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Pipeline Right of Way Monitoring and Notification System

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Agreement No. PIR-14-014

California Energy Commission

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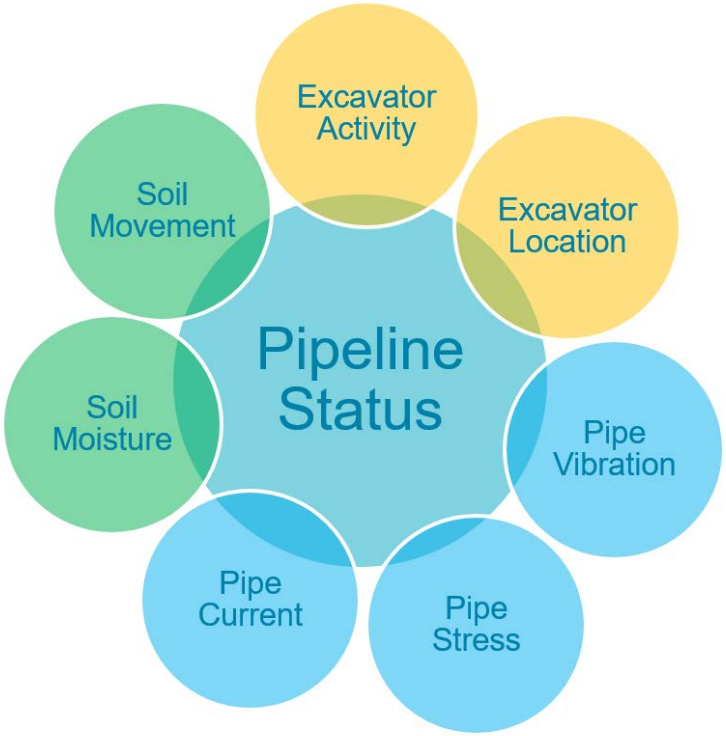
Outline

- Background and Motivation for PIR-14-014 Program
- Project Scope
- Technology Development Progress and Readiness
- Field Test Plans with Utility Companies Support

Background: Risks to Pipeline Safety

- There are multiple threats on the pipeline right of way (ROW)
- Third party excavator damage is the primary threat
- There are also slower acting, cumulative risks to consider
- Multiple, overlapping technologies will be used for monitoring
- The need is to provide operators timely alerts of developing risks



Project Goals PIR-14-014

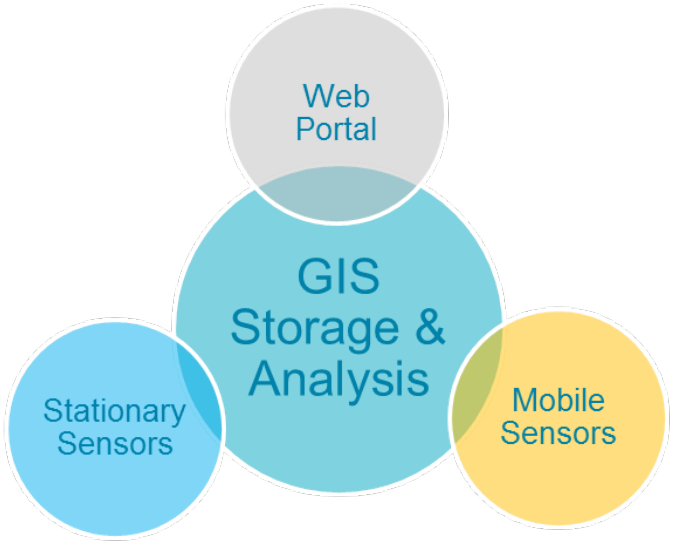
- Deploy and Demonstrate a pipeline monitoring system that can detect ROW encroachments and alert operators in real time
- Three technology areas will be applied during this project.
  - Mobile GPS enabled sensors mounted on excavators
  - Stationary sensors mounted on pipelines in the ROW
  - Machine learning on a cloud platform to digest the sensor data
- Risk reduction is achieved by instrumenting the most active excavators and high consequence lines.
  - It is not practical to cover 100% of either category.

