College of Engineering, Forestry, and Natural Sciences
Dept. of Mechanical Engineering

Solar Irradiance Measuring Device

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Overview

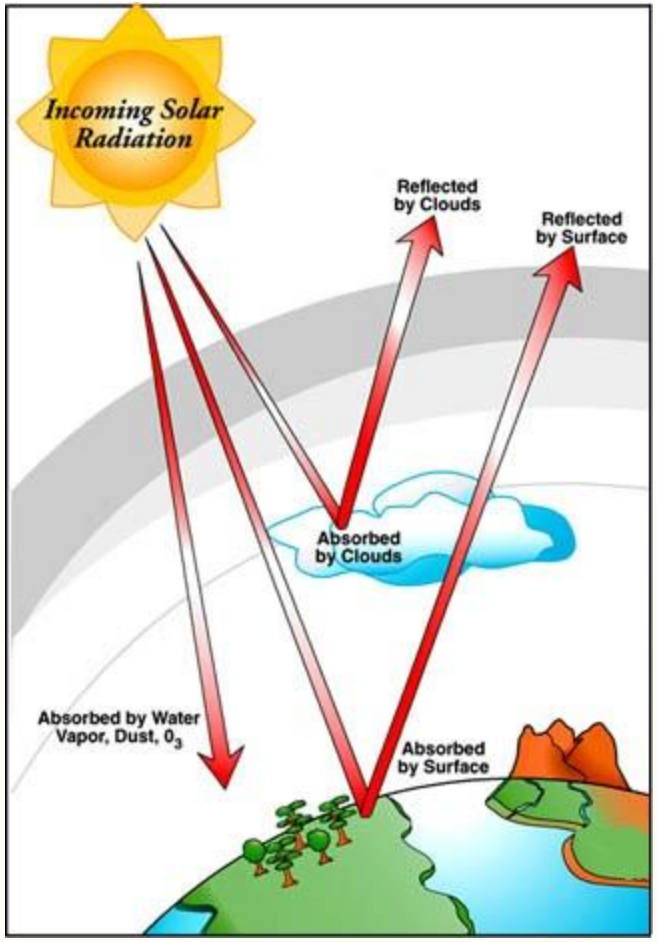
- Clients
- Project Definition
- Design Analysis
- Data Analysis
- Future Plans
- Timeline
- References

Clients

- **NextEra Energy**
  - **Construction and operation of energy production sites**
- **Institute for Sustainable Energy Solutions**
  - **Dr. Tom Acker**
  - **David Willy**

