

Program Final Report
PFR-10163

Hurrevac eXtended (HVX): Hurricane disaster planning, training, operations for emergency managers

R. G. Hallowell

3 January 2023

Lincoln Laboratory
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LEXINGTON, MASSACHUSETTS



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Massachusetts Institute of Technology
Lincoln Laboratory

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Robert G. Hallowell
Group 21

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Lexington

Massachusetts

Hurrevac eXtended (HVX): Hurricane Disaster Planning, Training, and Operations for Emergency Managers

Robert Hallowell

HVX Closeout Program #10163

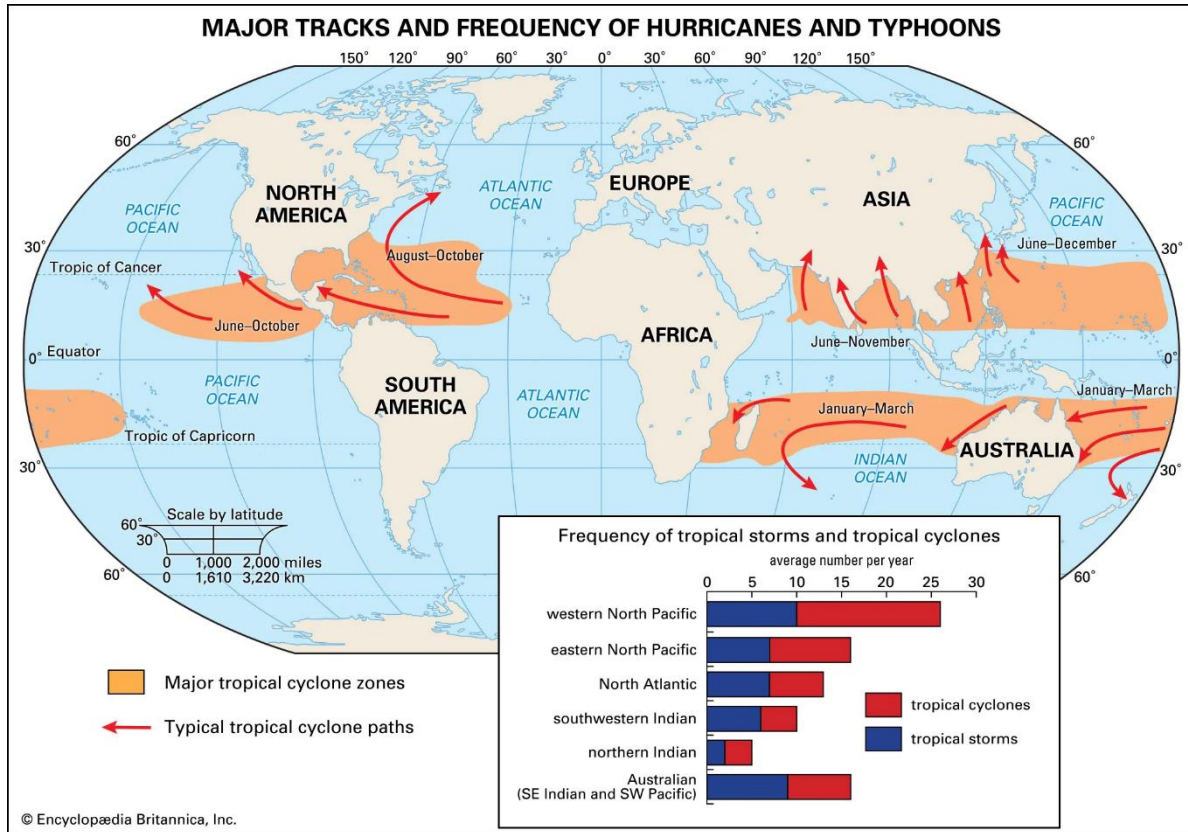
3 January 2023



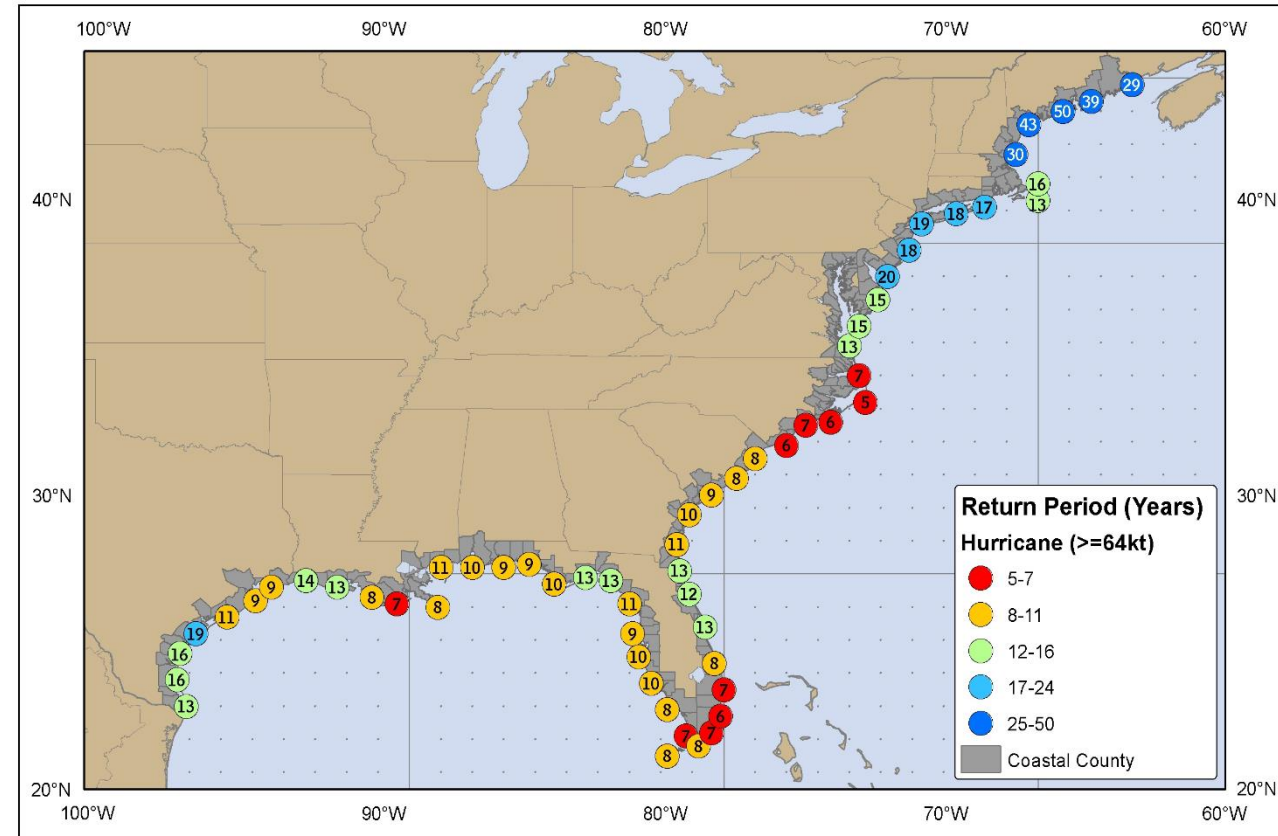


Tropical Cyclone Climatology

Worldwide Tropical Cyclone Tracks and Frequency



Frequency of U.S. Landfalling Hurricanes



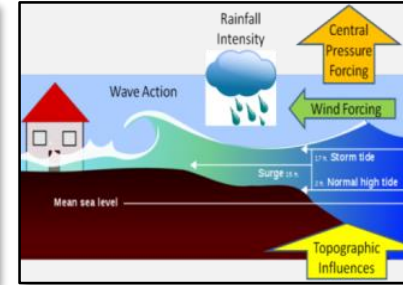


Hurricane Hazards/Impacts

U.S. Hurricane Damages (Top 10 1980–2022)

| Name(year) | Damages(\$B) |
|----------------|--------------|
| Katrina (2005) | \$186.3 |
| Harvey (2017) | 148.8 |
| Maria (2017) | 107.1 |
| Sandy (2012) | 81.9 |
| Ida (2021) | 78.7 |
| Irma (2017) | 59.5 |
| Andrew (1992) | 55.9 |
| Ike (2008) | 40.2 |
| Ivan (2004) | 31.6 |
| Michael (2018) | 29.0 |

Storm Surge



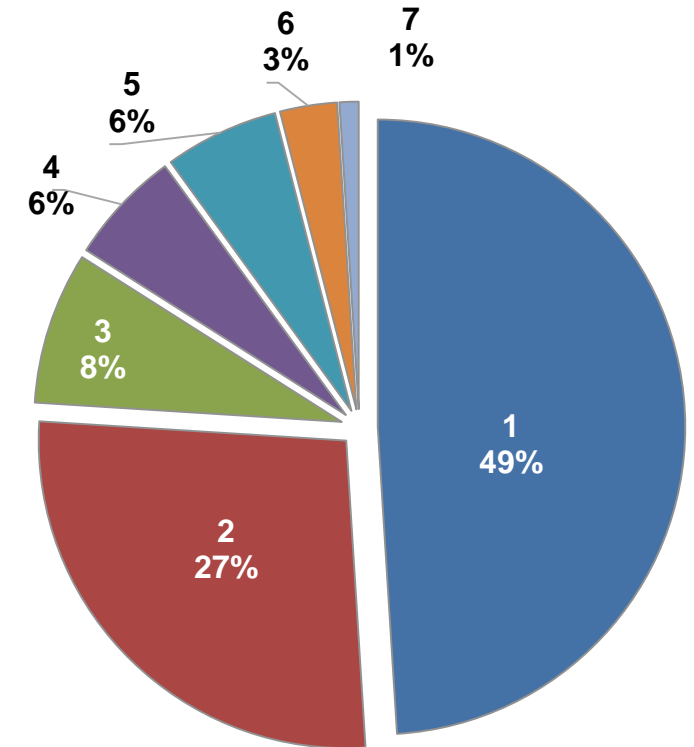
Winds



Inland Flooding



Causes of U.S. Hurricane Fatalities (1960–2012)





Hurricane Evacuations

“I make the best wrong decision that I can make” – Local emergency manager



- Evacuations can take days
- Need to be ordered well ahead of storm, under high forecast uncertainty

As Harvey submerges Houston, local officials defend their calls not to evacuate

By Amy B Wang, Cleve R. Wootson Jr. and Ed O'Keefe August 28, 2017 [Email the author](#)

Governor delays evacuation decision until Friday evening forecast

SEPTEMBER 8, 2017 BY SOUTH CAROLINA RADIO NETWORK

Why the 'tough love' on Hurricane Matthew evacuation?

By Juliette Kayyem, CNN National Security Analyst
Updated 6:50 AM ET, Fri October 7, 2016

How New Orleans' Evacuation Plan Fell Apart

September 23, 2005 - 12:00 AM ET

'People making decisions hesitated'

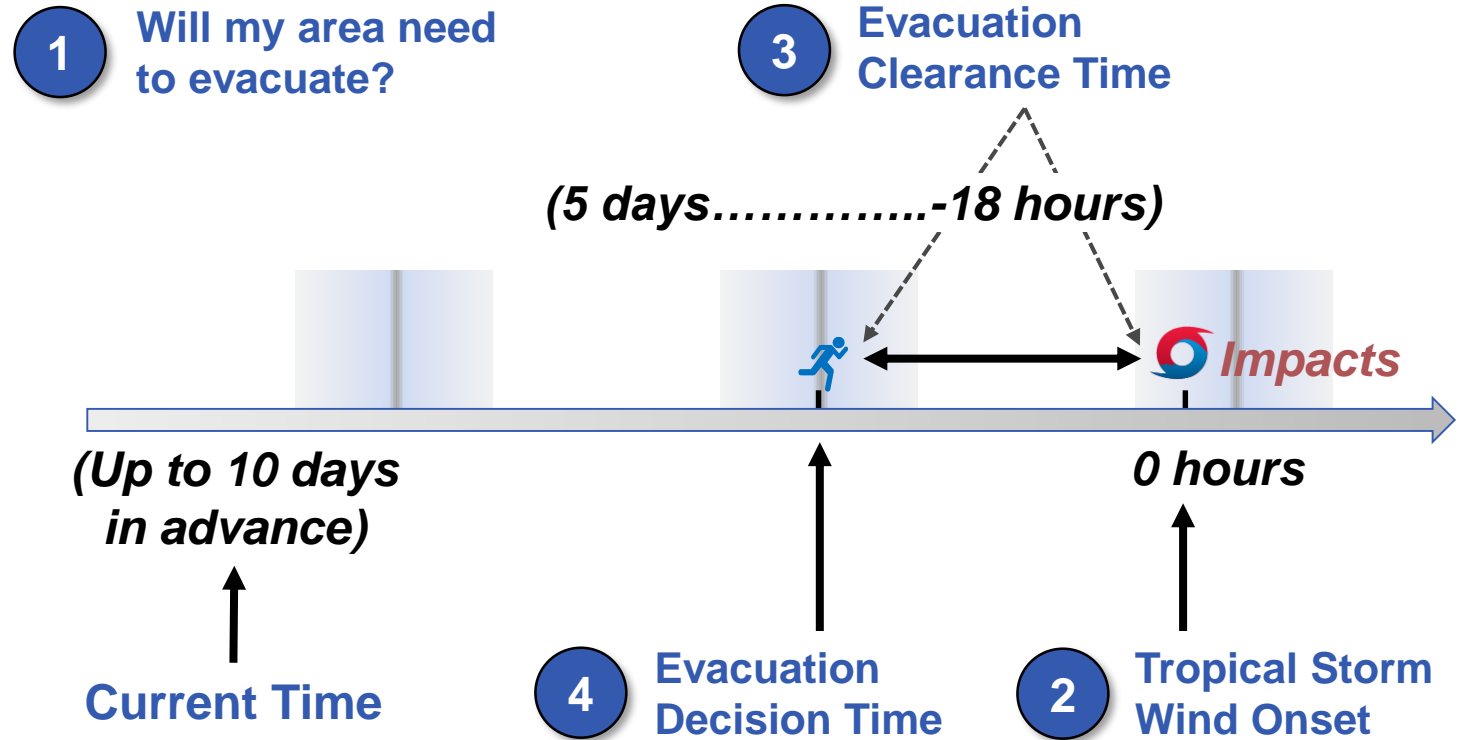
More officials' jobs may fall to Katrina response criticism

Tuesday, September 13, 2005; Posted: 6:28 p.m. EDT (22:28 GMT)

