Flooding Challenges

- 30 million people live in floodplains

- 100 million people at risk

- Develop and transition to operational use next generation technology to create new capabilities or enhance existing capabilities and processes to reduce fatalities and property losses from flood events
Current Flood Sensing Technology

– United States Geological Survey (USGS) and NOAA installs, monitors, and maintains over 2.7 million river reaches through ~8,000 river forecasting points.

– Approximately 1,300 of those streamgages were not operational due to the lack of funding

– USGS streamgages average around $15,000 to procure and install

– U.S. municipalities and their stakeholders require increased situational awareness prior to, during, and after flooding events

– Existing sensor systems are too capital intensive to densely deploy and maintain
Derived Requirements and Use Cases

- Targeted flood warnings and forecasts
  - Densify streamgage network
  - Monitor riverine tributaries
  - Early flash flooding alerts
  - Advanced & localized alerts for communities
  - Enhance First Responders’ operations
  - Data to “fill in the gaps”

- Leverage the latest sensing & wireless technologies
  - Lower lifecycle costs
  - Scalable with flexible business rules

Enhanced Floodplain Management through the use of Widely Distributed Flood Sensor Networks

Enhanced situational awareness for communities

Inform mitigation measures
Next Generation Sensors - Part of the Solution

- Low-cost Internet of Things (IoT) based sensor
- Multi-wireless connectivity for all-terrain coverage
- Multi-sensing
- Ruggedized, corrosion resistance
- Low-maintenance
- Easy and rapid deployment

Deployed alpha sensor pilot in Charlotte-Mecklenburg, NC
Flood Sensor System Operational View

Enhanced Floodplain Management through the use of Widely Distributed Flood Sensor Networks
Flash Floods and Expedited Notifications

- Flash floods are the number one cause of weather-related deaths in the United States.

- Informing residents
  - Text, smartphone application, smart home alerts
  - Mapping and Geofencing

- Assist emergency responders with optimizing and prioritizing resources
  - Real-time video
  - Customized alerts water level and rate of change

Deployed alpha sensor in Ellicott City, MD
High-water Alert Lifesaving Technology (HALT)

- 50% of flood-related drowning's are vehicle connected

- >$50,000 per installed legacy HALT system

- In addition to assisting emergency responders
  - Department of Transportation
  - Utilities
  - Hospitals
Dams and Levees – Critical Infrastructure Monitoring

– 84,000 Dams and 100,000 miles of levees, many without monitoring and warning systems
Dams and Levees - Deployed Sensor Pilots

- 4 sites with 2 sensors per site in Kentucky using alpha prototypes
  - One at the reservoir upstream
  - One at the downstream spill-way
  - Expand with Beta sensors to ~50 sites

Deployed sensor pilots at Dam spillway outlet

Flood sensor alpha dashboard

Enhanced Floodplain Management through the use of Widely Distributed Flood Sensor Networks
Modeling and Flood Forecasting

- 1% floodplain today will not be the 1% tomorrow

- Developing enhanced data sets for flood forecasting

- WSEL creation for variety of percent annual chance events

- Derived flood depth grids (flood depth above ground surface)

- Flood depth grid derivations in proximity of streamages
Modeling - Gage Stage Composite Grid

- Flood depth grids to Gage stage composite grids

- Enabling a comprehensive set of gage stage composite grids through a widely distributed and dense network of flood sensors will enhance flood forecasting

Gage Stage Composite Grid Dataset Examples
Mitigation and Loss Avoidance

– Structure and Infrastructure Projects
  • Measuring High Water Marks (HWM)
  • Loss avoidance studies
  • Acquisition, Relocation, Elevation

– Planning Mechanisms
  • National Flood Insurance Program (NFIP) Community Rating System (CRS)
  • Building Codes
  • Floodplain regulations
  • Open space preservation

Locating High Water Marks

Winston-Salem, NC Sensor Pilot
Improvements and Cost Savings in Estimating Substantial Damage

- Current FEMA Substantial Damage Estimator (SDE) process:
  - Model flooding across a large area given few high water mark (HWM) observations
  - Using the flood model and other data attempt to identify structure level damage that need inspection
  - Send inspectors to field for inspections
  - The result is high numbers of “Not Substantially Damaged” structures inspected

Designated counties in NC for Hurricane Florence

Measuring depth of flood for SDE
Real-time Automated Estimations

- Light-version prototype of the full-feature sensor, low-maintenance sensor for rugged outdoor applications
  - 20 foot depth range, 0.05 inches resolution, 0.05 inches accuracy
  - Self-calibration
  - 3-5 years maintenance cycles
  - Integrated cellular link
  - Internal rechargeable battery with compact solar panel

- Lease Bundle (including data plan and warranty) < $15 per month

- Early alert capability for homeowners

- Risk based flood insurance
Advanced Flood Warning System Utilizing Low-Cost IoT Sensors

- Address market gap in cost-effective flood monitoring and high-density sensor deployment
- Scalable IoT network of highly-reliable and easily deployable sensors
- Development funded in-part by DHS SBIR Phase-II
- Deployed Alpha Prototype Pilots:
  - State of North Carolina
  - Commonwealth of Kentucky
  - Howard County, MD
  - City of Charlotte - Mecklenburg, NC
  - City of Norfolk, VA
- Alpha pilots provided field data and enhancements, Beta release Q2’19, Product release Q4’19
Wide-Area Flood Sensing Network