Project Collaborators PIR-14-014

- Sponsorship and Oversight
  - California Energy Commission
- Technical Direction
  - Gas Technology Institute - Prime
    - Leidos Engineering - Sub
- Utility Test Sites
  - Southern California Gas
  - Pacific Gas & Electric
- Technology Collaborators
  - Acellent Technologies

Technology Implementation

- Provide real-time alerts of activity on ROW using:
  - Stationary sensors that are placed on critical pipelines
  - Mobile sensors that are placed on pieces of excavation equipment
  - Cloud hosted platforms to store and analyze data from both sources
  - Web portal that allows users to view data



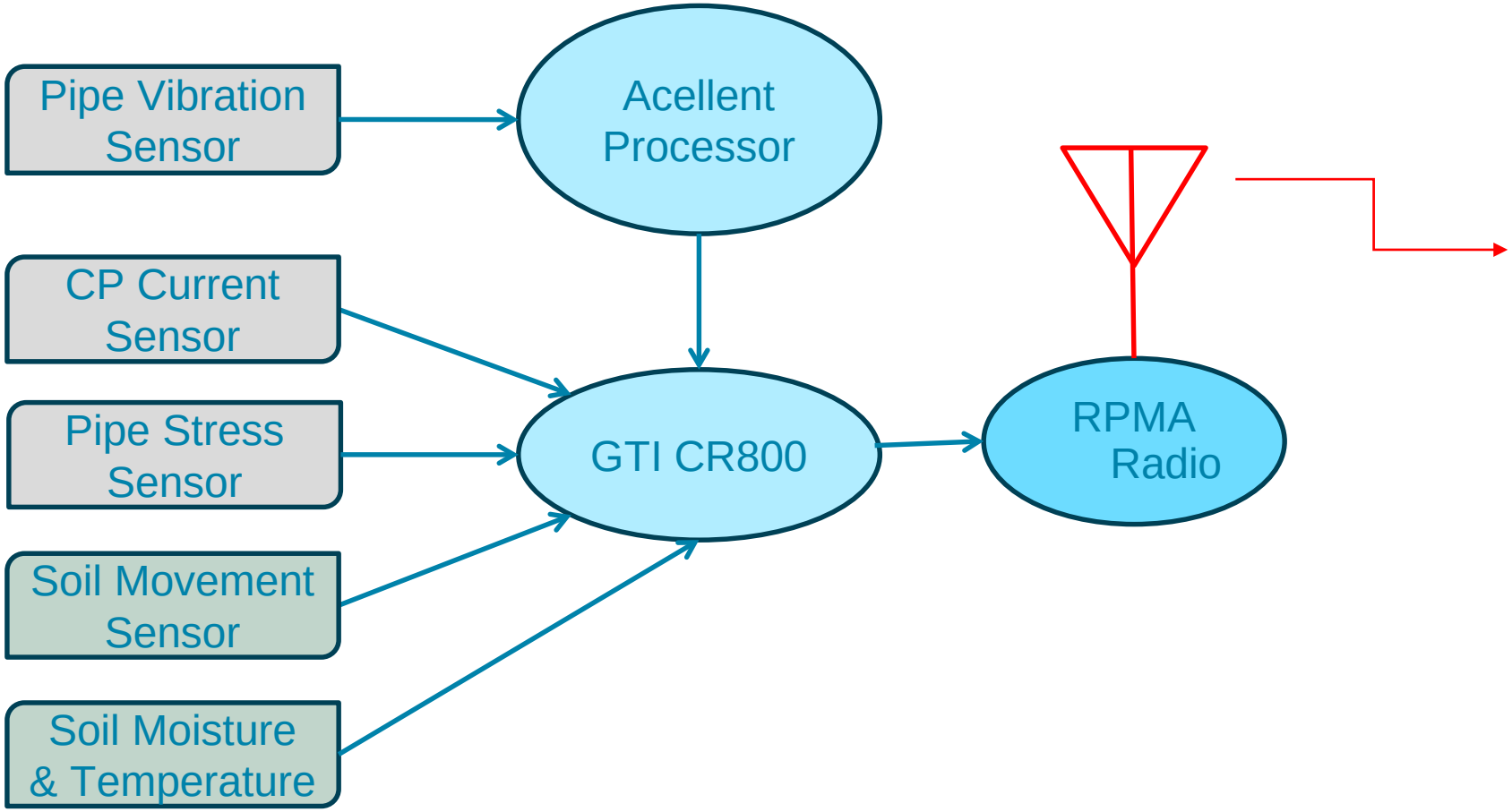
Sensors

- ROW Monitor Hardware Design
  - 1) Prepare a detailed design of the stationary sensor hardware for deployment,
  - 2) Prepare a detailed design for mobile hardware to be placed on excavating machinery, and
  - 3) Agree on final design with the various project stakeholders.