Hurricane evacuation orders are complex, high-impact, high-regret decisions



Hurricane Evacuation Decision Timeline

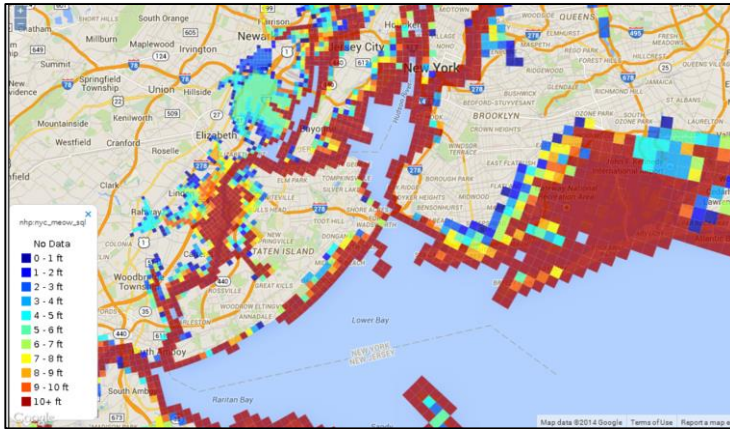


Evacuation decisions require understanding the uncertainty in forecasted timing and impacts

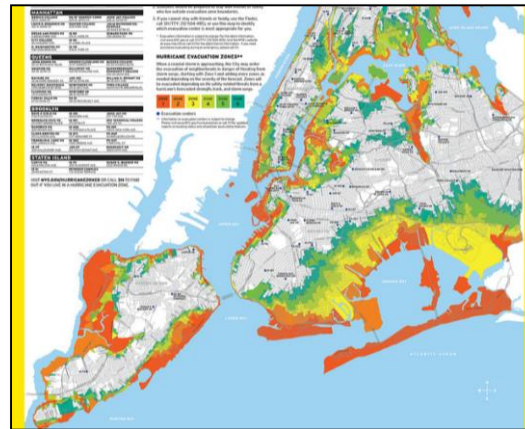


Hurricane Evacuation Decisions

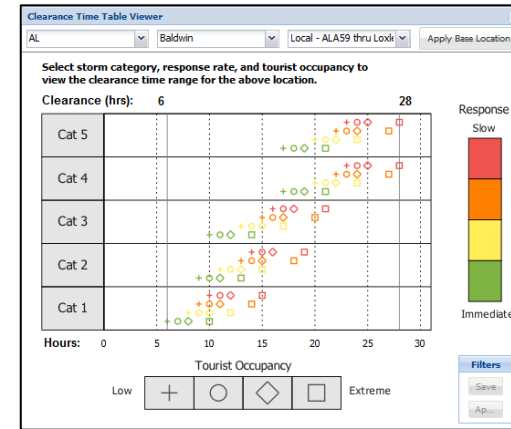
Storm Surge Hazard



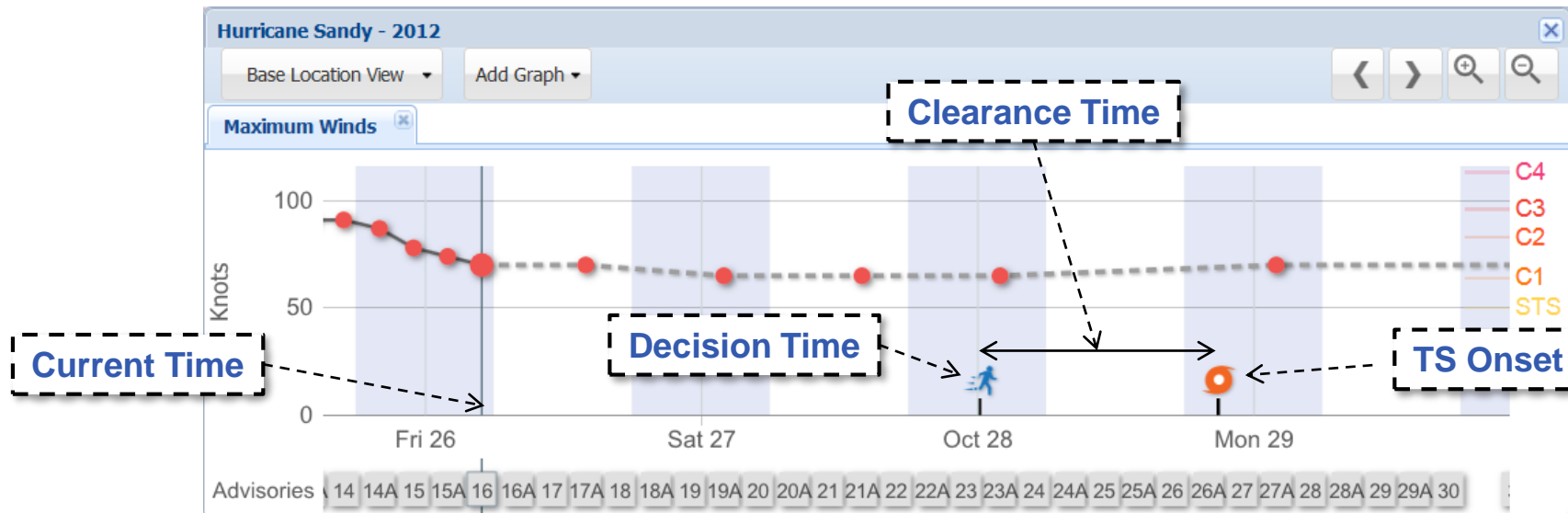
Evacuation Zones



Clearance Times



Storm Forecast





Hurricane Disaster Response Cycle

Continuous Situational Awareness and Decision Support



Years: Risk Assessment, Planning and Training



Monitoring and Modeling



Days / Hours

Evacuation and Mitigation Decisions



Days / Hours

Rapid Response and Resource Allocation



Days / Weeks

Damage Assessment



Weeks / Months

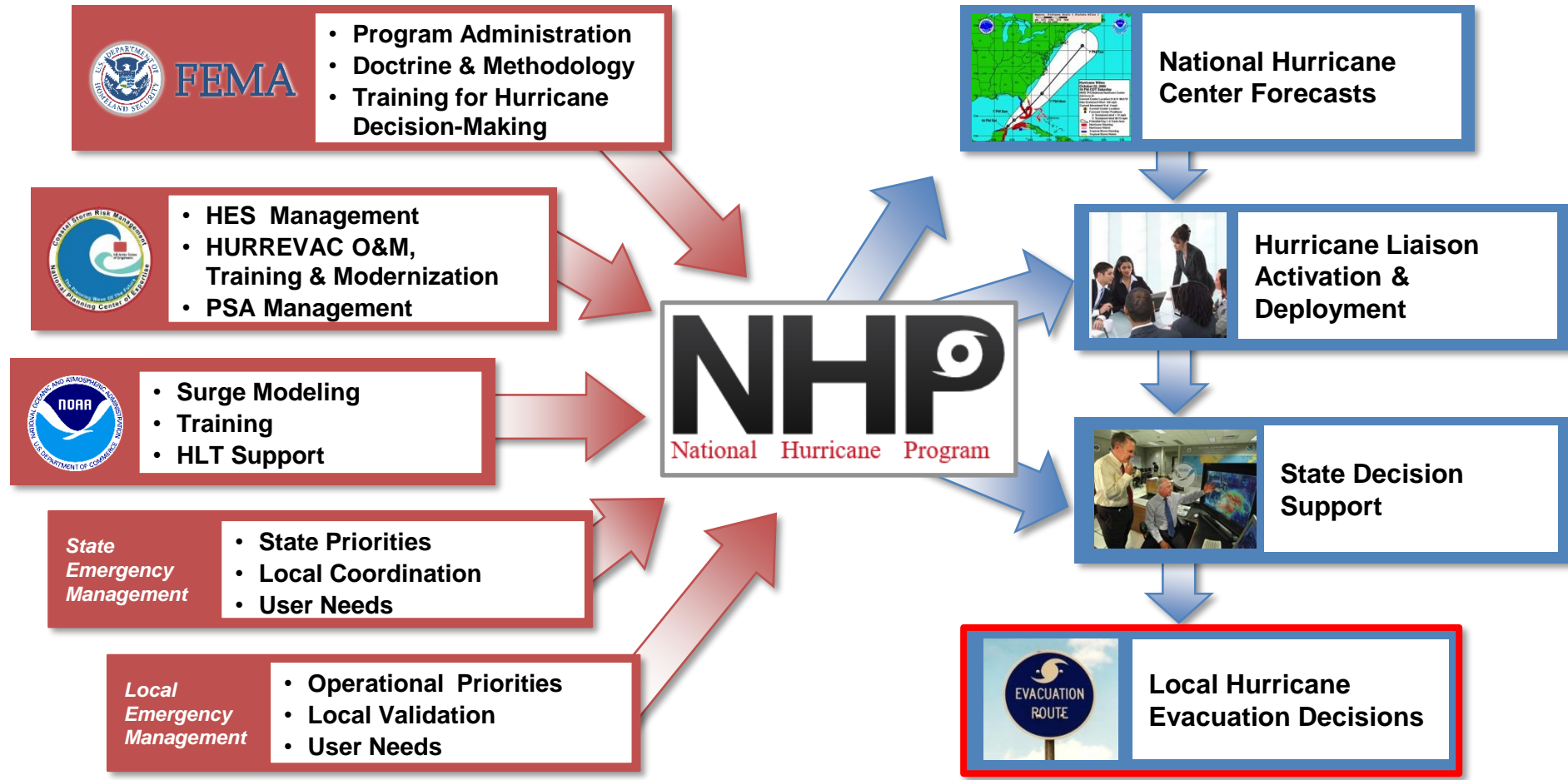
Recover and Rebuild



National Hurricane Program*

Planning

Response



Provide training, operational tools, technical and policy assistance to EMs in support of their hurricane evacuation and response decisions during hurricane threats



HVX Development Timeline

Stakeholder Engagement



Technology Gap Analysis



HVX User Groups



HVX Transition to FEMA Vendor

HVX Operational
(Sea Island Software
hvx.hurrevac.com)



2013

2014

2015

2016

2017

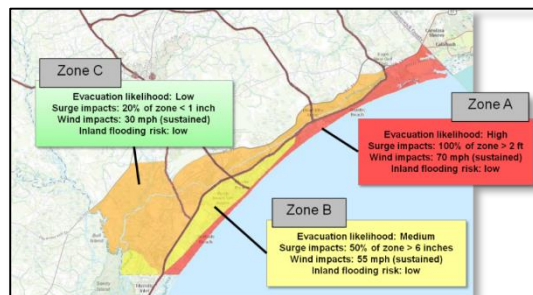
2018

2019

2020

2021

Technology Pilots



Tools and Products Development

HVX Development



Decision platform, gaming tools

“Operational” Prototype



2016, 2017 & 2018 Hurricane Seasons




HURREVAC Storm simulation suite – 2022 National Hurricane Conference “Outstanding Achievement Award”



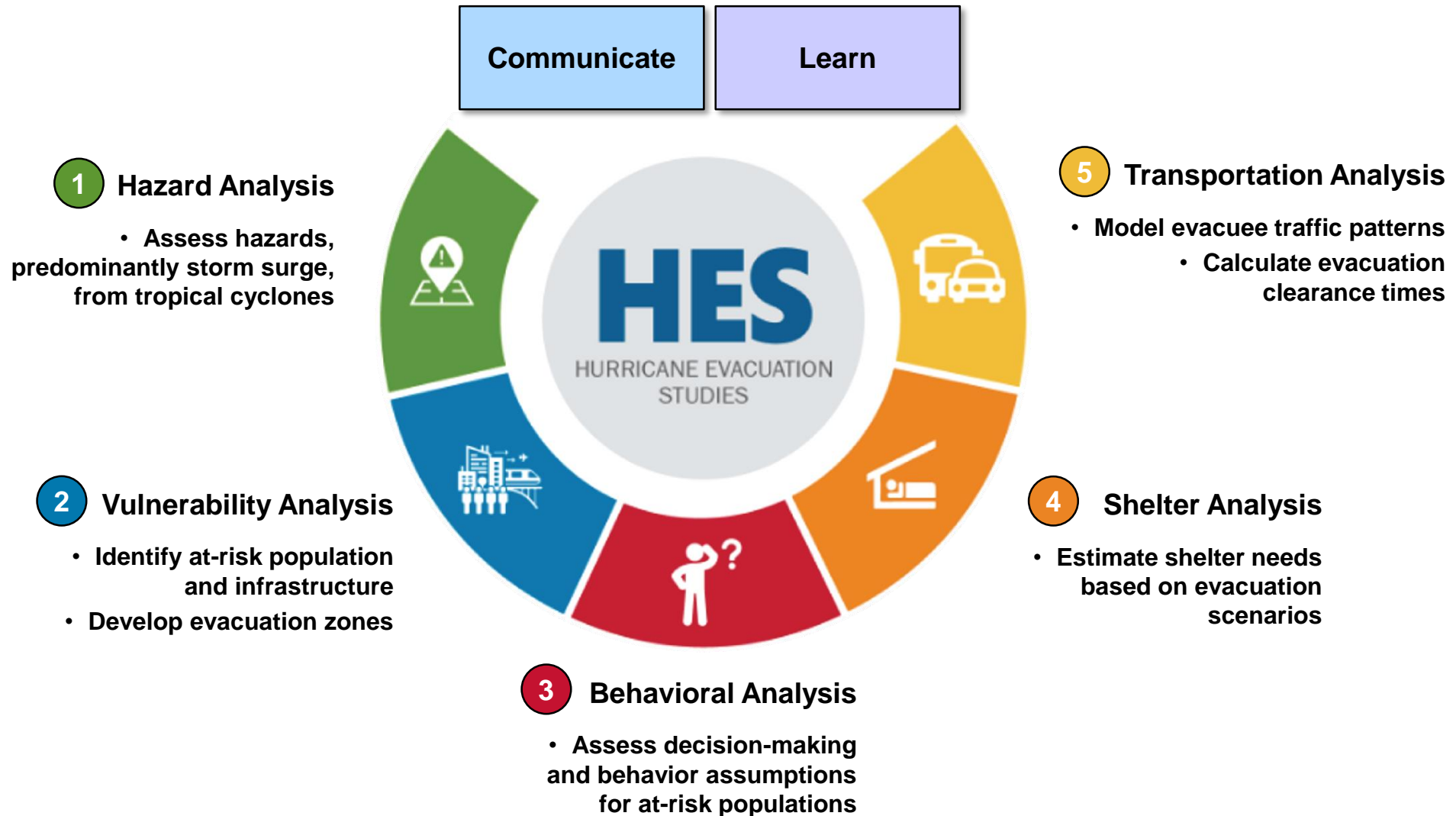
HVX Program Funding History

DHS Science & Technology Directorate Funding FY13 – FY20

|  Science and Technology | | Phase 1 (Gap Analysis, Technology Pilots) | | Phase 2 (Guidance Doc & HES-SUMMIT, HVX Platform) | | Phase 3 (HVX pilots and extensions) | Phase 4 (HVX Transition) | Transition (Core system components) | Transition (Training) |
|--|----------|---|-------------------|--|-------------------|--|-----------------------------|--|--------------------------|
| | | FY13 | FY14 | FY15 | FY16 | FY17 | FY18 | FY19 | FY20 |
| | | (Jun 13 - Sep 13) | (Oct 13 – Sep 14) | (Oct 14 – Mar 16) | (Mar 16 – Apr 17) | (May 17 – May 18) | (May 18 – Apr 19) | (May 19 – Apr 20) | (May 20 – Jul 21) |
| Performers | MITLL | \$150K | \$400K | \$2,750K | \$1,250K | \$820K | \$832K | \$834K | \$500K |
| | Sandia | \$150K | \$400K | \$1,000K | 0 | 0 | 0 | 0 | 0 |
| | CSE-Corp | 0 | 0 | \$250K | 0 | 0 | 0 | 0 | 0 |
| TOTAL BY PHASE | | \$1,100K | | \$5,250K | | \$820K | \$832K | \$834K | \$500K |
| TOTAL BY FY | | \$300K | \$800K | 4,000,000 | 1,250,000 | \$820K | \$832K | \$834K | \$500K |
| TOTAL PROJECT | | \$9,336K (all performers) [\$7,536K MITLL*] | | | | | | | |

