Lessons Learned From Recent Disasters and the Use of New Technologies For Rapid Recovery

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Director of THC-IT
UH- University of Hurricanes

Presentation to 2017 Texas EM Conference

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Houston, Texas 77204-4003

http://hurricane.egr.uh.edu
THC-IT Objectives

The objectives of the Texas Hurricane Center for Innovative Technology (THC-IT) are:

1. to develop protocols for preparedness and speedy recovery of the public and private sectors (utilities, hospitals, petrochemical industries, transportation facilities, offshore platforms, cities and communities) after a hurricane or any other disaster.

2. to promote interdisciplinary research, education and training to develop state-of-the-art products and technologies to mitigate the wind, flooding and storm surge damages in the built environment and offshore structures due to hurricanes and any other disaster in the Gulf Coast region.

3. to protect the coastline by developing innovative approaches including a new shutter concept. (International Collaboration).

4. to develop a large population based integrated multi-infrastructure model (IM)² (power grids-utilities-commercial-residential-transportation-medical-security) with preparedness, recovery and repair capabilities (THC-(IM)²).

The Center will work with various other federal, state and local agencies and other University affiliates to coordinate the efforts before, during and after a hurricane or any other disaster in the region.
Multi-Infrastructure Model

1. Utilities
   - Water
   - Wastewater
   - Gas
   - Gas Stations

2. Hospitals

3. Residential/Offices

4. Transportation

5. Petrochemical/Commercial

Power Grid

- Generating Station (34.5 KV)
- Step-down Substation (4.16 KV)
- Distributing Substation (480V/208V/120V)
- Transmission Towers

Variables

- GIS
- Population
- Hurricane
- Flooding
- Ice Storm
- Wind Storm
- Coastal Protection
- Debris Clearance
RECENT DISASTERS IN TEXAS AND GULF OF MEXICO

1. Tornados……Dallas, Houston

2. Flooding …. Houston, Louisiana

3. Fire .. Texas

4. Hurricanes…Gulf of Mexico

5. Oil Spills.. Onshore, Offshore

6. Drought .. Texas

7. Corrosion.. Texas, Gulf of Mexico

8. Cyber Attacks.. Texas, Gulf of Mexico
THE EVOLVING WIRELESS WORLD Requires a New Test Approach

Modular instrumentation and FPGA-enabled user programmability are key ingredients in measurement solutions for present-day and enhanced future wireless communications equipment.

Wireless technology is ubiquitous, providing the means for communicating voice, data, and video around the world. It is quickly expanding from just human users to machine-to-machine (M2M) communications and Internet of Things (IoT) sensors connected to the internet for full-time access and control.

Within a decade, the number of connected devices is projected to outnumber people by 10 to 1. As a result, emerging and future wireless communications standards are transforming to address cases involving things as well as human users. The large number of things connected by wireless technologies will require new instrumentation and effective measurement approaches to meet future demands of a wirelessly connected world. The modular PXI instrument approach provides the capability and flexibility to meet those future wireless device measurement needs.

They reflect the changing requirements for technologies like IEEE 802.11ad, IEEE 802.11ax, Bluetooth 5.0, near-field communications (NFC), and more.

USE CASES LOOK TO THE FUTURE

The first wireless use case, Enhanced Mobile Broadband (eMBB), defines the evolution in network capacity and peak data rates expected from a future wireless technology. eMBB technologies will drive higher peak data rates through a combination of wider bandwidths, higher-order modulation schemes, and multiple-input/multiple-output (MIMO)/beamforming technologies.

Specifically for 5G, the eMBB use case is designed to deliver as much as 10-Gb/s downlink throughput, which is 100× the capability of single-carrier Long Term Evolution (LTE) cellular communications systems. The second use case, Massive Machine-Type Communication (mMTC), is designed...
1. COMPUTER DEPENDANCE........Internet/Public

2. HOW TO PROTECT ? (Local Systems)

3. Example: 99 Countries were affected recently
   – Health Care/NIH -Recently

Lost Your Wallet ? Panic..
Hazardous Places in the United States

Here are some highlights of the map, recently published in the New York Times:

- Some of the most hazardous places to live are located close to the border area of the Gulf of Mexico, a region that includes the eastern part of Texas, Louisiana, and Florida.
- The map points out that Dallas, Texas has highest risk of natural disasters.
- Some of the safest places to live are concentrated in the Northwest in states like Washington and Oregon.

Sources: Sperling’s Best Places; National Oceanic and Atmospheric Administration (tornado map); University of Miami (hurricane map); U.S. Geological Survey (earthquake map)

http://www.smartplanet.com/blog/thinking-tech/infographic-which-american-cities-are-most-vulnerable-to-natural-disasters/7114
Great State of Texas

What Disasters?

1. TORNADOS?
2. FLOODING?
3. Oil and Gas Wells?
4. Hurricane
5. Oil spill
WHY New Technologies?

(1) Increasing Number of Disasters

(2) Increasing Population and Industrial Growth

(3) Environmental Concerns

(4) New Technologies Can be Combined For Preparedness and Rapid Recovery. (Monitoring, Preparedness and Materials)
U.S. Drought Monitor
Texas

Drought Condition (Percent Area):

<table>
<thead>
<tr>
<th>Week</th>
<th>Date</th>
<th>Nothing</th>
<th>D0-D4</th>
<th>D1-D4</th>
<th>D2-D4</th>
<th>D3-D4</th>
<th>D4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current</td>
<td>4/8/2014</td>
<td>17.48</td>
<td>32.52</td>
<td>63.53</td>
<td>40.46</td>
<td>27.80</td>
<td>7.09</td>
</tr>
<tr>
<td>Last Week</td>
<td>4/1/2014</td>
<td>15.40</td>
<td>34.60</td>
<td>66.80</td>
<td>42.06</td>
<td>27.36</td>
<td>4.42</td>
</tr>
<tr>
<td>3 Months Ago</td>
<td>1/7/2014</td>
<td>28.13</td>
<td>71.87</td>
<td>43.89</td>
<td>29.84</td>
<td>5.82</td>
<td>0.79</td>
</tr>
<tr>
<td>Start of Calendar Year</td>
<td>12/31/2013</td>
<td>26.48</td>
<td>71.52</td>
<td>43.84</td>
<td>21.15</td>
<td>5.82</td>
<td>0.79</td>
</tr>
<tr>
<td>Start of Water Year</td>
<td>10/1/2013</td>
<td>6.62</td>
<td>93.38</td>
<td>70.05</td>
<td>25.06</td>
<td>4.01</td>
<td>0.12</td>
</tr>
<tr>
<td>One Year Ago</td>
<td>4/9/2013</td>
<td>0.44</td>
<td>99.56</td>
<td>99.44</td>
<td>69.35</td>
<td>29.91</td>
<td>11.56</td>
</tr>
</tbody>
</table>

View More Statistics

Intensity:
- D0 - Abnormally Dry
- D1 - Moderate Drought
- D2 - Severe Drought
- D3 - Extreme Drought
- D4 - Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

http://droughtmonitor.unl.edu/Home/StateDroughtMonitor.aspx?TX
Earthquakes/Tremors in Texas?

