Report on Collaborative Research for Hurricane Hardening

Provided by

The Public Utility Research Center
University of Florida

To the

Utility Sponsor Steering Committee

February 14, 2008

I. Introduction

The Florida Public Service Commission (FPSC) issued Order No. PSC-06-00351-PAA-EI on April 25, 2006 (Order 06-0351) directing each investor-owned electric utility (IOU) to establish a plan that increases collaborative research to further the development of storm resilient electric utility infrastructure and technologies that reduce storm restoration costs and outages to customers. This order directed IOUs to solicit participation from municipal electric utilities and rural electric cooperatives in addition to available educational and research organizations. As means of accomplishing this task, the IOUs joined with the municipal electric utilities and rural electric cooperatives in the state (collectively referred to as the Project Sponsors) to form a Steering Committee of representatives from each utility and entered into a Memorandum of Understanding (MOU) with the University of Florida's Public Utility Research Center (PURC).

The MOU has a term beginning March 1, 2006 and ending May 31, 2009, and may be renewed by mutual agreement of the Project Sponsors and PURC. In serving as the research coordinator for the Project outlined by the MOU, PURC manages the work flow and communications, develops work plans, facilitates the hiring of experts coordinates with research vendors, advises the Project Sponsors and provides reports for Project activities.

At its initial meeting, the Steering Committee identified four primary research areas, namely the economics of undergrounding, the measurement and analysis of hurricane winds at a granular level, best practices in vegetation management, and improved materials for distribution facilities. The Steering Committee decided

to initiate research on the first two topics, to hold a workshop on the vegetation management topic, and to look to vendors to conduct research on improved materials.

This report summarizes the work completed on the Steering Committee's areas of focus, with detail about specific accomplishments and activities from March 2007 through February 2008.[1] Sections II through IV provide information on the undergrounding research, wind research, and vegetation management workshop respectively. The budgeted dollars shown for each project are allocated on a percentage basis to each of the Project Sponsors as outlined in the MOU. PURC's budgets for work completed in 2007 are listed as Appendix A. The Conclusion of this report provides an overall assessment of the collaborative research program to date, including operational and financial viability and future planning to the extent these items are not already covered in the other sections of this report.

II. Undergrounding

An important consequence of hurricanes is that they often cause major power outages, which can last for days or even weeks. These outages almost always lead to a public outcry for electric utilities to move overhead power lines under ground. To some it seems intuitive that undergrounding facilities should protect them from damage. However, research shows that this is not necessarily the case: while underground systems on average have fewer outages than overhead systems, they can sometimes take longer to repair. Furthermore forensic analyses of recent hurricane damage in Florida found that underground systems may be particularly susceptible to storm surge.

While there are numerous studies on undergrounding electric infrastructure, missing from this work was a comprehensive survey of what is known and what is not yet known, current analyses of Florida cases where overhead facilities have been moved underground, and a methodology that can be used to consistently estimate the costs and benefits of specific undergrounding proposals in Florida. The Steering Committee elected in 2006 to undertake a study of undergrounding overhead facilities to help fill these gaps in the existing research. The project is divided into three phases: Phase I conducts the comprehensive survey; Phase II analyzes Florida undergrounding cases; and Phase III develops a methodology and a computer model for projecting undergrounding costs and benefits for specific undergrounding proposals.

The Steering Committee issued an RFP for this research in late 2006 and, based on its knowledge of power delivery systems, expertise in risk management and

[1] PURC's February 2007 report provides details for work prior to March 2007. It is available on PURC's web site and the FPSC's web site (www.purc.ufl.edu and www.floridapsc.com/utilities/electricgas/eiproject/).

reliability issues, and proven ability to analyze the complex utility issues, InfraSource Technology (now Quanta Technology) was selected as the vendor by the Steering Committee in November 2006. InfraSource began work in December 2006.[2] The budget for Phase I of this project was $40,000. The budget for Phases II and III was $220,000, although additional travel costs have been incurred for meetings.

