PERSISTENT SYSTEMS

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1 March 2019

WAVE RELAY®

MOBILE AD HOC NETWORKING (MANET) RADIOS FOR SITUATIONAL AWARENESS IN OILS SPILL RESPONSE AND RECOVERY

DISTRIBUTION STATEMENT: Presented to attendees of California Oil Spill Response Technology Conference 2019.
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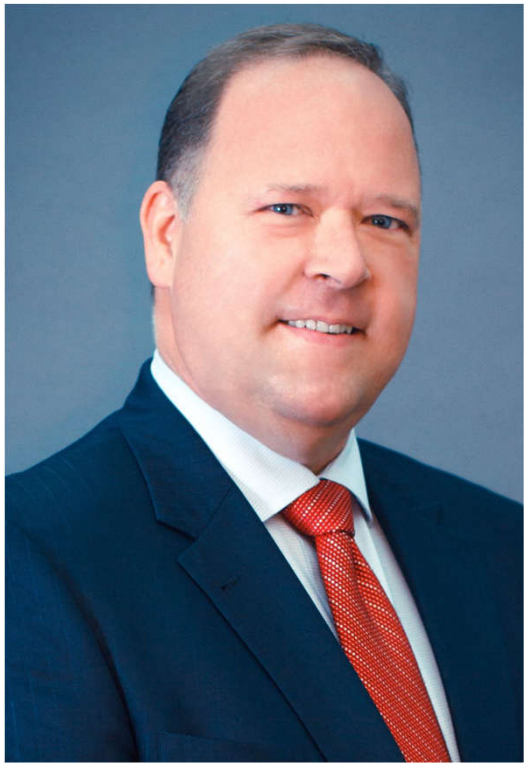
Agenda

- **Some Background**
  - About your presenter and Persistent Systems
- **The Problem**
  - Observations and Challenges in Oil Spill Response Coordination
- **The Technology**
  - Radios, MANETs and Situational Awareness
- **What is a MANET, what is Wave Relay®?**
  - Share Voice, Video, Situational Awareness
  - Mobile Connectivity and ATAK platform
- **Lessons Learned / Examples**
  - ERMA, Deepwater, Norway
- **Q/A & Wrap Up**


Background
Presenter and Company

A bit about me…



Jeremy Hickman

- Persistent Systems, LLC
- Director of Business Development
  U.S. Government and Public Safety
- Since February 2018

Background

- Commercial markets in 1990s
- Raytheon in 2000s – "First Responder"
- EOIR at L-3, Pelco, Moog

Specialties

- Incident response, critical infrastructure security, government communications and surveillance
- Imaging Technologies
- Mobile Ad hoc Networking(MANET)

Persistent Systems Company Overview

Persistent Systems is inventor/Sole Manufacturer of Wave Relay®
Thousands of Wave Relay® MANET systems deployed on government programs

BUSINESS

- Established 2007
- 170 Employees (and growing)

LOCATIONS

- HQ, Engineering, Final Assembly, QC
  - New York, NY
- Sales and Customer Support
  - Pinehurst, NC Office
  - Fort Collins CO, Office
- International Reseller Network

EXPERTISE

- Mobile Ad hoc Networking (MANET)
- Streaming Media, Distributed Algorithms

MADE IN USA

ISO 9001:2015 CERTIFIED

Wave Relay® MPU5 & Module
NIST National Institute of Standards and Technology U.S. Department of Commerce
FIPS 140-2 Certified

The Problems

Challenges and Observations in Oil Response Coordination

Ob1: Timely Information Needed for Decision Making

"Timely and reliable information is essential across both the containment and response operations to achieve better decision-making, ensure safe operations, and inform stakeholders."