1847 - 2004

2005 - 2015

http://www.ig.utexas.edu/research/seismology/TXEQ/faq_tx.html
Tornado, Hail & Wind in Texas

YEAR 2010

Tornado in Dallas. April 2017

Damage to Car Sales Facility: ROOF FAILURE?
NEIGHBORHOOD DAMAGES, DALLAS
Tornado touched down in southwest Houston - ABC13 Houston
abc13.com/weather/tornado-touched-down-in-southwest-houston/1820960/
Mar 29, 2017 - Tornado touched down in southwest Houston. ... Severe storms moved through the Houston area throughout the day Wednesday, leaving damage behind. The National Weather Service confirms that a tornado touched down in southwest Houston this morning.

KTRK Houston Weather Alerts | abc13.com
abc13.com/weather/alerts/
The ABC13 News Weather Alerts page keeps you informed on the latest with Houston weather and the surrounding area so that you can stay safe.

5 tornadoes confirmed in Houston area, NWS says - Click2Houston
www.click2houston.com/.../powerful-storms-leave-behind-damage-in-houston-area-1
Mar 29, 2017 - HOUSTON - Storm survey teams have confirmed that five tornadoes ... A line of storms roared through the Houston area Wednesday, .... WEATHER UPDATE: The Shell Houston Open Grand Pro-Am is cancelled for today.

Tornado touches down near Bellaire as severe storms rake Houston ...
www.chron.com/.../houston/.../Hail-isolated-tornadoes-could-hit-Houston-11035516.p...
Mar 30, 2017 - Tornado touches down near Bellaire as severe storms rake Houston area. By John Boyd, Chron.com / Houston Chronicle, Margaret Kadifa, ...

Tornado reported near Houston as severe storms batter ... - USA Today
https://www.usatoday.com/story/weather/2017/02/14/.../storms-tornadoes/97890062/
Feb 14, 2017 - At least one tornado was spotted near Houston. ... said nearly 21,000 customers in the Houston area were without power as of 9 a.m. CT.

NWS confirms 4 tornadoes hit Houston area Wednesday | khou.com
www.khou.com/news/local/nws-confirms-4-tornadoes...houston-area/.../426937183
Mar 30, 2017 - The National Weather service confirmed four tornadoes hit the Houston area Wednesday.
# Characterization of the Flooding

## Table 1. Billion Dollar Flooding Events in the U.S

<table>
<thead>
<tr>
<th>Event</th>
<th>Impacted Areas</th>
<th>Affected Population</th>
<th>Losses</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gulf States Storms and Flooding</td>
<td>TX, AR, LA, MS, AL, GA, and FL</td>
<td>45 deaths</td>
<td>$3.6 billion</td>
<td>Severe storms and flooding, especially in the states of TX, AR, LA, MS, AL, GA, and FL</td>
</tr>
<tr>
<td>December 1982-January 1983</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Southern Flooding</td>
<td>TX, OK, LA, and AR</td>
<td>13 deaths</td>
<td>$1.8 billion</td>
<td>Torrential rains cause flooding along the Trinity, Red, and Arkansas Rivers in TX, OK, LA, and AR</td>
</tr>
<tr>
<td>May 1990</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Texas Flooding</td>
<td>Southeast Texas</td>
<td>19 deaths</td>
<td>$1.6 billion</td>
<td>Torrential rain (10-25 inches in 5 days) and thunderstorms cause flooding across much of southeast Texas</td>
</tr>
<tr>
<td>October 1994</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Texas Flooding</td>
<td>Texas</td>
<td>31 deaths</td>
<td>$1.4 billion</td>
<td>Severe flooding in southeast Texas from 2 heavy rain events, with 10-20 inch rainfall totals.</td>
</tr>
<tr>
<td>October 1998</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Texas and Oklahoma Flooding and Severe Weather†</td>
<td>Texas and also other states (KS, CO, AR, OH, LA, GA, SC)</td>
<td>31 deaths</td>
<td>$2.5 billion</td>
<td>A slow-moving system caused tremendous rainfall and subsequent flooding to occur in Texas and Oklahoma. The Blanco river in Texas swelled from 5 feet to a crest of more than 40 feet over several hours causing considerable property damage and loss of life. The city of Houston also experienced flooding which resulted in hundreds of high-water rescues. The damage in Texas alone exceeded $1.0 billion.</td>
</tr>
<tr>
<td>May 2015</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Texas and Louisiana Flooding†</td>
<td>Texas and Louisiana</td>
<td>5 deaths</td>
<td>$1.3 billion</td>
<td>Multiple days of heavy rainfall averaging 15 to 20 inches led to widespread flooding along the Sabine River basin on the Texas and Louisiana border. This prompted numerous evacuations, high-water rescues and destruction, as more than 1,000 homes and businesses were damaged or destroyed.</td>
</tr>
<tr>
<td>March 2016</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Houston Flooding†</td>
<td>Houston</td>
<td>8 deaths</td>
<td>$1.2 billion</td>
<td>A period of extreme rainfall up to 17 inches created widespread urban flooding in Houston and surrounding suburbs. Over 1,000 homes and businesses were damaged in addition to more than 1,800 high water rescues. This represents the most widespread flooding event to affect Houston since Tropical Storm Allison in 2001.</td>
</tr>
<tr>
<td>April 2016</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

http://www.ncdc.noaa.gov/billions/events
Louisiana flood damage at least $8.7 billion, governor says

By EMILY WAGSTER PETTUS and MELINDA DESLATTE - Associated Press - Saturday, September 3, 2016

BATON ROUGE, La. (AP) - Louisiana Gov. John Bel Edwards says his state had more than $8.7 billion in damage from catastrophic flooding in August, and the figure will increase as officials finish assessing damage to roads and other public infrastructure.

In it, the Democratic governor asked that Congress this month approve $2 billion in federal aid for Louisiana for housing, economic development and infrastructure. He said it's a "very reasonable request," adding to other programs assisting in Louisiana's flood recovery, such as aid from the Federal Emergency Management Agency.

"While short-term relief for immediate needs available through FEMA for items such as temporary rental assistance, essential home repairs and other disaster-related needs are greatly needed and greatly appreciated, our full recovery will not be realized without additional help," Edwards wrote.

