

Remote Sensing, Imagery, and Drones for Response and Recovery Workshop



November 14, 2019

National Alliance for Public Safety GIS (NAPSG) Foundation

napsfoundation.org | [@napsfoundation](https://twitter.com/napsfoundation)

AGENDA

- 09:00 AM Welcome/Introductions – Glen Russell, FEMA
- 09:05 AM Review of Session Topics – Glen Russell, FEMA
- **Part 1. Background: Remote Sensing, Imagery, and Drones**
- 09:10 AM Presentation: Defining emergency management's priority needs for imagery in response and recovery.
– *Glen Russell, FEMA*
- 09:20 AM Presentation: Available imagery and derived products for disasters – Austin Worcester, Civil Air Patrol *and Glen Russell, FEMA*
- 09:30 AM Legal and privacy considerations. – *Austin Worcester, Civil Air Patrol and Glen Russell, FEMA*
- 09:45 AM Presentation: Priorities/Information/Imagery Collection Plans during Response (POST Tool) – *Madeline Jones, New Light Technologies*
- 10:15 AM Presentation: UPADs - How state can be leveraging. – *Lt Col John Easley, NGB J-2*
- 10:30 AM Facilitated Discussion: What are your imagery gaps?

AGENDA

- **Part 2. Remote Sensing for Response**

- 10:45 AM Presentation: Disaster Rewind on remote sensing collection, exploitation, and coordination - *Glen Russell, FEMA*
- 11:05 AM Facilitated Discussion: Acquisition Plans – Do you have a plan? *Glen Russell, FEMA*

- **Part 3. Remote Sensing for Recovery**

- 11:25 AM Presentation: Business Case: Remote Sensing for Public Assistance – *Katie Picchione, FEMA*
- 11:40 AM Analysis on Erosion: Hurricane Dorian Case Study – *Catherine Bohn, Dewberry*

- **Part 4. Latest in Innovative Imagery Exploitation, Automation, and Artificial Intelligence**

- 11:50 PM Presentation: Remote Sensing Innovation Workshop - *Madeline Jones, NLT*
- 12:00 PM Remote Sensing - 'So What'? – *Glen Russell, FEMA, Austin Worcester, Civil Air Patrol and Catherine Bohn, Dewberry*
- 12:20 PM Wrap-up

Part 1. Background: Remote Sensing, Imagery, and Drones.

Defining Emergency Management's Priority Needs for Imagery in Response and Recovery.

Glen Russell, Remote Sensing Coordinator FEMA



Definition

Imagery is a Subset of Remotely-Sensed Data:

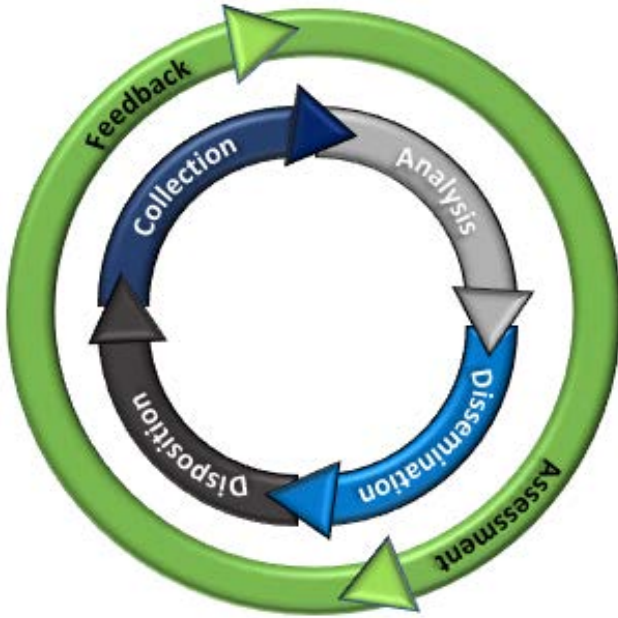
A likeness of any natural or created feature or related object or activity and the (general) positional data acquired at the same time, including products acquired by satellites, airborne platforms, unmanned aerial vehicles, **un-attended ground-based cameras**, **crowd-sourced imagery** or **videos**...or other similar means.

-Anonymous FEMA official, November 2018



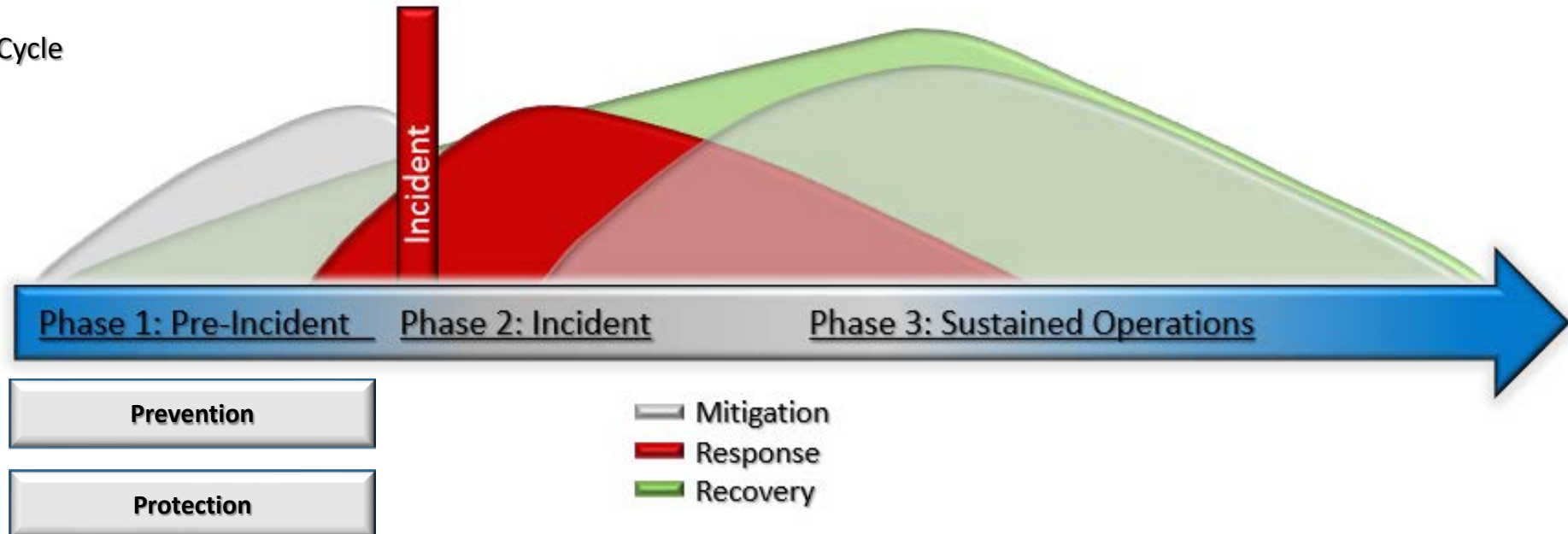
Simple to Complex/ Quick to Not-So-Quick

Remotely-Sensed Data



Disaster Information Management Cycle

- Is just one of many data types
- Can support every phase of the Disaster Lifecycle
- Is most useful when collected, processed, analyzed, and fused with other data to aid specific emergency management decisions
- Must match the specific mission and information requirements
- Varies by platform, format, volume, resolution, timeliness, accuracy, and usefulness



Data Priorities for FEMA Response and Recovery

Response: Community Lifelines



Recovery: Core Capabilities

Economic Recovery

Return economic and business activities (including food and agriculture) to a healthy state and develop new business and employment opportunities that result in an economically viable community.

Health and Social Services

Restore and improve health and social services capabilities and networks to promote the resilience, independence, health (including behavioral health), and well-being of the whole community.

Housing

Implement housing solutions that effectively support the needs of the whole community and contribute to its sustainability and resilience.

Infrastructure Systems

Stabilize critical infrastructure functions, minimize health and safety threats, and efficiently restore and revitalize systems and services to support a viable, resilient community.

Natural and Cultural Resources

Protect natural and cultural resources and historic properties through appropriate planning, mitigation, response, and recovery actions to preserve, conserve, rehabilitate, and restore them consistent with post-disaster community priorities and best practices and in compliance with applicable environmental and historic preservation laws and executive orders.

Key Recovery Programs

Individual
Assistance

Public
Assistance

Critical Infrastructure Sector Priorities During Disasters



Energy Sector



Transportation Systems Sector



Water and Wastewater Systems Sector



Chemical Sector



Commercial Facilities Sector



Communications Sector



Nuclear Reactors, Materials, and Waste Sector



Critical Manufacturing Sector



Dams Sector



Defense Industrial Base Sector



Emergency Services Sector



Food and Agriculture Sector



Financial Services Sector



Government Facilities Sector



Healthcare and Public Health Sector



Information Technology Sector



CISA
CYBER • INFRASTRUCTURE



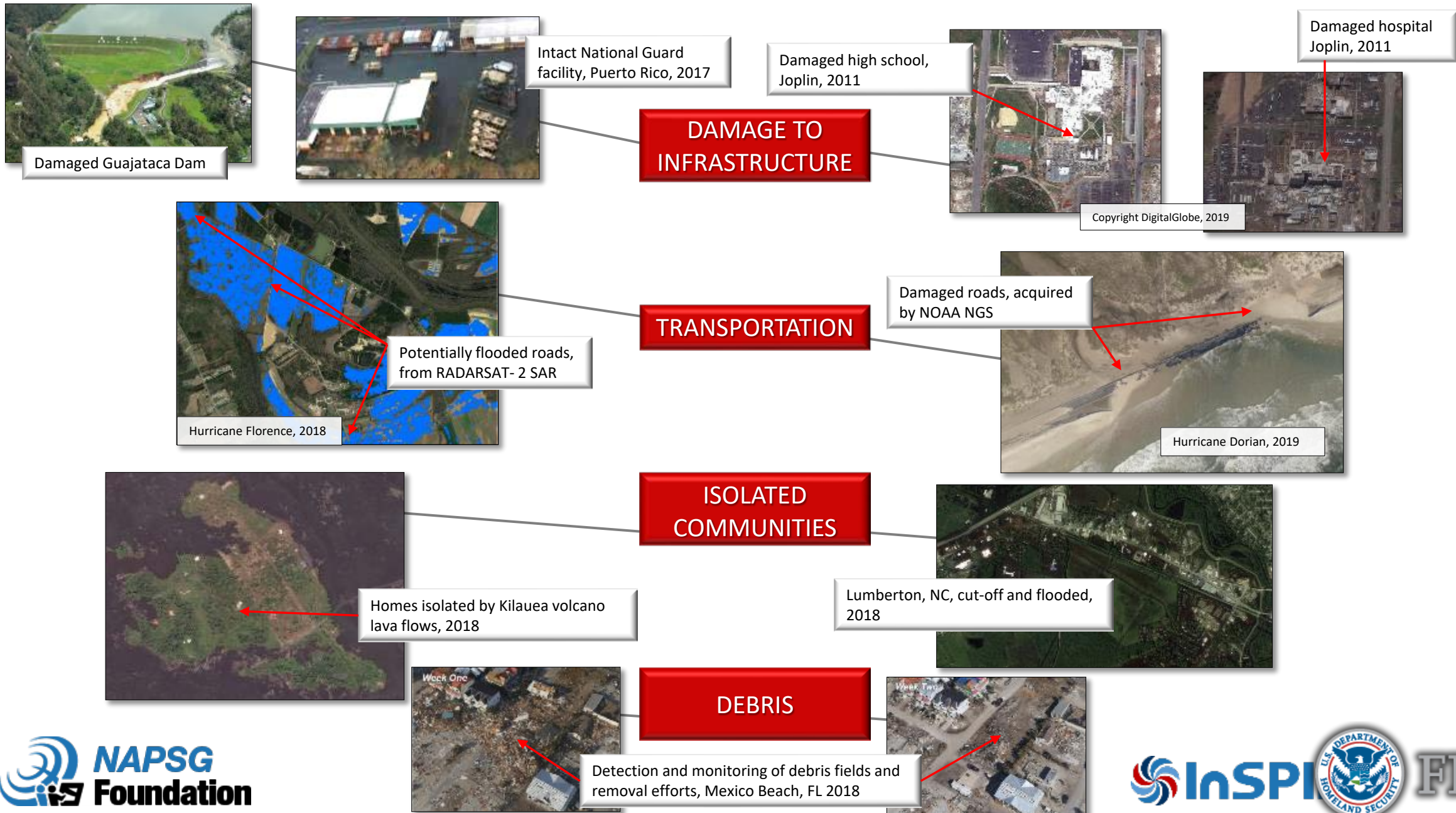
Regional Office Services



Remotely-Sensed Data Priorities for FEMA Response and Recovery

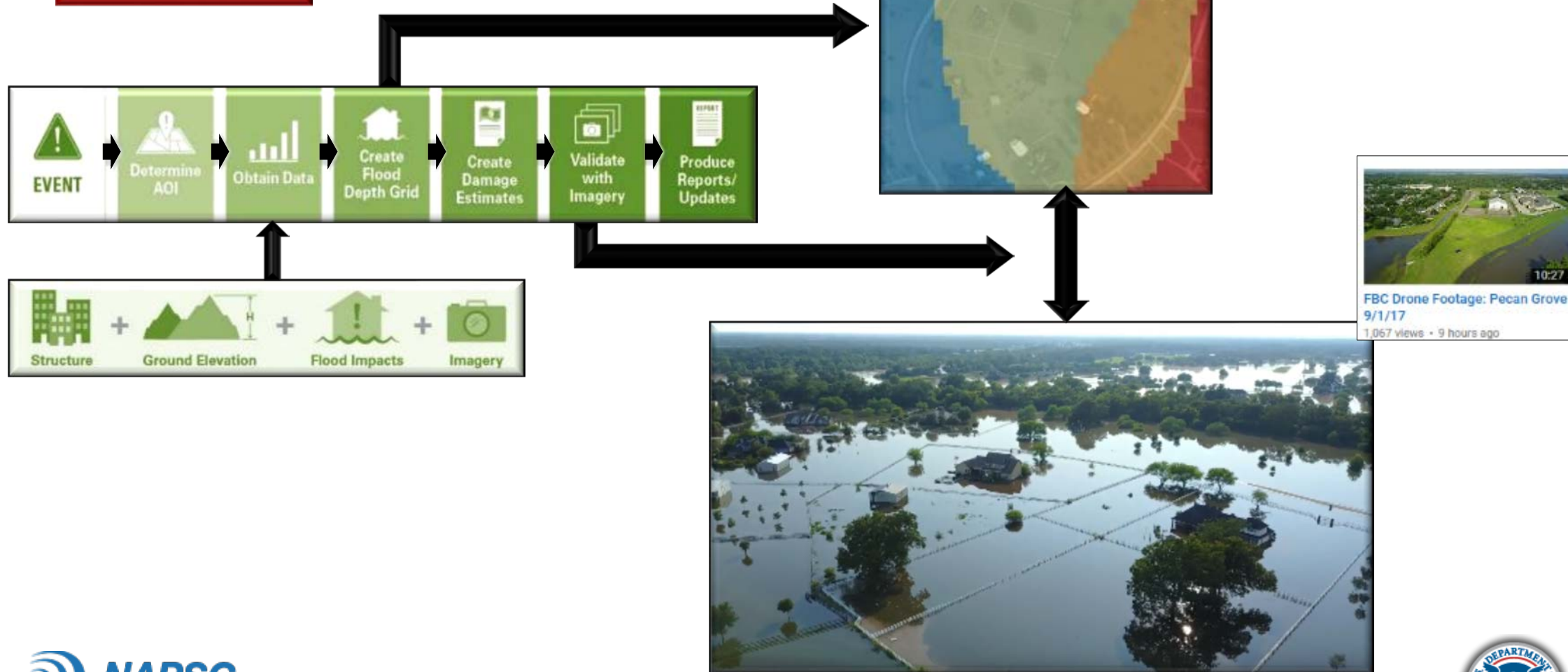
Problem Statements/Observables	Response L+96	Recovery L - 365+
▪ Determine wind/surge/flooding/mudslide impacts to 7 Community Lifelines (infrastructure)	✓	✓
▪ Identify damage to transportation sector (road, rail, bridge, airport, maritime ports) that may hinder movement of commodities or people into or out of the area	✓	✓
▪ Validate modeled numbers of destroyed/damaged residential and non-residential structures	✓	✓
▪ Detect and locate isolated communities*	✓	✓
▪ Locate, characterize, quantify debris	✓	✓
▪ Detect, locate areas of beach erosion, and quantify amount of eroded beach/soil		✓
▪ Monitor restoration of Community Lifelines and communities		✓

Remotely-Sensed Data “Hot Buttons”



Remotely-Sensed Data Hot Button: Geospatial Damage Assessments

Housing:
Geospatial
Damage
Assessments

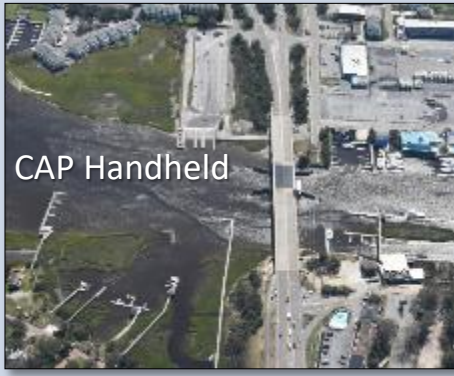
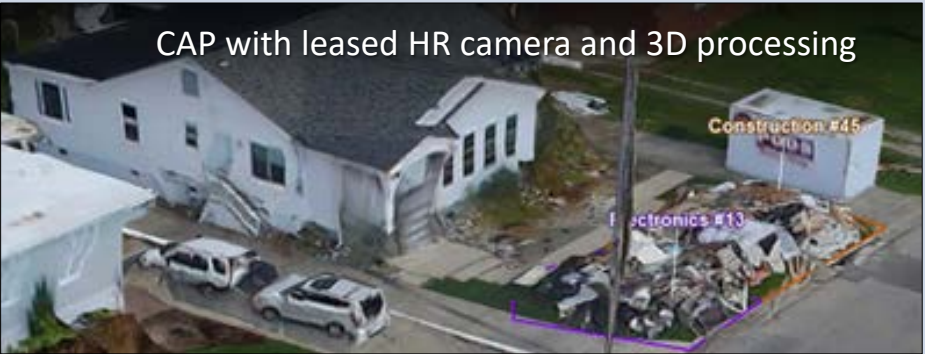


Available Imagery, Derived Products, and Models for Disasters

Glen Russell, FEMA
Austin Worcester, Civil Air Patrol

[illegible]

Remote Sensing for Disasters Menu

Requirement	Satellite	Manned Aerial	Unmanned Aerial
General Situational Awareness	<1 Meter Visible  10 Meter Visible 	CAP Handheld  NOAA 	 USACE sUAS
Full Motion Video	FEMA does not have access to motion imagery from space.  urthecast 	CAP SPred  CBP P-3  DoD P-8 	Citizen QuadCop 
Individual Structural Analysis	<1 Meter Visible 	CAP with leased HR camera and 3D processing 	 Citizen QuadCop

Remote Sensing for FEMA Disaster Response

“Blue-Sky” (Pre-Incident) Data

SATELLITE:

- U.S. (federal):
 - DoD/NextView
 - USGS/Landsat
- International:
 - ESA/Sent.-1, -2
 - Radarsat-2 (DoD)

AERIAL:

- U.S. (federal):
 - Civil Air Patrol
 - NOAA/NGS
 - USDA/NAIP
- Publicly available State/Local/Tribal data

“Gray-Sky” (Post-Incident) Data

SATELLITE:

- U.S. (federal):
 - DoD/NextView
 - USGS/Landsat
- International:
 - ESA/Sent.-1, -2
 - Radarsat-2 (DoD)
 - International Charter*
 - EU Copernicus EMS**

AERIAL:

- U.S. (federal):
 - Civil Air Patrol
 - NOAA/NGS
 - NASA UAV SAR
 - CBP Air and Marine
 - National Labs

Whole of Community Effort

NG/State/Local/Tribal

Private Industry

Citizens/Social Media

1a

Normal
Operations

1b

Elevated
Threat

1c

Credible
Threat

2a

Immediate
Response

2b

Deployment

2c

Sustained
Response

3a

Short-Term
Recovery

Long-Term
Recovery

PHASE 1: PRE-INCIDENT

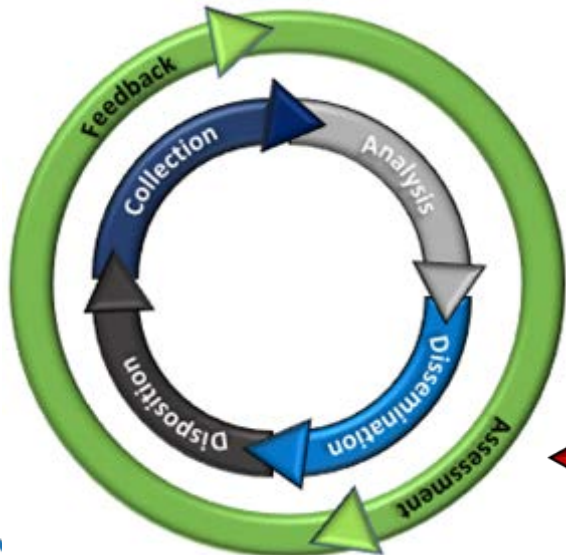
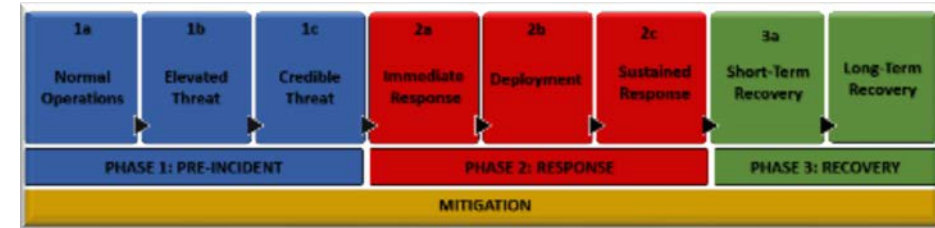
PHASE 2: RESPONSE

PHASE 3: RECOVERY

MITIGATION

FEMA Remote Sensing Platform/Sensor/Provider Selection Process

- Who is the requestor/customer?
 - What is their mission?
 - What decisions do they need to make?
- What information (or data) do they NEED?
- When do they NEED the data (information/product)...and in what format?
- Has some organization already collected it?
- What are the options for new collection?
 - Mission Assignments for Stafford Act incidents
 - Direct Federal Assistance = “Cost Share” to the state(s)
 - Federal Operations Support = No “Cost Share” but no state direction
 - What entity/echelon will Mission Assign?
 - Is a contract more appropriate or necessary?



Consider the WHOLE Process!

Remote Sensing Use Case 1: Response - Search & Rescue

Asset Owner	Assets	Sensors
Local First Responders	sUAS, Helicopters	Day/Night Video, Still cameras, Eyeball
State LEA or Other	Helicopters, Fixed Wing Aircraft	Day/Night Video, Still cameras, Eyeball
National Guard	UAS, Helicopters, Fixed Wing Aircraft	Day/Night Video, Still cameras, Eyeball
USCG	Helicopters, Fixed Wing Aircraft	Day/Night Video, Still cameras, Eyeball
AFAUX (CAP)	sUAS, Fixed Wing Aircraft	Day/Night Video, Still cameras, Eyeball
CBP, DoD (T10)	UAS, Helicopters, Fixed Wing Aircraft	Day/Night Video, Still cameras, Eyeball



Remote Sensing Use Case 2: Response – Situational Awareness

Asset Owner	Assets	Sensors
FSLTT First Responders	sUAS, Helicopters, Fixed Wing Aircraft	Day/Night Video, Still cameras, Eyeball
AFAUX	sUAS, Fixed Wing Aircraft	Day/Night Video, Still cameras, Eyeball
National Guard	UAS, Helicopters, Fixed Wing Aircraft	Day/Night Video, Still cameras, Eyeball
USCG	Helicopters, Fixed Wing Aircraft	Day/Night Video, Still cameras, Eyeball
NOAA NGS	Fixed Wing Aircraft	High resolution visible and IR cameras
CBP, DoD (T10)	UAS, Helicopters, Fixed Wing Aircraft	Day/Night Video, Still cameras, Eyeball



AFAUX (CAP) Handheld Oblique



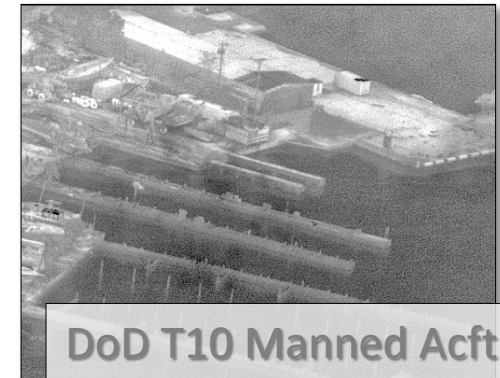
AFAUX (CAP) WaldoAir



NOAA NGS



DoD T10 Manned Acft



DoD T10 Manned Acft

Immediate Response

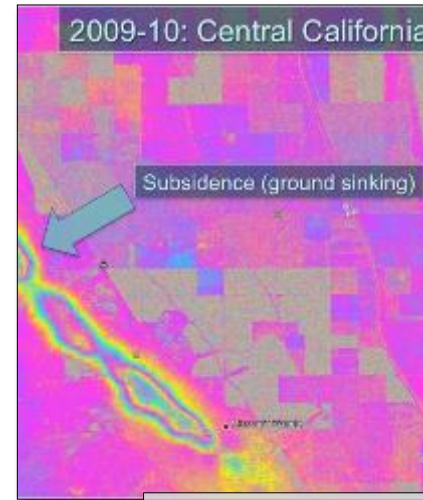
Deployment

Sustained Response

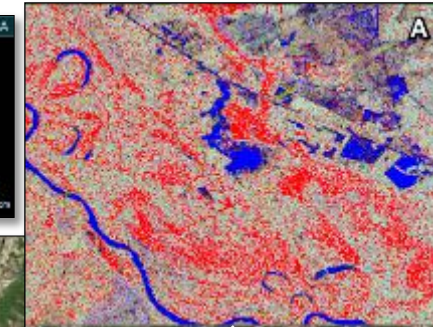
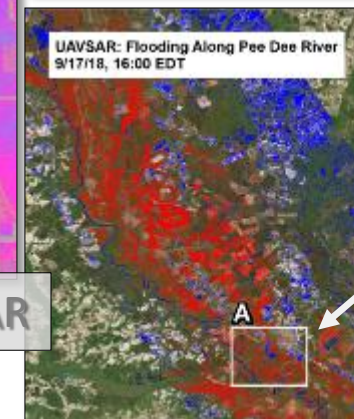
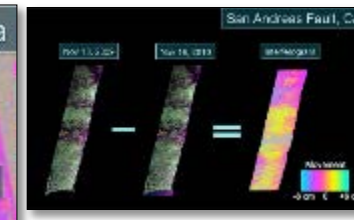
PHASE 2: RESPONSE ~Incident Onset thru 5 Days

Remote Sensing Use Case 2: Response – Situational Awareness

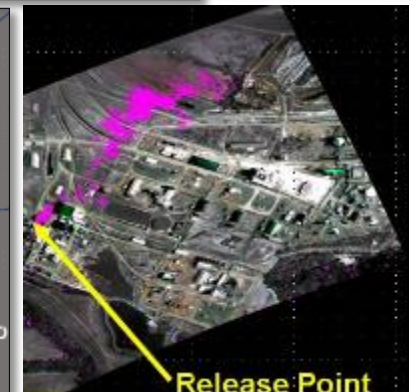
Asset Owner	Assets	Sensors
EPA	Fixed Wing Aircraft	Hyperspectral, Gamma, High Resolution Visible and IR cameras, Eyeball
NASA	UAV SAR (Manned)	SAR, Eyeball
Commercial	UAS, Helicopters, Fixed Wing Aircraft	Day/Night Video, Still cameras, IR, LiDAR, etc.