Deepwater Horizon Containment and Response: Harnessing Capabilities and Lessons Learned

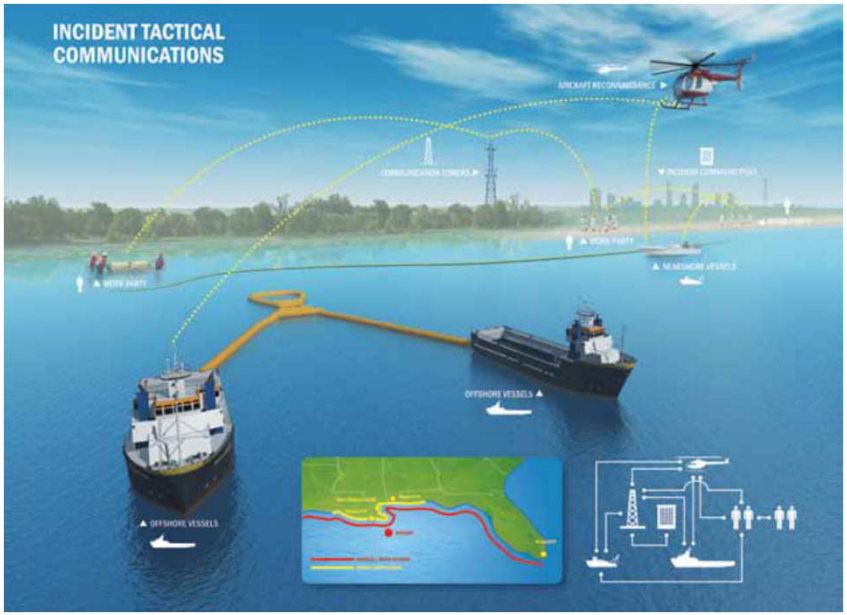


Fig 1. Tactical Communications Diagram from BP Lessons Learned

- A Common Operating Picture (COP) provides a real-time assessment of the entire response effort, providing leaders in command posts and the field access to the same information.
- The COP requires a developed, instantly deployable system to support the real-time sharing of information from/to response operations.
- Development of the COP requires a robust information backbone that provide a wide response capability and capacity.

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Ob1: Timely Information Needed for Decision Making

- Air assets equipped with state-of-the-art spectral and thermal capabilities can provide a more up-to-date and significantly more accurate operating picture if connected via a common communications data link.
- Tactical surveillance, when coupled with a datalink to support a COP, inherently drives speed, accuracy, and efficiency in response operations.

Fig 2. FMV from aircraft piped to Unified Command during Deepwater.

Key Takeaway: You Need a robust network to collect enough information quickly to allow for good decision making…and to communicate that decision.

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Ob2: You need ability to track/share with responders

"Many responders are from outside the region and unfamiliar with local geography."

Use of Remote Sensing Technology for Oil Spill Response: An Overview Report to the Administrator of CDFW, Office of Spill

Fig 3. ERMA Software Suite

- The Environmental Response Management Application® (ERMA) is a robust and extremely capable COP software suite.
- ERMA provides the IC/UC with the tools necessary to effectively respond to an oil spill. These tools, however, are hard to push to the "edge" and get into the hands of first responders and response team members.

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Ob2: You need ability to track/share with responders

- ESRI (ArcGIS) is used for most source GIS data activities (QGIS is being used as well).

- ESRI and Par Government have teamed to create ArcGIS Plugin for Android Team Awareness Kit (ATAK).
  - Will allow for "edge" users to have SA and send data to/from ArcGIS servers.
  - Real-time position data sent from ATAK to ArcGIS servers.
  - Real-time chat and coordination can be achieved on systems known to end-user (ArcGIS/ERMA and ATAK).

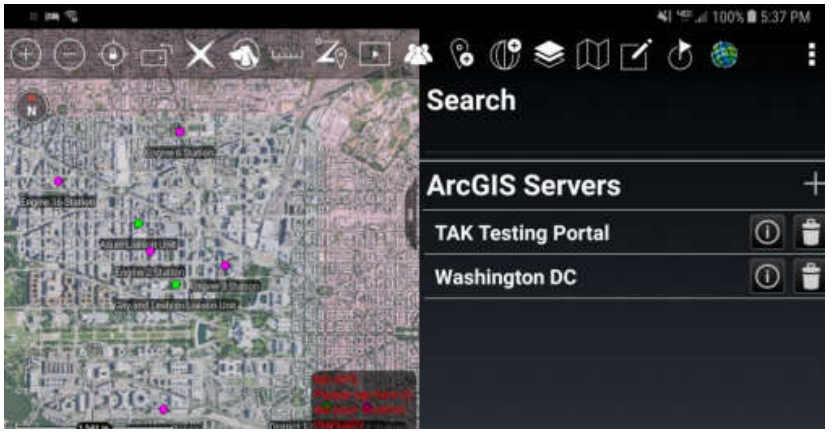

Fig 4. ATAK Android Situational Awareness App with links to ArcGIS server connections

Key Takeaway: When responders come from away, you need ability to share map information. ERMA and ArcGIS are good centralized tools, and soon advancements in ATAK will allow pushing data to responders in real-time.