Phases I and II have been completed and copies of the reports are available on PURC's web site and the FPSC's web site. These reports summarized the body of knowledge on the costs and benefits of undergrounding and analyzing four recent undergrounding cases in Florida. Completed in February 2007, Phase I found that existing studies consistently concluded that the conversion of overhead electric distribution systems to underground is costly and that these costs are in excess of the quantifiable benefits, except in rare cases where the facilities provide particularly high reliability gains or otherwise have a higher than average impact on community goals. According to the Phase I report, "This conclusion is reached consistently in many reports, always by comparing the initial cost of undergrounding to the expected quantifiable benefits. No prior cost benefit study recommends broad-based undergrounding, but several recommend targeted undergrounding to achieve specific community goals." The Phase I research found no studies that examined whether projected costs and benefits of undergrounding turned out to be accurate.

Phase II examined four specific undergrounding project case studies in Florida and was completed August 2007. Emergent observations from the case study analysis included:

- Cost per circuit mile vary widely based on a variety of factors
- Cost per customer vary widely based on both the cost per circuit mile and the amount of high density housing;
- Little data is available from the case studies on the impacts of undergrounding on non-storm reliability and hurricane performance, but the evidence suggests that the undergrounding had little impact on non-storm reliability and that hurricane reliability of underground systems is not perfect due to storm surge damage;
- There is very limited data on cost and benefits of undergrounding for these projects, whereas information is available about project description and project cost.

Further application of this work will take place in early 2008 with the completion of Phase III. Phase III develops and tests an *ex ante* methodology and computer model to identify and evaluate the costs and benefits of undergrounding specific facilities in Florida. The draft model will be completed in March 2008 and testing of the model will begin at that time.

[2] Quanta Technologies purchased InfraSource in 2007 and is now completing the project. The project team remains unchanged.

III. Wind Data Collection

Appropriate hardening of the electric utility infrastructure against hurricane winds requires: 1) an accurate characterization of severe dynamic wind loading, 2) an understanding of the likely failure modes for different wind conditions, and 3) a means of evaluating the effectiveness of hardening solutions prior to implementation.

The Project Sponsors are addressing the first requirement by contracting with the University of Florida's Department of Civil & Coastal Engineering (Department) and WeatherFlow to establish a granular wind observation network. There are currently 21 devices installed and reporting data. An additional 14 will be installed and operational by the end of February 2008 and a total of 50 devices are expected to be installed and working by the end of March 2008. Appendix B contains a map of the current and planned devices. This network of devices will capture the behavior of the dynamic wind field upon hurricane landfall.[3] Once a hurricane occurs and wind data is captured, forensic investigations of utilities infrastructure failure, conducted by the utility companies, can be overlaid with wind observations to correlate failure modes to wind speed and turbulence characteristics.

Appendix C contains the two reports that have come from this research. In response to an inquiry, the research team considered whether the data collected could be used to assess the potential for wind generation in Florida. Their January 2008 report titled "Use of WeatherFlow wind observing network for wind energy research" concludes that the network of devices can be useful for identifying locations where further research on wind generation might be productive. Their report incorporates a December 2007 report on the status of the placement of the wind measurement devices. Appendix D contains the project budget.

IV. Vegetation Management

The goal of this project was to improve vegetation management practices so that vegetation related outages are reduced, vegetation clearing for post-storm restoration is reduced, and vegetation management is more cost-effective. The project consisted of a workshop, held on March 5-6, 2007, that included vegetation management experts, utility arborists, FPSC staff, and PURC. The workshop report is available on PURC's web site and the FPSC's web site. The workshop participants' conclusions included:

[3] The devices capture wind direction, wind speed, temperature, and barometric pressure 24 hours a day, 365 days a year.