A storm that started Aug. 12 dumped as much as 2 feet of rain in some parts of Louisiana over two days, and the flooding has been described as the worst disaster in the U.S. since Superstorm Sandy struck the East Coast in 2012.
FLOATABLE WOOD DEBRIS

U. 59 and San Jacinto River Debris April 15, 2016 Flooding
1. Recovery? --Getting to Galveston .....How?
## Hurricanes and Debris

### Quantities of Debris After the Three Worst Hurricanes in the U.S.

<table>
<thead>
<tr>
<th>Event</th>
<th>Types of Debris</th>
<th>Quantity of Debris</th>
<th>Cost of Removal</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hurricane Katrina</strong></td>
<td>Curbside Debris, White Goods, Freon removal, Electronic Goods, Waste Containers, Hazardous waste Nonhazardous waste</td>
<td>3.4 million CY in Alabama! 45.8 million CY in Mississippi! 64.3 million CY in Louisiana!</td>
<td>$3.4 billion</td>
<td>Katrina disaster recovery presents the most massive clean-up in America’s history.</td>
</tr>
<tr>
<td><strong>Hurricane Ike</strong></td>
<td>Trees, White Goods, Hazardous waste Nonhazardous waste</td>
<td>5.0 million CY</td>
<td>$697.1 million</td>
<td>Total 1.2 million CY of sand was removed to a 12-inch depth.</td>
</tr>
<tr>
<td><strong>Hurricane Sandy</strong></td>
<td>construction &amp; demolition, Hazardous waste Nonhazardous waste</td>
<td>6.2 million CY</td>
<td>$675.5 million</td>
<td>Waterway debris More than 100,000 CY construction &amp; demolition debris, 195 cars &amp; vessels, 4 houses, 400,000 CY sediment</td>
</tr>
</tbody>
</table>
Quantification of Debris

Debris Volume and Debris Management Site Acreage Requirement by Category

<table>
<thead>
<tr>
<th>Strength</th>
<th>Volume of Debris (Cubic Yards)</th>
<th>Acreage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category 1</td>
<td>110,000</td>
<td>11</td>
</tr>
<tr>
<td>Category 2</td>
<td>430,000</td>
<td>44</td>
</tr>
<tr>
<td>Category 3</td>
<td>1,400,000</td>
<td>144</td>
</tr>
<tr>
<td>Category 4</td>
<td>2,700,000</td>
<td>278</td>
</tr>
<tr>
<td>Category 5</td>
<td>4,310,000</td>
<td>443</td>
</tr>
</tbody>
</table>
The USACE Hurricane Debris Estimating Model is designed to predict quantities of debris produced in urban/suburban areas.

\[ Q = H \times C \times V \times B \times S \]

- \( Q \) is the quantity of debris in cubic yards.
- \( H \) is the number of households.
- \( C \) is the storm category factor in cubic yards.
- \( V \) is the vegetation characteristic multiplier.
- \( B \) is the storm precipitation characteristic multiplier.
Factors

- **C** is the storm category factor as shown below. It expresses debris quantity in cubic yards (cy) per household by hurricane category and includes the house and its contents, and land foliage.

- **V** is the vegetation multiplier as shown below. It acts to increase the quantity of debris by adding vegetation, including shrubbery and trees, on public rights-of-way.

- **B** is the multiplier that takes into account areas that are not solely single-family residential, but includes small retail stores, schools, apartments, shopping centers, and light industrial/manufacturing facilities.

- **S** is the precipitation multiplier that takes into account either a “wet” or “dry” storm event. A “wet” storm for category 3 or greater storms will generate more vegetative debris due to the uprooting of complete trees.

<table>
<thead>
<tr>
<th>Hurricane Category</th>
<th>Value of “C” Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2 cy</td>
</tr>
<tr>
<td>2</td>
<td>8 cy</td>
</tr>
<tr>
<td>3</td>
<td>26 cy</td>
</tr>
<tr>
<td>4</td>
<td>50 cy</td>
</tr>
<tr>
<td>5</td>
<td>80 cy</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vegetative Cover</th>
<th>Value of “V” Multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light</td>
<td>1.1</td>
</tr>
<tr>
<td>Medium</td>
<td>1.3</td>
</tr>
<tr>
<td>Heavy</td>
<td>1.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Commercial Density</th>
<th>Value of “B” Multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light</td>
<td>1.0</td>
</tr>
<tr>
<td>Medium</td>
<td>1.2</td>
</tr>
<tr>
<td>Heavy</td>
<td>1.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Precipitation Characteristic</th>
<th>Value of “S” Multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light</td>
<td>1.1</td>
</tr>
<tr>
<td>Medium</td>
<td>1.3</td>
</tr>
<tr>
<td>Heavy</td>
<td>1.5</td>
</tr>
</tbody>
</table>
Flood Protection Systems

1. Temporary Storage Systems
   (a) Expandable storage drums next to highways and neighborhoods
   (b) Pumped out lakes and underground storage tanks
   (c) Dams with Shutters and recycle of rainwater

2. Expandable Drainage/Storm Sewer Systems
National Treasures (Gulf of Mexico)

4,000 platforms
35,000 miles of pipelines
15,000 wells

2\textsuperscript{nd} Largest Source of Income
<table>
<thead>
<tr>
<th>State</th>
<th>General Coastline</th>
<th>Tidal Shoreline</th>
<th>Hurricanes(1851-2016)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Actual Length (miles)</td>
<td>Percentage of U.S</td>
<td>Actual Length (miles)</td>
</tr>
<tr>
<td>Gulf of Coast</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alabama</td>
<td>53</td>
<td>0.43</td>
<td>607</td>
</tr>
<tr>
<td>Florida (Gulf)</td>
<td>770</td>
<td>6.21</td>
<td>5,095</td>
</tr>
<tr>
<td>Louisiana</td>
<td>397</td>
<td>3.21</td>
<td>7,721</td>
</tr>
<tr>
<td>Mississippi</td>
<td>44</td>
<td>0.36</td>
<td>359</td>
</tr>
<tr>
<td>Texas</td>
<td>367</td>
<td>2.96</td>
<td>3,359</td>
</tr>
<tr>
<td>Total Coast</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gulf</td>
<td>1,631</td>
<td>13.17</td>
<td>17,141</td>
</tr>
<tr>
<td>Atlantic</td>
<td>2,069</td>
<td>16.71</td>
<td>28,673</td>
</tr>
<tr>
<td>Pacific</td>
<td>7,623</td>
<td>61.56</td>
<td>40,298</td>
</tr>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>U.S</td>
<td>12,383</td>
<td>100</td>
<td>88,633</td>
</tr>
<tr>
<td>No.</td>
<td>County</td>
<td>Cities</td>
<td>Population</td>
</tr>
<tr>
<td>-----</td>
<td>------------</td>
<td>-----------------</td>
<td>-------------</td>
</tr>
<tr>
<td>1</td>
<td>Cameron</td>
<td>Brownsville</td>
<td>16,095</td>
</tr>
<tr>
<td>2</td>
<td>Willacy</td>
<td></td>
<td>1,033</td>
</tr>
<tr>
<td>3</td>
<td>Kenedy</td>
<td></td>
<td>701</td>
</tr>
<tr>
<td>4</td>
<td>Kleberg</td>
<td></td>
<td>7,837</td>
</tr>
<tr>
<td>5</td>
<td>Nueces</td>
<td>Corpus Christi</td>
<td>10,439</td>
</tr>
<tr>
<td>6</td>
<td>San Patricio</td>
<td></td>
<td>2,372</td>
</tr>
<tr>
<td>7</td>
<td>Aransas</td>
<td></td>
<td>1,716</td>
</tr>
<tr>
<td>8</td>
<td>Refugio</td>
<td></td>
<td>1,641</td>
</tr>
<tr>
<td>9</td>
<td>Calhoun</td>
<td>Port O'Connor</td>
<td>2,395</td>
</tr>
<tr>
<td>10</td>
<td>Jackson</td>
<td></td>
<td>6,094</td>
</tr>
<tr>
<td>11</td>
<td>Matagorda</td>
<td></td>
<td>6,097</td>
</tr>
<tr>
<td>12</td>
<td>Brazoria</td>
<td></td>
<td>14,861</td>
</tr>
<tr>
<td>13</td>
<td>Galveston</td>
<td>Galveston</td>
<td>44,116</td>
</tr>
<tr>
<td>14</td>
<td>Chambers</td>
<td></td>
<td>3,046</td>
</tr>
<tr>
<td>15</td>
<td>Jefferson</td>
<td>Port Arthur, Beaumont</td>
<td>14,239</td>
</tr>
<tr>
<td></td>
<td>Texas</td>
<td>6 Cities</td>
<td>132,682</td>
</tr>
</tbody>
</table>

