

**National Science Board Workshop
Task Force on Hurricane Science and Engineering**

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Hurricane Katrina Power & Telecommunication System Failure Modes

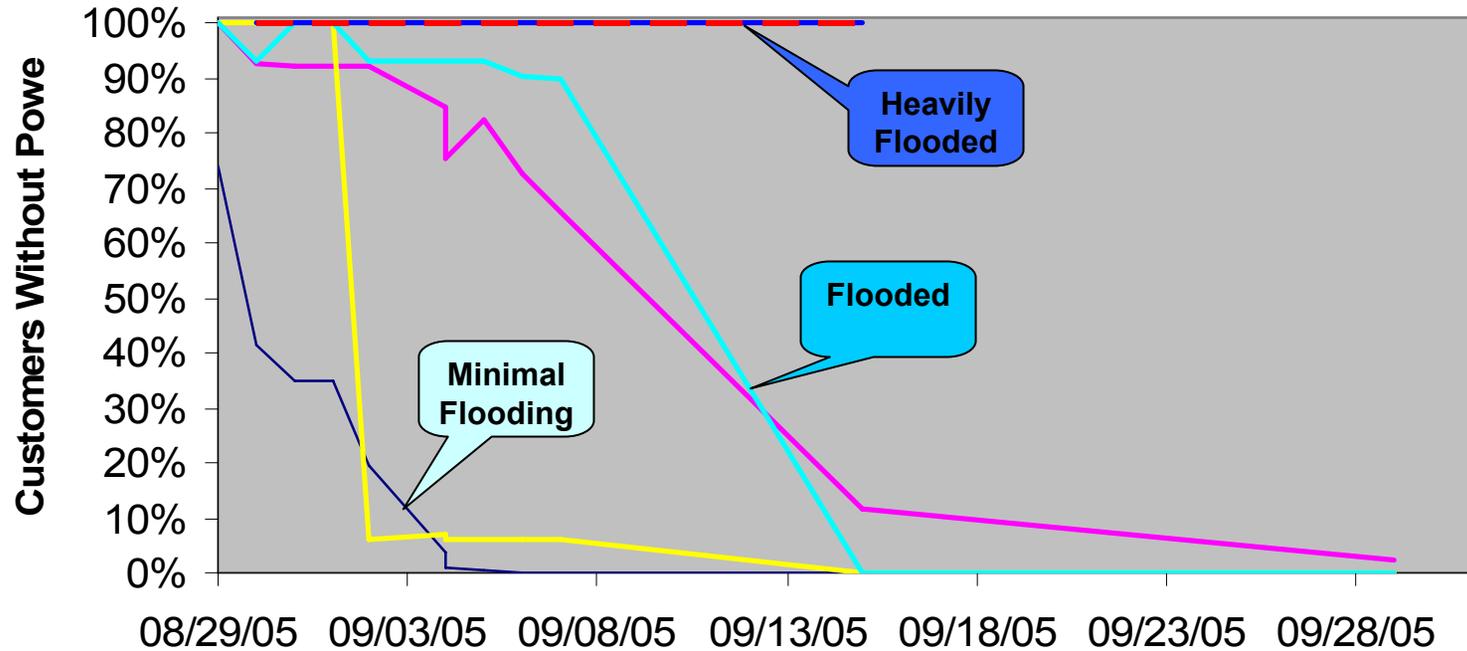
PROJECT OVERVIEW

NSF SGER Research Grant No. ECS-0554149

- Study the **infrastructure and procedural failure modes** that caused the **telecommunication network and power system** to become ineffective and fail
- **Gather Data** to assess the impact from Hurricane Katrina on the power grid and common carrier and governmental agency communications systems
- **New Orleans, Louisiana geographic area** : Jefferson, Lafourche, Orleans, Plaquemines, St. Bernard, St. Charles

Hurricane Katrina Impact on Electrical Utility System

Hurricane Katrina Electrical Power Disruption



Hurricane Katrina related Electrical Power Failures

CLECO Lake Pontchartrain North Shore

Prior to the storm

- **Disable automatic circuit breaker reclosure** to minimize equipment damage
- **Trucks and equipment moved north** out of the way of the storm

During & after storm

Wind Damage

- **Transmission lines de-energized** primarily due to fallen trees

Water Damage

- **Tidal surge** came into Slidell Area from Lake Pontchartrain
- **8 to 12 feet of water** in Lakeshore Estates, Eden Isles, and Oak Harbor
- **Uncontrolled movement of debris damaged electrical equipment**
- **Transformers severely damaged by influx of flooding salt water**
- **South Slidell Substation flooded** and damaged by water
- **Water intrusion into transformer oil systems forced cooling oil out**
- **Recent and continued failures of equipment due to salt water corrosion**

Hurricane Katrina related Telecommunication Failures

Louisiana State Police Radio Network

- Propane powered **generators at tower sites could not be refueled**
- **T-1 circuits for radio tower interconnection failed** limiting communication to the local node
- **Deployed the mobile command post**
- **High traffic volume caused congestion and failure**
- **VoIP phones worked** until uncontrolled access from the internet was allowed

Local Radio Interoperability

- Disastrous local communication **problems due to incompatible interagency radios**
 - There is no nationwide interoperability plan, only local efforts
 - LSP needs a robust, redundant, self-healing dedicated communications system
 - Open architectures preferred based on IP, with security measures

Hurricane Katrina related Telecommunication Failures

Satellite Radio Phones

Satellite phones **bogged down with uncontrolled traffic load** and became ineffective.