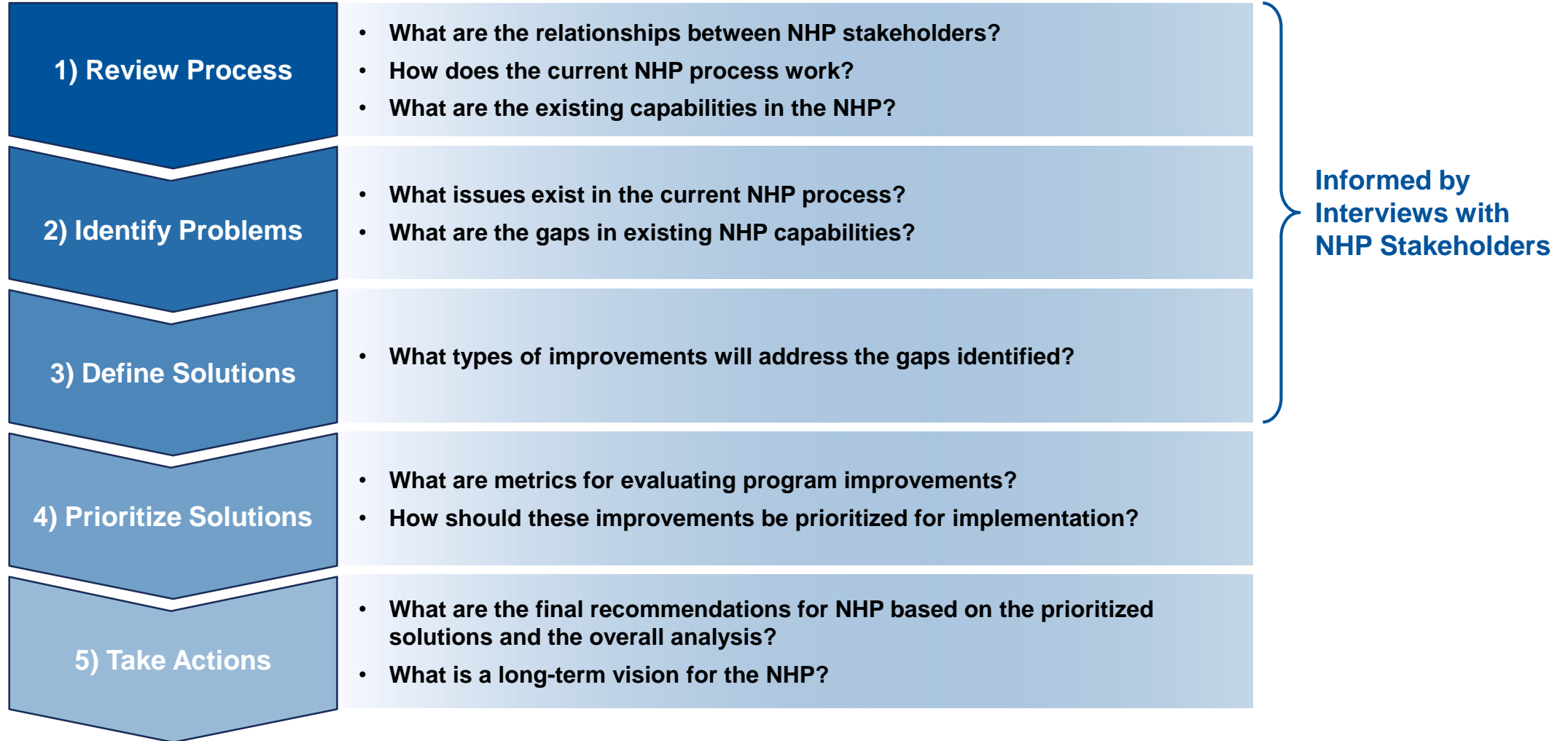


Evacuation Planning Process and Challenges





Analysis Process Overview





Technical Approach

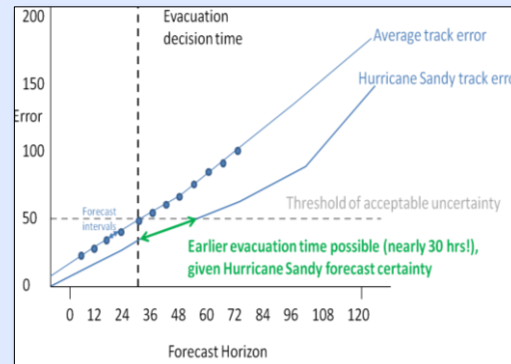
Program Goal: Modernize the “technology” components of the National Hurricane Program (NHP)

Operations Analysis



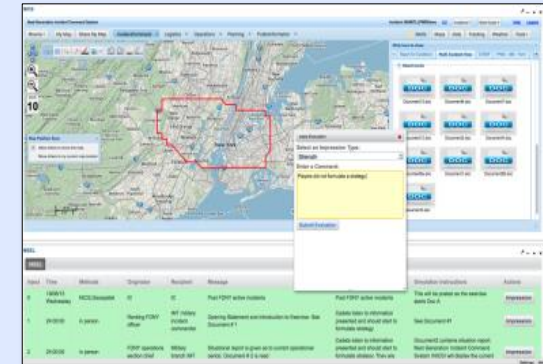
- Interview stakeholders
- Identify gaps

Concept Exploration



- Prototype solutions
- Analyze effectiveness

Technology Development

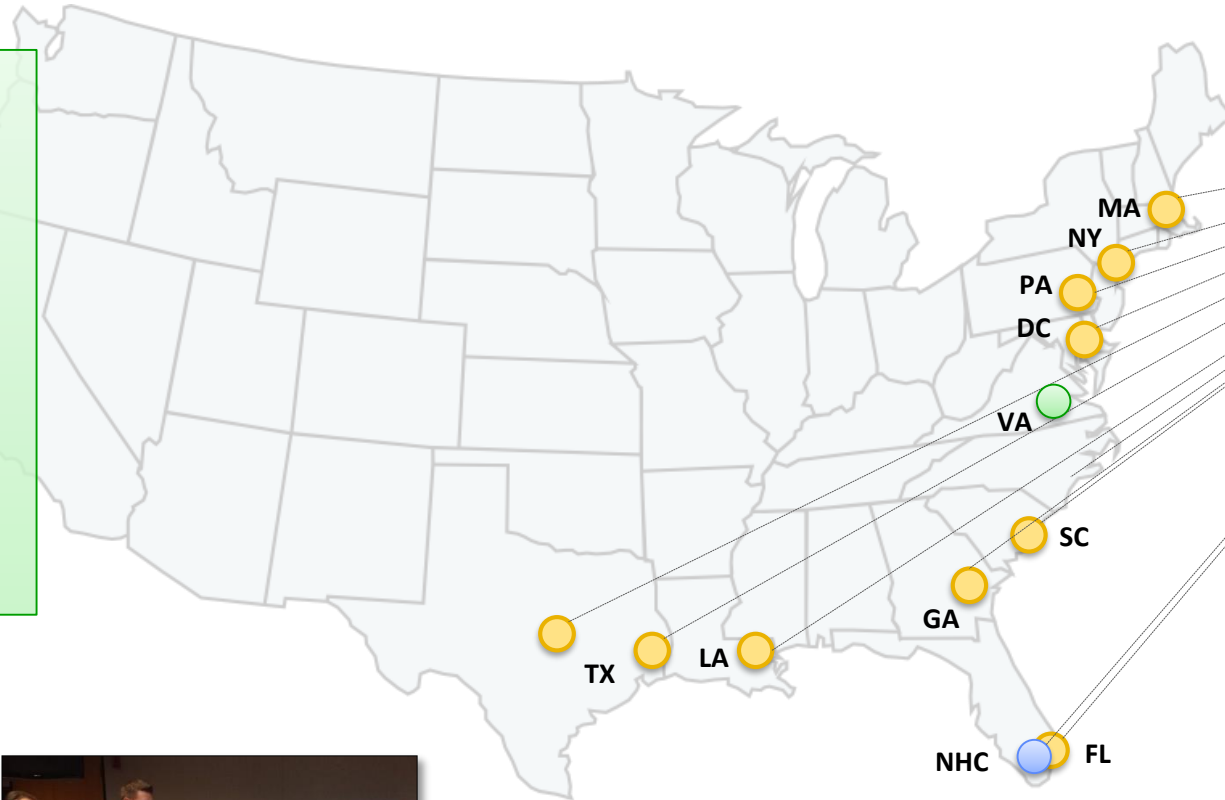


- Build new technology
- Transition to operations



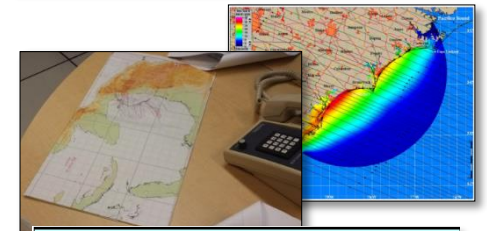
Step 1-3: Stakeholder Interviews

- **Federal**
 - FEMA (HQ & Regions)
 - NWS NHC
 - NWS LFOs
 - USACE
- **State and local level**
 - 17+ Interviews of EMs
- **Sea Island Software**
 - HURREVAC developer



- **Structured interviews**
 - In-person
 - Phone-based
- **NHC Training**
 - L324 @ NHC

The team conducted over 50 interviews



U.S. Virgin Islands

QUESTION 2 - WHAT SHOULD BE THE EXTENT OF AN EVACUATION FROM THE STORM?

| STATION | STATION NUMBER | STATION NAME | STATION TYPE | STATION STATUS | STATION OPERATIONAL SINCE | STATION OPERATIONAL UNTIL | STATION OPERATIONAL SINCE | STATION OPERATIONAL UNTIL |
|---------|----------------|--------------|--------------|----------------|---------------------------|---------------------------|---------------------------|---------------------------|
| 1 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 |
| 2 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 |
| 3 | 3000 | 3000 | 3000 | 3000 | 3000 | 3000 | 3000 | 3000 |
| 4 | 4000 | 4000 | 4000 | 4000 | 4000 | 4000 | 4000 | 4000 |
| 5 | 5000 | 5000 | 5000 | 5000 | 5000 | 5000 | 5000 | 5000 |
| 6 | 6000 | 6000 | 6000 | 6000 | 6000 | 6000 | 6000 | 6000 |
| 7 | 7000 | 7000 | 7000 | 7000 | 7000 | 7000 | 7000 | 7000 |
| 8 | 8000 | 8000 | 8000 | 8000 | 8000 | 8000 | 8000 | 8000 |
| 9 | 9000 | 9000 | 9000 | 9000 | 9000 | 9000 | 9000 | 9000 |
| 10 | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 |