NASA UAV SAR

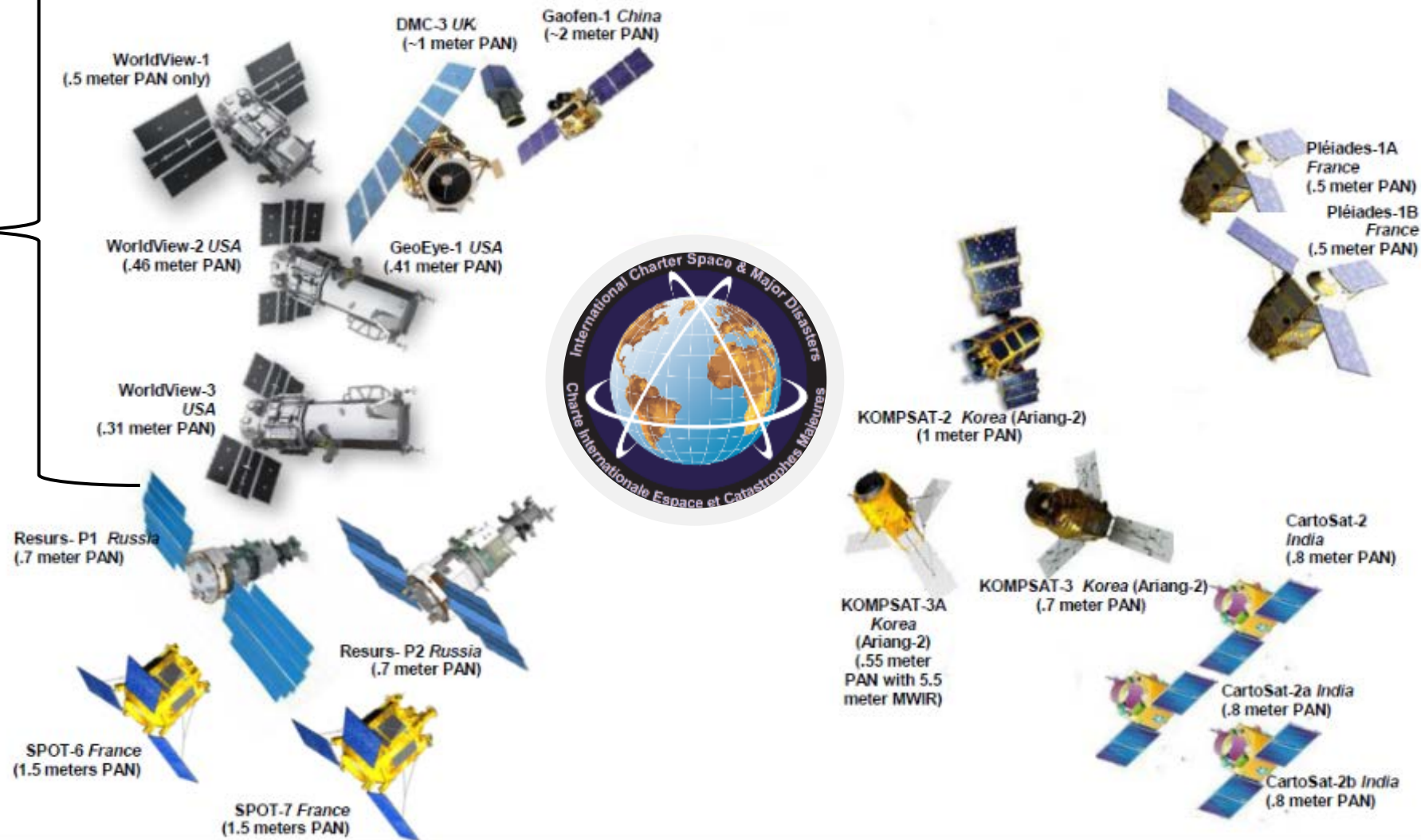


- ✓ An **Infrared Line Scanner*** to image the plume
- ✓ A **High Speed Infrared Spectrometer*** to identify and quantify the composition of the plume
- ✓ **Gamma-Ray Spectrometer** Packs for Radiological Detection (NaI and LaBr) and two **BF₃ Neutron Detector** arrays
- ✓ High Resolution **Digital Aerial Cameras*** with ability to rectify for inclusion into GIS



Remote Sensing Use Case 2: Response – SA from Space

Access to **U.S. High Resolution** satellites via NextView contract (NSG)



International Charter for Space and Major Disasters Visible Imagery Satellites with Ground Sample Distances **(GSDs) of two meters or less**

Immediate Response

Deployment

Sustained Response

PHASE 2: RESPONSE ~Incident Onset thru 5 Days

Remote Sensing Use Case 2: Response – SA from Space

Platform: WorldView-2
GSD: 57 cm
Date: 2011-05-29



Joplin, Missouri, Sunday afternoon, May 22, 2011:

Fatalities: 158

Injuries: 1,150

Costliest single tornado in U.S. history

Insurance payout: \$2.8 billion

Destroyed structures: vic. 2,000

Pre-Incident



USDA FSA

Post-Incident



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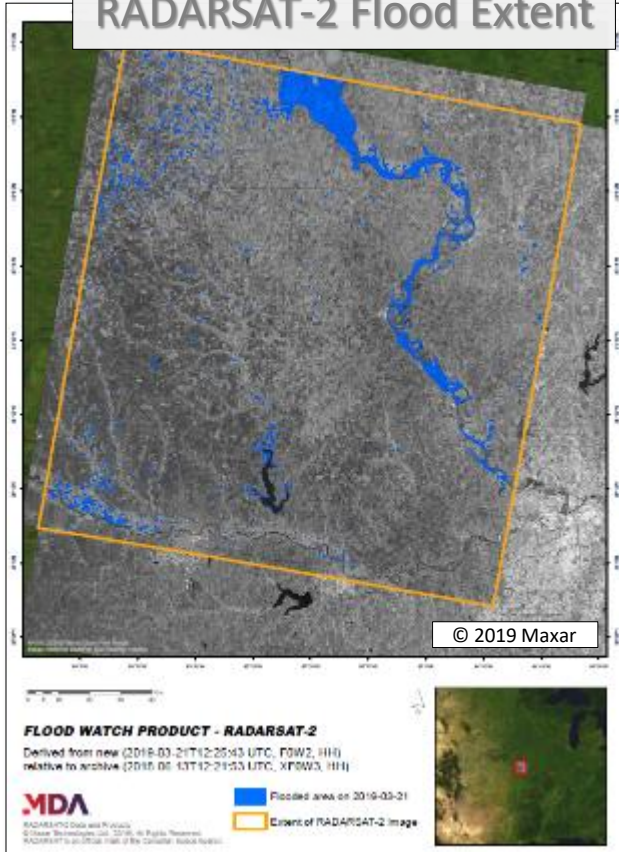
Long-Term Recovery



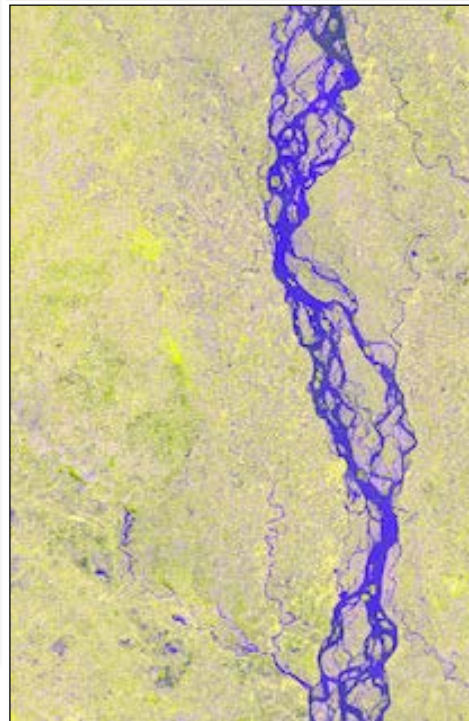
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Remote Sensing Use Case 2: Response – SA* from Space

RADARSAT-2 Flood Extent



Colorized Sentinel-1 SAR Image, ESA



Medium Resolution Multispectral and SAR Satellites

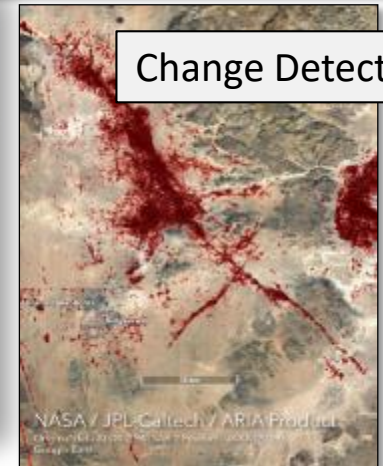
LANDSAT-8



WorldView-3 SWIR



Change Detection



Immediate Response

Deployment

Sustained Response

PHASE 2: RESPONSE ~Incident Onset thru 5 Days

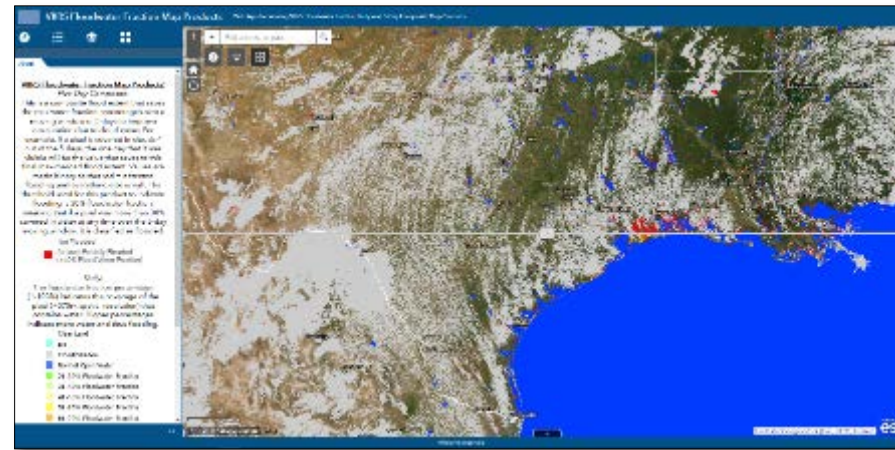
*Situational Awareness

Imagery-Derived Products

Manually Interpreted and Annotated Images



Self-Serve Web Apps and Image Services



Semi- & Automated Classification & Feature Extraction

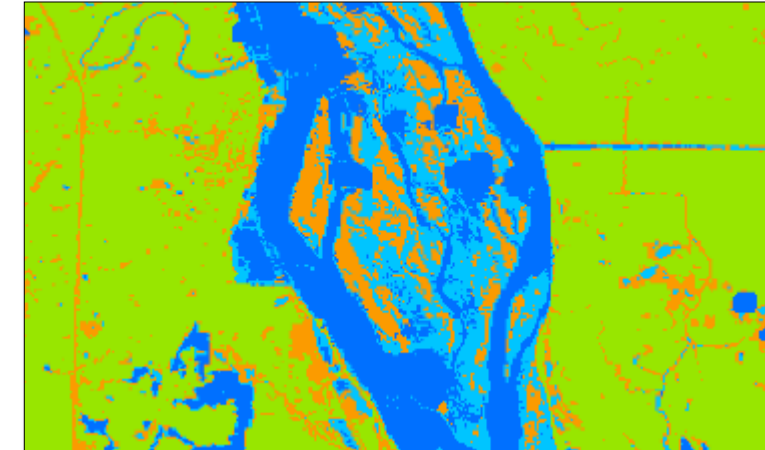


Image Services

ESRI ArcGIS Feature Services:

<https://imageryuploader.geoplatform.gov/arcgis/rest/services/ImageEvents/MapServer>

OFC WMS & WFS Links:

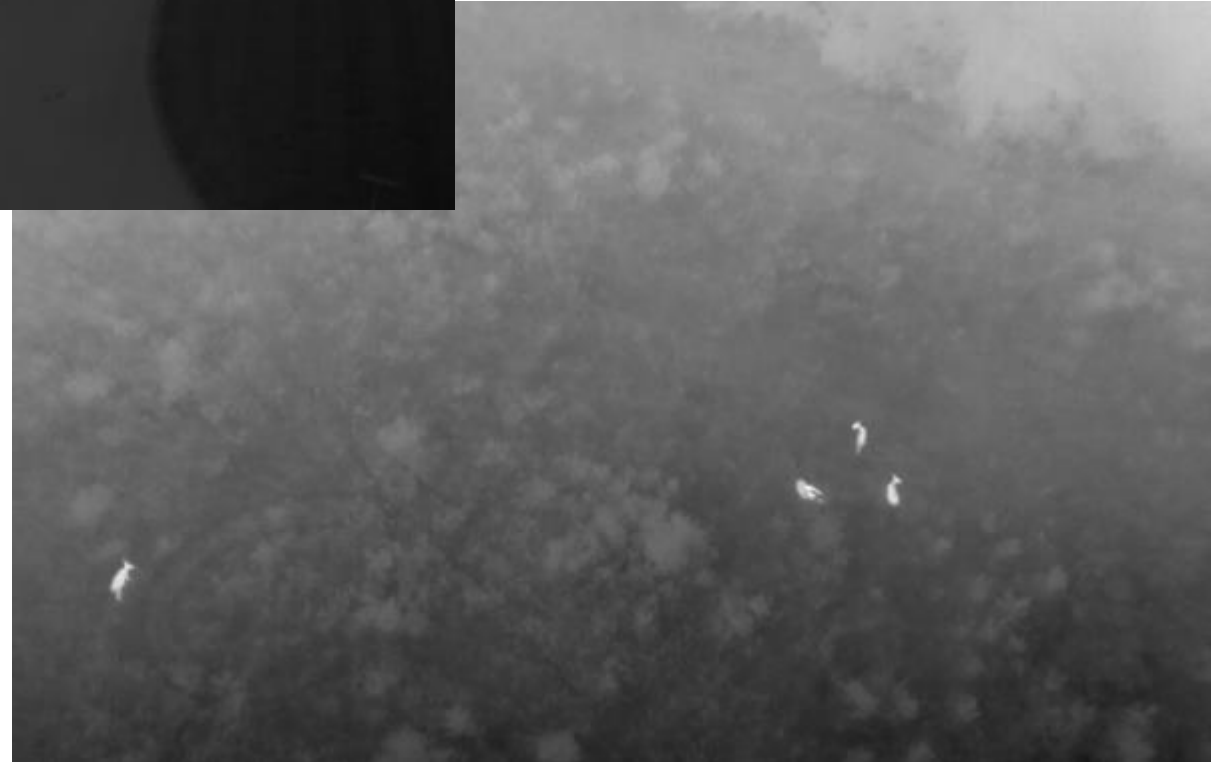
<https://imageryuploader.geoplatform.gov/arcgis/services/ImageEvents/MapServer/WMSServer?service=WMS&request=GetCapabilities>

Object-Oriented Observations

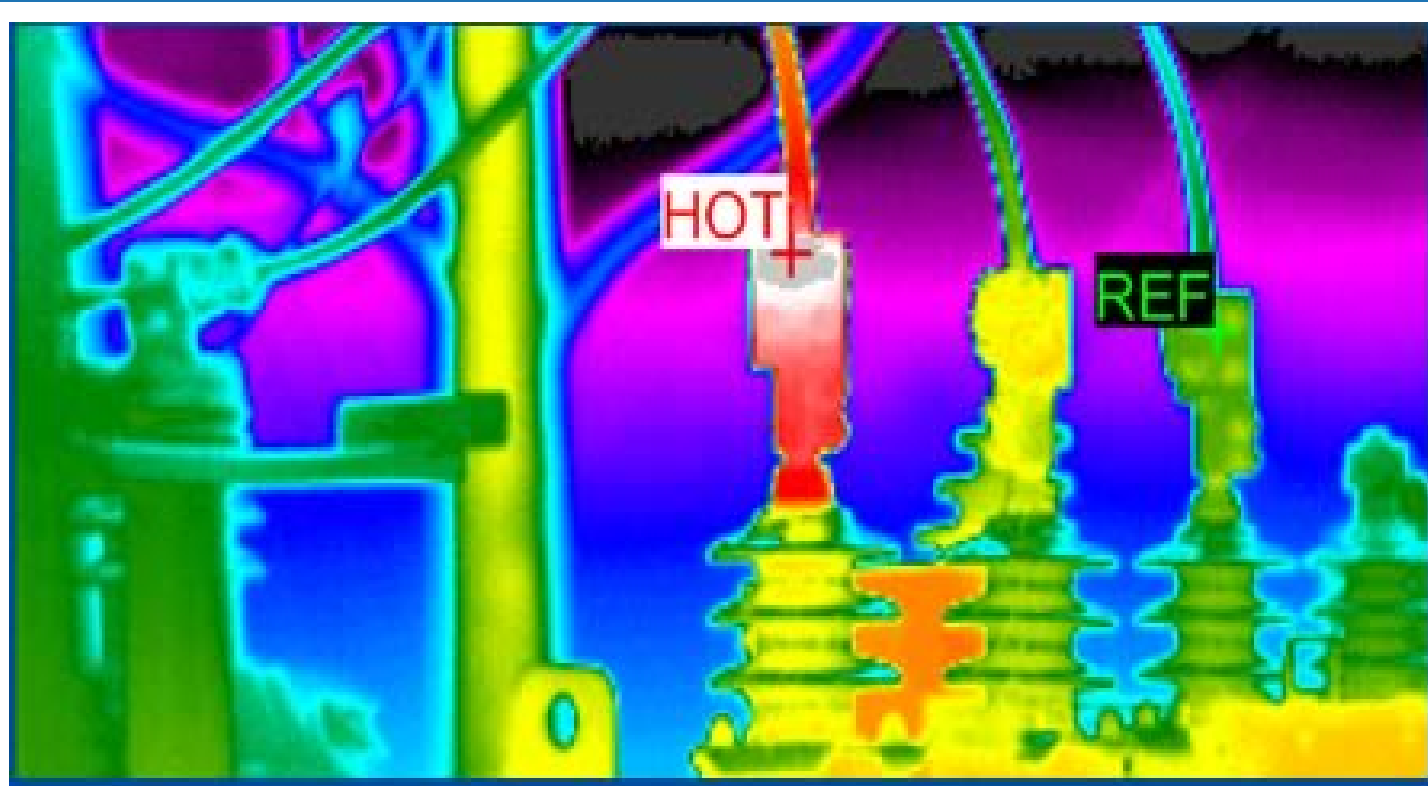


sUAS/GIS Responses

Person Search



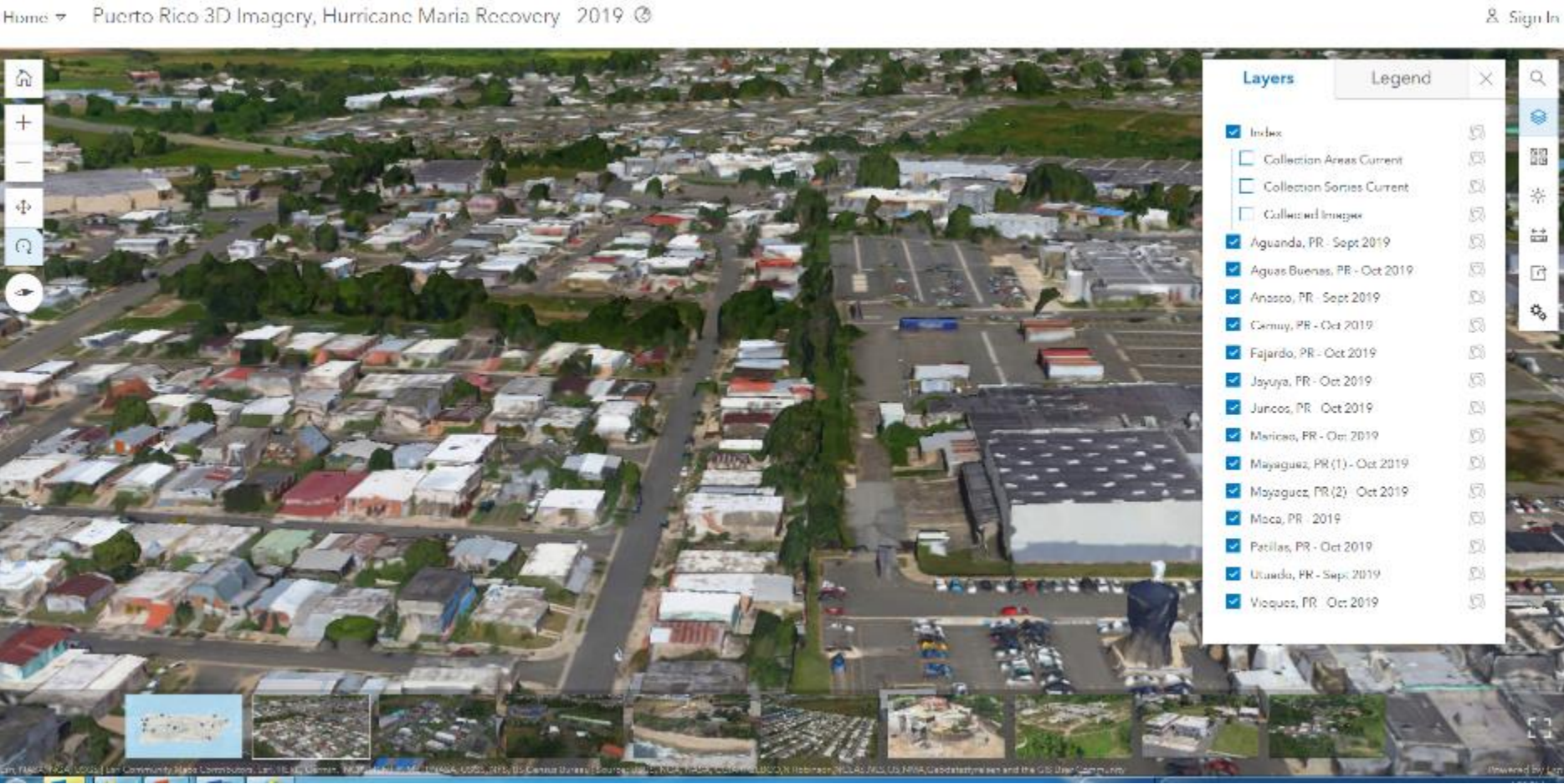
Thermography



The Georeferenced Orthomosaic



3d CAP Imagery



[LINK](#)

Legal and Privacy Considerations.

Glen Russell, FEMA

Austin Worcester, Civil Air Patrol

Legal and Privacy Considerations:

- *Satellite and Manned Platform Aerial Data*
–Glen Russell, FEMA
- *Unmanned Aerial Systems*
–Austin Worcester, Civil Air

Privacy and Restrictions: Satellite and Manned Platform Aerial Data

- Department of Defense and EO 12333
 - ✓ NextView satellite data
 - ✓ AF AUX
- Licensed Data:
 - ✓ NextView
 - ✓ Charter
 - ✓ Aerials
 - NICB, etc.
 - FEMA-contracted
- DHS and FEMA Privacy Office Requirements
 - ✓ Response vs. Recovery?

Executive Order 12333 (1981)

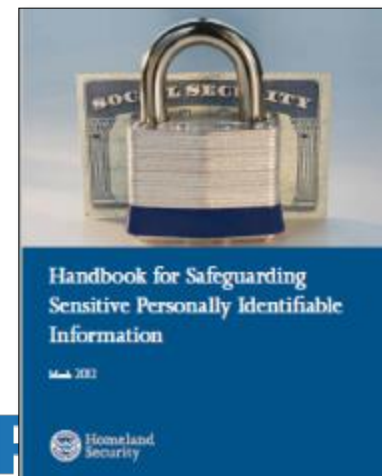
As amended by EO 13284 (2003), 13355 (2004), and 13470 (2008)

United States Intelligence Activities

End User License Agreement

Contract:

Applicability. This license applies to imagery and products licensed under the Contract, including data downlinked to domestic and foreign ground stations.



