

MWDPTC meeting November 2024

**Introduction to Fiber optic sensing theory
and real world examples**

A search engine for the physical world

FiberSense
Geoff Roberts
Presentation to MWDPTC
11-2024

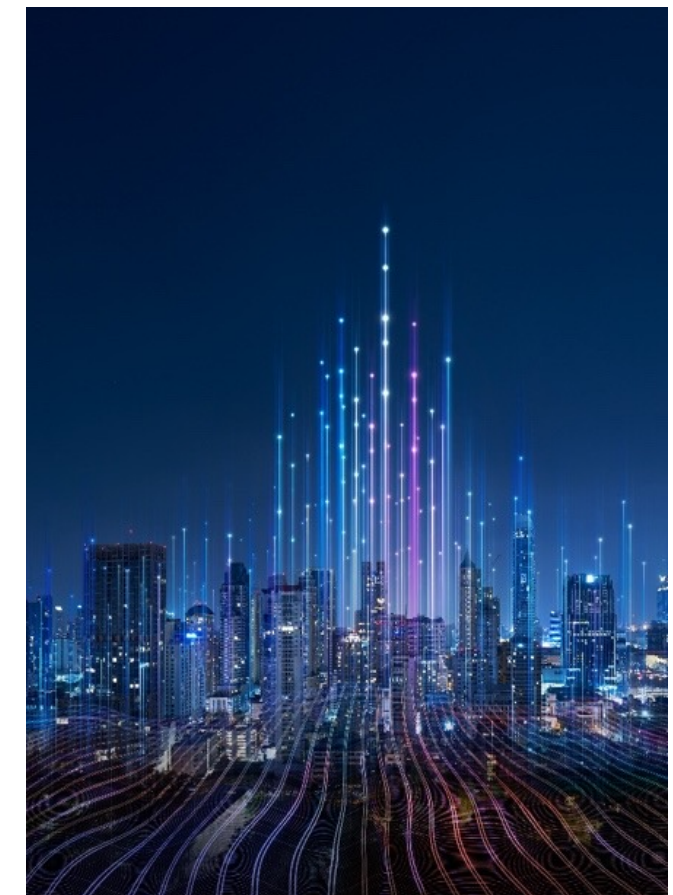
About FiberSense

Deep technology company, focusing on Distributed Fiber Sensing (DFS) over existing cable infrastructure in cities and oceans.

Building world-wide, total cover, sensor grid solution for cities and oceans.

World class technical and commercial team working at the Intersection of DFS, integrated photonics, sonar signal processing enhanced by AI and machine learning.

Delivering total cover dynamic digital twins of cities with applications that really work.



Our mission: Changing the way we perceive the world around us

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The paradox of sensing

...the more sensing data we capture...the less we actually know...

What we want

Situational awareness
I need to understand Real Time about my UG network

Accurate – false positive/false negative
Actionable Insights into operations

Complexity of supporting new technology

Economic scale to deploy and maintain
Including technical upgrades

What we actually get

I only see snapshots
...cameras seldom know where to look or what's important...

I have >5 million data points, but none tell me leak locations
Too many alarms...I turn the sensors off – best day ever

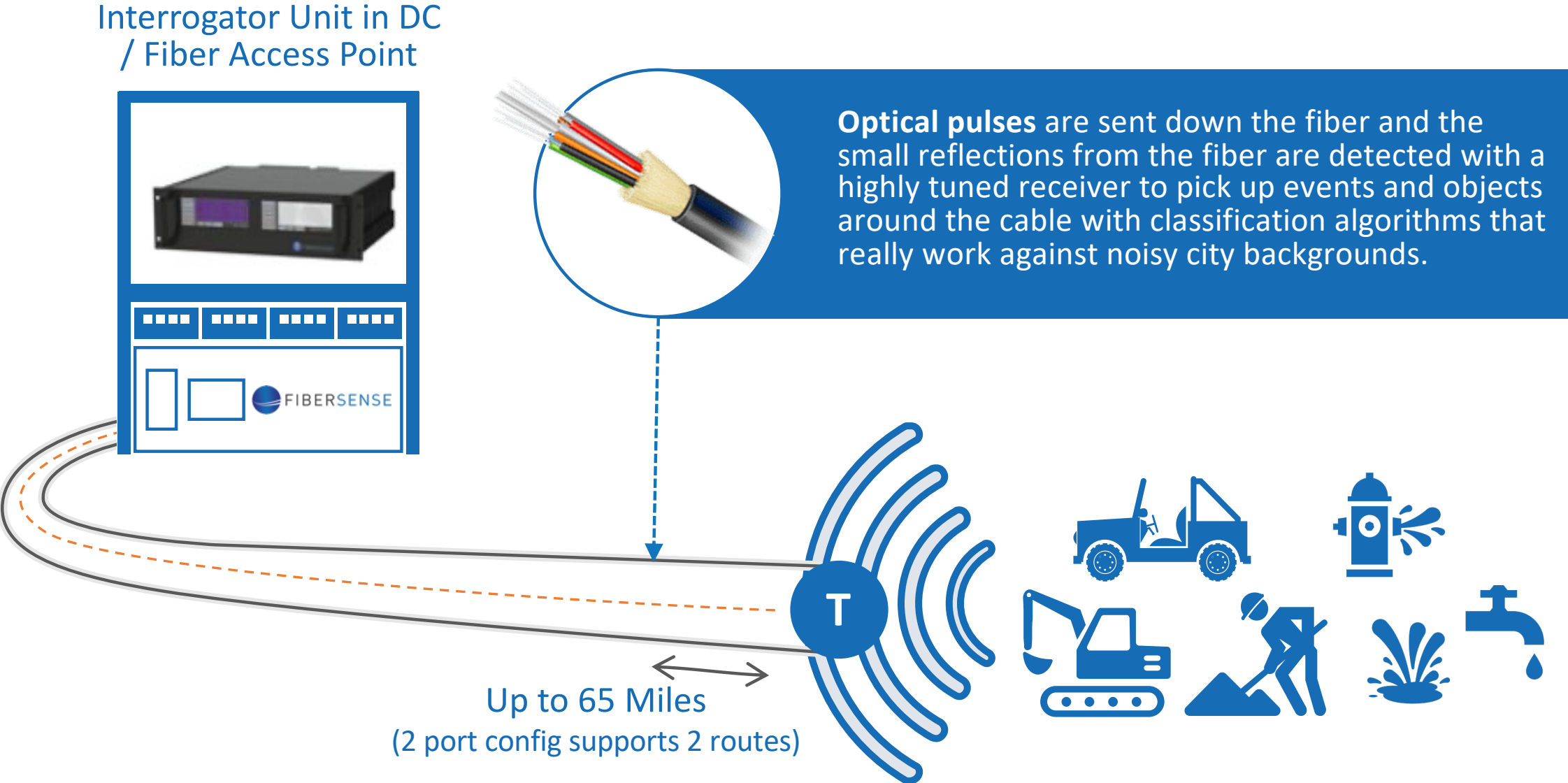
Challenge to recruit and retain the specialized skills sets needed

Point sensors cost more to deploy, maintain, and upgrade than expected
I cover less of my system for more \$\$\$ and
it takes longer to deploy than expected

**Enter colinear fiberoptic sensing and
“Sensing as a Service”**

How the FiberSense technology Works

FiberSense technology enables existing fiber optic cables to act as a massive continuous array of super precise vibration sensors. Each FiberSense unit is equivalent to deploying up to **15-30,000+ virtual vibration sensors** for expansive network coverage.



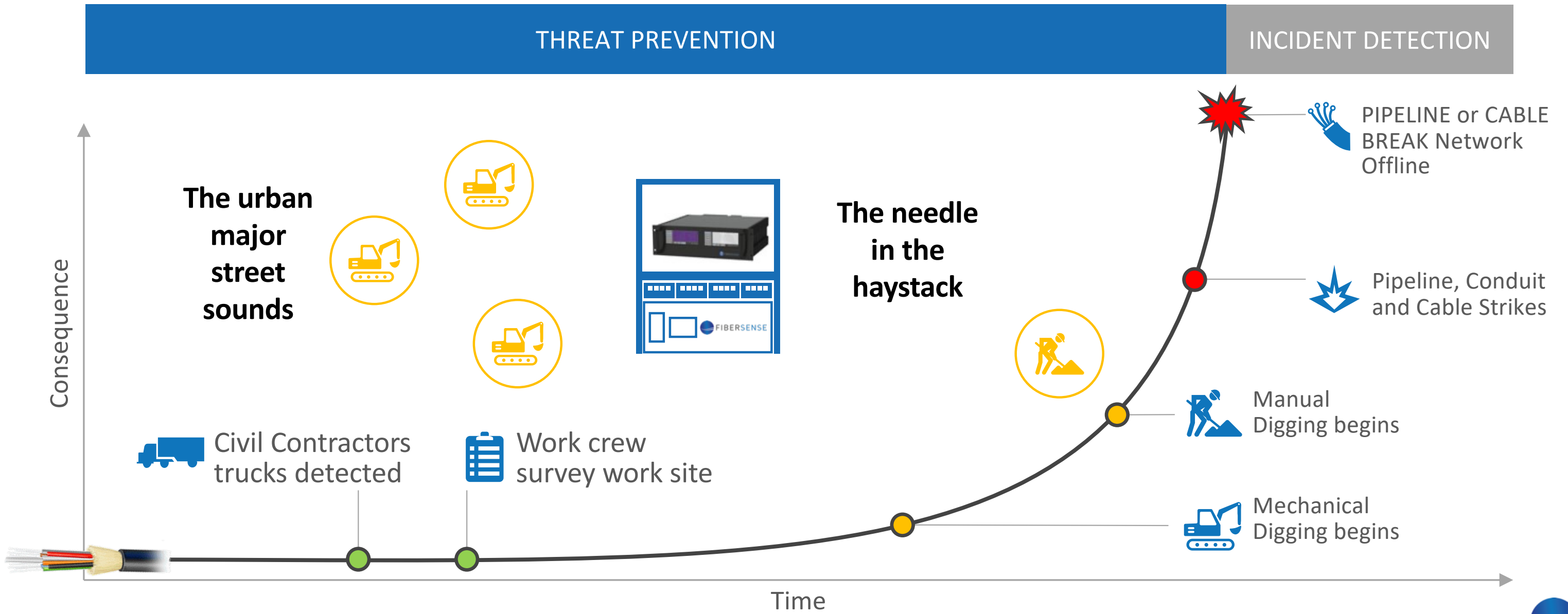
Objects detected to date		Objects and events by location	Object and event analysis tools developed to date	Object and event property distinctions
Excavation (boring, concrete saws, jack hammers, chisels, compactors) and road works Cars Trucks Buses Motorcycles Street sweepers Garbage trucks Trams Trains Ships leaving harbour Cyclists Pedestrians Low level aircraft Power transformers Water pumps Generators Electric motors Extraction fans	Earthquakes and seismic activity in ultra-high spatial resolution Vehicles moving Fireworks detonation Speeding and high-risk vehicles detected in normal traffic Irrigation Rain/Hail Power cable shunt faults Water leaks Oil leaks Cable installations	Off road On road and which lane of road Driveway entrance Traffic lights Intersections Parking Drop off points – airports/bus/train/tram stops Buildings – residential, commercial, government Street address Tunnels	SONAR derived acoustic and vibration analysis Tracking of objects for path and extended dwell data collection High resolution relationships between objects, events and locations in cities	Objects and events class Position Speed Direction Acceleration Object weight Track/Path object or event moved in grid Stationary activity of excavation machinery Variation in machinery properties (speed, vibration signature change) Temperature

“Sensing as a Service” initially focused on damage prevention and related capabilities in noisy urban environments = DigitalAsset™