Stationary Sensor Platform

- Must provide reliable radio link under challenging conditions
  - Ingenu Wireless Random Phase Multiple Access (RPMA)
- Must provide interfaces for various sensors
  - Convert and process sensor signals to digital format
- Should be low power for operation in remote locations
  - Sparse RPMA transmission to IP access points

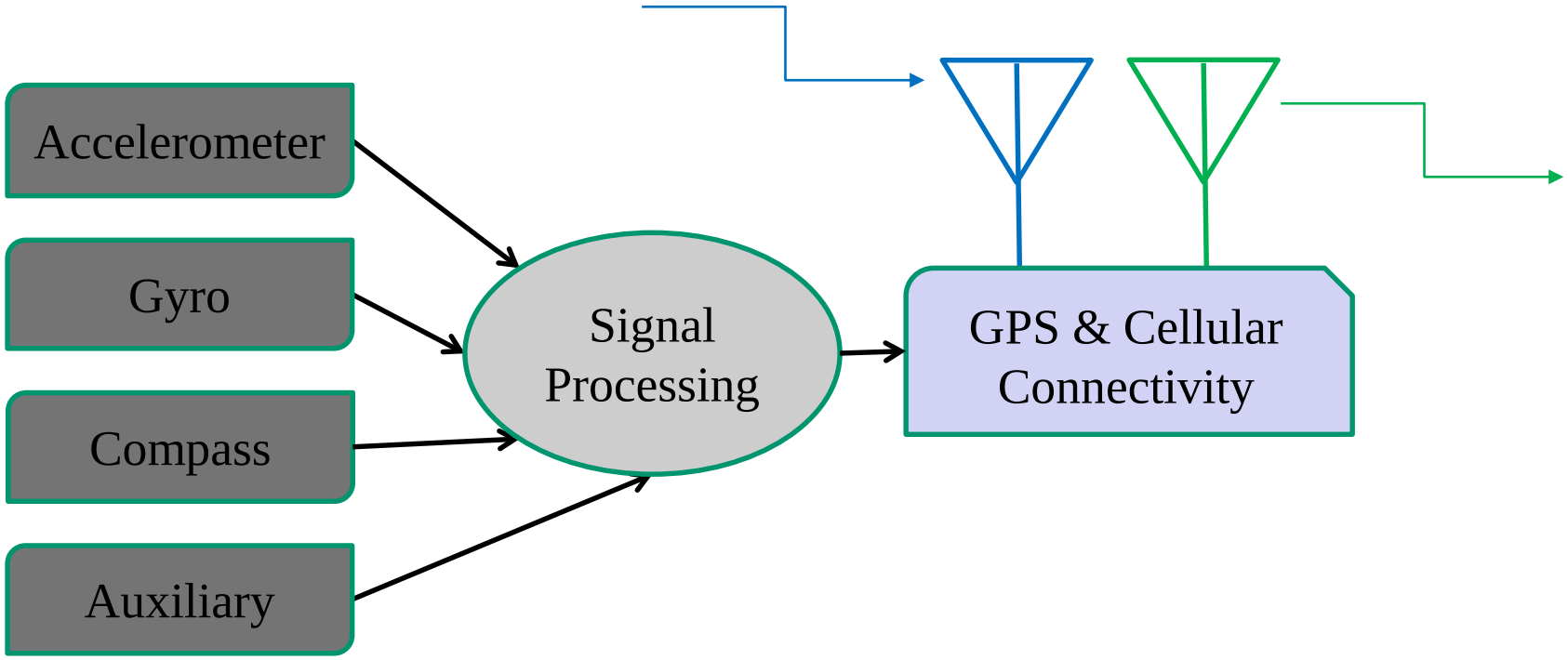
Stationary Sensor Node Architecture



Mobile Sensor Platform

- Provide information on the status of excavation machinery
  - Capture the state of motion and current GPS location of excavator
- Provide a cellular connection back to analytic platform
  - Need reasonable coverage in the test area
- Provide on board processing for event filtering
  - Transmit when motion or geo-fence condition is met