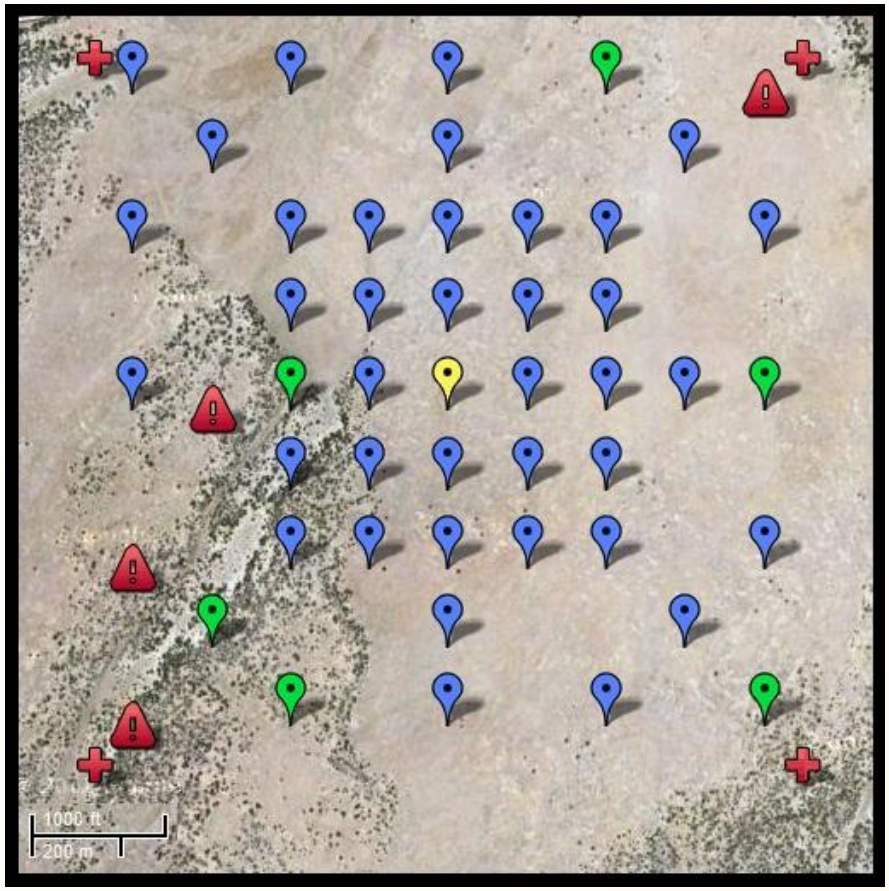
Irradiance Definition

- Energy flux $[\frac{W}{m^2}]$
- Changes with weather
  - Inconsistent output
- Variance data used to determine viability of solar site



Current Site

- **Located at COBar Ranch**
  - **35 miles north of the San Francisco Peaks**
- **1 square mile**
- **50 sensors**



Needs Identification

- **Current problems:**
  - **Large number of devices in use**
  - **Long set-up time / permanent**
  - **Data collection errors**
  - **Large area usage**
  - **Access issues**
  - **High cost**

Needs and Goals

Need Statement:

The current system is inefficient with its use of land, man hours, and produces poor data.

Goal:

Design a relatively small, portable solar irradiance measuring system that can accurately quantify variance in solar irradiance over a larger area.

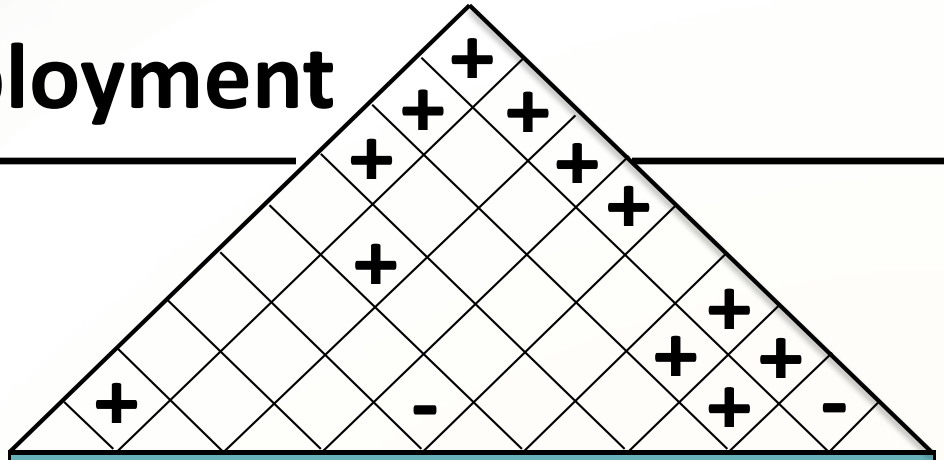
Objectives

Objectives	Basis for Measurement	Units
Scales Down	Fit into Current Site	Ft^2
GPS Location	Data Collection	Ft
Easy Set-up/Operation	Data Collection	Time
Longevity	Durability	Months
Size	Transportable	Ft^3
Weight	Manageable	Lb
Cost	Inexpensive	$$

Constraints

- Data Correlation
- $A_{surface} \leq 7800\ ft^2$ (100 ft diameter circle)
- Safe data storage
- Setup Time ≤ 16 Man Hours
- Stand Alone Functioning
- Accurate sensor location
- Synchronous data collection
- Cost
- Longevity