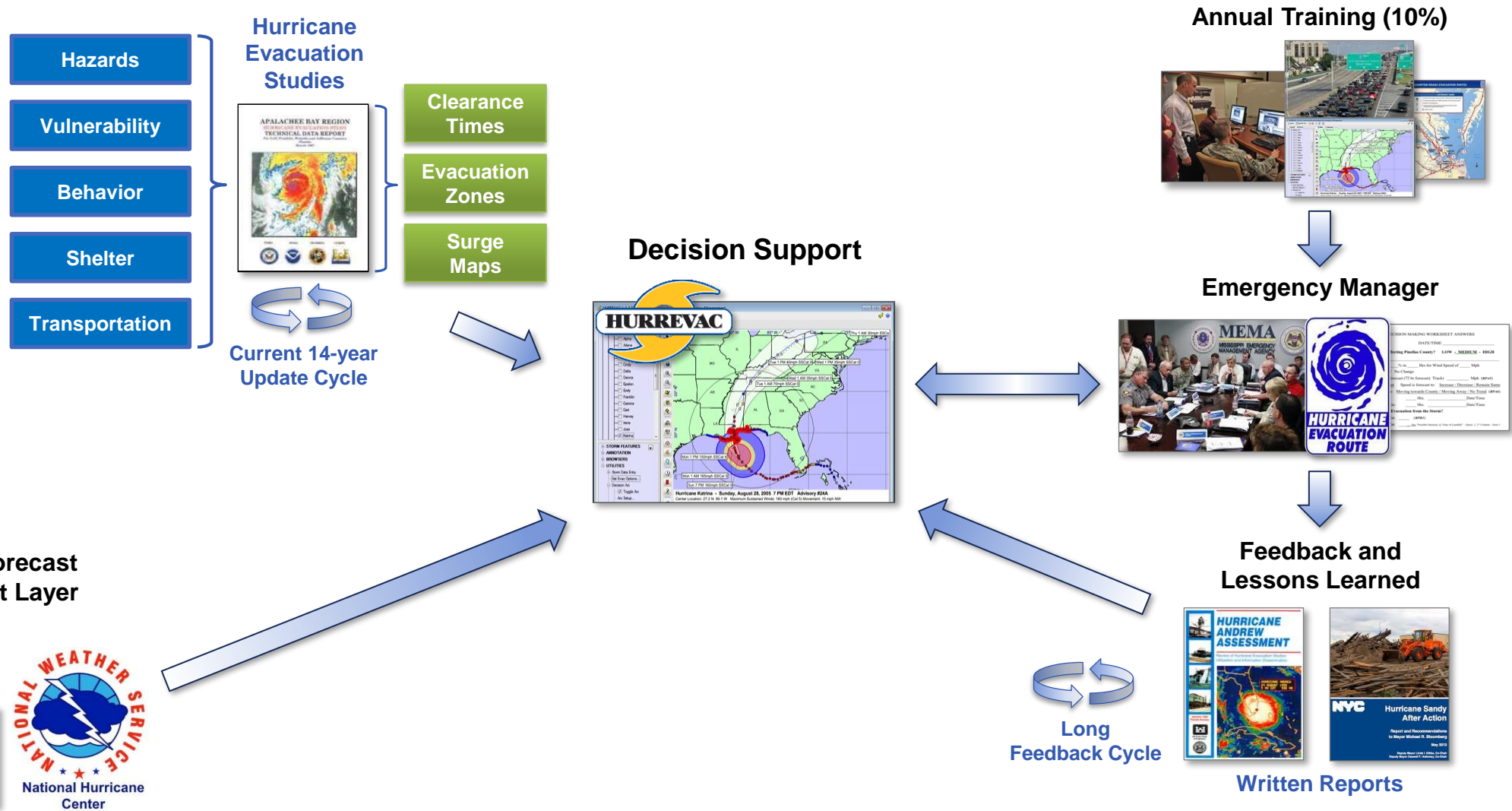


Technology Gap Recommendations

| Recommendation | Interviewee Gaps Addressed |
|--|--|
| Evolve HURREVAC into an integrated decision-support platform | 5, 12, 21, 23, 25, 30 |
| Transform weather forecast products into guidance that is directly relevant to local decision-making (EM product layer) | 9, 13, 15, 18, 19, 20, 22, 25, 27 |
| Provide more comprehensive and accessible training | 8, 14 |
| Improve the efficiency of the Hurricane Evacuation Study (HES) process | 1, 2, 10, 11 |
| Establish, document, and share best practices for the NHP | 3, 6, 16, 17, 28 |
| Extend the scope of NHP to consider “Mitigation” and “Resilience” | 7 |
| Implement a metrics-based improvement process | 4, 24 |

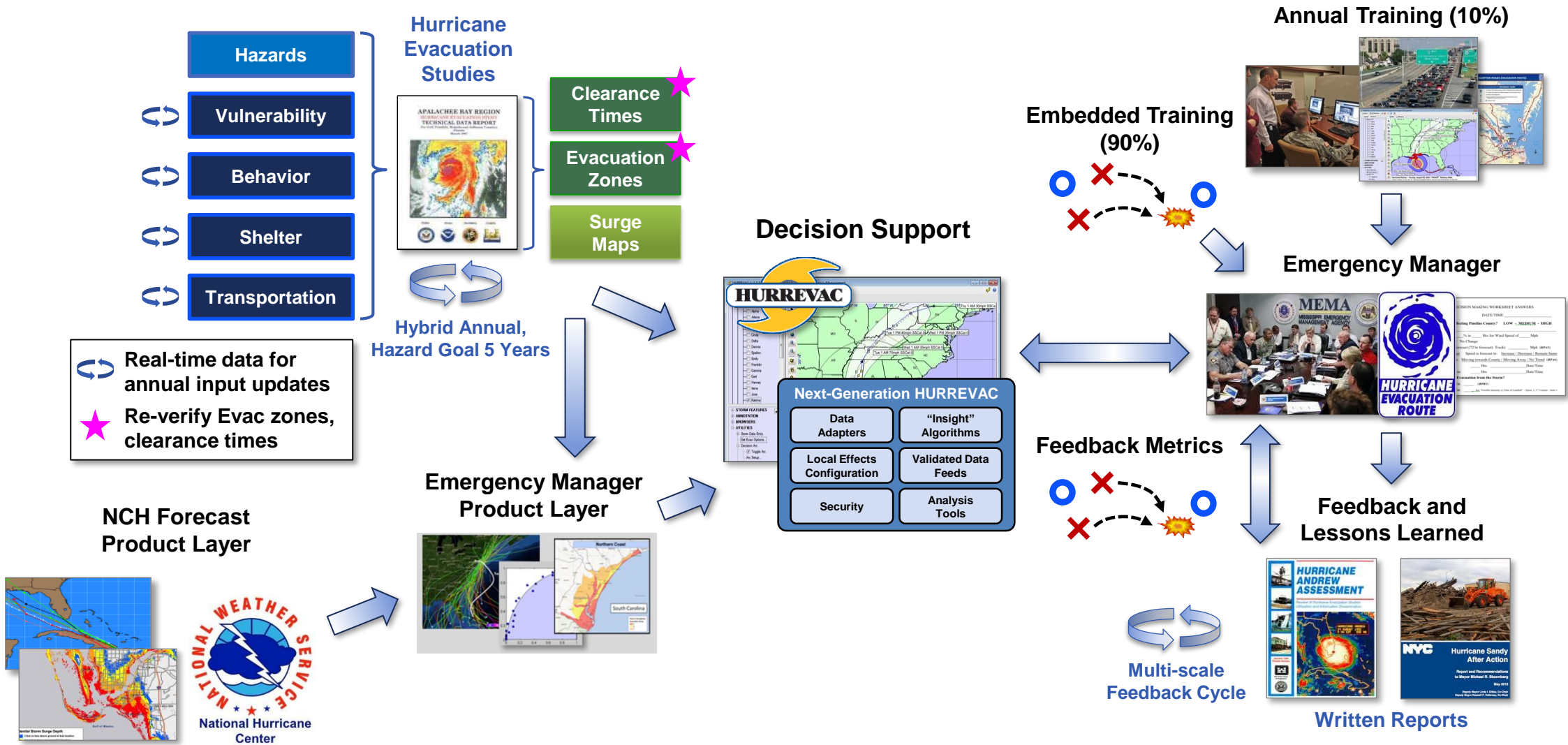


NHP Technology Components (As-is)





NHP Technology Components (To-be)





Next Steps: “Solution Pilots” (FY14)

- Further explore recommendations through prototyping
 - Establish pilots with select jurisdictions
 - Learn → prototype → test → gather feedback → repeat
 - Inform solution feasibility and operator acceptance

| Pilot Focus | Hypothesis | Exploration Approach |
|---------------------------|---|---|
| Decision Support Platform | A common decision platform will increase decision effectiveness | <ul style="list-style-type: none">• Identify pertinent data• Integrate data• Explore analytics |
| Immersive Training | Practicing decisions often will lead to better decisions | <ul style="list-style-type: none">• Develop scenarios• Run exercises• Collect decision data |
| Best Practices | Collecting and distributing best practices will improve nation’s capabilities | <ul style="list-style-type: none">• Assemble expert panel• Define decision timeline• Validate findings |
| HES Efficiency | Modular HESs can improve the HES process | <ul style="list-style-type: none">• Centralize HES results• Merge with other data• Prototype decision tools |



Evacuation Decision Support (before HVX)

Hurricane Evacuation Studies

Hurricane Evacuation Studies

- Hazards
- Vulnerability
- Behavior
- Shelter
- Transportation

SOUTH CAROLINA HURRICANE EVACUATION STUDY TECHNICAL DATA REPORT
December 2013 - Final Report
FEMA

TECHNICAL GUIDELINES for Hurricane Evacuation Studies

- Paper-based reports
- Telephone behavioral surveys
- Long 2–5 years process

Operational Decision Support



- Legacy Windows-only system, proprietary data formats
- Limited graphical/analytical capabilities

Training / Exercises

QUESTION 2 – WHAT WOULD BE THE EXTENT OF AN EVACUATION FROM THE STORM?

| WINDS | CENTRAL PRESSURE | CAT | INTENSITY FORECAST ERROR | POSSIBLE INTENSITY @ TIME OF LANDFALL | RESPONSE STORM CATEGORY |
|---|---|-------|--------------------------|--|---|
| CURRENT INTENSITY (Risk Profile B1): WINDS (mph) _____ CAT _____ HOW IS STORM INTENSITY FORECAST TO CHANGE BEFORE LANDFALL (RP B2)? | CURRENT ADVISORY _____ MB (Hurricane Reports - Storm Status - L&O) | _____ | _____ | 1. HOW MANY HOURS UNTIL FORECAST LANDFALL (RP B4): _____ HRS 2. WHAT IS MPH ERROR FOR THAT TIME PERIOD (start at 1st)? _____ MPH 3. FORECAST INTENSITY AT LAND-FALL _____ MPH (Hurricane Reports - Storm Status - List go to 2nd column - find "X" in first where "X" = RP B4 from above - scan where X = 1 hr, 30 min) | WIND TS Strong TS = Cat 1 Cat 1 Cat 2 Cat 3 Cat 4 Cat 5 |
| HOW CLOSE IS MAX. FORECAST WIND AT TIME OF LANDFALL TO NEXT HIGHEST STORM CATEGORY (RP B3)? _____ mph | PREVIOUS _____ MB UP DOWN | | | | |
| NOTE: If current intensity is within 5 mph of the next category, and the forecast shows an approaching or flat path, the next higher category. CHECK THE HLS from RESULTS for FURTHER INFO. WATCH WARNING! | NOTE: Pressure can drop before the storm arrives. | | | | |

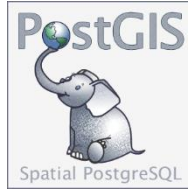
NHC Training Classes

- In-person sessions, limited budget
- Train <10% annually
- Separate training for tools & decisions
- Time-consuming exercise creation



Key Architecture-Enabled Transformations

Open Source / Open Standards



- Reduces cost of operations
- Supports rapid inclusion of new products
- Enables diverse contributors and connections

Enable the User

Risk Profile Question Definition

| Impact Point or Time | Feature or Characteristic | Relationship | Location | |
|----------------------|-----------------------------------|----------------------|---|------------|
| Specific Timeframe | 48 hour forecast | Forward speed | Base region Current: Duval County, Florida | |
| | 72 hour forecast | Wind probability | | Average |
| | 120 hour forecast | Wind speed | | Maximum |
| | 120 or 72 hr. forecast | Rainfall | | Minimum |
| | Closest approach | Error cone intersect | | Time Until |
| Change Over Time | Currently | Intensity | True/False | |
| | By Advisory | Bearing | Value | |
| | From current position to landfall | Tide | Category | |
| | Around closest approach | Track direction | | |
| | Across several advisories | Evac. decision time | | |
| | | Watches/warnings | | |
| | | Tourist Population | | |
| | | SS category diff | | |

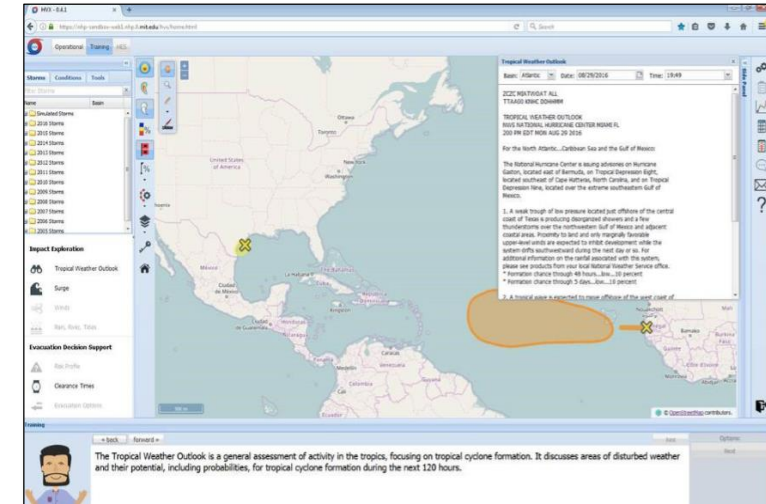
Current Selection

72 hour forecast | Wind speed | Category | Duval County, FL

Cancel Next

- Products that can be easily configured by the user
- Flexibility to visualize the data with simple interfaces

Embed Training



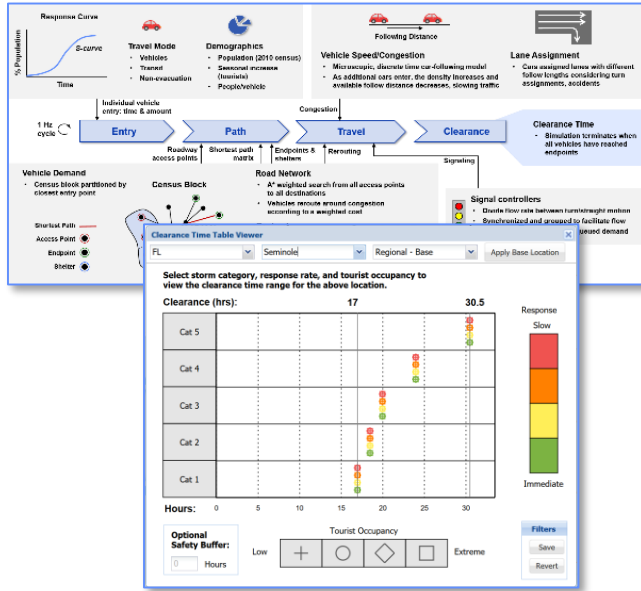
- User trains with same tools with which they respond
- Simulation tools allow user to tailor scenarios to their location

HVX provides a maintainable, sustainable and engaging platform to meet each emergency manager's decision-making needs