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Ob3: Scalable Network Needed for growth in # of Sensors

- Wide swath of manned and unmanned sensors will be deployed in future oil spill responses, including Unmanned Ground Vehicles (UGV), Unmanned Aerial Vehicles (UAV), Unmanned Underwater Vehicles (UUV), and Unmanned Surface Vehicles (USV).
- The deployment of these assets will significantly impact the accuracy and efficiency of response efforts during the oil spill.

Fig 5. Unmanned vessel with UAS for oil spill sampling utilizing MPU5

Fig 5. UAS sampling for oil in water utilizing Persistent Systems' Embedded Module.

- These assets need to be able to communicate with each other and provide data to local decision makers (air to surface on oil location) and to IC/UC for response coordination.
- The tactical network needs to support a wide ecosystem of unmanned and manned partners to ensure that every asset is able to communicate and provide real-time information.

Key Takeaway: A dynamic, tactical network for information exchange is required to support the wide ecosystem of assets deployed to oil spill response.

Ob4: Spills Happen Away From Infrastructure

Large oil spills will typically occur in austere, remote locations with minimal infrastructure to support.

- Thirty (30) percent of oil consumed around the world comes from offshore oil wells (International Energy Agency). Oil accounts for a third of global maritime trade and number of ships that transport crude oil and petroleum products has increased by 73% since 2000.

- Infrastructure to support response communications and information is minimal to none in these austere, off shore environments.
  - Even VHF is hard to utilize in these environments, as noted in the ARGO case by USCG Sector Detroit/Atlantic Strike Team (satellite phones and cell phones were utilized to maintain COP when they were available).
  - AAR emphasized the need for a "wireless solution designed to maintain connectivity in all dynamic environments".

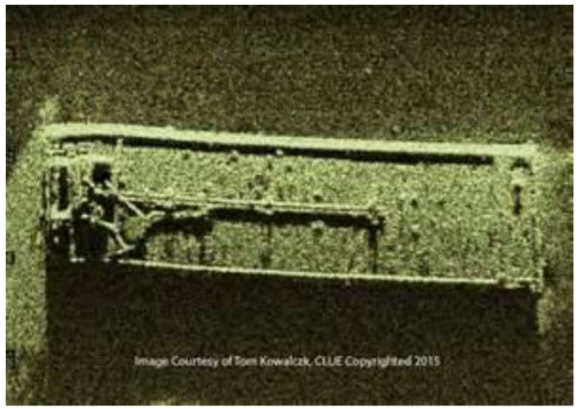

Fig 7. ARGO Case on Lake Erie

Ob4: Spills Happen Away From Infrastructure

- In 2017, the USCG setup a long haul network in Alaska (covering over 130 miles)
- Used it to provide services, including internet and full motion video from Grand Singatook and Tin City to Nome, AK.
- This demonstrated the ease of setup and robust capability of the MPU5 and ability to provide services in austere locations.

Fig 8. ATAK Android Situational Awareness App with links to ArcGIS server connections

Key Takeaway: You Need the ability to create a network on the fly, in remote locations, and across long distances.

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Ob5: Countries building networks for Oil Spill Response

Fig 9. Norwegian Network Diagram

Fig 10. Norwegian FMV from Aircraft

"When oil spills occur, the ability to exchange information quickly between ships, planes, and other actors can greatly limit the damage caused by the spill."

Norwegian Coastal Administration report

- Norway is building out a network infrastructure of Maritime Broadband Radios (MBR). Radios will be installed on all oil recovery vessels and any plane/vessel that takes part in oil spill response and recovery.
- MBR network is a traditional mesh network. It does not benefit from the capabilities of MANET. It is, however, an important step in the right direction for establishment of network infrastructure and capabilities prior to an oil spill.

""The MBR allows us to respond faster with the right actions".