- Scalable IoT network of highly-reliable multi-sensing nodes with all-terrain coverage
- Multiple wireless communication types within network and to-cloud
- Multiple message format and data interfaces support by software layers (e.g. ALERT2)
- Cloud services and data analytics rules engine are readily customizable
- Cloud sensor database and analytics software API
- Software & Cloud and hardware plug-in support for 3rd party sensors

Enhanced Floodplain Management through the use of Widely Distributed Flood Sensor Networks
### Advanced Low-Cost Flood Sensor & Multi-Sensing Platform

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sensor capability</strong></td>
<td>➢ Water: Height &amp; Rate of Change, Presence</td>
</tr>
<tr>
<td></td>
<td>➢ GPS, Air pressure, Temperature</td>
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<tr>
<td></td>
<td>➢ Imagery/camera</td>
</tr>
<tr>
<td></td>
<td>➢ Rain Gauge</td>
</tr>
<tr>
<td></td>
<td>➢ External sensor expansion: SDI-12 &amp; Analog I/V</td>
</tr>
<tr>
<td></td>
<td>➢ Digital output for external device control</td>
</tr>
<tr>
<td><strong>Communication</strong></td>
<td>➢ LTE-M Cellular with Fallback Iridium satellite SBD link</td>
</tr>
<tr>
<td></td>
<td>➢ LoRa, Mesh, WiFi (network &amp; mobile field-support)</td>
</tr>
<tr>
<td><strong>Configuration &amp; System Operation</strong></td>
<td>➢ Self-configuration and Cloud/remote configuration</td>
</tr>
<tr>
<td></td>
<td>➢ Local wireless handheld device</td>
</tr>
<tr>
<td></td>
<td>➢ Local data processing and rule-based operation</td>
</tr>
<tr>
<td><strong>Environment</strong></td>
<td>➢ Dust tight &amp; Water-immersible IP68</td>
</tr>
<tr>
<td></td>
<td>➢ Mechanical shock / vibrations: 6 ft drop on concrete</td>
</tr>
<tr>
<td></td>
<td>➢ Corrosion free, Outdoors &gt;10 years</td>
</tr>
<tr>
<td></td>
<td>➢ Operation Temperature: -40°C to 80°C</td>
</tr>
<tr>
<td><strong>Power</strong></td>
<td>➢ Solar with 5-10 yrs. internal Li-Ion rechargeable battery</td>
</tr>
<tr>
<td></td>
<td>➢ 4 weeks of operation with <strong>No Solar Charge</strong></td>
</tr>
<tr>
<td></td>
<td>➢ Optional external 12V power source</td>
</tr>
<tr>
<td><strong>Mount / Installation</strong></td>
<td>➢ Pole-mount, Free-standing, Wall, Bridges &amp; buildings</td>
</tr>
</tbody>
</table>
## Low-Cost Flood Sensor with Camera Specs

<table>
<thead>
<tr>
<th>Sensor Type</th>
<th>Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immersible Water Level Sensor</td>
<td>- Patent pending low-maintenance design &amp; operation</td>
</tr>
<tr>
<td></td>
<td>- Range: 20 ft</td>
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<tr>
<td></td>
<td>- Resolution: 0.05 inches, Accuracy: 0.5 inches</td>
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<tr>
<td></td>
<td>- Sampling rate: Adjustable, Max 1 samples/second</td>
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<tr>
<td></td>
<td>- Up to 300ft cable connection to the node electronics</td>
</tr>
<tr>
<td>Water Presence</td>
<td>- Multi-level contact detection in 1” steps</td>
</tr>
<tr>
<td>GPS</td>
<td>- GNSS, 56 channels, up to 8.5 ft location accuracy</td>
</tr>
<tr>
<td>Air Pressure</td>
<td>- 50–115 kPa, accuracy ± 1 kPa</td>
</tr>
<tr>
<td>Temperature</td>
<td>- -40°C to 85°C</td>
</tr>
<tr>
<td>Still Image</td>
<td>- 640 x 480 pixels</td>
</tr>
<tr>
<td></td>
<td>- Frame rate: 1-4 per second</td>
</tr>
<tr>
<td></td>
<td>- Lens: Fisheye, View angle: D:175° H:147° V:102°</td>
</tr>
<tr>
<td>Video (Optional HD)</td>
<td>- 640 x 480 pixels (HD: 1920 x 1080 pixels)</td>
</tr>
<tr>
<td></td>
<td>- Frame rate: 15 per second (HD: 60 per second)</td>
</tr>
<tr>
<td></td>
<td>- Duration: adjustable, default: 10 seconds</td>
</tr>
<tr>
<td></td>
<td>- Lens: Fisheye, View angle: D:175° H:147° V:102°</td>
</tr>
</tbody>
</table>
Software & API

- Cloud sensor database and analytics software API and multi-sensor data visualization
- Sensor system configuration, Sensor data fusion and filtering at edge or in-cloud
- Alert and exception monitoring services, Integrated Rules Engine and customization
- Customer & 3rd party cloud & data servers support
Conclusion

- Flooding is the number 1 natural cause of fatalities and property losses

- Assist with managing, response, and increased community resiliency
  
  - Real-time wide-scale situational awareness
  
  - Enhanced models and planning

- Advances in technology has made low-cost high-reliability flood and environmental sensing systems commercially available
  
  - Easily and rapidly deployable
  
  - Accurate and automated data analytics, alerts, and connectivity
  
  - Effective reliable data delivery to communities and first responders

Deployed Evigia alpha sensor in Norfolk, VA