OAK RIDGE National Laboratory

# Response, Recovery, and Dynamic Events

## GEOSPATIAL SOLUTIONS FOR RESILIENCE


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# A Dynamic Event in recent memory…

2000+ deaths

1.36M refugees displaced throughout the country

70% of structures severely damaged or destroyed

80% of the land area was under 8+ feet of water

No fresh water or electricity for months

Looting, rioting, and violence in the streets

Resident population reduced by 50%

Police force reduced by 25-50%

Most costly catastrophe in national history

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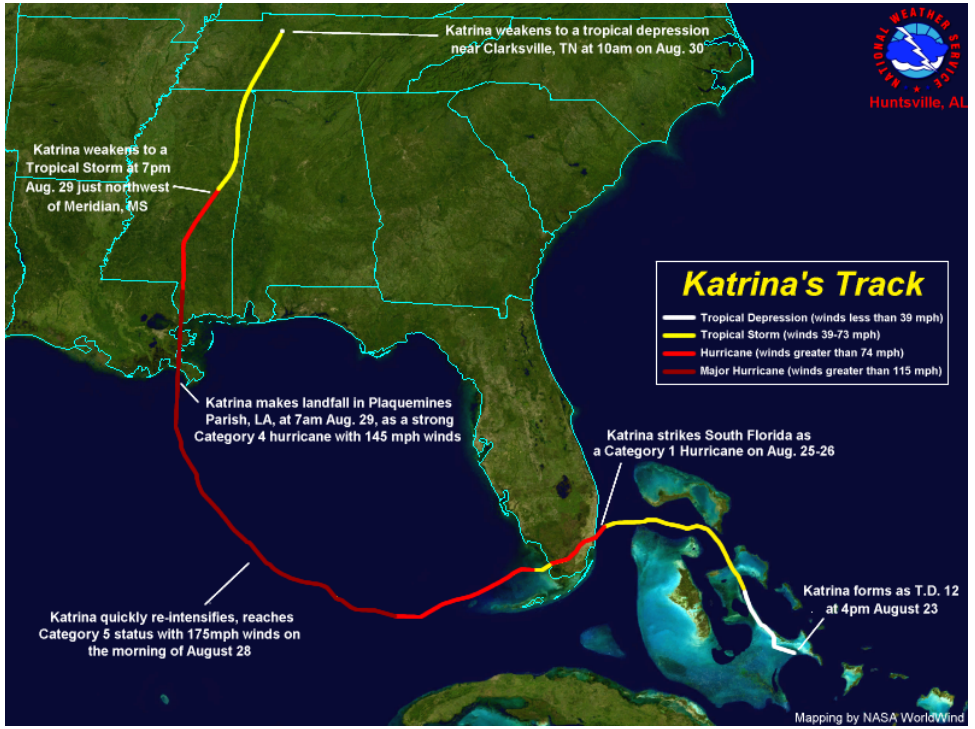

# August 25, 2005

Hurricane Katrina makes landfall in Florida as a Category 1 storm

9 people reportedly killed

Image credit:The Ledger, https://www.theledger.com/story/news/2005/08/27/s-fla-cleans-up-gulf-coast-braces-for-impact/26171160007/

# August 26-28, 2005

Hurricane Katrina moves into the Gulf of Mexico, grows to Category 5 storm.

Louisiana Governor declares State of Emergency. New Orleans Mayor issues mandatory evacuation order.

10,000 people shelter in Superdome

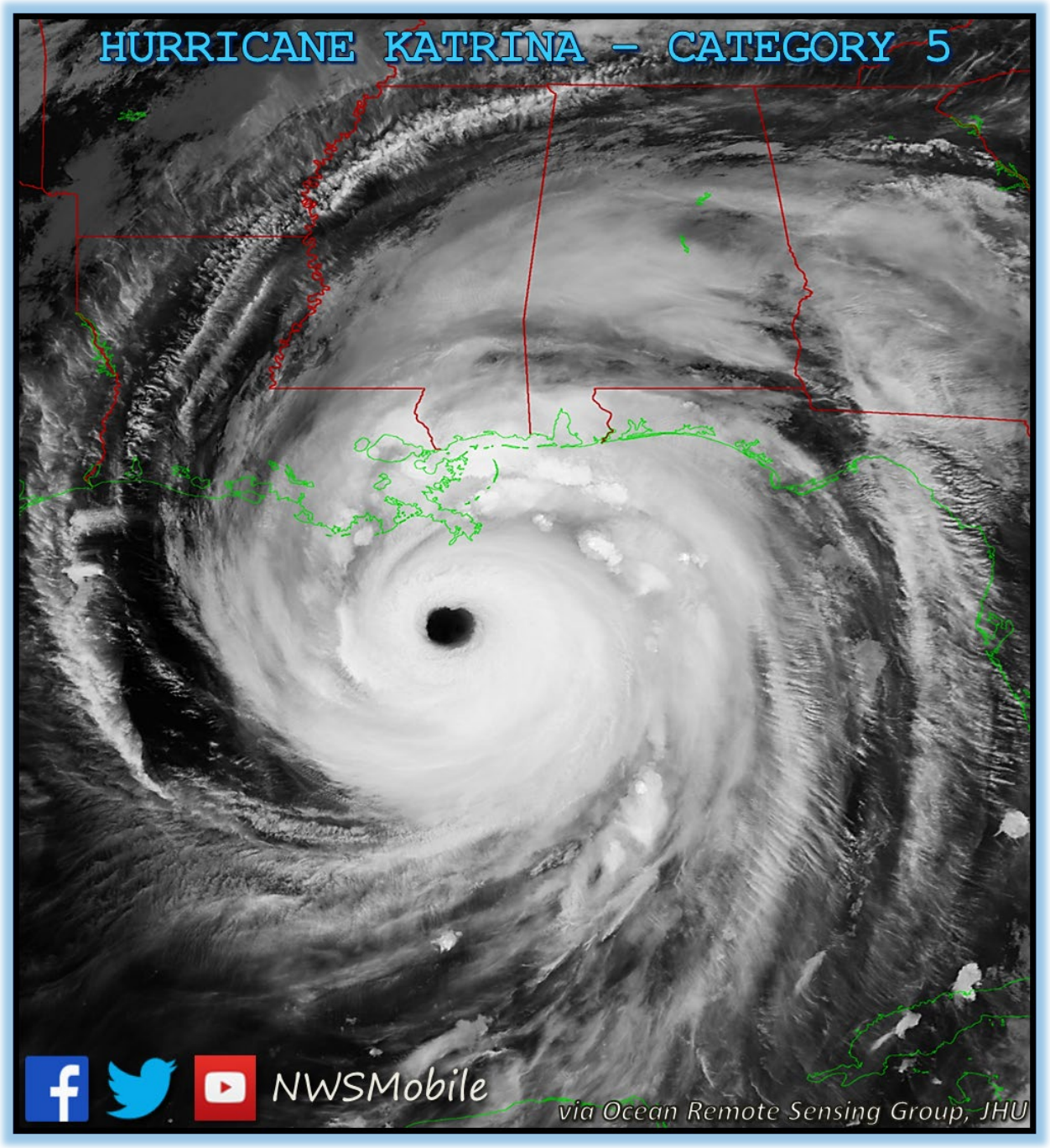


Image credit: National Weather Service, https://www.weather.gov/mob/katrina

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Image credit: FEMA, https://www.fema.gov/sites/default/files/2020-06/katrina_14372_large.jpg

# August 29, 2005

Hurricane Katrina makes landfall in New Orleans as a Category 4 storm. Lower 9th Ward levee is breached, floodwaters rise to 8 feet for ~20% of the city.

>1200 people rescued from floodwaters.