1. It is impractical to eliminate all tree-related outages during hurricanes of high-wind events.
2. Communication with and education for the public on all aspects of vegetation management as it relates to reliable utility operations is crucial.
3. Vegetation management programs must have access to adequate and consistent financial resources.
4. There is a need for training, recruiting, and retaining highly qualified, skilled tree crews.
5. Utilities should continue to monitor and patrol critical distribution facilities such as major feeders and feeders that serve critical infrastructure such as hospitals, police, and fire/rescue.
6. Storm preparation and restoration logistics are critical to timely and effective storm recovery
7. Cooperation between utilities and government at multiple levels is also important.
8. A dedicated tree forensic program can help provide data to make better use of resources in the future.

The budget for this project was contained in the February 2007 PURC report.

V. Conclusions

In response to the FPSC's Order 06-0351, IOUs, municipal electric utilities and rural electric cooperatives joined together and retained PURC to coordinate research on electric infrastructure hardening. Costs have been incurred according to the funding schedule set by the Steering Committee. This year, costs incurred have been towards research in the initiatives of granular wind research, undergrounding research, vegetation management, and PURC's coordinating work. The Steering Committee is currently considering next steps in these research areas.

The benefits of the work realized from the time of the last report (February 2007) to the time of this report include increased collaboration and discussion between members of the Steering Committee, greater knowledge in the area of vegetation management during storm and non-storm times, greater knowledge and significant archived data from wind collection sites and further understanding of wind during storm and non-storm events in the State of Florida, and more knowledge about hurricane and damage modeling towards further understanding of the costs and benefits of undergrounding. The Steering Committee has determined that PURC's coordination role should continue throughout the remainder of the effort.

Appendix A. PURC Budgets for 2007

RESEARCH COORDINATION FOR ELECTRICITY INFRASTRUCTURE HARDENING

Phase III - commencing January 1, 2007 and ending June 30, 2007

Undergrounding Study			
Personnel			
PURC Faculty (5 weeks)	$ 14,000.00		
Grad Student (5 weeks)	$ 3,300.00		
Administrative (2 weeks)	$ 2,800.00		
		$ 20,100.00	
Wind Study			
Personnel			
PURC Faculty (2 weeks)	$ 5,600.00		
Grad Student (3 weeks)	$ 1,980.00		
Administrative (4 weeks)	$ 5,600.00		
	$ 13,180.00		
Travel			
Steering Committee meetings (1)	$ 130.00		
	$ 130.00		
		$ 13,310.00	
Vegetation Management			
Personnel			
PURC Faculty (2 weeks)	$ 5,600.00		
Grad Student (2 weeks)	$ 1,320.00		
Administrative (1 week)	$ 1,400.00		
	$ 8,320.00		
Travel			
Vegetation Management Workshop	$ 797.19		
	$ 797.19		
		$ 9,117.19	
Miscellaneous			
Global Crossing Conference Calls		$ 1,320.00	
Subtotal		$ 43,847.19	
University Overhead (25%)		$ 14,615.73	
Total		$ 58,462.92	

Faculty Activities
Drafting work plans for wind study, vegetation management, and materials
Drafting RFP for wind study
Drafting report from vegetation management workshop
Reviewing undergrounding reports
Drafting report for FPSC
Organizing and managing weekly conference calls
Attending meeting with FPSC staff or sponsors
Managing PURC staff working on project

Graduate Student Activities
Editing RFP for wind study
Participating in and taking minutes for weekly conference calls
Maintaining PURC work plan for overseeing projects
Serve as scribe for vegetation management workshop
Drafting report from vegetation management workshop

Administrative Activities
Developing budgets
Proofreading all materials
Taking minutes on conference calls
Organizing conference calls and meetings
Developing all administrative documents, such as contact lists and invoices