Kjetil AasbØ, Senior Advisor
Norwegian Coastal Administration

Summary of Key Oil Spill Response IC Challenges

- Too many cooks… lots of personnel responding
  - Many government agencies: CG, EPA, FEMA, local F&W, LE, etc.
  - Also industry: Oil Company, Ship owner, Cleanup, Fishing and Tourism
- Typically occur in austere and remote areas
  - Far from infrastructure, no communications
  - Far from housing, long daily commute
- Establishing chain of command difficult
  - Command has low situational awareness
  - Location of assets and responders uncertain
  - Non-local responders unfamiliar with geography
  - Dissemination of information to responders difficult
- Situation Continually Changes
  - Location may change as situation evolves
  - Fixed and backhaul networks difficult to stabilize
  - Number and type of responders continually changing

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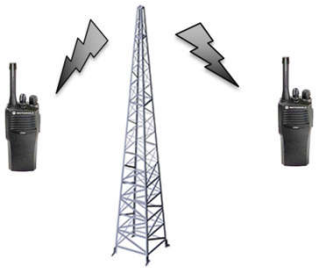
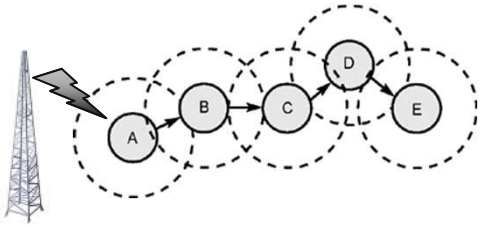
Technology
Radio, MANETs, Wave Relay®

Types of Radios: LMR/LTE, Mesh, MANET?



Traditional LMR/LTE Network:

- 1 to Many topology
- User transmits/receives via Primary Antenna
- Main Antenna "Anchors" the coverage area



Mesh Networking

- Repeaters Nodes
- Shared Routing – "Hopping"
- Users are nodes
- User may transmit via partner node to Primary Antenna
- "Peers" expand coverage back to Anchor

MANET (Mobile Ad Hoc Network)

- No Master Node
- Radios work as a "Collective"
- Network is Self-Forming & Self-Healing
- No Single Point of Failure

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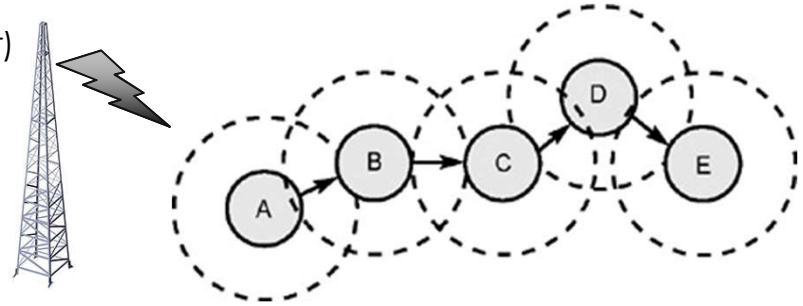
What is Wave Relay® and Why MIMO?

Wave Relay® is a MANET

- Mobile Ad Hoc Networking is like a MESH (but better)
- Radios have Shared Routing, Nodes are Repeaters
- Users may transmit via partner nodes
- More than just voice, for video and situational awareness



MPU5 uses 3X3 MIMO

- Multi-In Multi-Out radios provide better range and throughput versus single antenna (SISO) radios
- MPU5 achieves 100 MBPS TCP/IP performance
- New RF cards bring up to 10W Transmit Power

Wave Relay® with MIMO Increases:

- Throughput and Speed
- Signal Propagation
- Range for Non-Line-of-Sight (NLOS) environments
- Subterranean and Building Penetration Communications
- Antenna Flexibility with Multiple RF ports