Image credit: Associated Press, https://apnews.com/today-in-history/august-29

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Image credit: John McCusker/The Times-Picayune, https://www.npr.org/sections/pictureshow/2010/08/24/129400381/telling-their-stories

# August 30, 2005

Katrina proceeds north through Tennessee.

Meanwhile, 2nd levee fails in New Orleans, ~80% of the city is underwater (up to 20 feet).

Up to 100,000 people estimated to be stranded in homes, on roofs, or in shelters.

Looting reports begin.

Image credit: New York Times, https://www.nytimes.com/2015/05/24/us/decade-after-katrina-pointing-finger-more-firmly-at-army-corps.html

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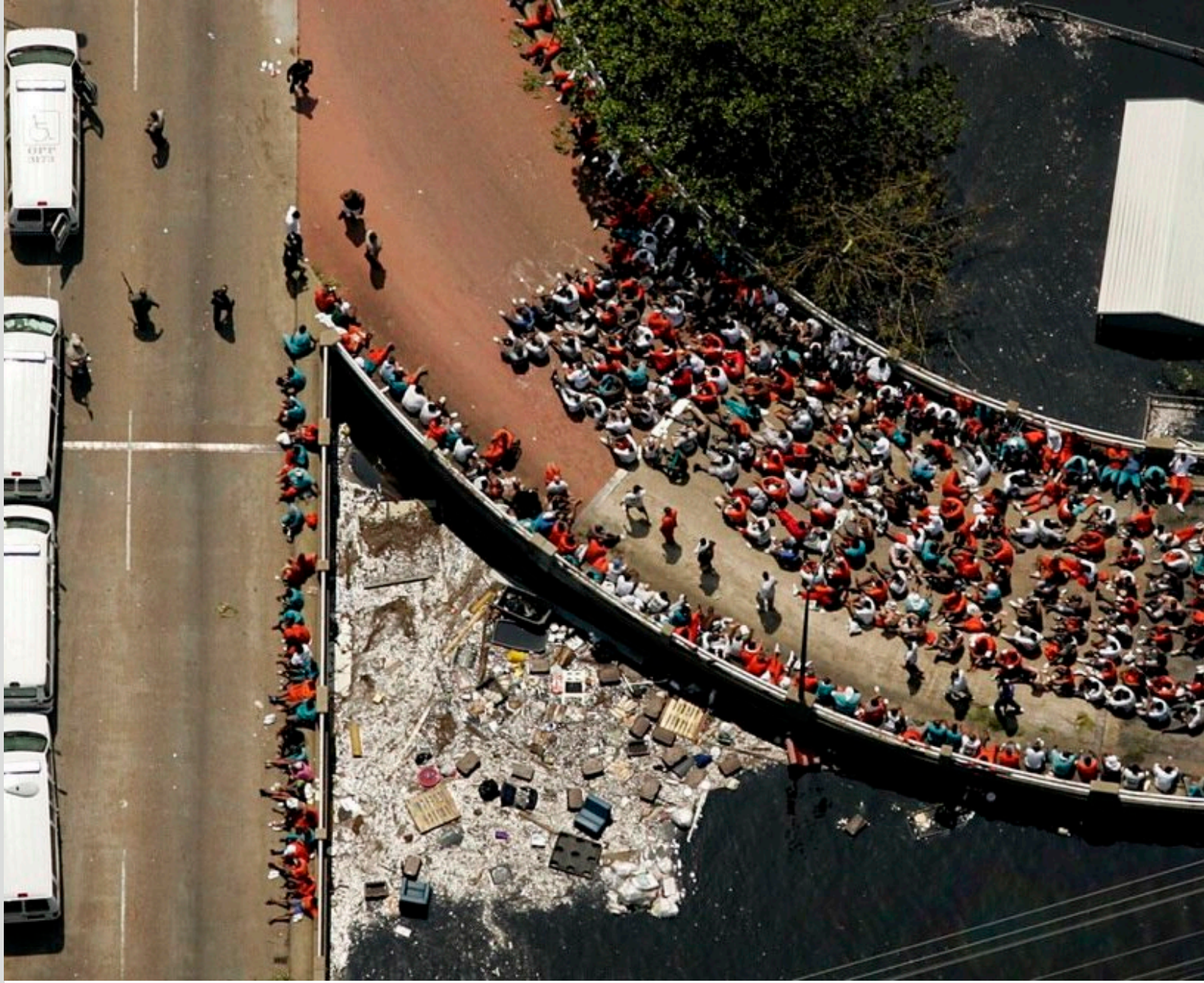


Image credit: Smiley N. Pool/The Dallas Morning News, https://www.npr.org/sections/pictureshow/2010/08/24/129400381/telling-their-stories

# August 31, 2005

Evacuation of Superdome begins, taking “refugees” to Houston Astrodome.

Looting spreads rapidly, distracting first responders from rescue.

3rd levee breached.

Image Credit: FEMA, https://www.fema.gov/sites/default/files/2020-06/katrina_14461_large.jpg

# September 1, 2005

National Guard deploys 30,000 troops to assist in rescue and restore order.

Violence continues, FEMA evacuations halted because of gunfire, military helicopters shot at while evacuating residents.

Superdome and Convention Center has swollen to 45,000 refugees.

Image Credit: Associated Press/Jim Pool, https://www.chicagotribune.com/2024/08/29/today-in-history-hurricane-katrina-strikes-louisiana/

# September 2, 2005

Explosions at New Orleans chemical plant.

15 airlines begin flying refugees to San Antonio.

US and European oil reserves tapped to keep gasoline prices from spiking.

Image Credit: Vincent Laforet/New York Times
https://www.nationalgeographic.com/environment/article/hurricane-katrina

# September 3-5, 2005

7000+ active duty military deployed to New Orleans, with National Guard now at 40,000.

200 police officers have walked off the job, 500 more unaccounted for.

Superdome is fully evacuated.

Carnival Cruise housing 7000 refugees on cruise ships


Image Credit: Eliot Kamenitz/The Times-Picayune, https://www.npr.org/sections/pictureshow/2010/08/24/129400381/telling-their-stories

# September 6-8, 2005

Levees mostly patched, USACE begins pumping water out of the city, remains 60% underwater.

