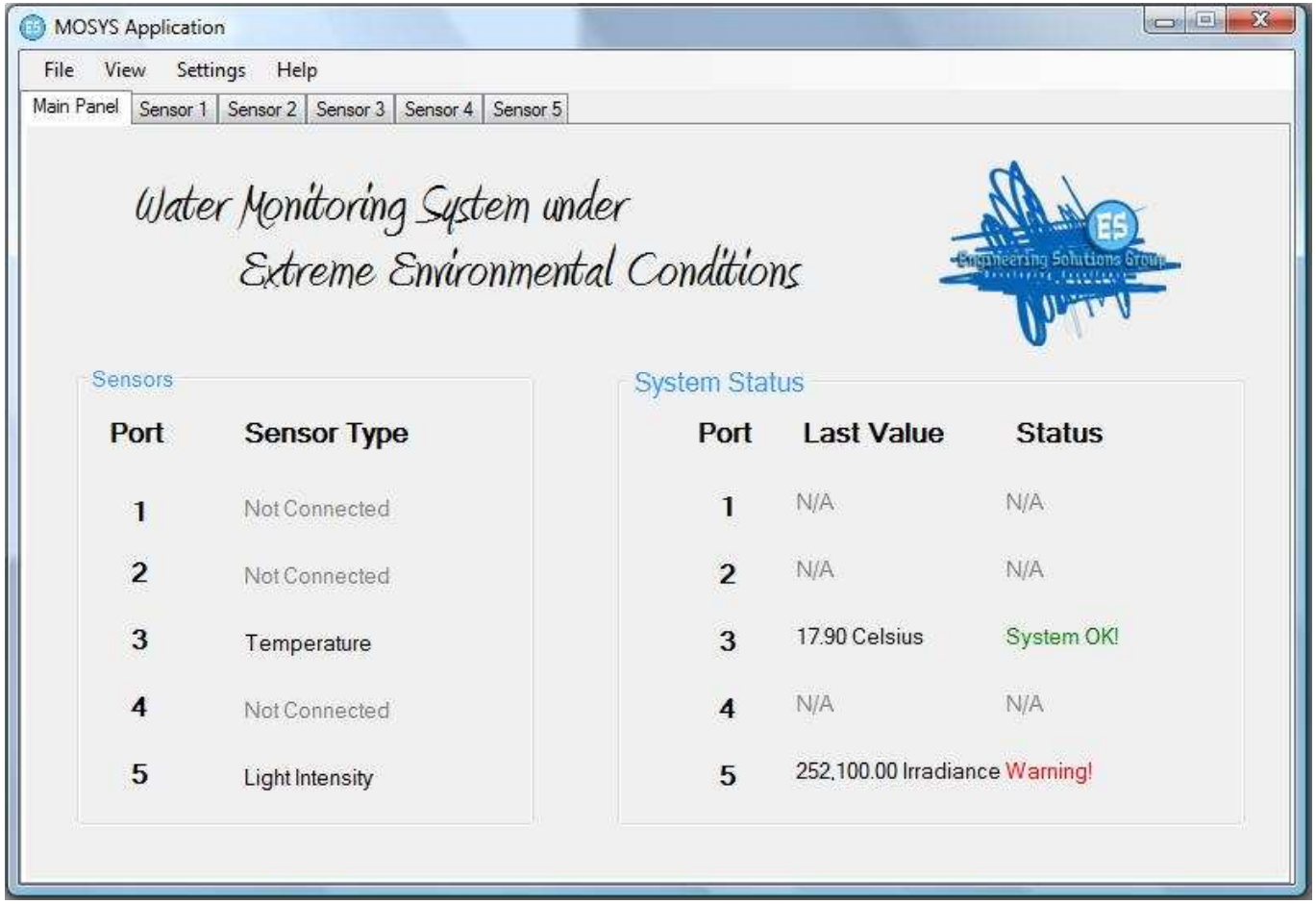
# SOFTWARE – TECHNICAL DETAILS

- Technology
  - C# Language
  - Visual Studio .Net 2008 IDE
  - Database was implemented in SQLite