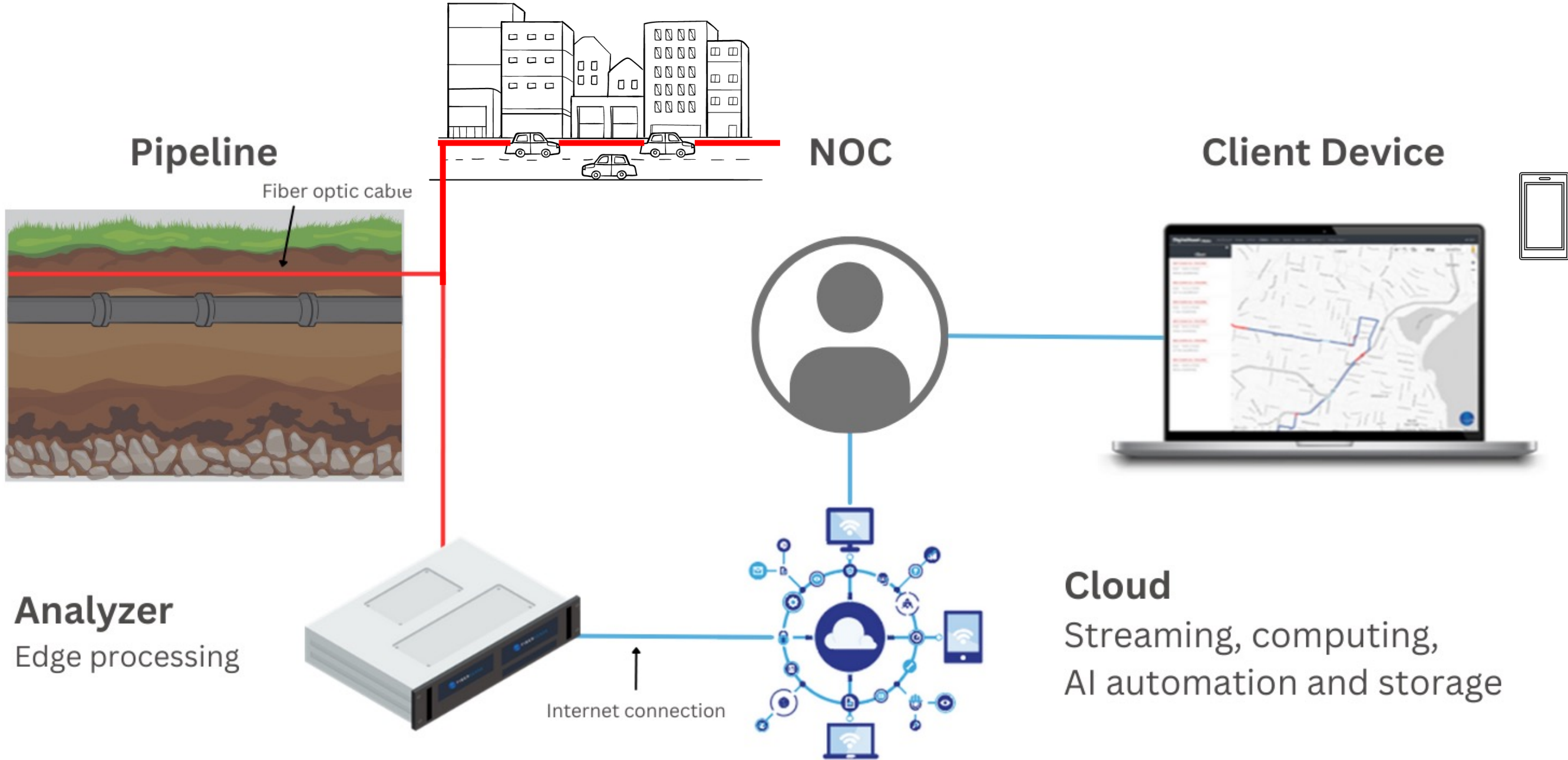
DigitalAsset™

Example: of system capture of events in field from an urban environment (Sydney) – done as blind test



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The Topology to deliver “Sensing as a Service”



Why does FiberSense offer “Sensing As A Service”?

To capture desired benefits of colinear sensing: 3 fundamental challenges must be overcome

1. The technology is complex, requiring specialized skills in sonar and photonics.
2. The technology continues to evolve on **both** dimensions of hardware and software,
3. A deep and adaptable technical ecosystem is required to deliver **actionable solutions** with low false positives and false negatives 24/7

Must solve
on all 3
dimensions

“Sensing as a Service”

- FiberSense is essentially a **search engine of the physical world** – global observation of physical events under different conditions provides immeasurably superior insights and actionable intelligence.
- The model works because it delivers an adaptable and improving ecosystem that continually increases in utility value for the end user.

The Threat Discrimination: for intrusion detection

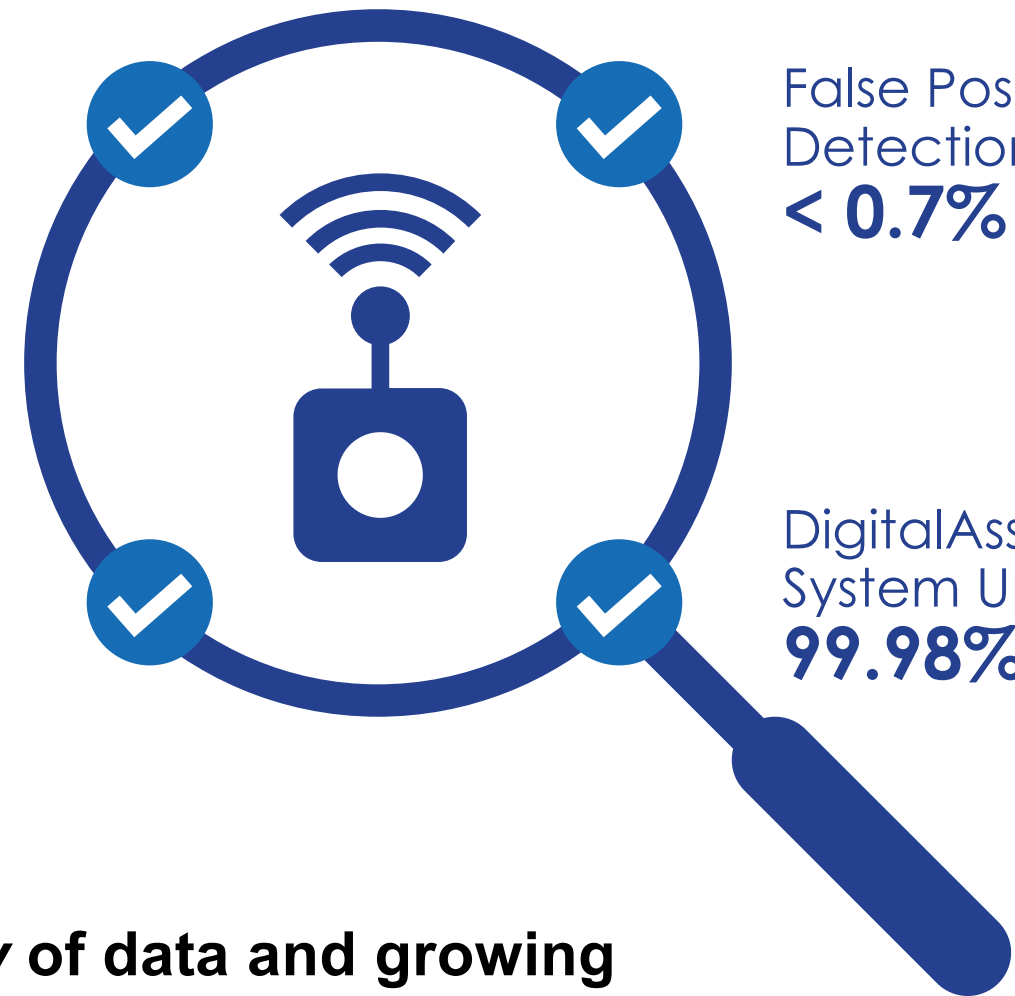
Civil work threat discrimination – Detect, classify, and locate > 30 million mile/hours

Examples of what can we detect:

- Excavators
- Backhoes
- Jackhammers
- Concrete saws
- Trencher
- And other civil work activity

False Negative
Detection Rate
< 0.02%

Average
Interdiction
Time (city)
< 90minutes



False Positive
Detection Rate
< 0.7%

DigitalAsset™
System Uptime
99.98%

Currently capturing > 80TB per day of data and growing

Understanding how it works in the wild *examples & results*

Intrusion protection – *a local example*

Water mainline leak detection and location

Combined storm and sewer system flow monitoring

Vehicle flow and pedestrian monitoring

Rewinding an event

Map View of the 30 days – Dallas area network w/ DigitalAsset™

Event History

Displaying all 32 alarms

[Add Event](#) [Show Filters](#)

POTENTIAL ASSET STRIKE ALARM

Start: 16:55 (-0500) 24 Jul 2024 30016m
 End: 16:56 (-0500) 24 Jul 2024 30016m
 [SHP9]
 15490 Dallas Pkwy, Dallas, TX 75248, USA
 Ref: 57c31215

POTENTIAL ASSET STRIKE ALARM

Start: 15:29 (-0500) 24 Jul 2024 29958m
 End: 16:56 (-0500) 24 Jul 2024 29913m
 [SHP9]
 15440 Dallas Pkwy, Dallas, TX 75248, USA
 Ref: N0C-a97e62fd

POTENTIAL ASSET STRIKE ALARM

Start: 07:44 (-0500) 24 Jul 2024 3203m
 End: 15:22 (-0500) 24 Jul 2024 3203m
 [SHP3]
 1552 N Glenville Dr, Richardson, TX 75081, USA
 Ref: c6f90325

POTENTIAL ASSET STRIKE ALARM

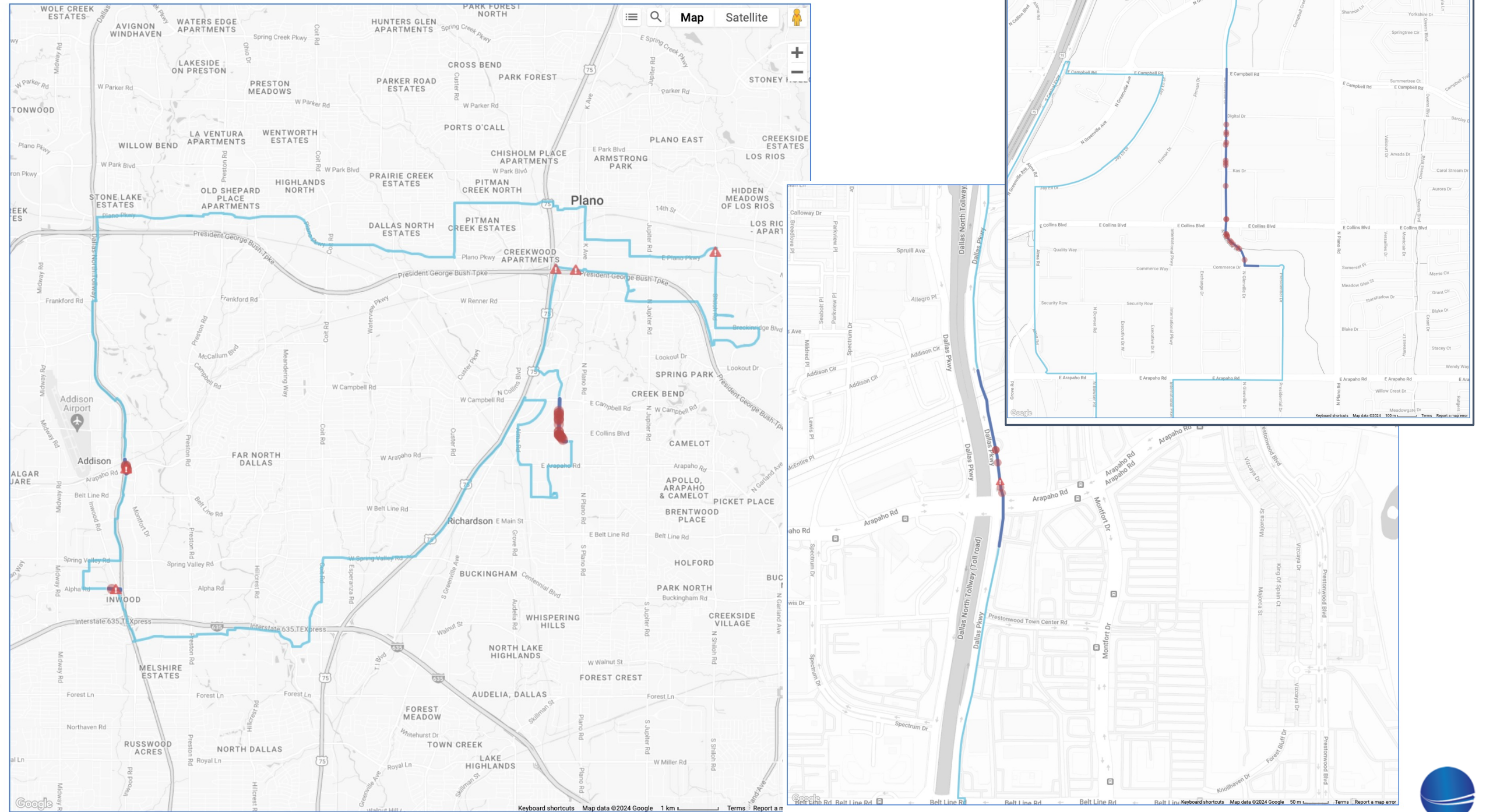
Start: 11:40 (-0500) 24 Jul 2024 29901m
 End: 11:56 (-0500) 24 Jul 2024 29901m
 [SHP9]
 15414 Dallas Pkwy, Dallas, TX 75248, USA
 Ref: 6c1f221c

CABLE ACTIVITY ALARM

Start: 09:36 (-0500) 24 Jul 2024 9092m
 End: 09:53 (-0500) 24 Jul 2024 9092m
 [SHP3]
 3976 N Central Expy, Richardson, TX 75080, USA
 Ref: N0C-00ca5fac

