ITE TECHNICAL SESSION | ADAPTIVE SIGNAL CONTROL

Camarillo AI Adaptive Project

Why we modernized, how Miovision Surtrac works, and test bed results after one month on Arneill Road

City of Camarillo, California — Traffic Engineering

Arneill Rd corridor · ~230,000 signal cycles · August 14 – September 14, 2026

AGENDA

Thirty minutes, three parts

1

Why Camarillo modernized

~7 min

November 6, 2024. What a wildfire evacuation did to a signal network running on grid power and fixed timing plans, and the capital program that followed.

2

How AI adaptive control works

~9 min

Detection, scheduling and coordination in Miovision Surtrac. What the algorithm is doing second by second, and what it is not doing.

3

Test bed results after one month

~12 min

Natural on/off operation on the Arneill Road test bed: delay, pedestrians and emissions.

Questions at the end. The method in Part 3 is reproducible with data most agencies already collect.



PART ONE

Why Camarillo modernized

A signal network is infrastructure until the day it is emergency infrastructure.

NOVEMBER 6, 2024

The Mountain Fire

9:00 a.m.

Ignition near Balcom Canyon and Bradley Road, Somis

19,904

acres burned before 100% containment on Nov 27

243 / 127

structures destroyed and damaged

~14,000

Ventura County residents under evacuation notice

PHOTO

Mountain Fire, Camarillo, November 2024.
Drop your own or a CAL FIRE image here.

Santa Ana winds drove the fire from Somis into Camarillo Heights and Camarillo Estates within hours. At the peak of the event roughly 42,000 Southern California Edison customers in the county were without power.

Sources: CAL FIRE incident reports; Ventura County Sheriff's Office of Emergency Services.

WHAT THE NETWORK DID

Las Posas went dark

- **The signals along Las Posas Road went dark.** Grid power was lost and there was no backup at the cabinet. Under California Vehicle Code 21800(d) a dark signal is legally an all-way stop, and drivers treat it as one only some of the time.
- **No timing plan was running at all.** Not adaptive, not coordinated, not free. A dark signal is not a signal running the wrong plan. It is no signal, and nothing in the cabinet was managing evacuation demand.
- **Staff had no remote visibility.** Without central monitoring or camera feeds, knowing what a corridor was doing meant sending someone to stand at it.
- **The only lever was manual.** Officers directing traffic at intersections, which pulls sworn personnel off evacuation and structure defense at the exact moment they are scarcest.

The result

Gridlock on the city's busiest corridors during an active evacuation.

Two of those problems are solvable with equipment. The other two are solvable with software.

THE RESPONSE

What Camarillo has built since

Opticom emergency preemption

Complete at all City-owned signals. Six remaining locations on Caltrans right of way at Lewis Road (SR 34).

Super capacitor battery backup

Signals stay in normal operation through an outage instead of going dark. Better heat tolerance and service life than lead acid.

AI adaptive video detection

Arneill Rd corridor. Replaced legacy loop and video detection, and added live remote visibility into field conditions.

CMAQ federal grant, 65 intersections

AI adaptive video, battery backup and new ATC controllers citywide. The largest resiliency investment in the network.

Fusus camera integration

Municipal traffic cameras into the public safety platform for situational awareness during incidents and closures.

Backup power keeps the signal alive. Adaptive control is what makes the surviving signal useful when demand stops looking like a Wednesday.