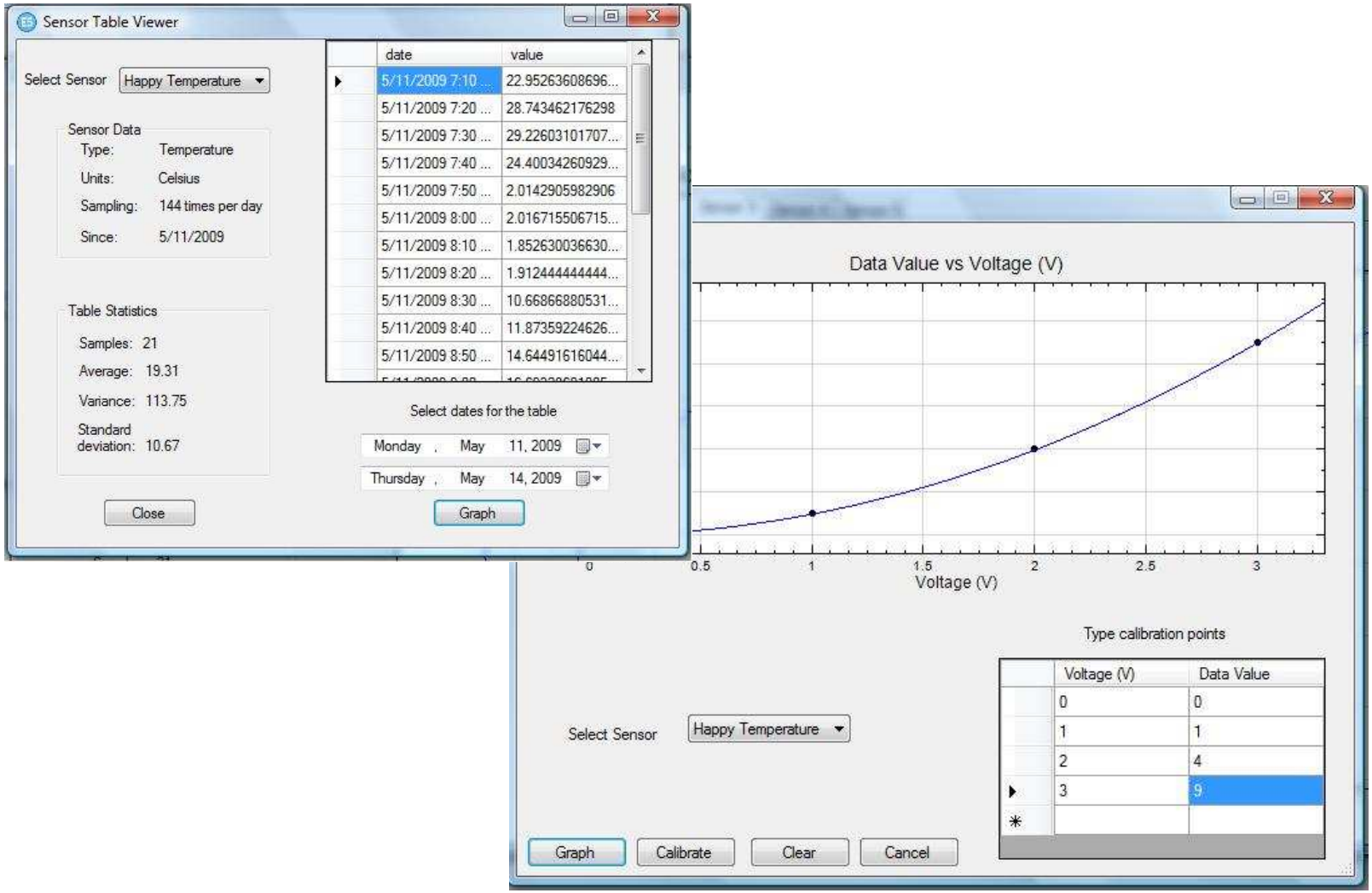
- Minimum System Requirements
  - Windows  XP or superior
  - Microsoft .Net Framework v 2.5 or higher
  - 512 MB RAM
  - 10 MB available in the hard disk.



