Connected Signals and Safety

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Alabama Department of Transportation

SW Region

Common Issue 1

- Stuck at a red light, and there isn’t a car in sight…

Common Issue 2

- You finally get a green light, and 500 feet down the next signal just turned red… Catching every signal on red.

Someone needs to time these signals...

Someone needs to do SOMETHING...

Original HSIP Application

Signal Timing Program

Why we need one, and what will it take?

Custom HSIP Application

In 2019, we had the following crashes:

Geographic Region	Total Crashes	At Intersection		Traffic Control	
		Yes, Crash Occurred at Intersection	% of Total	Signalized Intersections	% of Total
SW Region	**24,503**	**12836**	**52.4%**	**6540**	**26.7%**
Mobile Area	**22,864**	**12192**	**53.3%**	**6410**	**28.0%**
Mobile	15,741	9085	57.7%	4761	30.2%
Baldwin	5,938	2748	46.3%	1597	26.9%
Conecuh	391	78	19.9%	12	3.1%
Escambia	794	281	35.4%	40	5.0%
Grovehill Area	**1,639**	**644**	**39.3%**	**130**	**7.9%**
Clarke	400	228	57.0%	50	12.5%
Washington	206	57	27.7%	4	1.9%
Monroe	351	138	39.3%	30	8.5%
Choctaw	199	64	32.2%	8	4.0%
Marengo	333	100	30.0%	29	8.7%
Wilcox	150	57	38.0%	9	6.0%

Original HSIP Application

Using the 5% reduction and the 13% reduction, I then started to calculate a range of benefits based on achieving those crash reductions.

Geographic Region	Total Crashes	At Intersection		Traffic Control		Signal Timing Crash Reduction Totals	
		Yes, Crash Occurred at Intersection	% of Total	Signalized Intersections	% of Total	5% CRF	13% CRF
SW Region	**24,503**	**12836**	**52.4%**	**6540**	**26.7%**	**327**	**850.2**
Mobile Area	**22,864**	**12192**	**53.3%**	**6410**	**28.0%**	**320.5**	**833.3**
Mobile	15,741	9085	57.7%	4761	30.2%	238.05	618.93
Baldwin	5,938	2748	46.3%	1597	26.9%	79.85	207.61
Conecuh	391	78	19.9%	12	3.1%	0.6	1.56
Escambia	794	281	35.4%	40	5.0%	2	5.2
Grovehill Area	**1,639**	**644**	**39.3%**	**130**	**7.9%**	**6.5**	**16.9**
Clarke	400	228	57.0%	50	12.5%	2.5	6.5
Washington	206	57	27.7%	4	1.9%	0.2	0.52
Monroe	351	138	39.3%	30	8.5%	1.5	3.9
Choctaw	199	64	32.2%	8	4.0%	0.4	1.04
Marengo	333	100	30.0%	29	8.7%	1.45	3.77
Wilcox	150	57	38.0%	9	6.0%	0.45	1.17

Original HSIP Application

5% KABCO Reductions					13% KABCO Reductions				
Fatal (K)	Incapacitating (A)	Non-Incapacitating (B)	Possible Injury (C)	Property Damage Only (O)	Fatal (K)	Incapacitating (A)	Non-Incapacitating (B)	Possible Injury (C)	Property Damage Only (O)
0.3	3.5	21.3	29.5	265.9	0.8	9.1	55.3	76.8	691.4
0.3	3.4	20.8	29.0	260.6	0.8	8.9	54.2	75.3	677.7
0.2	2.6	15.5	21.5	193.6	0.6	6.6	40.2	55.9	503.3
0.1	0.9	5.2	7.2	64.9	0.2	2.2	13.5	18.8	168.8
0.0	0.0	0.0	0.1	0.5	0.0	0.0	0.1	0.1	1.3
0.0	0.0	0.1	0.2	1.6	0.0	0.1	0.3	0.5	4.2
0.0	0.1	0.4	0.6	5.3	0.0	0.2	1.1	1.5	13.7
0.0	0.0	0.2	0.2	2.0	0.0	0.1	0.4	0.6	5.3
0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.4
0.0	0.0	0.1	0.1	1.2	0.0	0.0	0.3	0.4	3.2
0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.1	0.1	0.8
0.0	0.0	0.1	0.1	1.2	0.0	0.0	0.2	0.3	3.1
0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.1	0.1	1.0

Original HSIP Application

Total Number of Signals	
416	
Coordinated	**Free**
122	294
Cost per Seasonal Signal (Coordinated)	**Cost per Non-Seasonal Signal (Coordinated)**
7000	4000
Cost per Seasonal Signal ("Free")	**Cost per Non-Seasonal Signal ("Free")**
2000	1500

*Average Signal Timing Cost of $3,600 per signal

Original HSIP Application

Geographic Region	5% KABCO Reductions					13% KABCO Reductions				
	Fatal (K)	Incapacitating (A)	Non-Incapacitating (B)	Possible Injury (C)	Property Damage Only (O)	Fatal (K)	Incapacitating (A)	Non-Incapacitating (B)	Possible Injury (C)	Property Damage Only (O)
SW Region	$ 479,378.85	$ 5,512,856.74	$2,741,351.46	$3,810,347.36	$2,559,240.12	$ 1,246,385.00	$ 14,333,427.52	$ 7,127,513.79	$ 9,906,903.14	$ 6,654,024.32
Mobile Area	$ 469,849.91	$ 5,403,273.96	$2,686,859.76	$3,734,606.51	$2,508,368.38	$ 1,221,609.77	$ 14,048,512.30	$ 6,985,835.38	$ 9,709,976.93	$ 6,521,757.78
Mobile	$ 348,979.00	$ 4,013,258.55	$1,995,653.56	$2,773,862.96	$1,863,079.85	$ 907,345.41	$ 10,434,472.24	$ 5,188,699.26	$ 7,212,043.71	$ 4,844,007.61
Baldwin	$ 117,059.33	$ 1,346,182.30	$ 669,409.52	$ 930,447.21	$ 624,939.83	$ 304,354.26	$ 3,500,073.97	$ 1,740,464.76	$ 2,419,162.74	$ 1,624,843.55
Conecuh	$ 879.59	$ 10,115.33	$ 5,030.00	$ 6,991.46	$ 4,695.85	$ 2,286.94	$ 26,299.87	$ 13,078.01	$ 18,177.80	$ 12,209.22
Escambia	$ 2,931.98	$ 33,717.78	$ 16,766.68	$ 23,304.88	$ 15,652.84	$ 7,623.15	$ 87,666.22	$ 43,593.36	$ 60,592.68	$ 40,697.40
Grovehill Area	$ 9,528.94	$ 109,582.78	$ 54,491.70	$ 75,740.85	$ 50,871.75	$ 24,775.24	$ 284,915.23	$ 141,678.41	$ 196,926.21	$ 132,266.54
Clarke	$ 3,664.98	$ 42,147.22	$ 20,958.34	$ 29,131.10	$ 19,566.06	$ 9,528.94	$ 109,582.78	$ 54,491.70	$ 75,740.85	$ 50,871.75
Washington	$ 293.20	$ 3,371.78	$ 1,676.67	$ 2,330.49	$ 1,565.28	$ 762.31	$ 8,766.62	$ 4,359.34	$ 6,059.27	$ 4,069.74
Monroe	$ 2,198.99	$ 25,288.33	$ 12,575.01	$ 17,478.66	$ 11,739.63	$ 5,717.36	$ 65,749.67	$ 32,695.02	$ 45,444.51	$ 30,523.05
Choctaw	$ 586.40	$ 6,743.56	$ 3,353.34	$ 4,660.98	$ 3,130.57	$ 1,524.63	$ 17,533.24	$ 8,718.67	$ 12,118.54	$ 8,139.48
Marengo	$ 2,125.69	$ 24,445.39	$ 12,155.84	$ 16,896.04	$ 11,348.31	$ 5,526.78	$ 63,558.01	$ 31,605.18	$ 43,929.69	$ 29,505.61
Wilcox	$ 659.70	$ 7,586.50	$ 3,772.50	$ 5,243.60	$ 3,521.89	$ 1,715.21	$ 19,724.90	$ 9,808.51	$ 13,633.35	$ 9,156.91

Original HSIP Application

After summing all of these up, I was able to come up with a decent B/C calculation for the Mobile Area:

BENEFITS		COST			
TOTAL (5%)	TOTAL (13%)	(Per Year)(From Other Spreadsheet)	B/C Ratio at 5% CRF	B/C Ratio at 13% CRF	Geographic Region
$ 15,103,174.53	$ 39,268,253.78	$ 600,000.00	25.17	65.45	SW Region
$ 14,802,958.52	$ 38,487,692.16	$ 500,000.00	29.61	76.98	Mobile Area
$ 10,994,833.93	$ 28,586,568.23				Mobile
$ 3,688,038.18	$ 9,588,899.28				Baldwin
$ 27,712.25	$ 72,051.84				Conecuh
$ 92,374.16	$ 240,172.81				Escambia
$ 300,216.01	$ 780,561.62	100000	3.00	7.81	Grovehill Area
$ 115,467.70	$ 300,216.01				Clarke
$ 9,237.42	$ 24,017.28				Washington
$ 69,280.62	$ 180,129.60				Monroe
$ 18,474.83	$ 48,034.56				Choctaw
$ 66,971.26	$ 174,125.28				Marengo
$ 20,784.19	$ 54,038.88				Wilcox

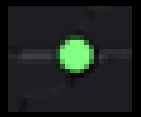
Humble Beginnings

- How do you “time” a signal?
- Not a single signal engineer in the SW Region
- Technicians did ALL signal timing…

- We knew how to connect devices to the network and have remote control over operations. Intuitively, this gives us insights into issues and the ability to address them remotely.