RESEARCH COORDINATION FOR ELECTRICITY INFRASTRUCTURE HARDENING

Phase IV - commencing July 1, 2007 and ending December 31, 2007

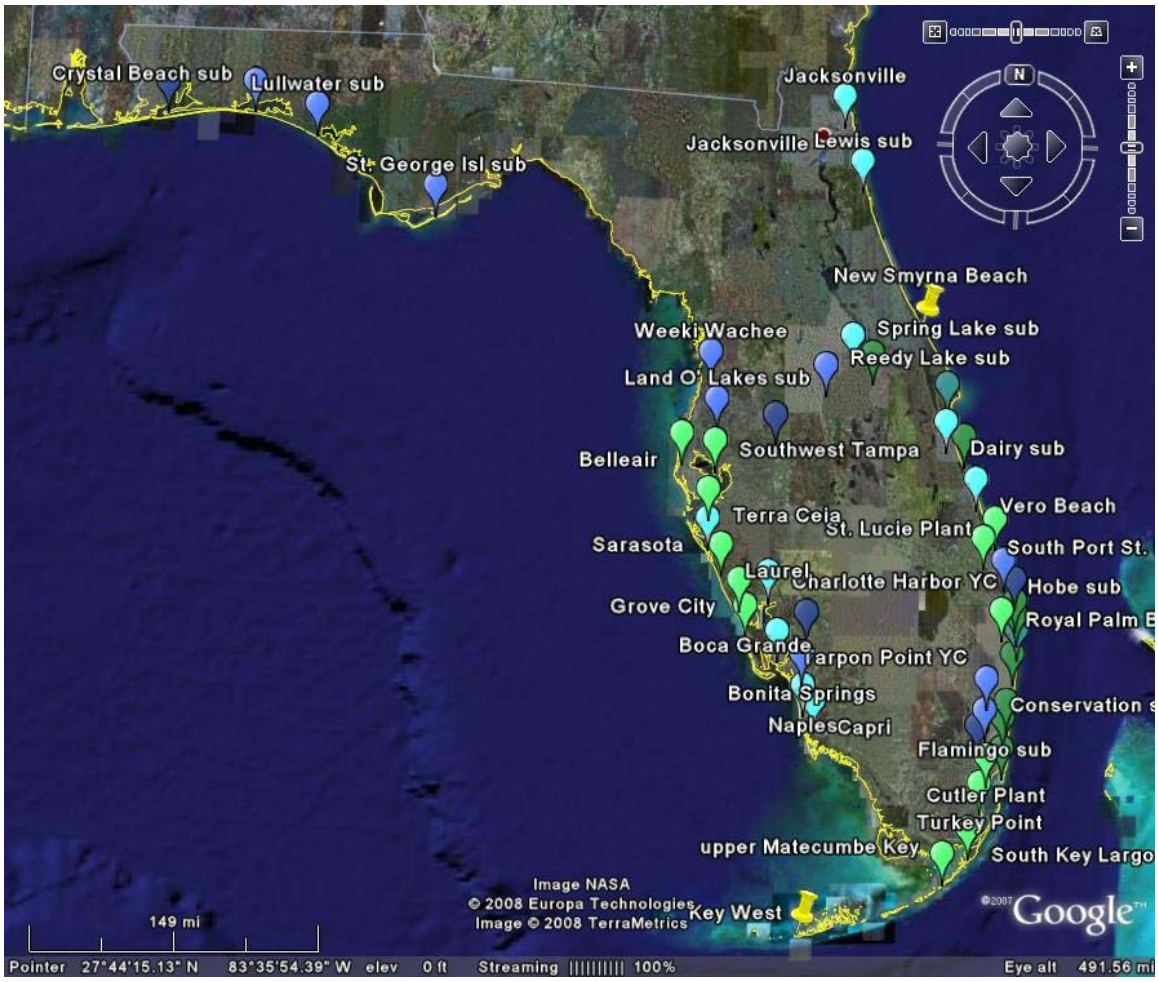
Undergrounding Study		
Personnel		
PURC Faculty (6 weeks)	$ 16,800.00	
Grad Student (5 weeks)	$ 3,300.00	
Administrative (2 weeks)	$ 2,800.00	
		$ 22,900.00
Wind Study		
Personnel		
PURC Faculty (2 weeks)	$ 5,600.00	
Administrative (2 weeks)	$ 2,800.00	
		$ 8,400.00
Travel		
Tallahassee Meeting	$ 300.00	
		$ 300.00
Miscellaneous		
Global Crossing Conference Calls		$ 2,500.00
Subtotal		$ 34,100.00
University Overhead (25%)		$ 11,366.67
Total		$ 45,466.67