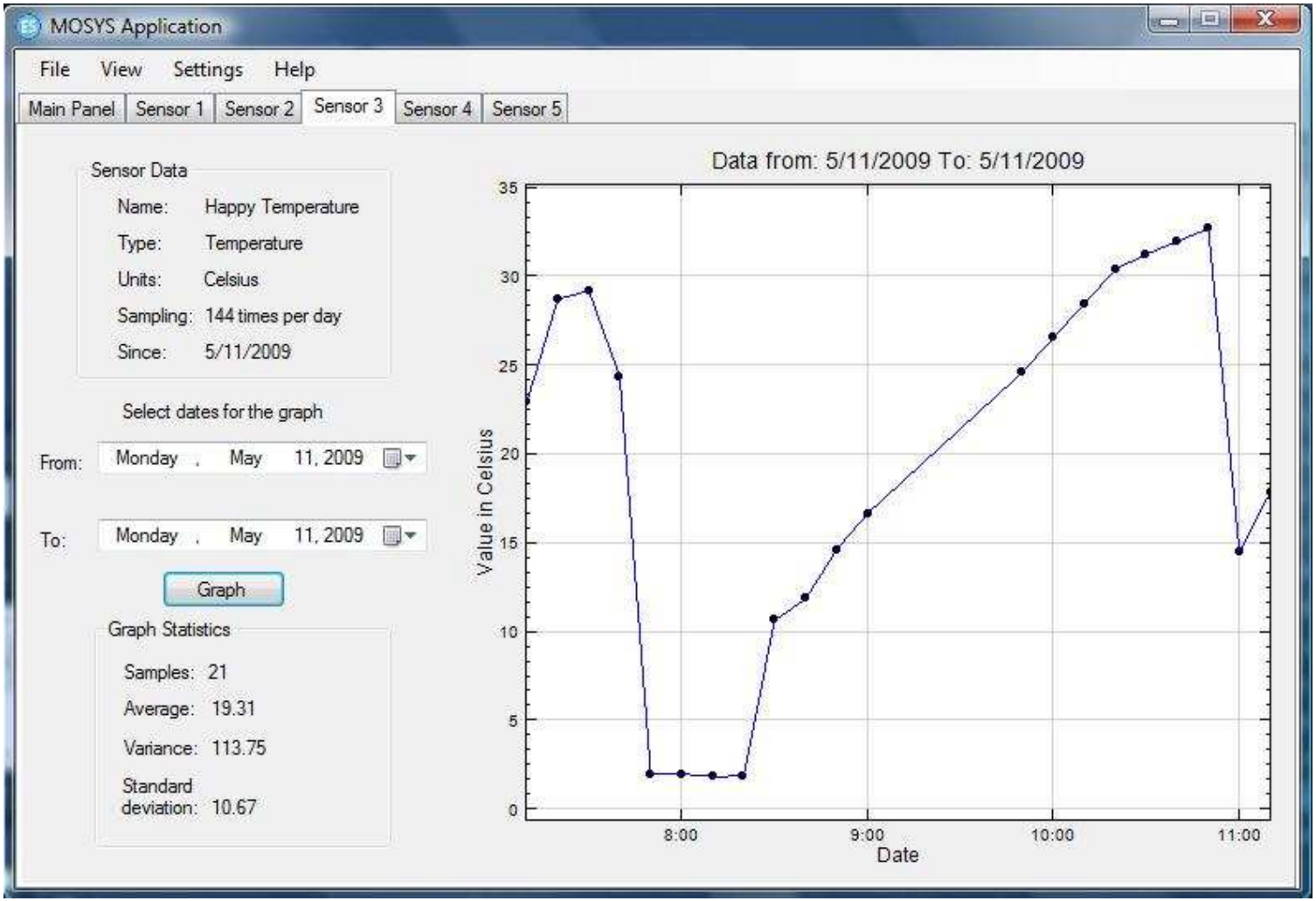
# SOFTWARE - GUI



# SOFTWARE - GUI



# SOFTWARE

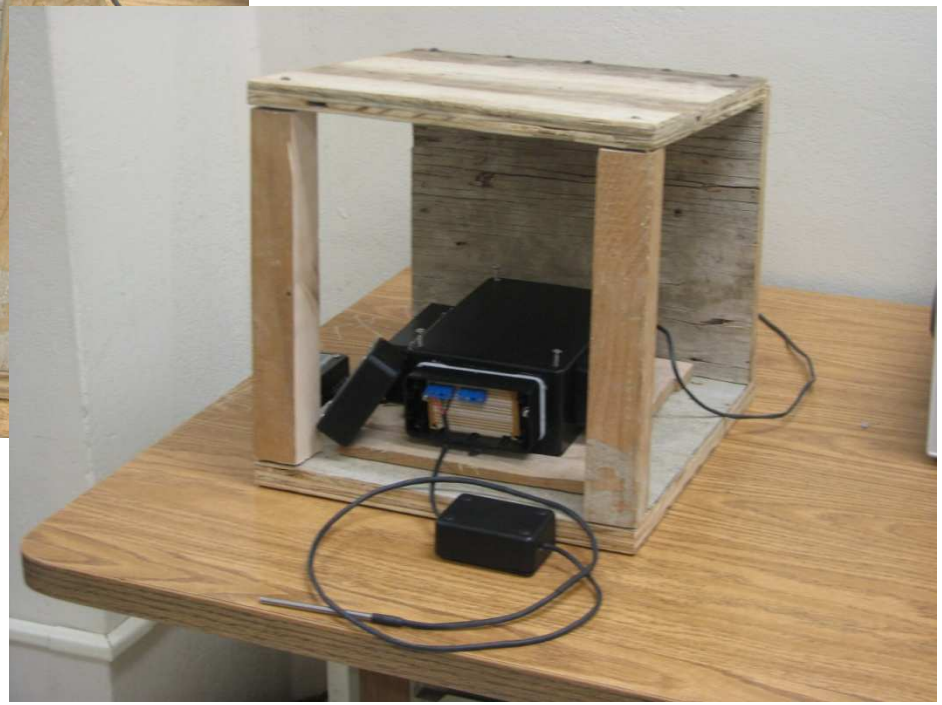

MOSYS Application
File
View
Settings
Help
Main Panel
Sensor 1
Sensor 2
Sensor 3
Sensor 4
Sensor 5
Sensor Data
Name: Happy Temperature
Type: Temperature
Units: Celsius
Sampling: 144 times per day
Since: 5/11/2009
Select dates for the graph
From: Monday , May 11, 2009
To: Monday , May 11, 2009
Graph
Graph Statistics
Samples: 21
Average: 19.31
Variance: 113.75
Standard deviation: 10.67
Data from: 5/11/2009 To: 5/11/2009
Value in Celsius
0
5
10
15
20
25
30
35
8:00
9:00
10:00
11:00
Date

# RESULTS

- The system conforms to the legal standards of a National Fish and Wildlife Reserve.
- Materials that can survive the harsh conditions of the Cabo Rojo's Salt Flats were used.
- The system can gather data at specified times.
- The graphical user interface provides many useful features.