The Evolution of Signal Connectivity

- From standalone controllers

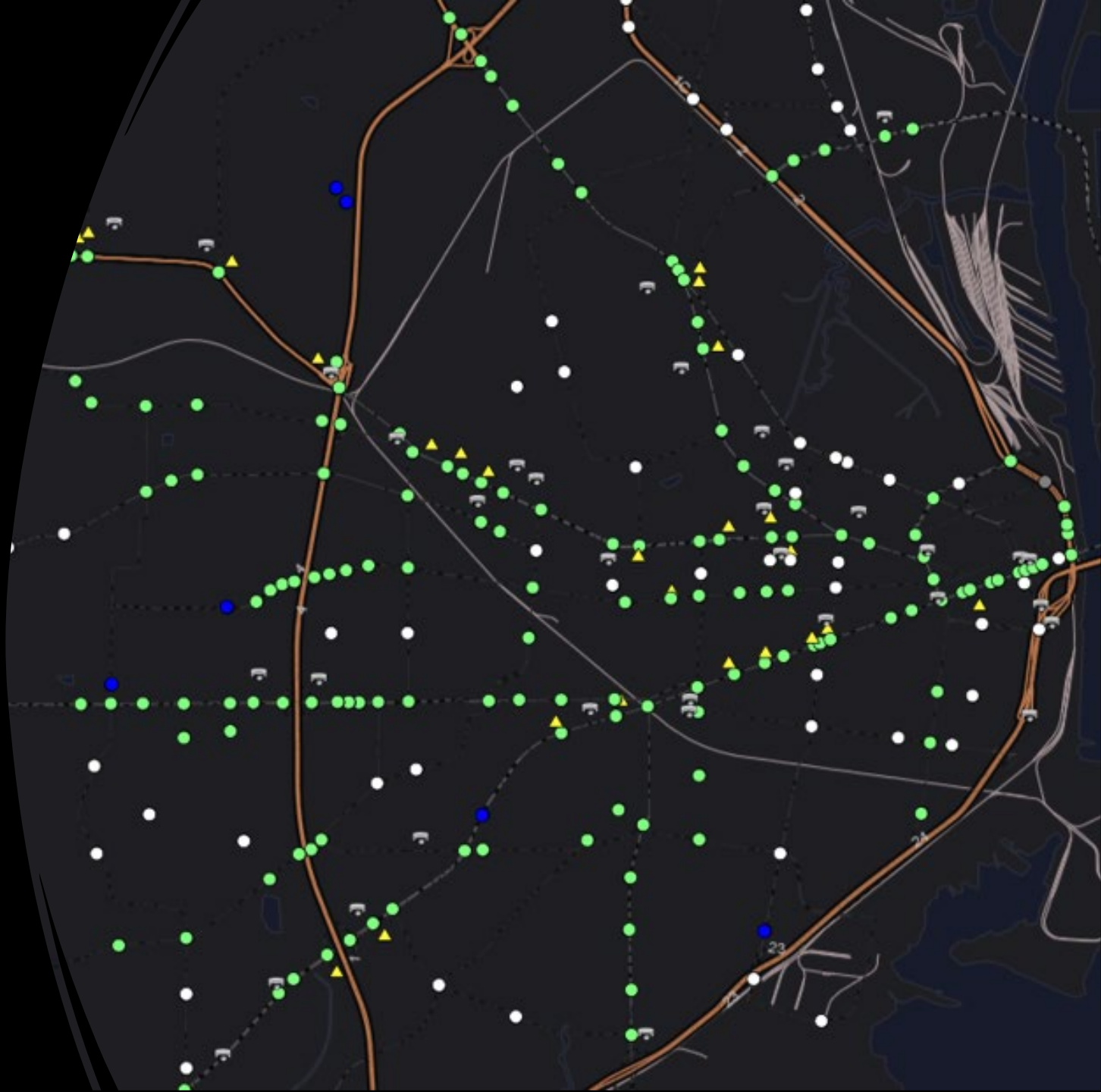


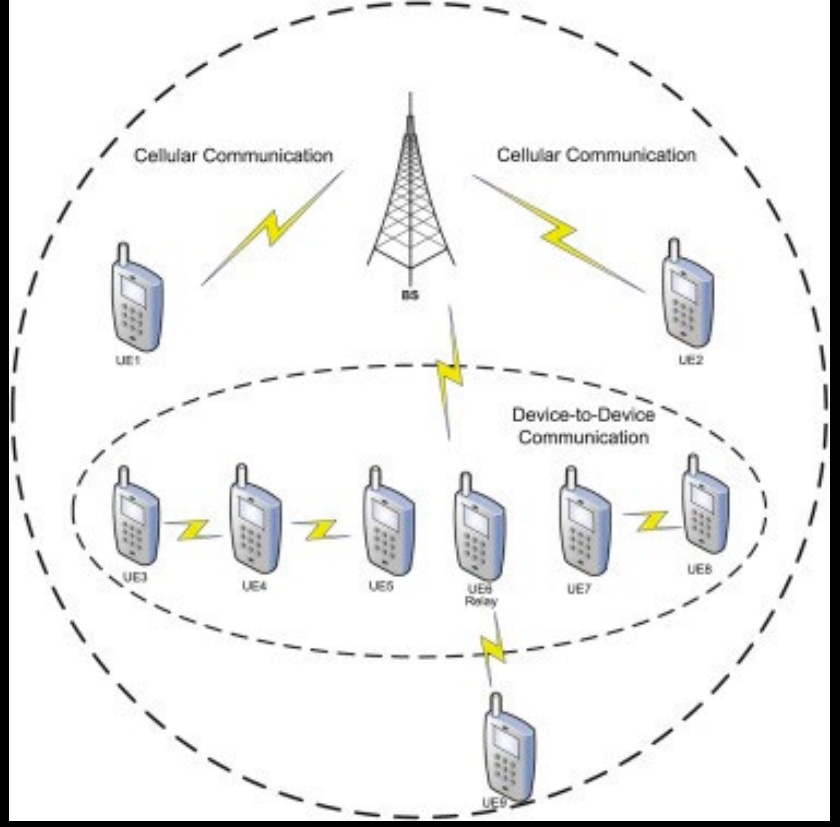
The Evolution of Signal Connectivity

- To Connected Corridors

The Evolution of Signal Connectivity

To Connected Traffic Grids



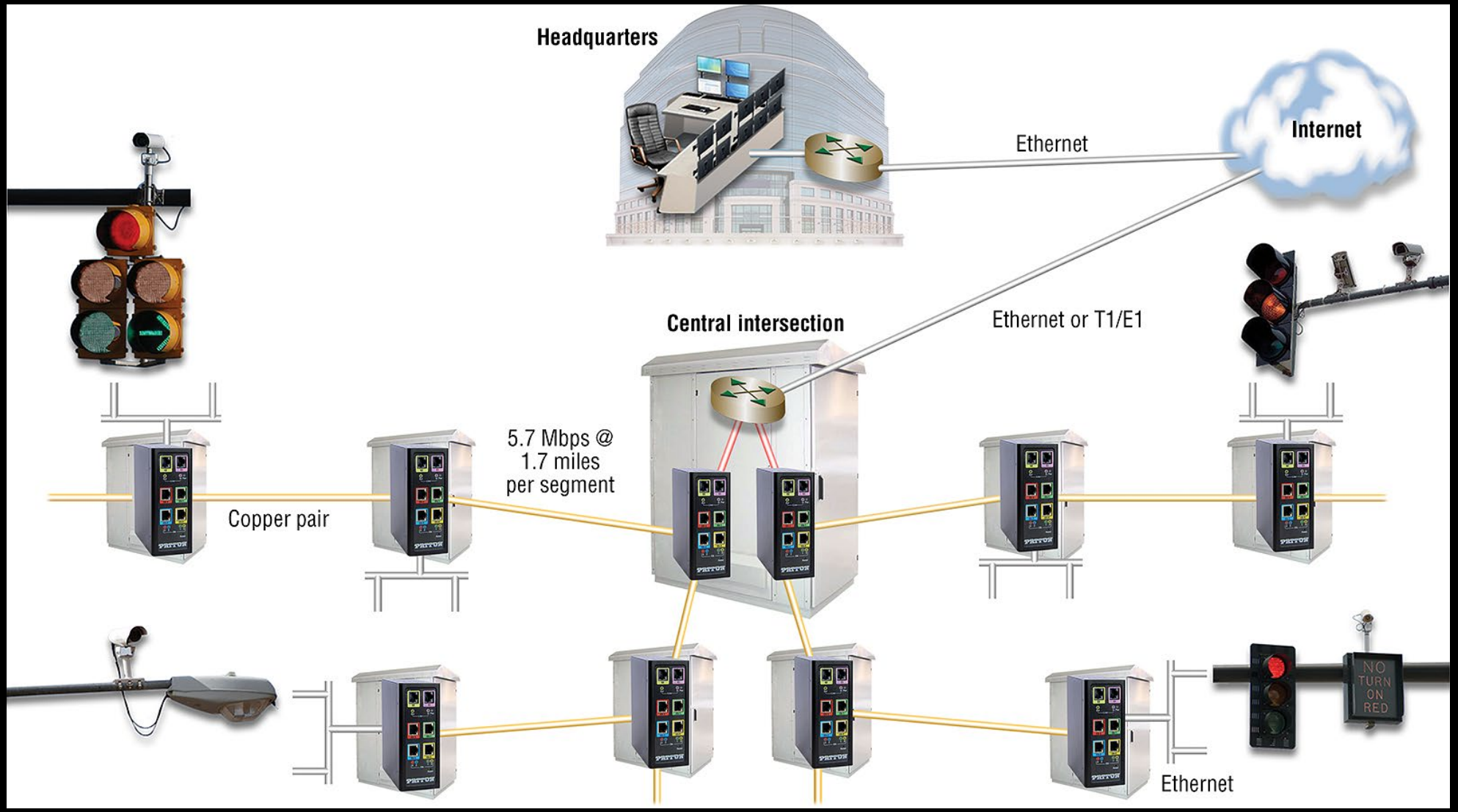


What Are Connected Signals?

Traffic signals connected to a remote computer via fiber, cellular, or VPN communications.

- **Functions Enabled:**
  - Remote control and timing updates.
  - Real-time monitoring (status, detection, comms health).
  - Automated alerts for faults or flash.
  - Integration with ATSPMs and CCTV.

What Are Connected Signals?