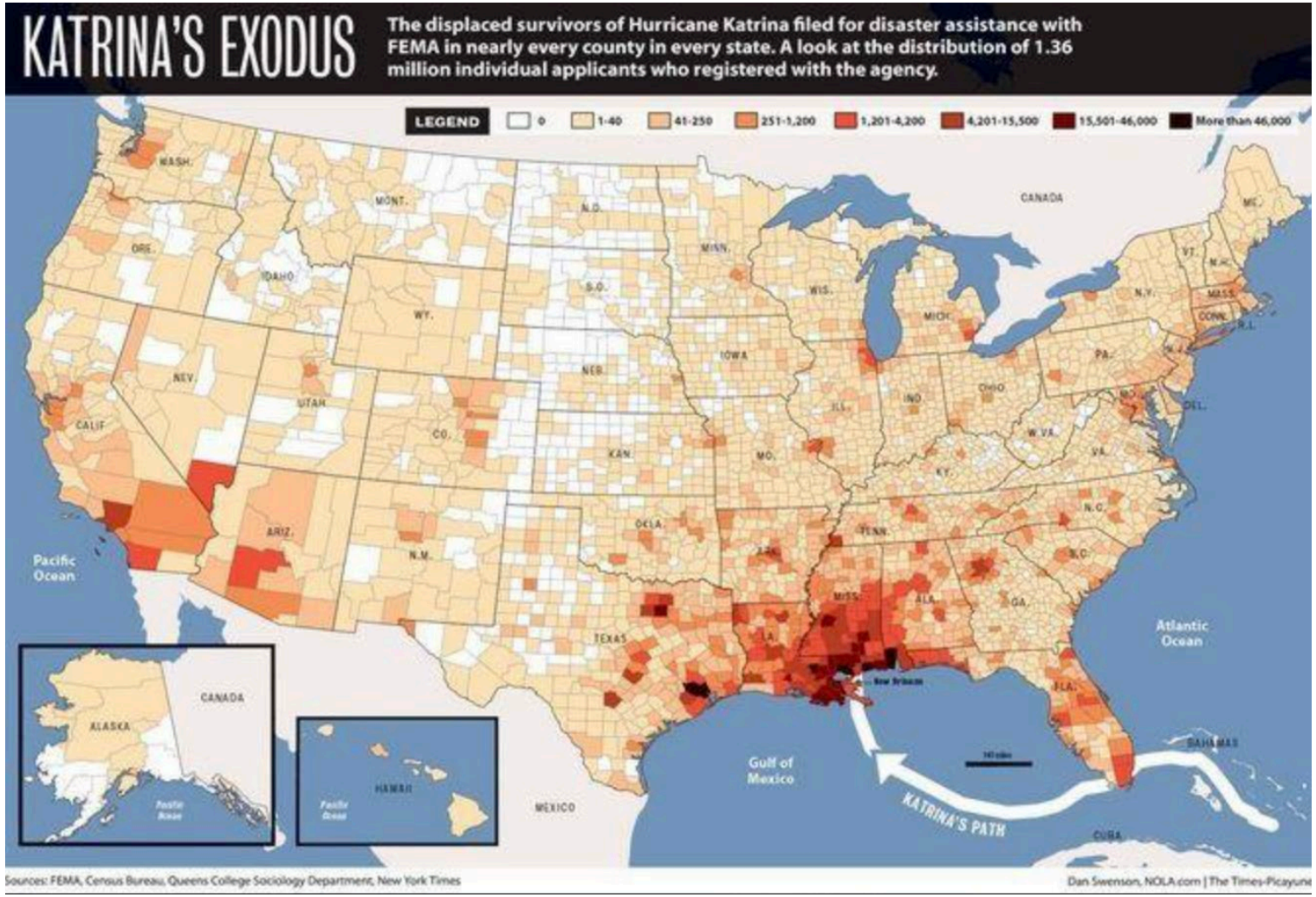
Less than 10,000 residents remain in the city.

Mayor issues emergency declaration that people can be removed from the city with force.

Congress authorizes $52B aid package.

Image Credit: NASA, LandSat 5 TM
https://earthobservatory.nasa.gov/images/15445/hurricane-katrina-floods-new-orleans

# Scale of Katrina's impact was felt nation-wide




Estimated 1.36M people dispersed throughout the US

2000+ lives lost

3M homes without power

23% of nation's oil refining capacity shuttered (Katrina plus Rita)

Estimated $200B in damage (costliest hurricane in US history)



Image courtesy: https://www.nola.com/news/hurricane-katrina-migration-where-did-people-go-where-are-they-coming-from-now/article_b84a9b86-e0dc-511a-872d-09fef0012508.html

# Hurricane Katrina was a quintessential ‘dynamic event’. Dynamic events are not unique, and not just environmental…

Syria Civil War

Sudan Civil War

Rohingya Crisis

## …and many more

# Recovery for New Orleans – and any dynamic event – is multifaceted and interdependent

## Infrastructure

Infrastructure is damaged/destroyed, accessibility is impacted, and essential services are unavailable

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Estimated 134,000 households damaged

$14B cost to repair/upgrade levees

1200 freshwater systems, 200 wastewater plants affected

## Population

Populations disperse, are unequally impacted, and lack equitable access to recovery resources

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1-year post Katrina, the population of New Orleans was still less than 50% of pre-Katrina

By 2015, the population had recovered to 80% of pre-Katrina numbers

## Economy

Businesses close, unemployment rises, supply chains are disrupted, and commerce is impacted

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$120B in Federal spending to support Katrina recovery, but >60% addressed emergency relief as opposed to rebuilding

Shifting industrial drivers from tourism and energy to tech, engineering, medical

## Order/Stability

Governments experience reduced ability to maintain safety, security, and essential services

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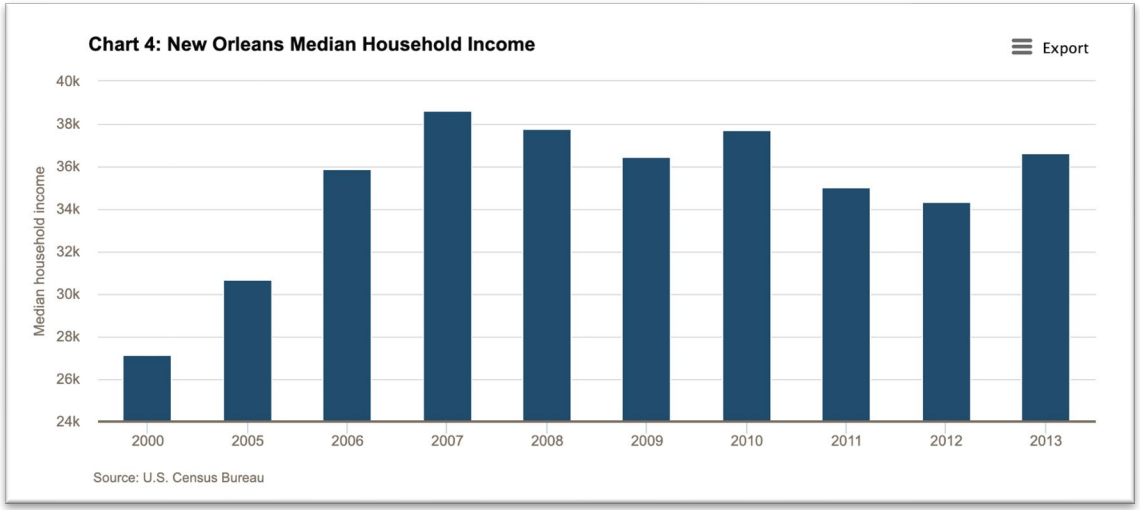
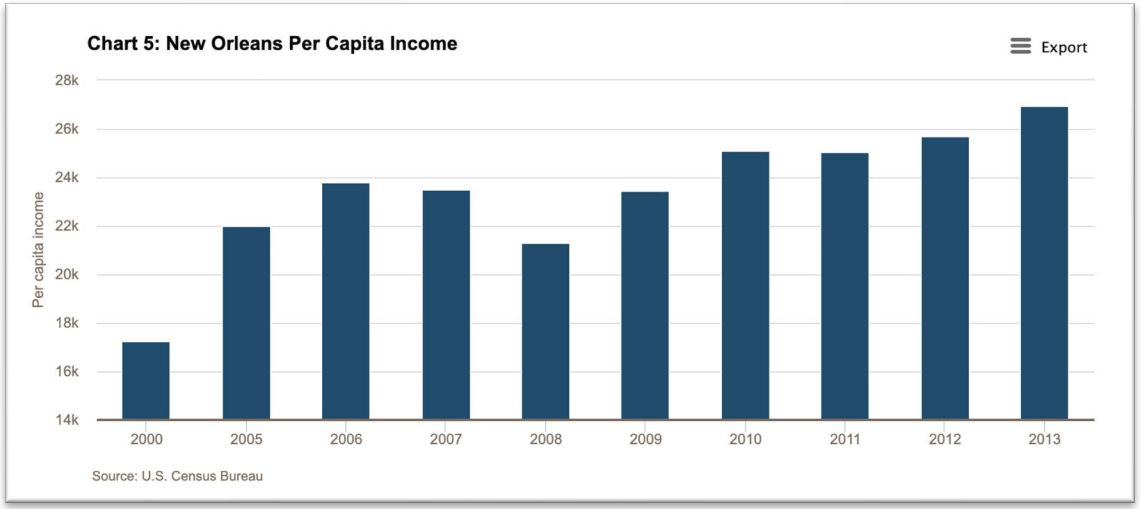
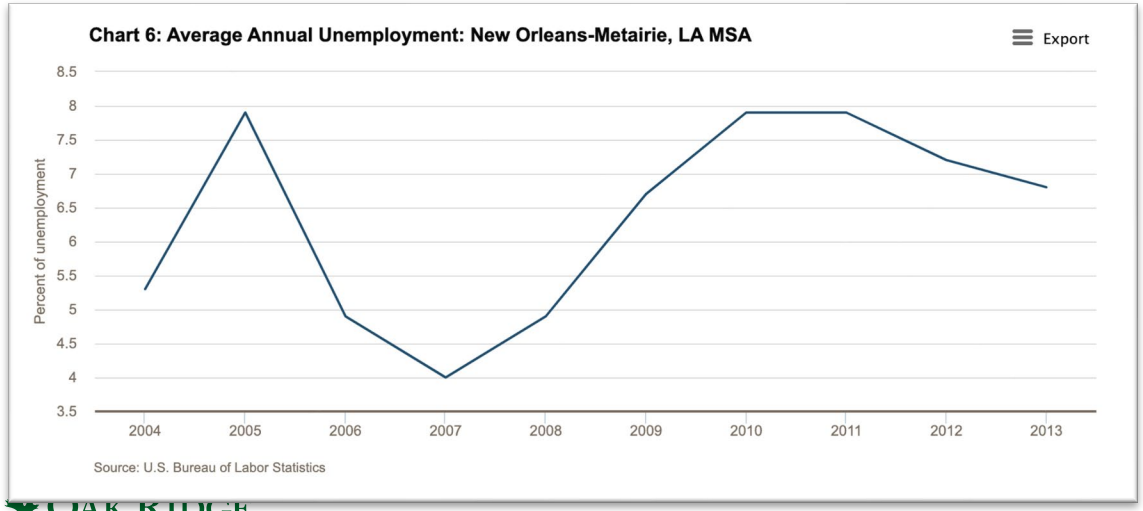
New Orleans police force was only at 75% capacity 10 years post-Katrina