UAS Standards and Regulations

Civilian Govt. COA vs FAA Part 107

U.S. Government Use (Civilian vs DoD)

State Regulation???

American Security Drone Act of 2019

FAA Reauthorization Act of 2018

Priorities/Information/Imagery Collection Plans during Response (POST Tool)

Madeline Jones, NLT

POST: Prioritizing Operations Support Tool

Ran Goldblatt, Chris Vaughan, Glen Russell, Madeline Jones, Carl Anderson,
Andrew Strauch, Jody Hoon-Starr, Brad Bottoms, Robert Pitts*

InSPIRE
Galveston, TX
November 12-14 2019

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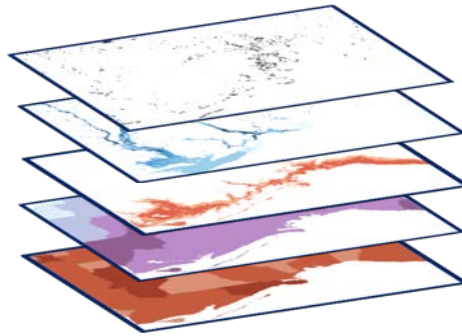
POST Roadmap

- **POST: What?**

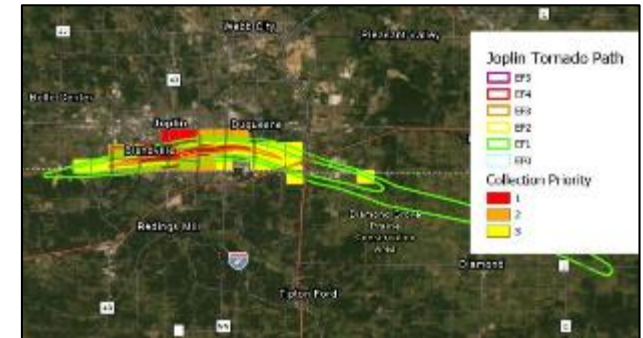
- Overview
- Prioritizing Data Collection

- **POST: How?**

- Standardization
- Hazard Probability Score (HPS)
- Affected Community
- Aggregation



- POST_ArcGIS_Pro.tbx
 - Social Vulnerability and Collection Priorities (with enriched parcels)
 - Social Vulnerability and Collection Priorities (only with hazard extent)



- **POST: Where?**

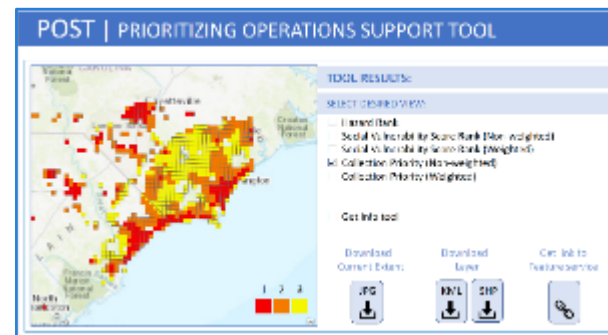
- ArcGIS Pro + Python
- Results published as web services

- **POST: Demo**

- Joplin Missouri EF₅ Tornado (May 2011)

- **POST: What's Next?**

- Next-Gen Web Application
- Lifelines



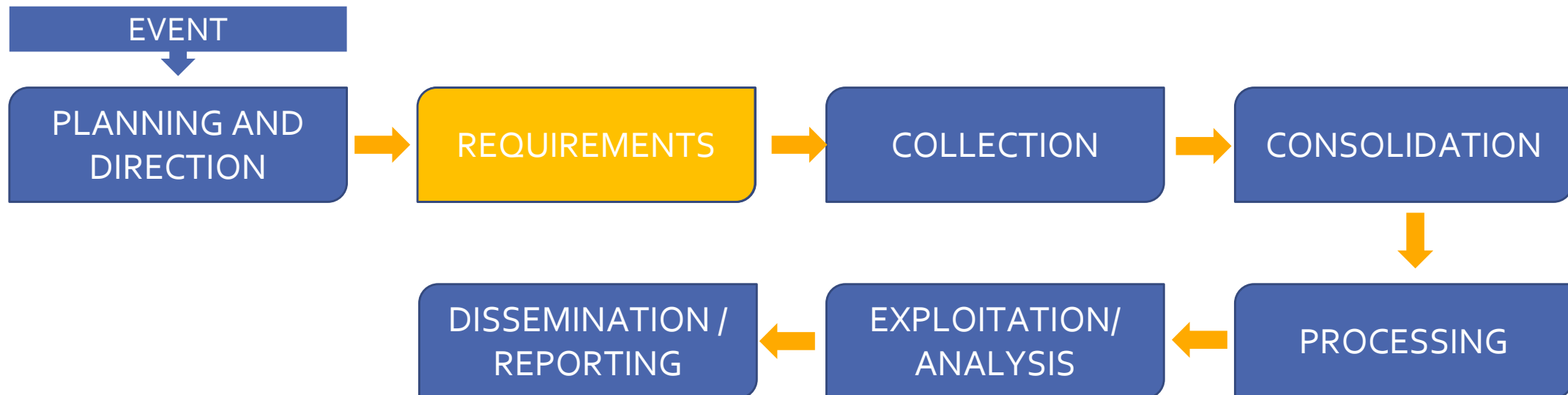
POST: WHAT?

OVERVIEW

POST = Prioritizing Operations Support Tool

During an event FEMA must quickly understand the **magnitude of impacts** upon citizens and communities.

Collection of imagery must be **properly planned** and implemented to **optimize its value** to response and recovery.



POST: WHAT?

OVERVIEW

POST = Prioritizing Operations Support Tool

During an event FEMA must quickly understand the **magnitude of impacts** upon citizens and communities.

Collection of imagery must be **properly planned** and implemented to **optimize its value** to response and recovery.

In the past, there was a lack of **scientific methodologies** and **standard workflows** to operationalize and automate the way the imagery was collected.

POST is a method for **prioritizing** collection of imagery during disaster response.

However, POST can be implemented across the wider disaster response community, i.e. search & rescue, logistics, planning, etc.

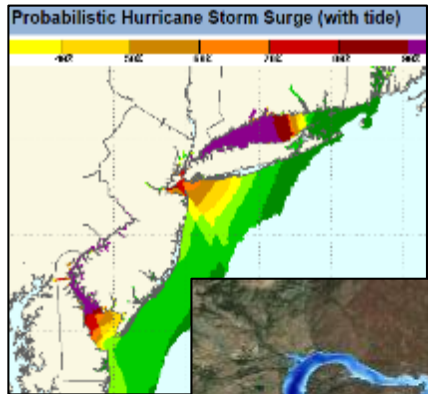
POST: WHAT?

PRIORITIZING DATA COLLECTION

1. **HAZARD PROBABILITY:** Which areas are most likely to be hit?
2. **HAZARD SEVERITY:** Which areas are most likely to be severely damaged?
3. **AFFECTED POPULATION:** Where are vulnerable people most likely to be impacted?

Hazard and intensity

Coastal Surge



Wind



Riverine Flooding

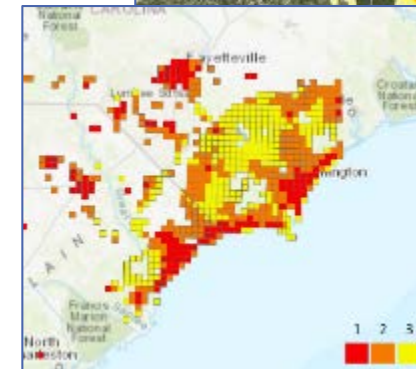
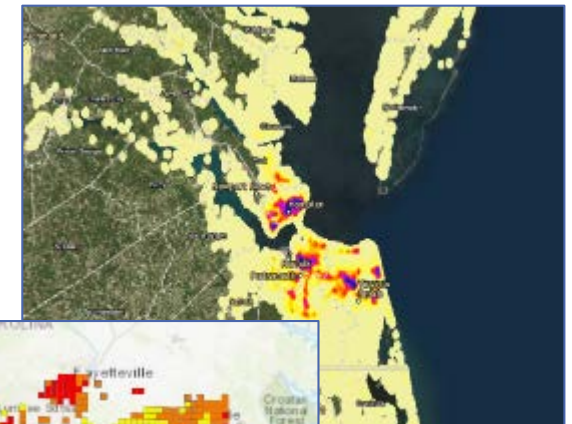
Effect on the community

Structure, infrastructure



Population
and
Vulnerability

Exposure and impacts



POST: WHAT?

OVERVIEW

POST OBJECTIVES:

POST was designed to help FEMA and the disaster response community prioritize response operations during disasters **with a focus on collection of satellite imagery**.

Currently, POST relies on three main data sources to determine priorities:

1) HAZARD DATA:

Hazard extent, flood depth grids, wind speed etc.

2) STRUCTURAL DATA:

Residential parcels (point on structure)

3) POPULATION VULNERABILITY DATA:

13 population vulnerability criteria derived from ACS Census data

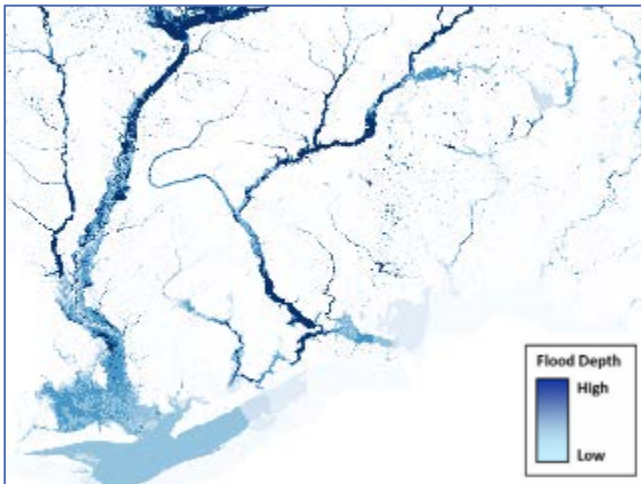
POST: WHAT?

PRIORITIZING DATA COLLECTION

DAILY HAZARD DATA

- Flood Depth Grids
- Surge (probabilistic or hindcast)
- Wind forecast

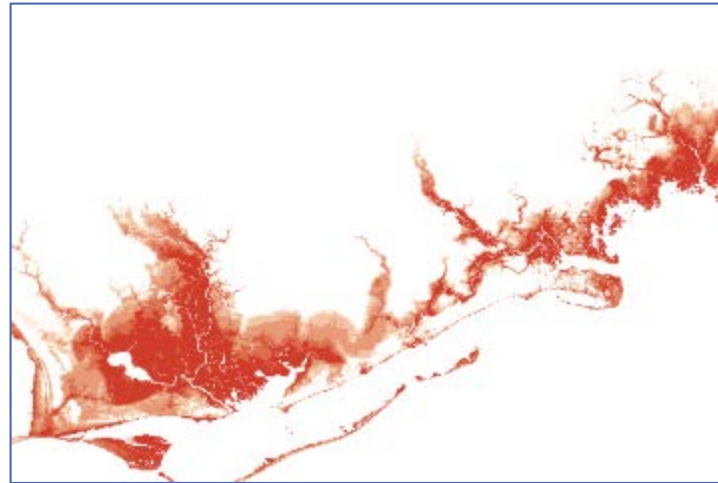
Flood extents/depth grids



PNNL
USACE

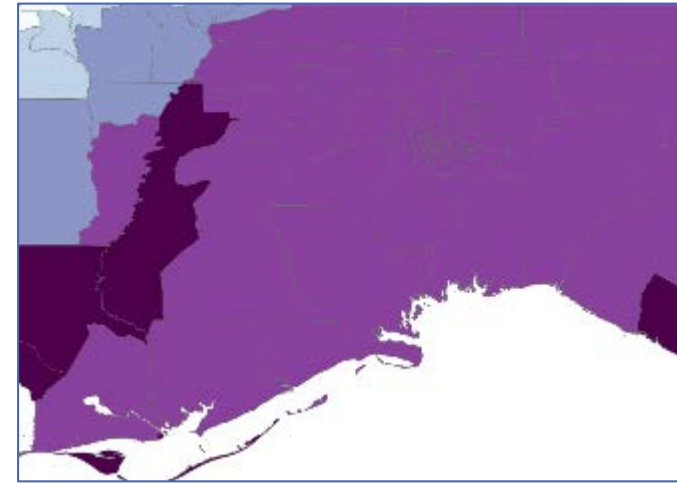
FEMA
NASA

Surge



NHC P-surge
NHC hindcast surge
(NOAA/FEMA)

Wind speed



Hazus
ARA windfield

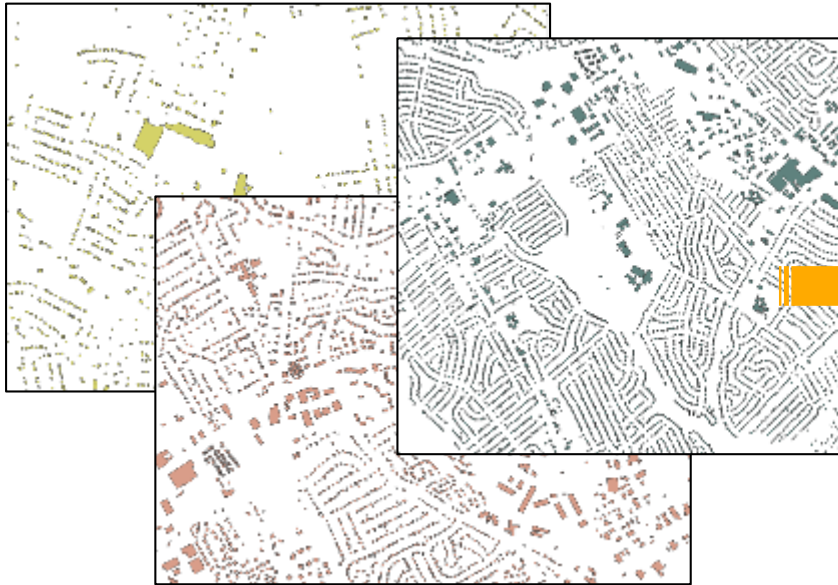
POST: WHAT?

PRIORITIZING DATA COLLECTION

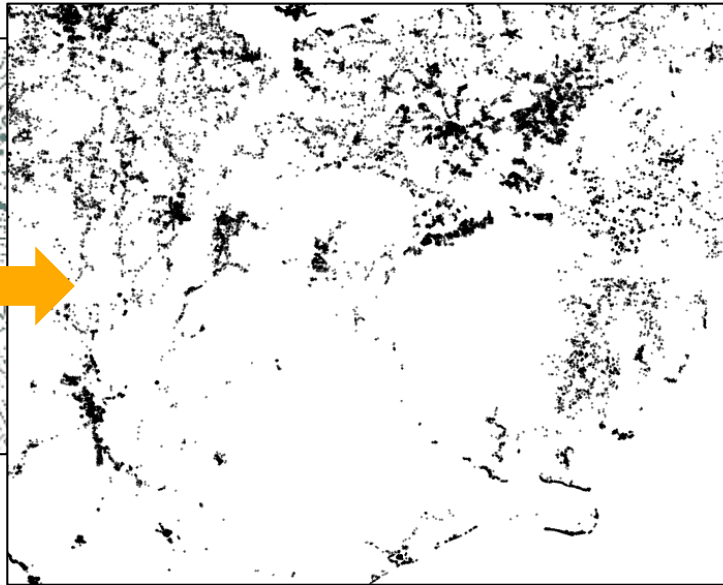
COMMUNITY ASSETS & STRUCTURAL DATA

- CoreLogic Parcels
- HIFLD Open CIKR
- ORNL building outlines
- Microsoft building outlines

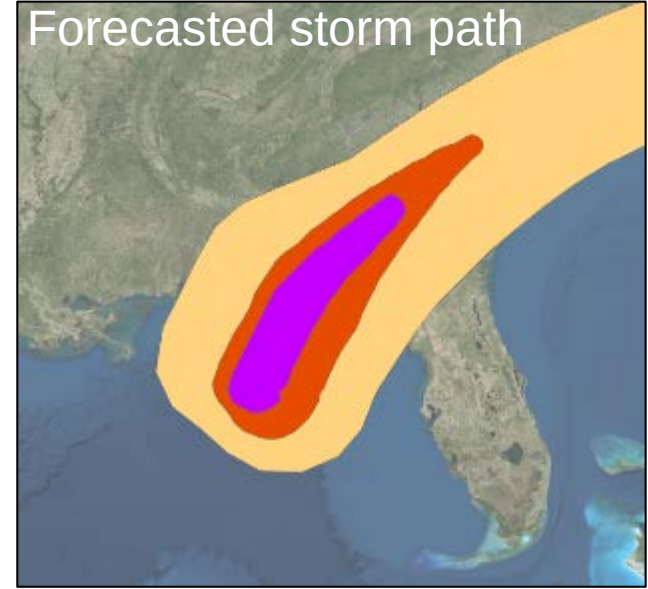
Parcel polygon or Building Outline



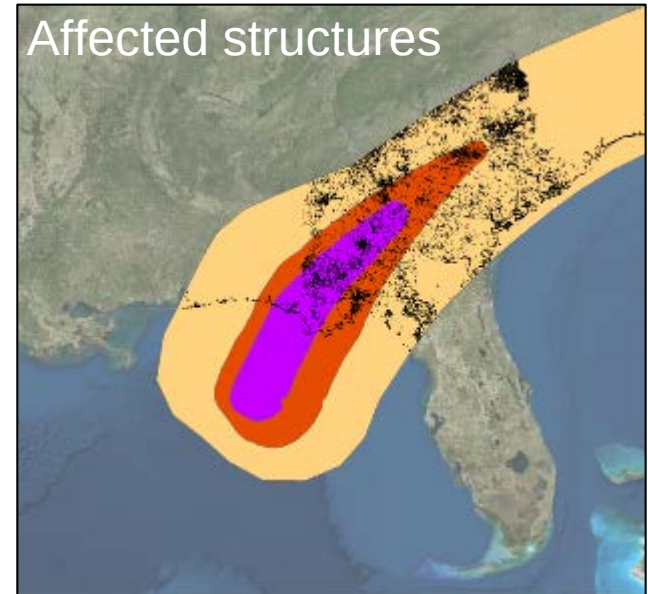
Point on structure



Forecasted storm path



Affected structures



POST: WHAT?

PRIORITIZING DATA COLLECTION

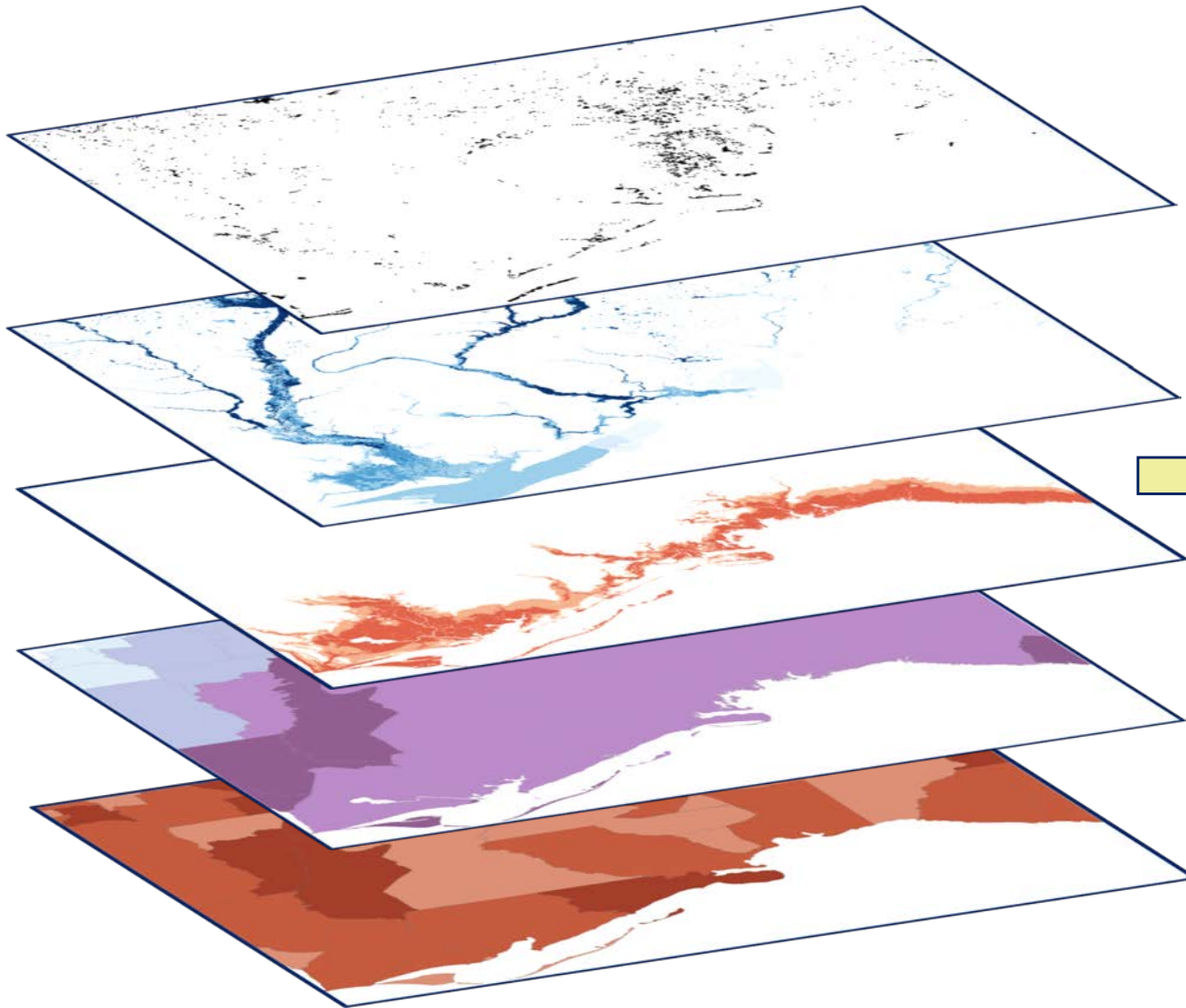
Parcels

Depth grids

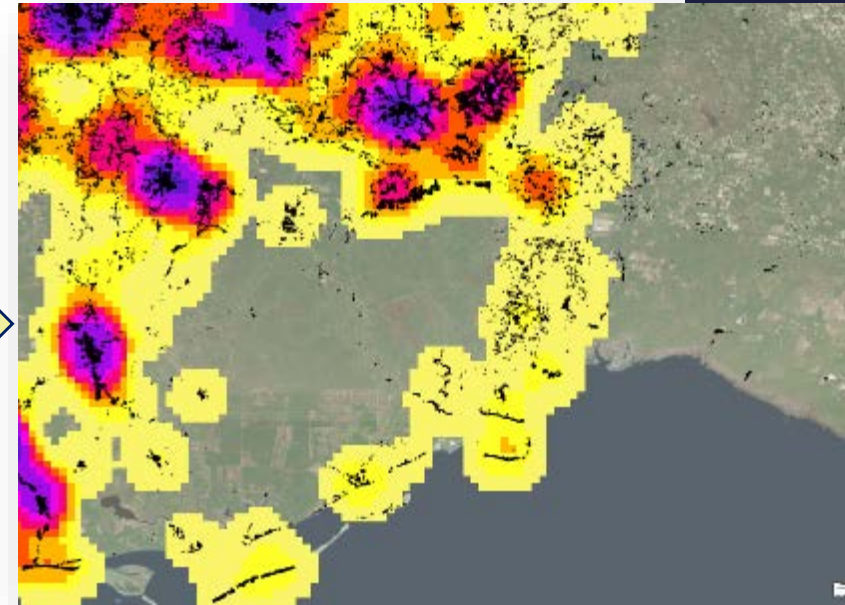
Surge

Wind speed

SVI

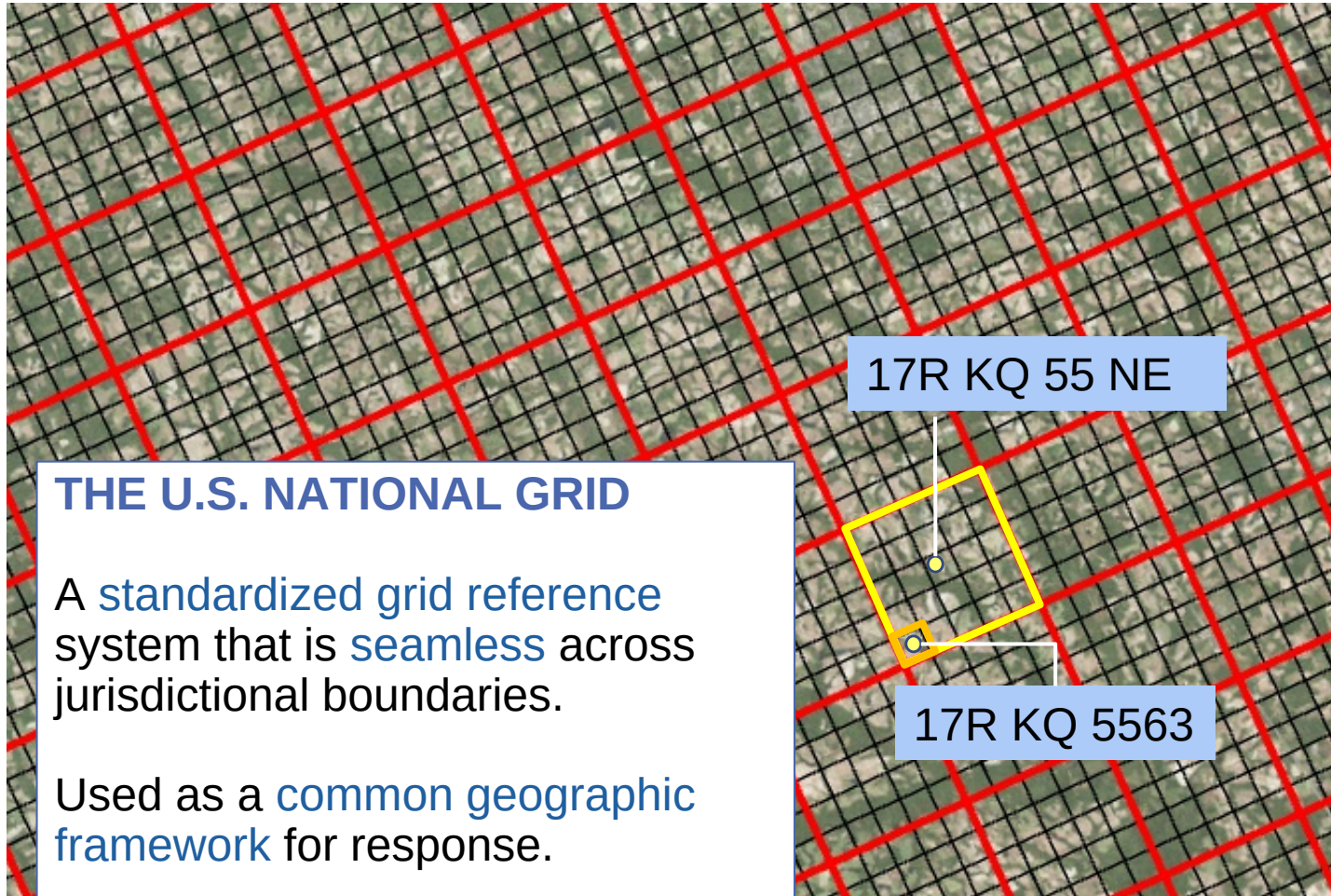


Hazard probability map



POST: HOW?