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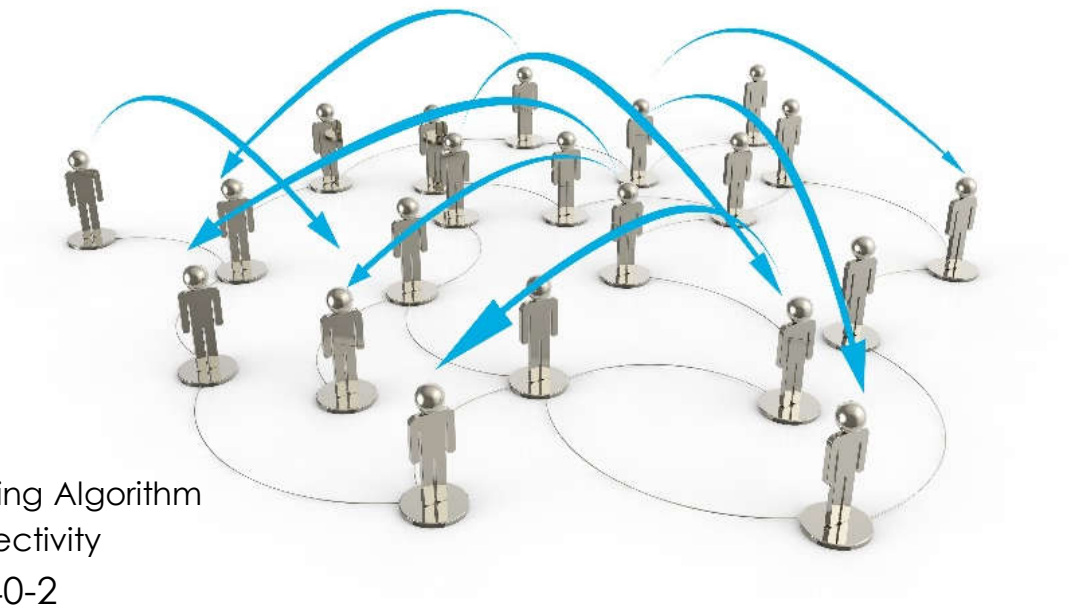
Why is Wave Relay® compelling?



All the benefits of MANET:

- No Master Node
- Network is Self-Forming & Self-Healing
- Radios work as a "Collective"
- No Single Point of Failure

PLUS Wave Relay® provides:

- **Efficiency:** Proprietary Distributed Routing Algorithm
- **Ease of Use:** Seamless Layer 2 IP Connectivity
- **Security:** Suite B Encryption/FIPS 140-2
- **Scalability:** Highest proven number of nodes or hops

"…It Just Works…"

–government customer

Expand Existing Infrastructure, or Create Your Own As Needed

Key Features for Wave Relay on MPU5

MPU5 Handheld/Tactical

MPU5 is a:

Tactical Radio (Mesh/MANET)

Computer

- Android O/S (FIPS 140-2 Certified)

Audio Device

- 16 Channels of Audio
- Dual Push To Talk
- Radio of IP Tethering

Video Device

- Video Encoder
- Video Decoder
- Video Transceiver

Situational Awareness Device

- GPS / Network SA sharing
- Runs / Includes ATAK

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The most SCALABLE and Highest Throughput MANET

A record MANET Size: 320 nodes

- Fort Bragg, 2018 APR – 320 MPU5's
- At customer site, not a lab
- Success Criteria: All users access two videos, multiple talk groups, SA data
- Result: We had bandwidth to spare

Exceeded customer expectations

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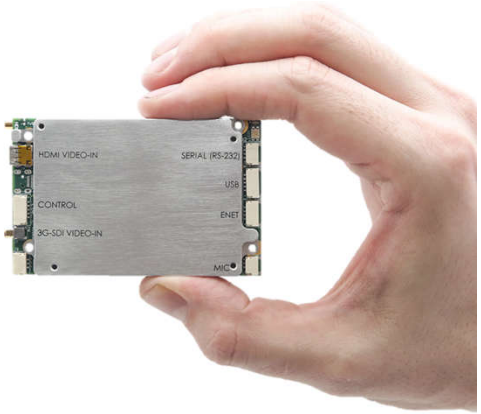
Wave Relay® Form Factors

MPU5 Handheld

Tracking Antenna System

Embedded Tower Kit



Embedded Module

Plus Cloud Relay® for tying together infrastructure nodes, connecting geographically distant MANET enclaves over Layer 3 networks.