ALDOT SW Region's GO TO for Connected Signals

$3,500 Ethernet Capable Traffic Signal Controller

$2,500 Cell Modem & Antenna

$45 per Month Data Plan

Modernization and Standardization

1 standard controller in every signal remotely connected, monitored, operated

RTOP

REGIONAL TRAFFIC OPERATIONS PROGRAM

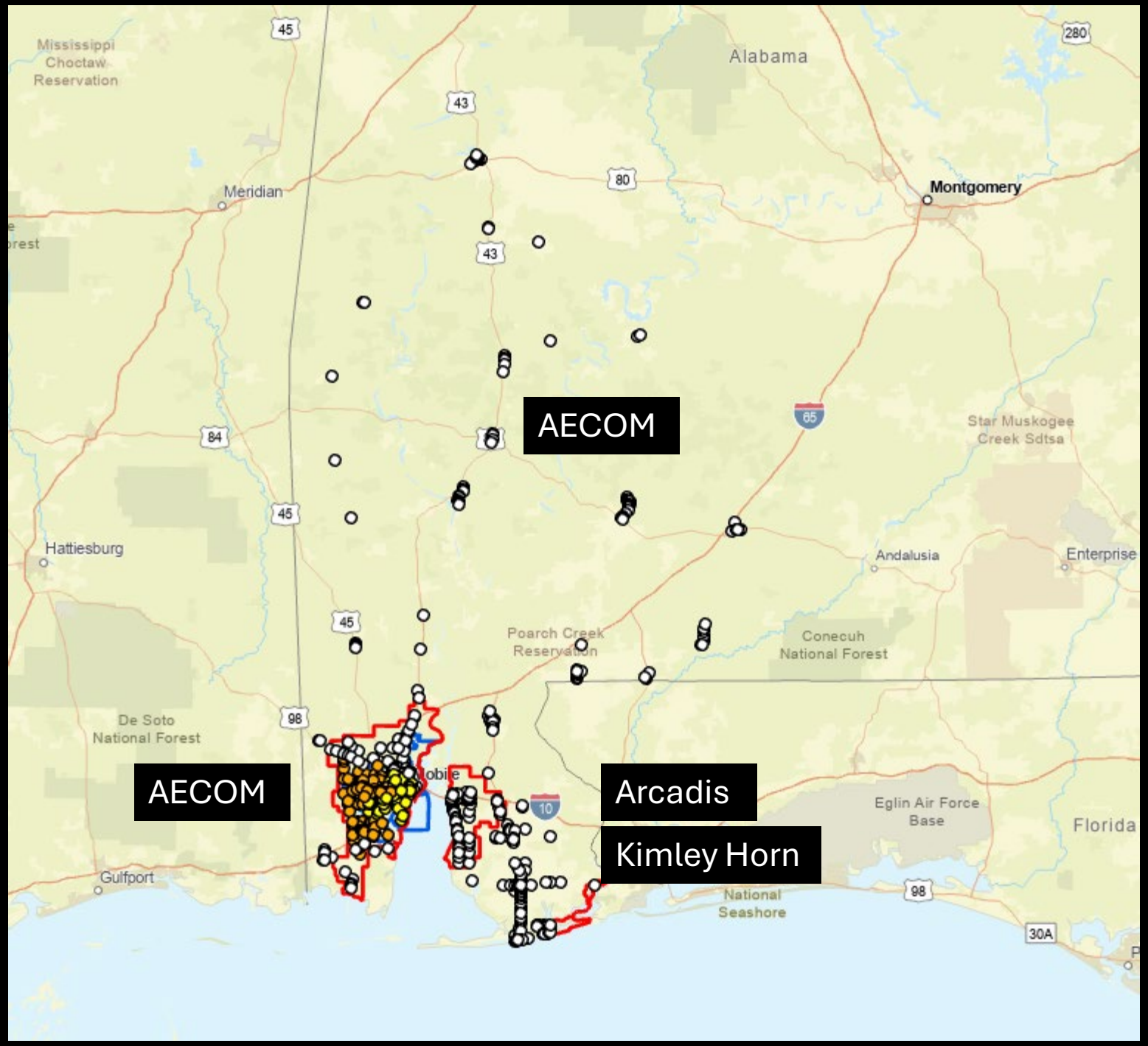
ALDOT

MOBILE
ALABAMA

ALDOT
Alabama Department of Transportation

MOBILE COUNTY
STATE OF ALABAMA • SINCE 1812


RTOP
REGIONAL TRAFFIC OPERATIONS PROGRAM


AECOM
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Meridian
Montgomery
Hattiesburg
Andalusia
Enterprise
Star Muskogee Creek Sdtsa
Poarch Creek Reservation
Conecuh National Forest
De Soto National Forest
Mobile
Eglin Air Force Base
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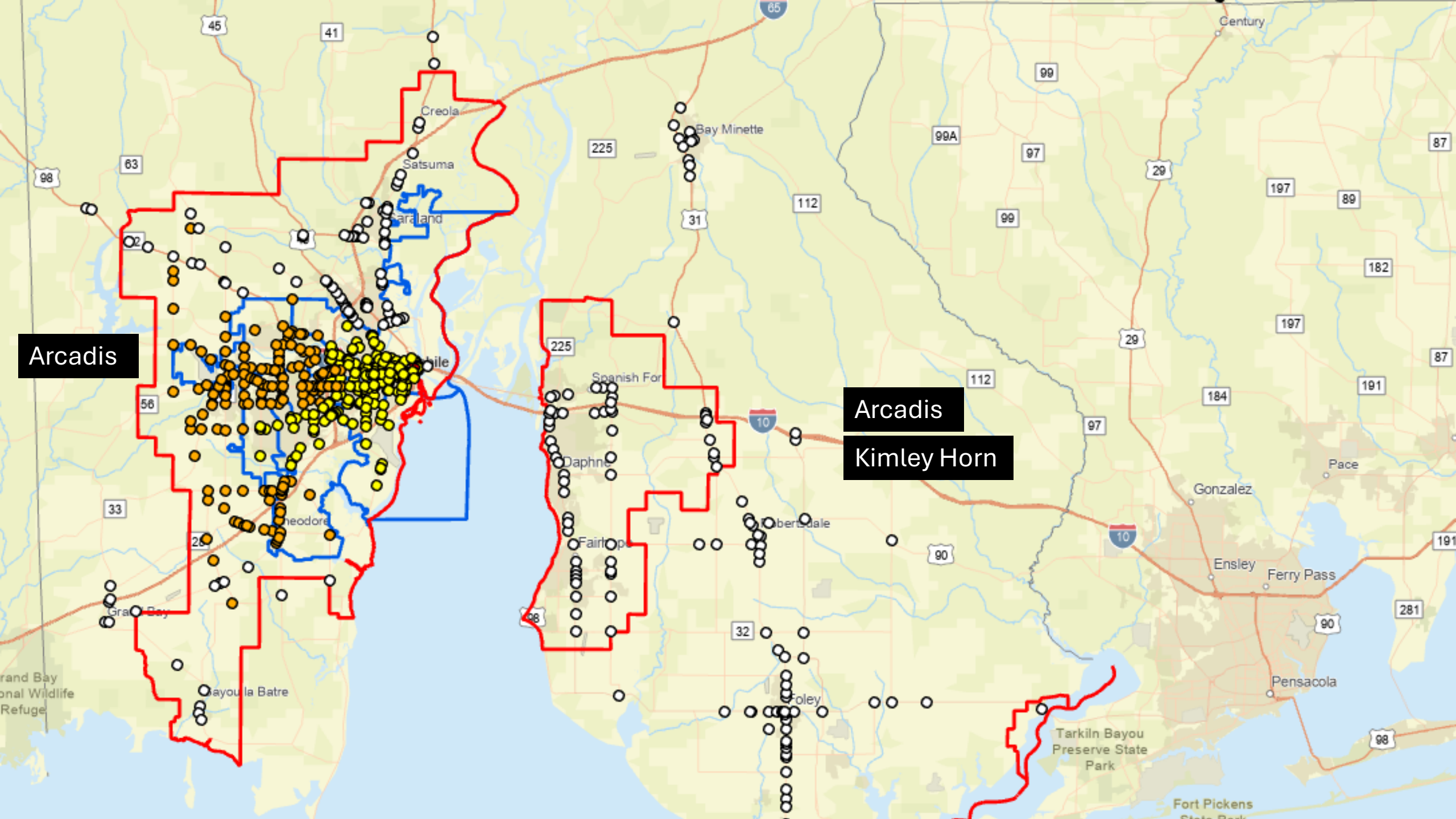
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Tarkiln Bayou Preserve State Park
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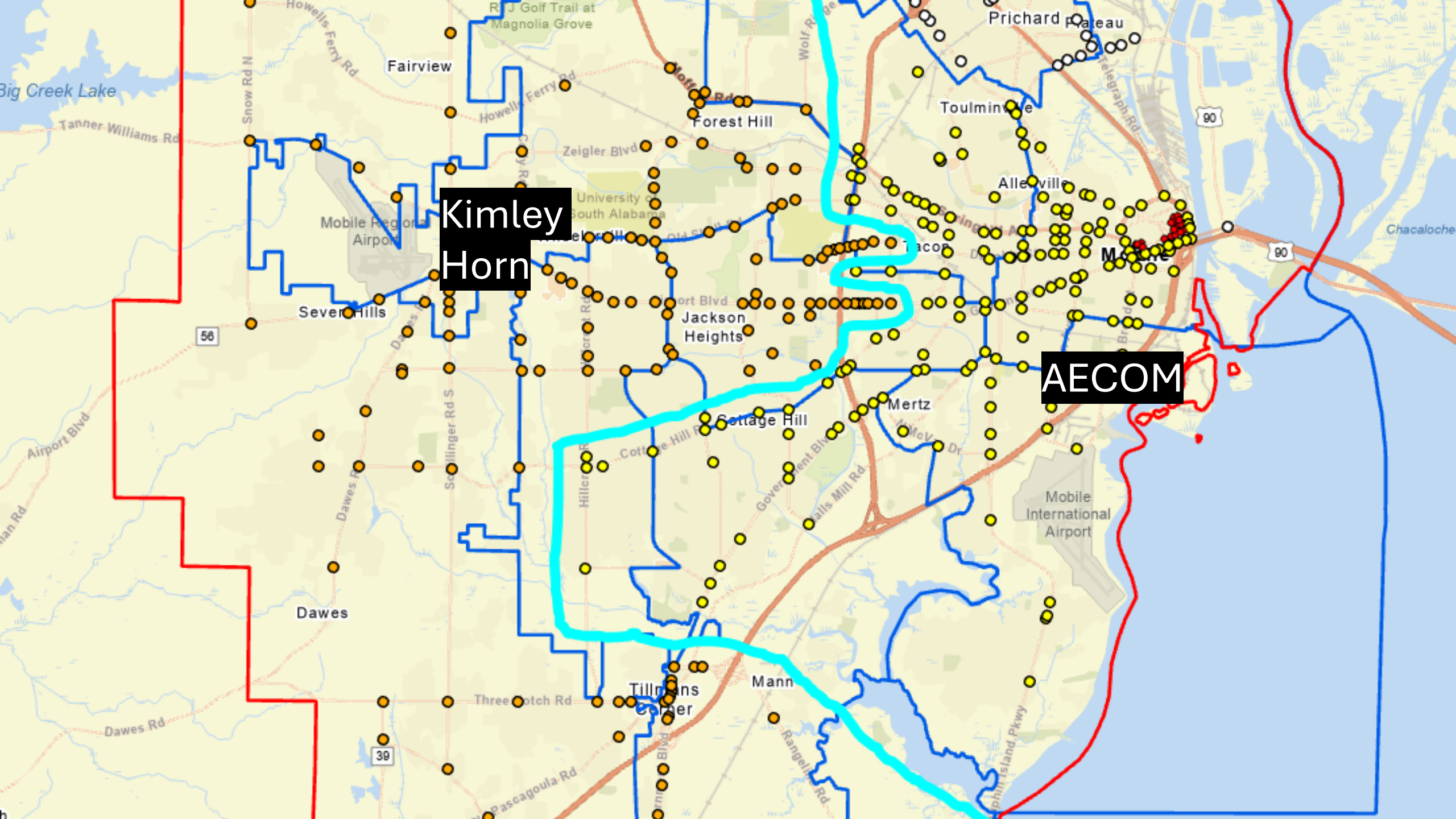

Kimley Horn
AECOM
Fairview
Forest Hill
Prichard
Toulminville
Alleyville
Mobile Regional Airport
University of South Alabama
Jackson Heights
Seven Hills
Cottage Hill
Mertz
Mobile International Airport
Dawes
Tillmans Corner
Mann
Big Creek Lake
Tanner Williams Rd
Howells Ferry Rd
Snow Rd N
Zeigler Blvd
Moffett Rd
Wolf Ridge Rd
Telegraph Rd
Airport Blvd
Dawes Rd
Three Notch Rd
Pascagoula Rd
Scollinger Rd S
Cottage Hill Rd
Halls Mill Rd
Rangeline Rd
Chacaloche
56
39
90

ALDOT SW Region's Connected Signal Network

- Over **700+ connected signals** in Southwest Region.
  - 99% of all signals in 1/5 of the State.

- Connectivity methods:
  - 80+ Fiber
  - 615+ Cellular Modems

- System used: **Centracs** (Econolite)
  - Discontinued Siemens' Tactics Control Software
  - Discontinued SCOOT Adaptive
  - Discontinued Centracs Adaptive
  - Tested and not pursuing Econolite's E-Adaptive

ALDOT SW Region's Connected Signal Network

- Collaboration with Cities/Counties/Consultants
- MAJOR Workforce Development
- 250+ RTOP Cameras to date
- 250+ Detection Systems in the works

ALDOT SW Region – Ownership vs Maintenance vs Operations

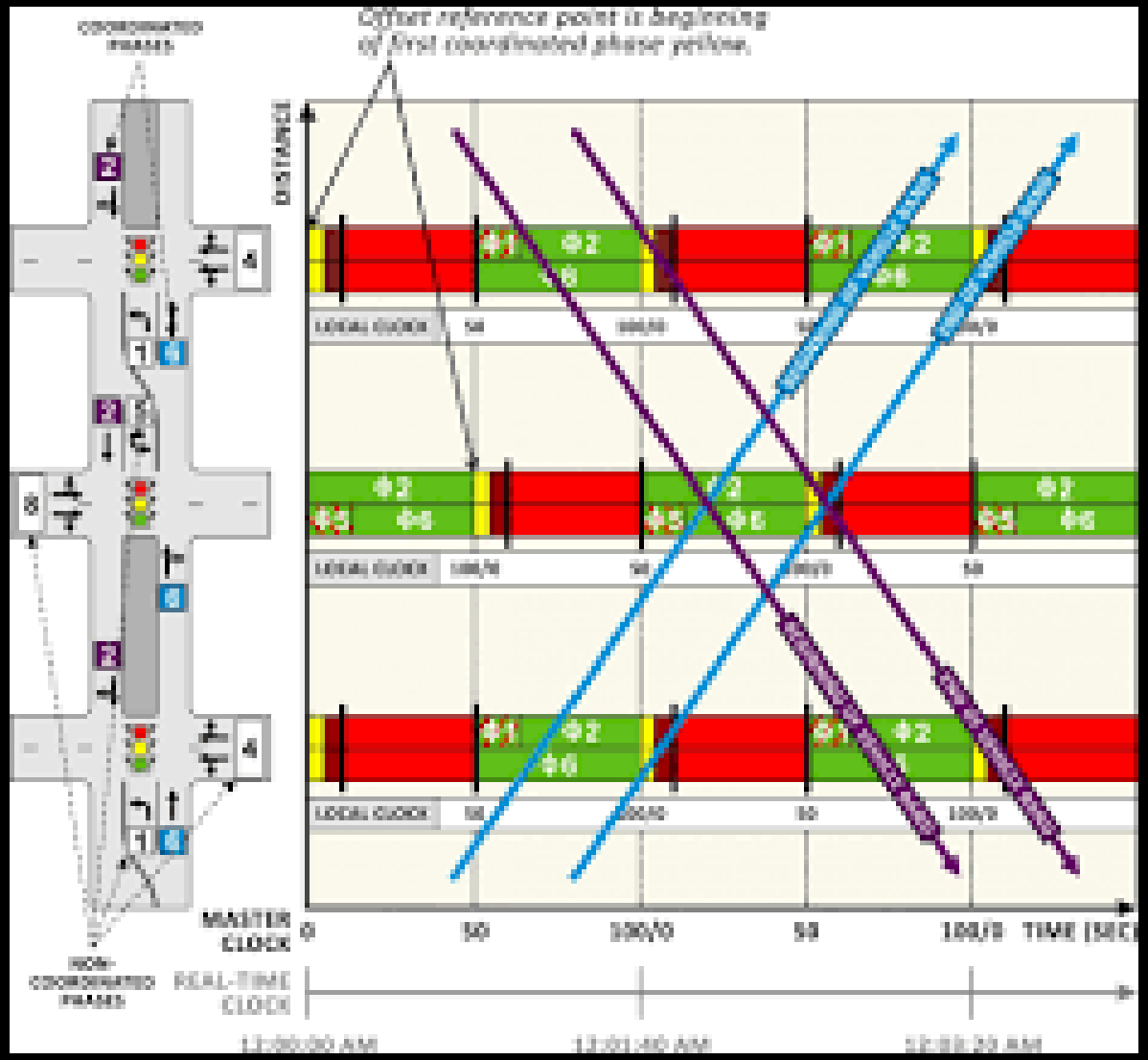
Agency	Ownership	Maintenance	Real Time Operations
ALDOT	64	282	470+
City of Mobile	300	300	200+
Mobile County	75	25	25
Other Cities/Counties	260+	25+	25

How Connectivity Improves Safety

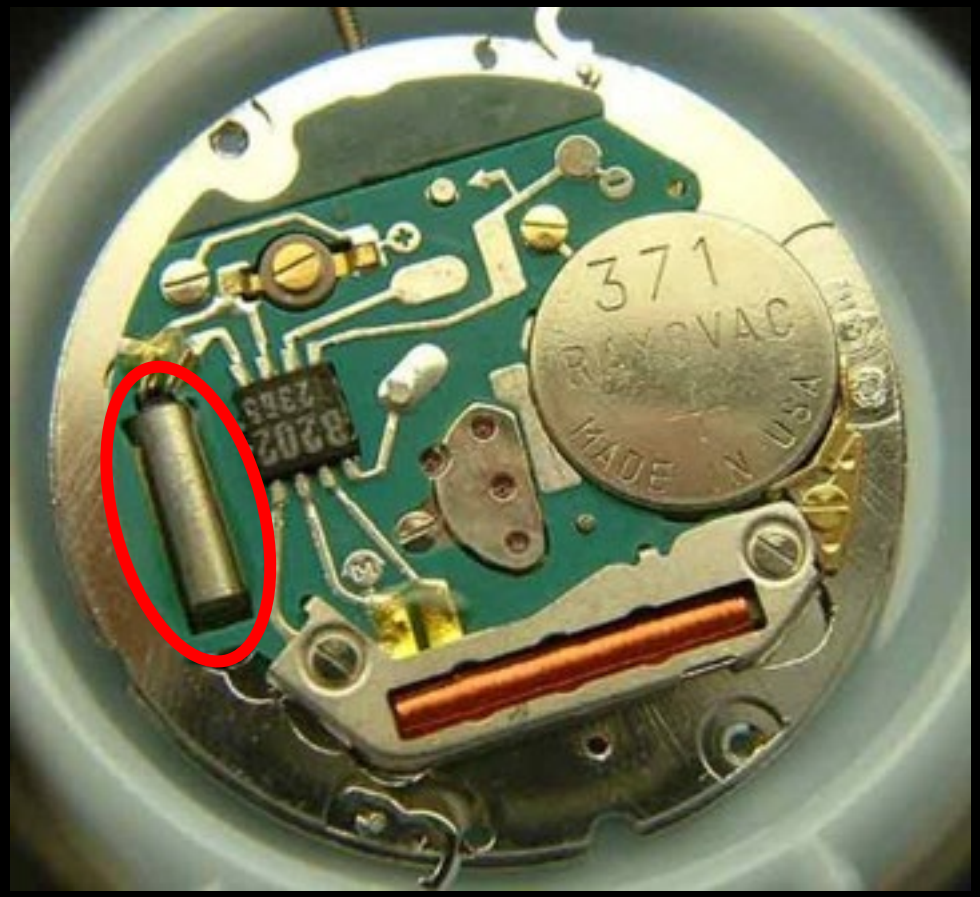
- **Faster response** to malfunctioning signals (flash, power loss, detection failures).
- **Data visibility** into how each part of the signal system is functioning enables responsive maintenance.
- **Data storage** can store historical detection data giving year round traffic data
- **Signal performance measures** (SPMs) highlight red/yellow trap risks, split failures, etc.
- **Rapid Retiming** can update and improve signal timing in mere hours or days instead of weeks or months or years.
- **Centralized oversight** ensures coordinated operations across jurisdictions.
- **Supports incident management** — operators can immediately place corridors in flash or change timing to support detours.