STANDARDIZATION

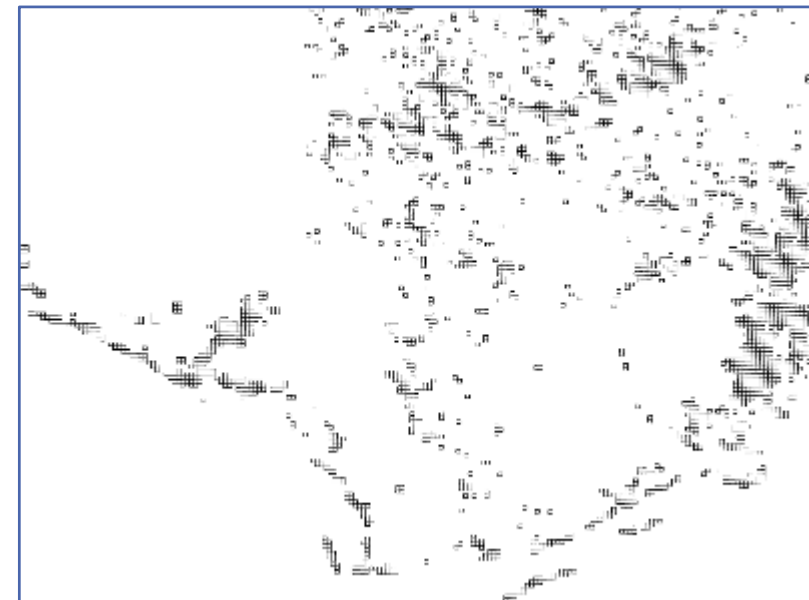
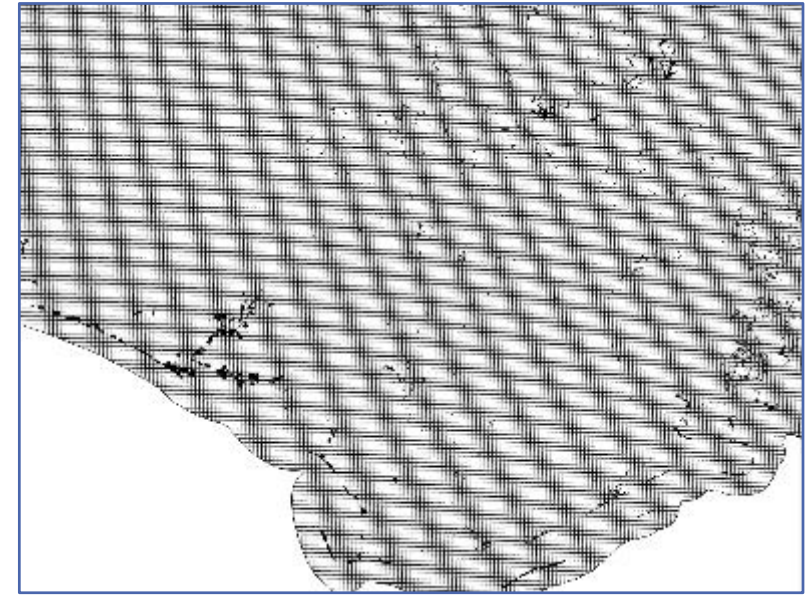


THE U.S. NATIONAL GRID

A **standardized** grid reference system that is **seamless** across jurisdictional boundaries.

Used as a **common geographic framework** for response.

USNG 1 Km Grid Cells
USNG 5 Km Grid Cells



USNG cells in affected area

POST: HOW?

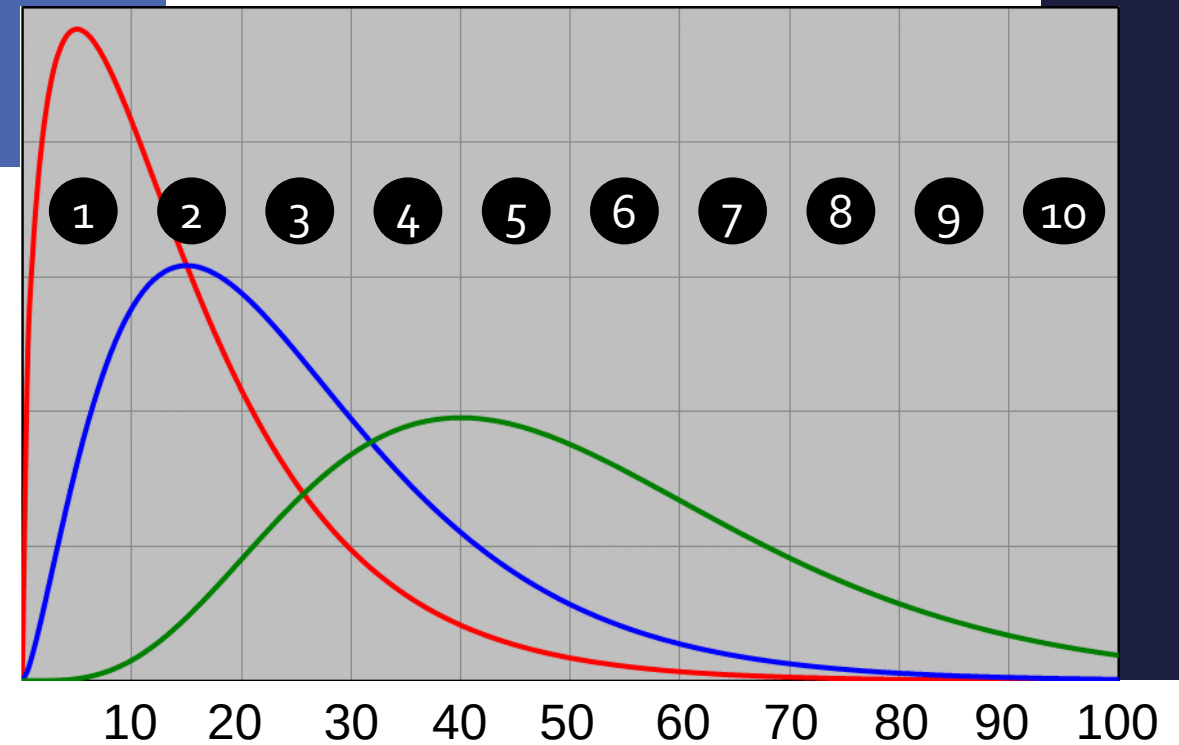
HAZARD PROBABILITY SCORE

1) HAZARD SCORE PER AFFECTED PARCEL:

The sum of the percentile ranks of each variable
(flood depth, surge, wind)

$$\text{HPS}_i = \text{FloodDepthGrid}_{pr} + \text{Surge}_{pr} + \text{Wind}_{pr}$$

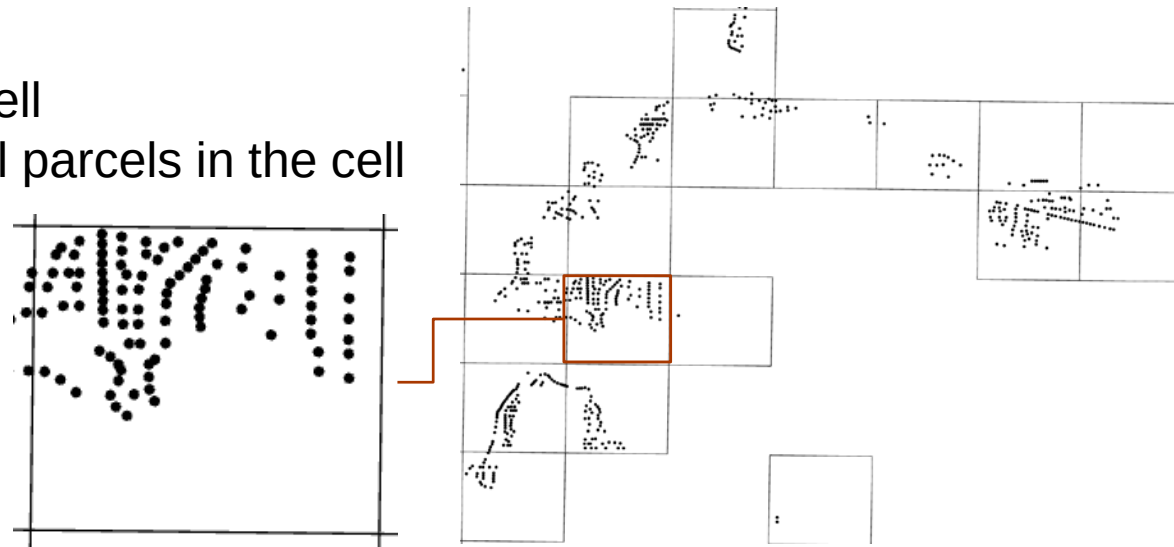
Where pr is the *percentile rank* (1 – 10) of each parcel (i).



2) HAZARD SCORE PER USNG CELL:

Assign a hazard score for each USNG Cell
Score is calculated as the sum HPS of all parcels in the cell

$$\text{HPS}_j = \text{HPS}_i + \text{HPS}_i + \dots + \text{HPS}_n$$



POST: HOW?

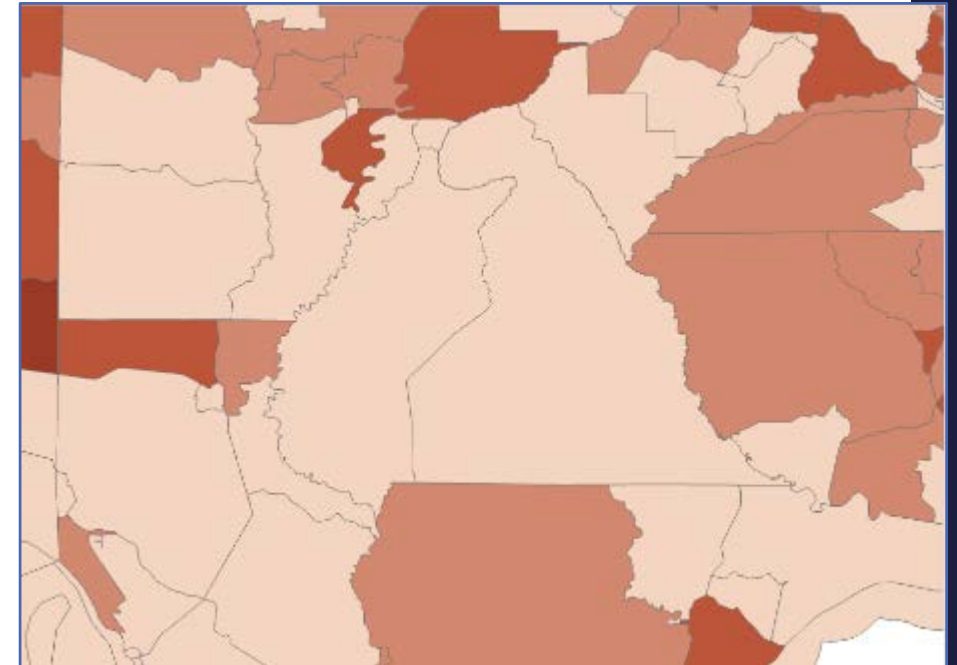
AFFECTED COMMUNITY

Next step: identify the most **vulnerable population** within these cells

Accounting for social characteristics identified by FEMA relevant to population vulnerability

1. Population
2. Number of Households
3. Number of Housing units
4. Population age 65 and over
5. Population age 16+ and unemployed
6. Population 16+ not in labor force
7. Population American Indian or Alaska Native
8. Number of Households in poverty
9. Number of Households on disability and food stamps
10. Number of Households on disability no food stamps
11. Number of Households with food stamps/SNAP
12. Number of Households with public assistance
13. Number of Housing units that are mobile homes

US Census Bureau of Statistics
American Community Survey
5-year estimates

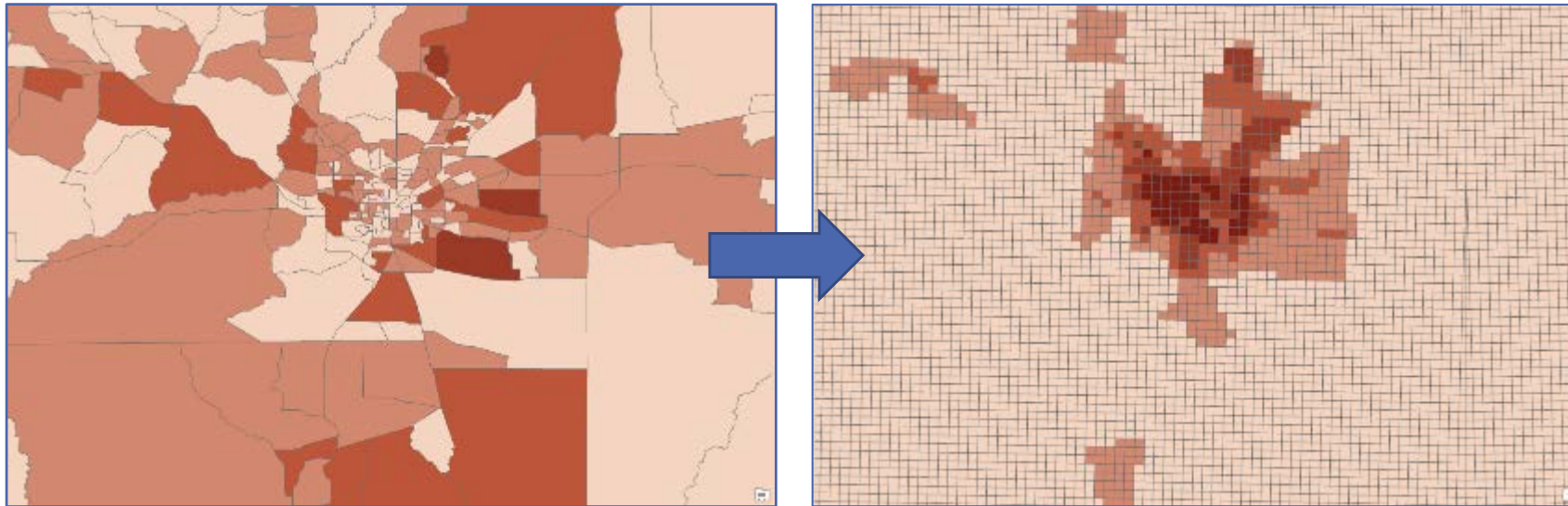


POST: HOW?

AFFECTED COMMUNITY

FROM ADMINISTRATIVE BOUNDARIES at the **block** level

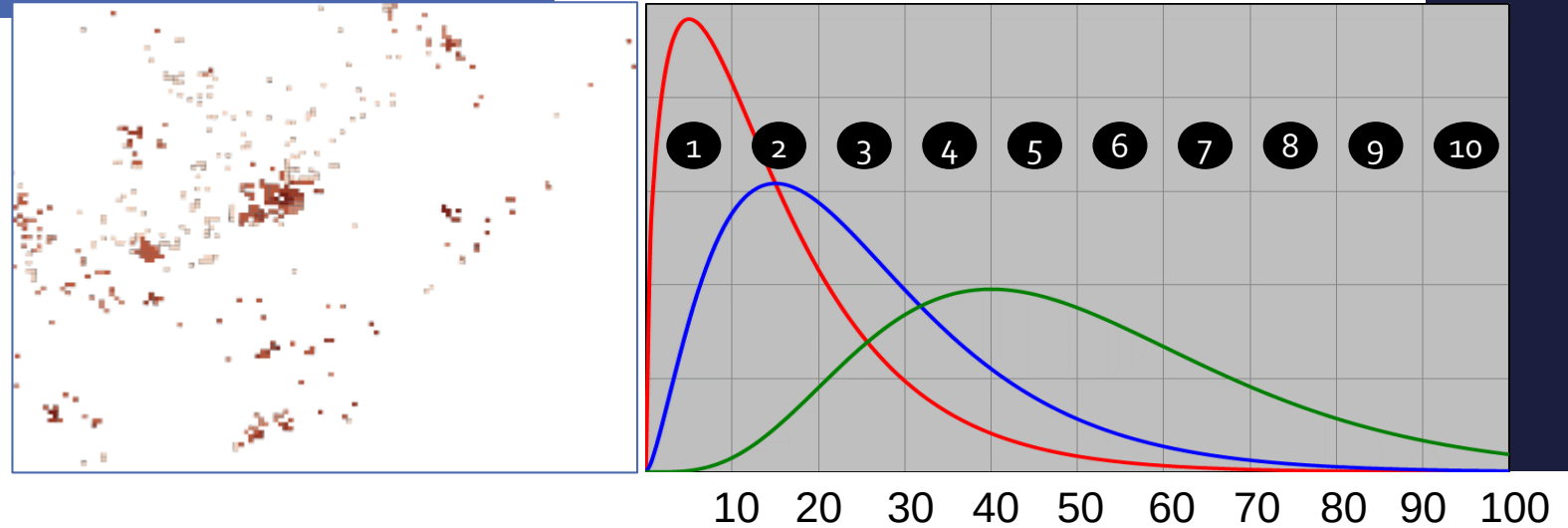
TO A STANDARDIZED GEOGRAPHIC DIVISION where census data is tabulated to a standardized geography (USNG) and **A SPATIALLY UNIFORM DIVISION OF DEMOGRAPHIC DATA**



POST: HOW?

AGGREGATION

For each cell we calculate a **weighted sum** (w) of the **percentile ranks** (pr) of each social vulnerability criterion



$$\text{Aggregated SV score} = \text{pop}_{pr} * w + \text{hholds}_{pr} * w + \text{hunits}_{pr} * w + \text{age65}_{pr} * w + \text{unemp16}_{pr} * w + \text{nolaborforce16}_{pr} * w + \text{amalask}_{pr} * w + \text{hpov}_{pr} * w + \text{hdisfs}_{pr} * w + \text{hdisnfs}_{pr} * w + \text{hfssnap}_{pr} * w + \text{hpa}_{pr} * w + \text{humb}_{pr} * w$$

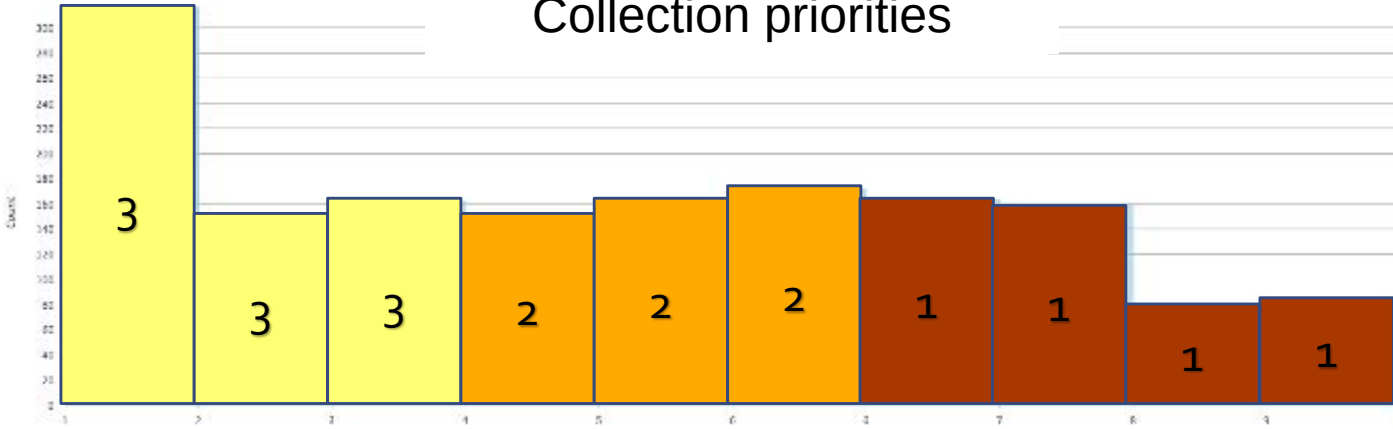
Where pr is a percentile rank of each criterion and w is a user defined relative weight of the criterion (0-10)

1. Population (pop)
2. Number of Households ($hholds$)
3. Number of Housing units ($hunits$)
4. Population age 65 and over ($age65$)
5. Population age 16+ and unemployed ($unemp16$)
6. Population 16+ not in labor force ($nolaborforce16$)
7. Population American Indian or Alaska Native ($amalask$)
8. Number of Households in poverty ($hpov$)
9. Number of Households on disability and food stamps ($hdisfs$)
10. Number of Households on disability no food stamps ($hdisnfs$)
11. Number of Households with food stamps/SNAP ($hfssnap$)
12. Number of Households with public assistance (hpa)
13. Number of Housing units that are mobile homes ($humb$)

A relative weight (w)
for each criterion

COLLECTION PRIORITIES

Collection priorities

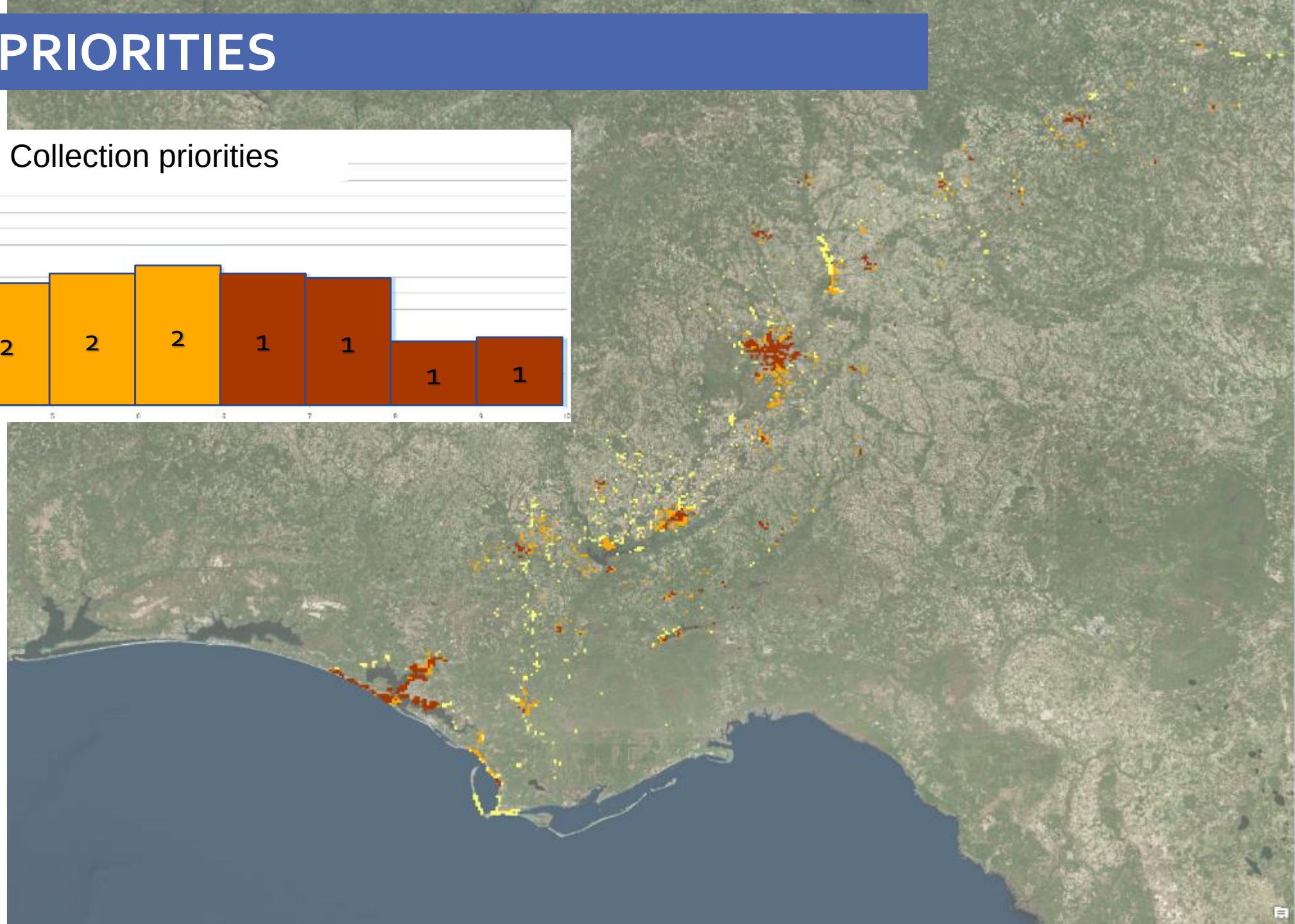


Score rank

Priority 1

Priority 2

Priority 3



POST: WHERE?