Quality Function Deployment



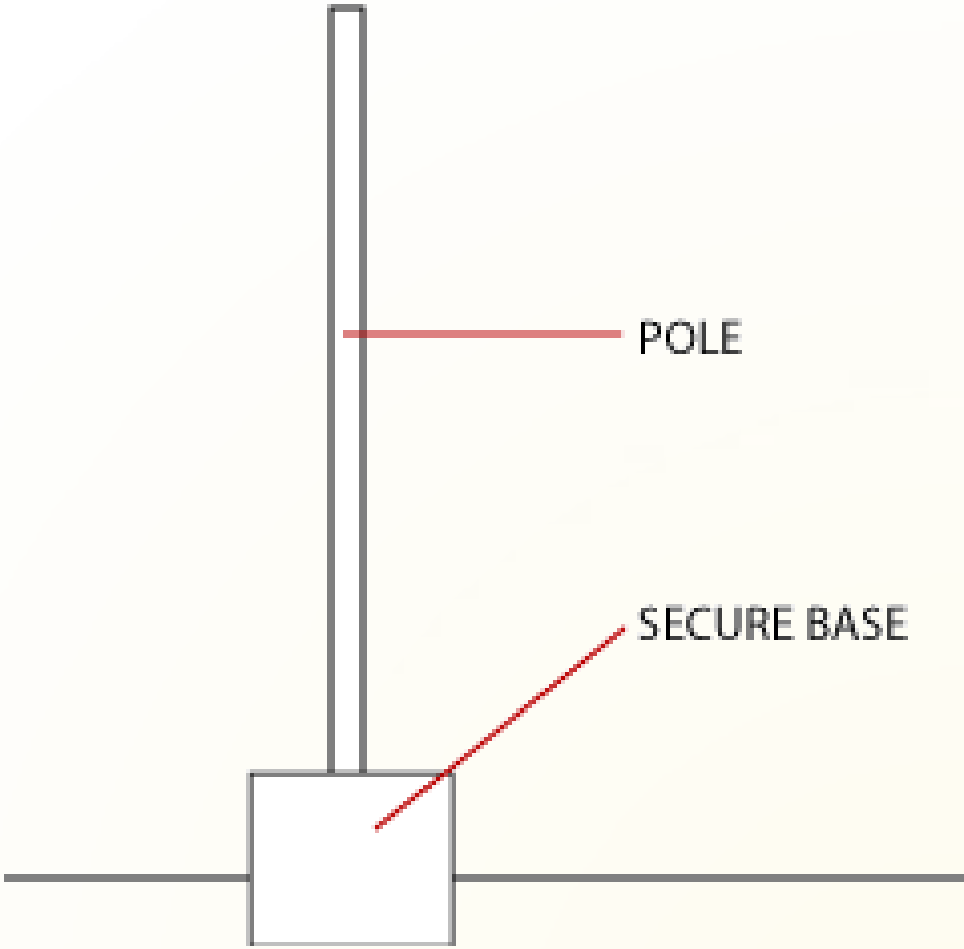
Customer Requirments	Engineering Requirements: Surface area	Set-Up Time	GPS Location	Data Storage	Frequency	Longevity	Packed Sized	Weight	Cost
Scales Down Current Site	X						X		
Useable Data Collection			X	X	X				
Store Data Safely				X		X			X
Easy to Set Up		X						X	X
GPS Location for Each Sensor			X	X					
Stand Alone Functioning				X		X			X
Time Stamped Data				X	X				
Inexpensive	X								X
Units	ft^2	hours	ft	days eq.	Hz	months	ft^3	Lb	$
Engineering Targets	~7800	16	±1	30	1	14	30	50	5000

Tripod

- Instruments mounted on simple tripods
- Tripods secured to ground
  - Stakes in earth
  - Expansion bolts in rock
- Found a tripod for $31.44

Bucket Post

- 5 gallon buckets filled with concrete
- Sleeve formed in concrete for tee
- Sensors mounted to post



Data Acquisition

- **Campbell Scientific CR-1000**
  - **Proven in industry**
  - **8 pyranometer channels**
  - **Max sampling rate:100Hz**

- **Li-Cor LI-200 Pyranometer**
  - **Compatible with a Campbell Scientific Data Logger**
  - **Average Error <5%**