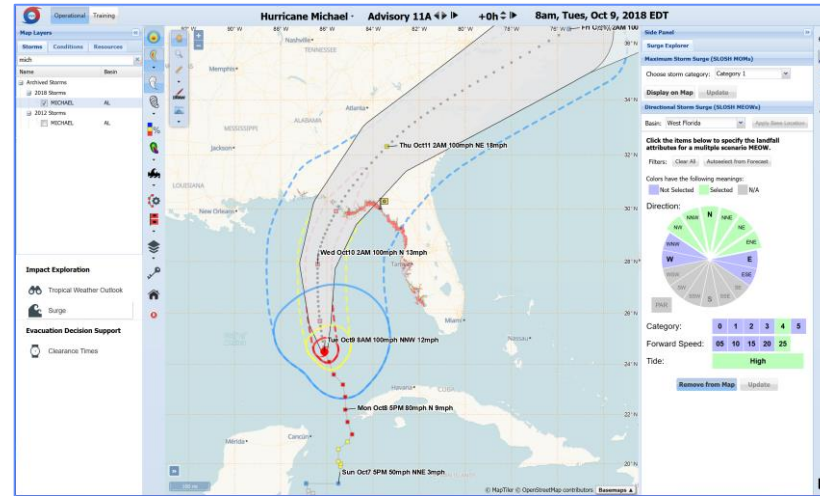
Evacuation Decision Support with HVX

Hurricane Evacuation Studies



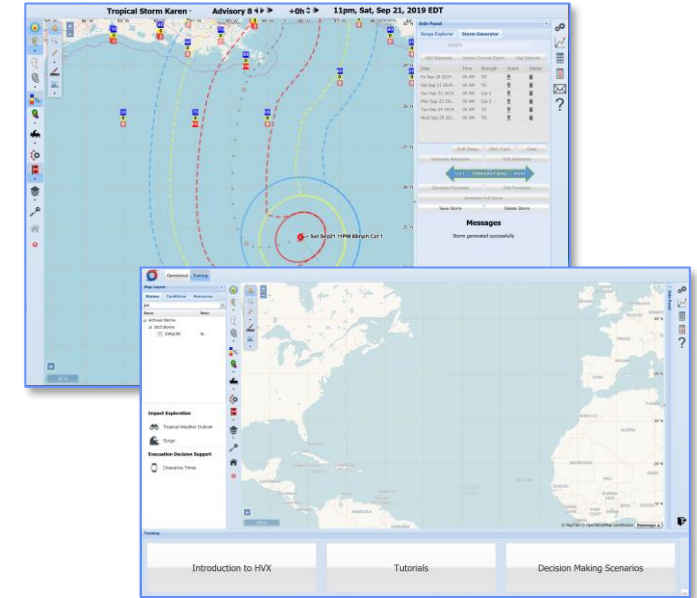
- In-platform graphics
- Standardized transportation model (RTEPM) via portal
- Full HVX-HES integration (pending)

Operational Decision Support



- Anywhere, any time, any device
- Advanced temporal and spatial mapping/analytics
- Surge explorer

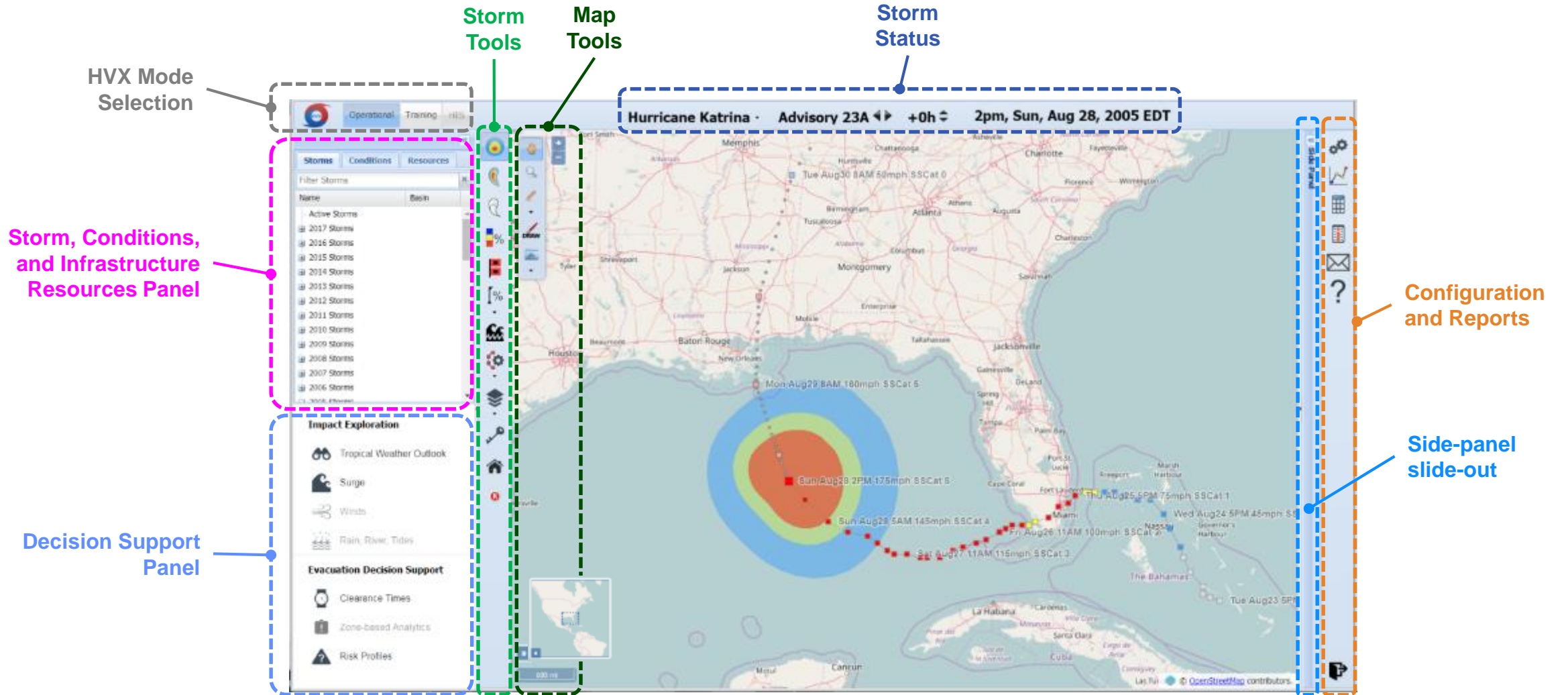
Training/ Exercises



- Embedded training for platform features, product tutorials and decision making – available to all
- Exercise creation tool generates full product suite in minutes



HVX GUI Components





HVX Walkthrough

Username or email
Bobh@ll.mit.edu

Password
.....

[Forgot Password?](#)

Login

New user? [Register](#)

FEMA Homeland Security Science and Technology US Army Corps of Engineers

Caution: HVX is a experimental prototype to assist Emergency Managers in planning, decision-making and responding to tropical storm threats and evacuations. HVX is still in development by MIT Lincoln Laboratory under sponsorship from the Department of Homeland Security Science and Technology (DHS S&T) Directorate and the Federal Emergency Management Agency (FEMA) National Hurricane Program. HVX is an experimental prototype undergoing test and evaluation. HVX is NOT an operational system and should not be used for operational decisions during active events. Access is restricted to authorized users with approved credentials, and these credentials are only valid for the individual for which they were assigned. Questions, comments and feedback should be directed to support@hurrevac.com.

Note: Although HVX may be used with several browsers, recent versions of Chrome and Firefox are recommended for best results.

HVX is the National Hurricane Program's web-based, device independent evacuation decision support platform.



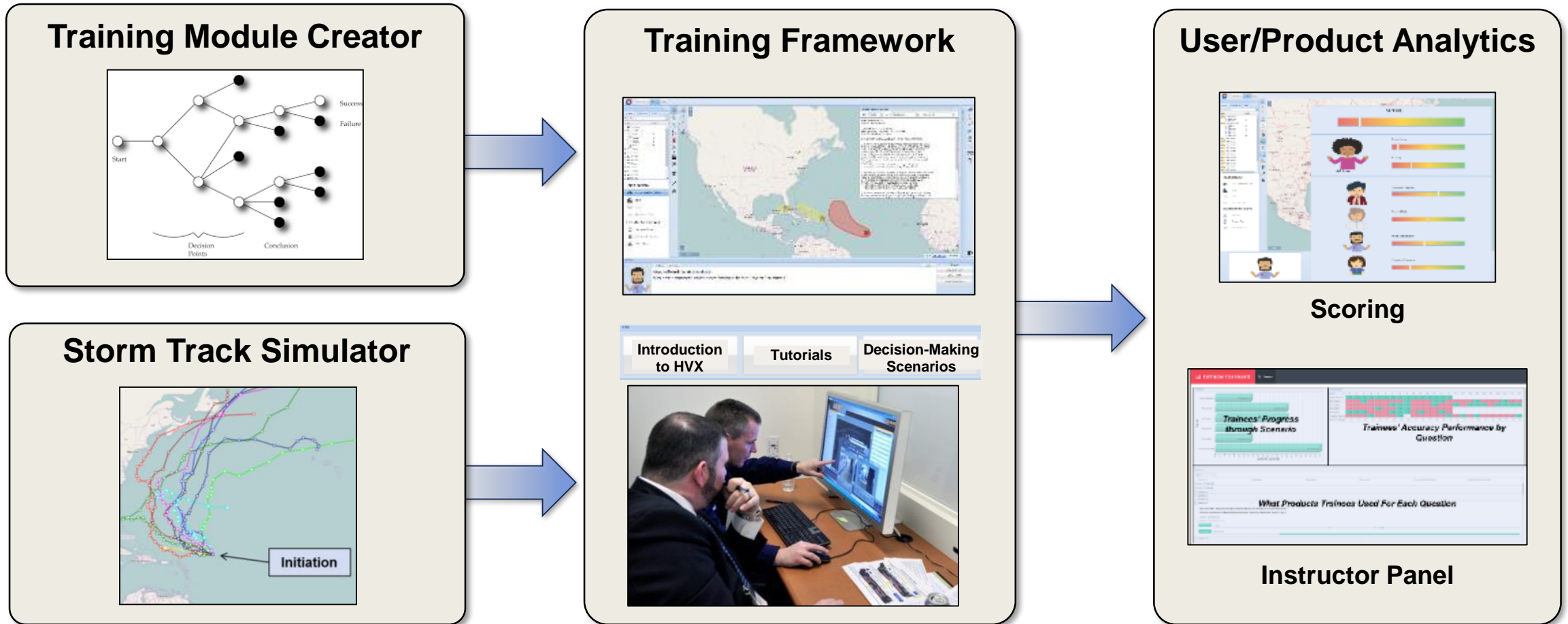
Training Interface

The screenshot displays the HVX Training Interface. The main window features a map of the Eastern United States and the Caribbean region. On the left, there is a sidebar with sections for 'Storms' (listing years from 2006 to 2017), 'Impact Exploration' (with options like Tropical Weather Outlook, Surge, Winds, Rain, River, Tides), and 'Evacuation Decision Support' (with options like Clearance Times, Zone-based Analysis, Risk Profiles). Below the map, a 'Training' section contains three modules: 'Introduction to HVX', 'Tutorials', and 'Decision Making Scenarios'. Each module is associated with a callout box:

- Introduction to HVX**: How to use HVX Interface controls/tools
- Tutorials**: How to use the weather layers, products, tools for decision-making
- Decision Making Scenarios**: How to use the weather layers, products, tools for decision-making using simulated storms

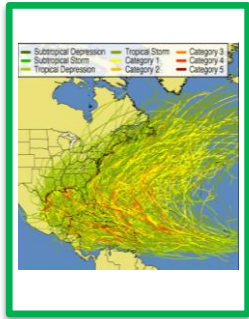


Training Capability Components

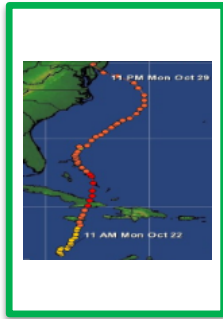




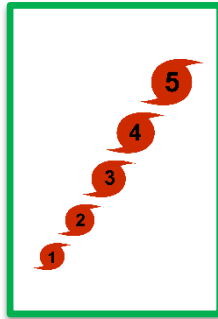
Storm Simulation Components



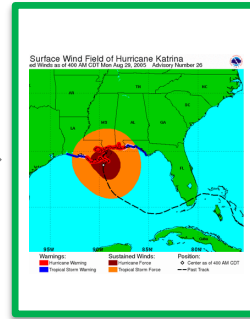
Historical Database



Track



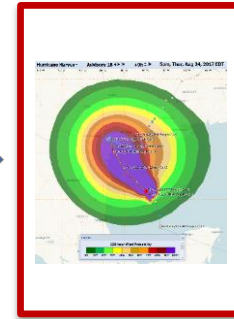
Strength



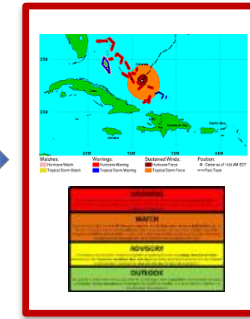
Wind Radii



Forecast Tracks plus winds



Wind Probability



NHC Wind Watches & Warnings



Location-based Wind Probability



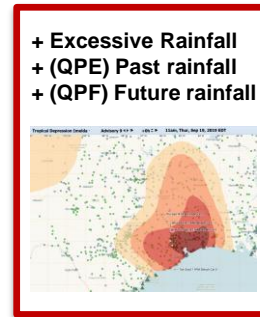
Surge Impact (MEOW-based)



NHC Surge Watches & Warnings



Text Advisories



Inland Rainfall



River/Tide Gauges



Tropical Weather Outlook



Simulating Forecast Discussions

Archive of 10K Discussions

Text Advisories: JOAQUIN #33

Forecast Advisory Public Advisory Forecast Discussion Wind Speed Probabilities

Text Advisories: SANDY #31

Forecast Advisory Public Advisory Forecast Discussion Wind Speed Probabilities

Text Advisories: MATTHEW #34

Forecast Advisory Public Advisory Forecast Discussion Wind Speed Probabilities

HURRICANE MATTHEW DISCUSSION NUMBER 34
NWS NATIONAL HURRICANE CENTER MIAMI FL AL142016
1100 AM EDT THU OCT 06 2016

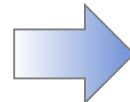
The satellite presentation of the hurricane has continued to improve, with a distinct eye surrounded by very deep convection, and T-numbers are oscillating around 6.0 on the Dvorak scale. Data from an Air Force reconnaissance plane traversing the eye of the hurricane also indicate that Matthew has strengthened. The initial intensity is estimated at 120 kt, based mainly on SFMR data and an eye-wall dropsonde.

Environmental conditions appear favorable for additional intensification today while Matthew approaches the east coast of Florida. After 24 hours, land interaction is likely to cause some weakening, and later in the period increasing shear should cause a more rapid decrease in winds. The NHC forecast is slightly above most of the guidance during the first 24 hours due to the recent intensification, and follows the weakening trend of the consensus thereafter.

Aircraft fixes show that Matthew is moving toward the northwest or 325 degrees at 10 kt. The steering flow has not changed and Matthew is expected to move around the western periphery of the subtropical ridge located over the western Atlantic during the next 24 to 36 hours. After that time, the ridge will shift eastward allowing the hurricane to move northward and then sharply turn eastward while it becomes embedded within the mid-latitude westerlies. By the end of the forecast period the steering pattern is forecast to change again and a weakening cyclone is expected to turn southward.