POTENTIAL ASSET STRIKE ALARM

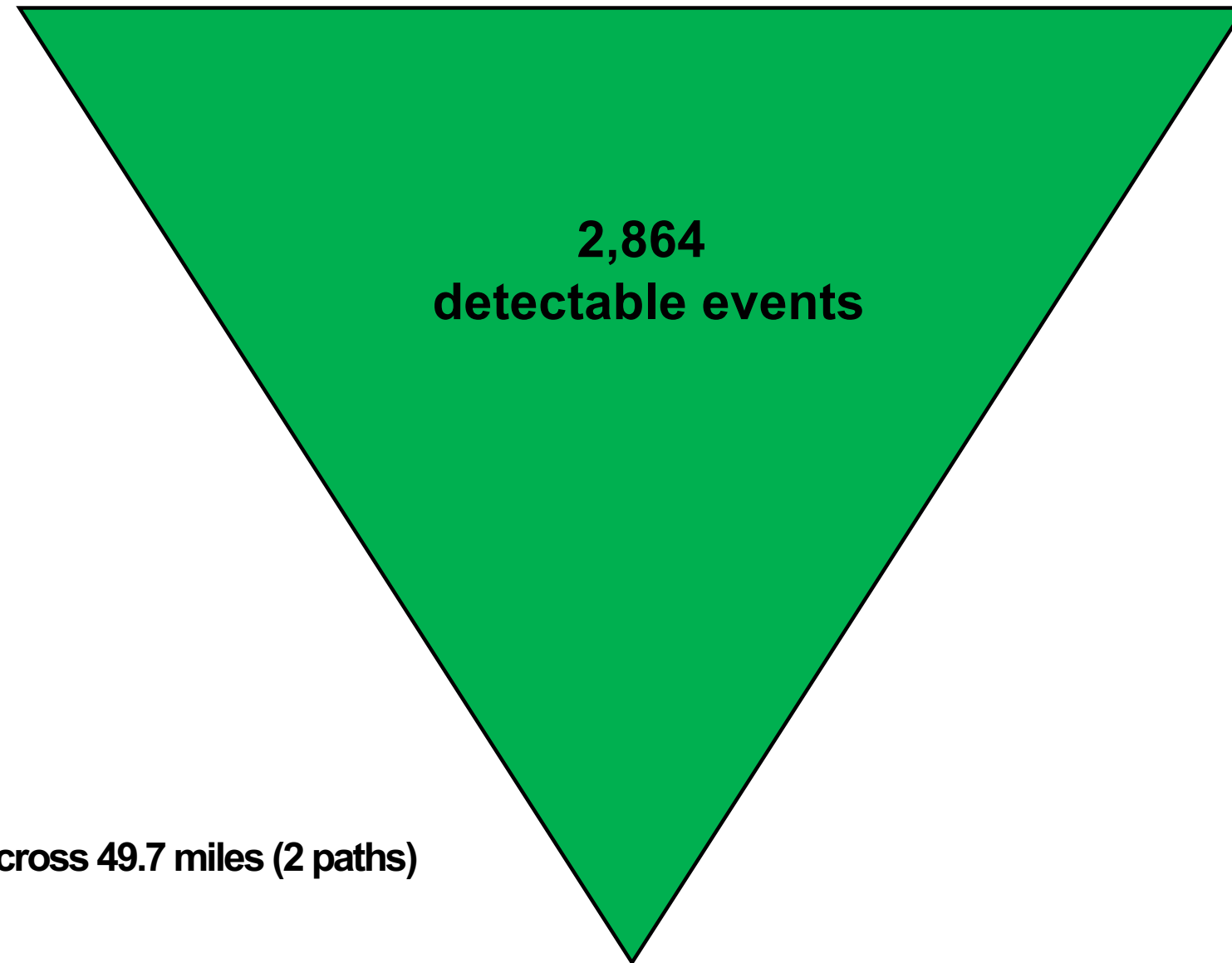
Start: 07:25 (-0500) 24 Jul 2024 29990m
 End: 07:27 (-0500) 24 Jul 2024 29990m
 [SHP9]
 15440 Dallas Pkwy, Dallas, TX 75248, USA
 Ref: 1770b417



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Example: *Behind the scenes*: Fiber customer over a 30-day period

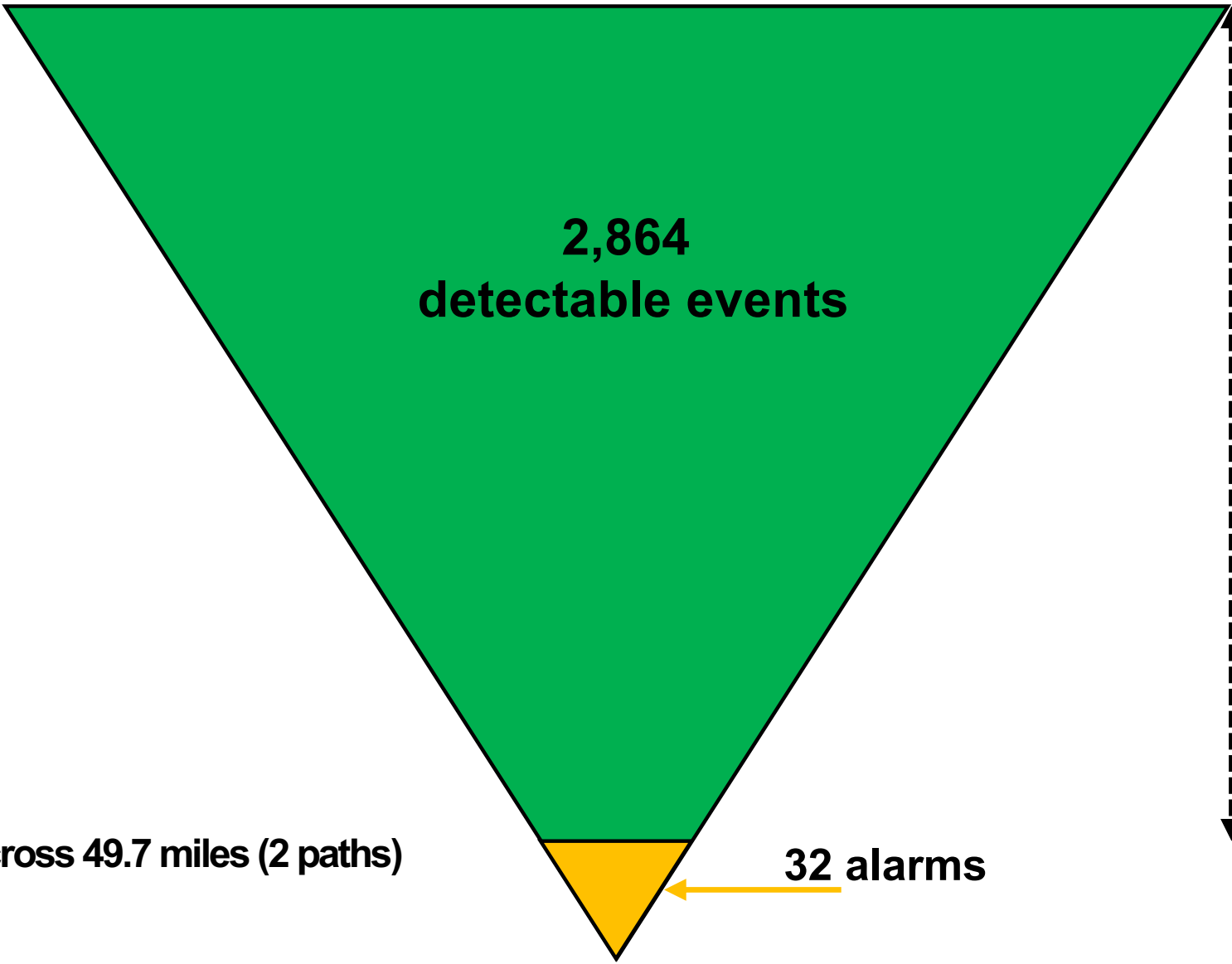


Data is from June 24th till July 24th Across 49.7 miles (2 paths)
in Dallas, TX

Interdiction = Alarms outside of a permit (dig ticket) zones and
within approximately 5m from the monitored asset.



Example: *Behind the scenes*: Fiber customer over a 30-day period



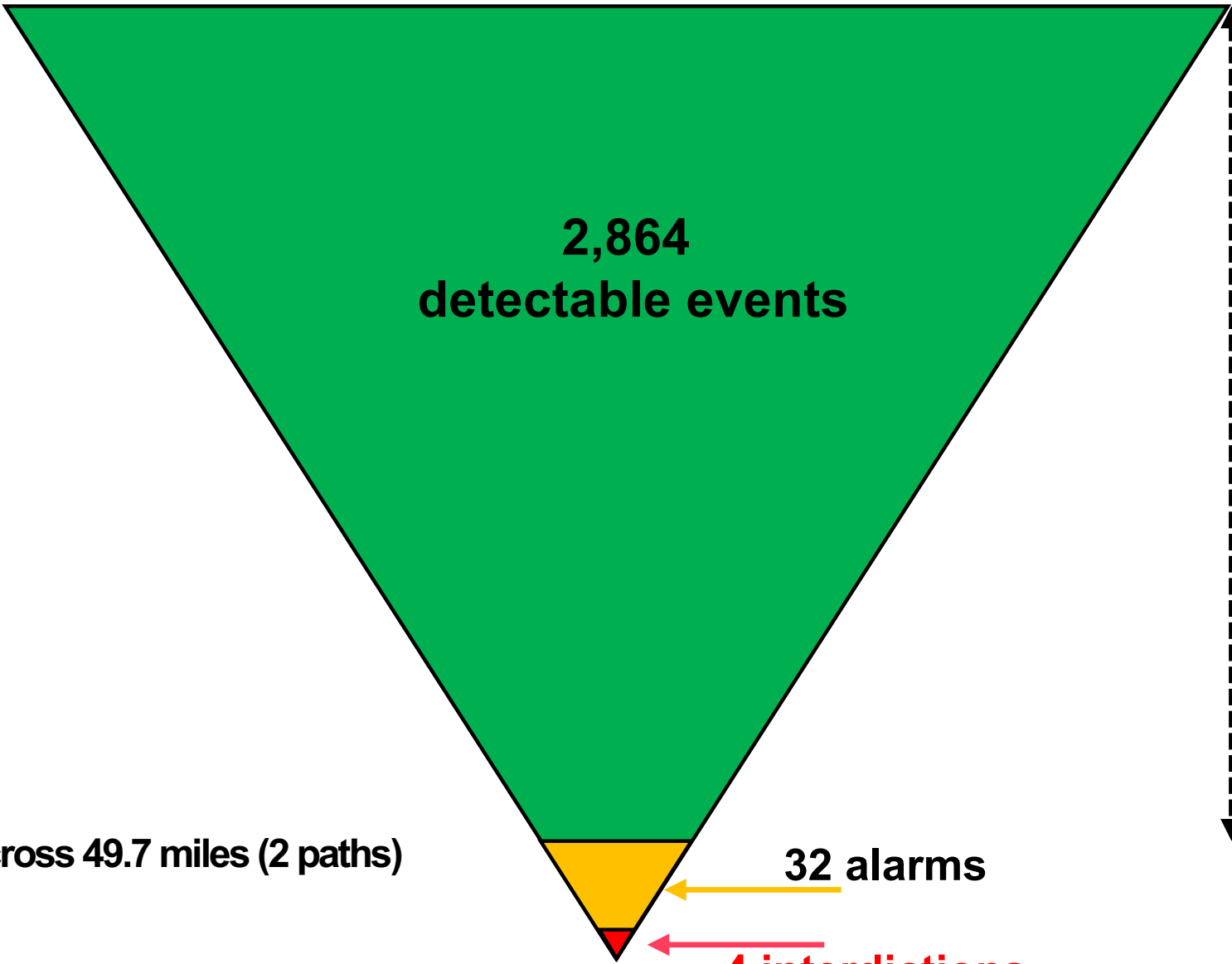
FiberSense
AI, ML, and algorithms
98% reduction of
individual events down
to alarms

Data is from June 24th till July 24th Across 49.7 miles (2 paths) in Dallas, TX

Interdiction = Alarms outside of a permit (dig ticket) zones and within approximately 5m from the monitored asset.



Example: *Behind the scenes*: Fiber customer over a 30-day period



**FiberSense
AI, ML, and algorithms
98% reduction of
individual events down
to alarms**

**Further FiberSense
analysis = 87% reduction
of alarms down to 4
interdictions**

4 interdictions

*In this example – FiberSense provides
interdiction service for customer*

Data is from June 24th till July 24th Across 49.7 miles (2 paths)
in Dallas, TX

Interdiction = Alarms outside of a permit (dig ticket) zones and
within approximately 5m from the monitored asset.



DigitalAsset™ Interdiction 1- [NOC-1688ae93](#)

Key Points

- **Very close proximity** to the asset.
- No active dig ticket
- Party identified
- The construction crew knew the location of the asset but was reminded to be careful.
- Elevated to asset owner

Interdiction Report

Wednesday, 26 Jun 2024

Potential Asset Strike

NEAR ASSET (<10M) YES	INTERDICTION COMPLETE YES
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NEAREST ADDRESS 3598 E Plano Pkwy Plano TX 75074 USA	PATH SHP3 OPTICAL DISTANCE 20718 m	EVENT NOC-1688ae93 LOCATION 33.00838, -96.664921
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REQUESTED AT 15:35 UTC	ARRIVED AT 16:56 UTC	ELAPSED 81 mins
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WITHIN SLA YES	CONFIRMED ROGUE YES	FALSE POSITIVE NO
--------------------------	-------------------------------	-----------------------------

DISTANCE FROM ASSET 3 m	ESCALATED TO ASSET OWNER YES	CONSTRUCTION CREW KNOWS ASSET LOCATION YES
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WHAT COMPANY IS CONDUCTING THE ACTIVITY? City of Plano	IS THE CONSTRUCTION CREW STILL ON SITE? YES
---	---

WAS ANY CONSTRUCTION ACTIVITY FOUND ON SITE? YES	HOW MANY DAYS WILL THE WORK BE TAKING PLACE ON SITE? They are not sure.
--	--

SUMMARY

Interdiction team found a road crew from Plano City working on roadway repairs at the intersection. The Fiber is marked along the route.