# PRODUCT



# PRODUCT

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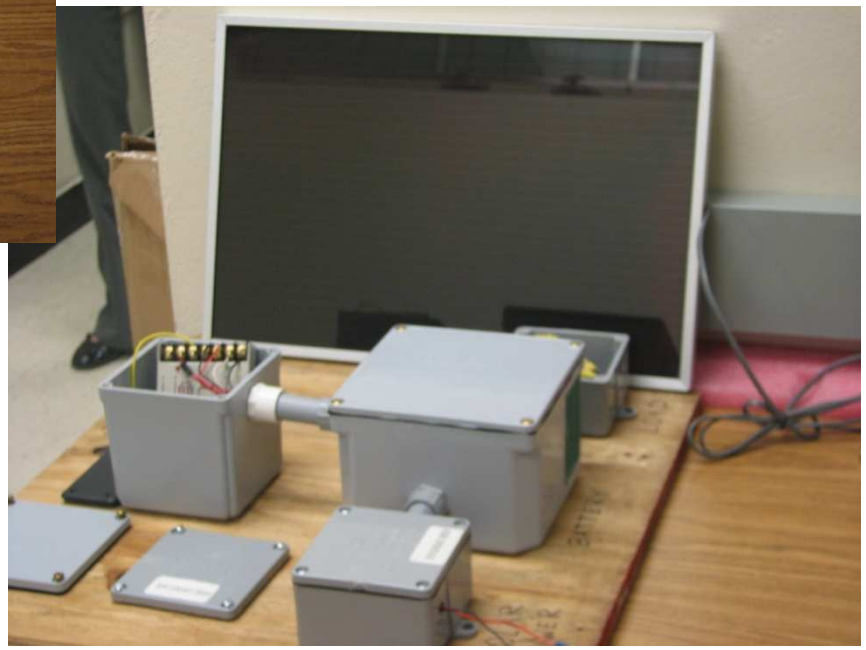

# BUDGET ANALYSIS

- Human Resources
  - Proposed:

| Employees | Position | $/hr | Billable Hours | Non-billable hours | Payment/Contact |
|---|---|---|---|---|---|
| **Misael Perez** | Software Engineer I | 19.71 | 200 | 79 | $3942.00 |
| **Ricardo L. Rivera** | Software Engineer I | 19.71 | 200 | 79 | $3942.00 |
| **Jose A. Peguero** | Hardware Engineer I | 19.71 | 200 | 79 | $3942.00 |
| | | | | Employment Cost | $11,826.00 |
| | | | | Unemployment Insurance | $165.56 |
| | | | | Retirement | $1,773.90 |
| | | | | State Insurance Fund | $183.30 |
| | | | | Social Security | $733.21 |
| | | | | Medicare | $171.48 |
| | | | | **Total Employment Cost** | **$14,853.45** |

# Budget Analysis

- Human Resources
  - Actual:

| Employees | Position | $/hr | Billable Hours | Non-billable hours | Payment/Contact |
|---|---|---|---|---|---|
| **Misael Perez** | Software Engineer I | 19.71 | 200 | 100 | $3942.00 |
| **Ricardo L. Rivera** | Software Engineer I | 19.71 | 200 | 100 | $3942.00 |
| **Jose A. Peguero** | Hardware Engineer I | 19.71 | 200 | 100 | $3942.00 |
| | | | | Employment Cost | $11,826.00 |
| | | | | Unemployment Insurance | $165.56 |
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| | | | | Medicare | $171.48 |
| | | | | **Total Employment Cost** | **$14,853.45** |