**Additional Counties Vulnerable to Hurricanes**

<table>
<thead>
<tr>
<th>No.</th>
<th>County</th>
<th>Cities</th>
<th>Population</th>
<th>%/yr</th>
<th>Category and Number of Hurricanes</th>
<th>Total</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>Harris</td>
<td>Houston</td>
<td>63,786</td>
<td>56.9</td>
<td>3 4 1 2 0</td>
<td>7 3</td>
<td>Highest population growth</td>
</tr>
<tr>
<td>17</td>
<td>Orange</td>
<td></td>
<td>5,905</td>
<td>15.5</td>
<td>2 1 1 1 0</td>
<td>3 2</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Fort Bend</td>
<td>Sugar Land</td>
<td>30,000*</td>
<td>14.6</td>
<td>2 1 1 1 0</td>
<td>0</td>
<td>Second largest population</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>8 Cities</td>
<td>232,373</td>
<td>24.6</td>
<td>14 11 11 6 0</td>
<td>25 17</td>
<td>30% of Texas Population</td>
</tr>
</tbody>
</table>

* Best Estimates
Table 1. History of Hurricanes in Texas Coast with Death & Damage

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Audrey</td>
<td>06/27/1957</td>
<td>Cameron, Louisiana and Sabine Pass</td>
<td>9</td>
<td>150</td>
<td>4</td>
<td>NOAA</td>
</tr>
<tr>
<td>Debra</td>
<td>07/24/1959</td>
<td>Freeport, Galveston</td>
<td>0</td>
<td>7</td>
<td>1</td>
<td>NOAA</td>
</tr>
<tr>
<td>Carla</td>
<td>09/14/1961</td>
<td>Port Lavaca</td>
<td>31</td>
<td>400</td>
<td>4</td>
<td>NOAA</td>
</tr>
<tr>
<td>Cindy</td>
<td>09/17/1963</td>
<td>High Island</td>
<td>3</td>
<td>13</td>
<td>1</td>
<td>NOAA</td>
</tr>
<tr>
<td>Beulah</td>
<td>09/20/1967</td>
<td>Padre Island</td>
<td>58</td>
<td>0</td>
<td>3</td>
<td>NOAA</td>
</tr>
<tr>
<td>Celia</td>
<td>08/03/1970</td>
<td>Corpus Christi</td>
<td>0</td>
<td>454</td>
<td>3</td>
<td>NOAA</td>
</tr>
<tr>
<td>Fern</td>
<td>09/09/1971</td>
<td>Freeport, Matagorda</td>
<td>0</td>
<td>30</td>
<td>1</td>
<td>NOAA</td>
</tr>
<tr>
<td>Allen</td>
<td>08/10/1980</td>
<td>Brownsville</td>
<td>7</td>
<td>300</td>
<td>3</td>
<td>NOAA</td>
</tr>
<tr>
<td>Alicia</td>
<td>08/17/1983</td>
<td>Galveston</td>
<td>21</td>
<td>2 billion</td>
<td>3</td>
<td>NOAA</td>
</tr>
<tr>
<td>Bonnie</td>
<td>06/26/1986</td>
<td>High Island</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>NOAA</td>
</tr>
<tr>
<td>Chantal</td>
<td>08/01/1989</td>
<td>High Island</td>
<td>13</td>
<td>100</td>
<td>1</td>
<td>NOAA</td>
</tr>
<tr>
<td>Jerry</td>
<td>10/15/1989</td>
<td>Galveston</td>
<td>3</td>
<td>70</td>
<td>1</td>
<td>NOAA</td>
</tr>
<tr>
<td>Claudette</td>
<td>07/08/2003</td>
<td>Matagordla</td>
<td>1</td>
<td>180</td>
<td>1</td>
<td>NOAA</td>
</tr>
<tr>
<td>Rita</td>
<td>09/17/2005</td>
<td>Jasper</td>
<td>113</td>
<td>10 billion</td>
<td>3</td>
<td>NOAA</td>
</tr>
<tr>
<td>Ike</td>
<td>09/01/2008</td>
<td>Galveston, Houston</td>
<td>81</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

>29 billion

2
Gulf of Mexico Hurricane Tracks (1990 – 2016)

Total No -15 (Category ≥ 3)
Recent Hurricanes and Lessons Learned (3 Worst Hurricanes)

Estimated Losses Atlantic Hurricanes
Cost refers to total estimated property damage

<table>
<thead>
<tr>
<th>Rank</th>
<th>Hurricane</th>
<th>Season</th>
<th>Damage (billion $)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Katrina</td>
<td>2005</td>
<td>108</td>
</tr>
<tr>
<td>2</td>
<td>Sandy</td>
<td>2012</td>
<td>65</td>
</tr>
<tr>
<td>3</td>
<td>Ike</td>
<td>2008</td>
<td>29.5</td>
</tr>
</tbody>
</table>

Source: National Hurricane Center
Paths of Hurricane Sandy, Ike and Katrina
U.S. Gulf Coast Region (NOAA Website)
**Analyses**