OBSERVATIONS

[17:05 UTC]
Road repair

RECOMMENDATIONS

Zone Creation
Escalation to asset owner
FS NOC will continue to monitor



DigitalAsset™ Interdiction 2 - NOC-12373d13

Key Points

- **Very close proximity** to the asset.
- No active dig ticket
- Party identified
- The construction crew knew the location of the asset but was reminded to be careful.
- Elevated to asset owner

Interdiction Report FIBERSENSE

Potential Asset Strike Thursday, 27 Jun 2024

<p>NEAR ASSET (<10M) YES</p> <p>NEAREST ADDRESS 5013 Alpha Rd Farmers Branch TX 75244 USA</p> <p>REQUESTED AT 15:08 UTC</p> <p>WITHIN SLA YES</p> <p>DISTANCE FROM ASSET 5 m</p>	<p>INTERDICTION COMPLETE YES</p> <p>PATH SHP9</p> <p>OPTICAL DISTANCE 23934 m</p> <p>ARRIVED AT 16:14 UTC</p> <p>CONFIRMED ROGUE YES</p> <p>ESCALATED TO ASSET OWNER NO</p>	<p>EVENT NOC-12373d13</p> <p>LOCATION 32.933054, -96.823615</p> <p>ELAPSED 66 mins</p> <p>FALSE POSITIVE NO</p> <p>CONSTRUCTION CREW KNOWS ASSET LOCATION YES</p>
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10:51 5G 81

WhatsApp

Tu ubicación

32°55'59.0"N 96°49'25.0"W

1 min 1 min 1 min

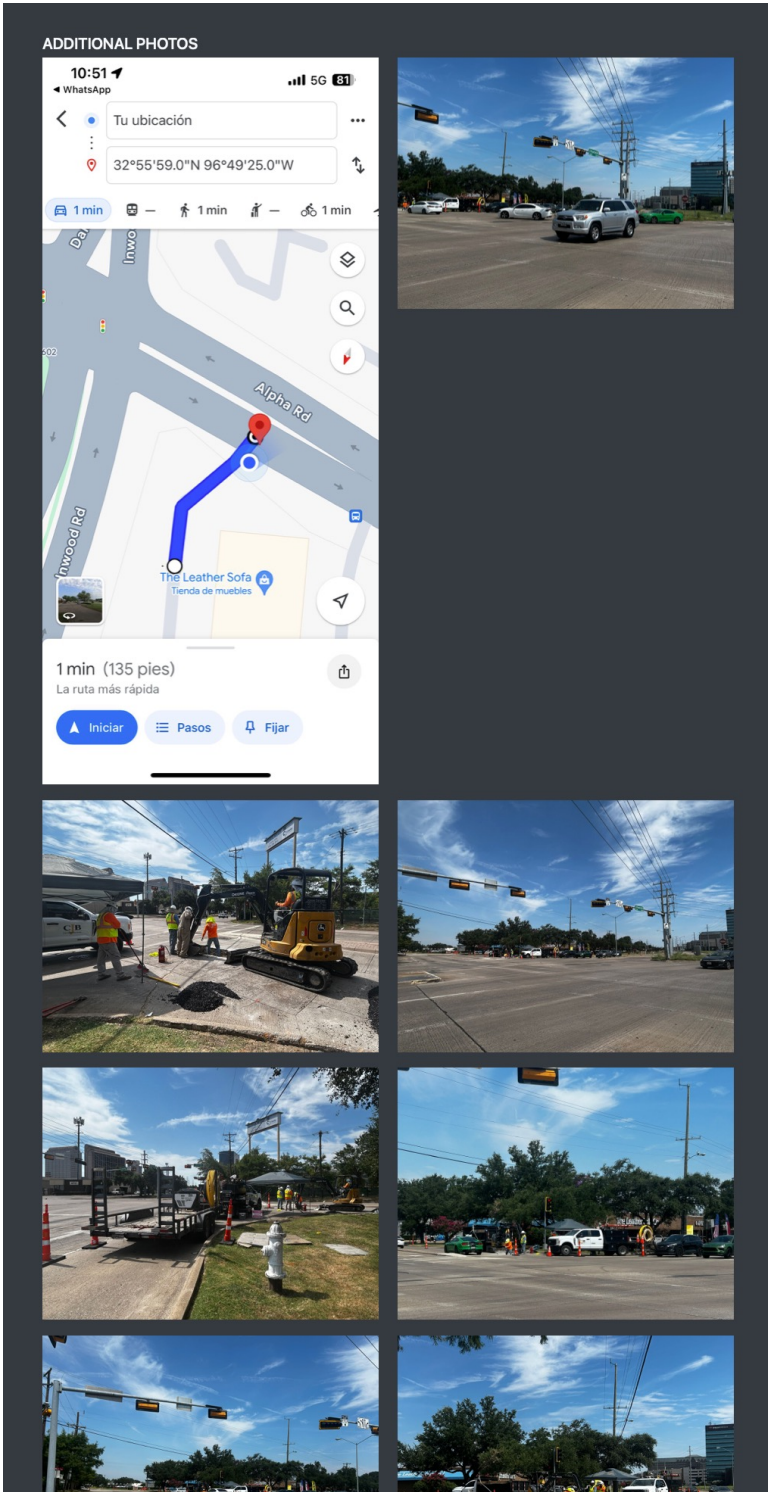
<p>WHAT COMPANY IS CONDUCTING THE ACTIVITY? City of Dallas</p> <p>WAS ANY CONSTRUCTION ACTIVITY FOUND ON SITE? YES</p>	<p>IS THE CONSTRUCTION CREW STILL ON SITE? YES</p> <p>HOW MANY DAYS WILL THE WORK BE TAKING PLACE ON SITE? From 3 to 8 days</p>
--	---

SUMMARY

Interdiction team found road repairs underway. The fiber route is marked with flags and the team working on the site said they were aware of the fiber in the area. FS NOC will continue to monitor.

OBSERVATIONS
Reparacion de carretera

RECOMMENDATIONS
Zone Creation
FS NOC will continue to monitor



DigitalAsset™ Interdiction 3 - 5330cde6

Key Points

- The construction crew **DID NOT** know the location of the asset.
- No dig ticket
- Party identified
- Put on notice and reminded to be careful.
- Elevated to asset owner

Interdiction Report FIBERSENSE

Potential Asset Strike Monday, 1 Jul 2024

<p>NEAR ASSET (<10M) YES</p> <p>NEAREST ADDRESS 15434 Dallas Pkwy Dallas TX 75248 USA</p> <p>REQUESTED AT 18:29 UTC</p> <p>WITHIN SLA YES</p> <p>DISTANCE FROM ASSET 9 m</p> <p>SIGNAL ENDED AT 19:35 UTC</p>	<p>INTERDICTION COMPLETE YES</p> <p>PATH SHP9</p> <p>OPTICAL DISTANCE 29945 m</p> <p>ARRIVED AT 19:14 UTC</p> <p>CONFIRMED ROGUE YES</p> <p>ESCALATED TO ASSET OWNER YES</p>
---	---

<p>EVENT 5330cde6</p>	<p>LOCATION 32.959989, -96.820712</p>	<p>ELAPSED 45 mins</p>
<p>FALSE POSITIVE NO</p>	<p>CONSTRUCTION CREW KNOWS ASSET LOCATION NO</p>	

<p>WHAT COMPANY IS CONDUCTING THE ACTIVITY? Heart Consultant</p> <p>WAS ANY CONSTRUCTION ACTIVITY FOUND ON SITE? YES</p>	<p>IS THE CONSTRUCTION CREW STILL ON SITE? YES</p> <p>HOW MANY DAYS WILL THE WORK BE TAKING PLACE ON SITE? more than 3 month</p>
--	--

SUMMARY

Heart Consultant, a construction company, is conducting road repairs along Dallas Parkway. The work will last for three months, and involves the use of a bucket excavator.

OBSERVATIONS

Construction company Heart Consultant is performing road repair along Dallas Parkway, approximately nine meters from the fiber asset. The work will be ongoing for three months. A bucket excavator is being used for this project.

RECOMMENDATIONS

Escalated to asset owner and zone created.

FS NOC will continue to monitor.



DigitalAsset™ Interdiction 4 - [NOC-00ca5fac](#)

Key Points

- **NEAR MISS**
 - This event was in such close proximity to the asset that it was flagged as a cable activity alarm.
 - The construction crew **DID NOT** know the location of the asset
 - No dig ticket
 - Party identified
 - Put on notice and reminded to be careful.
 - Elevated to asset owner

Interdiction Report

FIBERSENSE

Cable Activity Wednesday, 24 Jul 2024

NEAR ASSET (<10M) YES	INTERDICTION COMPLETE YES	
NEAREST ADDRESS 3976 N Central Expy Richardson TX 75080 USA	PATH SHP3 OPTICAL DISTANCE 9092 m	EVENT NOC-00ca5fac LOCATION 33.00465, -96.707135
REQUESTED AT 14:55 UTC WITHIN SLA YES DISTANCE FROM ASSET 2 m	ARRIVED AT 16:45 UTC CONFIRMED ROGUE YES ESCALATED TO ASSET OWNER YES	ELAPSED 110 mins FALSE POSITIVE NO CONSTRUCTION CREW KNOWS ASSET LOCATION NO

11:45 5G 73%

Tu ubicación

33°00'16.7"N 96°42'25.7"W

1 min 1 h 14 4 h 33 20 min

AssuredPartners
Accuver Americas

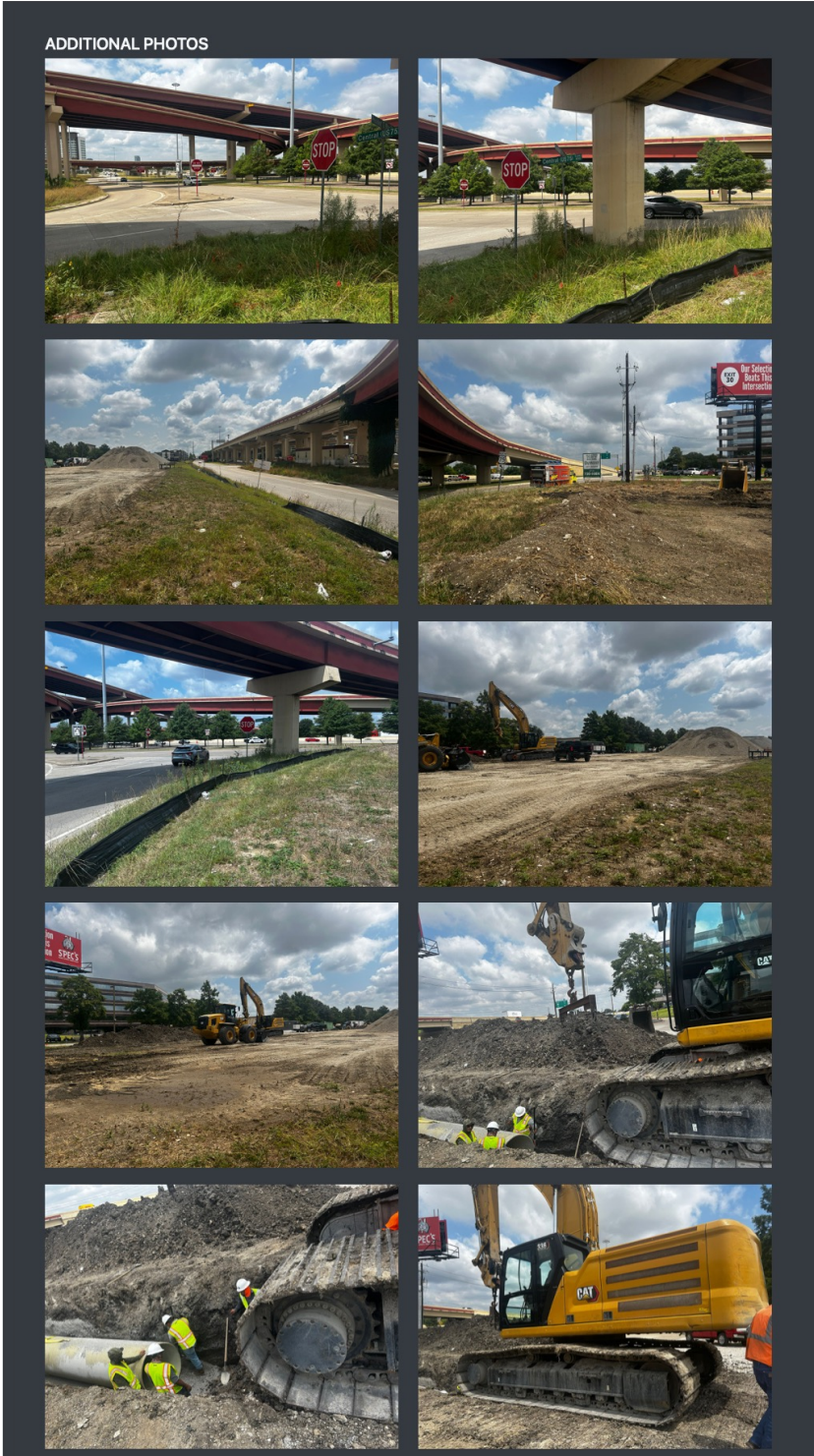
WHAT COMPANY IS CONDUCTING THE ACTIVITY? Wilson Contractor services	IS THE CONSTRUCTION CREW STILL ON SITE? YES
WAS ANY CONSTRUCTION ACTIVITY FOUND ON SITE? YES	HOW MANY DAYS WILL THE WORK BE TAKING PLACE ON SITE? 3-4 Weeks

SUMMARY

Our interdiction team arrived onsite to find a crew with Wilson Contractor Services working with a section of large piping they had dug up. The crew was using a large crane at the time of arrival to assist the crew in the dug out section. The crew informed our team this work will continue up to 4 weeks from today.