Landline

Landline telephone connections and switches functioned until the **lines became damaged and the switches failed after power was lost** as the **back-up generators ran out of fuel** and/or were **knocked out by flooding**.

Cellular

Cell towers failed when the **backup batteries depleted and generators ran out of fuel and were flooded**.

911

The chaos that followed Hurricane Katrina was magnified by the failure of communications networks. Emergency communications and **911 call centers were overwhelmed** as subsequent **flooding took out radio systems, cell towers and back-up generators**.

Hurricane Katrina Power & Telecommunication System Failure Modes

CHALLENGES

- Obtain specific data from agencies and corporations reluctant to cooperate
- Combining data in varied formats into a unified database
- Obtaining missing and incomplete data
- Correlating failures to wind, water, surge
- Recovering historic data prior to loss or alteration

Research Opportunities: Prior to Landfall

- **Automated Regional Storm Plan**
 - Computer and telecommunications technology to gather data and automate a storm plan
 - involving all emergency agencies, common carriers, and infrastructure support
- **Highly mobile robust, telecommunications systems**
 - Transported to a disaster site
 - For emergency responders
 - Interoperability enforced
- **Mobile City Systems**
 - Containerized modular dwellings, mobile hospitals, habitats
 - Power & Communication interconnection and coordination

Research Opportunities: Landfall

- **Interoperability and Ad Hoc Wireless Networks**

Katrina search and rescue teams could not communicate with each other; their radios used different frequencies. Under the Louisiana Totally Interoperable Environment (LATIE) plan 22 parishes will be connected to a unified communications network.

- **Software Defined Radio (SDR) systems**
- **Instantly deployable ad hoc wireless meshes**
- **Digital packet radios for emergency backup**
- **Cognitive radios - equivalent of the military Joint Tactical Radio System**

- **Voice over Internet Protocol (VoIP)**

The Internet has proved less vulnerable to failure than other telecommunications links.

- **Cox maintained some Internet service of VoIP for local and 911 calls**
- **Louisiana State Police able to use their Intranet VoIP for voice calls**

The inherent redundancy in the IP network provided the robust performance of networks in these cases.

Research Opportunities: Landfall

- **Wi-Fi Mesh Networks**

Wi-Fi mesh networks offer a robust communication system capable of surviving a disaster of Katrina's magnitude. Conventional phone systems are vulnerable to single point failures of the centrally located switches

- **Adapts to failures and exhibits robust performance**
- **Supports VoIP, and enables widespread connectivity to the Internet**
- **Efficient and inexpensive, nodes consuming about 10 watts, and with an implementation cost of about \$350**

- **Sensor Networks**

The design and use of a satellite sensor network to

- **Acquire coastal and infrastructure data**
- **Assess the real time state of the impact of the hurricane**
- **This data is critical to emergency personnel**

Research Opportunities: Post Landfall

- **Electric Power**
 - **Extensive failures** of transformers, underground switchgear, cables, insulators and other pad mounted and underground equipment under prolonged submerged conditions.
 - The industry has recently reported **continued failures** of such equipment long after (several months) the hurricanes have passed.
 - There is a **pressing need for applied research** to mitigate these problems for equipment subject to being submerged for prolonged intervals during and after hurricanes.

New modalities of research & collaboration

- **Louisiana Board of Regents 2006 Post-Katrina/Rita Research and Education Forum - Scope**

Faculty and students in science and engineering who have skills in sociology, coastal sciences, urban planning, engineering, information technology, policy and management, transportation, human ecology, health sciences, physical and natural sciences have an opportunity to develop special topics, newly designed courses, and directed studies to gather and analyze data on the multiple impacts of major disasters. At the same time, there is an urgency to protect the historical investment in the human and equipment capital of higher education that represents strengths that will influence future trajectories of higher education. **All of these disciplines, both established and planned, will be asked to evaluate and mitigate the 'risks' associated with living in a vulnerable coastal environment.** The challenges are to make new discoveries, develop new technologies, and establish policies that can resolve the environmental, cultural, and economic demands of a healthy coast over the next century.

Resources and realignments needed to achieve breakthrough research

Hurricane Katrina Power & Telecommunication System Failure Modes

Under this NSF SGER Research Grant No. ECS-0554149, we are studying the infrastructure and procedural failure modes that caused the telecommunication network and power system to become ineffective and fail. Data is being gathered to assess the impact from Hurricane Katrina on the power grid and common carrier and governmental agency communications systems. Agencies such as the La. State Police, La. PSC, and CLECO are providing good data documenting the system failures and cause. However, other agencies such as BellSouth and Entergy have not been cooperative despite our emphasis that the final report is to document what happened and why, not who is to blame.

- **The communication and electrical power systems are complex, interconnected, interrelated, and span multiple private and public entities.**
- **It is important that independent research be conducted to explore innovative ways to establish robust communication and electrical power systems.**
- **Success hinges on open collaboration among universities, the power and telecommunication industry, and local, state, and federal government.**