Before Connectivity…

Coordination/Synchronization



Time and Crystal Quartz Clocks: Clock Drift

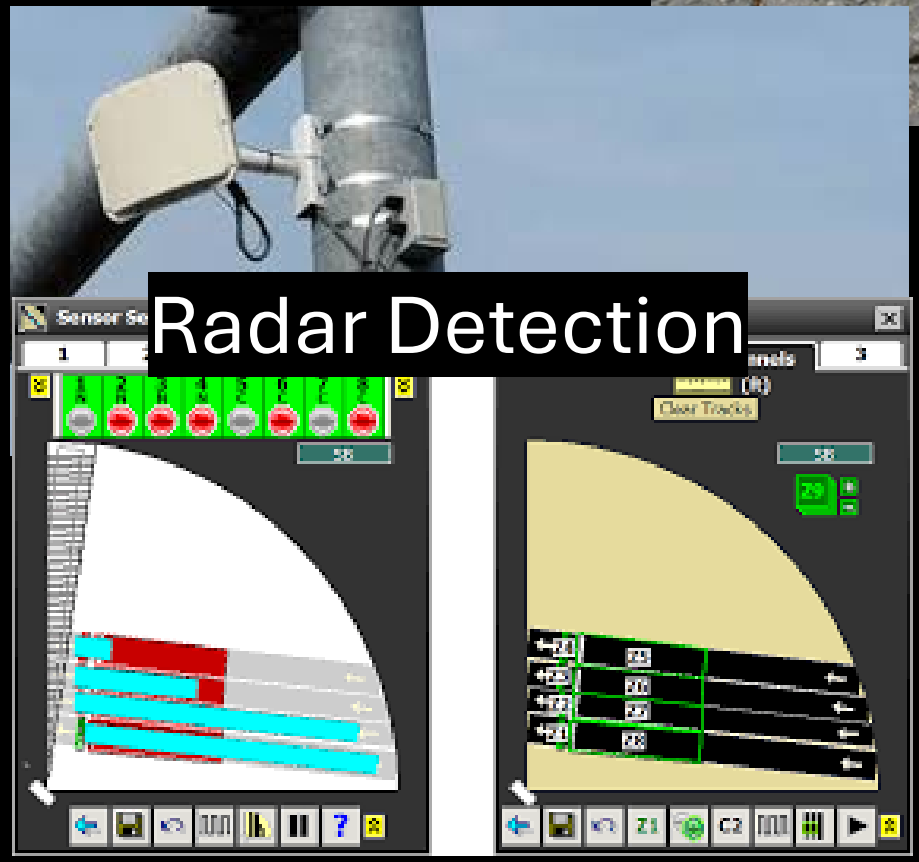


Clock Drift Illustration

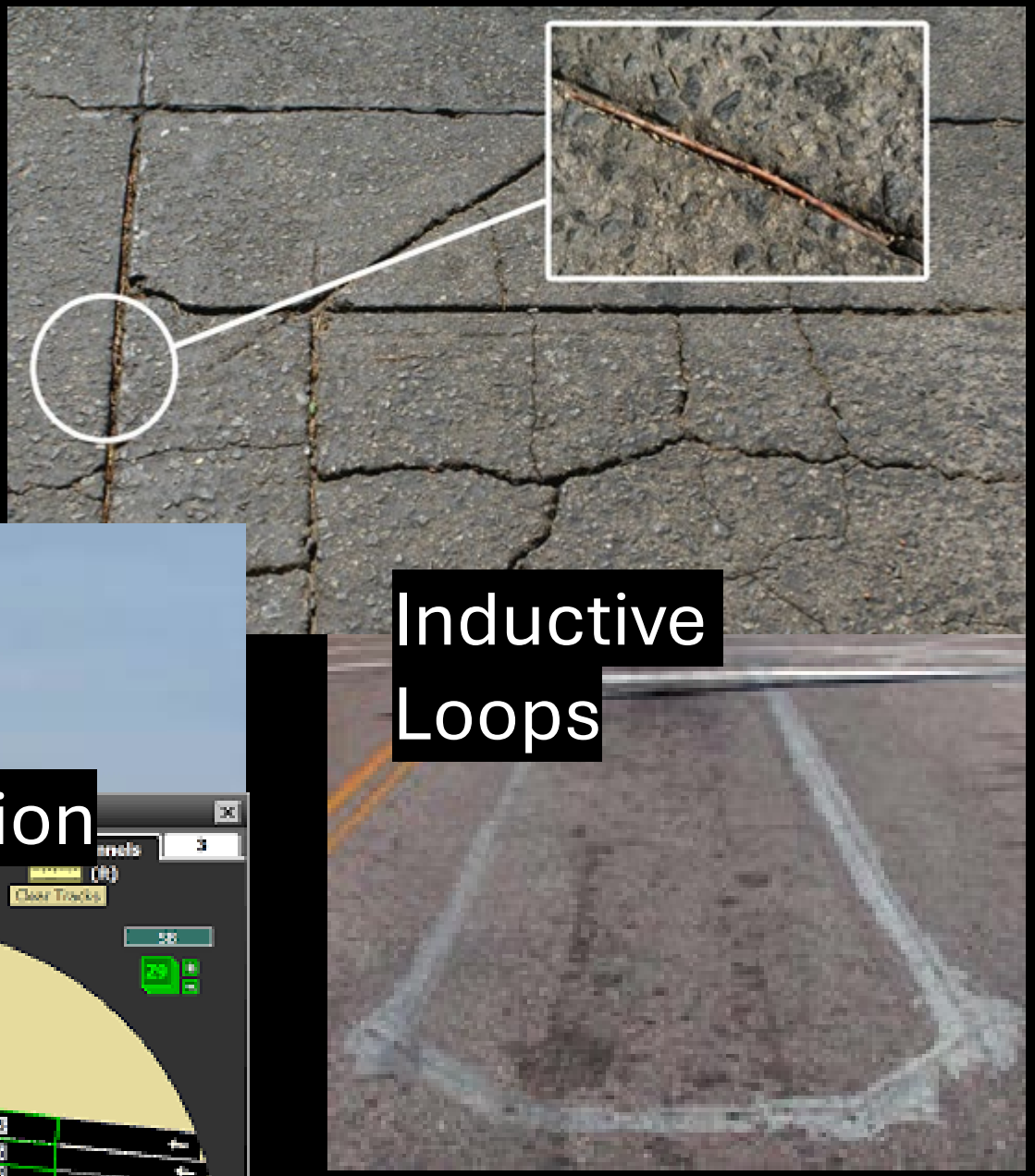
14:30:34	14:29:30	14:30:17	14:30:18	14:28:35
14:29:05	14:30:59	14:29:15	14:29:57	14:29:35
14:27:27	14:32:36	14:29:47	14:31:53	14:32:53
14:30:56	14:30:14	14:32:49	14:32:14	14:32:37
14:28:26	14:29:02	14:27:16	14:28:22	14:32:35