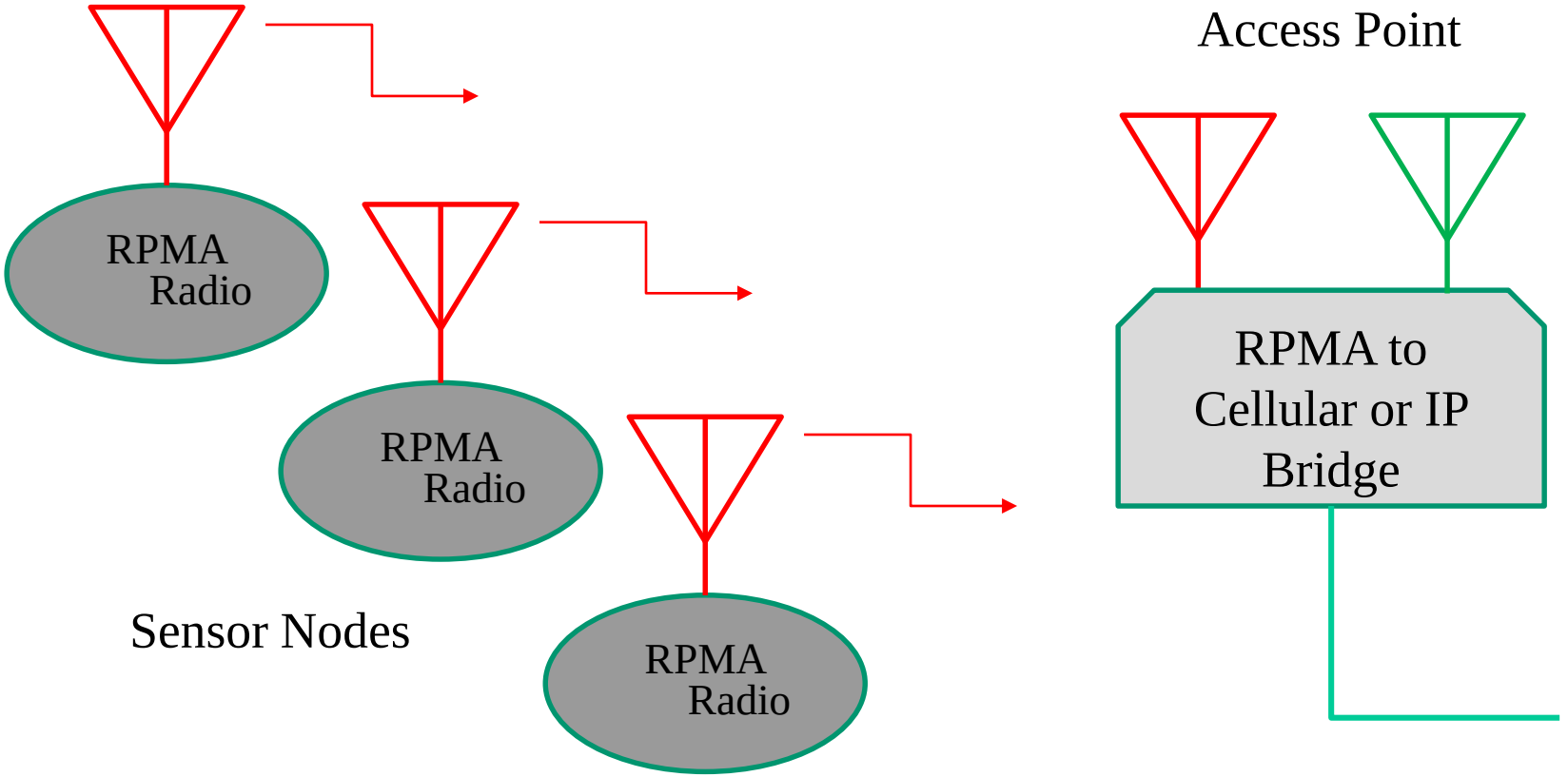
Mobile Sensor Architecture



Communication

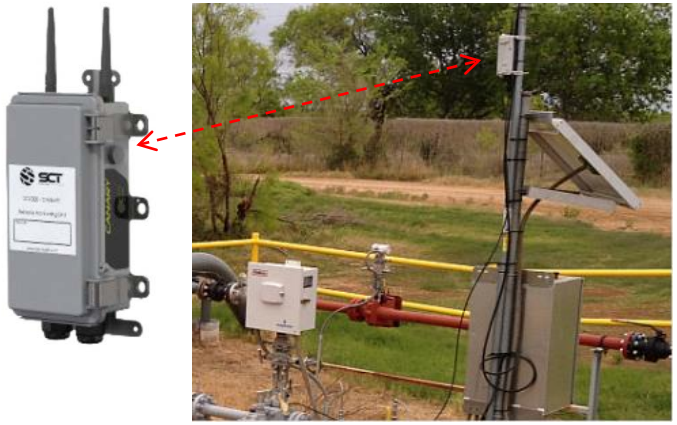
- Mobile GPS EEN Sensors make use of 3G/4G infrastructure.
- Stationary Sensors make use of RPMA wireless technology.
- RPMA access points provide bridge to IP transport.

Stationary Sensor Network Architecture



Wireless Hardware for Stationary Network

- The stationary sensors require wireless “end nodes” where the sensors are located.
- The end nodes connect to an access point that must be on 24/7.
- Range is up to 20km; several 1000 nodes can share one access point.