KEY MESSAGES:

1. Matthew is likely to produce devastating impacts from storm surge, extreme winds, and heavy rains in the northwestern Bahamas today, and along extensive portions of the east coast of Florida tonight.
2. Evacuations are not just a coastal event. Strong winds will occur well inland from the coast, and residents of mobile homes under evacuation orders are urged to heed those orders.
3. Hurricane winds increase very rapidly with height, and residents of high-rise buildings are at particular risk of strong winds. Winds at the top of a 30-story building will average one Saffir-Simpson category higher than the winds near the surface.
4. When a hurricane is forecast to take a track roughly parallel to a coastline, as Matthew is forecast to do from Florida through South Carolina, it becomes very difficult to specify impacts at any one location. Only a small deviation of the track to the left of the NHC forecast could bring the core of a major hurricane onshore within the hurricane warning area in Florida and Georgia. Modest deviations to the right could keep much of the hurricane-force winds offshore. Similarly large variations in impacts are possible in the hurricane watch and warning areas in northeast Georgia and South Carolina.



Sentence Classification

Bob will **weaken** as it passes over Puerto Rico
Shear aloft will **weaken** Sandy.....

Katrina will **strengthen** over warmer water.....
Warm sea surface temperatures **increase**

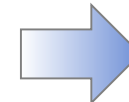
The models **diverge** and makes the track.....
A front to the north makes the track **uncertain**

Variable Identification

<storm type> (tropical storm, hurricane, ...)
<name> (Sandy, Matthew, ...)
<strength change> (weaken, strengthen,...)
<uncertainty> (challenge, certain, ...)

Storm Technical Data

Forecast position is <lat, lon>
Motion estimate is <value>
Forward speed is <value>



Simulated Discussion

Text Advisories: Chris #23

Forecast Advisory Public Advisory Forecast Discussion Wind Speed Probabilities

TROPICAL DEPRESSION CHRIS DISCUSSION NUMBER 23 NWS NWS NATIONAL HURRICANE CENTER MIAMI FL a1032020 2300 EST THU 7 30 2020

ONCE IT TRAVELS FAR ENOUGH NORTH CHRIS WILL ENCOUNTER NOT ONLY MUCH COOLER OCEAN TEMPERATURES IT WILL ALSO LIKELY MOVE INTO A LESS HOSTILE SHEAR ENVIRONMENT. THIS FORECAST AGREES WELL WITH THE PREVIOUS ONE AS WELL AS WITH THE CONSENSUS GUIDANCE THROUGH ABOUT 72 HOURS. CHRIS HAS BEEN MOVING MOSTLY NORTHWARD AROUND 359 / 19 KT DYNAMICAL TRACK PREDICTION MODELS ARE IN GOOD AGREEMENT ON A GENERALLY NORTHWARD MOTION DURING THE FORECAST PERIOD AS A LARGE AREA OF MID-TROPOSPHERIC HIGH PRESSURE IS LIKELY TO REMAIN TO THE NORTH OF THE TROPICAL CYCLONE OVER THE NEXT SEVERAL DAYS. BASED ON THE FLIGHT-LEVEL AND SFMR-ADJUSTED SURFACE WINDS THE INTENSITY IS BEING MAINTAINED AT 30 KT.

THE INTENSITY FORECAST IS IN BETWEEN THE GFDL AND SHIPS MODELS BUT NOT AS AGGRESSIVE AS THE LATTER WHICH BRINGS CHRIS TO 30 KNOTS. VISIBLE IMAGERY SHOWS THAT CHRIS HAS BECOME LESS ORGANIZATION DURING THE PAST SEVERAL HOURS DUE TO 10-15 KT LOWER SHEAR. OUTER BANDS REMAIN IMPRESSIVE AND THE SATELLITE INTENSITY ESTIMATES ARE 30 KT FROM BOTH TAFB AND SAB. A BLEND OF SUBJECTIVE AND OBJECTIVE DVORAK ESTIMATES OF T1.0 AND T3.0 T-NUMBERS, AND A PEAK FLIGHT-LEVEL WIND OF 30 KT AT 1000.0 MB REPORTED BY A RECONNAISSANCE AIRCRAFT YIELDS AN INTENSITY OF 30 KT. SCATTEROMETER AND MICROWAVE DATA INDICATE THAT THE CIRCULATION ASSOCIATED WITH THE BROAD LOW PRESSURE AREA EAST-SOUTHEAST OF NEW YORK CITY HAS BECOME LESS DEFINED.

SOME FLUCTUATIONS IN INTENSITY ARE EXPECTED INTO TONIGHT AS CHRIS WILL REMAIN IN A LOW SHEAR ENVIRONMENT WITH SSTs OVER 5 C. THE SYSTEM IS EXPECTED TO REMAIN A TROPICAL DEPRESSION THROUGH THE REMAINDER OF THE FORECAST PERIOD WHICH FOLLOWS CLOSELY WITH ECMWF GUIDANCE. BASED ON THE LATEST RECON FIXES THE TRACK IS ADJUSTED SLIGHTLY TO THE NORTH OF THE PREVIOUS ONE. THE FORECAST CONTINUES TO DEVELOP BASED ON THE NEW INFORMATION COLLECTED. SUBJECTIVE DVORAK INTENSITY ESTIMATES WERE 30/35 KT FROM ALL SITES.

I HAVE KEPT CHRIS ON A FISHHOOK-SHAPED TRACK TURNING NORTH THEN NORTH. THIS PATH IS VERY CLOSE TO CLIMATOLOGY. CHRIS'S INVOLVEMENT WITH THE ITCZ COMPLICATES THE INTENSITY FORECAST. THE MOTION ESTIMATE IS 359 / 19 KT. THE INTENSITY IS BASED ON SATELLITE ESTIMATES OF 30 KT AND AN EARLIER 35-KT WIND REPORT FROM NEW YORK CITY.

FORECASTER SMITH

FORECAST POSITIONS AND MAX WINDS

INIT 31/0300Z 43.5N 75.9W 30 KT 35 MPH



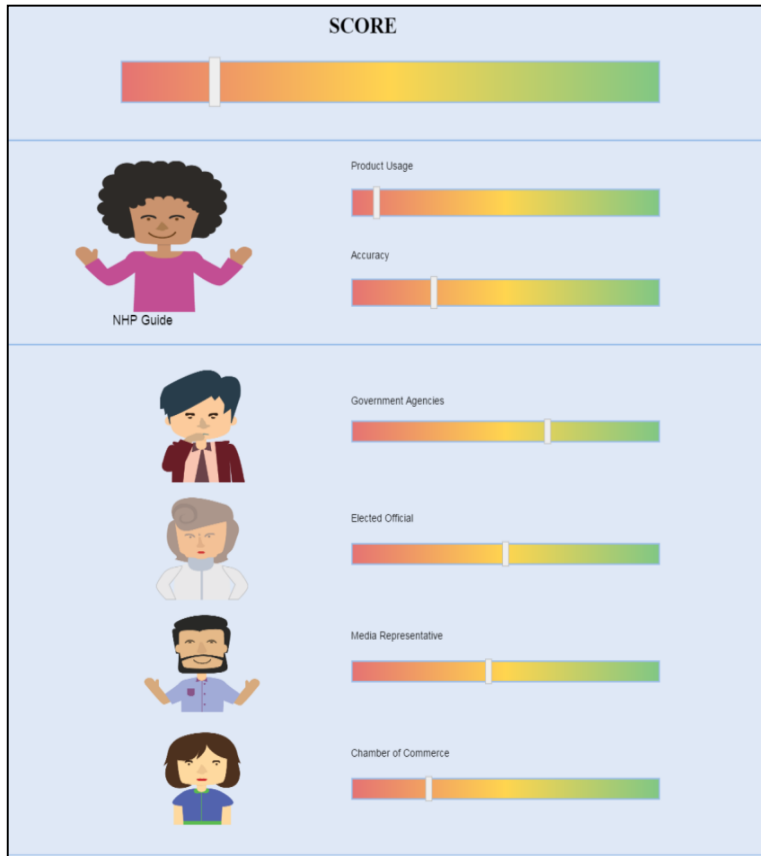
Storm Track/Forecast Simulation



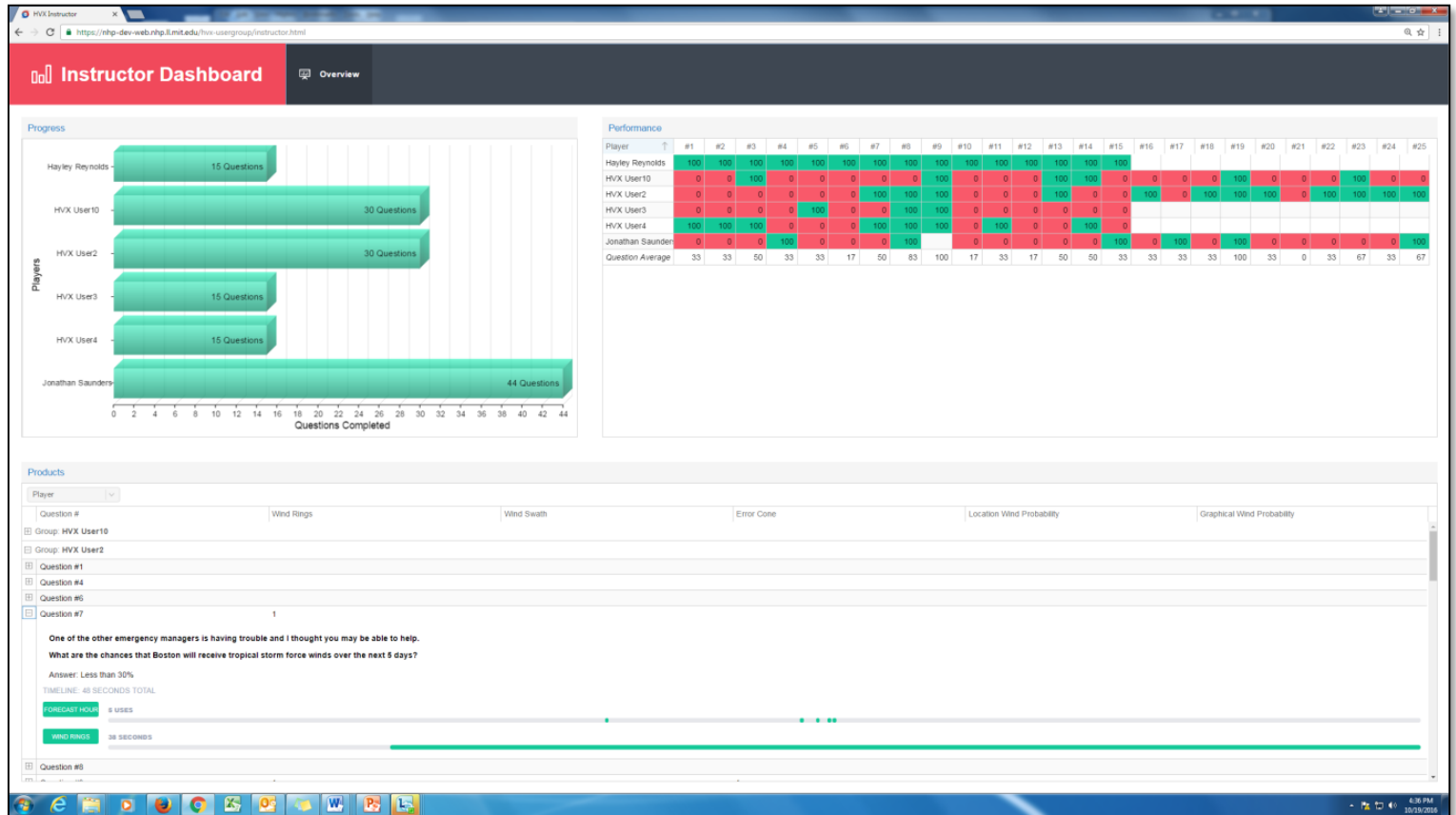


Training User Analytics

Individual Scores



Instructor Screen





HVX-HES Integration

Hazards



Vulnerability



Behavior

| Hypothetical Evac. Decision | | | |
|-----------------------------|--------|--------|--------|
| | Cat. 1 | Cat. 2 | Cat. 3 |
| Evac. | 42% | 53% | 68% |
| Stay | 52% | 42% | 26% |
| ? | 6% | 5% | 6% |

Shelter



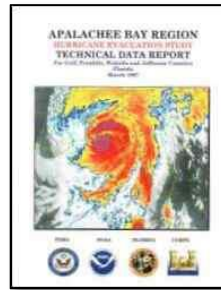
Transportation



Hurricane Evacuation Studies

Update Goal:

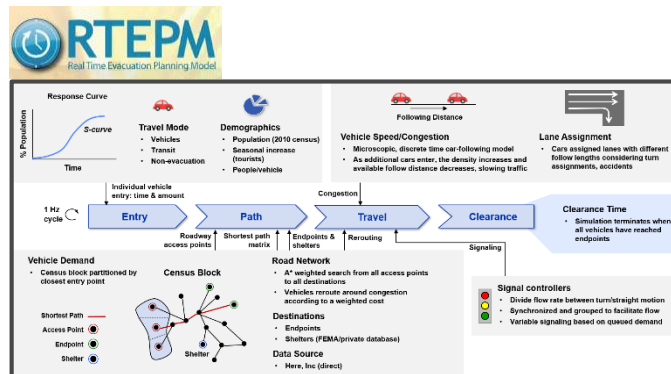
- Full Hazard – Every 5 years
- Hybrid – Annual



Clearance Times

Evacuation Zones

Surge Maps



Operational Training HES

Storms Conditions Resources

Filter Resources

- County / Evac Zone Boundaries
- FEMA Regions
- Infrastructure
 - Hurricane Evacuation Routes
 - Open Red Cross Shelters
 - Mobile Homes
- Post-Storm Assessment
- Library
 - NHP Guidance Document
 - HES Documents
 - Alabama
 - Connecticut
 - Delaware and Dalmaria
 - Georgia
 - Louisiana
 - Maryland
 - Massachusetts
 - Mississippi
 - New Hampshire
 - New Jersey
 - New York
 - North Carolina
 - Pacific Islands

Impact Exploration

- Tropical Weather Outlook
- Surge
- Winds
- Rain, River, Tides

Evacuation Decision Support

- Clearance Times
- Zone-based Analytics
- Risk Profiles

Clearance Time Table:

| | NC | Brunswick | Standard Evacuation Times |
|-------|----|-----------|---------------------------|
| Cat 5 | | 7.3 | 17.3 |
| Cat 4 | | | |
| Cat 3 | | | |
| Cat 2 | | | |
| Cat 1 | | | |

Surge Window

MEOW Mixer

Choose Basin: Wilmington/Myrtle Beach

Click the items below to specify the landfall attributes for a multiple scenario MEOW.