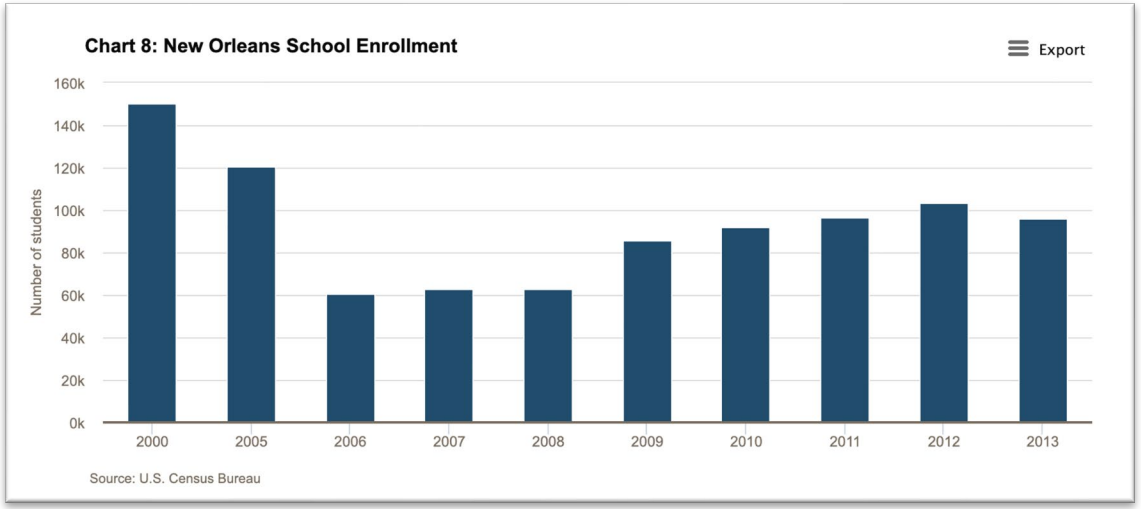
Significant environmental health and human health impacts to address

# A Rapid Recovery, or a Different City Altogether?




Charts courtesy: https://www.atlantafed.org/economy-matters/2015/08/20/new-orleans-10-years-after-katrina

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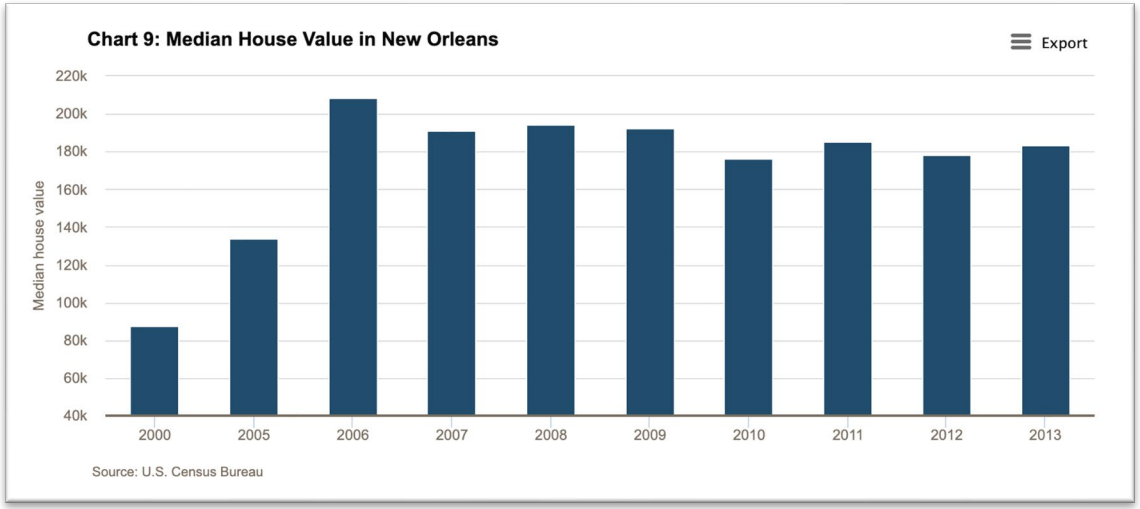


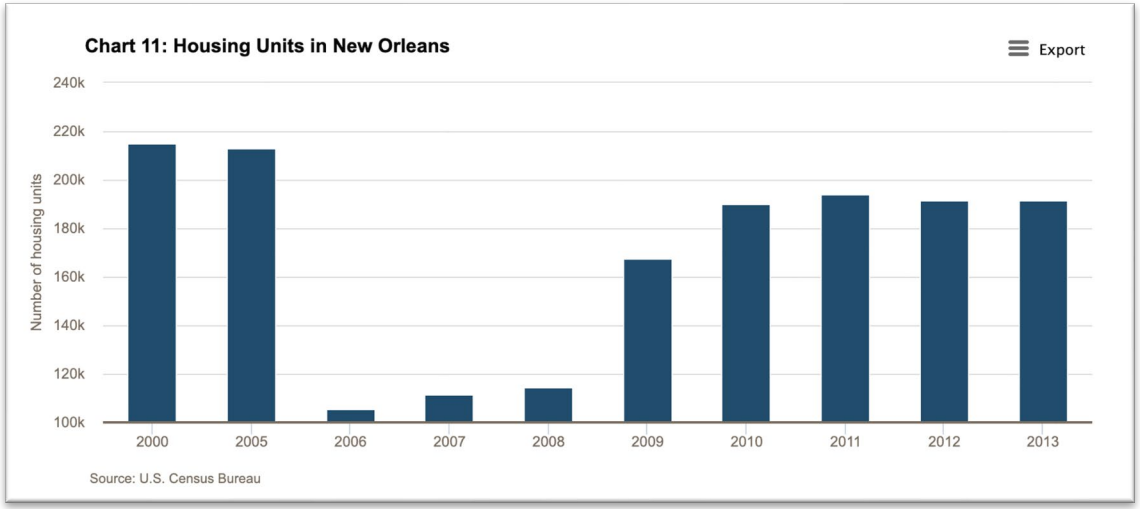


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# Recovery Isn’t Just Returning to a Pre-Event State

“At the highest level, the way that you honor the loss from disaster is by rebuilding something better. This is something I call not just resilience, but radical resilience—the idea that you can transcend what you were before, and that's a way of honoring those who suffered. That's happened arguably both in downtown New York, which is much more vibrant than it was before, and in greater New Orleans, where we have what the publisher of Forbes called the greatest economic comeback of our lifetime.”