Status of Detection

Detection Cameras

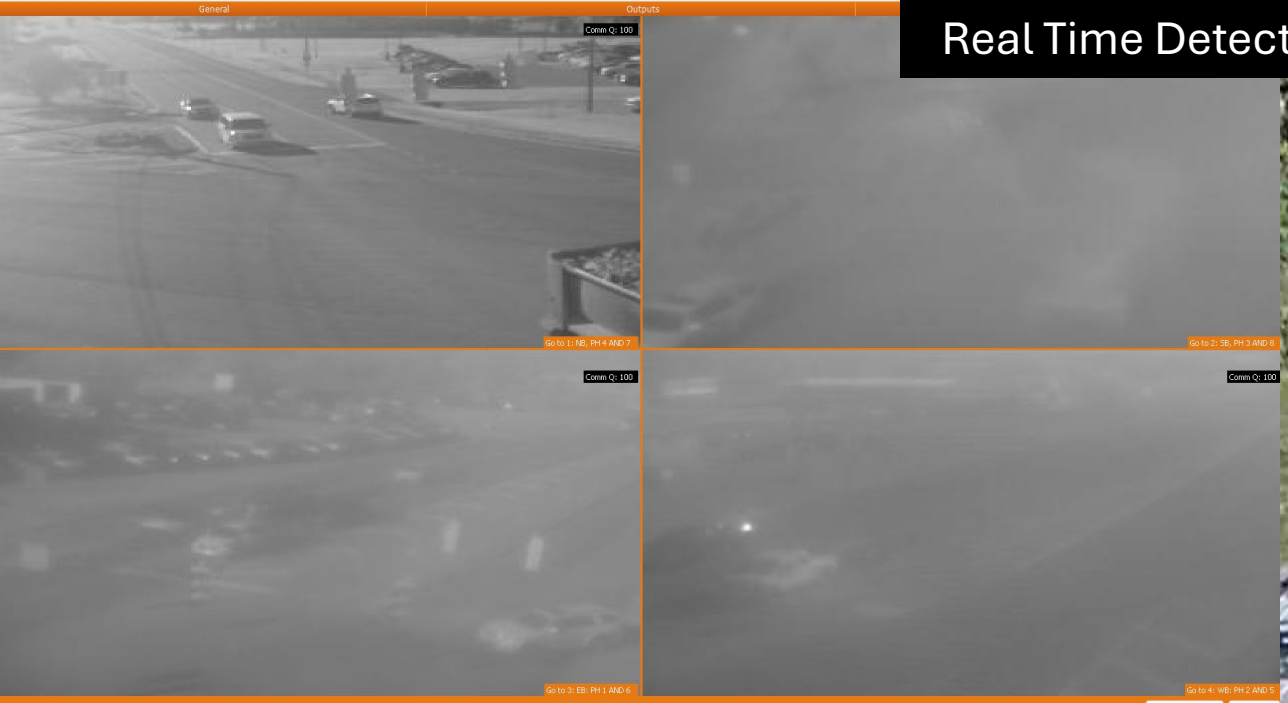


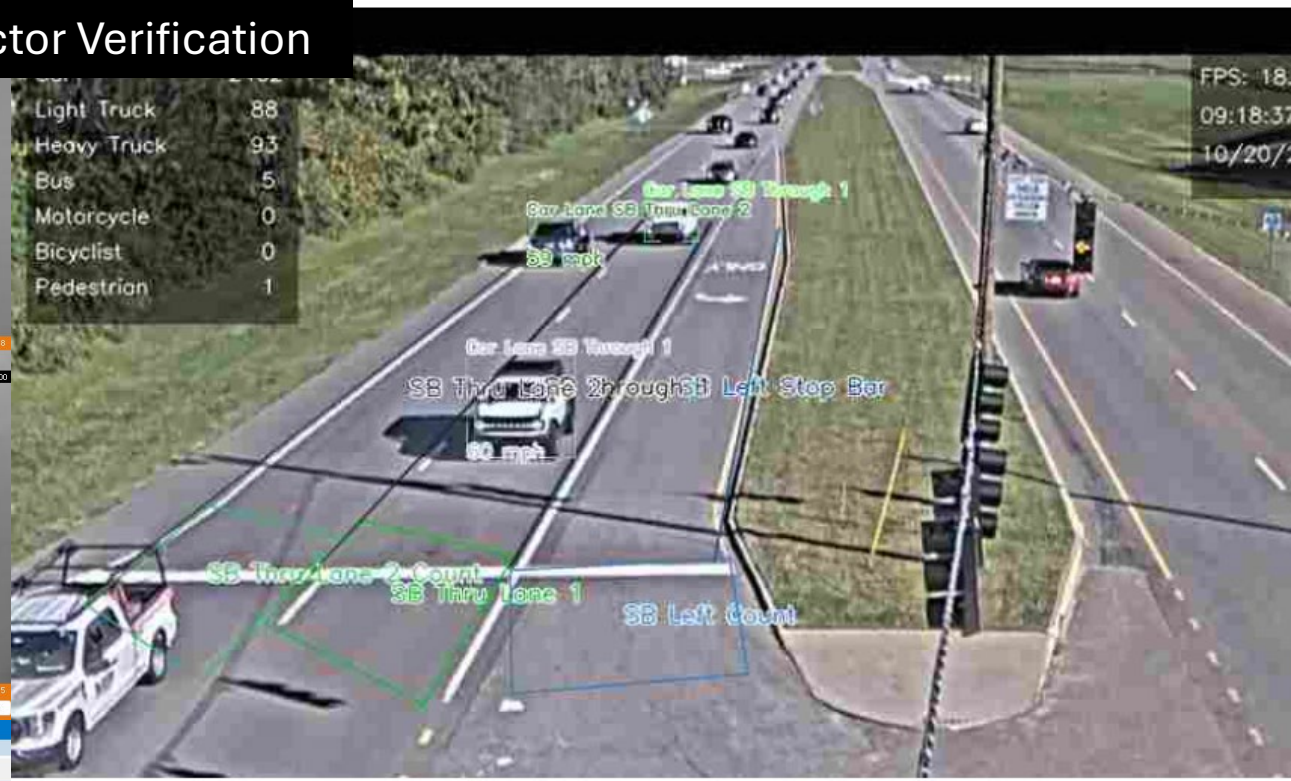
Radar Detection



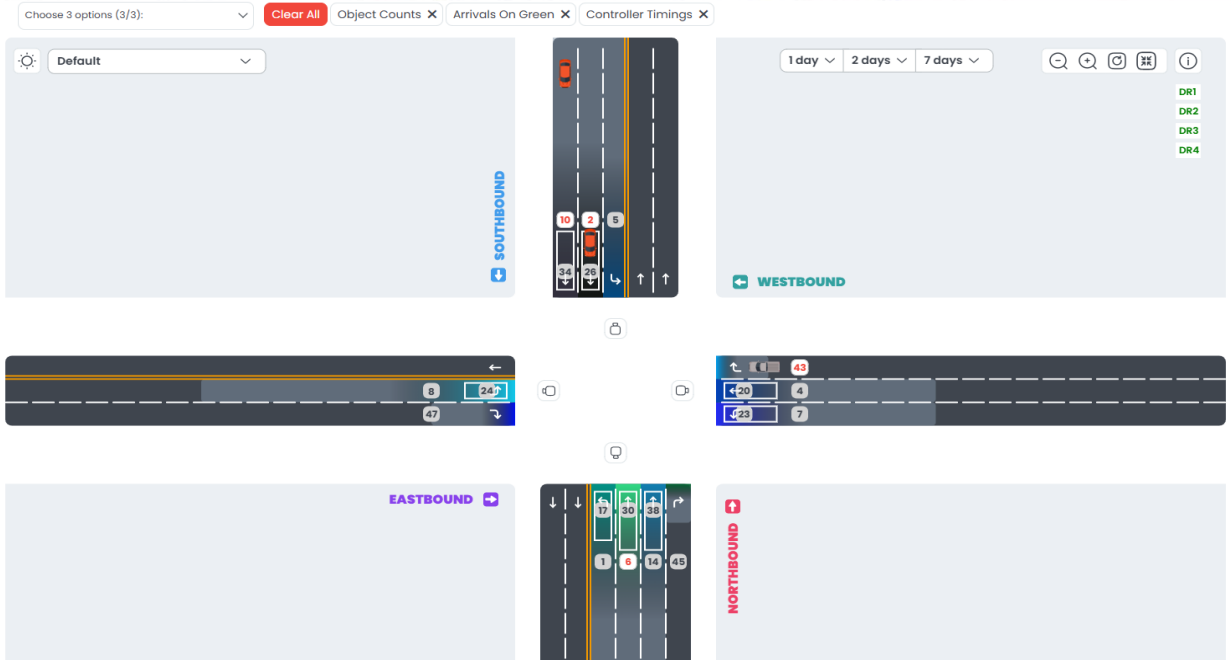
Inductive Loops

Real Time Detector Verification

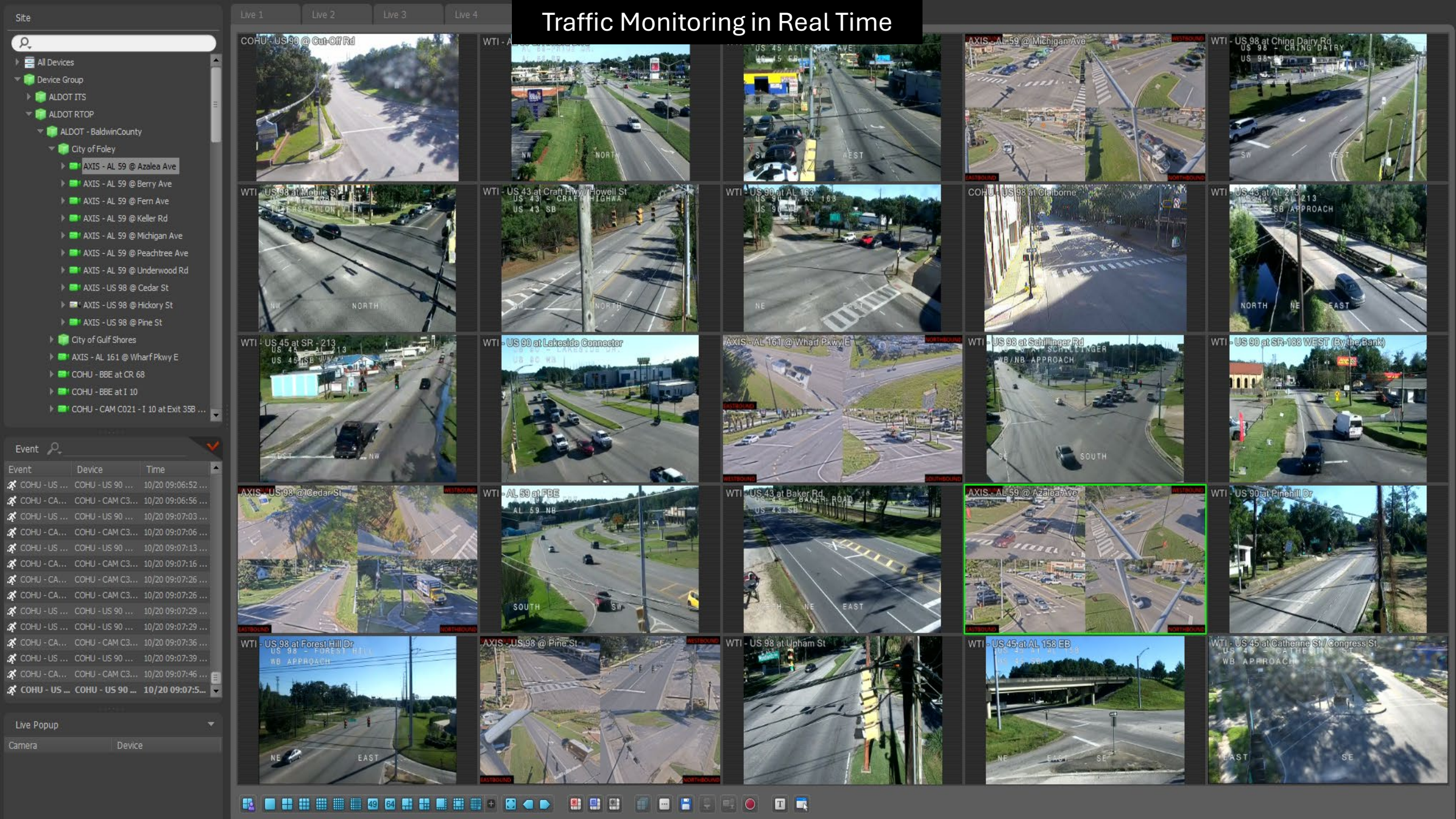




	Object ID	Quality	Distance X (feet)	Distance y (feet)	Object Type	Velocity in Direction (mph)	Zone
1	25066	81.1682	129.321	226.355	30	12.2805	16.6
2	25054	84.3826	76.6241	175.368	30	0	6
3	25014	85.0388	-84.1238	121.751	30	7.30187	1



Traffic Monitoring in Real Time



Real Time Status of Signals

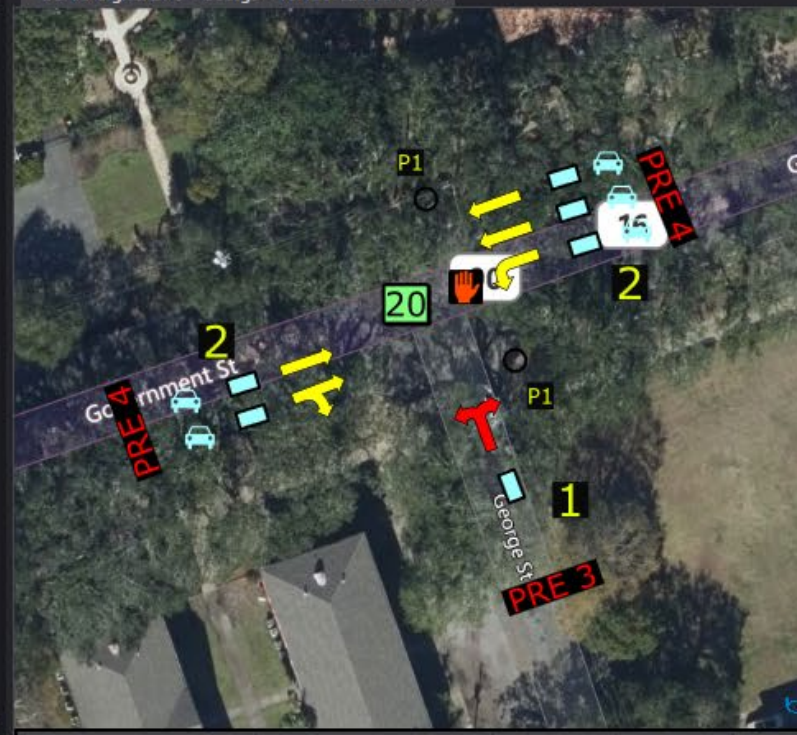
Manual Commands x

Add... | Edit... | Copy... | End/Delete

Action	Targets	Start	End	Entered By

Map Viewer x | EOS Front Panel US 90 Signal 55A - CR 55 - 10.109.79.178 x

US 90 Signal 27C - George - 10.109.126.194 x

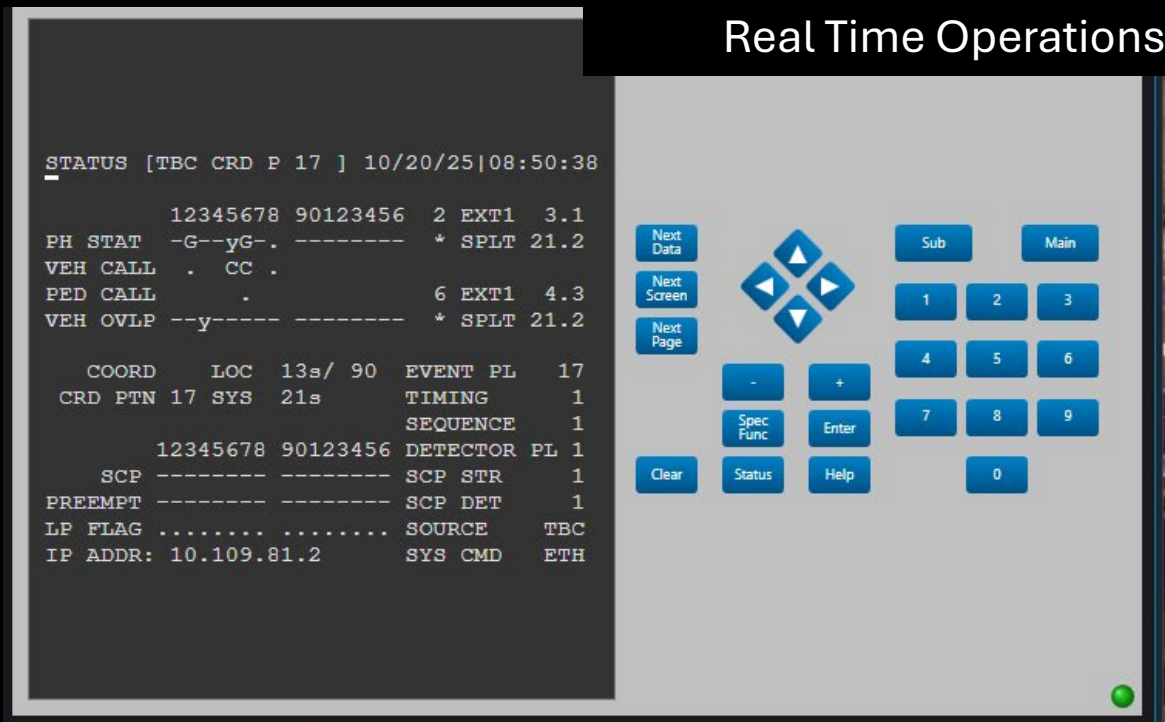


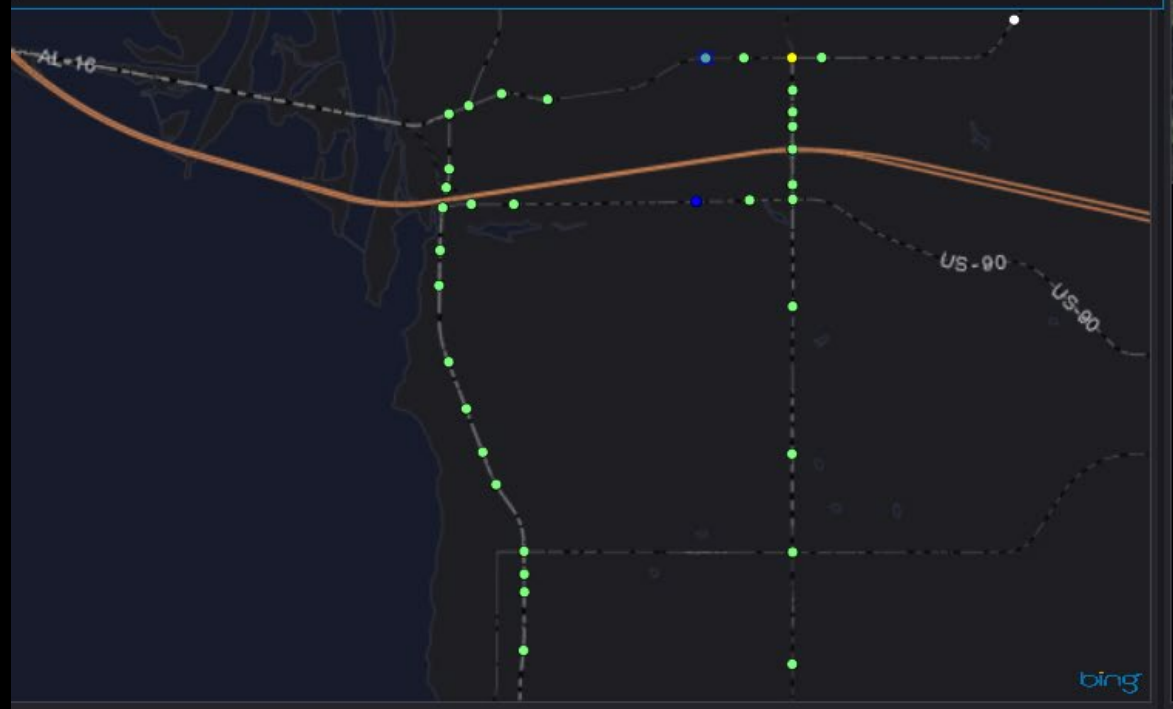
Mode / Pattern	Coordination	Time	Preempt	Alarms
Desired: NON/NON Current: TOD/20	Actual / Prog Cycle 1 / 120 Offset 9 / 9	Last 08:51:10 Error: 3s		

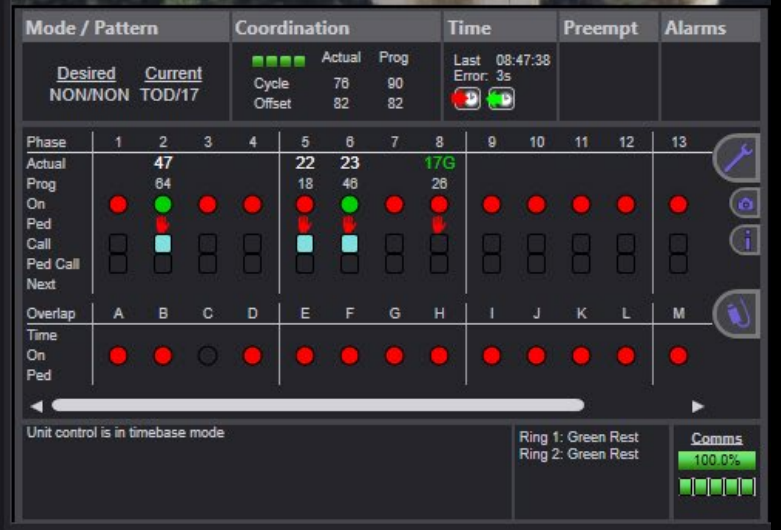
Phase	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Actual	10G	220												
Prog	30	90												
On	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Ped	↓	↓												
Call	■	■												
Ped Call														
Next	↑													