ArcGIS Pro + Python

POST is currently available as an ArcGIS Pro Toolbox.

The screenshot shows the ArcGIS Pro interface. The main map displays a view of the United States with a focus on the eastern half, showing state boundaries and major cities. The catalog pane on the right lists various toolboxes and datasets. A red line originates from the catalog pane and points to a callout box that provides a detailed view of the 'POST_ArcGIS_Pro.tbx' toolbox.

POST_ArcGIS_Pro.tbx

- Social Vulnerability and Collection Priorities (with enriched parcels)
- Social Vulnerability and Collection Priorities (only with hazard extent)

Historic VA Registration	Percent in Poverty	Median Household Income (Dollars)	Medicare Beneficiaries	Power Dependent Devices (DME)
200	10.1	20141	13415	
242	8.5	82667	152033	

POST: WHERE?

ArcGIS Pro + Python

POST_ArcGIS_Pro.tbx

- Social Vulnerability and Collection Priorities (with enriched parcels)
- Social Vulnerability and Collection Priorities (only with hazard extent)

Geoprocessing

Social Vulnerability and Collection Priorities (with enriched parcels)

Parameters Environments

GDB storing the USNG cells
data\USNG_With_Social_Vulnerability\WithACS2017\USNG_Enriched_ACS17\EnrichedUSNGACS17.gdb

Grid cells size (1km or 5km)

Enriched parcel layer

Fields storing the hazard data

GDB storing the output

Population (weight)
1

Households By Presence Of People Under 18 (weight)
1

Housing units (weight)
1

Population age 65 and over (weight)
1

Population age 16+ and unemployed (weight)
1

Population 16+ not in labor force (weight)
1

Population American Indian or Alaska Native (weight)
1

Households in poverty (weight)
1

Households with disability and food stamps (weight)
1

Households with disability, without food stamps (weight)
1

Households with food stamps/SNAP (weight)
1

Households with public assistance (weight)
1

Housing units that are mobile homes (weight)
1

1km or 5km

Enriched Structures

Hazard Extent

Output Location

Weighted Demographics

Geoprocessing

Social Vulnerability and Collection Priorities (only with hazard extent)

Parameters Environments

GDB storing the USNG cells
data\USNG_With_Social_Vulnerability\WithACS2017\USNG_Enriched_ACS17\EnrichedUSNGACS17.gdb

Grid cells size (1km or 5km)

Hazard extent

GDB storing the output

population (weight)
1

Households By Presence Of People Under 18 (weight)
1

Housing units (weight)
1

Population age 65 and over (weight)
1

Population age 16+ and unemployed (weight)
1

Population 16+ not in labor force (weight)
1

Population American Indian or Alaska Native (weight)
1

Households in poverty (weight)
1

Households with disability and food stamps (weight)
1

Households with disability, without food stamps (weight)
1

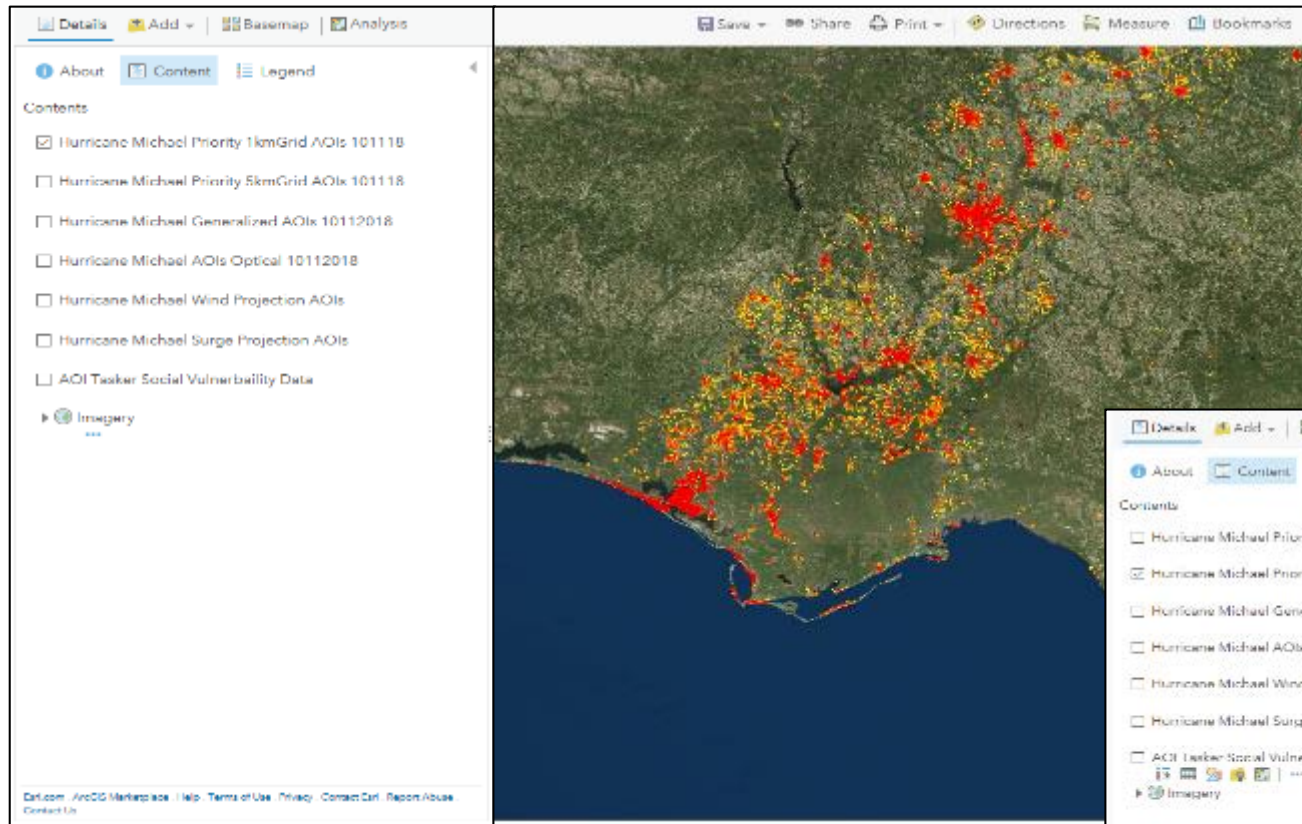
Households with food stamps/SNAP (weight)
1

Households with public assistance (weight)
1

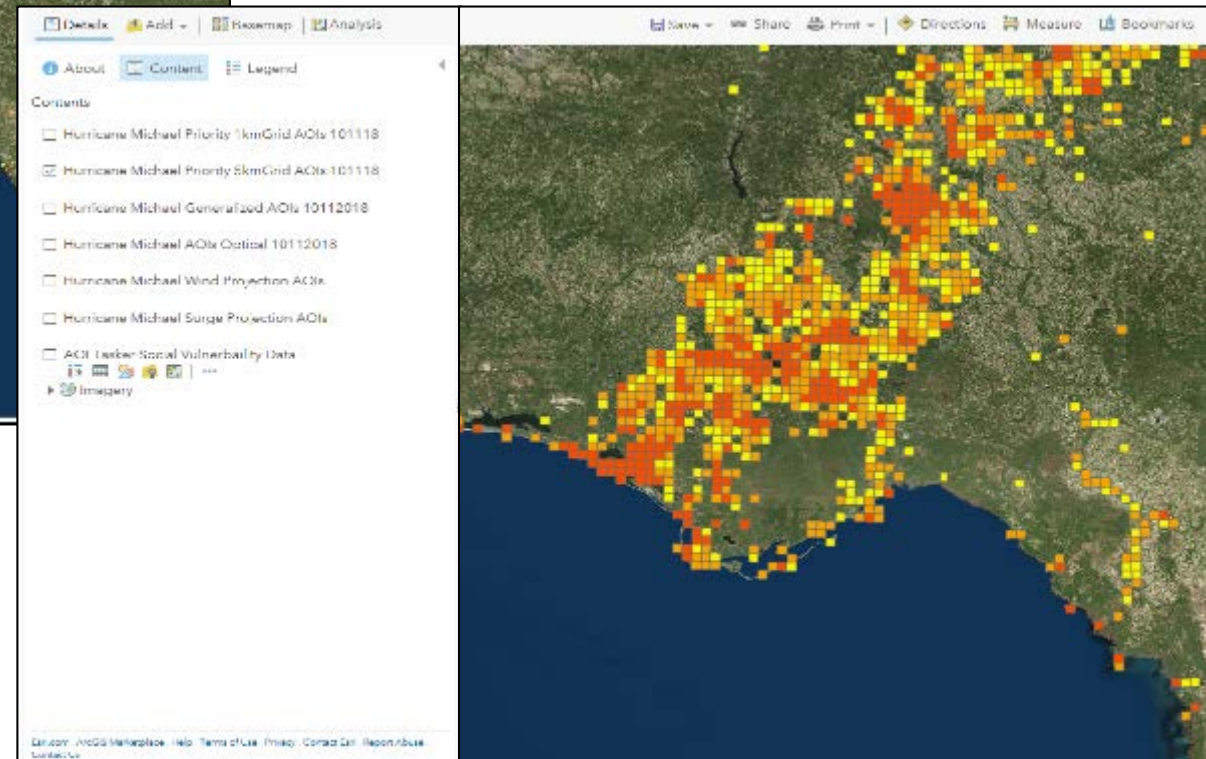
Housing units that are mobile homes (weight)
1

POST: WHERE?

RESULTS PUBLISHED AS WEB SERVICES



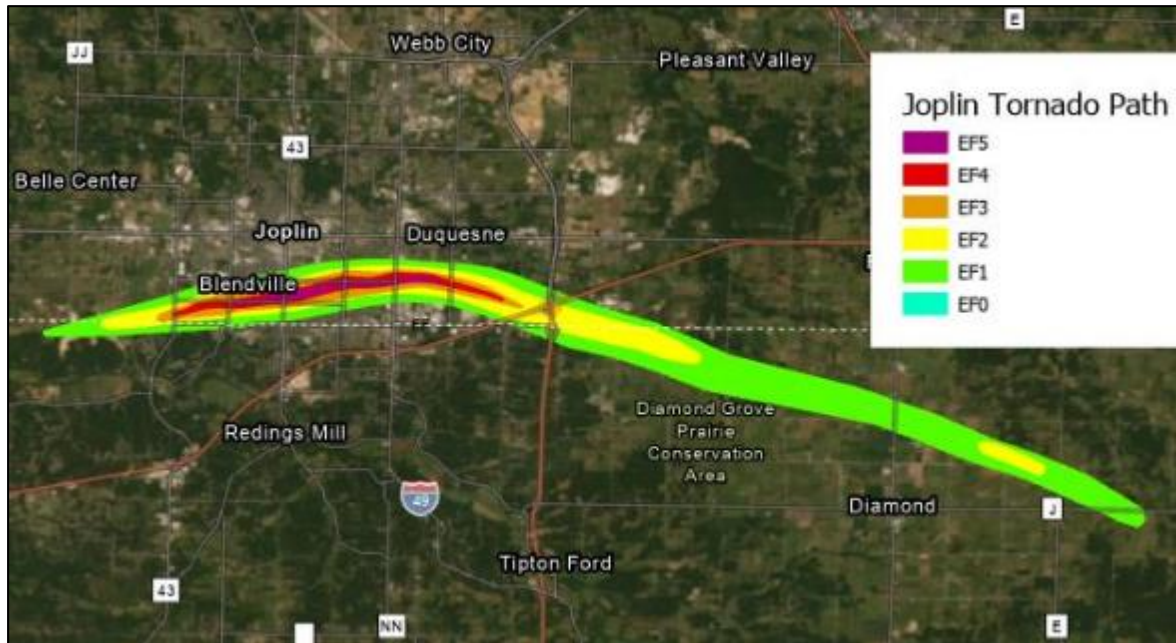
Hurricane Michael (2018)
POST results at 1km & 5km



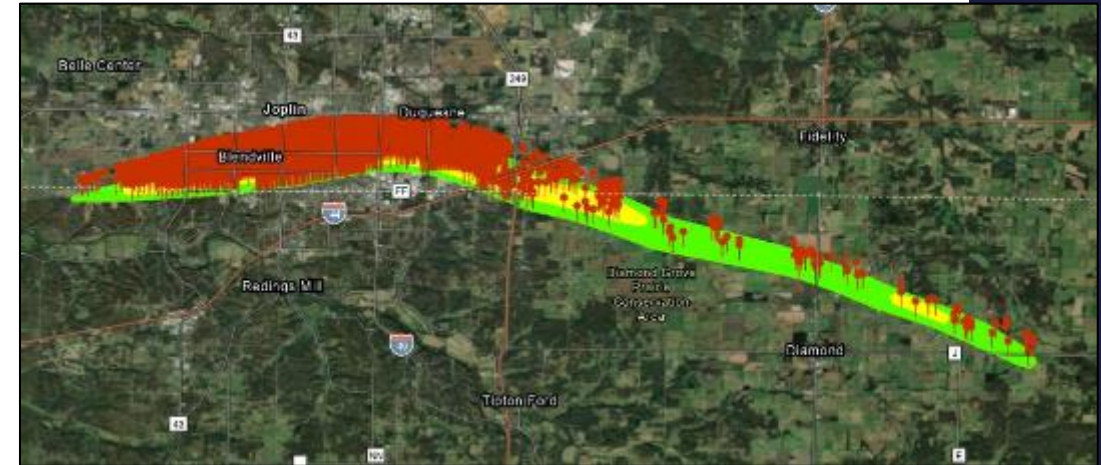
POST: DEMO

Joplin, Missouri EF5 Tornado (May 2011)

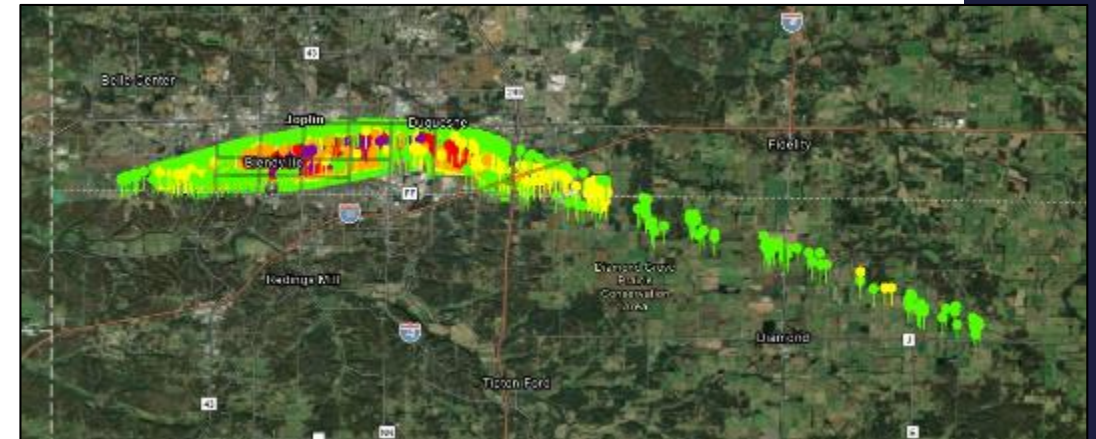
Tornado Path (NWS)



Buildings within Tornado Path



Buildings within Tornado Path + EF



POST: DEMO

Joplin, Missouri EF5 Tornado (May 2011)

POST results – demographics equally weighted



Geoprocessing

Social Vulnerability and Collection Priorities (with enriched parcels)

Pending edits.

Parameters Environments

GDB storing the USNG cells
EnrichedUSNGACS17.gdb

Grid cells size (1km or 5km)
1

Enriched parcel layer
joplin_parcel_ef

Fields storing the hazard data
efint

GDB storing the output
FEMA counties summary.gdb

Population (weight)
1

Households By Presence Of People Under 18 (weight)
1

Housing units (weight)
1

Population age 65 and over (weight)
1

Population age 16+ and unemployed (weight)
1

Population 16+ not in labor force (weight)
1

Population American Indian or Alaska Native (weight)
1

Households in poverty (weight)
1

Households with disability and food stamps (weight)
1

Households with disability, without food stamps (weight)
1

Households with food stamps/SNAP (weight)
1

Households with public assistance (weight)
1

Housing units that are mobile homes (weight)
1

POST: DEMO

Joplin, Missouri EF5 Tornado (May 2011)

POST results – Poverty & Mobile Homes weighted HIGHER



Geoprocessing

Social Vulnerability and Collection Priorities (with enriched parcels)

Pending edits.

Parameters Environments

GDB storing the USNG cells
EnrichedUSNGACS17.gdb

Grid cells size (1km or 5km)
1

Enriched parcel layer
joplin_parcel_ef

Fields storing the hazard data
efint

GDB storing the output
FEMA counties summary.gdb

Population (weight)
1

Households By Presence Of People Under 18 (weight)
1

Housing units (weight)
1

Population age 65 and over (weight)
1

Population age 16+ and unemployed (weight)
1

Population 16+ not in labor force (weight)
1

Population American Indian or Alaska Native (weight)
1

Households in poverty (weight)
10

Households with disability and food stamps (weight)
1

Households with disability, without food stamps (weight)
1

Households with food stamps/SNAP (weight)
1

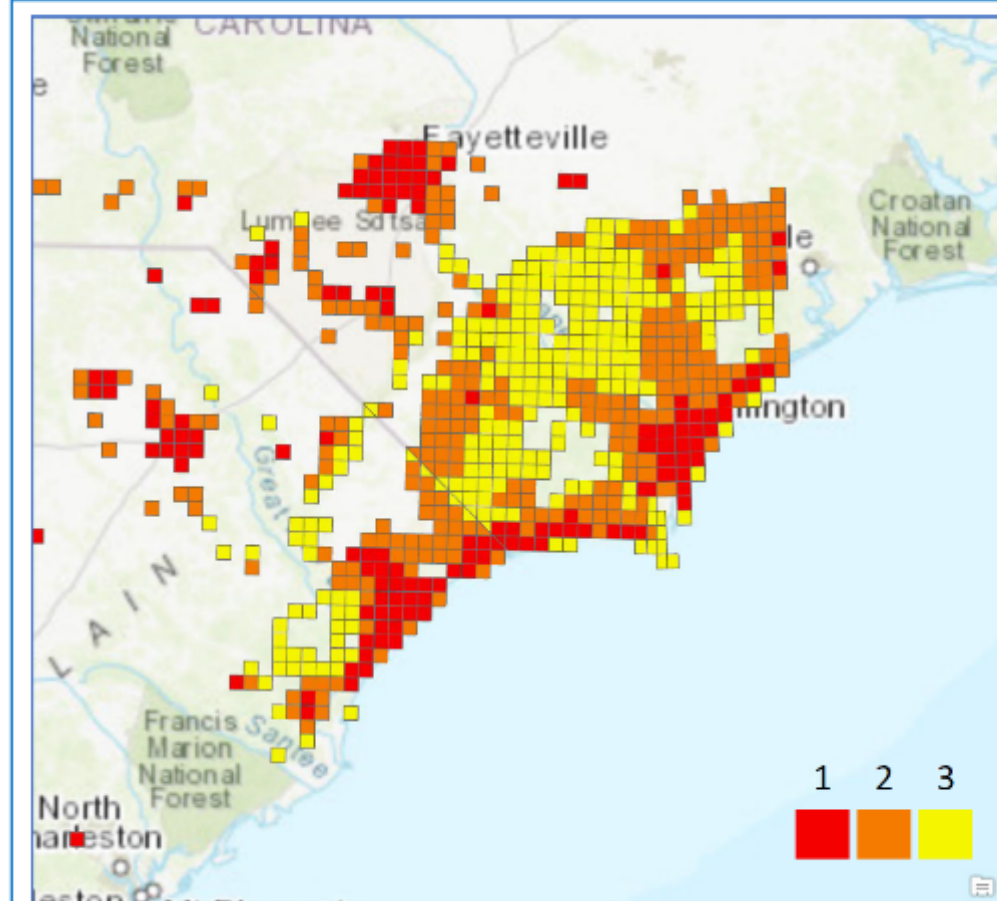
Households with public assistance (weight)
1

Housing units that are mobile homes (weight)
10

POST: WHAT'S NEXT?

NEXT-GEN WEB APPLICATION

POST | PRIORITIZING OPERATIONS SUPPORT TOOL



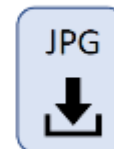
TOOL RESULTS:

SELECT DESIRED VIEW:

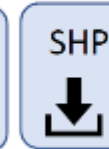
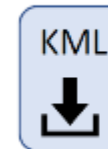
- ☐ Hazard Rank
- ☐ Social Vulnerability Score Rank (Non-weighted)
- ☐ Social Vulnerability Score Rank (Weighted)
- ☒ Collection Priority (Non-weighted)
- ☐ Collection Priority (Weighted)

☐ Get info tool

Download
Current Extent



Download
Layer



Get link to
Feature service



POST: WHAT'S NEXT?

LIFELINES

Currently, POST does not account for critical and community infrastructure.

There is a need for a systematic, objective and defensible method to identify areas where critical and community infrastructure are broken or not fully functioning.

The next generation of POST will provide the disaster community a tool for **timely assessment** of the **status** of critical business and government functions during disasters by evaluating not only their current status/functionality but also by **predicting their failure** due to any **cascading impacts** between functions.

The functionality of critical infrastructure is based on the seven COMMUNITY LIFELINES.



THANK YOU!