Select All Options Clear Choices

Colors have the following meanings:

- Not Selected
- Selected
- N/A for current basin

Direction:

Category: 0 1 2 3 4 5

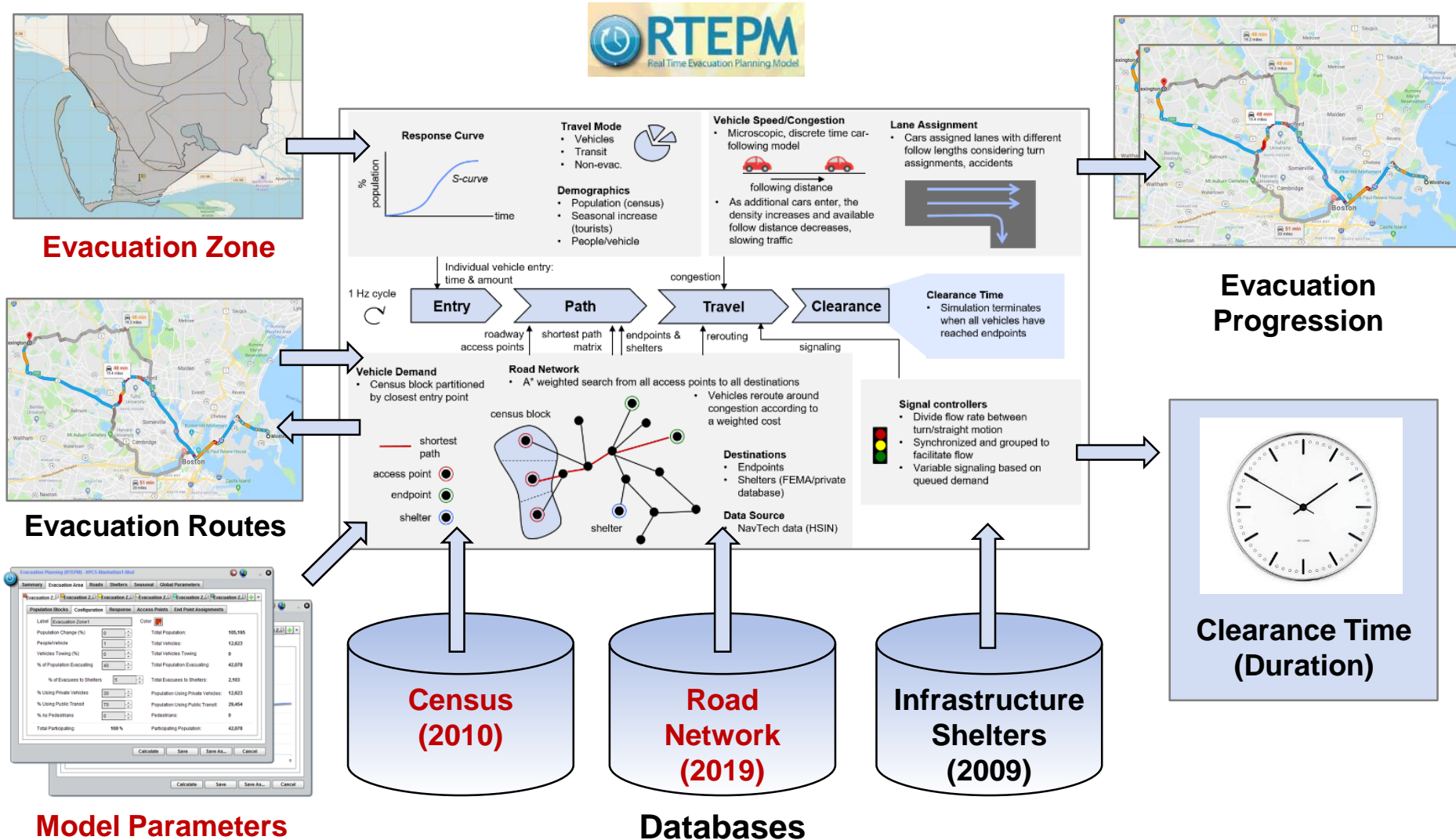
Forward Speed: 05 15 25 35

Tide: Mean High

Remove from Map Update

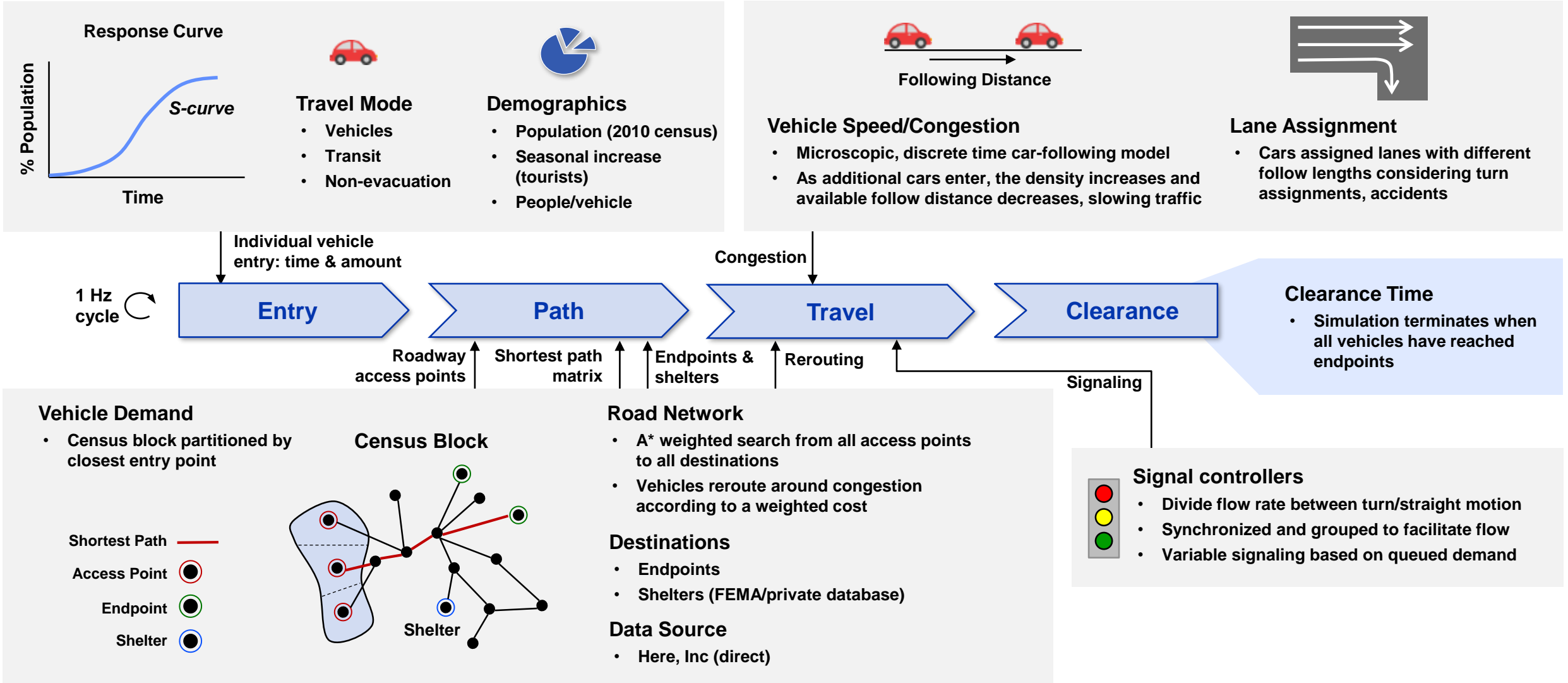


Clearance Time Modeling Architecture





Evacuation Planning Transportation Model





HVX “In the Field” 2016-2019 Hurricane Seasons

HADR staff deployed to FEMA National Response Coordination Center (NRCC) with HVX:

- Hermine (2016)
- Harvey (2017)
- Matthew (2016)
- Irma (2017)
- Maria (2017)



Transition to Web-based HURREVAC (Sea Island Software) Beta 2018:

- Alberto (2018)
- Florence (2018)
- Gordon (2018)
- Michael (2018)
- Lane (2018)
- Olivia (2018)

Transition to Operations (2019):

- Dorian (2019)
- Flossie (2019)

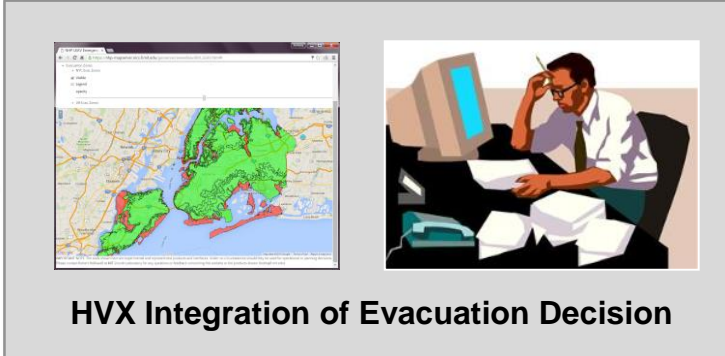


(Near-term) Technology Pilots for FY18

Local Evacuation Alert Verification (LEAV)



National Evacuation Zone Database

HVX Integration of Evacuation Decision



- Integrated Public Alert & Warning System (I-PAWS)
- NOAA's "Weather Emergency Alert"
- FEMA's Common Alerting Protocol (CAP)

Mass-Care Food & Shelter Estimation App



Impact Area from HVX



Generate needs assessment from track forecast:

- Shelter
- Meals
- Bedding
- Housing

| Agency | AMT | REQ | MAI | MAI | MAI | MAI |
|---------------|-----|-----|-----|-----|-----|-----|
| Food Services | 100 | 100 | 100 | 100 | 100 | 100 |
| Meals | 100 | 100 | 100 | 100 | 100 | 100 |
| Bedding | 100 | 100 | 100 | 100 | 100 | 100 |
| Housing | 100 | 100 | 100 | 100 | 100 | 100 |

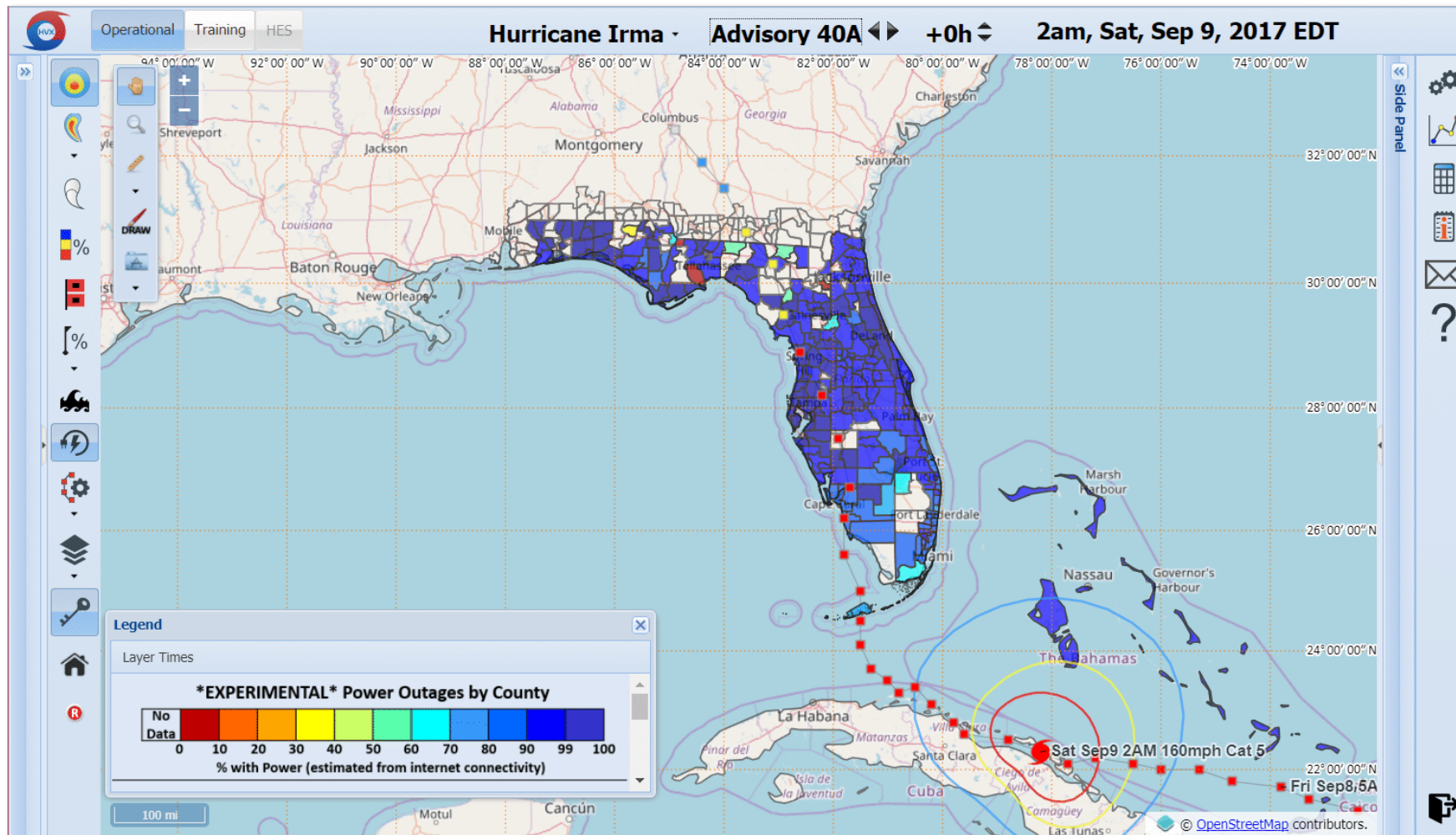


Rules of Practice

MassCare Operations



Integrating External Data: Real-time Power Outages

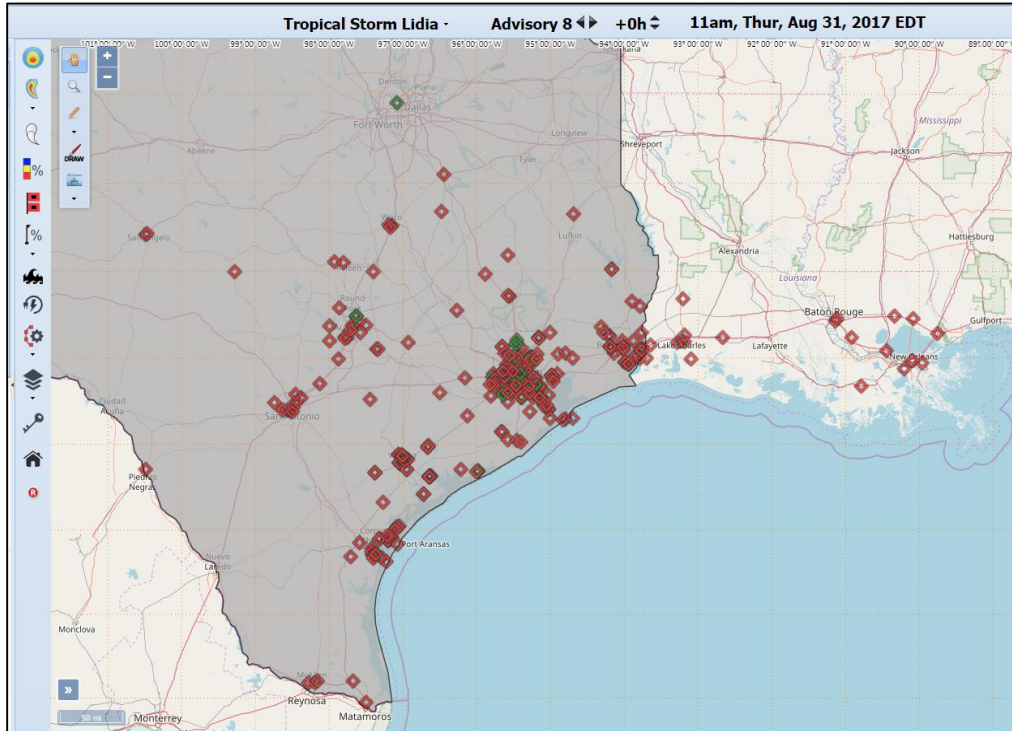


HVX provides a maintainable, sustainable and engaging platform to meet each emergency manager's decision-making needs