Overlap	A	B	C	D	E	F	G	H	I	J	K	L	M	N
Time On Ped	●	●	●	●	●	●	●	●	●	●	●	●	●	●

Real Time Operations

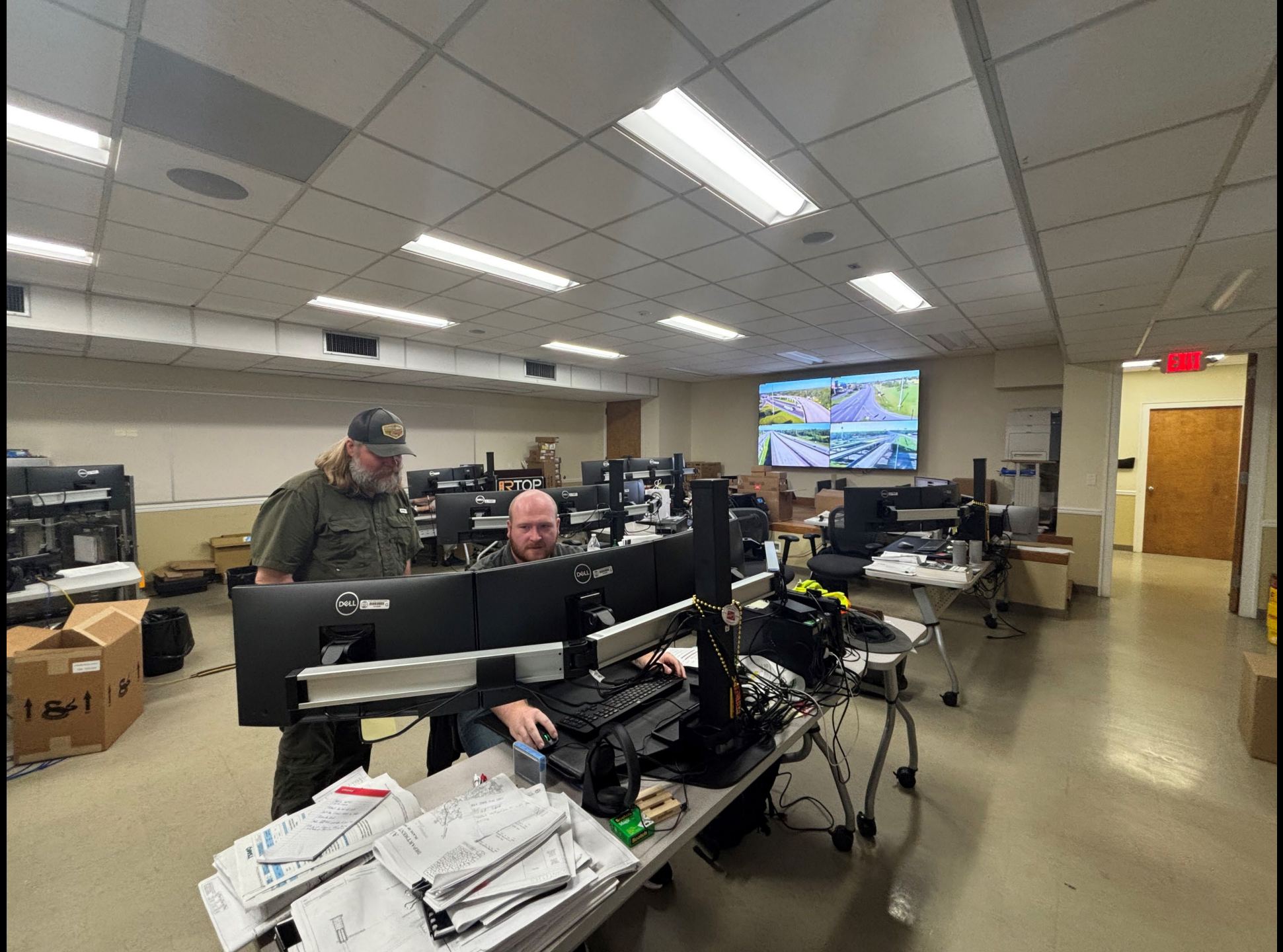






Enables Real Time Tech Support


EXIT


EXIT


WARNING

Active Traffic Management Capabilities

- Mardi Gras Parades
- South Alabama Football Game Days
- Seasonal Beach Traffic
- Interstate Diversion for Crashes
- Special Events
  - Downtown Mobile
  - USA Campus
  - Fairgrounds

Challenges and Lessons Learned

- Network reliability (fiber vs. cellular latency).
- Security (VPN, firewalls, port control).
- Training
- Importance of standardization and regional collaboration.
- Use of FYA

Challenges and Lessons Learned

- STAY AWAY FROM ADAPTIVE SYSTEMS
- Be weary of high pressure sales pitches! The detection market is rife with dishonest claims and recurring costs.
- AI Camera systems and radar systems are best.
- Non-AI Camera systems SHOULD NOT be installed on span wire signals!!!
- Re-evaluate for protected vs permissive vs protected/permissive left turn operation. Most signals are never restudied after installation.

Common Issue 1

- Stuck at a red light, and there isn’t a car in sight…

BROKEN DETECTION!! The signal has no idea you are there…

Common Issue 2

- You finally get a green light, and 500 feet down the next signal just turned red… Catching every signal on red.

No coordination/synchronization!!!

Also heavily influenced by broken detection…

We need better engineering…

CURRENT STATUS AND EXPECTATIONS

- Users should receive fewer red lights and for shorter durations on major roadways between 6 AM and 7 PM (This can vary route to route).

- During early morning and late night hours, users should expect little to no improvement today.

- Users waiting to turn onto a major roadway that has been coordinated may experience more delay than they once had.

Myths and Reality

- Before RTOP, average arrival on green was in the 30% range
- With good coordination, average arrival on green should be in the 60-80% range.
- Coordination/Synchronization does not mean you will get every signal on green without stopping.
- Most cycle lengths are between 60-120 seconds. FHWA recommends a maximum of a 180 second cycle.

WHAT'S NEXT?

- DETECTION UPGRADES
  - $6M this year to replace and modernize vehicle detection.
  - An estimated $15M is needed regionally to modernize and ensure working detection at all traffic signals.
- PTZ Camera Installations
  - Over 100 Cameras are being installed this year.
  - An estimated $1M is needed to outfit each signal with a camera.
- TIMING PLANS
  - Engineers will continue to assess signal performance, observe patterns, and look for ways to improve the timing.

WHAT'S NEXT?

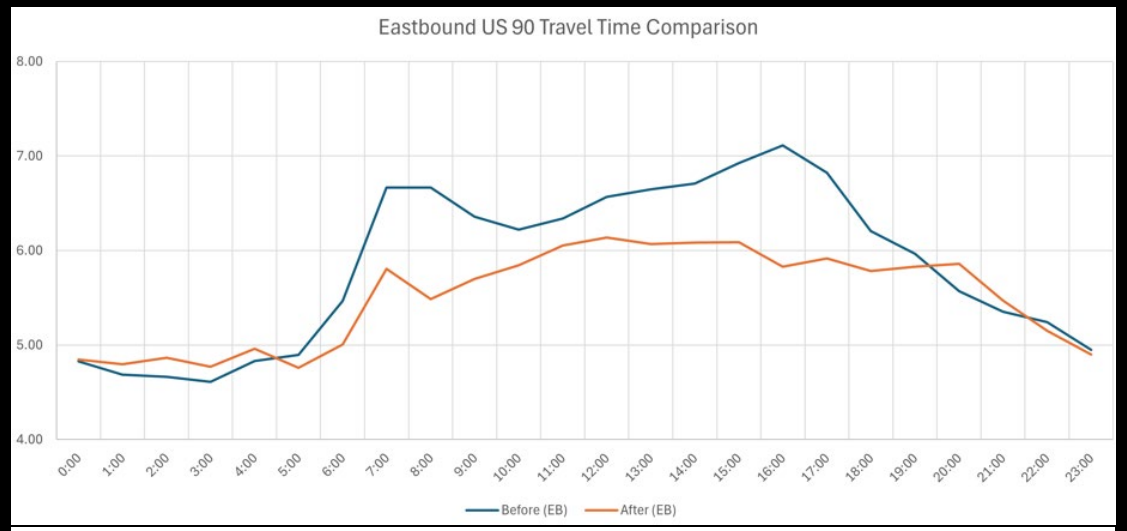
- Re Warranting Left Turn Operations
  - Change protected/permissive by time of day and volumes/gaps
  - Replace ALL permissive left turns with FYA

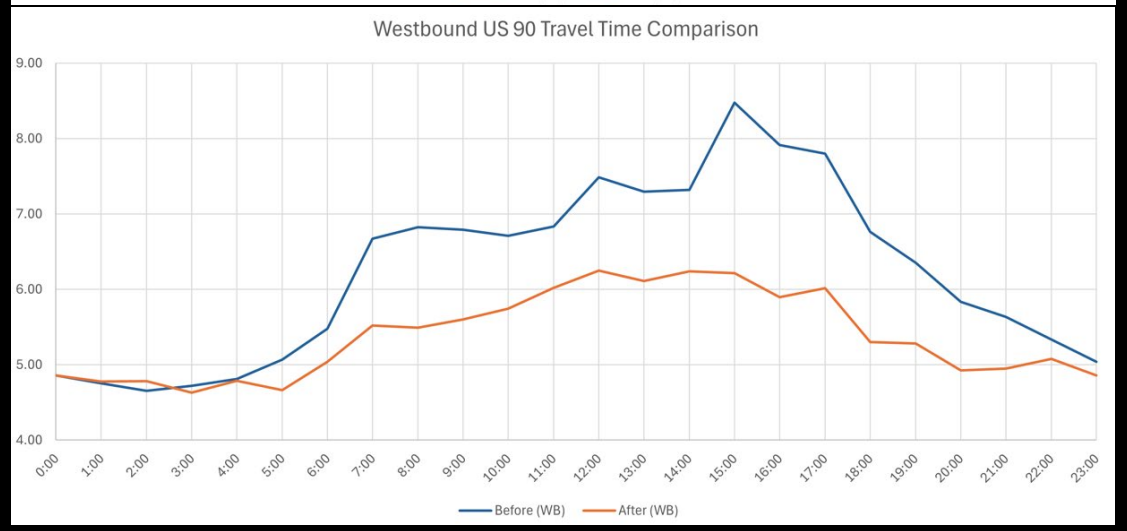
Mobility Effects

US 90/Government Street
(Pinehill Drive to Common Street)

AECOM

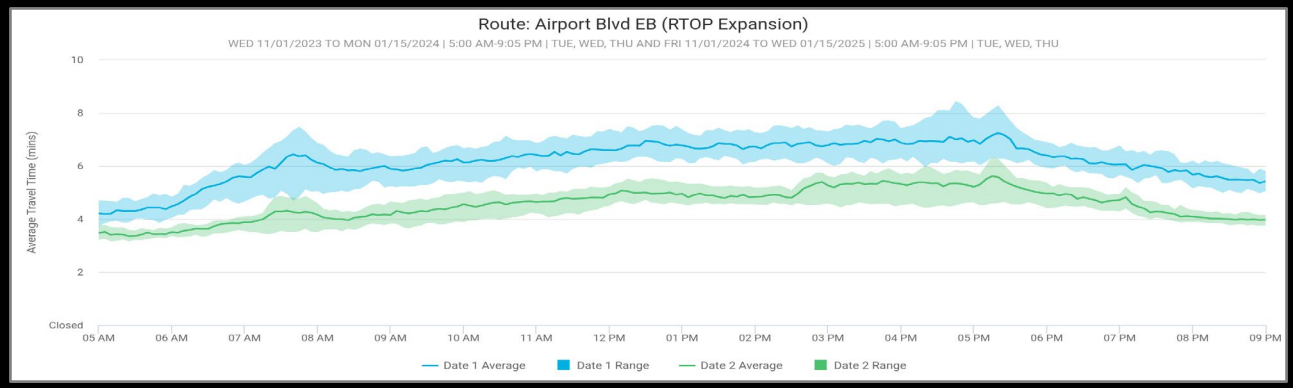
- Reduced travel times by up to 28%.
- Daily cost savings: $4,490 in fuel savings and time savings per day to the local economy
- ADT ranges from 14,000 to 28,000 cars per day





Airport Boulevard

(Cody Rd to University Blvd)



- Before/After Travel Time results show a 26% improvement in both directions
  - AM Eastbound Commute: 29% reduction in travel time, 29% reduction in buffer time
  - PM Westbound Commute: 30% reduction in travel time, 24% reduction in buffer time
- Daily cost savings: $19,508.00 in fuel savings and time savings to the local economy
- ADT ranges from 25,000 to 41,000 cars per day