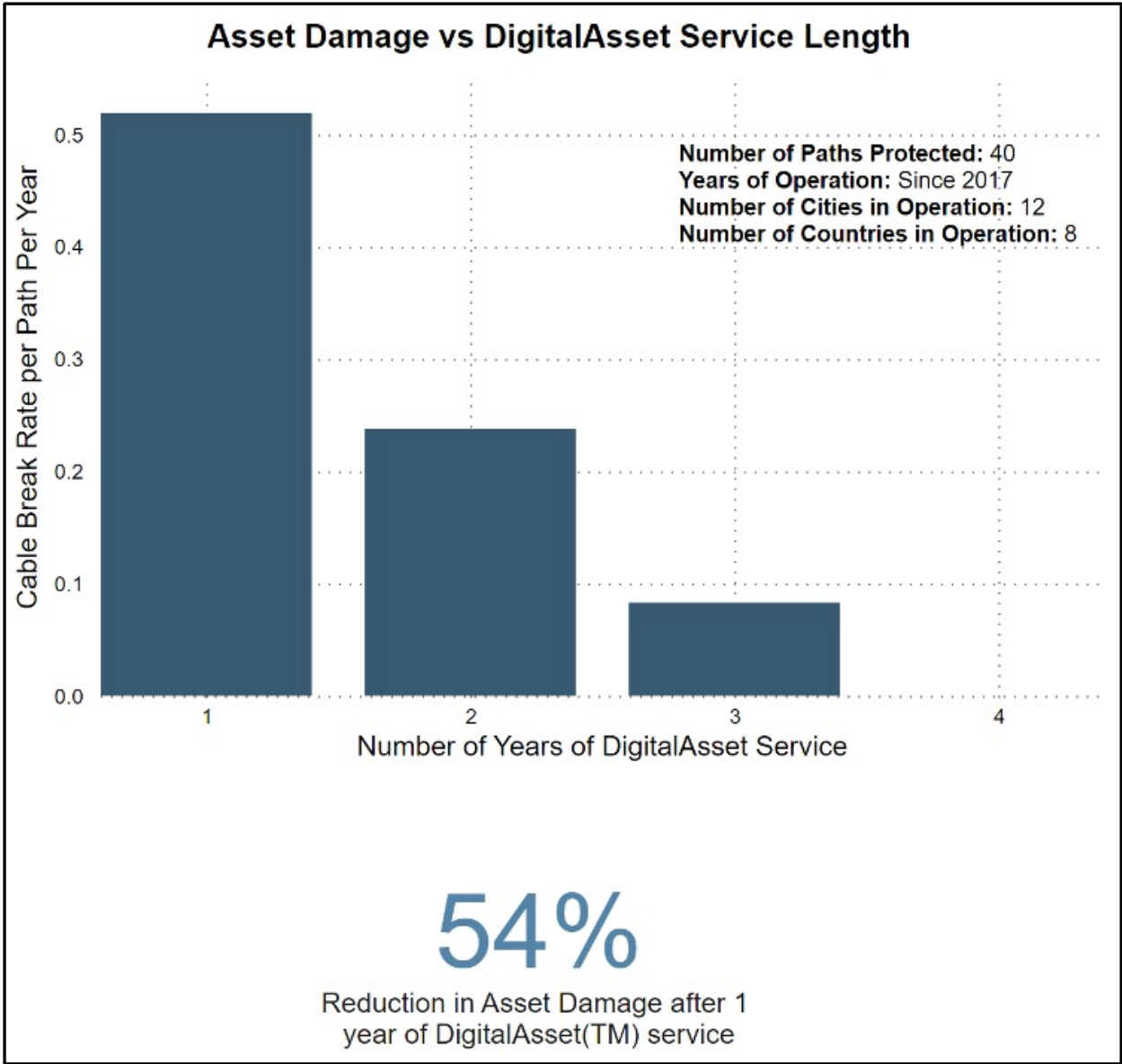
OBSERVATIONS
New Building construction

RECOMMENDATIONS
Escalate to asset owner
Zone Creation
FS NOC to monitor

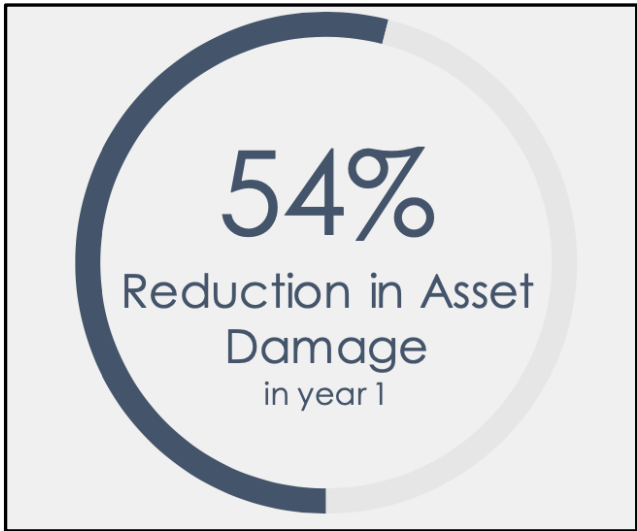


Damage Prevention: Results matter

Creating a Safety Culture through Target Oversight



Since 2019, damage prevention improvement statistics (Common Ground Alliance – CGA) in North America have essentially been flat.



Across 40 paths in 12 cities in 8 countries enhancing community safety and reliability.

Complemented by *subsequent* **>50% compound Year-on-Year** decrease in damage in year 2 and year 3

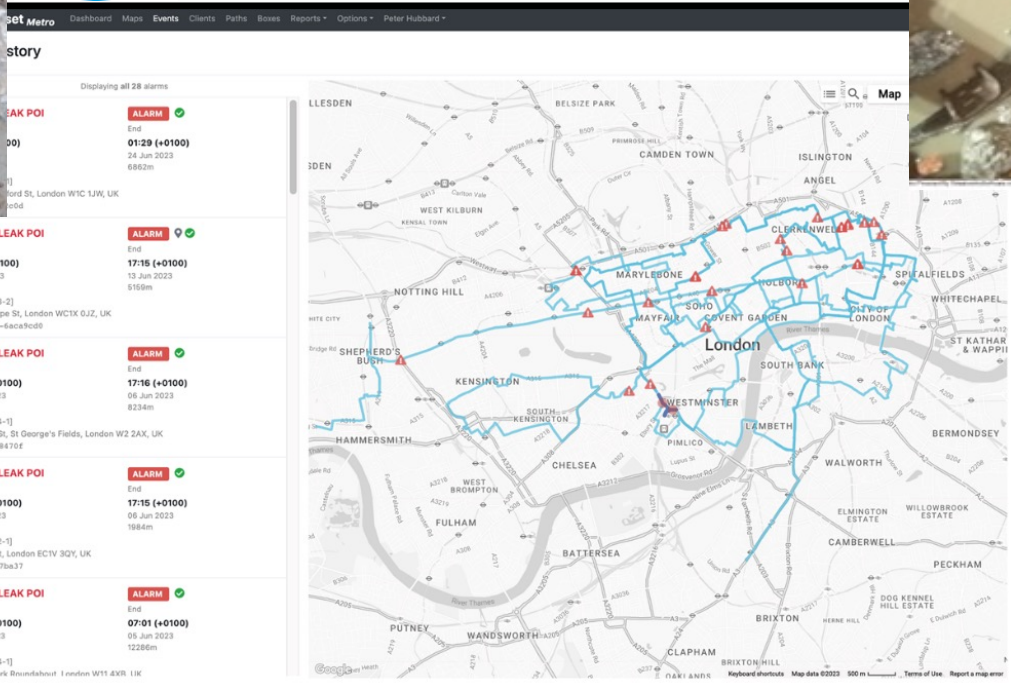
Water, sewer, and storm systems: What types of problems does it solve?

ID and locate leak before it is observable at the surface

Refining pre-burst leak precursor detector

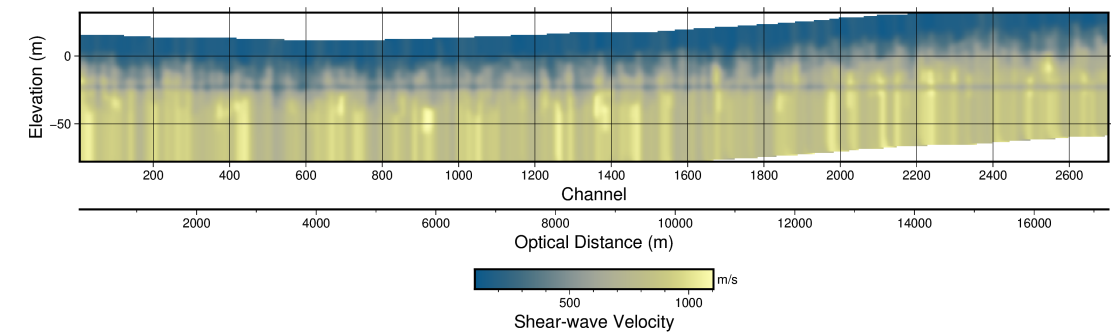


Leak Detection & Location



ID and locate average 1 leak POI per 4 km of mainline per year

Earth Movement



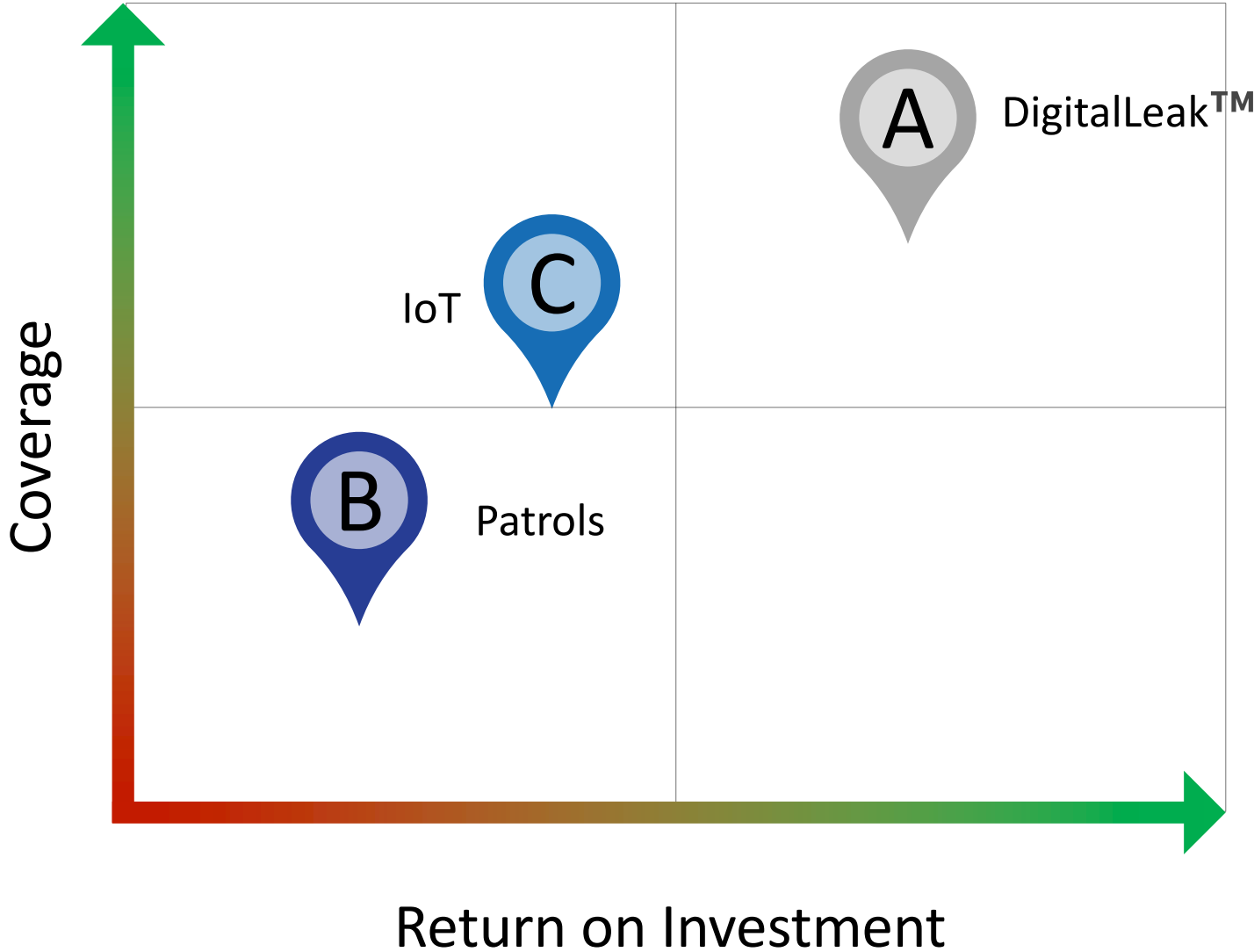
Vs30 shear wave analysis can also be applied to earthen dam and levee monitoring

There is a related solution for seismic PGA (peak ground acceleration) by address analysis available within minutes post event to triage and prioritize response focus.



DigitalLeak™ Coverage vs ROI

Augment, integrate or replace with existing programs



- A** DigitalLeak™ provides high coverage and ROI for critical infrastructure.
- B** Comparatively low cost, however the probability of intercepting an event is low.
- C** High cost per meter/foot, and coverage limited due to rollout footprint.