-Michael Hecht, president and CEO of Greater New Orleans Inc.

# Geospatial Tools and Data

# Underpin All Successful Response and Recovery Efforts

# Geospatial Tools & Data for Response & Recovery

## Response Efforts

Focused on Saving Lives and Restoring Basic Services – **Answering the Where**

- Infrastructure operations and navigability
- Grounded in damage assessment

Implemented Top Down

- National/state/local emergency management agencies and first responders
- Highly coordinated, standardized, and structured

## Recovery Efforts

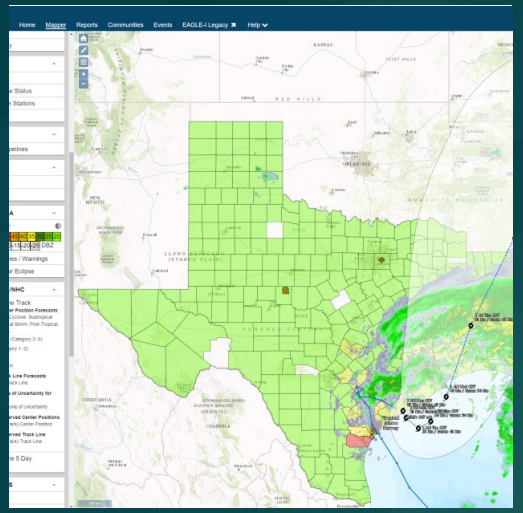
Focused on Restoring Socioeconomic Stability – **Answering the Who, What, and How Much**

- Available, accessible, equitable, reliable, resilient
- Grounded in community prosperity

Implemented Bottom Up

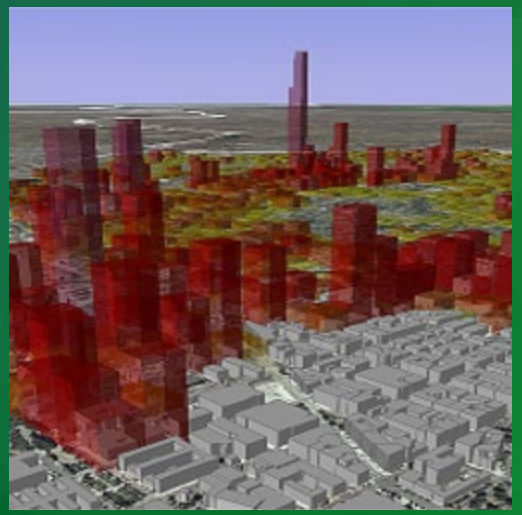
- Local institutions, community groups, businesses
- Highly disaggregated, lacks standardization, requires flexibility

# If we are to establish resilient communities that “build something better”, we need…



**Comprehensive Pre-Event Geographic Understanding**

**Efficient Data Collection, Conditioning, and Distribution**



**Effective Geographic Metrics for Change Monitoring**

# Comprehensive Pre-Event Geographic Understanding

Recent remotely sensed data and derivative products

Full inventory of buildings, critical infrastructure, points of interest

Detailed understanding of population distribution, demographics, socioeconomic status, commuting patterns

Data is FAIR – findable, accessible, interoperable, and reusable

# Efficient Data Collection, Conditioning, and Distribution

Orderly: Data update strategy to guide spatiotemporal monitoring

Fast: Automated workflows for updates and new observations

Reliable: Trusted workflows to produce trustable results

Documented: Metadata to track source, lineage, accuracy, etc.

Shared: Accessible by stakeholders, local and national

# Effective Geographic Metrics for Change Monitoring

Defined metrics up front for response, recovery, and growth that guide

- Data collection and analysis
- Foundational data creation
- Spatial resolution and temporal update cycles
- Change monitoring thresholds
- Partnerships and stakeholders

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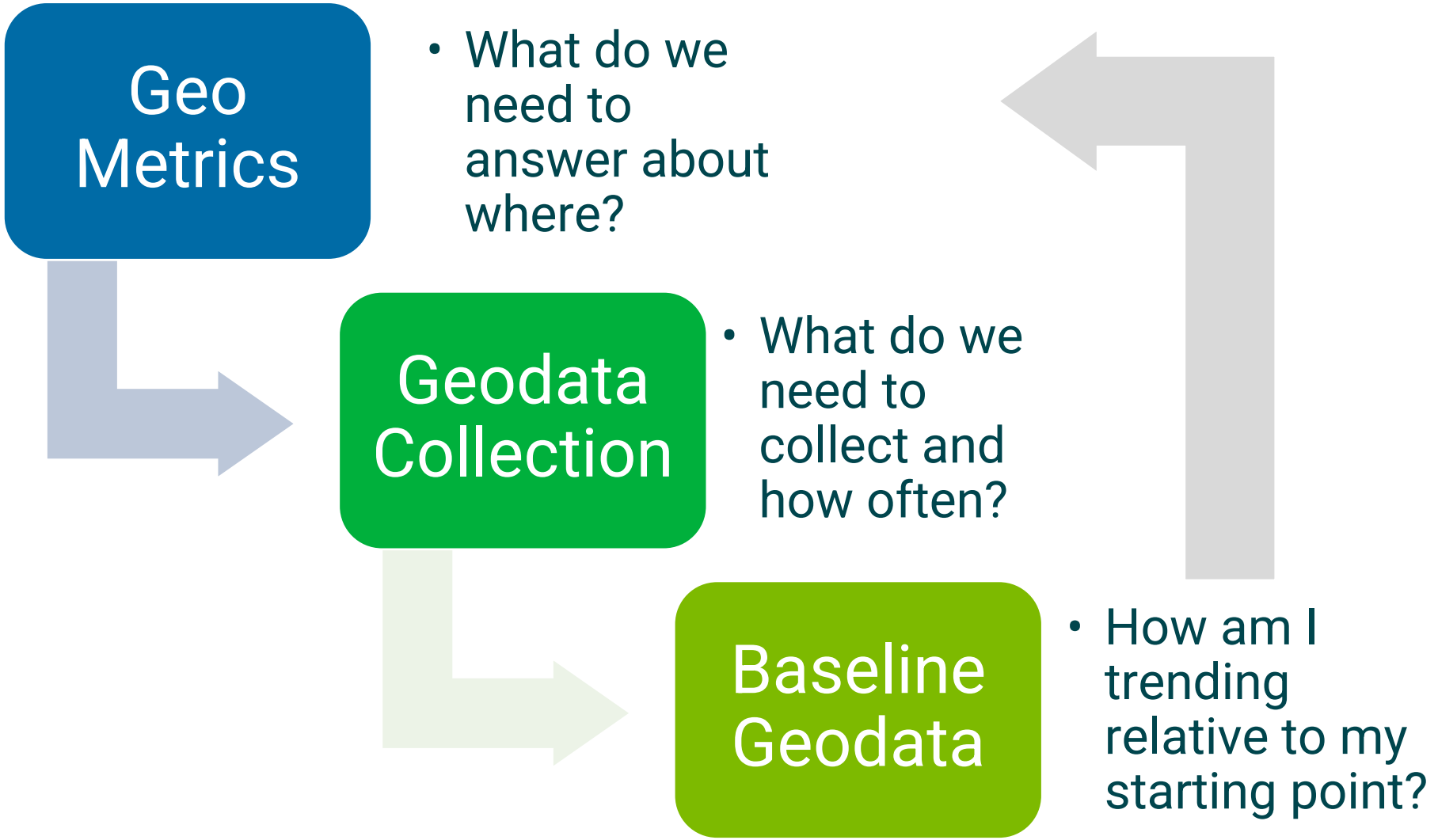
# Recovery from Dynamic Events starts with defining recovery metrics