This hardware was not chosen by design team, but provided by client

Data Transfer

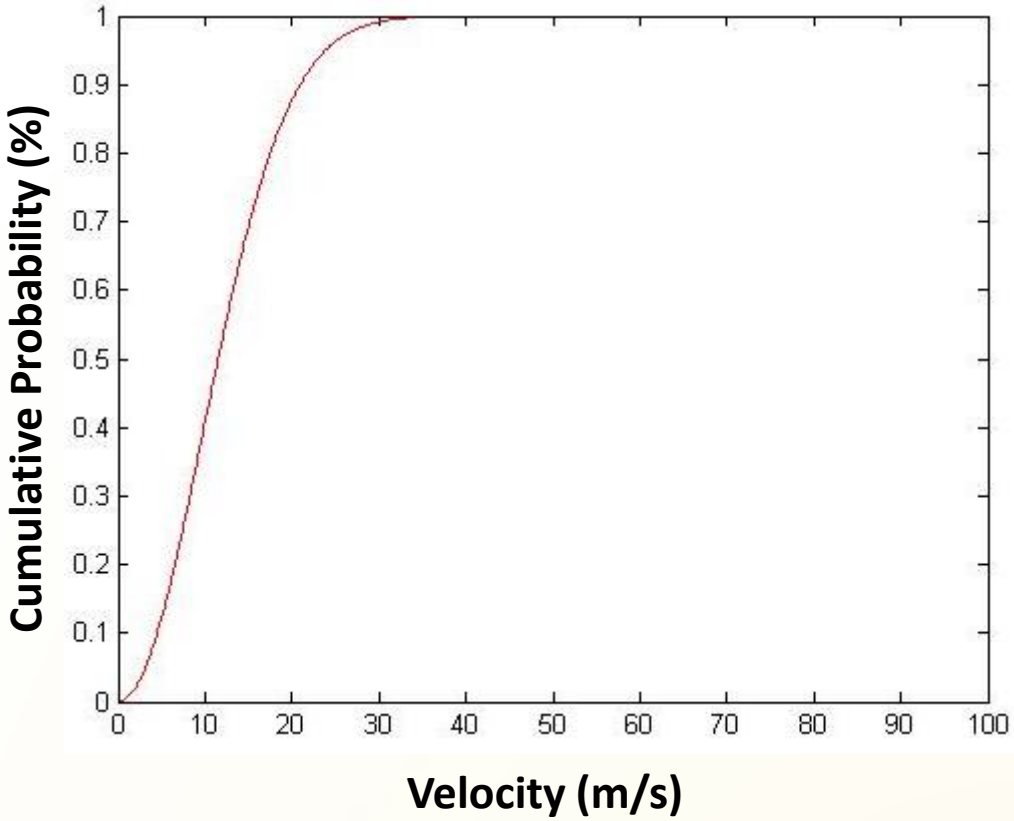
- **Wired:**
  - **Simple setup**
  - **Sensors come with 50 foot cable**
  - **Negligible voltage drop**
- **Wires will be housed in flexible conduit**
- **Protects wires from**
  - **Cows**
  - **Rodents (eg. field mice)**
  - **Ultra violet rays**
  - **Water**

Data Correlation

- **Correlating Stations 14 and 18 to Station 13 gives X and Y components of velocity.**
- **Magnitude of found velocity: V=12.2$\frac{m}{s}$**

Data Correlation Cont.

- **Applied a special statistical distribution and found a cumulative distribution function (CDF)**



Data Correlation Cont.

- Using percentages from the CDF, the cloud velocities were found
- Knowing these velocities and the distance between new sensors, a sampling rate was found.