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DHS example use of MPU5 for Situational Awareness

Border Patrol Example, using ATAK on Display

- CBP uses Wave Relay® for
  - Incident Response
  - Law enforcement activities
- Multiple Platforms used:
  - Aircraft (Fixed-Wing, Helicopter, Aerostat)
  - Vehicles
  - Dismounted Walkers/Patrols
- Multiple functions used:
  - Voice Communications w/PTT
  - RoIP tethering (Motorola)
  - Video / Sensor Sharing
  - ATAK for Situational Awareness

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Wave Relay® with Cloud Relay® Extends Network

Leverages Value From Existing Investments

Dismounts & Vehicles

Airborne Relay

TOC/COP

Relocatable Sensors

Ground-Based Tower Relay

Individual Patrols

- **Cloud Relay®** Connects MANETs over Infrastructure
- Reach Back to TOC/COP over High-Speed Data Network
- Bridge legacy radio systems via Radio-Over-IP gateway
- Connect multiple users/MANETs over existing infrastructure
- Have Situational Awareness (GPS/COT/ATAK)
- TAK connectivity from First Responders to HQ in Real Time
- Share Full Motion Video / chat in both directions
- Push-to-Talk Voice (over MANET)
- Access Internet / external networks from edge

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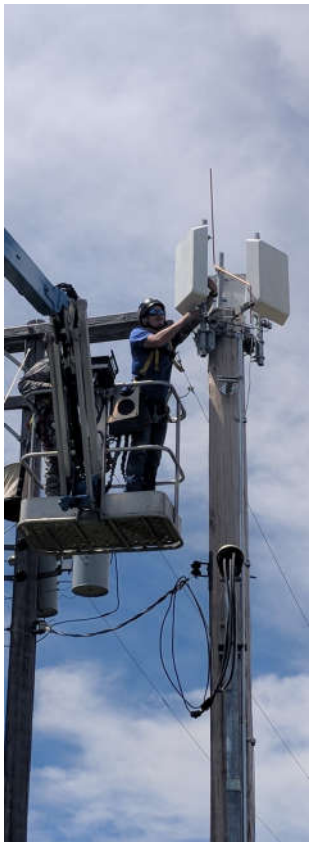
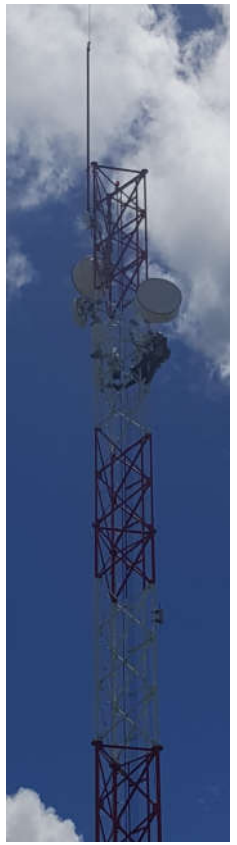
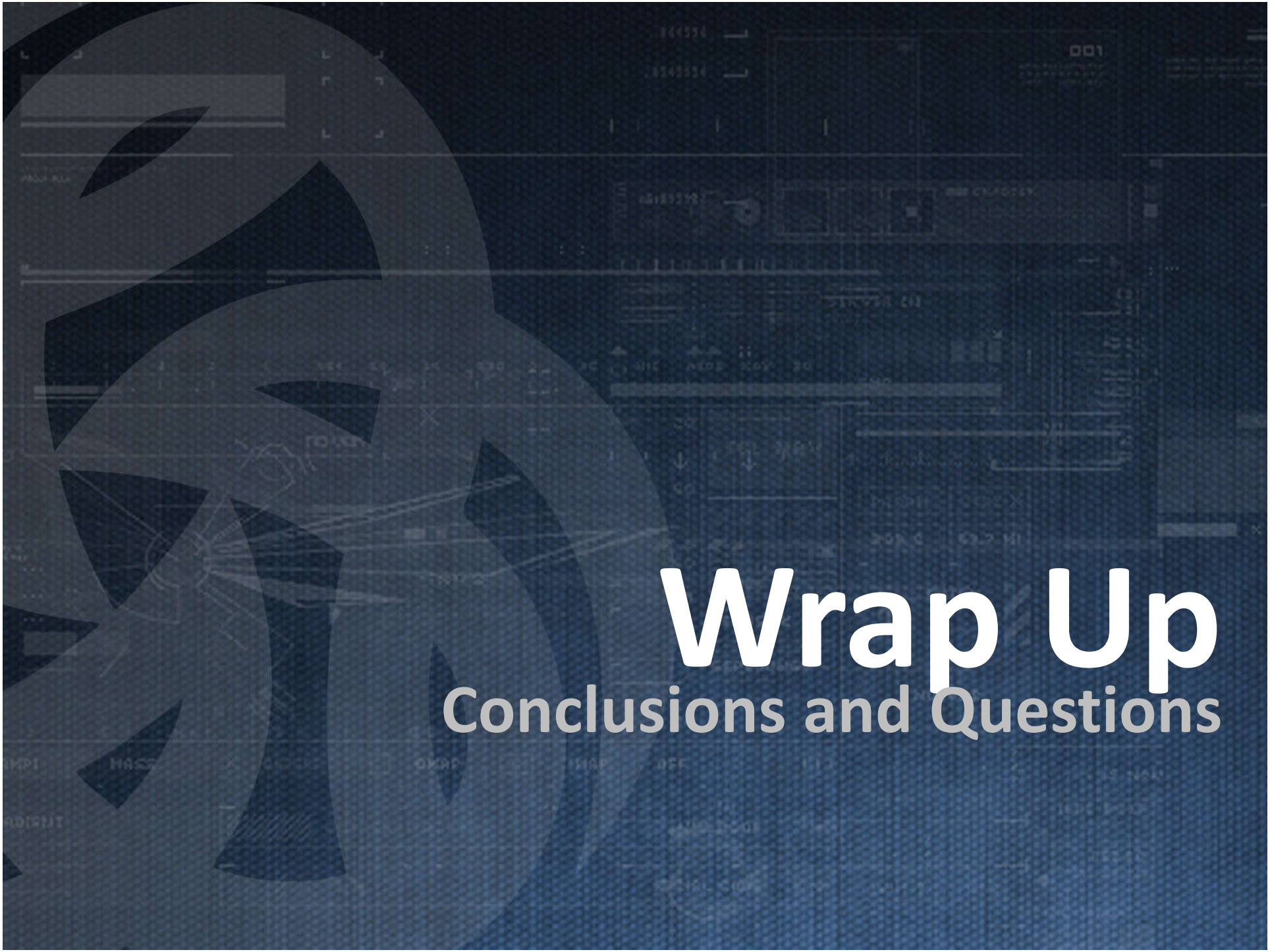
Tower KIT Antennas for pre-deployed coverage