# ORNL’s Role in National and International Dynamic Event Response and Recovery

Critical Infrastructure Mapping

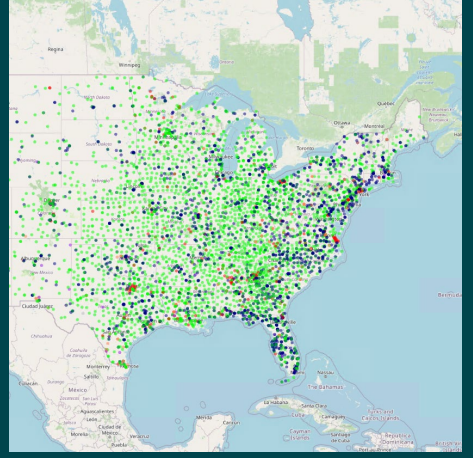
Complete Inventory of US Buildings

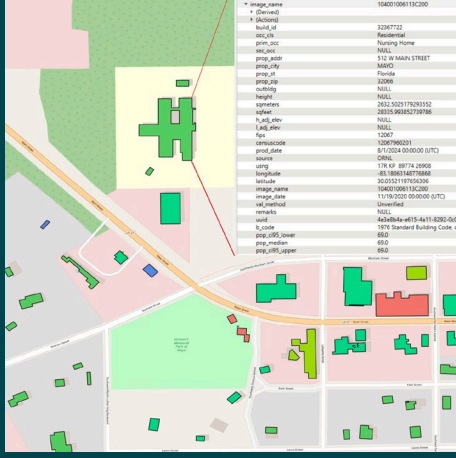
Rapid Response Data Collection

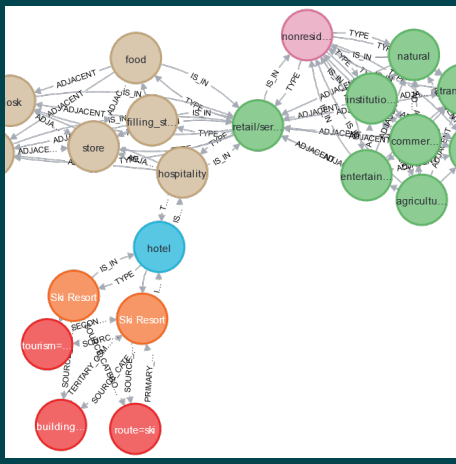
Accelerating the Data to Decisions

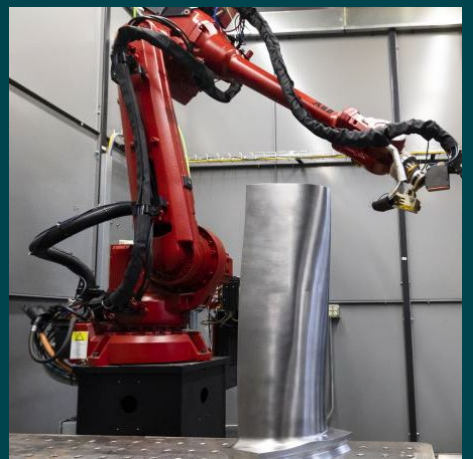
Geospatial Supply Chain at the Edge

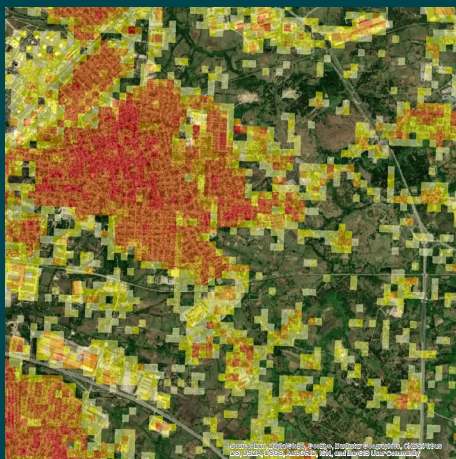
Population Dynamics Monitoring









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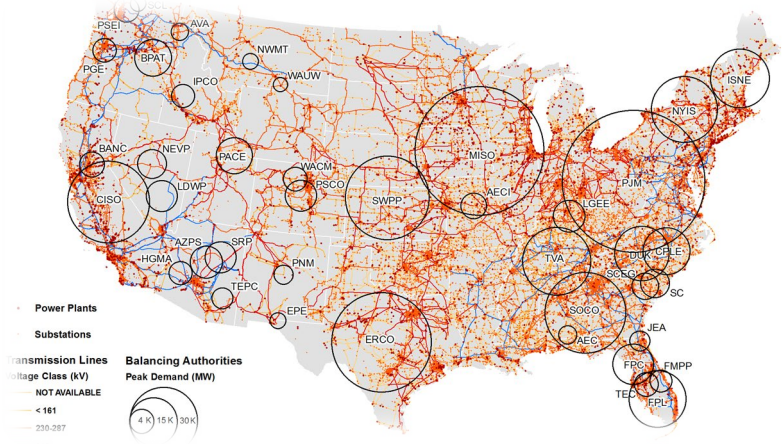
# Critical Infrastructure Mapping – HIFLD Energy Layers and Outage Monitoring

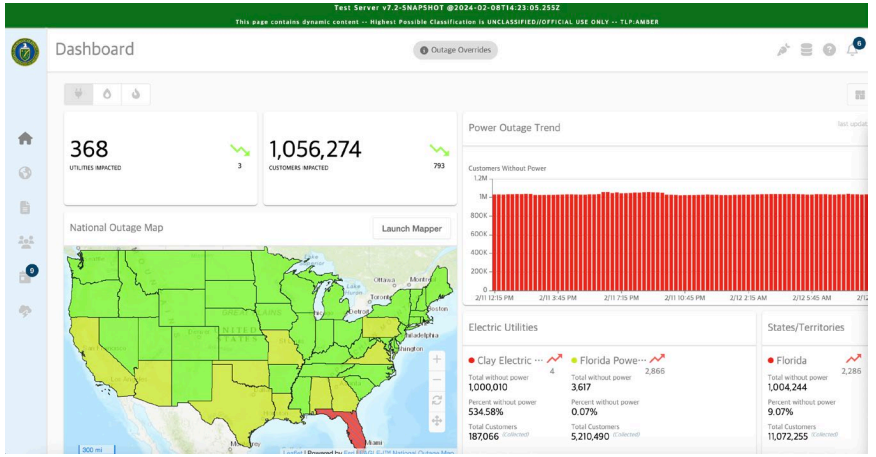
Build and maintain 17 US National Critical Infrastructure layers and US Energy Infrastructure layers for HIFLD