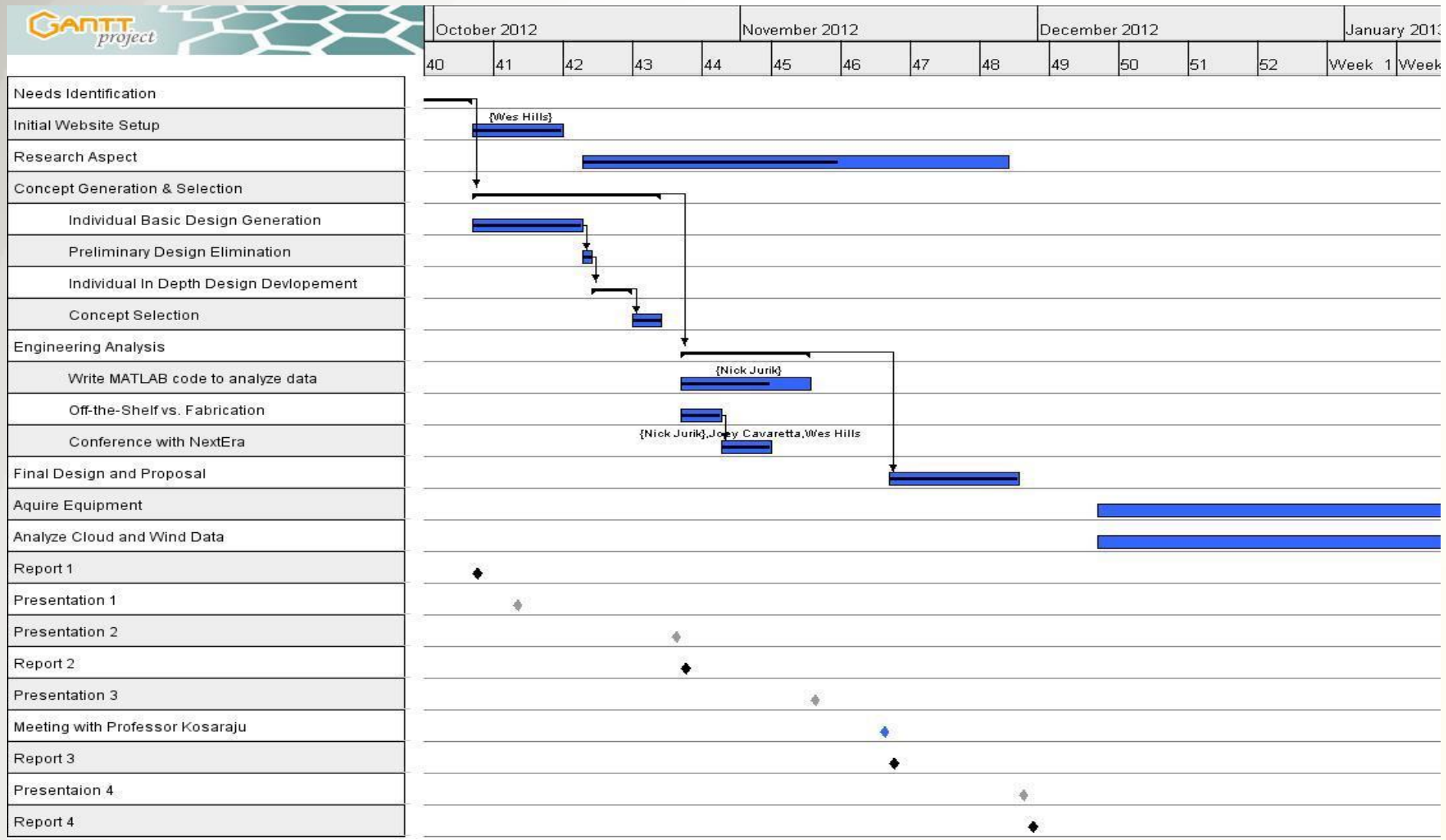
Data Correlation Cont.

Cloud Velocities that can be Captured (Percent)	Sampling Rate (Hz)
65	1.16
70	1.24
75	1.33
80	1.43
85	1.56
90	1.71
95	1.96
100	∞

Future Plans

- Continue data analysis
- Research wind/cloud movement behavior
- Obtain and learn how to use hardware components
- Develop and construct new site

Time Line


GANTT project
October 2012
November 2012
December 2012
January 2013
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Week 1
Week
Needs Identification
Initial Website Setup
Research Aspect
Concept Generation & Selection
Individual Basic Design Generation
Preliminary Design Elimination
Individual In Depth Design Devlopement
Concept Selection
Engineering Analysis
Write MATLAB code to analyze data
Off-the-Shelf vs. Fabrication
Conference with NextEra
Final Design and Proposal
Aquire Equipment
Analyze Cloud and Wind Data
Report 1
Presentation 1
Presentation 2
Report 2
Presentation 3
Meeting with Professor Kosaraju
Report 3
Presentaion 4
Report 4
{Wes Hills}
{Nick Jurik}
{Nick Jurik},Joey Cavaretta,Wes Hills

Resources

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- www.envcoglobal.com/taxonomy/term/685/0
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- Flood, Ronald K., Dr. Tom Acker, and David Willy. *Prescott Airport Solar Facility Solar Variability Study*. Tech. N.p.: n.p., n.d. Print.

Questions