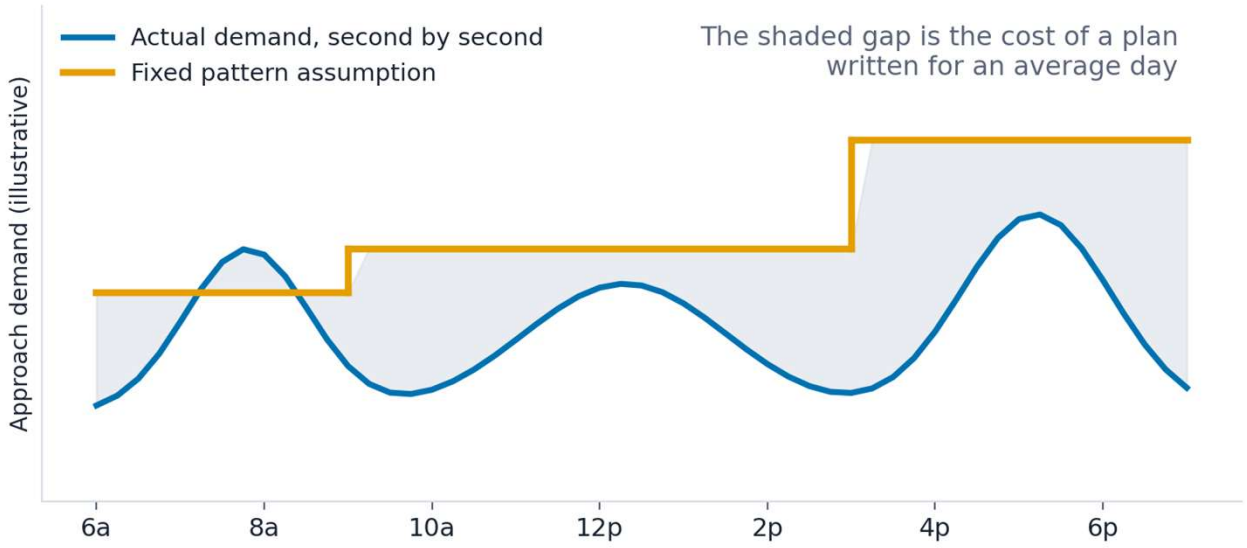
PART TWO

How AI adaptive control works

Detection, scheduling and coordination. What Surtrac is doing second by second.

THE BASELINE

Fixed and coordinated control is a plan written for an average day



Illustrative, not measured data.

What we do today

An engineer studies counts, builds a handful of time-of-day patterns, and the controller runs whichever one the clock says.

The plan is right on the average day it was built from, and progressively wrong on every other one. It ages, and nothing in the cabinet tells you it is aging.

Retiming is the accepted fix. In practice most agencies retime on a multi-year cycle, if at all.

LAYER ONE: DETECTION

The camera stops being a loop replacement

1 Legacy loops and video

Presence and call. A binary: is there metal or motion over this zone. The controller learns that a phase has demand, nothing more.

2 AI video detection

Objects are detected, classified and tracked across the field of view: vehicles, bicycles, pedestrians, and where each one is right now.

3 What that gives the algorithm

Approaching platoons with position, speed and size, not just a call. That is the input adaptive control needs and legacy detection cannot supply.

4 It is shared, not just local

What one intersection sees does not stay there. Vehicle data is passed to the neighboring signals, so each one knows what is heading its way before it arrives.

Adaptive control is only as good as what it can see. Detection is not a line item to value engineer out of the project.

LAYER TWO: THE ALGORITHM

Surtrac treats an intersection as a scheduling problem

PHOTO

Miovision camera, cabinet or intersection.
Drop your own project photo here.

The reframe

Most systems ask which stored plan fits best right now. Surtrac asks a different question: given the vehicles I can see approaching, what sequence of phases clears them with the least total delay?

It is single-machine scheduling

The intersection is the machine. Approaching platoons are jobs waiting to be processed. Each phase change is a setup cost, paid in yellow and all-red.

The algorithm sequences the jobs to minimize cumulative delay across all approaches, subject to the constraints the cabinet already enforces.

That framing is why it handles the things fixed plans handle badly: a lane closure, a double-parked truck, an incident, or an evacuation surge. None of those need a stored pattern. They just change the jobs in the queue.

THE LOOP

Four steps, repeated every second

1

Detect

Build clusters of approaching vehicles from the detection feed: how many, where, how fast.

2

Schedule

Solve for the phase sequence over a rolling horizon, typically the next minute or two, that minimizes cumulative delay.

3

Execute

Commit only the first decision. Hold the current phase or change it now.

4

Recompute

Throw the rest of the schedule away and solve again with a second of fresher data.

Why commit only the first decision?