Endpoint/Remote with RPMA Radio + Interface

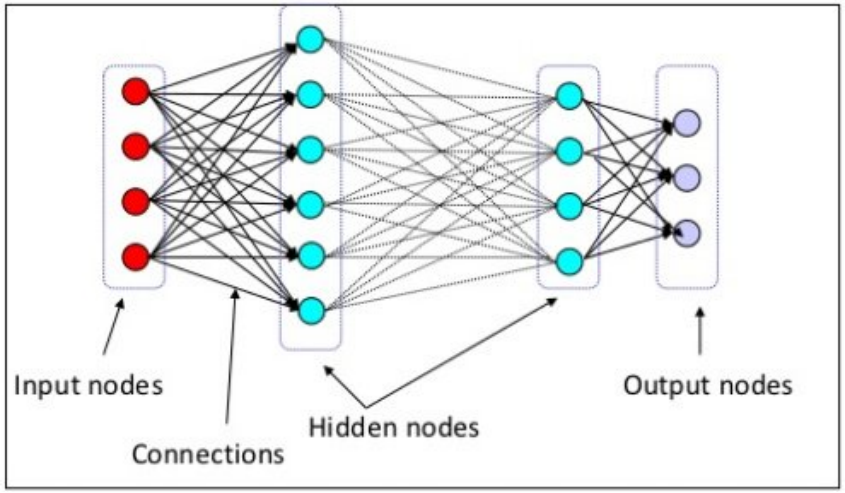
RPMA Access Point

Analytics

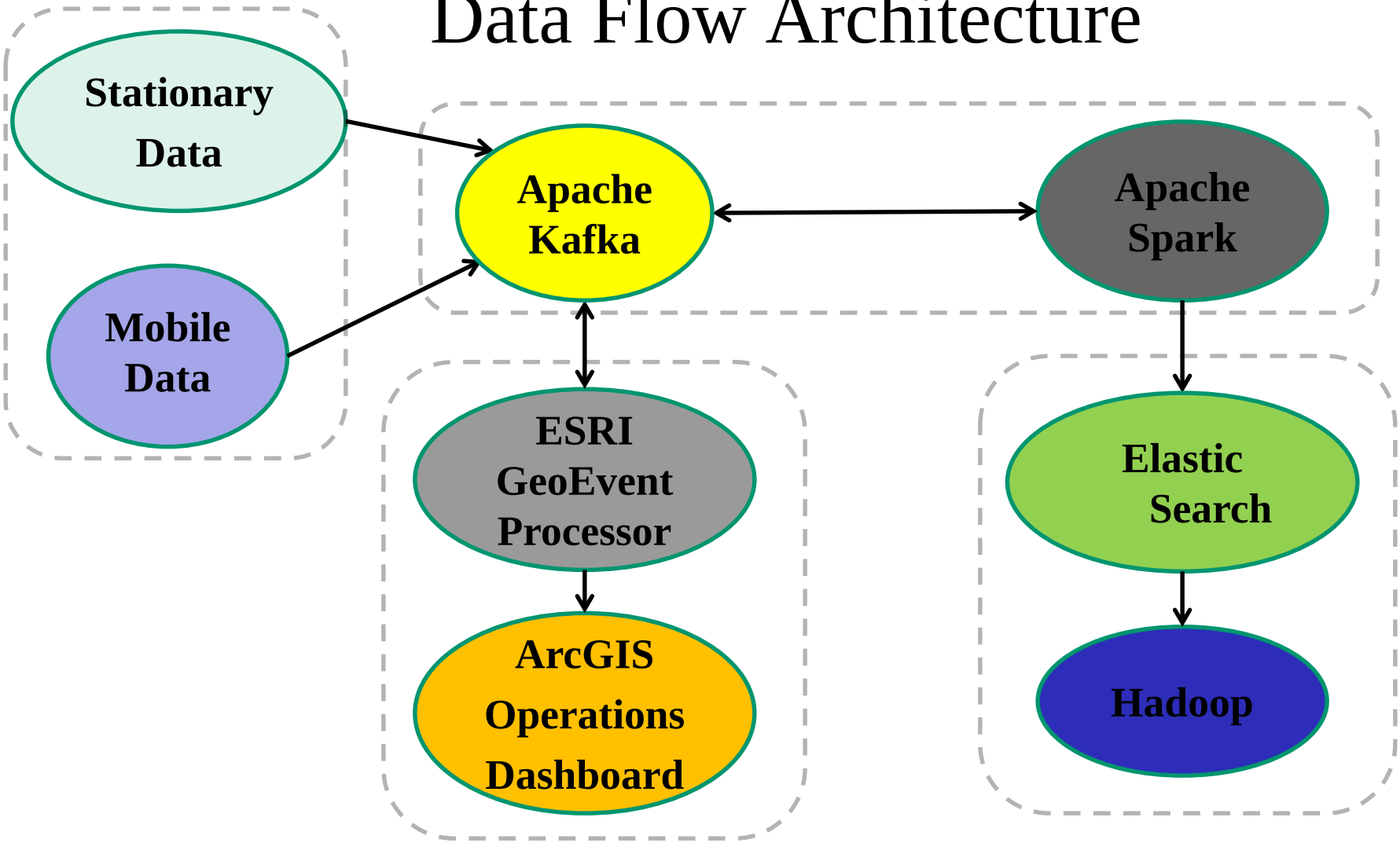
- Data Analytics
  - 1) Capture the current practice for encroachment alerts,
  - 2) Extract the business logic of alert process,
  - 3) Construct analytics to extract threats from background noise, and
  - 4) Provide alerts in accordance with the established practice.