Ran Goldblatt
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Madeline Jones
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Madeline.Jones@NLTGIS.com

National Guard Unclassified, Analysis, Production, and Dissemination Units (UPADs)

What They Are and How States Can Leverage Them

Lt Col John Easley, NGB J-2





UPAD OVERVIEW

UNCLASSIFIED



Unclassified Processing, Analysis & Dissemination



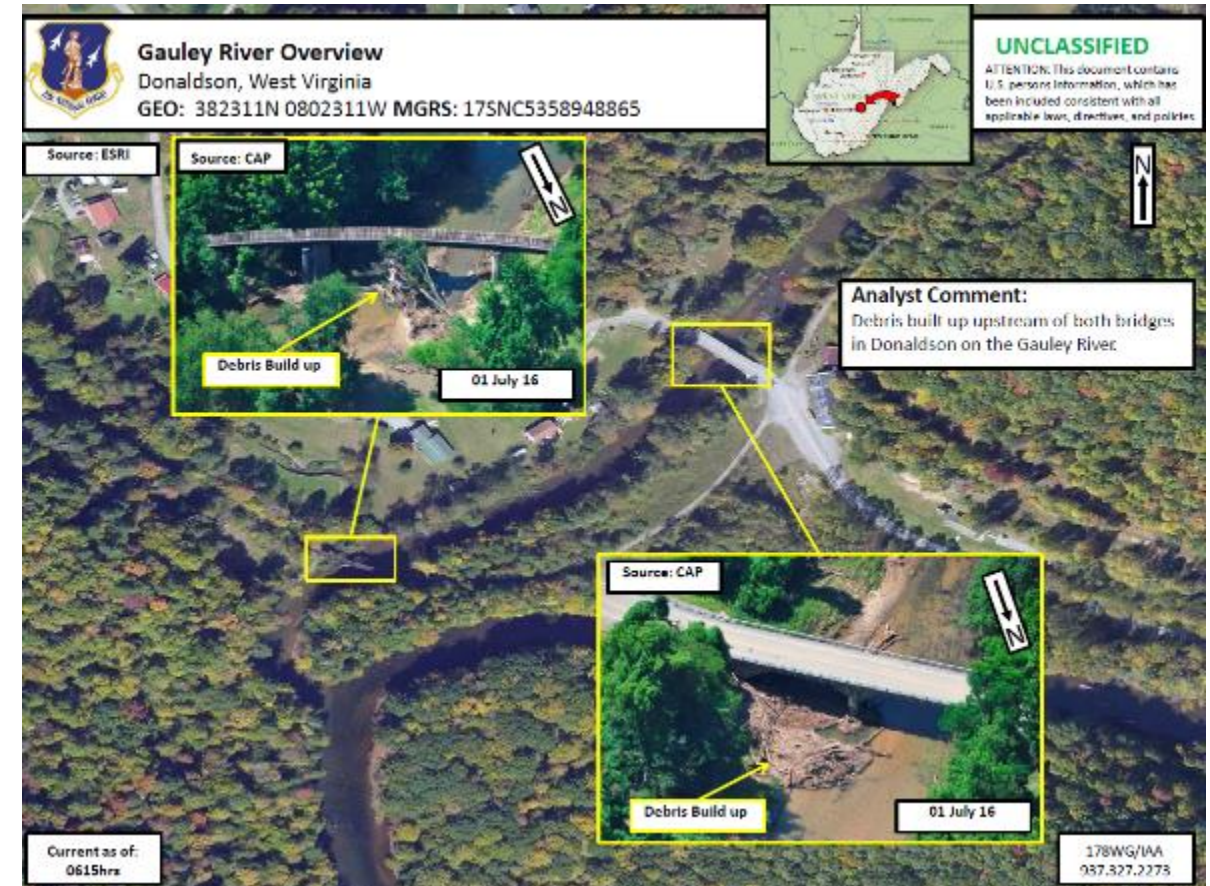
Components:

- 13 UPAD Sites (13 operational +2)
- UPAD Prime
- DAART Collaboration Tool
- Dedicated GIS Equipment
- Unclassified, dedicated internet

Process:

- Receives raw data
- Develop tailored products based on CCIRs/PIRs/EEIs
- Shares products and data through DAART

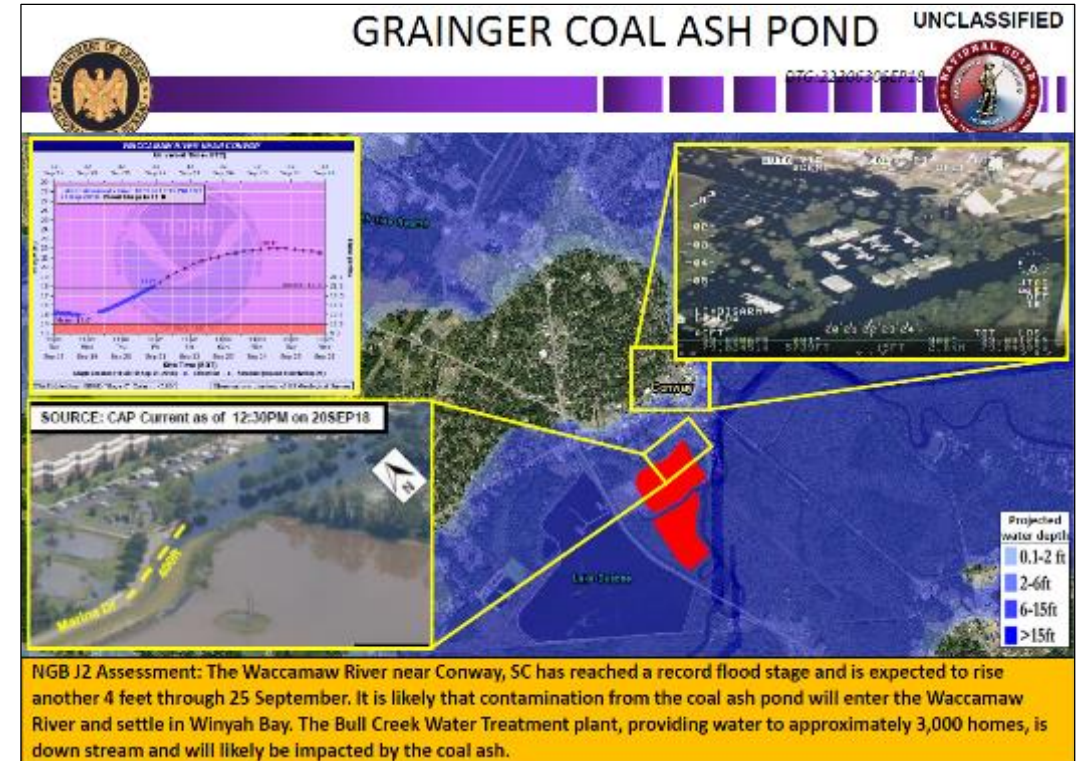
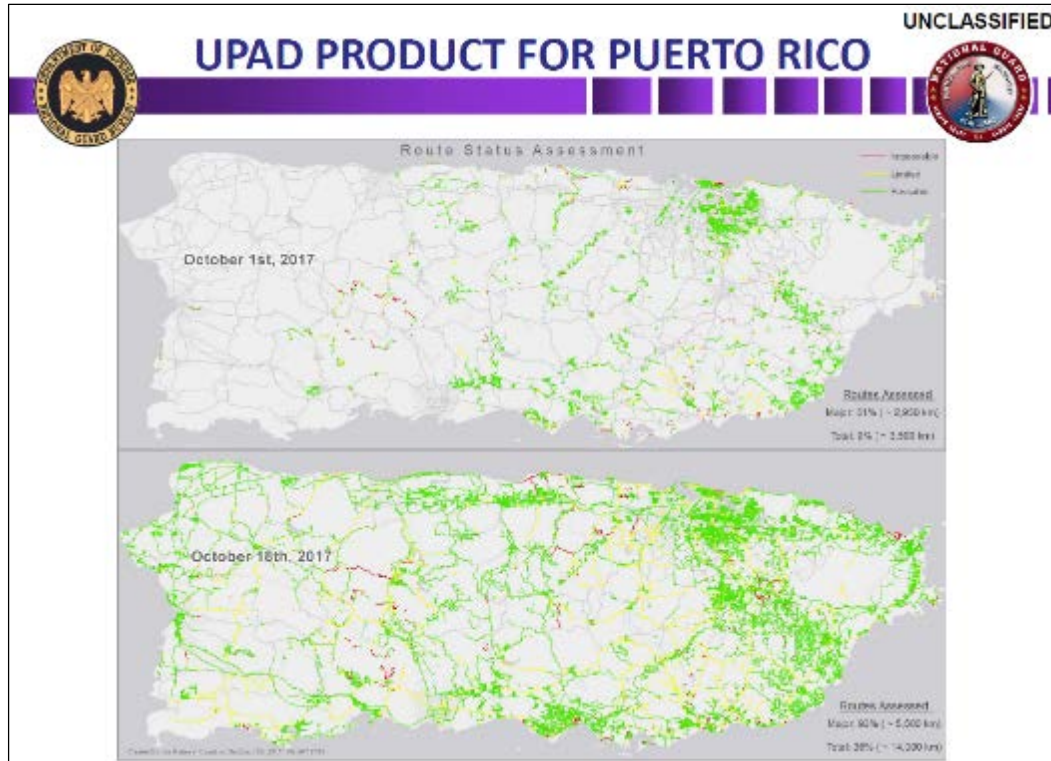
Typical UPAD Products



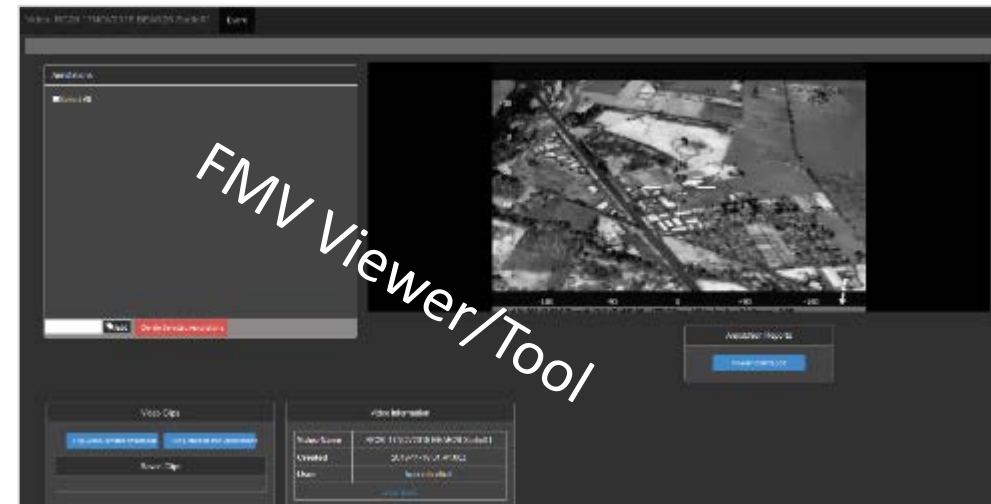
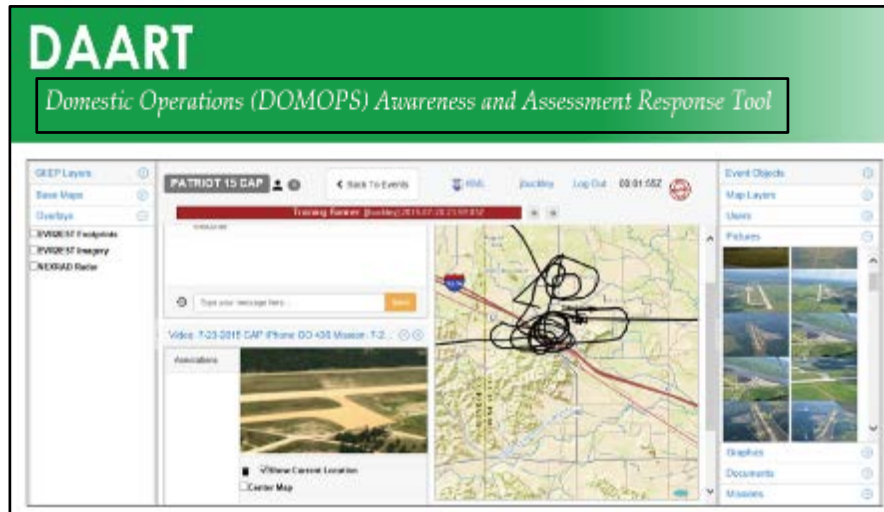
FEMA Region IV-Requested Analysis



More than Imagery Analysis...



UPAD Dissemination via DAART



DOMOPS Awareness and Assessment Response Tool (DAART) Suite

“Providing Imagery, Video, Geospatial/GEOINT, C2 and Collaboration Capabilities to and from the Operational and Incident Awareness & Assessment (IAA) Communities Supporting National Guard Civil Support (NGCS) and Defense Support of Civil Authorities (DSCA) Missions”

<https://daart.us>



State J-2 Requests UPAD Support via NGB J-2

NGB-J2 Support

Contingency Response

- Support J2 requests
- Provides strategic direction for IAA lines of effort, manpower, and shared platform de-confliction
- Manages DAART collaboration Site
- Arranges for augmentation and assistance to JFHQ-State J2s and UPADs
- Conduit for State- J2 to national remote Sensing Agencies

Steady-State

- Trains State and partners on Collection management and IAA functions
- Develops IAA policy
- Collects best practices
- Proper Use Memorandums



JFHQ-State J2

Provides situational awareness and expected threat COAs to state leadership via IAA

Contingency Response

- Executes collection plan
- Provides....
 - Damage assessment
 - Predictive analysis
 - IAA reporting and production

Steady-State

- Develops...
 - IAA Campaign Plans
 - Collection Decks
- Trains & Develops IAA SMEs
- File Proper Use Memorandums

Facilitated Discussion

What are your imagery gaps?

- Are there types of imagery not being acquired that you need? (e.g. thermal, NIR, etc.)?
- Is imagery being acquired and processed fast enough for you to make decisions?
- What are some of your imagery derived product gaps? (e.g. comprehensive flood extents, debris volumes, etc.)?

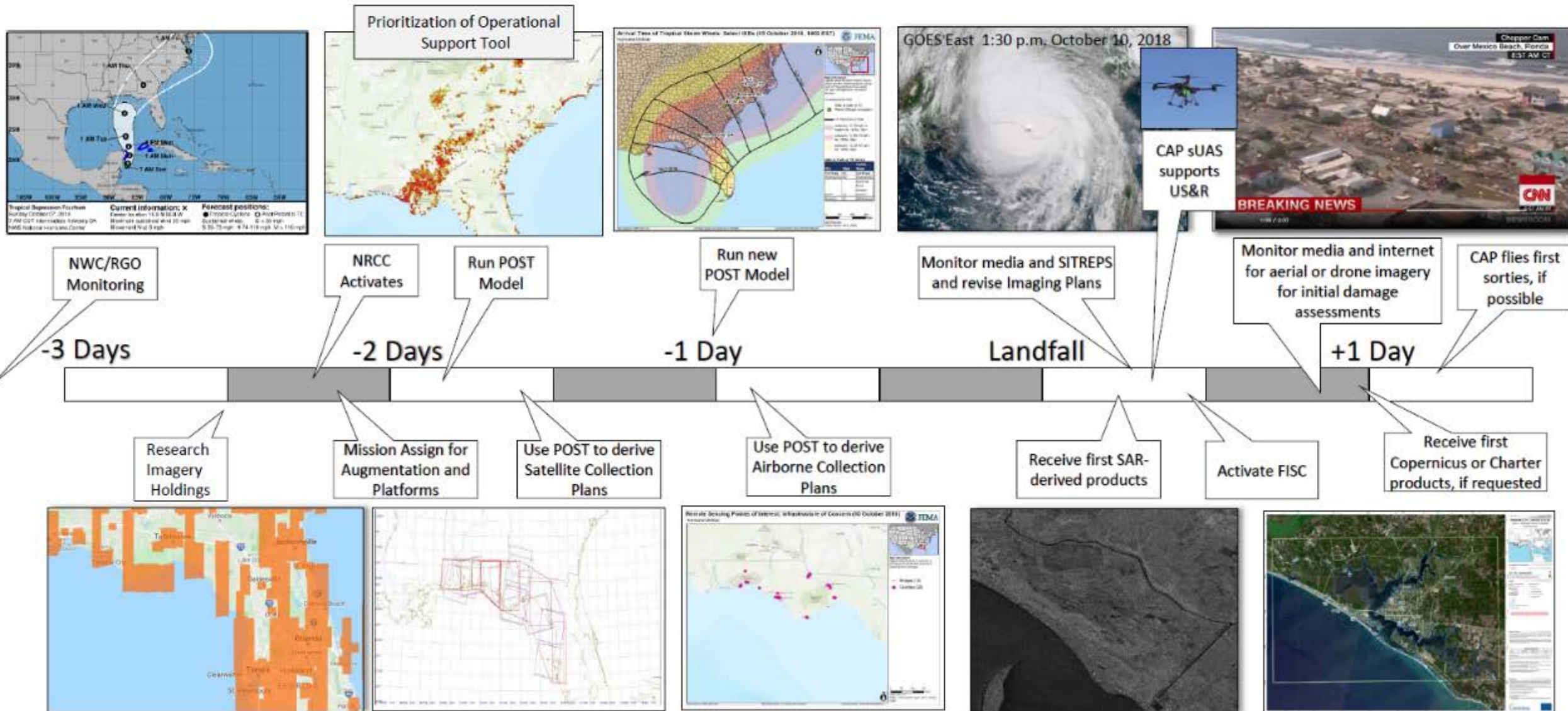
Part 2. Remote Sensing for Response

Disaster Rewind on Remote Sensing Collection, Exploitation, and Coordination

Glen Russell, FEMA

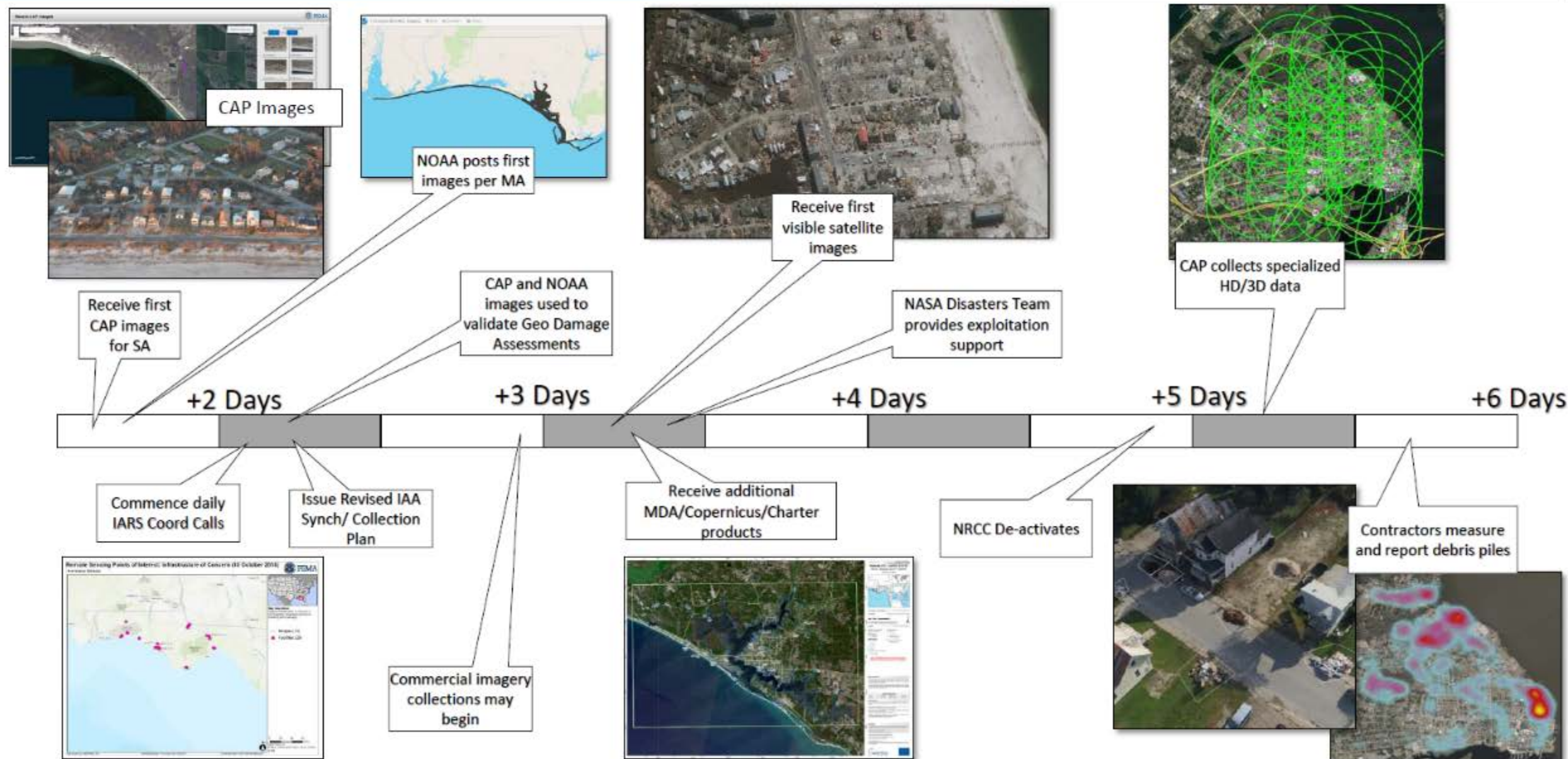
Remote Sensing for Response to Notice Event

Hurricane Michael near Mexico Beach, FL
October 10, 2018



Remote Sensing for Response to Notice Event

Hurricane Michael near Mexico Beach, FL
October 10, 2018



Facilitated Discussion

- Does your organization/jurisdiction have an imagery acquisition plan?
- What does your plan include?
- Has your plan be implemented? If so, what were the challenges and/or successes?

Part 3. Remote Sensing for Recovery

Business Case: Remote Sensing for Public Assistance

Katie Picchione, FEMA

FEMA Recovery Programs and Acronyms

Preliminary Damage Assessments (PDA)



Declaration



Public Assistance (PA)



Individual Assistance (IA)

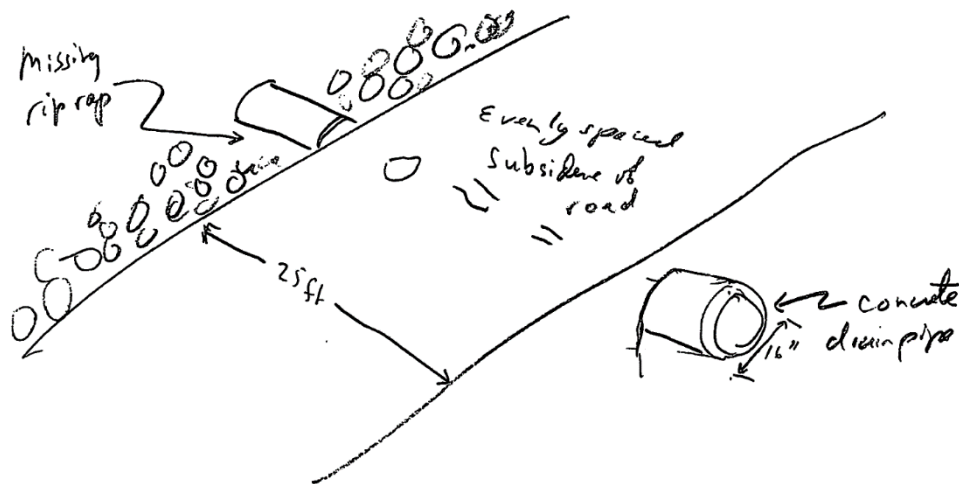
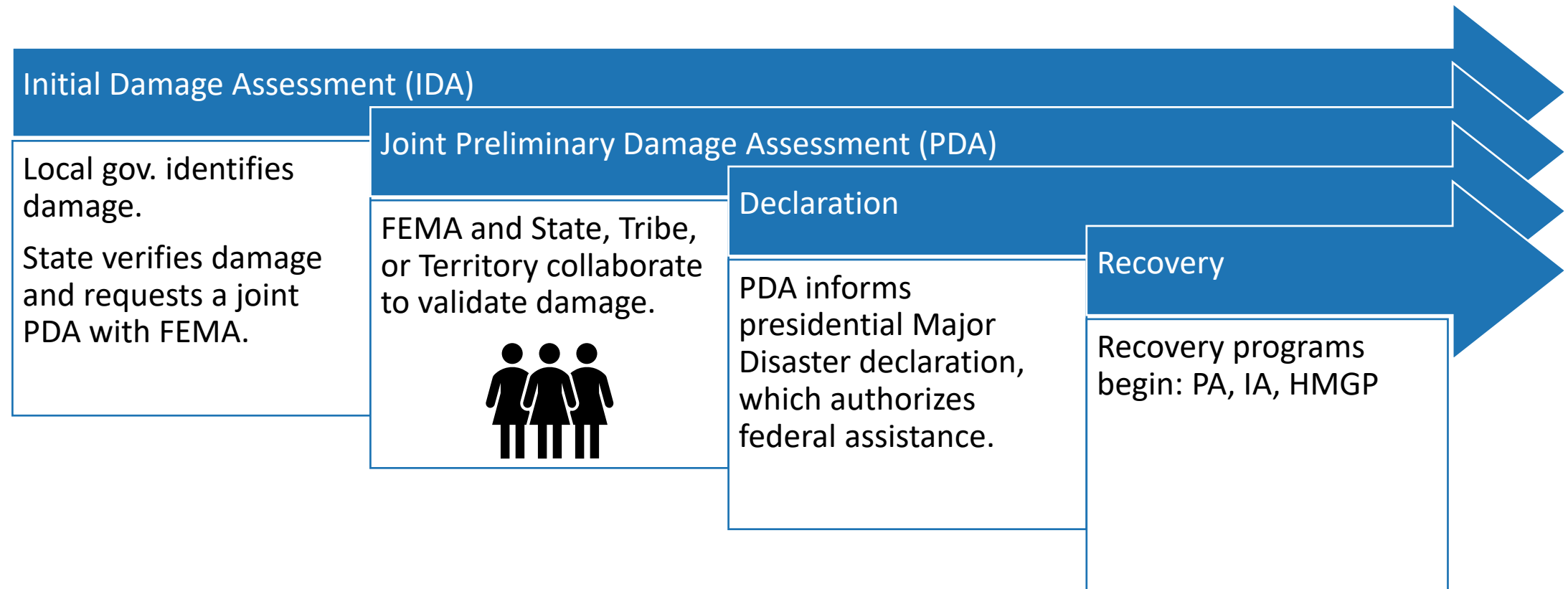


Photo Credit: PA Site Inspection Report

Photo Credit: IA Program and Policy Guide

Initial and Preliminary Damage Assessments (IDAs and PDAs) are used to determine if Federal assistance is needed



FEMA's Public Assistance (PA) program provides federal funding for debris removal, emergency work, and infrastructure repairs