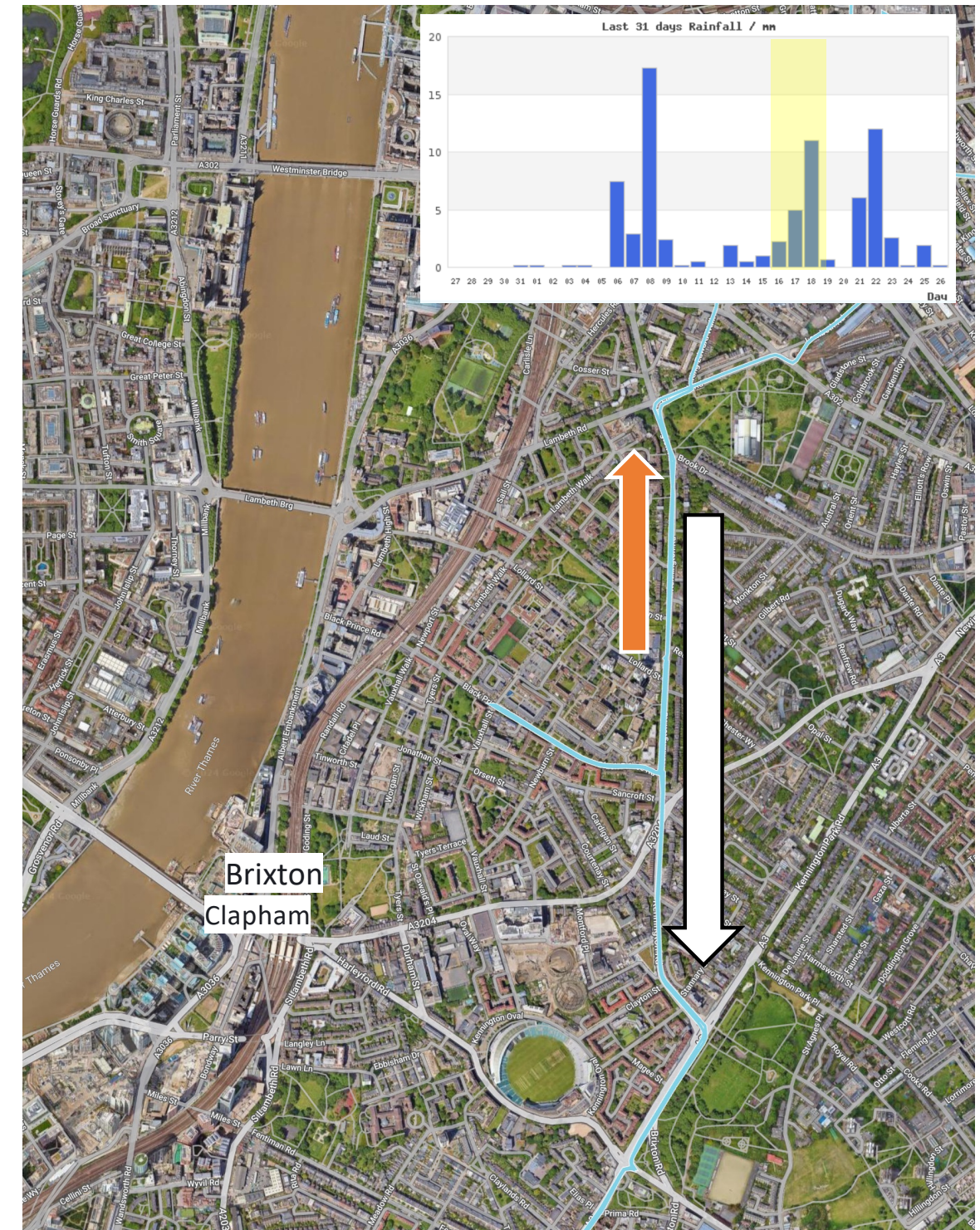
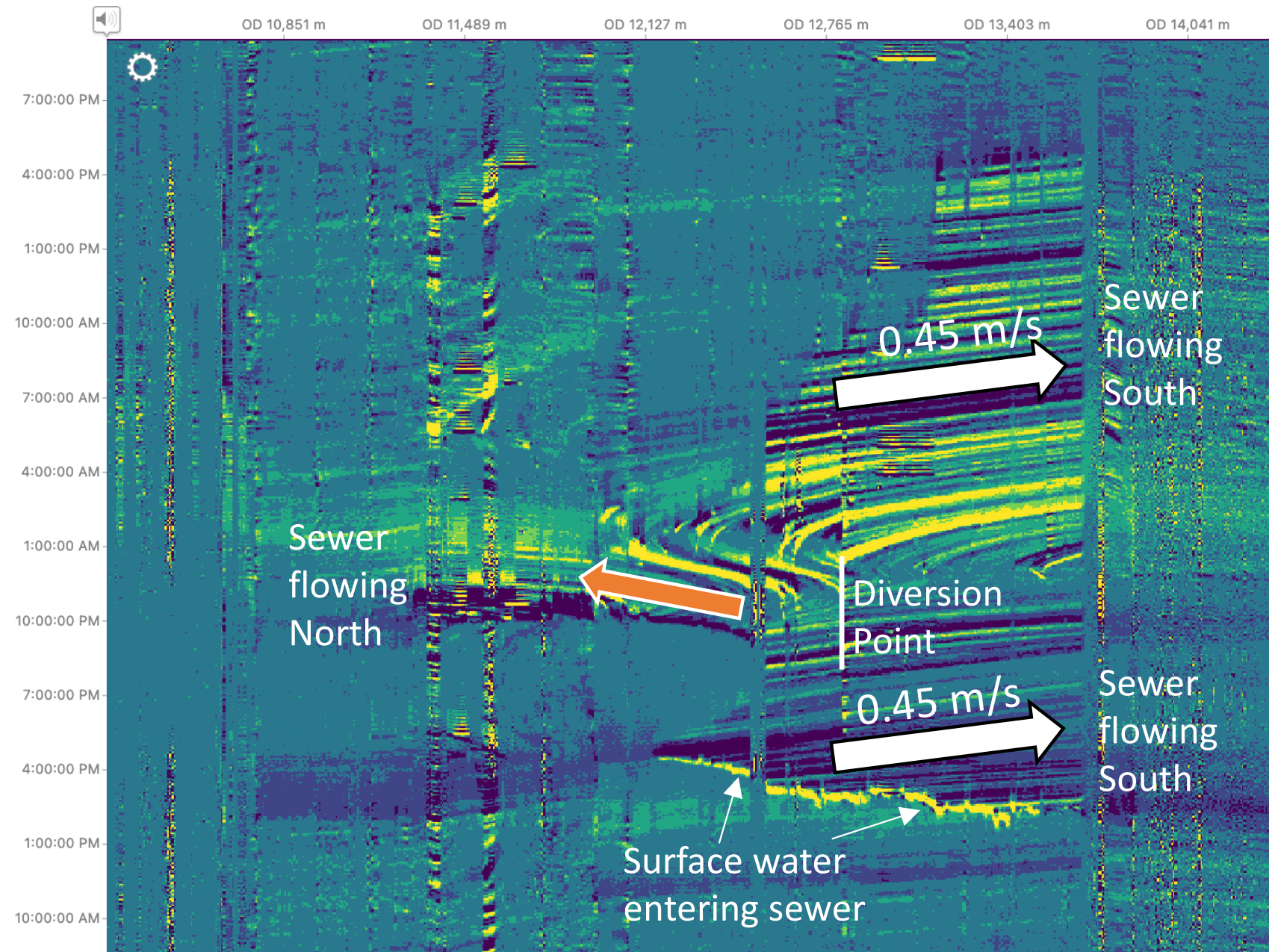
Co-linear monitoring provides a paradigm shift in how to think and utilize sensing. In contrast to IoT, linear sensing provides the ability to see the forest and trees.

Major water utility w/ >5,000-mile mainline network: “...this is the lowest cost leak detection solution before even considering damage prevention benefits...”



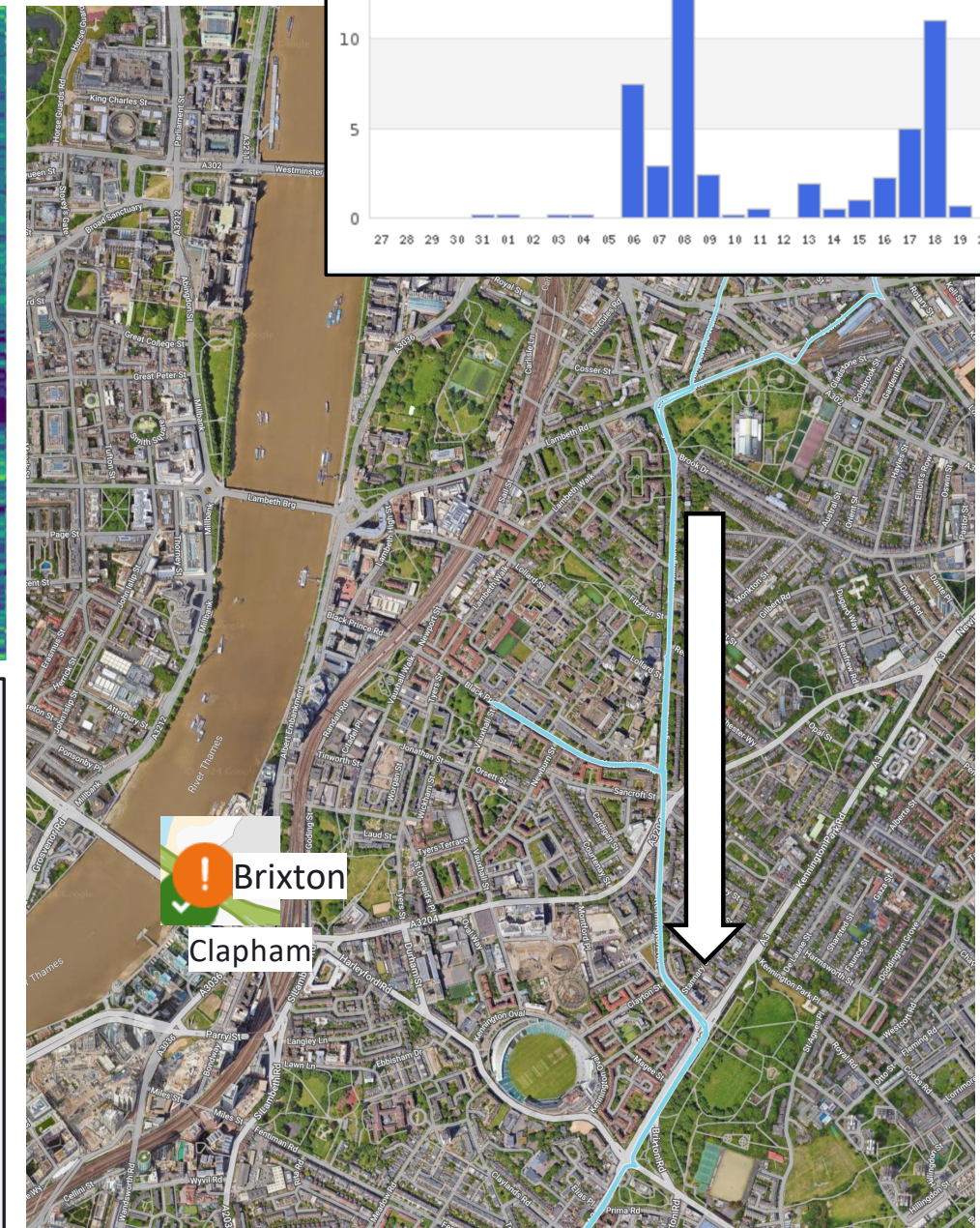
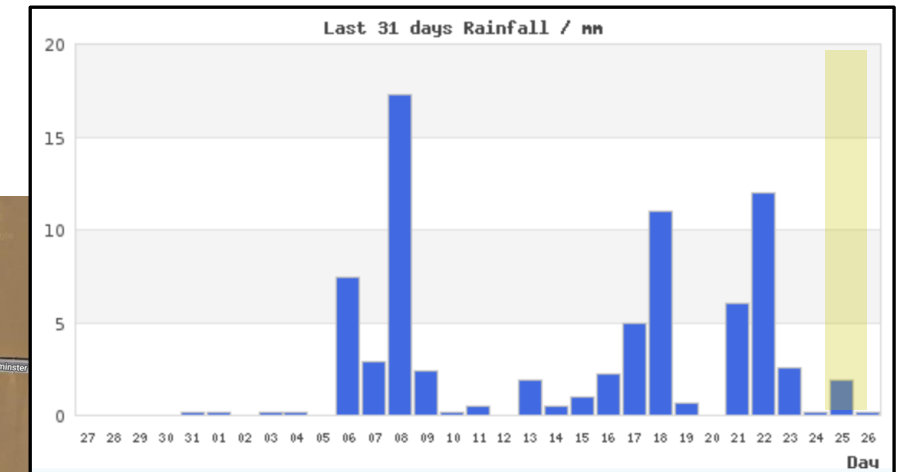
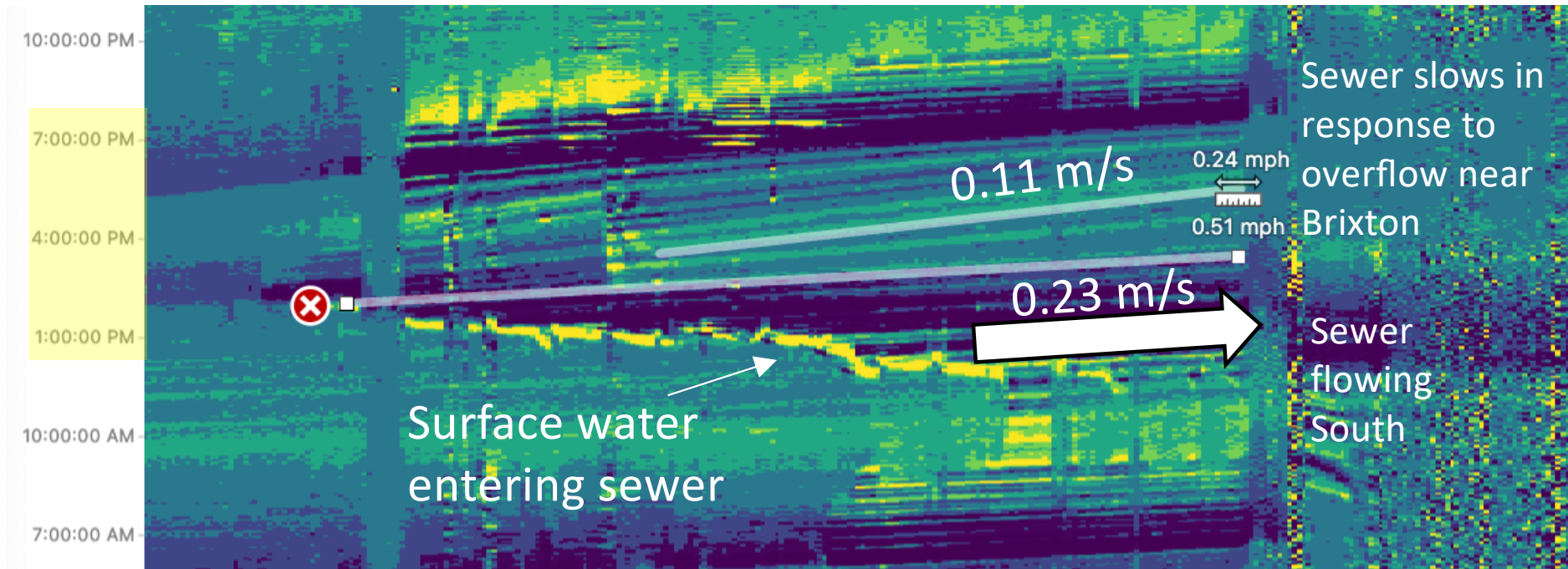
Sewer Flow Monitoring