Analytics for Event Identification

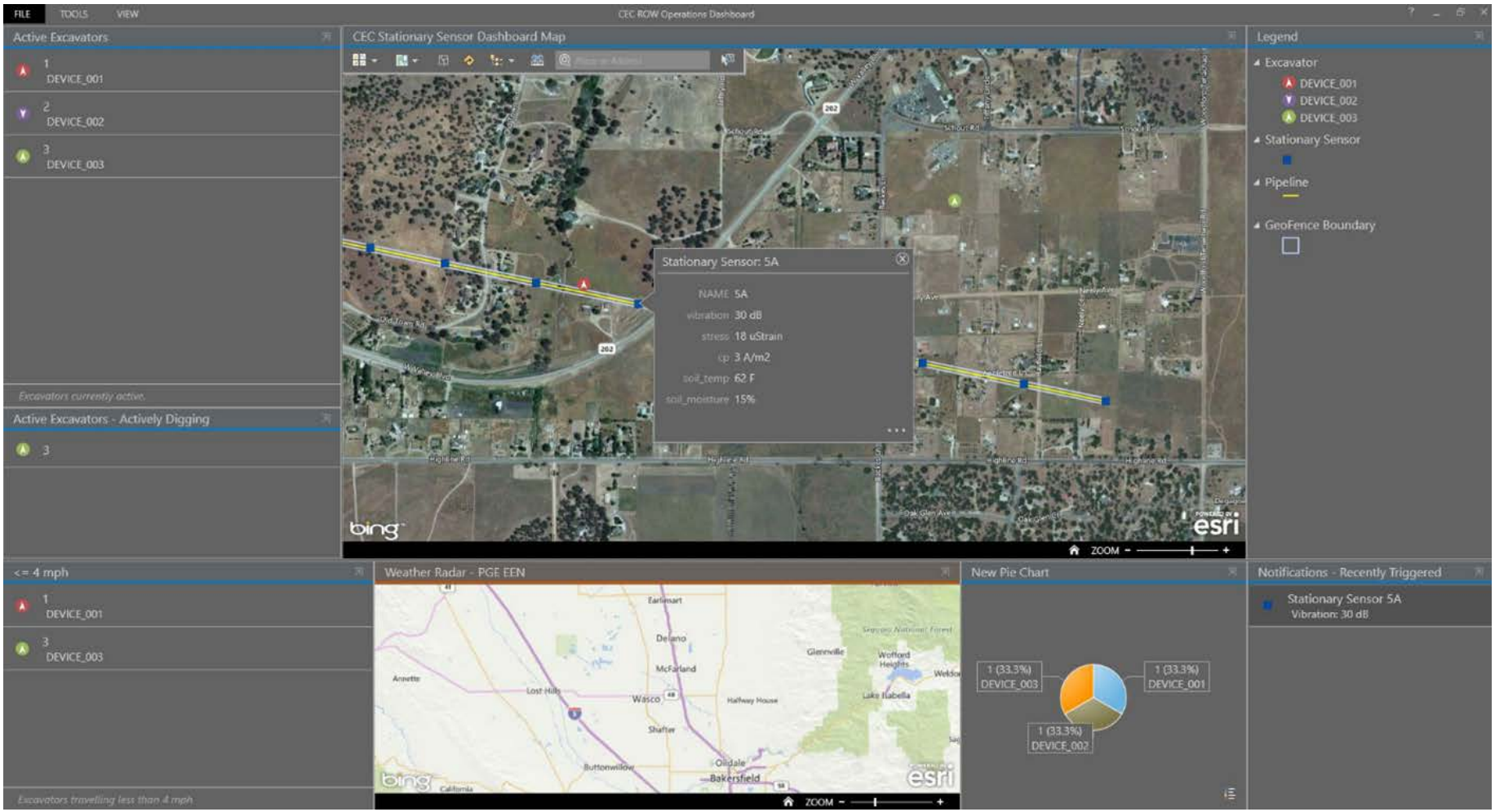
- GTI will develop analytics to extract significant events from background noise.
- Machine learning methods, such as Causal Bayesian Networks or deep learning, will be used.
- This will ensure that operators are issued alerts that are actionable.