Debris



Infrastructure

Photo Credit: Katie Picchione, 2018

Application 1: Plan debris removal and substantiate costs

Identify location, quantity, type



PC: Dewberry and FEMA GIS, Hurricane Michael debris assessment

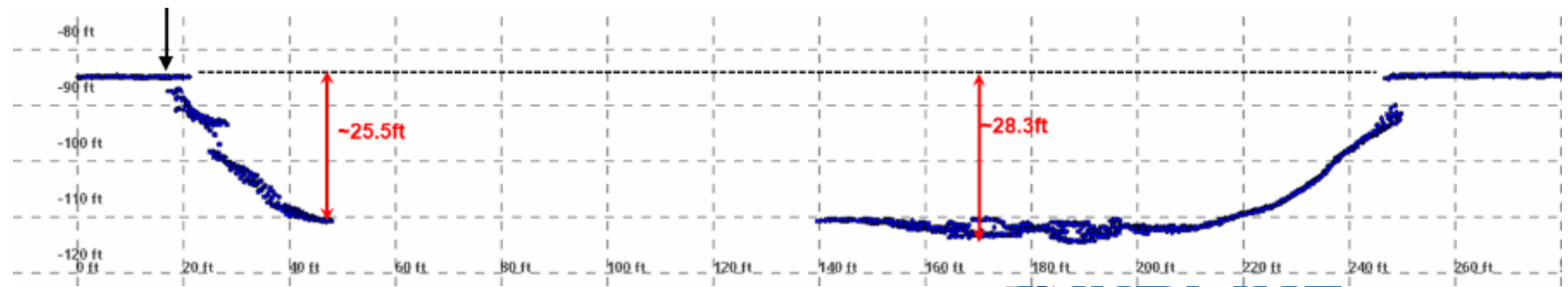
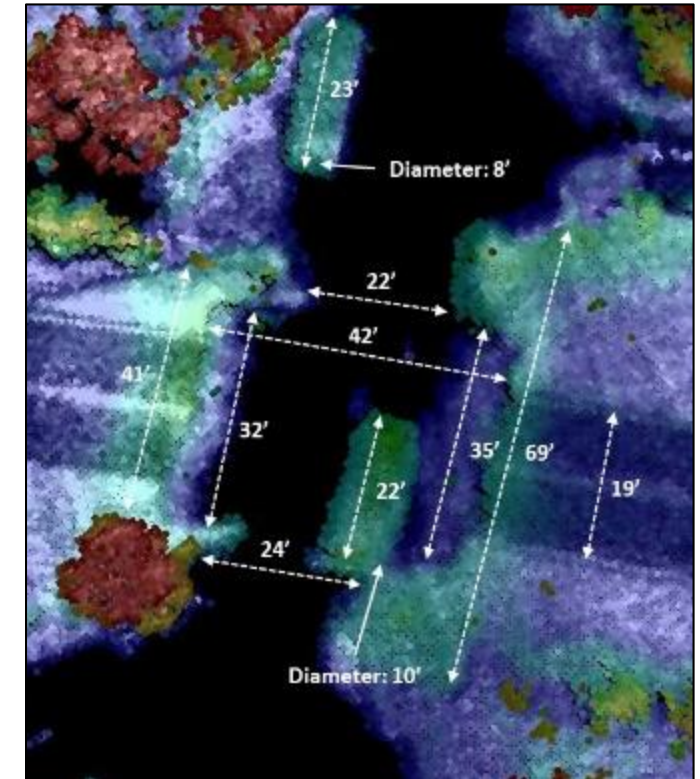
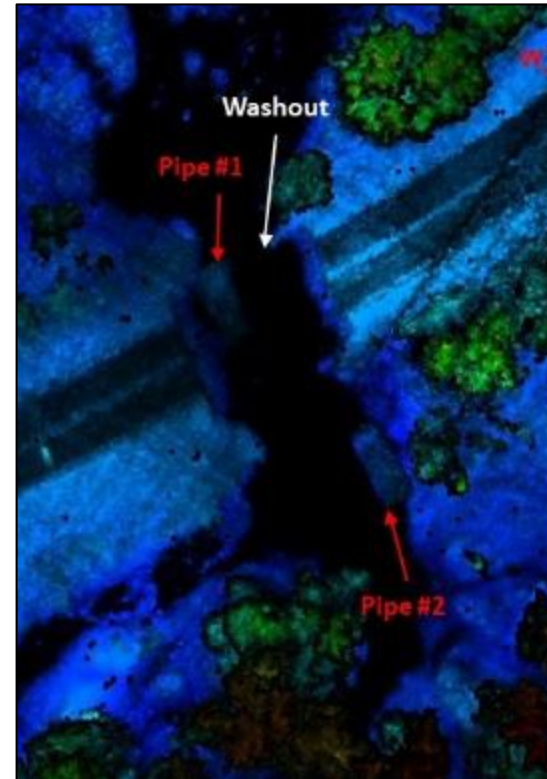
Monitor removal



PC: OIG Report, Irma Debris Monitoring, August 2018

Application 2: Quantify cost to repair damaged facilities

- Need to capture
 - Dimensions
 - Materials
 - Repairs
- Remote Sensing
 - Thermal
 - Spectral
 - Change analysis
 - Electro-optical



Damage descriptions and dimensions include

Facility Description for every site - this information is used to understand what the original facility looked like

- Facility Type
- Facility Name
- Facility Description (purpose, use)
- Address/Location
- GPS Coordinates (include start and end for facilities or damage longer than 200ft)
- Year Built
- Dimensions: type, measure, and units (e.g. Width 10ft x Length 40ft x Depth 5ft)
- Shape
- Capacity/Volume/Quantity/Number and units
- Materials
- Make/Model/Type

Facility Damage Description - confirm damages were caused by the incident, during the incident period

- Disaster number
- Date damaged
- Description of the cause of damage

Component Description and Damage – include for each damaged component (e.g. wall, pavement)

- Component location
- Dimension, material, and capacity of the original component
- Dimensions of the damage
- Make/Model/Type
- Capacity/Volume/Quantity/Number, units

Ideas

Technology	Application
Point-cloud data (LIDAR, photogrammetry)	Document dimensions of damaged facilities; change detection (e.g. Calculate volume of fill to repair a road)
Multi-spectral imagery	Identify debris types and materials at damaged facilities
Synthetic Aperture Radar (SAR)	Assess integrity of damaged infrastructure
Artificial intelligence (AI) and machine learning	Classify damage, automate damage assessments, estimate costs of repair
Algorithms	Automatically calculate extents, quantity, cost of damage (e.g. estimate the volume of debris in an area)
Drones	Observe specific sites at high resolution using various sensors; monitor repairs (e.g. monitor debris removal operations)
Infrared/thermography	Feature extraction; observe electrification; monitor repairs

Analysis on Erosion: Hurricane Dorian Case Study

Catherine Bohn, Dewberry

Hurricane Dorian Beach Erosion Case Study

- Hurricanes causing repetitive beach erosion
- FEMA Public Assistance Program will fund replacement of sand on engineered beaches if eligible (Category G)
- Can we use pre-event and post-event imagery to determine if previous PA Category G projects were impacted by Dorian?



Hurricane Dorian



Hurricane Florence



Hurricane Michael
Images Source: NOAA

Hurricane Dorian Beach Erosion Case Study

- Data

- Query Category G beach facility impacted since 2016
- Included State, Disaster Number, facility description, damage description
- Location information included coordinates and address

Event	Sta	Work_Catego	Facility_Name	Address_1	Address	City	Latitud	Longitu	Facility_Type	Damage_Descriptio	Facility_Description
4337DR-FL	FL	G	Captiva Island Beaches	Island Wide		Captiva	26.5512	-82.2019	Beach	Beach Erosion	Island Wide
4337DR-FL	FL	G	Beach Pavilion	5819 Driftwood Parkway		Cape Cora	26.54333	-81.9511	Beach Pavilion	Missing shingles and b	post & beam framed, concrete fl
4337DR-FL	FL	G	Dune Crossover			Indian Riv	27.6922	-80.368	Beach Access Stairs	Stairs damaged.	Stairs
4337DR-FL	FL	G	Chains, Shingles and Fenders			Riviera Be	26.77096	-80.0529	Port of Palm Beach	Berth & Dock repair...	Commercial port used to disem
4337DR-FL	FL	G	Mara-G-006			Indian Riv	24.69193	-81.0849	park/beach	Decking lost others disa	7-acre park and beach with 2 v
4337DR-FL	FL	G	Holmes Beach Channel Markers and Port Signs			Holmes Be	27.50983	-82.7146	Holmes Beach channe	Hurricane winds destr	improved waterway and access
4337DR-FL	FL	G	Longboat Key Engineered Beach	2850 Gulf of Mexico Dr		Longboat	27.3679	-82.6262	Engineered Beach No	Erosion and deflation	The Project is a locally construct
4337DR-FL	FL	G	Siamang Animal Exhibit Damage	1301 Summit Boulevard		West Pal	26.66651	-80.0699	Zoological Society of t	Siamang Island Exhibit	Siamang Island Exhibit
4337DR-FL	FL	G	Beach	250 North Ocean Blvd.		Lantana	26.5763	-80.0555	beachfront area	Loss of 2 Lantana Publi	signs near pavilion
4337DR-FL	FL	G	Reach 7 - Phipps Ocean Park	360 South County Road		Palm Bea	26.70294	-80.0365	Beach	Hurricane flood and to	sand beach located in Palm Bea
4337DR-FL	FL	G	Reach 8 - Beach Front	360 South County Road		Palm Bea	26.70294	-80.0365	Beach	Hurricane flood and to	sand dune located in Palm Bea
4337DR-FL	FL	G	Phipps Ocean Park			Palm Bea	26.6396	-80.0381	Municipally Owned Be	Damage to roof materi	Phipps Ocean Park, a recreation
4337DR-FL	FL	G	Reach 3 Beach Front	360 South County Road		Palm Bea	26.7029	-80.0365	Beach	Hurricane flood and to	Lost Sand
4337DR-FL	FL	G	Lift Station #18	539 N. Ocean Dr.		Riviera Be	26.7048	-80.0417	City of Riviera Beach	Damaged fence	Lift Station # 18
4337DR-FL	FL	G	Lift Station #153	200 East 13th St.		Riviera Be	26.7048	-80.0417	City of Riviera Beach	Damaged fence	Lift Station #153
4337DR-FL	FL	G	Lift Station #12	1441 West 23rd St.		Riviera Be	26.78181	-80.078	City of Riviera Beach	Damaged fence	Lift Station #12
4337DR-FL	FL	G	South County Beach Sand Renourishment	3150 Will Fee Rd		Ft Pierce	27.3712	-80.4816	engineered beach (se	South County Beach Se	placement of 682,500 CY of beac
4337DR-FL	FL	G	Collier Creek	abutting Marco River		Marco Isla	25.97417	-81.7328	Rock jetty separating	Tidal swing and wave	Jetty adjacent to Collier Creek in
4337DR-FL	FL	G	County beaches	2101 47th Terrace E		Bradenton	27.45836	-82.5363	Manatee County beac	Beach erosion	Coquina Beach and is an "Engine
4337DR-FL	FL	G	Miami Dade Fire Rescue Haulover Ocean Rescue	13731 Collins Avenue		Miami Be	25.91532	-80.1225	Haulover Beach - Lifeg	Lifeguard tower sustai	a wooden structure that is used
4337DR-FL	FL	G	Virginia Beach Key Park Trust	4000 Virginia Beach Dr		Key Biscay	25.73582	-80.1573	Beach with various rec	Park equipment dama	82 acre facility and beach compr
4337DR-FL	FL	G	Municipal Beach	2500 Ocean Ave.		Riviera Be	26.78322	-80.0327	public beach	Replace damaged guar	having a lifeguard tower
4337DR-FL	FL	G	Kingfish Boat Ramp			Holmes Be	27.49722	-82.7036	Boat Ramp with small	Sign damaged, Landsc	Boat Ramp with small beach

211 projects
5 states
10 declared disasters

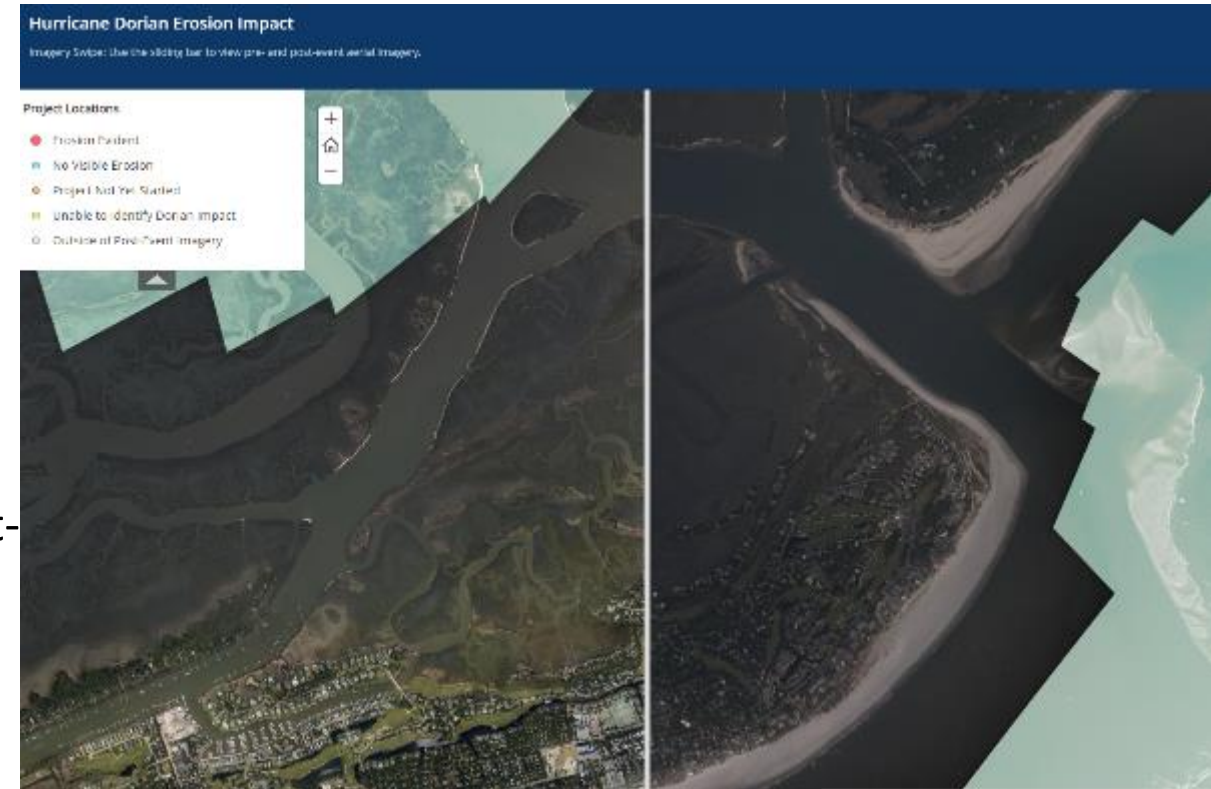
Hurricane Dorian Beach Erosion Case Study

- Analysis
 - Locate the project and review pre-Dorian and post-Dorian imagery to determine erosion impact
 - Indicate in attribute if Dorian erosion was evident

Sounds simple, right?

Hurricane Dorian Beach Erosion Case Study

- Pre-event imagery
 - Need the imagery as close to the storm impact to understand pre-event conditions
- Post-event imagery
 - Ideal collection time is 2-4 weeks after the event
 - Use previous Cat G projects as input to image collection area
 - Analysis
 - Locate the project and review pre-Dorian and post-Dorian imagery to determine erosion impact
 - Indicate in attribute if Dorian erosion was evident
 - Helps to have similar color gradient to pre-event imagery



Hurricane Dorian Beach Erosion Case Study

- Projects
 - Was project completed before the storm?
 - Is the project in the right location?
 - e-event imagery
 - Need the imagery as close to the storm impact to understand pre-event conditions
- Attributes
 - Not just “Erosion Identified”
 - Need domains

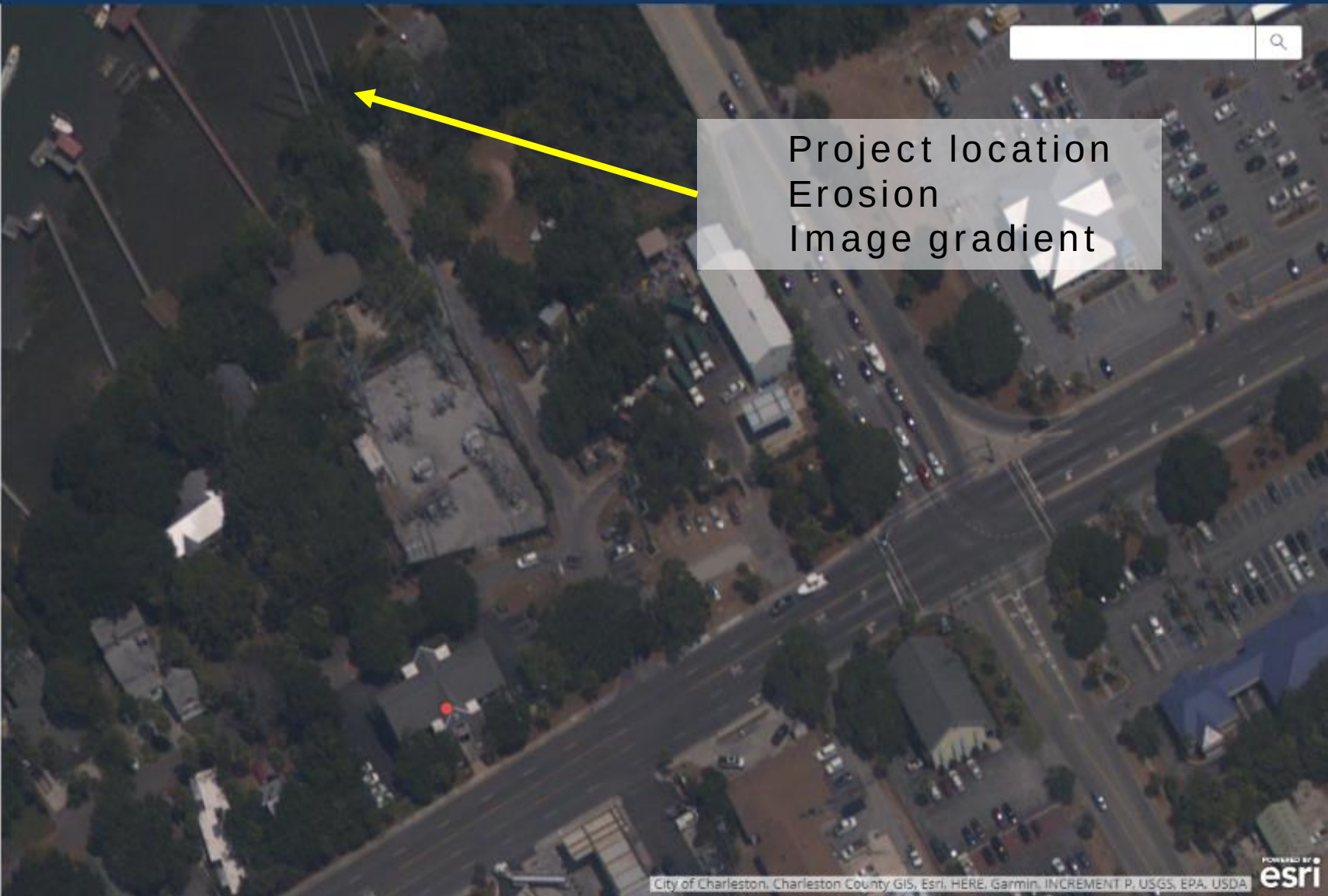
Project Locations

- Erosion Evident
- No Visible Erosion
- Project Not Yet Started
- Unable to Identify Dorian Impact
- Outside of Post-Event Imagery

- Project Locations
- Erosion Evident
 - No Visible Erosion
 - Project Not Yet Started
 - Unable to Identify Dorian Impact
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Post-Event Imagery	
Event	4346DR-5C
State	SC
Work_Categ	G
Facility_N	replenish beach sand and approaches; repair beach side drainage issues with sand
Address_1	1207 Palm Blvd
Address_2	
City	Isle of Palms
Latitude	32.79
Longitude	-79.79
Facility_T	public beach
Damage_Des	281,000 CY sand lost
Facility_D	an Engineered Beach,

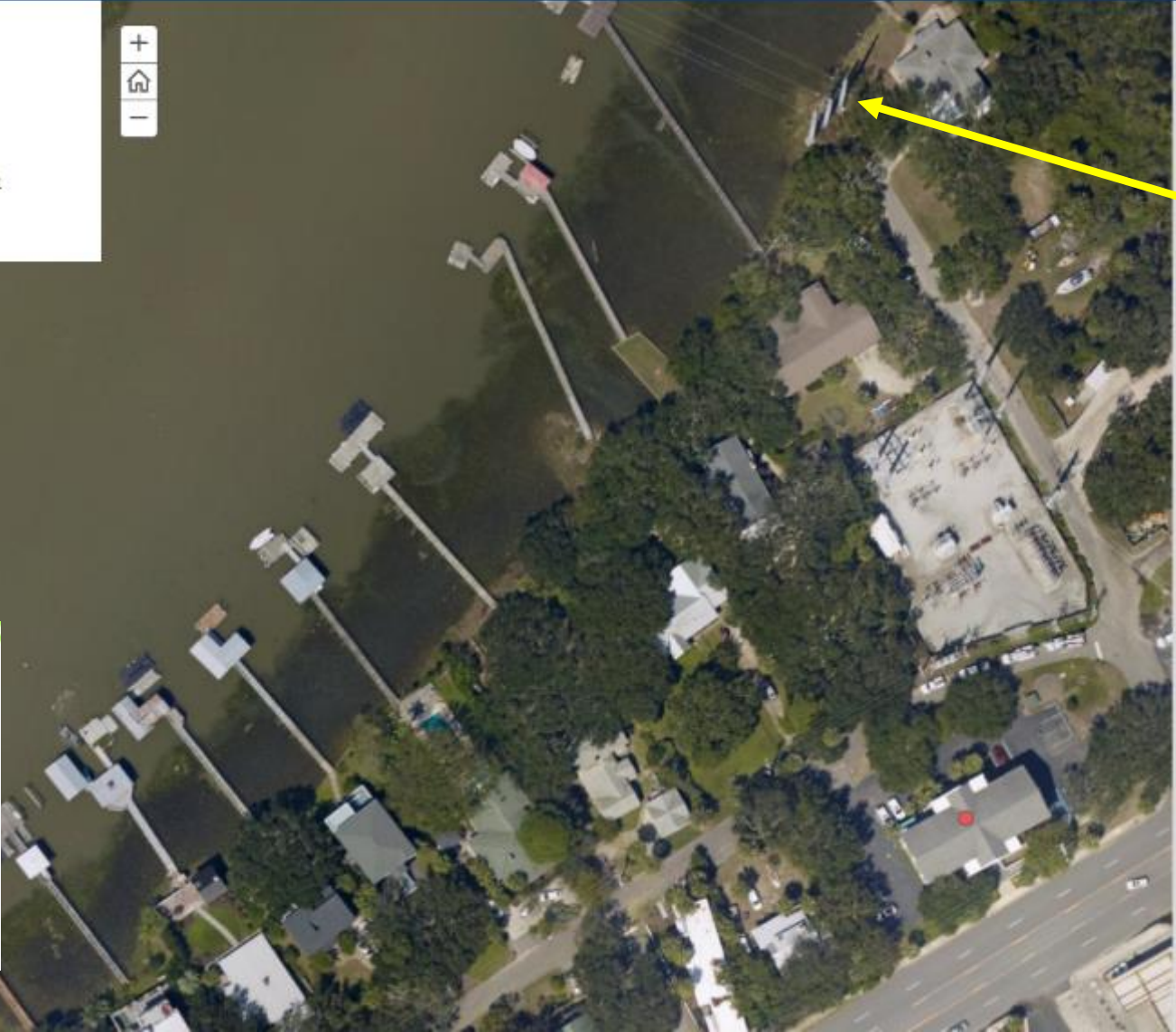


Project Locations

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Map navigation controls: zoom in (+), home, zoom out (-).