Faculty Activities
Examining and editing reports on case studies
Examining and editing reports on ex ante methodology
Examining and editing reports on work plan for testing ex ante methodology
Investigating hurricane models
Performing background research on hardening issues
Drafting report for FPSC
Plan steering committee meeting for early 2008
Organizing and managing weekly conference calls
Attending meetings with FPSC staff or sponsors
Managing PURC staff working on project

Graduate Student Activities
Participating in and taking minutes for weekly conference calls
Maintaining PURC work plan for overseeing projects

Administrative Activities
Proofreading all materials
Taking minutes on conference calls
Organizing conference calls and meetings
Developing all administrative documents, such as contact lists and invoices
Developing budgets
Financial management

Appendix B: Map of Wind Measurement Devices, March 2008 (projected)



(Source: Dr. Kurt Gurley)

Appendix C. Reports on Wind Data Research

Use of WeatherFlow wind observing network for wind energy research

Kurt Gurley, University of Florida
Jay Titlow, WeatherFlow
January 24, 2008

The WeatherFlow (WF) wind observing network is currently being installed in Florida, consisting of 21 operational stations and more coming online in February. A summary of the status of that wind observing network begins on page two for reference.

This wind observing network is being considered for use as a source of information for studies regarding wind energy generation. This document is a summary of our views on the usefulness of the WF data network for this purpose in Florida.

It is clear that final decisions on the efficacy of wind power generation at a given location will require more detailed wind data at a given location than can be provided by the WF sites. However, the WF data can provide an important resource for a first-layer analysis of regions in Florida worthy of additional consideration.

The proper placement of wind turbines requires detailed knowledge of sustained wind magnitude, direction, and turbulence in the regions under consideration. First-level analysis involves the determination of the year-round sustained winds in order to assess the feasibility of wind power generation from these winds. Unfortunately, existing public domain archives (NWS, NODC, etc.) do not represent coastal regions well due to sparse placement of observation stations. Coastal region wind flow is particularly diverse, exhibiting strong variability in sustained wind speed in the transition from the coast to even a few miles inland due to sea breezes and other phenomena specific to coastal wind flow. The existing databases that classify the suitability of winds for power generation do not have the resolution to adequately describe this variability. It is possible that an evaluation of the suitability of a location based on observations made even a few miles inland can miss substantially higher sustained winds at the shoreline.

One of the main motivations for the creation of the WF network is to study these coastal wind flow patterns and quantify the coastal transition features. Preliminary analyses of WF data from the northeast region of the coastal U.S. clearly demonstrate that shoreline winds may be well suited for power generation, even when the predominant wind classification in that region does not support that conclusion (due to a lack of necessary observational resolution when making the classification).

The final placement of wind turbines will require a more thorough analysis of winds than can be offered by the WF network (e.g. at multiple elevations at the same location). However, the existing and still expanding network along the coast of Florida represents a significant new source of information to identify regions worthy of further study. Specifically, these WF sites provide year-round wind information in critical locations where the transitional wind behavior from ocean to inland is not well understood and

poorly documented. After a sufficient period of data collection, this new WF network may indicate wind generation opportunities not yet recognized.

Status of Wind Observing Network for Florida Utilities

Originally distributed December, 2007

Project Summary

WeatherFlow has partnered with the University of Florida and the Florida utilities consortium to design, install, and maintain a wind observation network to collect high quality meteorological information during tropical storms and hurricanes. Measuring the overland ground-level wind behavior during landfall provides information that is useful to utility companies in the process of hardening their infrastructure (power distribution, housing, emergency facilities, etc.) against hurricane wind loads. The wind network reports data to an online database in real-time 24 hours a day, 365 days a year.