Because the schedule past the first move is a prediction, and predictions decay. Solving a fresh problem every second is cheaper than being wrong for the next ninety.

COORDINATION WITHOUT A COMMON CYCLE

Each intersection tells its neighbor what is coming



- **Forward: the plan becomes the neighbor's forecast.** When an intersection commits a schedule it knows when vehicles will be released downstream. It sends that projection to the next intersection, which treats it as predicted arrivals and schedules around it.
- **Backward: softpressure.** Downstream intersections report queue conditions upstream, so an intersection will not discharge a platoon into a link that is already saturated.
- **No central computer, no common cycle.** Every intersection solves its own problem and exchanges information with its neighbors. That is what decentralized means, and it is why the approach scales to a grid rather than only a corridor.

WHAT ADAPTIVE IS NOT

Three corrections, and the safety envelope

It is not a self-tuning cycle.

There is no background cycle length being adjusted. There is no cycle at all in the traditional sense; there is a sequence of scheduling decisions.

It is not learning from your history.

It optimizes on vehicles detected right now. It does not train on months of counts and it will not quietly drift toward a bad habit.

It is not a substitute for engineering.

Phase sequence, clearance intervals, pedestrian timing, detection design and safety review are still yours. The algorithm schedules within what you allow it.

If a vendor cannot tell you which of these it respects, that is your answer.

The safety envelope

Everything underneath is unchanged:

- Conflict monitor and MMU
- Minimum and maximum green
- Yellow change and red clearance
- Pedestrian walk and clearance
- Emergency vehicle preemption

Preemption still wins. Adaptive schedules inside the cabinet's rules, it does not replace them.

WHAT ELSE THE DETECTION LAYER BUYS

Safety tools that come with the same cameras

Pedestrian red extension

If someone is still in the crosswalk when clearance ends, the camera sees them and the red holds. Slower pedestrians get the time they actually need instead of the time a formula assumed.

Red light running analytics

Violations are counted and time stamped by approach and by hour. Timing changes and enforcement requests get made from data instead of from complaints.

Near miss analytics

Conflicts that did not become collisions are detected and classified. That is a leading safety indicator, available now rather than after five years of crash history.

Video recording

Recorded intersection video lets staff review a collision, a complaint or a claim after the fact, without waiting for the condition to happen again.

None of these are adaptive control. They are what you get for free once the corridor can see, and they are usually the easiest part of the project to justify.

PART THREE

Test bed results

One month of natural on/off operation on the Arneill Road test bed.

WHY ARNEILL ROAD

We picked the hardest corridor we had

1 Four tightly spaced signals

Barry, Daily, Pickwick and Ponderosa sit close together. Tight spacing is exactly where fixed coordination struggles: a common cycle and offset that works for one pair breaks the next pair.

2 A fire station right off the corridor

Preemption fires multiple times a day. Every preempt throws a coordinated corridor out of step, and it takes several cycles to recover the offsets.

3 Heavy pedestrian demand

Nearly 17,800 walk phases across four signals in a single month. Pedestrian service and vehicle progression pull directly against each other here.

4 Two of the four cross arterials

Daily Dr and Ponderosa Dr are arterials in their own right. On this corridor the minor street is not a quiet side street, it carries real volume.

This was not a corridor chosen to make adaptive look good. If it could not show a benefit here, it was not going to show one anywhere in Camarillo.

WHY THIS STUDY

Adaptive is usually judged by a before/after study. This month handed us a paired comparison.

1

The usual method

Deploy adaptive, compare a period before against a period after. Season, construction, demand growth and detector changes all move between the two.

2

What happened here

Adaptive ran roughly 84% of weekday hours. The remaining 500+ hours reverted to coordinated patterns 1–4, interleaved across the same month.

3

Why that matters

Both modes are exposed to the same corridor, the same season and largely the same demand profile, a within-month comparison, not across years.

SITE AND METHOD

Four signals, two data streams, no field crew

THE CORRIDOR

- Arneill Rd & Barry St
- Arneill Rd & Daily Dr
- Arneill Rd & Pickwick Dr
- Arneill Rd & Ponderosa Dr

Weekdays only, 07:00–19:00, the only window where both control modes occur.