**Table 1 Hurricane Prediction of Atlantic Hurricane Season by FSU, NOAA, and CSU**

<table>
<thead>
<tr>
<th>Year</th>
<th>FSU</th>
<th>NOAA</th>
<th>CSU</th>
<th>Actual number</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TNS</td>
<td>H</td>
<td>TNS</td>
<td>H</td>
<td>TNS</td>
</tr>
<tr>
<td>2016</td>
<td>NA</td>
<td>NA</td>
<td>70% probability of 10-16</td>
<td>70% probability of 4-8</td>
<td>14</td>
</tr>
<tr>
<td>2015</td>
<td>12-17</td>
<td>4-8</td>
<td>70% probability of 6-11</td>
<td>70% probability of 3-6</td>
<td>8</td>
</tr>
<tr>
<td>2014</td>
<td>70% change of 5-9</td>
<td>70% chance of 2-6</td>
<td>70% probability of 8-13</td>
<td>70% probability of 3-6</td>
<td>9</td>
</tr>
<tr>
<td>2013</td>
<td>15</td>
<td>8</td>
<td>13 - 20</td>
<td>7-11</td>
<td>18</td>
</tr>
<tr>
<td>2012</td>
<td>13</td>
<td>7</td>
<td>70% chance of 9-15</td>
<td>70% chance of 4-8</td>
<td>10</td>
</tr>
</tbody>
</table>

Gulf of Mexico?
Analytical Method: Hurricane Frequency - Poisson’s Distribution

\[ f(h) = \exp(-\lambda) \times \lambda^h / h! ; \ (h=0,1,2,...) \]

where \( h \) is the number of hurricane per year, \( \lambda \) is the expected number of hurricanes during a year.
# THC Hurricane Predictions for Year 2016 (Update: June 1, 2016)

<table>
<thead>
<tr>
<th>Forecaster</th>
<th>Date of forecast</th>
<th>Number of Atlantic Storms</th>
<th>Number of Hurricanes</th>
<th>Number of Hurricanes entering the Gulf of Mexico</th>
<th>Number of Hurricanes entering Texas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colorado State University (CSC)</td>
<td>June 01, 2016</td>
<td>14</td>
<td>6</td>
<td>Not available</td>
<td>Not available</td>
</tr>
<tr>
<td>Tropical Storm Risk (London, England)</td>
<td>May 27, 2016</td>
<td>17</td>
<td>9</td>
<td>Not available</td>
<td>Not available</td>
</tr>
<tr>
<td>North Carolina State University (NCSU)</td>
<td>April 15, 2016</td>
<td>15-18</td>
<td>8-11</td>
<td>Not available</td>
<td>Not available</td>
</tr>
<tr>
<td>National Oceanic and Atmospheric Administration (NOAA)</td>
<td>May 27, 2016</td>
<td>70% probability of 10 - 16</td>
<td>70% probability of 4 - 8</td>
<td>Not available</td>
<td>Not available</td>
</tr>
<tr>
<td>Meteorological Office (UK)</td>
<td>May 12, 2016</td>
<td>14</td>
<td>8</td>
<td>Not available</td>
<td>Not available</td>
</tr>
<tr>
<td>Texas Hurricane Center University of Houston (THC-IT)</td>
<td>June 01, 2016</td>
<td>Not available</td>
<td>Not available</td>
<td>No hurricane: 34% 1 hurricane: 37% 2 hurricane: 20%</td>
<td>No hurricane: 71% 1 hurricane: 25% 2 hurricane: 4%</td>
</tr>
</tbody>
</table>
Storm Paths in Galveston, Texas

Isaac Storm 1900

Ike storm 2008

https://sites.google.com/a/richmond.k12.wi.us/gt-ed-at-richmond/home/5th-grade
http://www.lawrencevilleweather.com/storms/2008/atlantic/ike.html
Summary and Conclusions

• U.S. Coast Must be Protected from Major Disasters.

• Combine New Ideas and Technologies to be Prepared.

• Rapid Recovery protocols must be developed for the region.
Controlling and Monitoring of Coastal Erosion andFlooding: Current Practices and New Solutions

http://hurricane.egr.uh.edu/
## Length of Coastline and Hurricanes

<table>
<thead>
<tr>
<th>State</th>
<th>General Coastline</th>
<th>Tidal Shoreline</th>
<th>Hurricanes(1851-2016)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Actual Length (miles)</td>
<td>Percentage of U.S</td>
<td>Actual Length (miles)</td>
<td>Percentage of U.S</td>
</tr>
<tr>
<td><strong>Gulf of Coast</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alabama</td>
<td>53</td>
<td>0.43</td>
<td>607</td>
<td>0.68</td>
</tr>
<tr>
<td>Florida (Gulf)</td>
<td>770</td>
<td>6.21</td>
<td>5,095</td>
<td>5.75</td>
</tr>
<tr>
<td>Louisiana</td>
<td>397</td>
<td>3.21</td>
<td>7,721</td>
<td>8.71</td>
</tr>
<tr>
<td>Mississippi</td>
<td>44</td>
<td>0.36</td>
<td>359</td>
<td>0.41</td>
</tr>
<tr>
<td>Texas</td>
<td>367</td>
<td>2.96</td>
<td>3,359</td>
<td>3.79</td>
</tr>
<tr>
<td><strong>Total Coast</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gulf</td>
<td>1,631</td>
<td>13.17</td>
<td>17,141</td>
<td>19.34</td>
</tr>
<tr>
<td>Atlantic</td>
<td>2,069</td>
<td>16.71</td>
<td>28,673</td>
<td>32.35</td>
</tr>
<tr>
<td>Pacific</td>
<td>7,623</td>
<td>61.56</td>
<td>40,298</td>
<td>45.47</td>
</tr>
<tr>
<td>Artic</td>
<td>1,060</td>
<td>8.56</td>
<td>2,521</td>
<td>2.84</td>
</tr>
<tr>
<td>U.S</td>
<td>12,383</td>
<td>100</td>
<td>88,633</td>
<td>100</td>
</tr>
</tbody>
</table>
Major Disaster Management Triangle

Coastal Erosion

Flooding

Debris

Disaster Management ........$?

$ 4 to 5 Billion/year

Cost ?
Objectives

The overall objective was to investigate the issues related to coastal erosion, flooding and floating debris. The specific objectives are as follows:

• **Characterize the types of coastlines**, quantify the erosion and evaluate the coast protection methods.

• **Characterize the types of inland and coastal flooding**, evaluate the monitoring systems, and evaluate the flood protection methods.

• **Characterize the types of floating debris**, evaluate the monitoring systems, and evaluate the debris removal methods.

Also potential for developing new theories to quantify coastal erosion, flooding and floating debris and integration of new technologies will be evaluated.
Coastal Erosion
(Dynamic Geo-Physical-Bio-Chemical Continuous Process)

• There are number of factors influencing the coastal erosion and erosion rates are as follows:
  • (a) type of geological formations exposed along the coast – natural resistance to erosion
  • (b) waves, wind and local flooding – driving force
  • (c) engineered coastal protections – artificial protections and
  • (d) weather and sea level changes – environmental conditions.