Consistent and Reliable trip times

Safety Effects

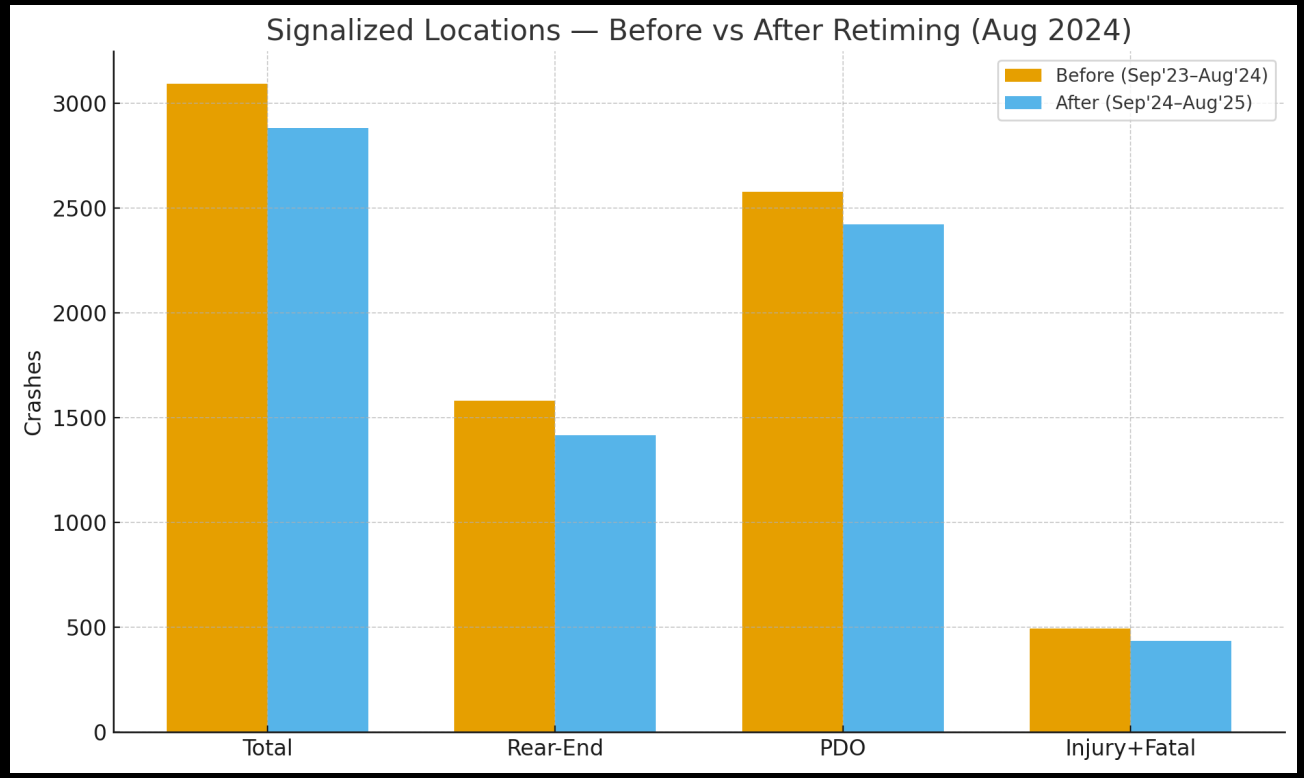
Other Items In The Data

- Covid Impacts
- Replacement of detection at various signals
- Installation of traffic signal backplates on corridor segments
- Installation of FYA at various signals
- Traffic growth
- Changing land use/road conditions
  - US-98 in Mobile County
  - AL-158 in Mobile County
  - AL-181 in Baldwin County
  - Toll Removal in South Baldwin County

Network Wide Analysis of City of Mobile

Crash Type	Before	After	Difference	% Change	CRF (%)
Total	3095	2882	-213	-6.9	6.9
Rear-End	1581	1417	-164	-10.4	10.4
PDO	2579	2423	-156	-6	6
Injury+Fatal	494	437	-57	-11.5	11.5

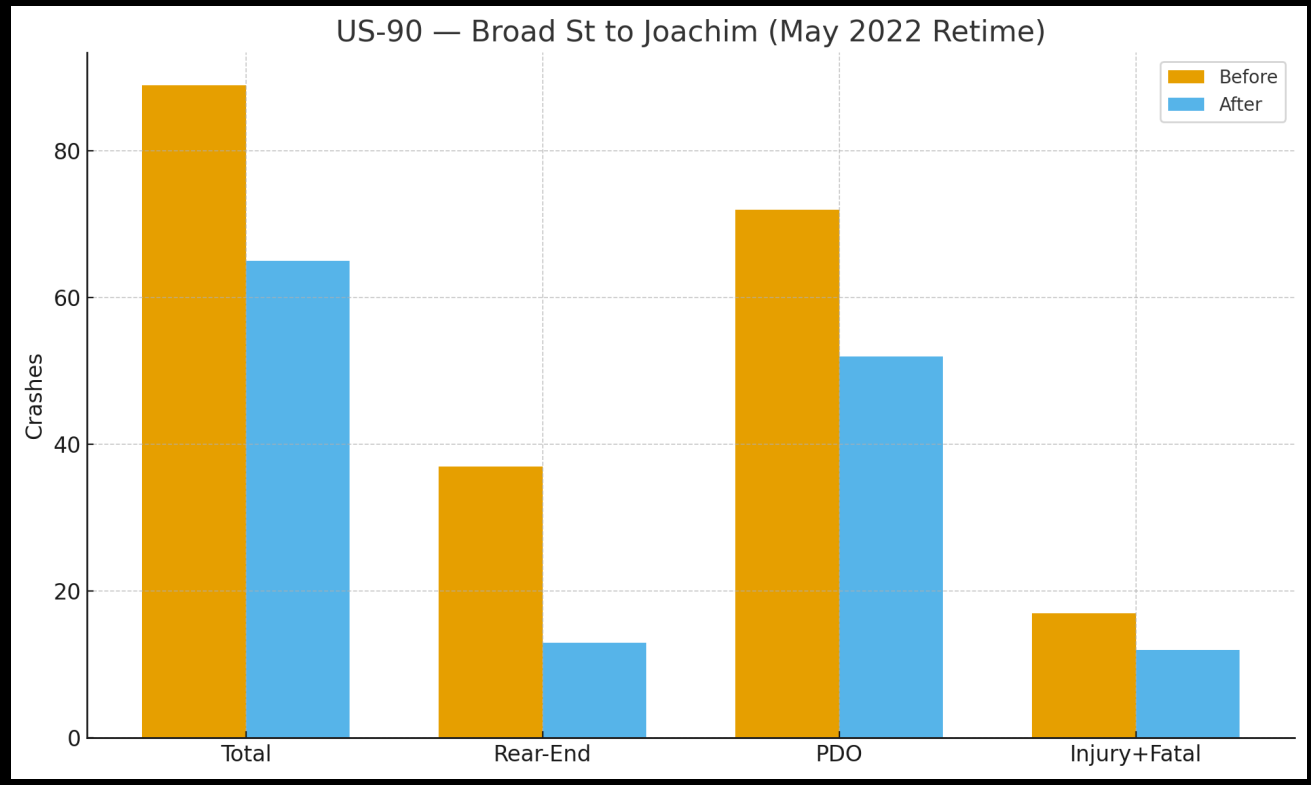
*Retimed August 2024



US-90 From Broad St to Joachim St

Crash Type	Before	After	Difference	% Change	CRF (%)
Total	89	65	-24	-27	27
Rear-End	37	13	-24	-64.9	64.9
PDO	72	52	-20	-27.8	27.8
Injury+Fatal	17	12	-5	-29.4	29.4

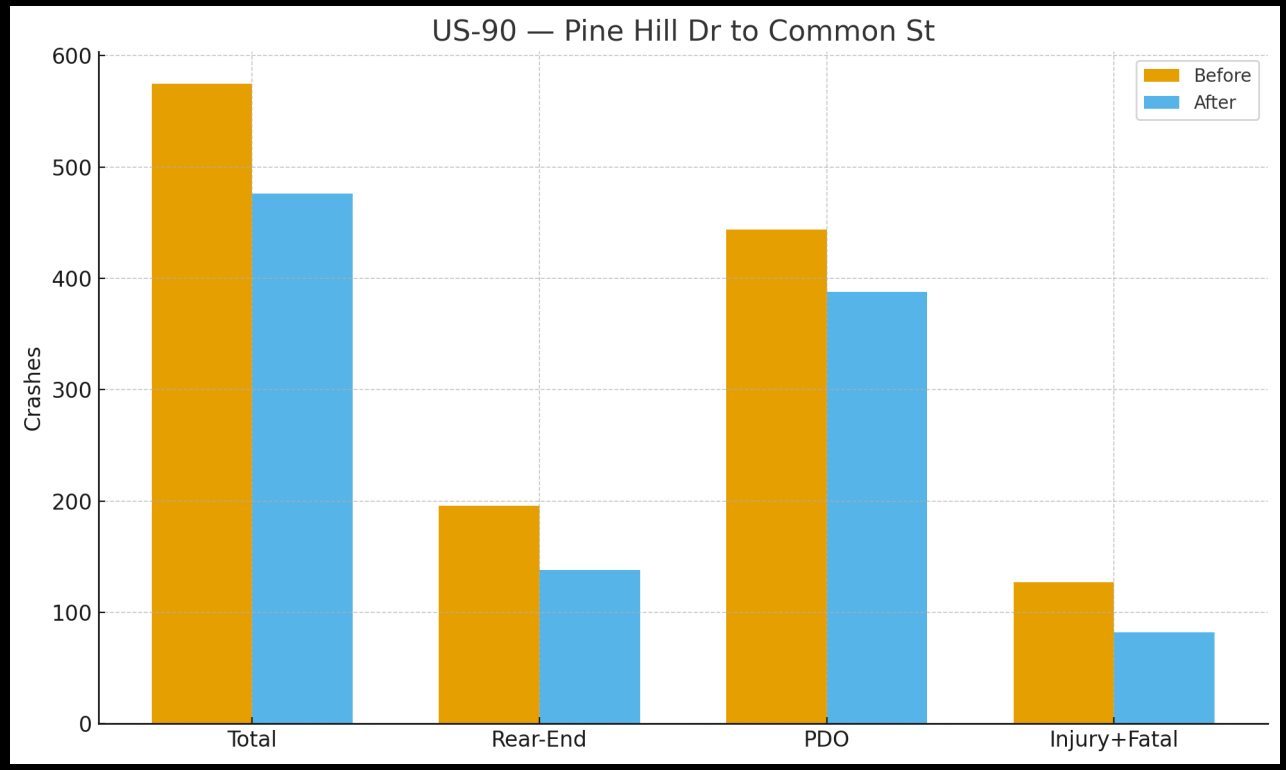
*Retimed May 2022



US-90 From Pinehill Dr to Common St

Crash Type	Before	After	Difference	% Change	CRF (%)
Total	575	476	-99	-17.2	17.2
Rear-End	196	138	-58	-29.6	29.6
PDO	444	388	-56	-12.6	12.6
Injury+Fatal	127	82	-45	-35.4	35.4

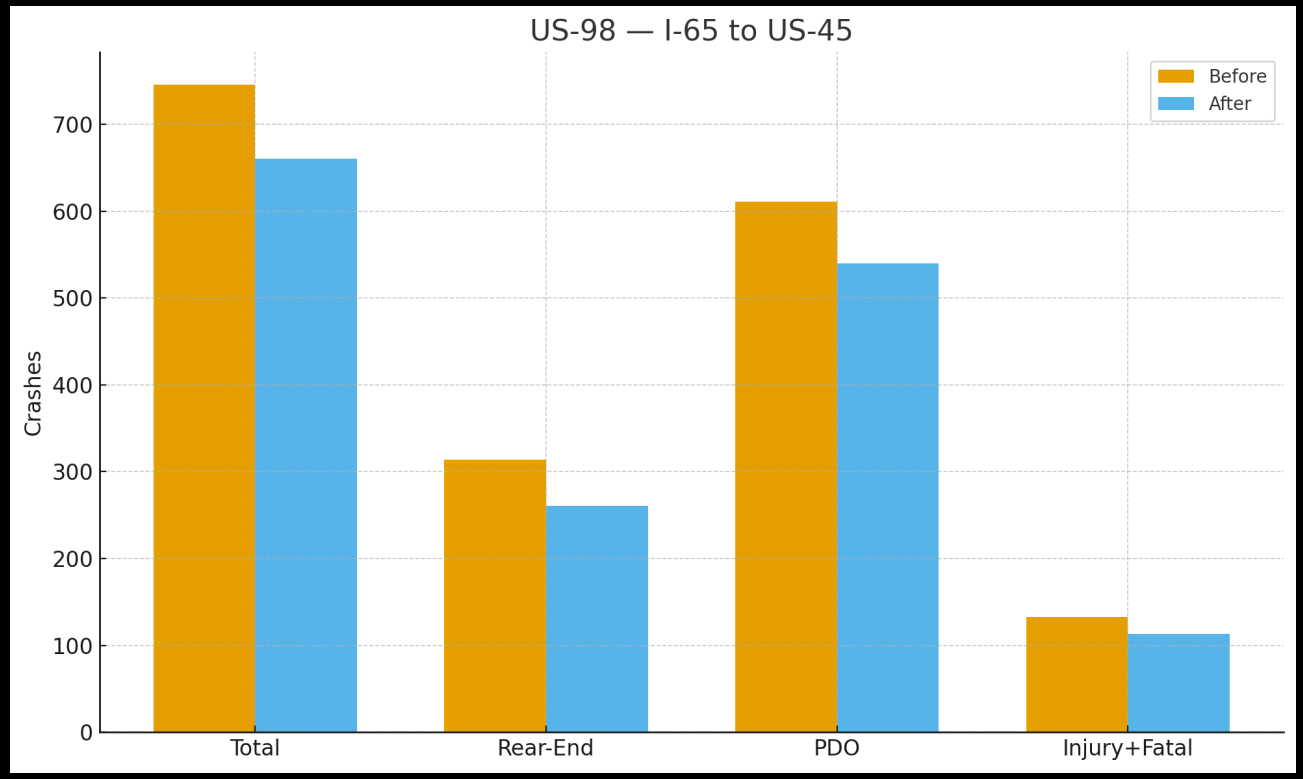
*Retimed April 2022



US-98 From I-65 to US-45

Crash Type	Before	After	Difference	% Change	CRF (%)
Total	746	660	-86	-11.5	11.5
Rear-End	314	261	-53	-16.9	16.9
PDO	611	540	-71	-11.6	11.6
Injury+Fatal	133	113	-20	-15	15