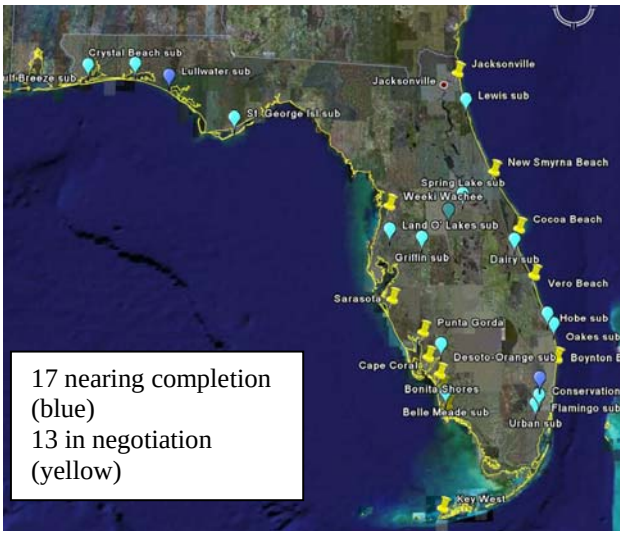
Locations for the fixed sites are selected in cooperation with the University of Florida wind engineering team, and include utility properties, such as substations as well as other state and private property. The instruments are mounted on either existing commercial communication towers or on customized concrete poles designed and installed to support the wind instrumentation.