Coastal erosion typically results in a landward retreat of the coastline resulting in salt-water into fresh water area.
Characterization (3 Types)

- **Type 1** Rock Coastline
- **Type 2** Rock and Soil Coastline
- **Type 3** Soil Coastline
Distribution of Types of Coastlines in the U.S.

1. Ecola State Park, Oregon
2. Glass Beach, California
3. Lanikai Beach, Hawaii
4. Gulf of Mexico, Texas
5. Gulf State Park, Alabama
6. Jupiter Island, Florida
7. Rutherford Beach, Louisiana
8. Gulf of Mexico, Texas
9. Cape May, New Jersey
10. Cumberland Island, Georgia
11. Assateague Island, Maryland
12. Hampton Beach, New Hampton
13. Hammonasset State Park, Connecticut
14. Sand Beach, Maine
15. Cape Disappointment State Park, Washington

The map shows the distribution of types of coastlines in the U.S., with the top 15 locations highlighted.
## Erosion Rates and Cost in the U.S.

### Table 2. Erosion Rates and Cost in the U.S.

<table>
<thead>
<tr>
<th>Shorelines</th>
<th>Coastal Erosion, Erosion Rate (m/Year)</th>
<th>Cost (Millions of Dollars)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Long Term</td>
<td>Mean</td>
</tr>
<tr>
<td>Gulf Coast</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alabama</td>
<td>-0.4 ± 0.8 [1]</td>
<td>-1.1 [4]</td>
</tr>
<tr>
<td>Mississippi</td>
<td>-2.3 ± 1.9 [1]</td>
<td>-0.6 [4]</td>
</tr>
<tr>
<td>Texas</td>
<td>-0.7 ± 1.7 [1]</td>
<td>-1.2 [4]</td>
</tr>
<tr>
<td>Pacific Coast</td>
<td>0.9 ± 0.07 [3]</td>
<td>-0.005 – 0 [4]</td>
</tr>
<tr>
<td>U.S.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Energy Rate is Causing Erosion (New Hyperbolic Model)

(b) Quantification (Fluid Induced Erosion)

- Shear Stress in Hyperbolic form is defined as Eq. (1)
  \[
  \tau = \frac{\dot{\gamma}}{A + B\dot{\gamma}} \quad (1)
  \]
- At critical strain rate the Hyperbolic shear stress is shown in Eq. (2)
  \[
  \tau_c = \frac{\dot{\gamma}_c}{A + B\dot{\gamma}_c} \quad (2)
  \]
- Energy rate per unit volume \( \dot{\varepsilon} \left( \frac{Pa}{s} \right) \) is
  \[
  \dot{\varepsilon} = \int d\dot{\varepsilon} = \int \tau d\dot{\gamma} \quad (3)
  \]
- Substituting shear stress Eq. (1) in Eq. (3), the energy rate will be derived as Eq. (4)
  \[
  \dot{\varepsilon} = -\frac{A \ln|A + B\dot{\gamma}|}{B^2} + \frac{\dot{\gamma}}{B} + C \quad (4)
  \]
Coastal Erosion

- (c) Monitoring
  - The Global Position System (GPS)
  - Light Detection and Ranging (LiDAR) surveys are used to measure the costal profile changes.
  - There are no real-time monitoring tools available for coastal erosion monitoring, where not only the location but also the material losses have to be quantified.
(c) Proposed Monitoring

Drone/Birds (Monitoring)!

Erosion rate = m/year .....1D

Erosion rate = Volume/year .....3D
(d) Protection (Needs Improvement)

- **(d) Protection**
  There are few common forms of coastal erosion control methods. These include: soft-erosion controls, hard-erosion controls, and others.

- **Long-term erosion controls**
  *Seawalls, dikes, wave breakers and groynes* serve as semi-permanent infrastructure. These structures are not immune from normal wear-and-tear and will have to be refurbished or rebuilt. It is estimated the average life span of a seawall is 50–100 years and the average for a groyne is 30–40 years.

- **Short-term erosion controls**
  These options, including *sandbags* and beach nourishments which are not intended to be long term solutions or permanent solutions. Another method, beach scraping or beach bulldozing allows for the creation of an artificial dune in front of a building or as means of preserving a building foundation.

- **New Methods for erosion controls**
  1. Artificial Islands to break waves,
  2. Geosynthetic membranes,
  3. Grouting
CONCLUSIONS

• Need to Develop Coastal Erosion Monitoring, Controlling and Protection Systems for Various Scales

• Need to develop temporary storage systems to minimize the impact of flooding

• Need to develop methods to minimize debris problems.
WE TAKE YOU TO NEW HEIGHTS
1. DRONE TECHNOLOGY

1. Designing of Light Weight Aircraft (lb?) and Range of Flying (Miles?)

2. Development of Camera (Accuracy)

3. Height of Flying (500 ft to 5000 ft)

4. Collection of Data (Millions of data/Minute?)

5. Processing of Data (Software)

6. Control Stations and Land Delivery
# Shapes, Sizes and Time

## Drone Flight Times

<table>
<thead>
<tr>
<th>Drone Model</th>
<th>Flight Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>DJI Phantom 3</td>
<td>17 - 20min</td>
</tr>
<tr>
<td>DJI Inspire 1</td>
<td>18 - 20min</td>
</tr>
<tr>
<td>Yuneec Q500 4K</td>
<td>20 - 25min</td>
</tr>
<tr>
<td>3DR Solo</td>
<td>20 - 25min</td>
</tr>
<tr>
<td>Hubsan X4</td>
<td>5 - 7min</td>
</tr>
<tr>
<td>Blade Nano QX</td>
<td>5 - 7min</td>
</tr>
<tr>
<td>Parrot Bebop</td>
<td>8 - 10min</td>
</tr>
<tr>
<td>TBS GEMINI</td>
<td>5 - 8min</td>
</tr>
<tr>
<td>3DR IRIS</td>
<td>10 - 15min</td>
</tr>
<tr>
<td>3DR X8</td>
<td>12 - 17min</td>
</tr>
<tr>
<td>Quanum Nova</td>
<td>8 - 11min</td>
</tr>
<tr>
<td>LaTrax Alias</td>
<td>5 - 7min</td>
</tr>
<tr>
<td>AR Drone 2.0</td>
<td>9 - 12min</td>
</tr>
<tr>
<td>QAV 400 RTF</td>
<td>8 - 12min</td>
</tr>
<tr>
<td>Proto X</td>
<td>5 - 6min</td>
</tr>
</tbody>
</table>
Commercially Available?
The small, low-flying robots of the Aerial Robotic Infrastructure Analyst program are designed as autonomous tools for complementing the efforts of engineers who are inspecting bridges or other facets of infrastructure. An inertial measurement unit and a 3-D laser scanner configured in much the same way as those mounted in the robots created a point cloud map, above, of a bridge in Big Run, Pennsylvania.
Reliably predicting the remaining run time is important when signaling for a drone to land. It's critical to have sufficient time to alter the drone's flight path and dock it safely for its next flight.