MODE

Cabinet coordination telemetry: controller running free vs. reverting to time-of-day pattern 1–4

OUTCOMES

Cycle-level signal performance measures: vehicle delay, arrivals on green, pedestrian phase wait

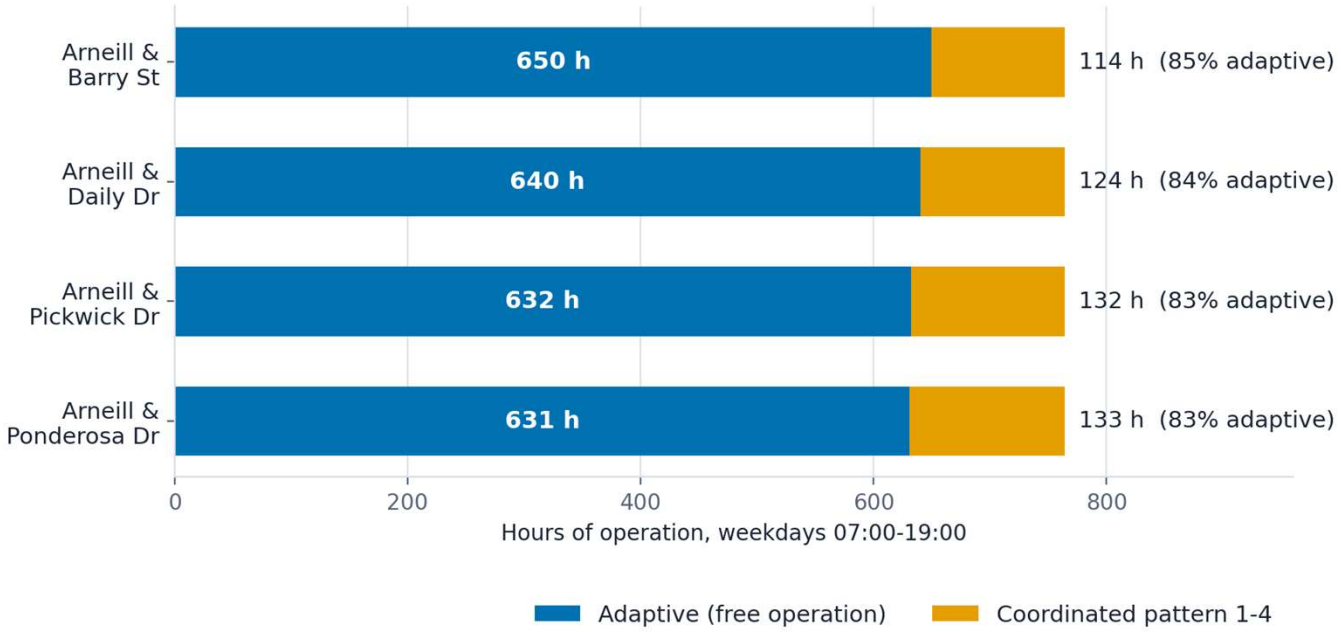
SAMPLE

~230,000 signal cycles; 2,553 adaptive hours vs. 503 coordinated hours; 17,757 pedestrian walk phases

Arneill Rd corridor, Camarillo CA — weekdays 07:00–19:00, Aug 14–Sep 14 2026; cycle-level signal performance data.