Data Flow Architecture



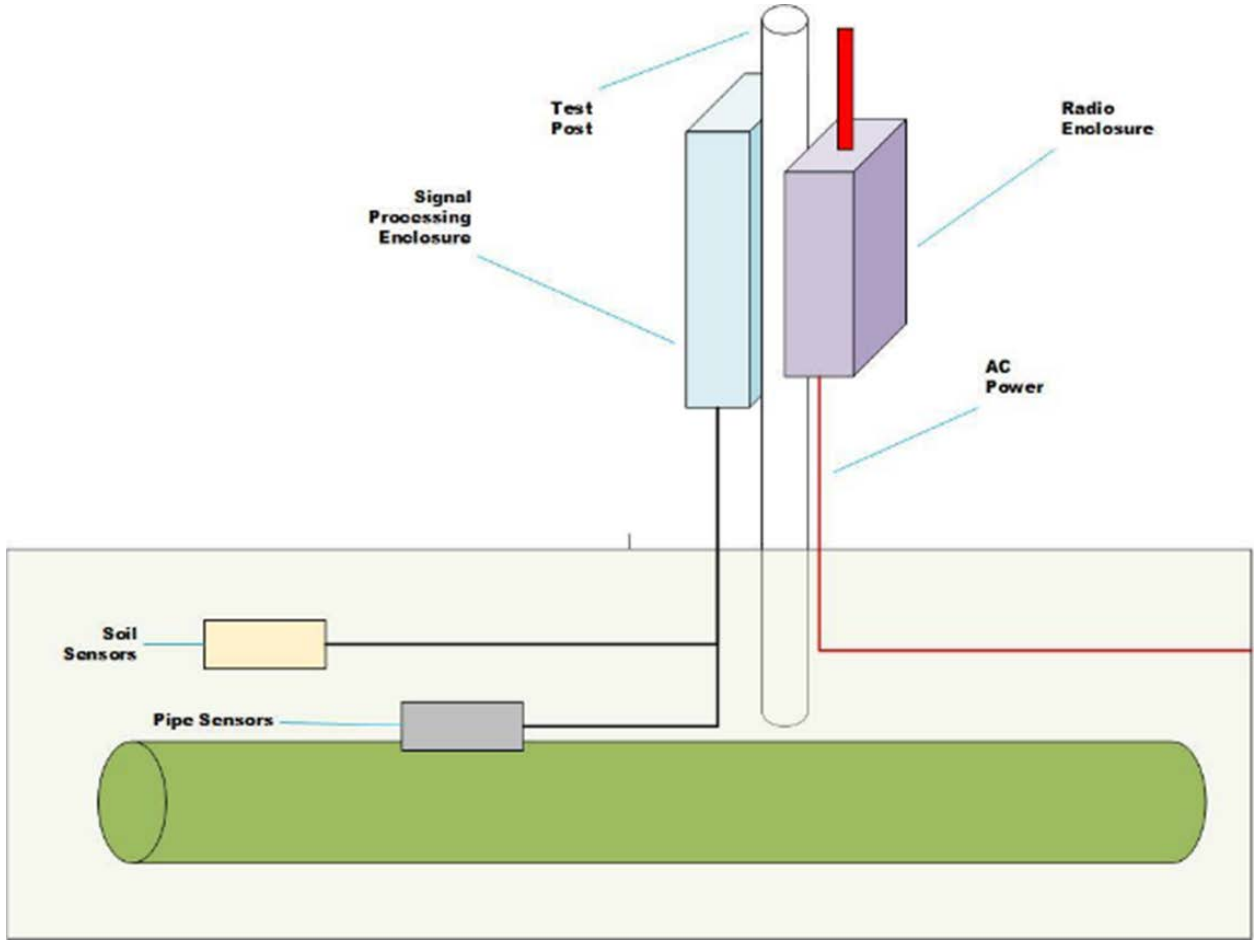
Esri Operations Dashboard for Stationary and Mobile Data



Current Work

- Construction of Stationary Hardware
- Construction of Mobile Hardware
- Pre-Deployment Testing

Stationary Sensor Installation Concept



Stationary Sensors Installed on Pipe

- These sensors are to be mounted directly on the pipe metal in a common location.

1. **Vibration sensor:** to capture impacts or activity near the pipe.
2. **Current sensor:** to track changes in electrical currents on the pipeline.
3. **Strain gauge:** track changes in tensile stress caused by immediate activity or long-term soil motion.

- These pipe sensors effectively turn long stretches of the pipeline into a distributed sensor.

