EXTREME VELOCITY WIND SENSOR

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Why A Hurricane Wind Sensor?

Kennedy Space Center (KSC) has the need to assess the mechanical stresses induced by high winds in their building and launch and landing structures.

Most buildings and support structures were fabricated prior or during the Apollo Program era.

If a hurricane hits KSC, there is a need to verify safety factors of buildings and support structures have not been exceeded.
Why Another Hurricane Wind Sensor?

- Current wind sensors used at KSC lack in two main areas:
  - Rotating cup or vane type anemometers have a high maintainability due to the wear-and-tear of their moving components.
  - There is a high degree of failure associated with such systems due to damage from extreme wind conditions.

- Experience developed from Hurricane Andrew (1992) demonstrated that existing wind sensing instrumentation would not withstand extreme hurricane winds.
**Why Another Hurricane Wind Sensor?**

- **TMB:** Needle pegged near 127 mph for 3-5 min...about 20 min before worst conditions.
- **177 mph gust (revised from 212 mph) before instrument failed.**
- **Lowest observed surface pressure...near 922 mb.**
- **30 m.p.h. 10-second flight-level wind.**
- **HST:** No data.
- **Turkey Point Power Plant:** Data terminate before worst conditions.
- **139 m.p.h. 10-second flight-level.**
- **176 m.p.h. 10-second flight-level wind.**
- **South Miami:** NHC: 115 mph, gust to 164 mph before instrument failed.
- **187 m.p.h. 10-second flight-level wind.**
- **BK Corp. HQ:** Maximum storm tide of 16.9 ft.
- **Fowey Rocks C-MAN:** 142 mph and gust to 169 mph at 4 a.m. EDT; failed before peak winds.
- **Needle pegged at 114 mph for 13 minutes.**
- **5:05 a.m. EDT:** 145 m.p.h. 922 mb. 175+ m.p.h. gusts.
Why Another Hurricane Wind Sensor?
Why Another Hurricane Wind Sensor?

- Kennedy Space Center (KSC) also has the potential of being subjected to high winds produced by other than hurricanes.

- Strong thunderstorms, small tornadoes and water spouts are normally encountered during the summer.
Our Hurricane Wind Sensor

Project Objectives

• Provide KSC with a wind sensor with the following characteristics:
  • rugged,
  • low profile,
  • highly reliable,
  • self-contained system for wind speed and direction,
  • Capable to measure wind speeds up to 300 mph, wind direction (in 45 degree increments) as well as temperature and RH.

• Provide KSC with a wind sensor design that has no moving parts to reduce operation and maintenance costs.
Our Hurricane Wind Sensor

Conceptual Design

- The Extreme Velocity Wind Sensor is a device for the measurement of wind speed through the use of pressure measurements across a known shape.

- Form is a typical streamlined Venturi profile (a double-inflection curve) revolved 360 degrees about an axis passing vertically through the center of the profile.

- The profile has a series of instrumented ports located near the center and periphery to allow for pressure measurements along the surface.

- The wind speed is calculated from applying Bernoulli's law to the pressure change created between the ports. (Eqn. $P = \frac{1}{2} \rho * k * V^2$).
Our Hurricane Wind Sensor

Conceptual Design

- Wind direction is derived from the pressure profile distributed over the surface. Additionally, temperature and relative humidity measurements are incorporated into the design.

- Project involved the use of multi-discipline sensor technology combined with the development of smart embedded software algorithms.

- Project also incorporated the knowledge developed using Computational Fluid Dynamics (CFD) simulation of the design.
Our Hurricane Wind Sensor

CFD Simulations of design
Our Hurricane Wind Sensor

Pressure Profile - 100 mph

Pressure Profile - 300 mph

CFD Simulations of design
Our Hurricane Wind Sensor

Project Present Status

• A Extreme Velocity Wind Sensor has been designed, developed, fabricated and is being tested at the present time.

• Sensor has been modeled and computer simulation has been performed using CFD software.

• Self-contained electronics has been conceptually designed. Analog section of design has been prototyped and initial testing performed.

• Testing of sensor at Embry Riddle Aeronautical University (ERAU) is scheduled for later this year.
National Aeronautics and
Space Administration

John F. Kennedy Space Center

SPACEPORT
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Wind Speed Sensor Module

Wind Direction Sensor Module
Our Hurricane Wind Sensor

Wind Tunnel Test of 3D Venturi (Static Pressure Time Series)

Record Number

Static Pressure (volts)

Tunnel Speed\(^2\)

Preliminary testing at ERAU
Project Next Steps

• Validate design at extreme wind velocities to 300 mph.

• Integrate methodology for wind direction determination.

• Optimize port locations to achieve best sensitivity and dynamic response.

• Optimize design to provide remote, standalone system capable of autonomously acquiring, recording, and storing storm information.

• Ruggedize the design for field deployment.

• Field deploy and test system.