CONTROL-MODE EXPOSURE

83–85% adaptive uptime at every signal



2,553
Adaptive hours across four signals

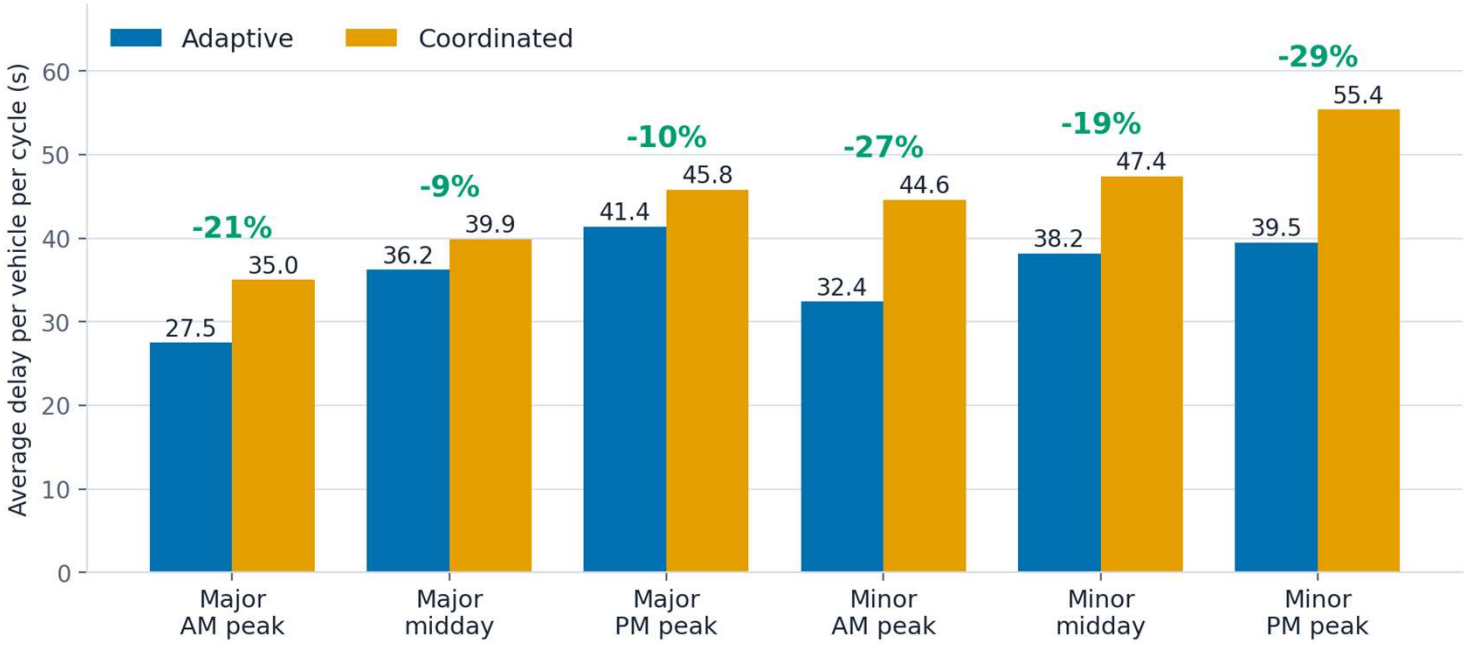
503
Coordinated hours available for comparison

~84%
Weekday hours under adaptive control

Arneill Rd corridor, Camarillo CA — weekdays 07:00–19:00, Aug 14–Sep 14 2026; cycle-level signal performance data.