Sensor Hardware Installation

- We are currently working with the utilities to qualify these installation methods.
- Soil condition sensors can be placed in trench backfill after the pipe sensors are in place.
- All sensors connect to a data logging device that aggregates the data for wireless transmission

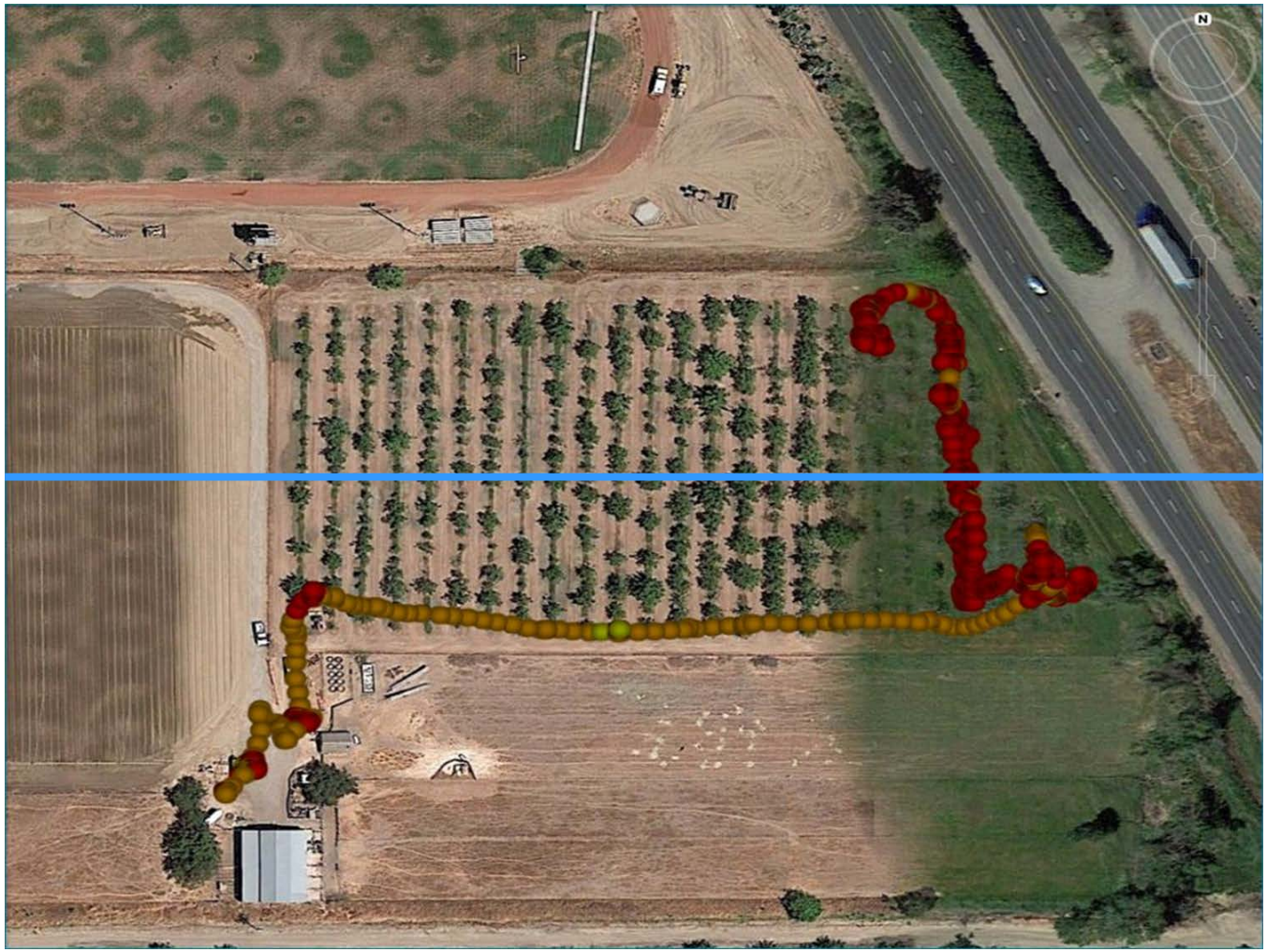
Mobile Sensor Development

- GTI has been working in the GPS Excavation Encroachment Notification (EEN) for several years.
- The proof of concept was demonstrated using repurposed Android phones.
- A “black box” version of the GPS EEN device is currently being developed and tested.

GPS EEN Device Prototypes

- Two different versions of GPS/cellular hardware are being tested.
- Both are functional; they have slightly different capabilities and capacity for expansion.

GPS EEN Data Example



Site Selection

- The utilities have provided their construction schedules for the near future.
- Several promising sites involving replacement or new construction have been identified.
- The work at these sites starts in the August to September time frame.
- The jobs are several months in duration.

Future Work

- Complete Pre-Deployment Testing
- Deployment of Monitor Hardware
- Field Testing of Hardware and Analytics

Thank You !

- Thank you for your time and attention
- Questions?