- Integrated Tower Antennas use POE (no RF Cabling)
- Three 120° sector antennas provide 360° coverage
- Deployed in remote areas of US
- PS can provide expertise, support prime contractor for installations



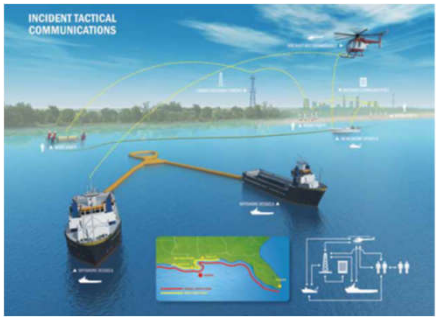


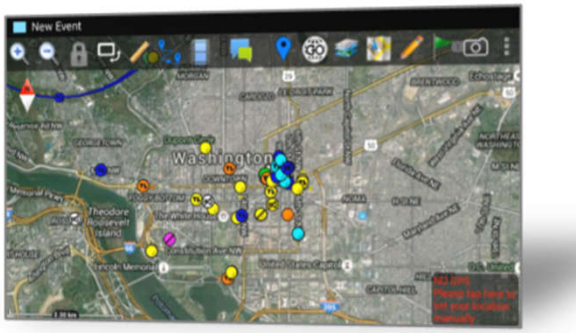
Wrap Up

Conclusions and Questions

Why use MANET for Oil Spill Response?

- Create infrastructure where you need it
- Ability to move as situation changes
- Personnel join/leave network automatically
- Talk and share location information
- Connect and share sensor data and video
- Pre-deployment not necessary, but an option





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Why Persistent Systems?

World leader in MANET technology

Largest supplier in this space, with proven technology and plenty of past performance

Large network of Wave Relay® systems already deployed across the US and world

Made in USA, HQ in NYC

MPU5 is a game changer, with unparalleled performance, feature set and value

Thank you.

I appreciate your time.

Any Questions?

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