# Budget Analysis

- Hardware Components
  - Proposed:

| Component | Model | Price | Qty | Cost |
|---|---|---|---|---|
| **Microcontroller** | MSP430F149 | $7.55 | 2 | $15.10 |
| **Radio** | WLNB-AN-DP101 | $109.06 | 2 | $218.12 |
| **RTC** | PCF2123 | $1.26 | 2 | $2.52 |
| **Salinity Sensor** | TBD | $300 | 2 | $600.00 |
| **Temperature Sensor** | TBD | $25.00 | 2 | $50.00 |
| **Solar Power Supply** | TBD | $150.00 | 1 | $150.00 |
| **Low Dropout Voltage Regulator** | LP2950-50LPR | $0.27 | 2 | $0.54 |
| **Low Dropout Voltage Regulator** | LP2950-33LPR | $0.27 | 2 | $0.54 |
| **Low Dropout Voltage Regulator** | TLV1117 | $0.29 | 2 | $0.58 |
| **Miscellaneous** | | $40.00 | 1 | $40.00 |
| **WLAN Router** | Airlink Wireless Access Point Router | $55.00 | 1 | $55.00 |
| **Enclosure Components** | TBD | $30.00 | 2 | $60.00 |
| | | | **Hardware Costs** | **$1,192.40** |



# BUDGET ANALYSIS

- Hardware Components
  - Actual:

| Component | Model | Qty. | Price ($) | S&H ($) | Subtotal($) |
|---|---|---|---|---|---|
| **Relative Humidity Sensor** | HS-2000V | 1 | 44.95 | 0 | 44.95 |
| **Temperature Probe** | AC2626J | 1 | 78.00 | 0 | 0.00 |
| **Light Sensor** | TSL239R | 2 | 5.99 | 9.99 | 21.98 |
| **Microcontroller** | MSP430 | 2 | 7.55 | 0 | 0.00 |
| **Microcontroller Development Kit** | FET Debugging Tool | 1 | 150.00 | 0 | 0.00 |
| **Solar Power System** | | 1 | 113.82 | 45.65 | 159.47 |
| ***- Solar Panel*** | ThinFilm 12V 5Watt | | *57.90* | | |
| ***- Charge Controller*** | 06-1024 | | *34.95* | | |
| ***- Battery*** | 12V 8AH | | *20.97* | | |
| **Solar Power Enclosures** | NA | 4 | 8 | 32.00 | 32.00 |
| **Wireless Module** | WiFly RN-111B | 2 | 69.65 | 43.35 | 183.25 |
| **Wireless Router** | Airlink Wireless Access Point Router | 1 | 55.00 | 0 | 55.00 |
| **Electrical Components** | NA | NA | 24.00 | 5.95 | 29.95 |
| ***- Voltage Regulators*** | | | | | |
| ***- Zener Diodes*** | | | | | |
| ***- Operational Amplifiers*** | | | | | |
| ***- Resistances*** | | | | | |
| **Miscellaneous** | NA | NA | 52.59 | 0 | 52.69 |
| ***- Cables*** | | | | | |
| ***- PCB Boards*** | | | | | |
| ***- Enclosures*** | | | | | |
| | | | | **TOTAL** | **$579.29** |



# CONCLUSION

- Product was delivered on time.
- Environmental and legal issues were a strong influence during the design phase of the project.
- Contingency plan were applied successfully.
- Project remained within the financial limits provided.

# Lessons Learned

- Spare parts are always good.
- The debugger is your best friend.
- Datasheets are not always right.
- A few nights without sleeping can be the solution.
- Development process is client oriented, not designer oriented.
- Gantt charts are very useful, only if you follow them.



# Future Work

- Optimization of the system to reduce the sampling time
- Addition of external memory
- Wireless communication can be improved to achieve higher communication distances
- Additional analog and digital ports for sensors

# ACKNOWLEDGEMENTS


- Professors
  - Fernando
  - Prof. Nayda G. Santiago
  - Prof. Manuel Rodríguez
- Teacher Assistants
  - Arnaldo A. Oliver
  - Celibette M. Ossorio
  - Rafael Vega
  - José J. Rodríguez "Dices"
- Sr. José Vargas
  - Joluvar Instruments
- Sr. Pedro Carrasquillo
  - PC Electronic
- Classmates
- Our Sponsors and Partners

# QUESTIONS