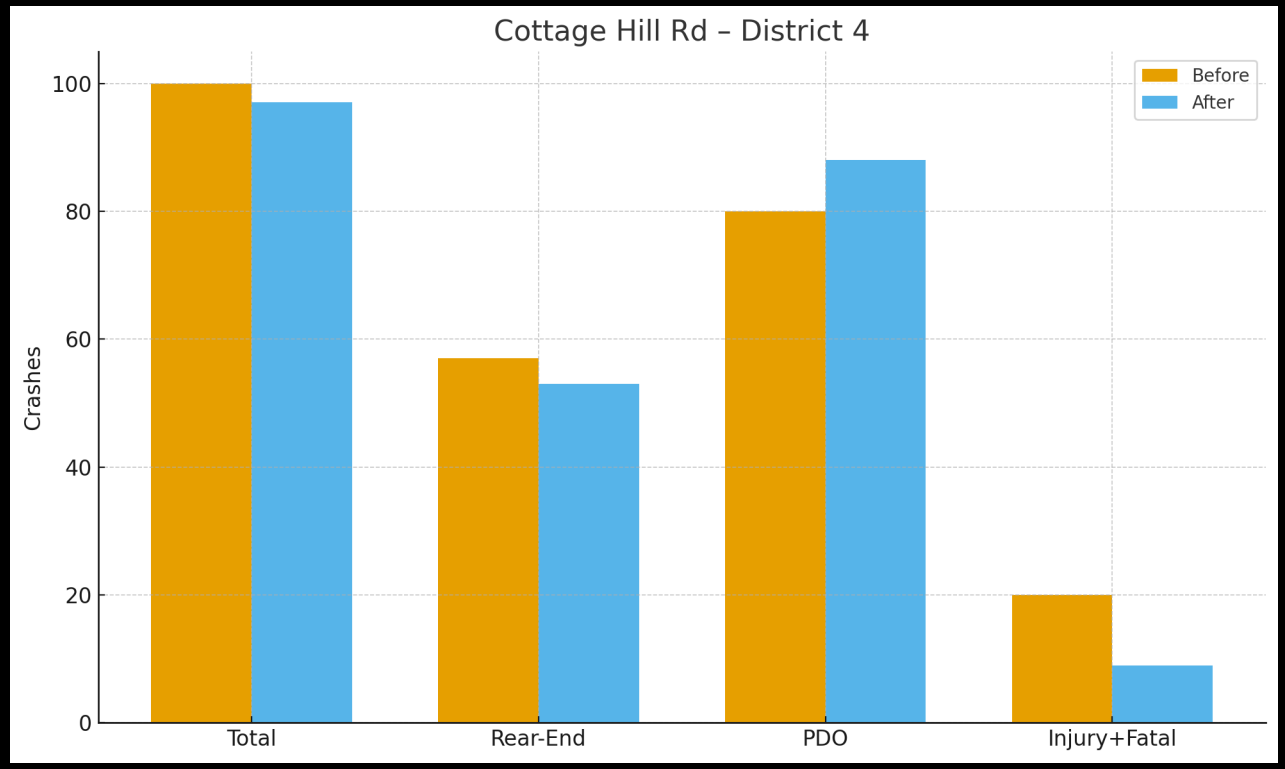
*Retimed April 2022



Cottage Hill Rd D4

Crash Type	Before	After	Difference	% Change	CRF (%)
Total	100	97	-3	-3	3
Rear-End	57	53	-4	-7	7
PDO	80	88	8	10	-10
Injury+Fatal	20	9	-11	-55	55

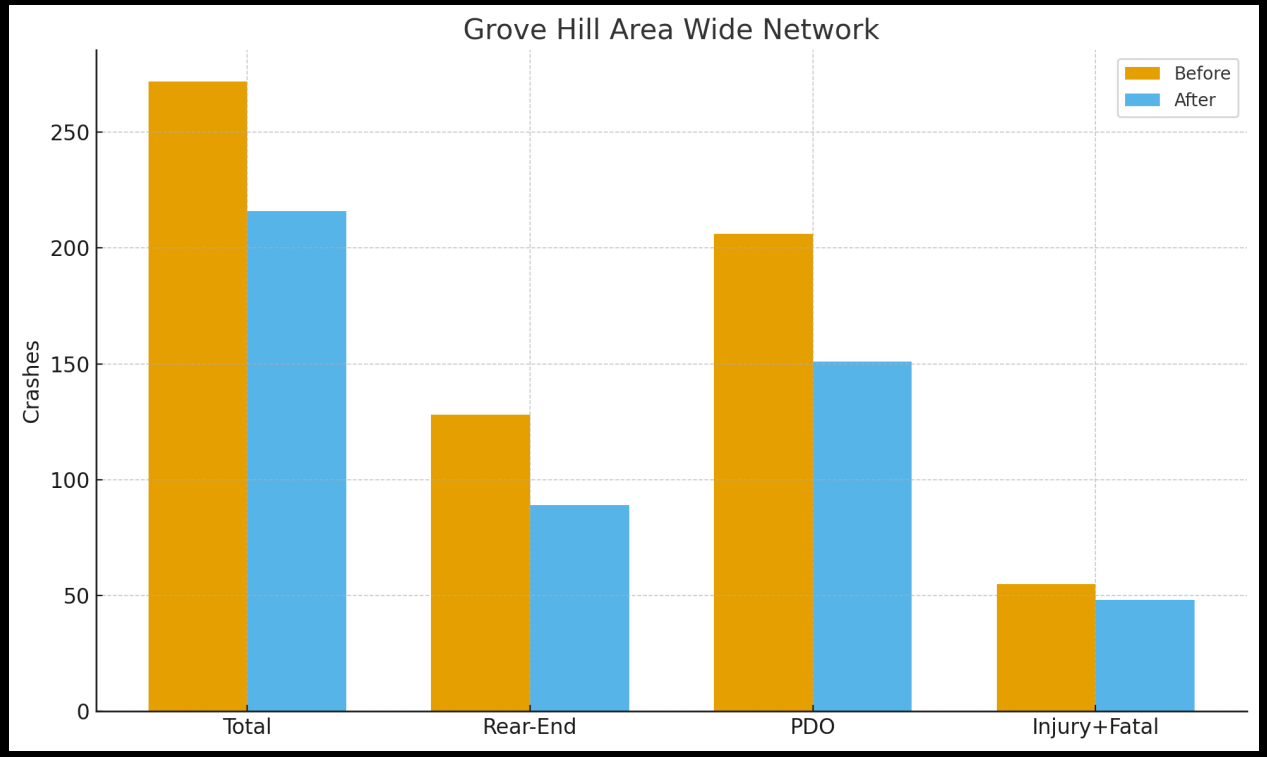
*Retimed October 2023



Network Wide Analysis of Grove Hill Area

Crash Type	Before	After	Difference	% Change	CRF (%)
Total	272	216	-56	-20.6	20.6
Rear-End	128	89	-39	-30.5	30.5
PDO	206	151	-55	-26.7	26.7
Injury+Fatal	55	48	-7	-12.7	12.7

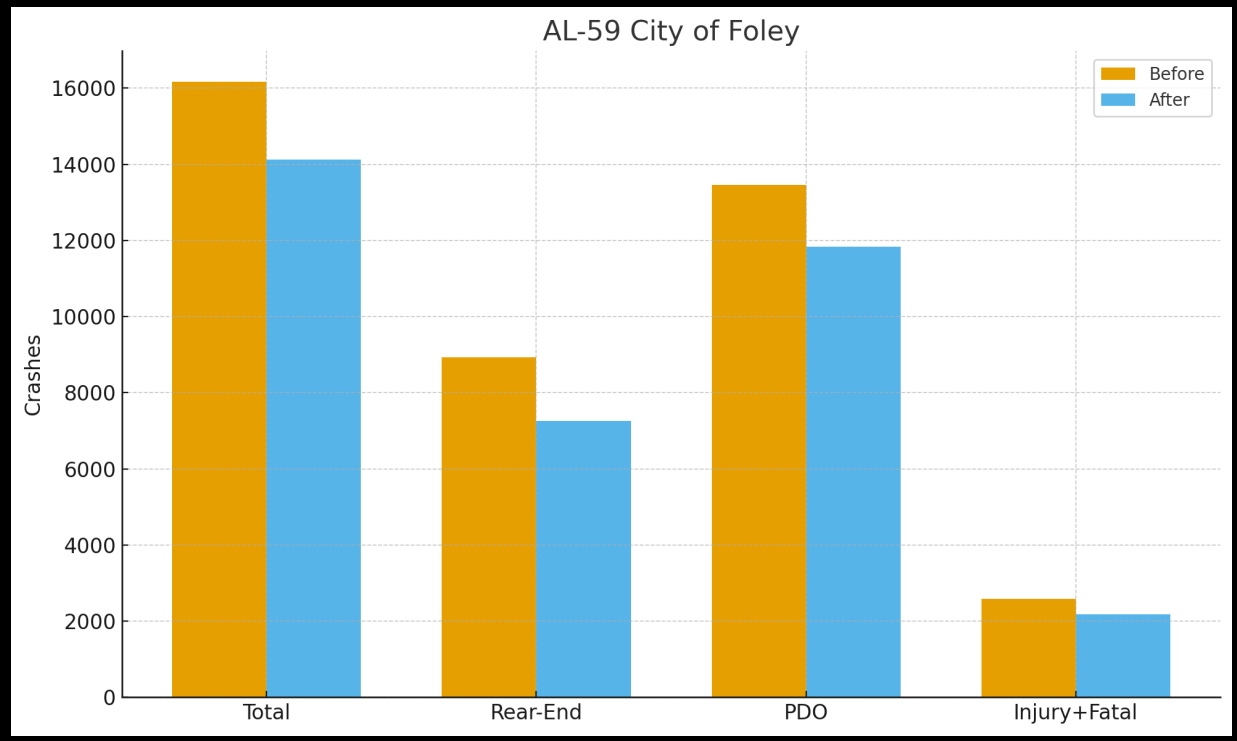
*Retimed November 2023



AL-59 in City of Foley

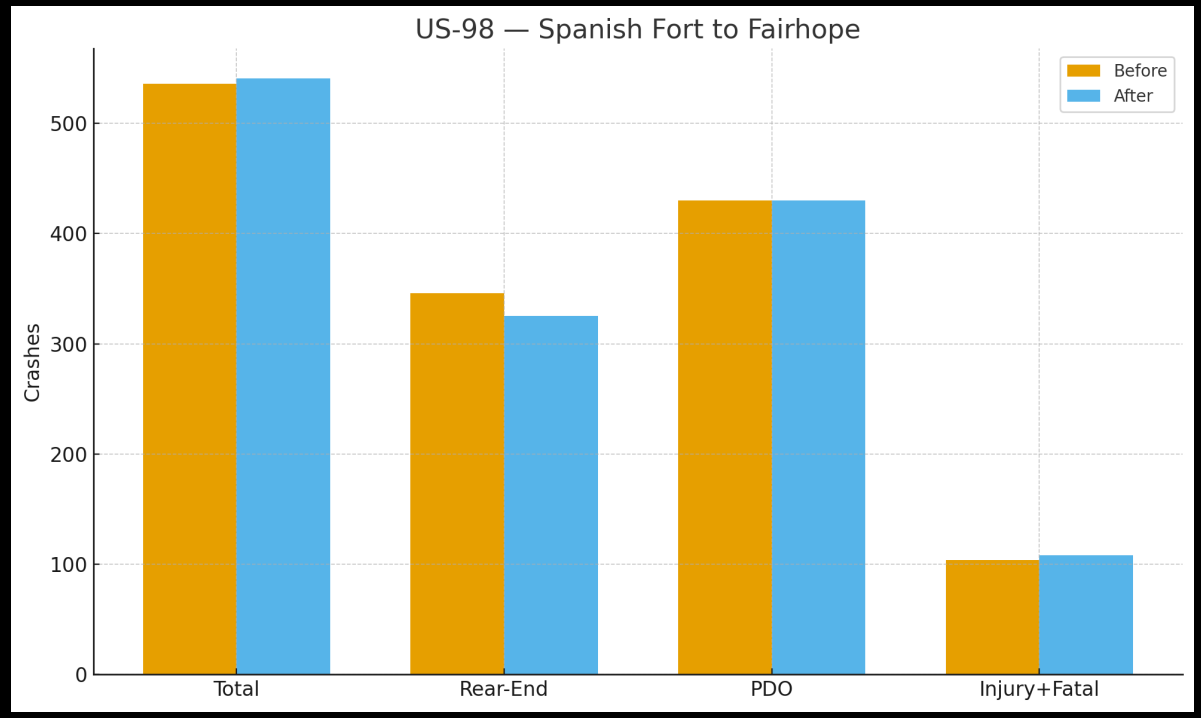
Crash Type	Before	After	Difference	% Change	CRF (%)
Total	16178	14125	-2053	-12.7	12.7
Rear-End	8930	7257	-1673	-18.7	18.7
PDO	13466	11831	-1635	-12.1	12.1
Injury+Fatal	2585	2179	-406	-15.7	15.7

*Retimed May 2021



US-98 from Spanish Fort to Fairhope

Crash Type	Before	After	Difference	% Change	CRF (%)
Total	536	541	5	0.9	-0.9
Rear-End	346	325	-21	-6.1	6.1
PDO	430	430	0	0	0
Injury+Fatal	104	108	4	3.8	-3.8



*Retimed August 2020

**Removed SCOOT Adaptive. Runs Time of Day based Coordination.

Overall Average CRF

Crash Type	Average CRF (%)
Injury+Fatal	22.77
PDO	11.54
Rear-End	24.81
Total	13.01

BC Calculation

Benefit–Cost Analysis Summary

Crash Reduction Benefits

Severity	Before	After	Change (Δ)	Unit Cost ($)	Benefit ($)
Property Damage Only	19,105	16,517	**2,588 fewer**	9,624	24,902,112
Possible Injury (C)	2,324	1,625	**699 fewer**	128,959	90,174,441
Non-Incapacitating Injury (B)	2,056	1,997	**59 fewer**	128,959	7,609,581
Suspected Serious Injury (A)	612	493	**119 fewer**	1,571,053	186,955,307
Fatal Injury (K)	142	138	**4 fewer**	1,571,053	6,284,212

Total Benefit

$315,925,653

Total Cost

$10,000,000

Benefit Cost Result

31 : 1

But is it really?

Recurring cost every year…

Limited safety and mobility gains going forward

Decreasing or discontinuing the program and funding will see these crashes return.

GETTING BACK LOST EFFICIENCY AND SAFETY MARGINS

Traditional Capacity Projects

- Take years to implement
- Only affect one intersection or roadway at a time
- Typically cost millions

Connecting Signals and Modern Timing Operations

- Can be implemented same year
- Can span entire regions on many roads
- $15K per signal to achieve

Questions?

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