HEADLINE RESULT

Delay fell under adaptive in every comparison



Range of improvement

9–21%

major street

19–29%

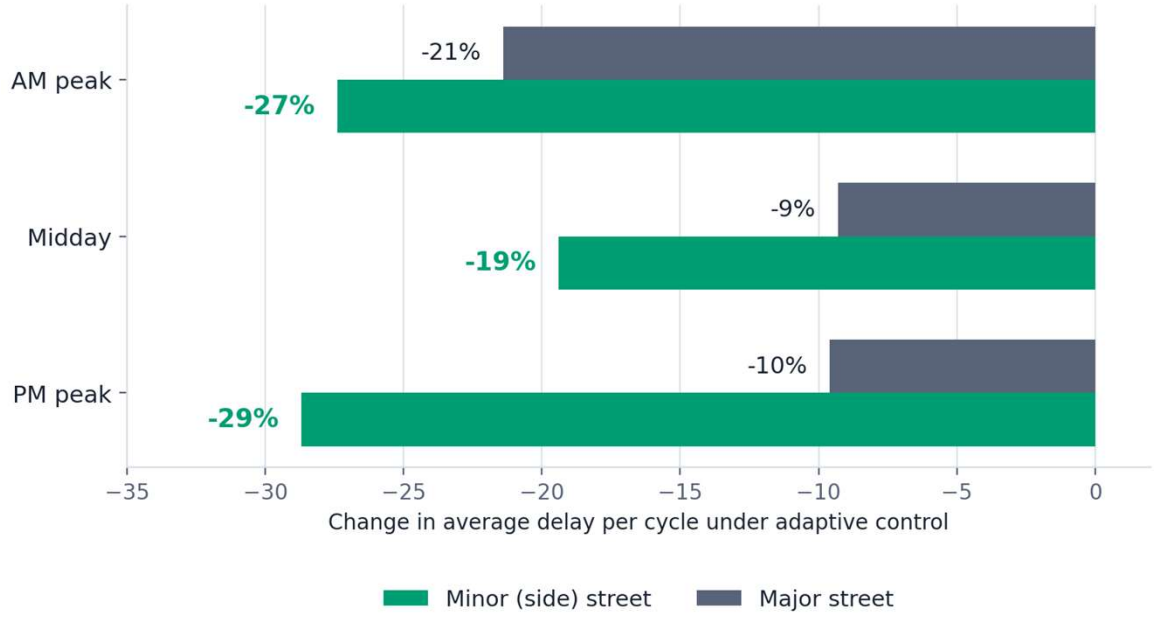
minor street

Largest single gain: minor street PM peak, 55.4 s → 39.5 s per cycle.

Arneill Rd corridor, Camarillo CA — weekdays 07:00–19:00, Aug 14–Sep 14 2026; cycle-level signal performance data.

THE EQUITY STORY

Side-street and cross-street users are the biggest winners



Who gains most

Minor-street delay fell 19–29% against 9–21% on the arterial. The larger relative gain lands on the movements that were worst served under fixed patterns.

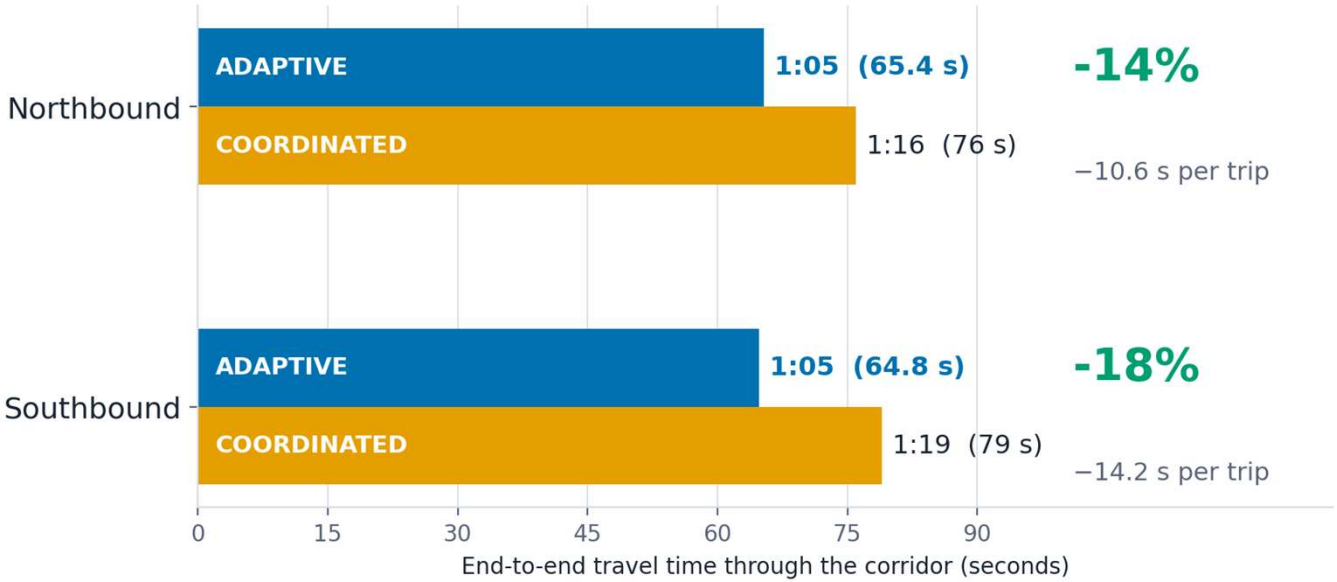
Under a coordinated background cycle, side streets wait out the arterial's fixed green whether or not traffic is present. Adaptive serves the demand that is actually there.