Major rain event Feb-18-2024 caused sewer flow diversion



Thames Water, London: Sewer Flow Monitoring

Major rain event Feb-18-2024 caused sewer flow diversion



Brixton Storm Relief Sewer
Feeds into: River Thames

[Improvement plan](#) for this location

Discharge recorded in the last 48 hours

Our monitor indicates this storm overflow discharged in the last 48 hours. This means there could be sewage in this section of the watercourse.

Most recent discharge

Started	Stopped	Duration
25/02/24 12:10	25/02/24 17:24	5 hrs 14 mins



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Is Sensing as a Service economic? – 3,500 mainline water network example

A mainline water network: Comprehensive coverage

- Intrusion protection and leak detection and location
- Continuously monitored 24/7 - System continues to learn and improve from global AI and ML
- **No capex investment or O&M** by the customer, FiberSense procures fiber & sensing units
- Customer provides secure location(s) for sensing units, power, and internet access
- Ability to begin scaling coverage ***within weeks*** of commitment – expand w/ utility priorities

Costs

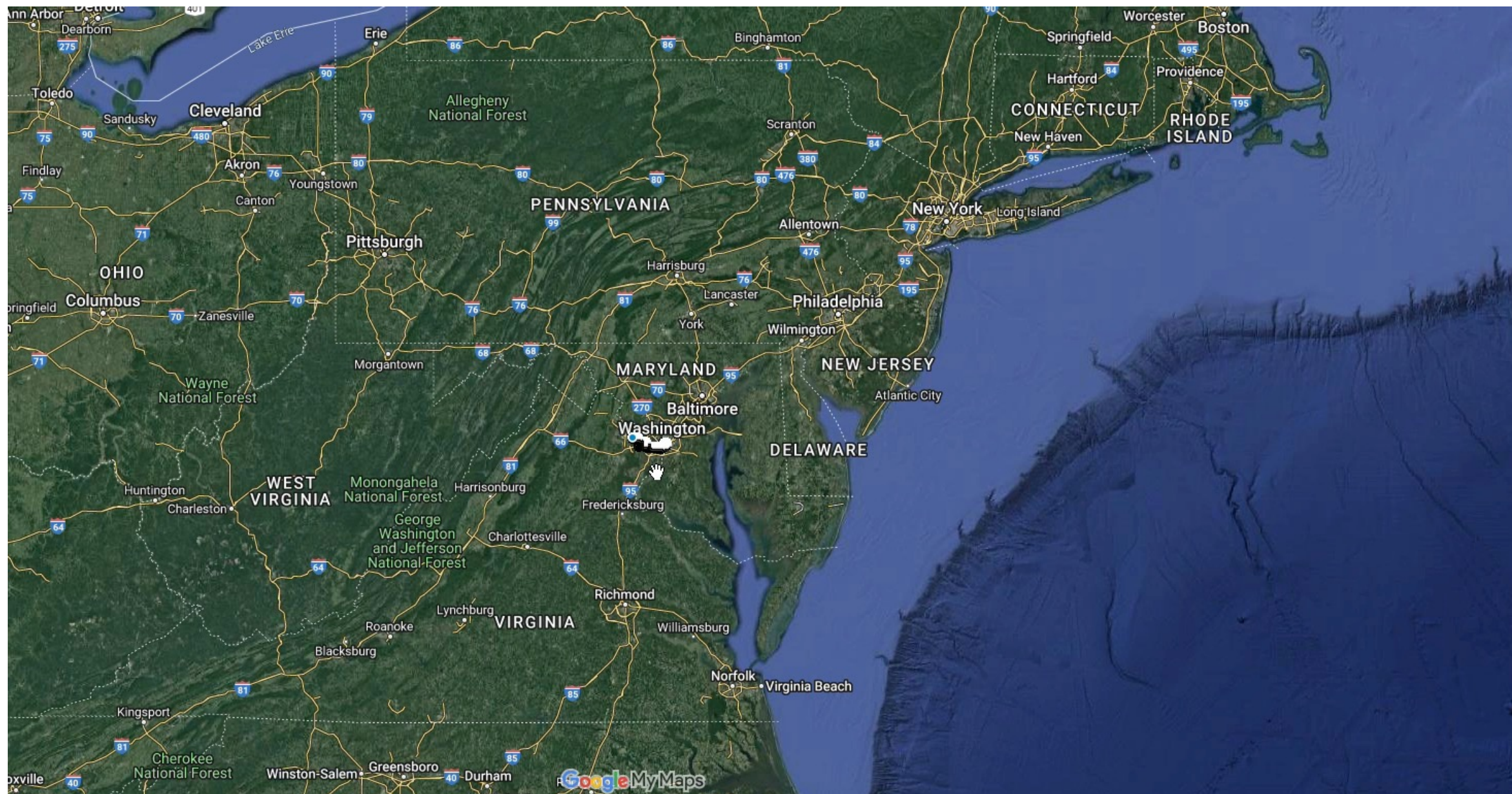
- One-time, non-recurring, system set-up costs plus monthly service cost for scale level service:

3,500-mile system with continuous 24/7 coverage = **~\$400K/month**

24/7 interdiction service would add an estimated ~10% to the cost at this scale
Other sensing and asset monitoring can be added depending on local conditions/needs

Equivalent to adding >1,000,000 point sensors

Example of how a city or geotechnical firm could use DigitalGeotech in Washington D.C. – sensitive fiber optic route between alphabet agencies



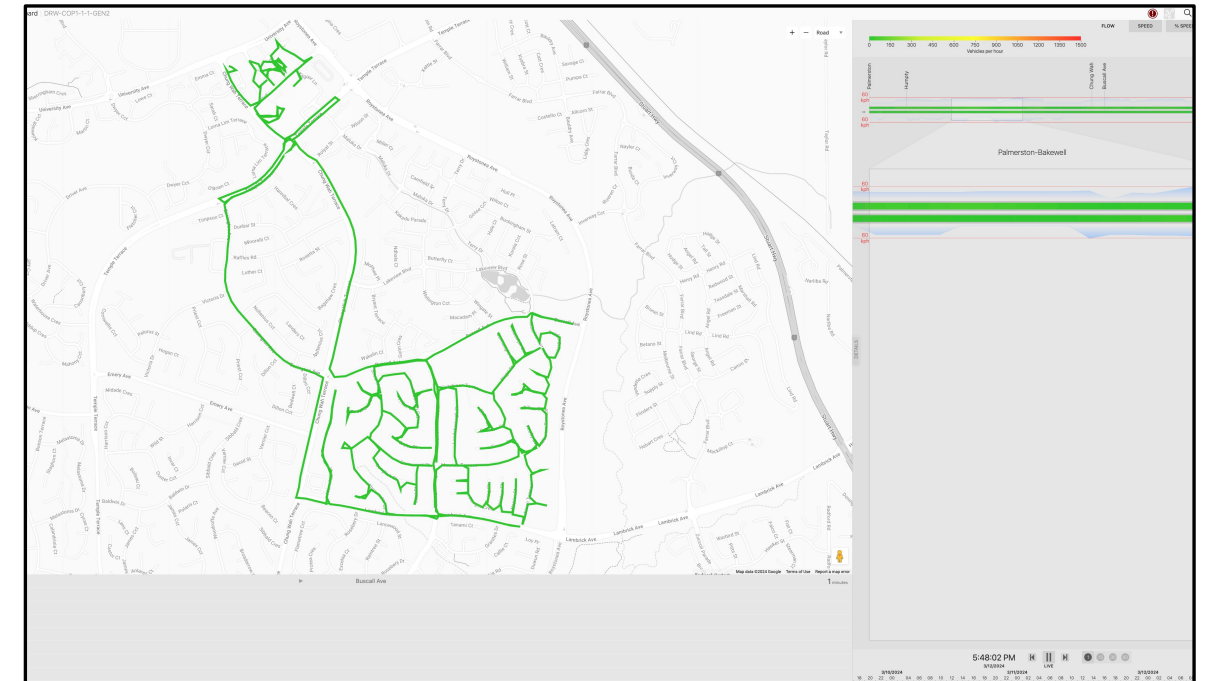
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Digital City mobility solutions: Road utilization

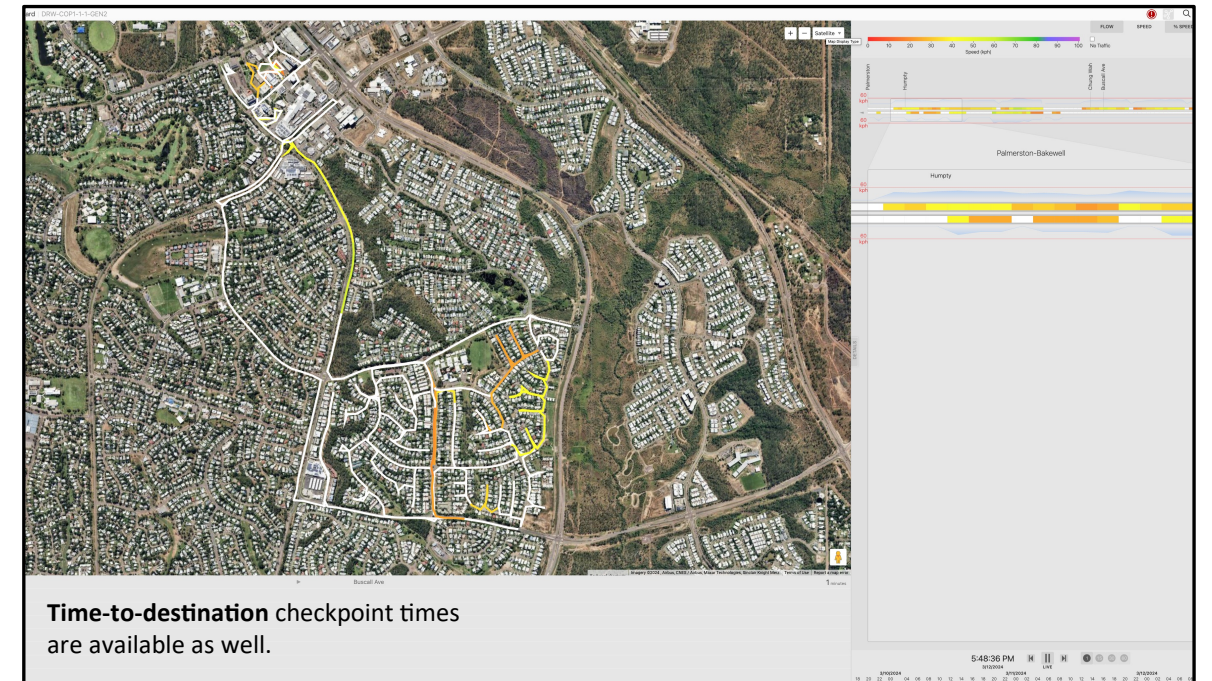
FiberSense provides real-time vehicle tracking data to inform decision-makers



Road utilization is analyzed both in real-time with a live dashboard and historically to provide road authorities, city governments, and others with data about infrastructure and human mobility patterns. Vehicle weight can also be monitored to help mitigate damage to essential infrastructure, like bridges.