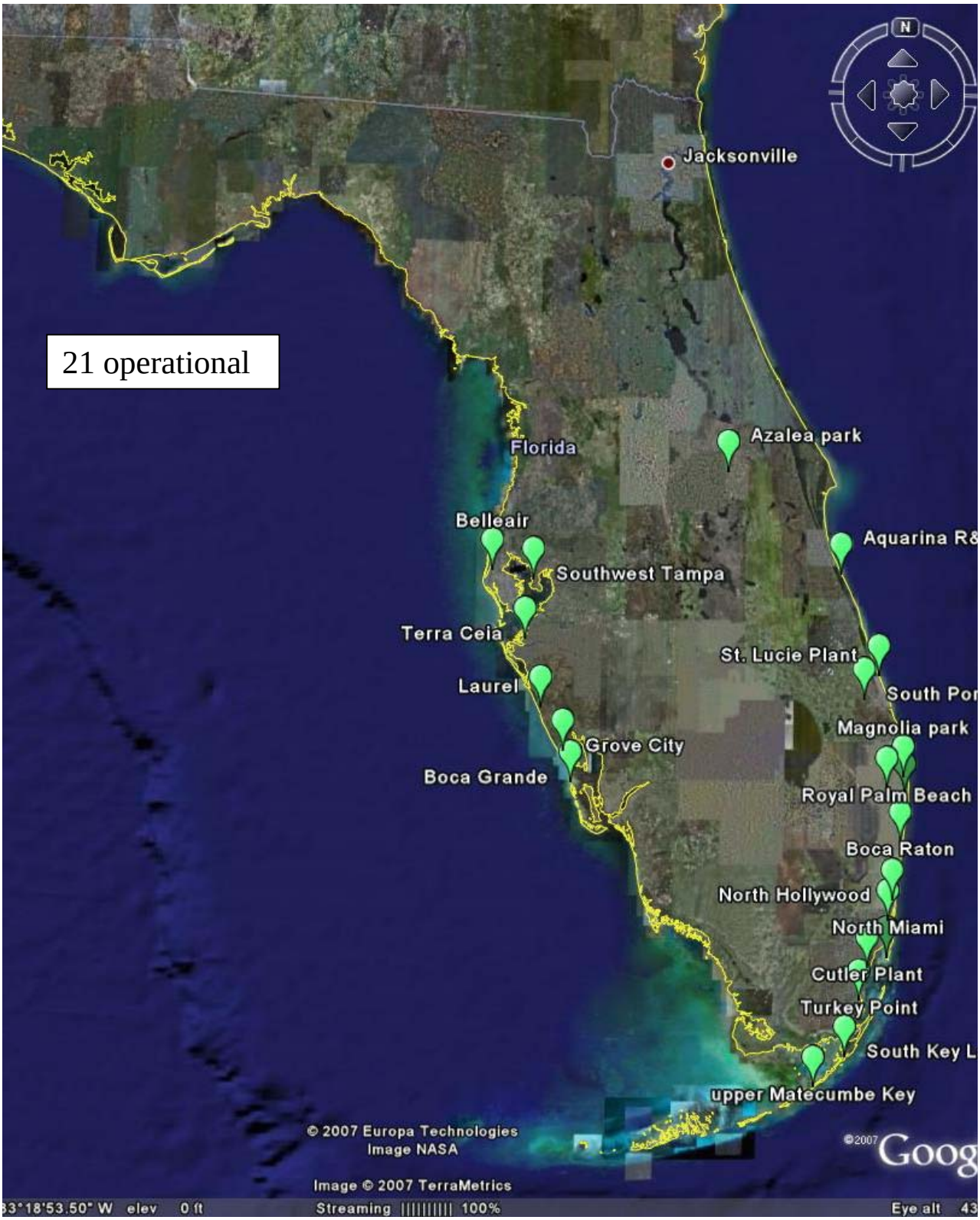
Current and Future Stations

To date WeatherFlow has 21 stations in Florida that are now providing data to the Florida utilities. Two more locations are ready to receive instrumentation, and 15 more are currently awaiting delivery and installation of the concrete pole and instruments. This brings the total number of stations that will be operational by early spring to at least 38. The two figures below show the currently operational stations (green icons) and the stations nearing completion (blue icons). An additional 13 locations are in various stages of negotiation, and more locations are still being identified. A reasonable projection for functional stations by the 2008 hurricane season is 50.

Data Archive Tool

The online database that houses the real-time reported wind, temperature and pressure from each station has recently been updated with an archive retrieval tool. This allows users within the WeatherFlow data-use agreement to access all past data collected by any site in the network. For example, utilities in the southeast can call up and save all data from coastal stations as Hurricane Noel passed Florida in late October.




21 operational
Jacksonville
Florida
Azalea park
Belleair
Aquarina R&
Southwest Tampa
Terra Ceia
St. Lucie Plant
Laurel
South Por
Magnolia park
Grove City
Boca Grande
Royal Palm Beach
Boca Raton
North Hollywood
North Miami
Cutler Plant
Turkey Point
South Key L
upper Matecumbe Key
© 2007 Europa Technologies
Image NASA
Image © 2007 TerraMetrics
Streaming 100%
Eye alt


17 nearing completion (blue)
13 in negotiation (yellow)
Crystal Beach sub
Lullwater sub
St. George Isl sub
Jacksonville
Jacksonville
Lewis sub
New Smyrna Beach
Spring Lake sub
Weeki Wachee
Reedy Lake sub
Land O' Lakes sub
Cocoa Beach
Griffin sub
Dairy sub
Vero Beach
Sarasota
Hobe sub
Punta Gorda
Oakes sub
Desoto-Orange sub
Boynton B
Cape Coral
Bonita Shores
Naples
Conservation
Belle Meade sub
Flamingo sub
Marco Island
Urban sub
Key West
Image © 2007 TerraMetrics
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Image NASA
140 mi
27°56'43.21" N 83°19'43.87" W elev 0 ft
Streaming 100%
Eye alt 459.6
©2007 Google

Appendix D. Wind Data Research Budget for the One Year Agreement with UF

Category	**Description**	**Budget**
Personnel	Students, faculty, lab technicians, fringe	$75,000
Equipment	Hurricane simulator parts and operation, hardware for data collection (poles, etc.)	$72,000
Travel	Site visits, installations	$10,000
Subtotal		$157,000
Indirect cost	25% of expenditures	$39,250
Total Budget		$196,250