**SOC**
(Systems on Chips)
(1) Navigation
(2) GPS
(3) Wireless Connection
Offshore Applications (1 hour)

Figure 2: The CT110 drone shown here is part of a toolbox of solutions offered by Insitu Pacific. It can fly missions up to one hour and fitted with various payloads. Depending on a customer’s needs, imaging options include electro-optical, infrared, photogrammetric LiDAR, full motion video, and still imagery. Image courtesy: Insitu Pacific
LAST SUMMER, the experimental use of unmanned aerial vehicles, also called drones, enabled the National Oceanic and Atmospheric Administration (NOAA) to study the interaction of the air and the sea during a major hurricane at lower altitudes than is possible in a safe manner with manned aircraft. The drones were used in mid-September during Hurricane Edouard, a storm of category 3 that passed to the east of Bermuda. They were launched by and controlled from one of NOAA’s Orion P-3 aircraft. This large four-engine turboprop flew either directly into the storm or remained just outside the hurricane during the experiments, explains Joseph Cione, Ph.D., a research meteorologist in NOAA’s hurricane research division. This division is based in Miami, but Cione works out of NOAA’s Boulder, Colorado, office.

Of the four drones deployed, two were unsuccessful, but the other two were flown within the hurricane for periods that ranged from 28 to 68 minutes. The data they sent back on air pressure, wind speed, temperature, moisture, and other variables are still being evaluated by NOAA, says Cione. One of the drones flew as low as 1,200 ft above sea level—well below the 3,000 ft altitude that is considered a floor for manned
What is Next?

1. Designing the Drone (Power, Weight Range) with Camera and Software
2. Educate the Engineers and the Public
3. Develop Guidelines
2. SMART CEMENT AND POLYMER COMPOSITES FOR DISASTER MONITORING
Oil & Gas Wells in the United States
HURRICANE + OIL SPILL + BURNS

Drones, Satellite, Lidar --- After the Disaster
OIL WELL CEMENTING

Major Issues with Wells

1. Cannot **Monitor** the **Installation** Operations

2. Cannot **Monitor** the Performance of the Cemented Wells During **Service Life**

3. New Material Technologies Can be Applied to Improve the Performance of Drilling Mud and Oil Well Cements (**Smart Materials with Sensing Capabilities**)
Basic Concept

Instrumented Casing

Smart Cement
Contamination

(a) ELEVATION

(b) PLAN

Selection Board (SB)
Impedance Spectroscopy (IS)

Water depth
Sea floor
Formation #1
Formation #2
Formation #3

Electrical & Thermocouple leads
Insulator ring to hold the electrical leads

Borehole
1. CEMENT

LIQUID \[\rightarrow\] SOLID

Curing: Chemical Reaction

2. Drilling Mud/Spacer Fluid

LIQUID \[\rightarrow\] LIQUID

Major Issues: Cement Solidification, Fluid Loss, Contamination, Cracking, Stresses?
Resistivity/Conductivity Measurements

1. Digital Resistivity Meter
2. Conductivity Meter
3. Four Probe Resistivity Meter
Electrical Resistivity of Drinks?

Cement Slurry?
Calibration of Test Setup (AC: 300 kHz)

Figure 3. Ohm-Meter with Typical Wire Placement in the Oil Well Cement Specimen

\[ R = \rho K \]
Piezoresistive Behavior of Smart Cement

AC measurement $f = 300$ kHz

![Graph showing the relationship between compressive strength and change in resistivity for 1 day of curing. The graph compares smart cement with normal cement and includes a model line.](image-url)
Initial Changes in Resistivity Due to OBM Contamination

Resistivity Doubled with 0.1% Contamination
Development and Characterization of Smart Cement for ... 
https://www.onepetro.org/conference-paper/OTC-25099-MS ▼
by C Vipulanandan - 2014 - Cited by 2 - Related articles
In this study well cement was modified to have better sensing properties, smart 
cement, so that its behavior can be monitored at various stages of construction ...

Smart cements and cement additives for oil and gas ...
www.sciencedirect.com/science/article/.../S092041051500061... ScienceDirect ▼
by JD Mangadlao - 2015 - Cited by 4 - Related articles
Cement materials are important not only for modern structures and buildings in 
expanding urban environments and mega projects, but also for a variety of ...

UH Researchers Create 'Smart Cement' - YouTube
https://www.youtube.com/watch?v=ezjxH_bt1Hg
Jul 2, 2015 - Uploaded by UHmultimedia
Researchers at the University of Houston are testing a new 
cement mixture that offshore oil rig operators could ...

[PDF] Development and Characterization of Smart Cement for ...
www.rpsea.org/files/4169/ ▼
Paper No. OTC-25099-MS. Development and Characterization of. Smart Cement for 
Real Time Monitoring of. Ultra-Deepwater Oil Well Cementing Applications.

Smart Cement Revolutionizes Well Casings - Concrete ... 
www.concretedecor.net/.../smart-cement-revolutionizes-well-casings/ ▼
Smart Cement Revolutionizes Well Casings. Plant Engineering reports that a 
researcher is trying to give cement sensing properties with applications in the oil ...

Searches related to smart cement
vipulanandan smart cement
smart board cement board
1. (WO2017015199) RAPID DETECTION AND QUANTIFICATION OF SURFACE AND BULK CORROSION AND EROSION IN METALS AND NON-METALLIC MATERIALS WITH INTEGRATED MONITORING SYSTEM

Pub. No.: WO2017015199  
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Priority Data: 02/195,233  
21.07.2015  
US

Title: (EN) RAPID DETECTION AND QUANTIFICATION OF SURFACE AND BULK CORROSION AND EROSION IN METALS AND NON-METALLIC MATERIALS WITH INTEGRATED MONITORING SYSTEM  
(FR) DÉTECTION ET QUANTIFICATION RAPIDES DE CORROSION ET D’ÉROSION DE SURFACE ET DE VOLUME DANS DES METAUX ET DES MATÉRIAUX NON METALLIQUES, À SYSTEME DE SURVEILLANCE INTEGRÉ

Abstract: (EN) Systems and methods for real-time detecting and quantification of surface and bulk corrosion and erosion in materials involve measuring and characterizing the electrical resistances, capacitances, and/or inducences of the materials and their interfaces, preferably by using an impedance analyzer precision LCR meter. The materials may be metals, non-metals (such as plastics, polymers, cements, concrete, ceramics, rocks and soils) and composite materials with various types of material constituents (such as metals, plastics, polymers, and cements).