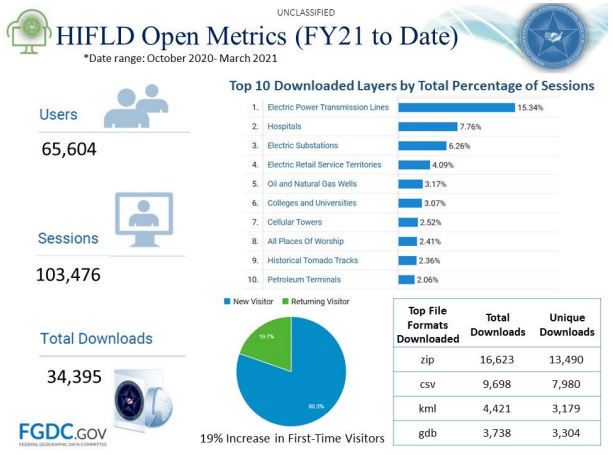
- Schools, hospitals, childcare centers, sports venues, waste facilities, and more
- Power lines, power plants, substations, oil and gas pipelines, refineries, and more

Operate EAGLE-I US-wide power outage management system

- County-level updates every 15 minutes for US

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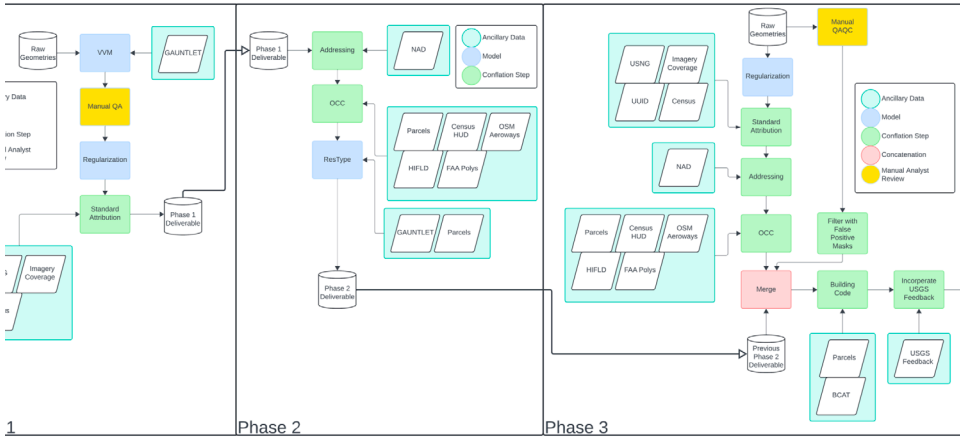
# Complete Inventory of US Buildings – USA Structures

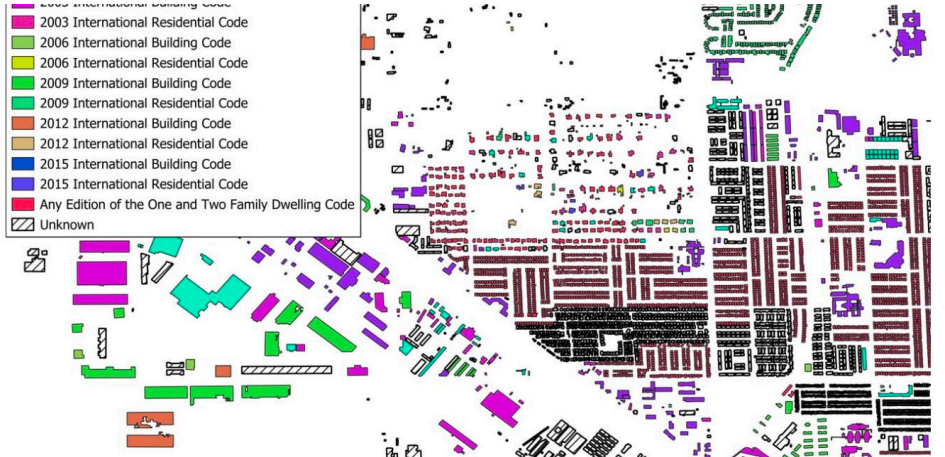
125 million building footprints in the US >400 square feet mapped from high-resolution imagery

Automated creation using generalized machine learning model and more than 100,000 training samples

Detailed HAZUS-compliant attribution

Includes spatiotemporal linkage to building code regulations

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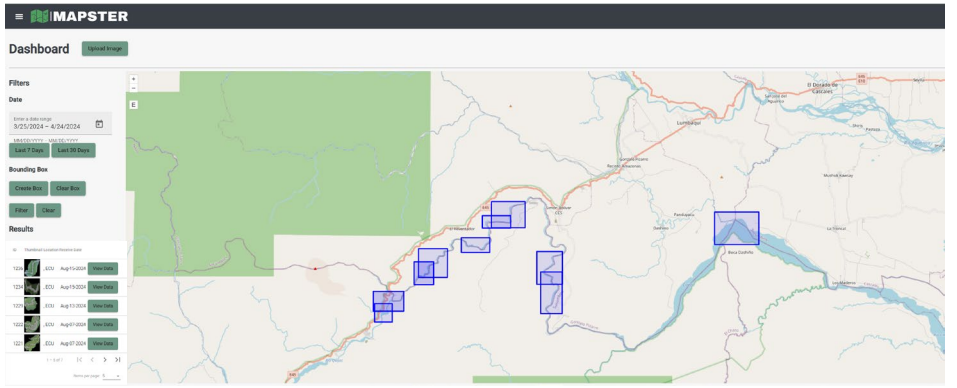
# Rapid Response Data Collection – UVDL and Mapster

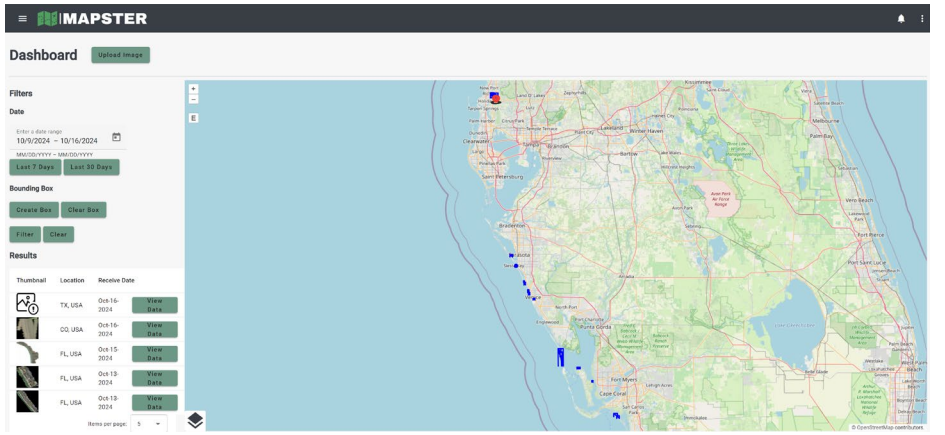
Drone-based emergency response data collection kits

Live data capture monitoring

Mission-based data standardization, organization, and retrieval from field to HQ

Machine learning for real-time object detection and alerting (e.g., downed power poles)

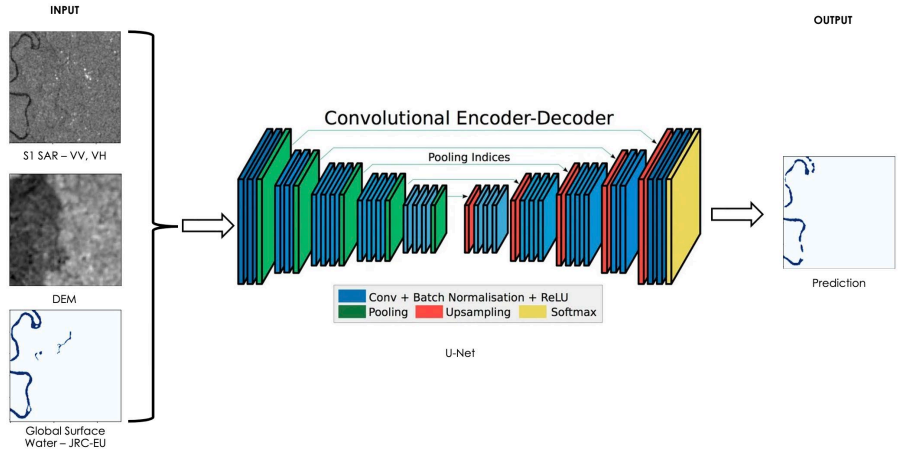
# Accelerating Data to Decisions – Communications + HPC + GeoAI