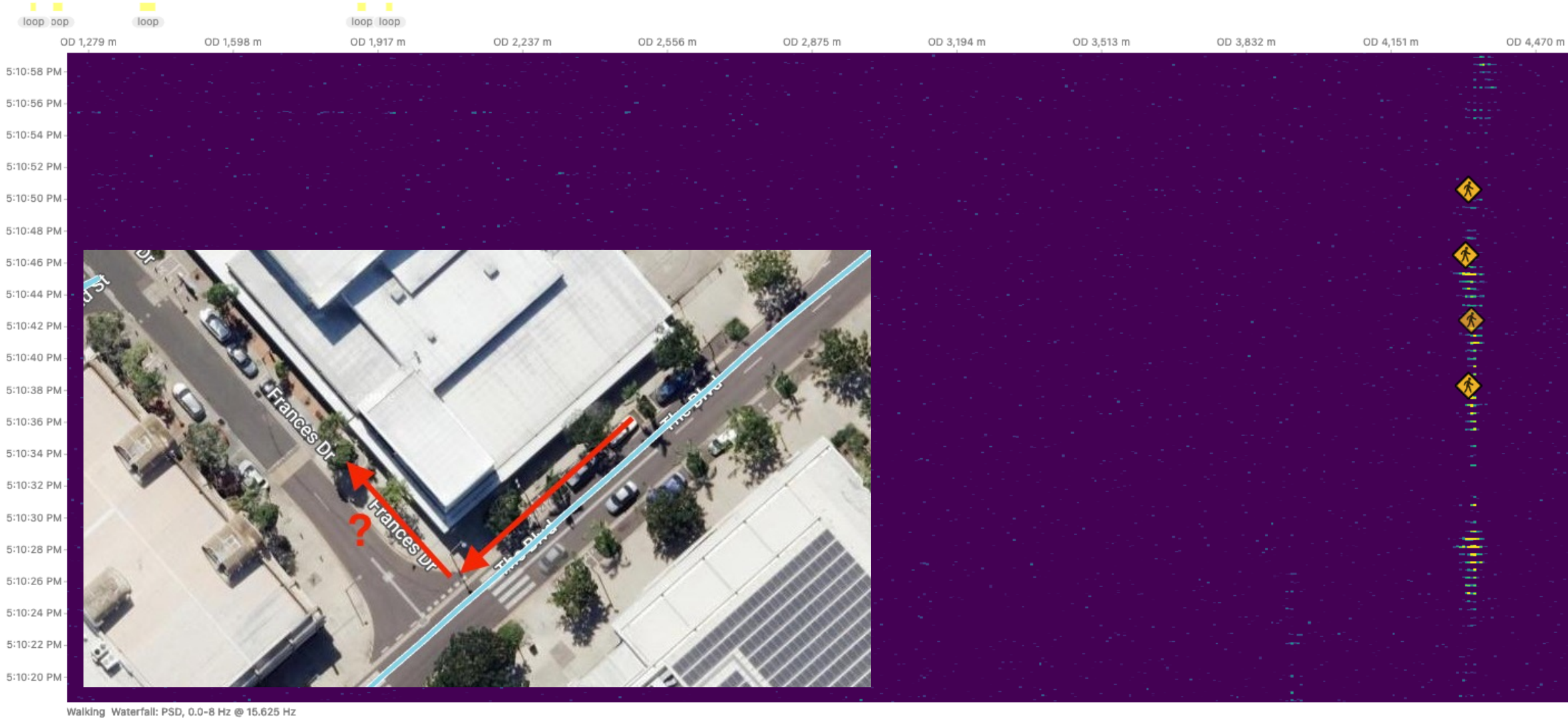
Congestion over 50-meter segments of the road provided in real time.



Average speed over 50-meter segments of the road provided in real time.

Pedestrian Tracking

FiberSense has developed footstep detection: monitor pedestrian traffic associated with vehicle mobility – bus stops, events, etc.

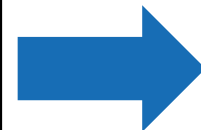


Unlocking potential insights – game changing real time detection of objects and events

*a confidential example
traffic event reconstruction*

FiberSense has a DigitalCity™ solution deployed for a city suburb

Ability to detect and track individual vehicles, time, speed, and direction



Pedestrian fatality occurred June 2023



Utilized existing fiber installed along roadway

Ability to track, w/o gaps two object types: pedestrians & vehicles

Rewind: Ability to go back in time to reconstruct objects and events

Partial summary of what FiberSense detection insights provided:

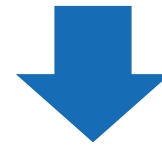
1. Time, direction, speed w/ changes of 19 vehicles over >10 km highway **plus** location, direction, speed of pedestrian, and road crossing point.
2. **Impact vehicle:** Speed of vehicle over >10 km segment, at impact location, breaking distance, and stopping point, vehicle left idling, occupants left then returned to vehicle, vehicle backs up, car turned off, occupants left, move on road & return, vehicle departs in wrong direction
3. All vehicles tracked to point and time where vehicle passed highway cameras for ID of witness vehicles and impact vehicle.

Analysis provided within hours of request

Local authorities performed blind test of FS system – confirming speed detection < 1% deviation from calibrated speedometers and GPS.

Imagine how effectively this tool could benefit Public Safety reconstructing accidents, intrusion, and damage events and, if needed, provide the ability to assign responsibility

A Digital City “Sensing as a Service” application for Typical City – initial focus on Central Business District (CBD)



Leverage 3rd Party fiberoptic cable installed in CBD – *supplement as needed*

Water Department

- Intrusion protection
- Leak detection and location
- Wastewater flow monitoring

Department of Public works

- Mobility improvement
- Heavy truck & bridge activity
- Stormwater events
- Fiber network protection

Public Safety

- Traffic movement
- Pedestrian movement
- Real-time event awareness and rewind

Electricity

- Intrusion protection
- Fault detection & location

Natural Gas

- Intrusion protection
- Leak detection and location

Others

Fiber network owners
Chilled water networks
Parking
Dams and levees

Each department or entity has custom access to a portal and alerts applicable to their activity



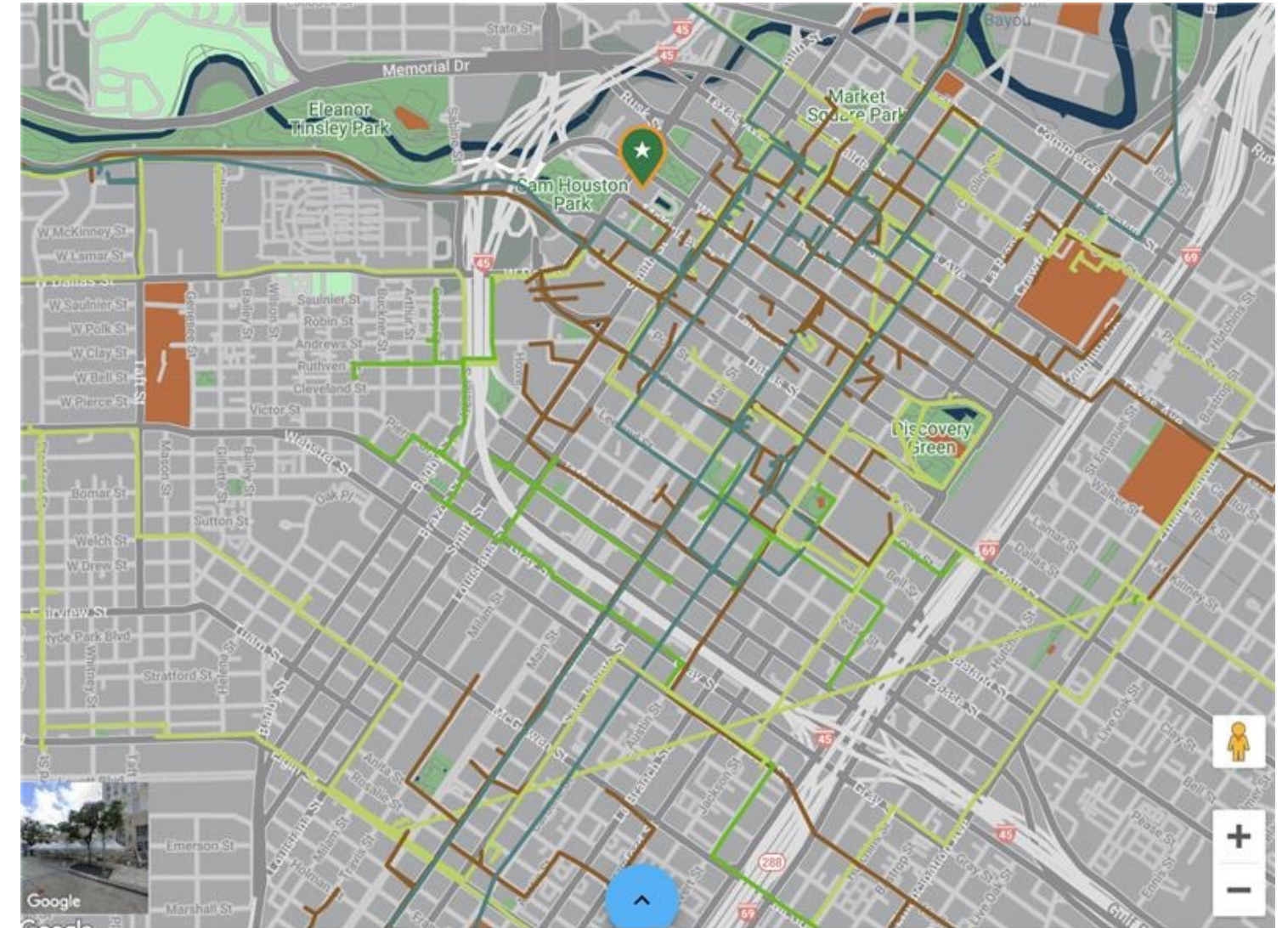
Example: active work
811 Permit & location
Contractor
Contact info
Rogue activity – outside 811 ticket



FIBERSENSE

Example: Houston CBD fiber – 3rd party owned routes only (5 primary only)

PS Lightwave



Crown Castle, Extenet, Fiberlight, Zayo

Questions?

How can we help solve your challenge?

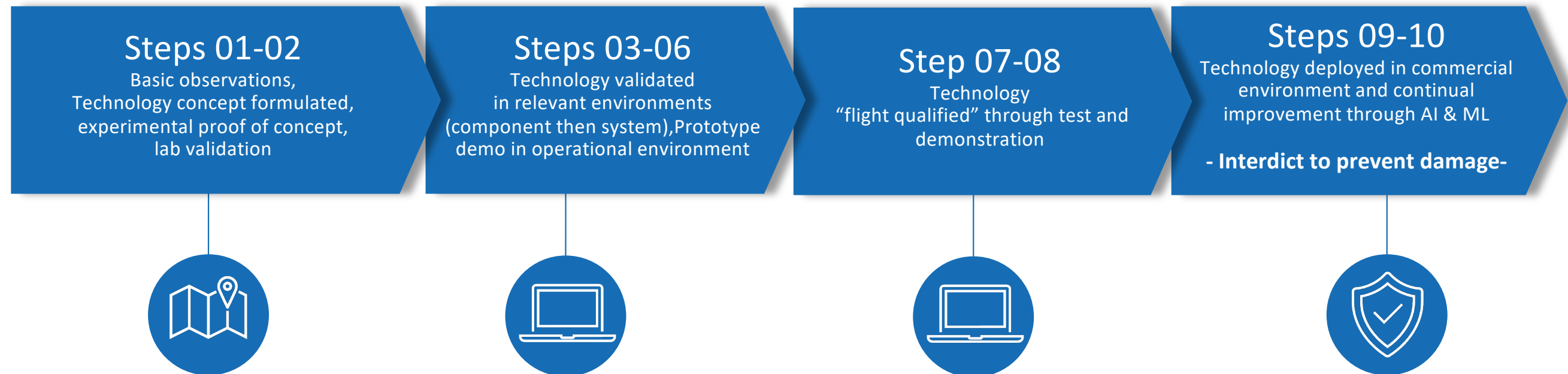
Appendix

How and Why FiberSense “Sensing as a Service” works

	FiberSense business model	Benefits to the end user
Hardware	Continuous investment in hardware upgrades	<ul style="list-style-type: none"> Maintenance and upgrades provided – no obsolescence risk
Software	Hardware enhanced by cloud level analytics	<ul style="list-style-type: none"> Routine, scheduled updates of analytical tools at all levels Includes massive data retention for analysis - “rewind” events...
	Ecosystem to accelerate learning through expanding library w/ increased utility value	<ul style="list-style-type: none"> Threats change/evolve – not constrained to localized experiences ML and AI algorithms adapt to meet changing global threats
Technical capabilities	Investment to hire/retain/develop team w/ highly specialized technical skills is costly.	<ul style="list-style-type: none"> Rent surgical skills w/ 24/7 access when needed vs. “own” Improving skills from global platform and experience
	24/7 NOC by technical team w/ global photonic & sonar skills applied to monitoring	<ul style="list-style-type: none"> 24/7 global expert review to provide monitoring insights Contributes: best-in-class false positive/negative performance
Two complementary approaches	Pay as you go - “Sensing as a Service”	<ul style="list-style-type: none"> Little or no capex to end-user w/ all of the above benefits
	Capitalized approach to service: “rate base”	<ul style="list-style-type: none"> Potential to capitalize investment w/o sacrificing benefits



The FiberSense rigorous multi-step Technology Readiness Level (TRL) Process to Commercialize a capability for Asset Protection



FiberSense solutions for different needs

DigitalAsset™ protects telecoms and linear underground assets from excavation

DigitalMarine™ protects subsea cables from fishing and anchoring, Can also observe cover change

DigitalLeak™ protects water/gas pipeline utilities from non-revenue water loss and catastrophic failure events. Enhancing for other liquids and gas products ex: CO₂

DigitalSeismic™ provides seismologists with EQ ground motion data, including in situ strain monitoring

DigitalGeotech™ provides engineers with SW dispersion data – Enhancing for dams and levees

DigitalCity™ provides city governments and road authorities with human mobility data (vehicle and pedestrian)

DigitalBridge™ provides civil engineers with bridge modes data and RT utilization