(FR) L’invention concerne des systèmes et des procédés pour la détection et la quantification en temps réel de la corrosion et de l’érosion de surface et de volume dans des matériaux, qui consistent à mesurer et à caractériser les résistances électriques, les capacités, et/ou les inductions des matériaux et de leurs interfaces, de préférence à l’aide d’un dispositif de mesure LCR de précision d’analyseur d’impédance. Les matériaux peuvent être des métaux, des non-métaux (tels que des plastiques, des polymères, des ciments, du béton, des céramiques, des rochers et des sols) et des matériaux composites avec divers types de constituants de matériau (tels que des métaux, des plastiques, des polymères, et des ciments).
Monitoring Bridge Structures

① Structural health monitoring can be done at locations of interest

② Some structural parts made of smart materials, can self-sense

3. Sensing of small pressures during disaster is important

4. Buried Sensors

http://www.smartmaterials.ca/
Sensing Pressures due to Hurricane Winds!!!

1. Piezoresistive Structural Sensor (PRSS)

2. Sensing small wind pressures will help in stability analysis of utility poles
Sensing Pressures due to Hurricane Winds!!!
3. Coastal Protection
COASTAL PROTECTION SYSTEMS

Natural Barriers (1 ft rise = 2.7 Miles?)

(a) Gravel Bars
(b) Sand Dunes
(c) Marsh Lands
(d) Mangrove Forests
ENGINEERED BARRIERS

- Sea Walls
- Levees
- Shutters (NEW)
New Ideas & Structural Modeling

1. Ike Dike (Shape, Size, Materials)

2. Shutter Concept (THC-IT) Coastal and Others

3. More Ideas?

CFD-FEM Modeling?
Coastal Protection - Vertical Cylindrical Barriers with Shutters

Side View of the barrier During Hurricane

- Smart Shutter
- Design ?, Material ?
- Beach
- Concreate Block
- Compressed Air Supply
- Rip-Rap
- Supporting Pile
- Sensors
- Wind
- Storm surge
Coastal Protection: Shutter Technology

1. No Interfere with Navigation
2. Not Exposed to extreme environmental conditions (sun, rain and tornados)
3. Environmentally friendly
4. Energy Harvesting.. Secondary Benefits
5. Oil Spill Protection
6. Adjustable Heights
7. New Technologies (Materials, Controls)
Buried Shutter Used to Enhance Energy?

City closer to coastal line normal tidal wave

Not Exposed to the Environment
Storm Surge

Protected city During hurricane
Major Design Issues And Challengers

1. Materials?
2. Control?
3. Underground Structure?
4. Energy Enhancement?
Adopt it with IKE-Dike?
Model Study: Coastal Protection Shutter

Texas Hurricane Center
for Innovative Technology
4. RESTORE ACT: New Proposal
Texas Coastal Community Resilience

Figure 1. Research Triangle with Major Components of the Proposed Study
5. Educational Topics

1. Annual Conferences
2. Workshops for Emergency Managers, Community Leaders & Teachers
3. Community Awareness Programs
4. Classes (Schools, Colleges, Universities)
5. Seminars
Summary and Conclusions

• Hurricane IKE Caused the Largest Amount of Loss in Texas!

• Other Disasters in Texas are Tornado, Fire, Drought and Flooding

• Rapid Recovery must be the major theme: (1) Debris Management, (2) Power Grids - Utilities (3) Coastal Protection and (4) Transportation Issues.

“Use Innovative Technologies – Smart Materials, Multi-Infrastructural Models & Coastal Shutters”
Summary and Conclusions

- **U.S. Gulf Coast** Must be Protected from Major Disasters.
- **Combine New Ideas and Technologies** to be Prepared.
- **Rapid Recovery protocols** must be developed for the region.
Next Hurricane and Disaster Conference is on August 4, 2017

HURRICANES, MAJOR DISASTERS, COASTAL PROTECTION AND RAPID RECOVERY IN TEXAS AND GULF COAST REGION

THC – 2017
9th Annual Conference

Texas Hurricane Center for Innovative Technology
(http://hurricane.ece.uh.edu)
Conference and Exhibition
Sponsored by
Texas Hurricane Center for Innovative Technology (THC-IT) &
Civil and Environmental Engineering
Industrial Engineering
University of Houston
August 4, 2017

University Hilton
University of Houston
Houston, Texas 77204-3902

Conference Registration
The Conference is presented in a one day concentrated format to update the community, emergency managers and suppliers who play an important role in hurricane and other disaster preparedness, loss mitigation and rapid recovery. Well known and influential speakers will provide valuable information to the conference attendees. Complete and return the registration form with the registration discount before July 29, 2016 for an advanced discount. Registration fee includes admission, lunch, coffee breaks, and free hotel parking. Registration and attendance will be limited to the first 120 registrants.

For Hotel Reservations call (832) 531-6300 or 1-866-327-1161 and ask for Hurricane and Other Disaster Conference Rate.

Top Reasons To Attend:
(1) Be informed about the latest plans and procedures in preparing for hurricanes and other major disasters in number of major Gulf coast cities.
(2) Network with state, city and county emergency managers, engineers, suppliers, consultants, researchers, educators, scientists, students and exhibitors.
(3) Presentations include debris management, preparedness, loss mitigation, evacuation, coastal protection, transportation issues, rapid recovery and new technologies that could influence your operations.
(4) View research posters from many Gulf Coast Universities and attend the reception.
(5) Houston is easily accessible from anywhere in the U.S.

For conference information or to reserve exhibition spaces call Dr. Vipu at (713) 743-4278.

REGISTRATION

Advanced Registration (by 7/29/2016) $150.00
At-Door Registration $165.00
Student Registration $85.00
Exhibitor $300.00
(A reception is planned in the exhibit area)

^One person has free registration
*Current I.D. and School Registration:

Please make check payable to THC-IT/UH and mail it to:
Conference Registration
THC-IT/Dept. C&E
University of Houston
Houston, TX 77204-4003
(Attn: Dr. C. Vipulanandan (Vipu))

Name______________________________
Nick Name__________________________
Company __________________________
Address ____________________________
City_____________State/Zip __________
Phone____________________________
Fax ______________________________
Email _____________________________
Contact Person _____________________
(office use only)

For more information
Phone: (713) 743-4278; Fax: (713) 743-4260
Email: CVipulanandan@uh.edu
LIST OF SPEAKERS: INVITED SPEAKERS - LEADERS

(1) CHIEF, Texas Department of Emergency Management (TDEM)

(2) County Judge, Brazoria County

(3) Director, Houston Galveston Area Council

(4) Port of Houston

(5) Houston Airport System

(6) U.S. Army Corps of Engineers

(7) Florida, Alabama

(8) Emergency Manager City of Houston

(9) New Technologies.............
Texas Hurricane Center
for Innovative Technology

http://hurricanes.egr.uh.edu