Other HVX Add-ons

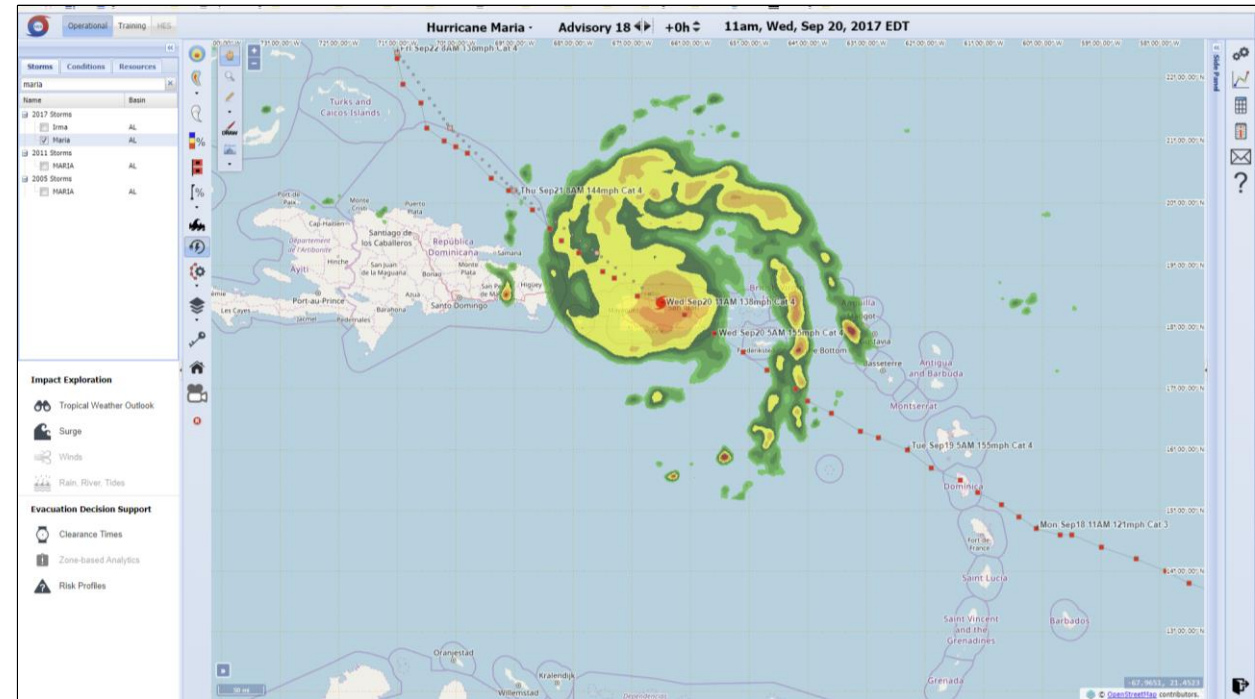
SABER Business Status



Sears, Costco, Macy's, Walmart, Walgreens, Target, gas stations, distribution centers

◆ Closed
◆ Open* or Limited Hours

Offshore Precipitation Capability (OPC)

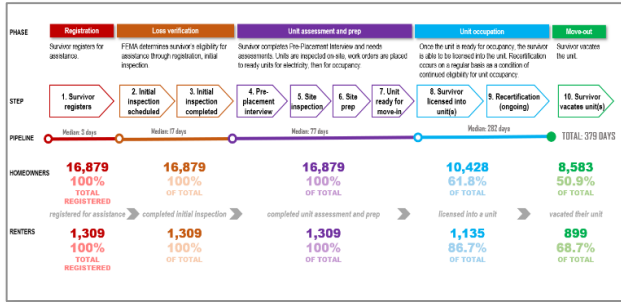


- San Juan lost NEXRAD radar during Maria
- NWS utilized OPC as their backup for weeks

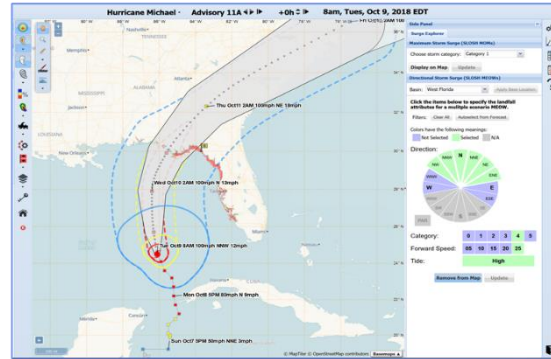


MIT LL Hurricane Related Work

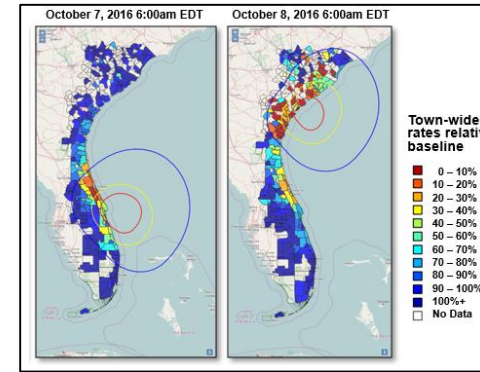
FEMA Direct Housing Assistance Performance Analysis



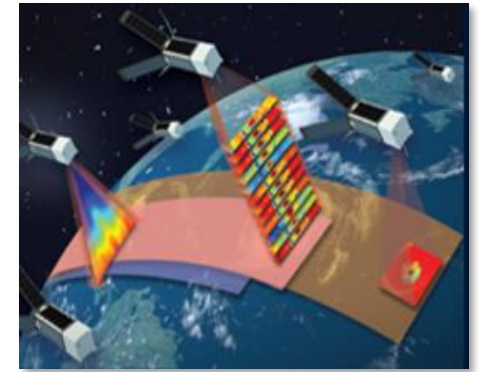
HURREVAC (HVX) Hurricane Evacuation Decision-support Platform



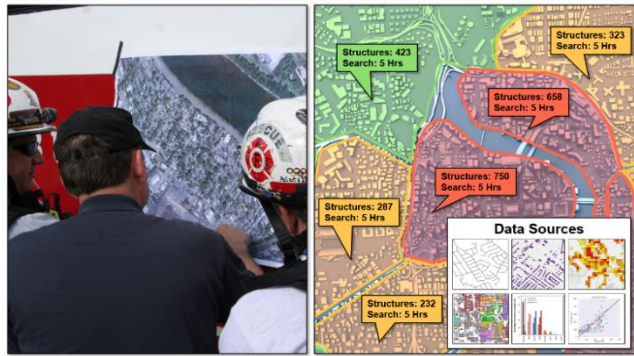
Cyber-Sensing Power Outages



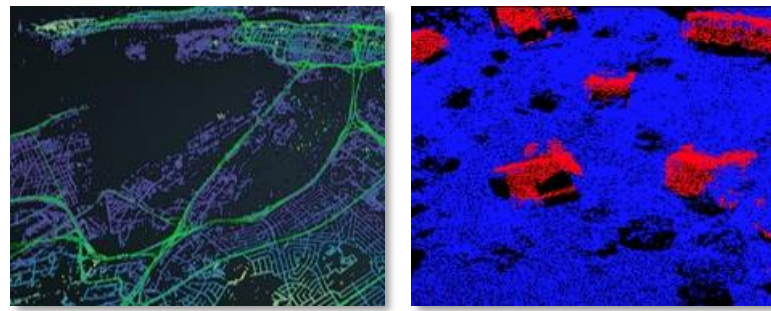
TROPICS Cube-sat Satellite Constellation (Division 9)



Predictive Analytics for Wide Area Search and Rescue (PAWSAR)



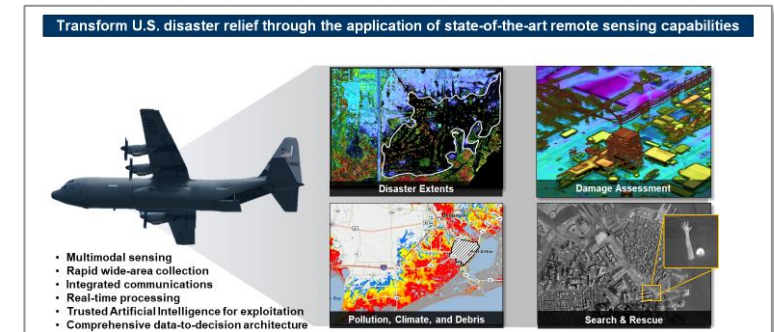
Lidar-based Sensing/Analytics for Damage and Debris Assessment



Damage Sensitive Routing

Building Detection

Multi-sensor HADR Remote Sensing Platform Concept

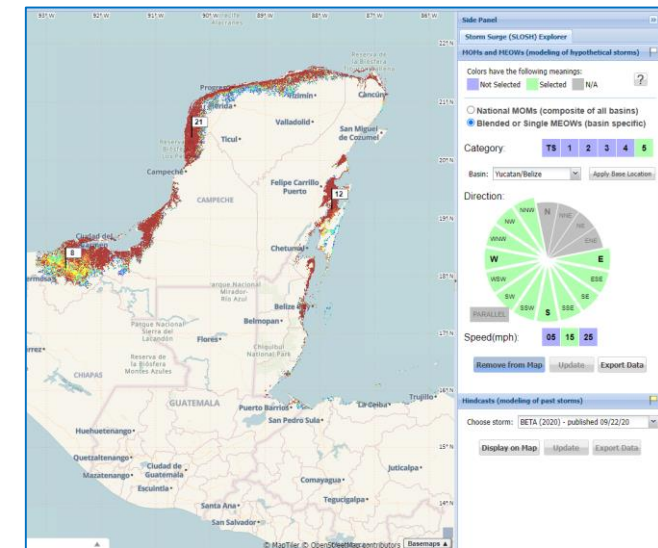
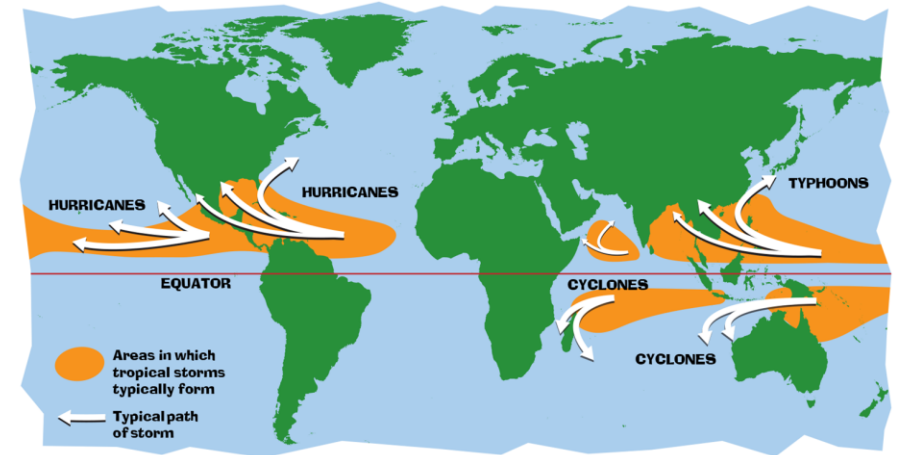




International Use of HURREVAC Platform

National Hurricane Program is domestically funded

- FEMA, USACE, NOAA-NHC
- Over 12K registered emergency managers (US military, federal, state, local, tribal)
- While the system ingests tropical cyclone and weather globally << 1% are international users
 - FEMA Policy/funding restrictions as domestic agency
 - Creating/maintaining a world-wide tailored tropical cyclone dataset out of scope for NHP
- Storm surge modeling created by NOAA-NHC primarily for U.S./territories
 - USAID, however, has funded NHC to perform storm surge modeling for Hispaniola, Yucatan and Belize
 - FEMA has granted temporary access to HURREVAC for these countries – but no long-term agreement





Potential for International Expansion

- **Leverage existing NHP HURREVAC architecture**
 - Extending HURREVAC for international use only requires separate servers and databases
 - Cloud infrastructure makes this straightforward
 - Co-development with NHP benefits from maintenance to existing core software
 - NHP is on board, but they need a partner
- **Expand storm surge modeling**
 - NHC can run storm surge models anywhere in the world
 - Could be enhanced by higher resolution coastal mapping (Lidar scanning)
- **Integrate existing international evacuation planning**
 - India in particular has a robust evacuation plan, others are more limited
- **Modular HURREVAC infrastructure allows tailored extensions, such as:**
 - Evacuation monitoring
 - Post-storm disaster assessment
 - Tsunamis and inland flooding