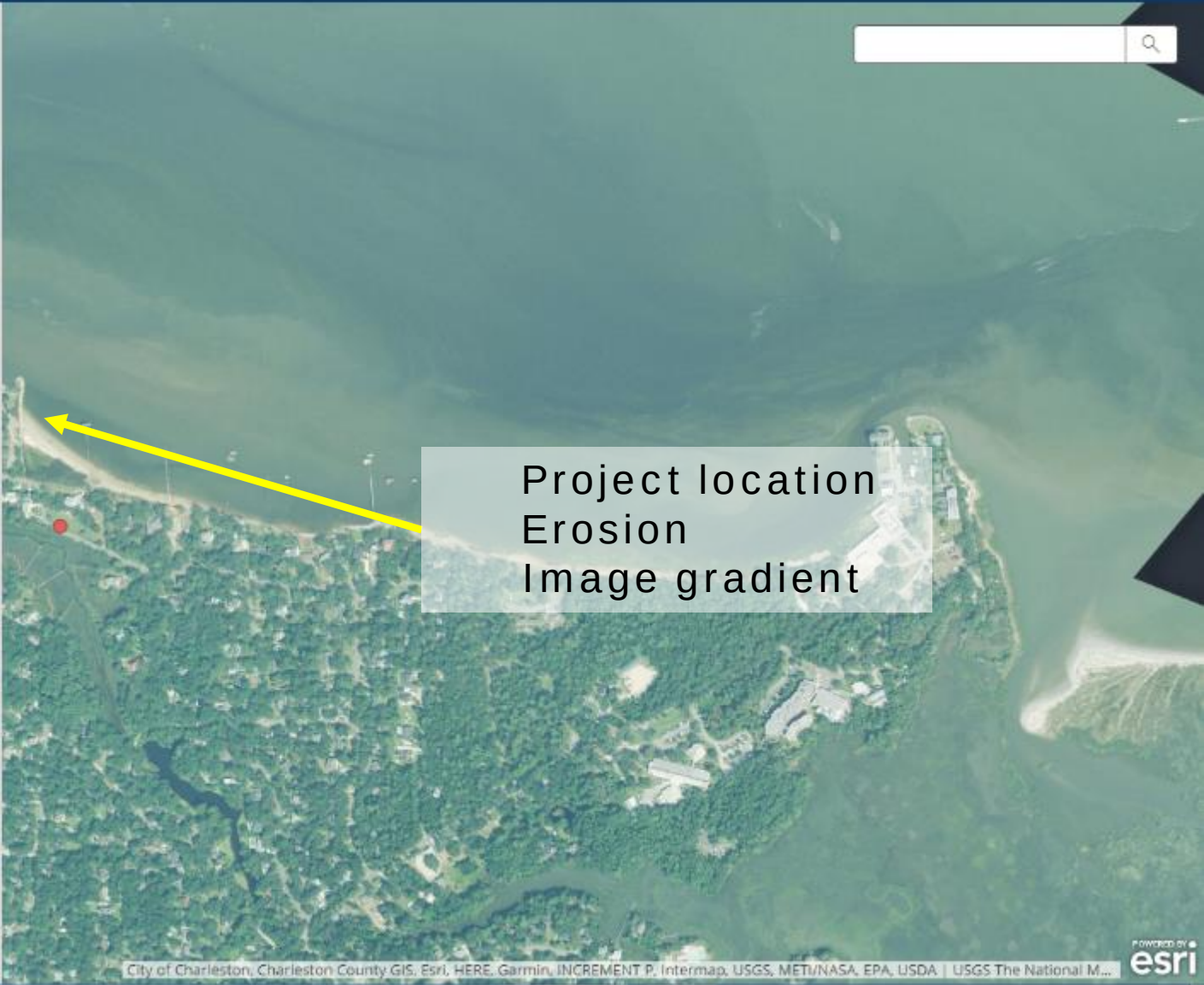
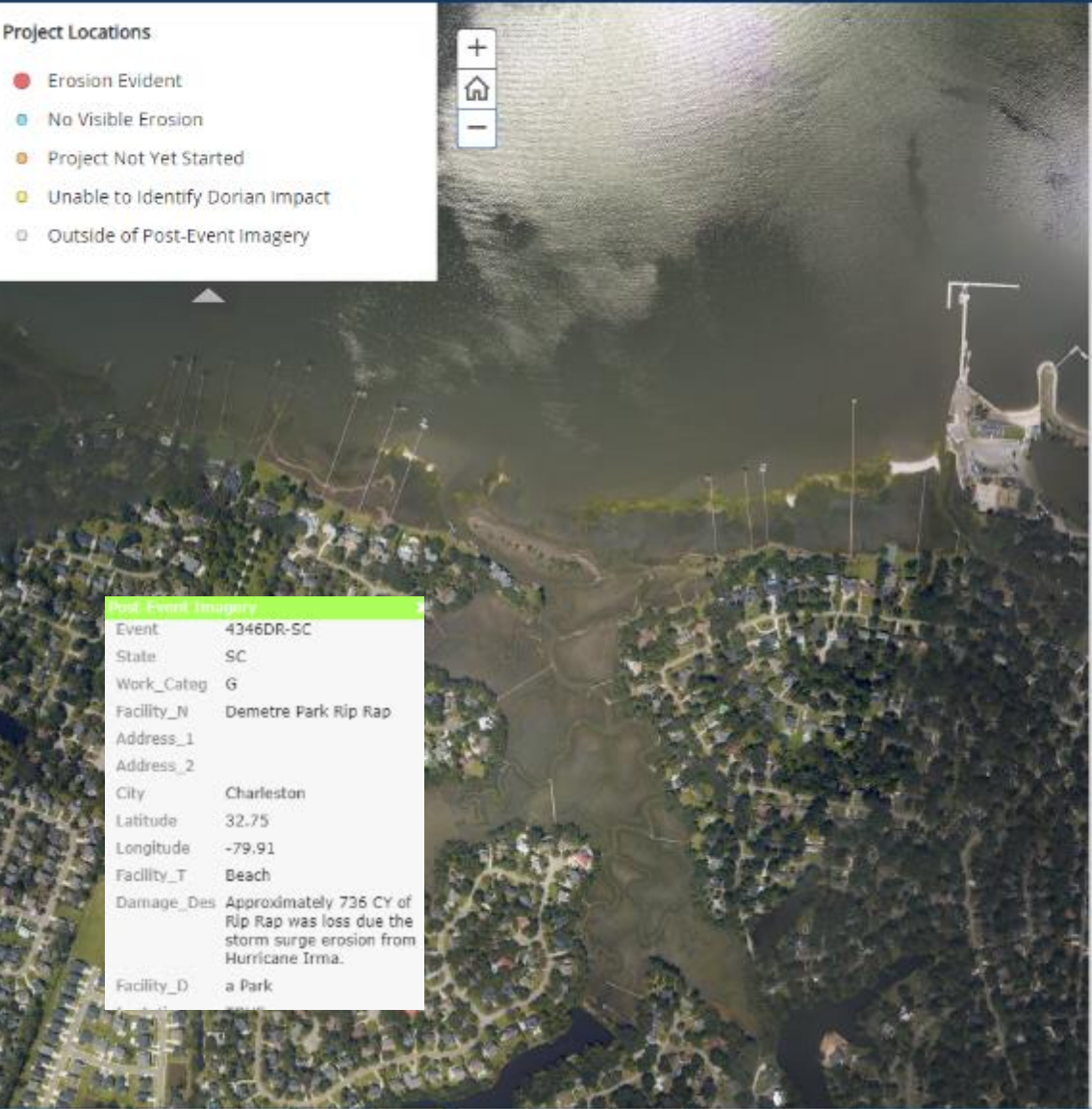
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Latitude	32.79
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Facility_T	public beach
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Project location
Erosion
Image gradient

Project Locations

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- No Visible Erosion
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- Unable to Identify Dorian Impact
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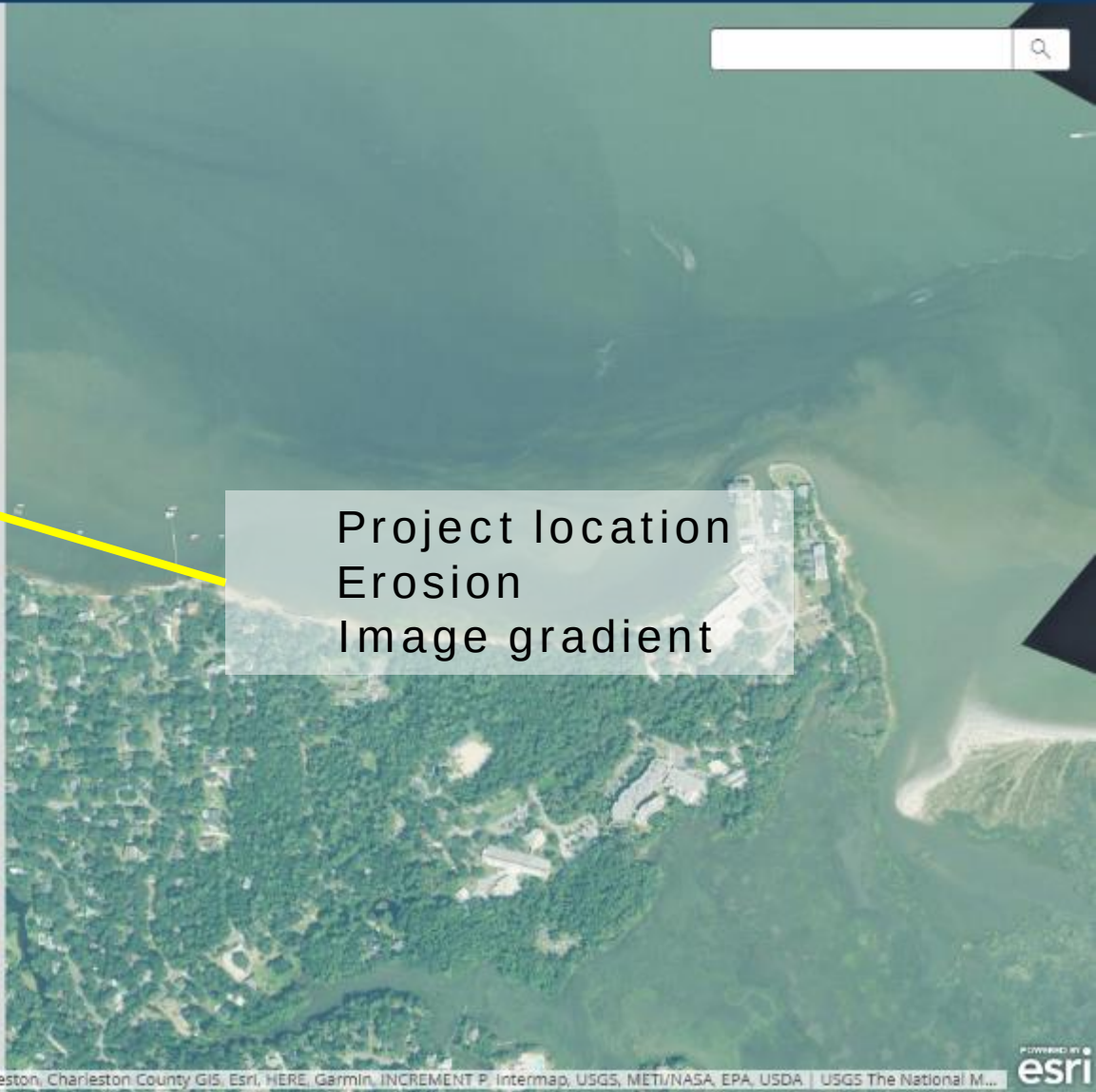
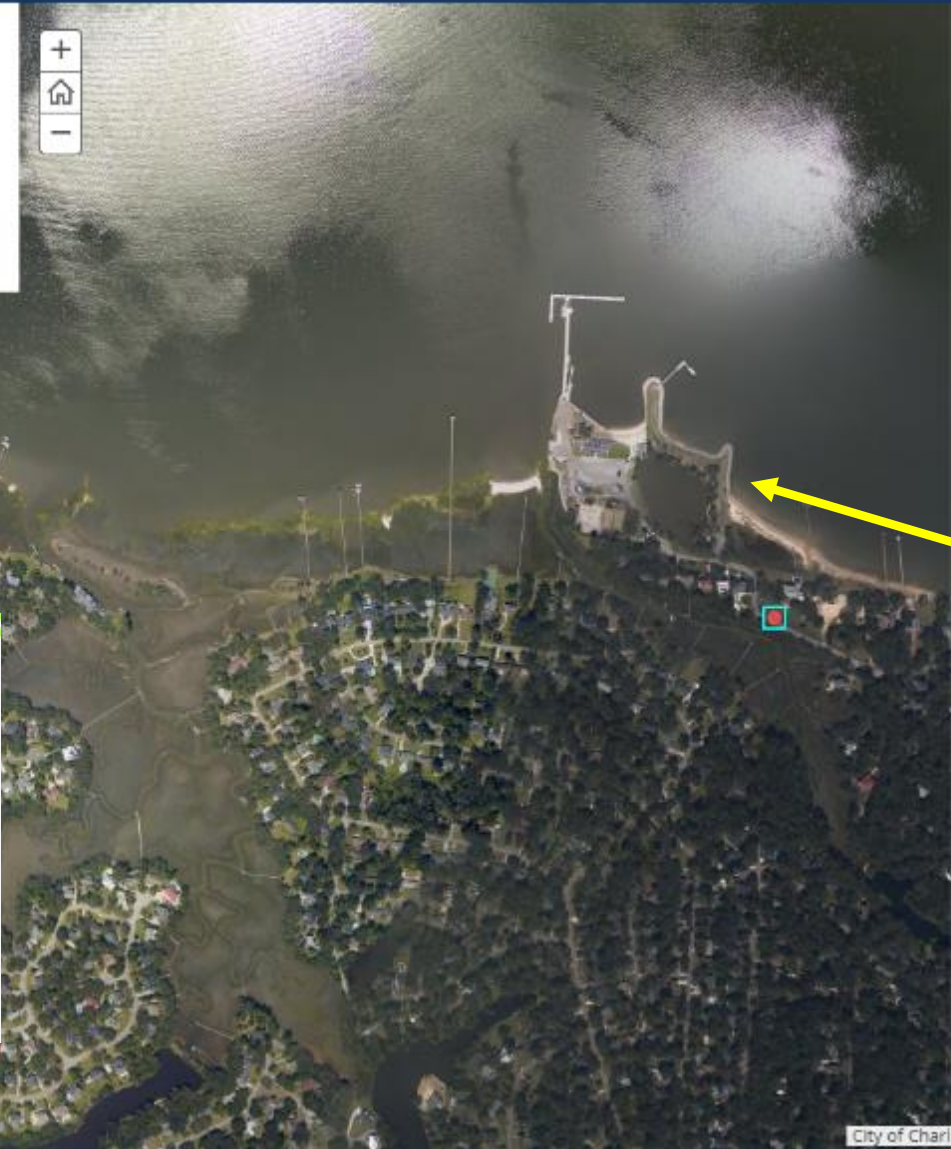


Project Locations

- Erosion Evident
- No Visible Erosion
- Project Not Yet Started
- Unable to Identify Dorian Impact
- Outside of Post-Event Imagery



Post-Event Imagery	
Event	4346DR-SC
State	SC
Work_Categ	G
Facility_N	Demetre Park Rip Rap
Address_1	
Address_2	
City	Charleston
Latitude	32.75
Longitude	-79.91
Facility_T	Beach
Damage_Des	Approximately 736 CY of Rip Rap was loss due the storm surge erosion from Hurricane Irma.
Facility_D	a Park

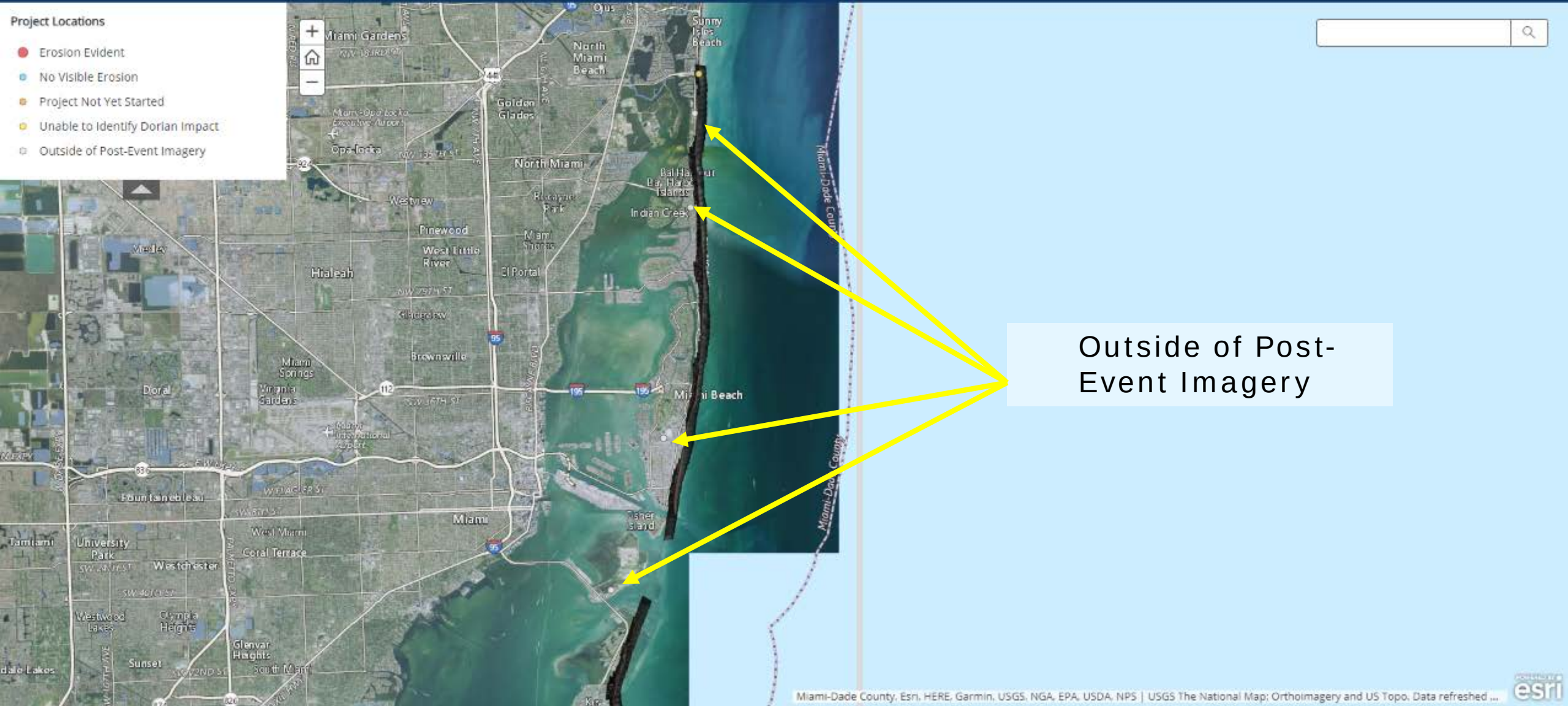


Project location
Erosion
Image gradient

City of Charleston, Charleston County GIS, Esri, HERE, Garmin, INCREMENT P, Intermap, USGS, METI/NASA, EPA, USDA | USGS The National M... esri

Imagery Swipe: Use the sliding bar to view pre- and post-event imagery.

Post-Dorian



Part 4. Latest in Innovative Imagery Exploitation and Automation for the Disaster Management Mission

LATEST IN INNOVATIVE IMAGERY EXPLOITATION, AUTOMATION, AND ARTIFICIAL INTELLIGENCE

FEMA Remote Sensing Innovation Workshop

August 28-29, 2019

FEMA Headquarters

Washington, DC

InSPIRE
Galveston, TX
November 12-14, 2019

Madeline Jones

Geophysical Data Scientist

Madeline.Jones@NLTGIS.com



FEMA REMOTE SENSING INNOVATION WORKSHOP

OBJECTIVES

- **Convene key leaders** in public sector research and development (R&D) with existing efforts focused on **advancing the use of different types of imagery/remote sensing to support the disaster management mission**.
- Develop a **baseline understanding** of the leading public sector R&D efforts underway, and the unique and specialized expertise each offers.
- Share the key mission and business requirements for **how imagery/remote sensing applies to the disaster management mission** and is applicable for addressing to answer the highest priority problem areas.
- **Identify potential approaches and innovative solutions** for addressing the top where all types of imagery/remote sensing can be brought together to best support disaster management.
- Develop a coordination strategy and **action plan for working together**; public sector R&D groups, technical users, and decision-makers to fully use remote sensing products prior to, during, and after an incident.



Jet Propulsion Laboratory
California Institute of Technology



JOHNS HOPKINS
APPLIED PHYSICS LABORATORY



Joint Artificial Intelligence Center

 **LINCOLN LABORATORY**
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

 **OAK RIDGE**
National Laboratory


Pacific Northwest
NATIONAL LABORATORY


Software Engineering Institute
Carnegie Mellon

CHALLENGES IN EMERGENCY MANAGEMENT

Determine wind/surge/flooding/mudslide impacts to 7 Community <u>Lifelines</u> (infrastructure)	<u>Monitor restoration</u> of Community Lifelines and communities
Identify damage to <u>transportation</u> sector (road, rail, bridge, airport, maritime ports) that may hinder movement of commodities or people into/out of the area	Detect, locate and enumerate structures affected by <u>power outages</u> or subject to high risks from cascading effects caused by power outages
Validate modeled numbers of <u>destroyed/damaged</u> residential and non-residential structures	Detect, locate areas of <u>beach erosion</u> , and quantify amount of eroded beach/soil
Detect and locate <u>isolated communities</u>	Locate, characterize, and quantify <u>debris</u>

CHALLENGES IN EMERGENCY MANAGEMENT

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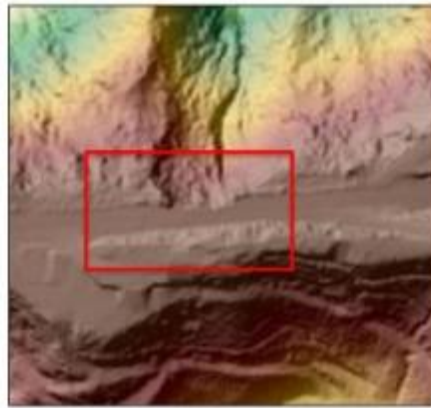
INNOVATIONS IN REMOTE SENSING

Damage Assessments



- Change in coherence using persistent scatter of pixels in SAR data to generate Damage Proxy Maps - [NASA ARIA](#)
- Deep learning algorithms using NOAA imagery to automate damage assessments (tested for Hurricane Dorian and Joplin Tornado) – [JHAPL](#)
- Near-Infrared/texture based change detection for damage assessments – [PNNL](#)
- Creating Damage Maps using Stereo Pairs at sensor resolution – [MIT LL](#)

Transportation Impacts



- Airborne lasers looking for vibrations on a stop-sign to detect traffic – [CMU](#)
- Interference of FM/AM to get a proxy measurement for the level of traffic on a road.
- Using LiDAR for Road & Bridge Damage Assessment – [MIT LL](#)

Debris Estimation



- UAS for measuring debris pile volumes - [Argonne](#)
- Using LiDAR for Debris Location & Quantification – [MIT LL](#)
- Rubble/Debris Detection using <3m Imagery– [PNNL](#)
- Building Extraction, Debris Estimation, and Settlement Mapping using Convolutional Neural Networks – [ORNL](#)

KEY FINDINGS

-  There is significant work being done with remote sensing applications for emergency response, but R&D leaders lack a feedback mechanism to review the effectiveness of remote sensing products and solutions intended for the Emergency Management (EM) Community during a disaster. Feedback such as: “Do the products address real-world information needs?”, “Are the products available in the timeframe needed?” and “Are they delivered in an operationalized format to inform action by decision makers?”
-  How do we enable collaboration amongst the R&D and EM communities that fosters innovation in the exploitation of imagery and remote sensing to address the most pressing real-world challenges in the disaster management mission?
-  Need a formalized working group of R&D leaders, decision-makers, analysts and scientist staff supporting the disaster mission, to develop and test solutions intended to address real-world challenges

KEY ACTIONS

- ➔ Form a working group with members of the R&D community with an identified mission statement and develop a **white paper** to assist with buy-in and case for funding
- ➔ Assemble a Tiger Team of FEMA and contract support staff to identify and share FEMA resources, i.e. Coordination of efforts during disasters, available data, etc.
- ➔ Test existing and proposed solutions in Virtual Tabletop and/or shadow real-world events

WANT TO KNOW MORE?

https://communities.geoplatform.gov/disasters/rsiw_afteractionreport/

@ 1:00pm

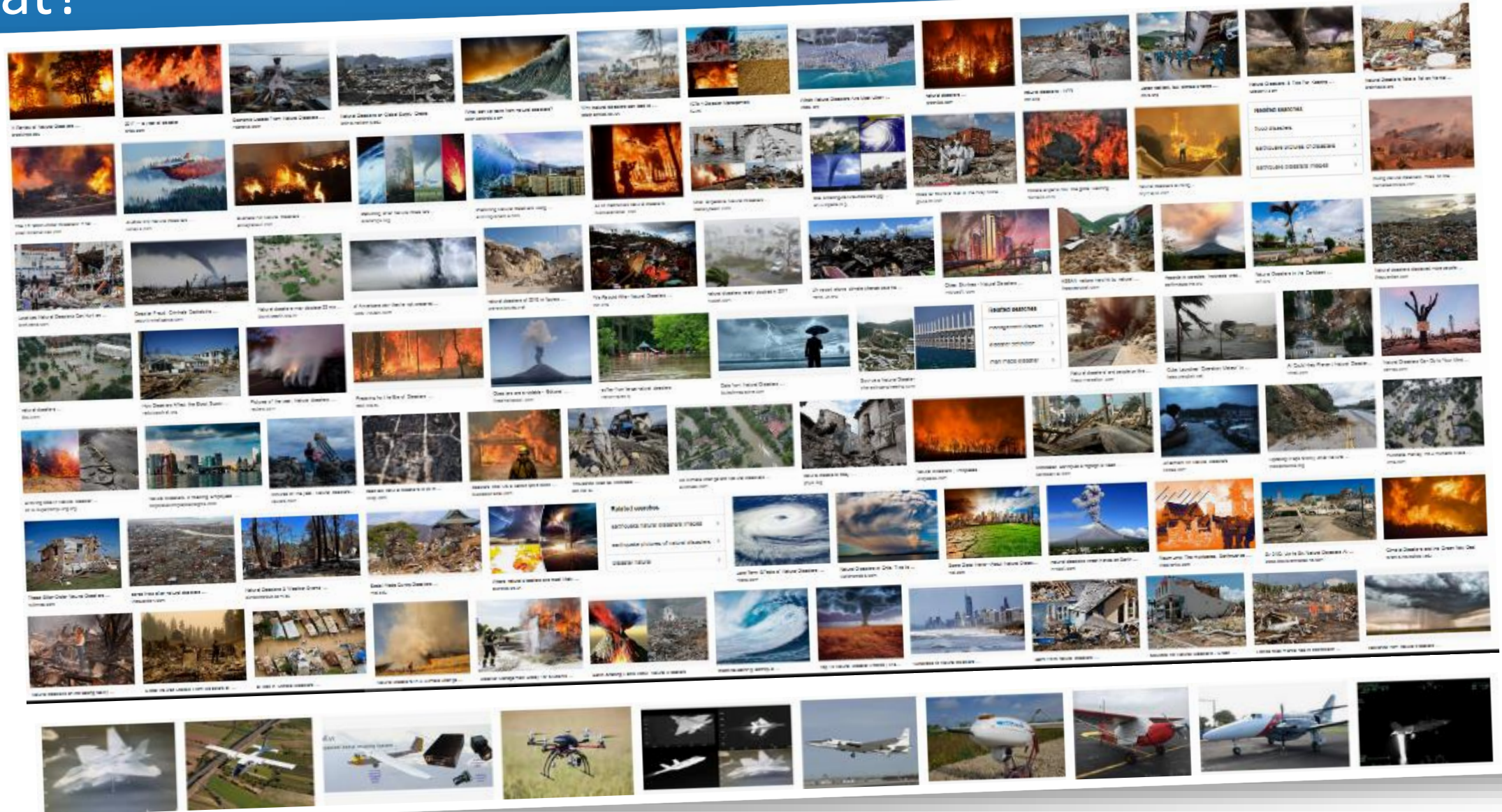
Remote Sensing Innovation Working Group Meeting

Thank you!

Remote Sensing Summary

Glen Russell, FEMA
Catherine Bohn, Dewberry

What?



So What?



Challenges:

- How do we ensure that the many FSLTT remote sensing teams do NOT all collect the same (RS) information?
- How do we, as the “Whole of Community” ensure that there are no critical information gaps?





MISSION TO EARTH

NASA-ISRO Synthetic Aperture Radar

Federally Funded Research and Development
Centers

THE CAPELLA 30-SMALL SAT SAR CONSTELLATION



NAPSG
Foundation

Annex B and ICPs of Plans

Wrap-up

Remote Sensing Innovation Working Group Meeting (Open)

Day3: Thursday, November 14, 2019

Time: 1:00-4:00pm

Thank you!