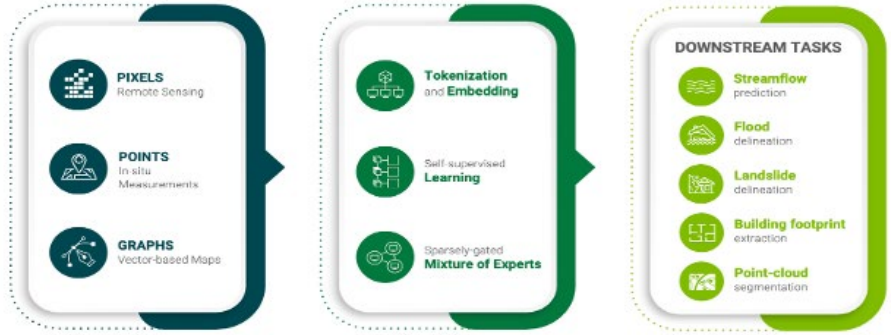
Novel communications methods to secure data transport

Small satellite ground station with high-performance computing link for rapid fusion and insights

AI-enabled automated flood detection from SAR

AI foundation model development unifying pixels (remote sensing), points (vector objects), and graphs (semantic ontologies)



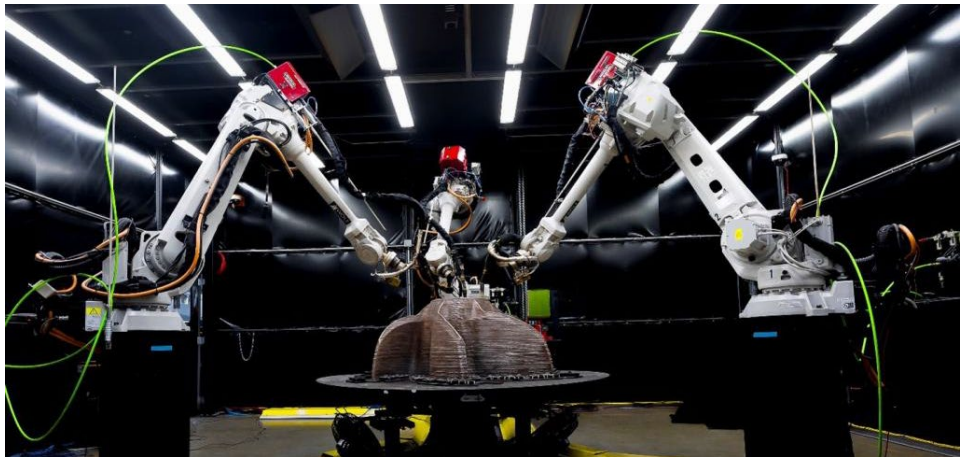



# Geospatial Supply Chain at the Edge – HPC and Manufacturing in a Box


Bringing high-performance computing and communications capabilities to the field for edge deployments and rapid data collection and processing

Integrating AI-enabled remote sensing and data fusion for rapid insights (integrated with sensors platforms)

Demonstrating the ability to manufacture custom drone parts for rapid repair to extend operations



Mitigating logistics and supply-chain risks during dynamic events

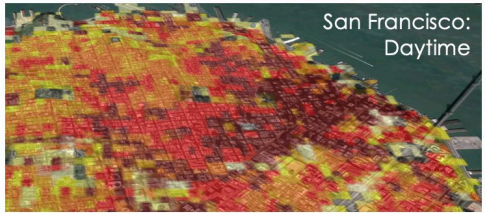
# Population Dynamics Monitoring – LandScan HD and UrbanPop

Global high-resolution gridded population datasets

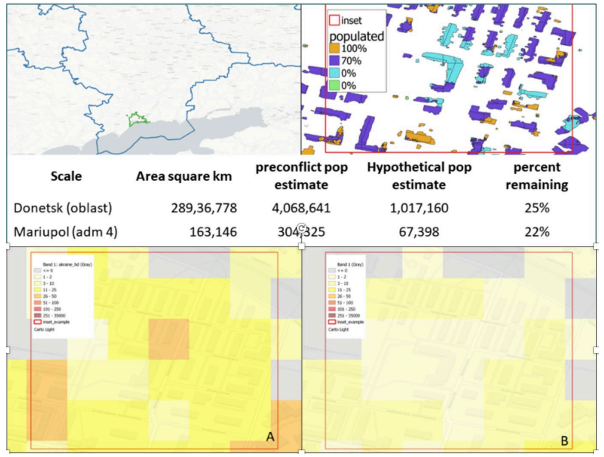
Time-variant building structure population density modeling

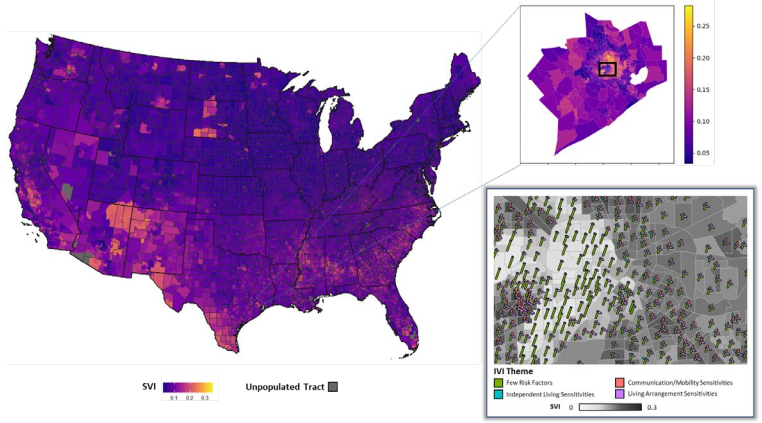
Event-based change detection and population movement monitoring

Synthetic population development and geodemographic assessments for risk, equity, and accessibility





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# Enduring Challenges

## Operationalizing the Crowd

Engaging the crowd can improve cultural wisdom, transparency, trust, and equity to the data creation process

Providing the community with tools to enable crowd-sourced contributions can improve understanding of conditions on the ground

Organizing pathways for bi-directional geospatial data contribution and enrichment can yield multiplicative benefits to data investments

## Avoiding the Geo-"Special" Mindset

Very few in the community of stakeholders in the response and recovery process are savvy geospatial experts

We can scale our geospatial impact by putting the power of geospatial into the broader community's hands

To accomplish this, we must commit to applying our geospatial expertise to simplify the experience, to deliver basic and intuitive tools for the average citizen

## Bridging Top-Down (Response) and Bottom-Up (Recovery) Efforts

Geospatial data creation and analysis supporting response is generally top-down, very structured, SOP-based

Geospatial data creation and analysis supporting recovery is generally bottom-up, disaggregated and disparate, loosely organized

Aligning and bridging the geospatial data creation and monitoring efforts will lead to economies of scale, mutual benefit, better preparation, and greater resilience

**“Geospatial information and spatial data infrastructure are key to advancing disaster risk reduction and sustainable development.”**

-Ban Ki-moon, former UN Secretary-General


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