This is the argument that resonates with a council or a neighborhood group: the people who complain about the corridor are usually on the side street.

Arneill Rd corridor, Camarillo CA — weekdays 07:00–19:00, Aug 14–Sep 14 2026; cycle-level signal performance data.

CORRIDOR TRAVEL TIME

Both directions gained, southbound most



Northbound

1:16 → 1:05

14% faster end to end

Southbound

1:19 → 1:05

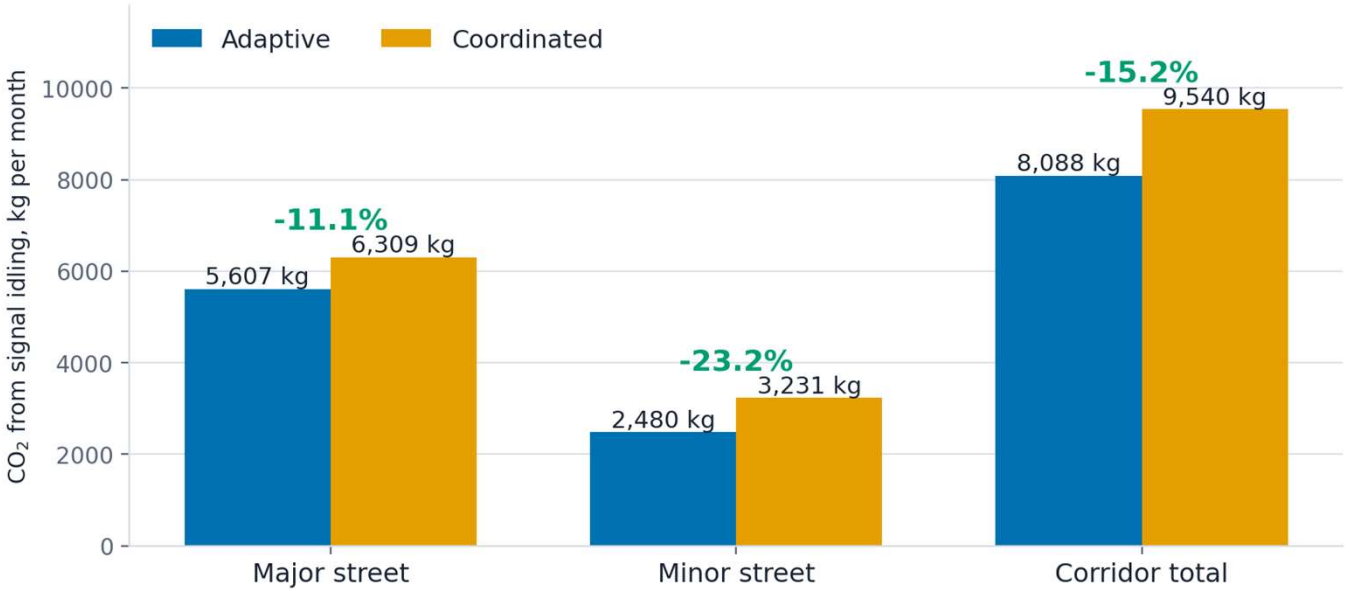
18% faster end to end

Both directions finish within a second of each other. Adaptive serves demand, not a favored direction.

Arneill Rd corridor, Camarillo CA — weekdays 07:00–19:00, Aug 14–Sep 14 2026; cycle-level signal performance data.

EMISSIONS

Less idling buys 15% less signal-attributable CO_2



−15.2%

Corridor CO_2 from signal idling

11.1% major, 23.2% minor

1,453 kg

CO_2 avoided in the month

1.45 metric tons

163 gal

Fuel not burned at the stop bar

654 vehicle-hours of idling

Annualized: roughly 17 metric tons CO_2 and 1,960 gallons of fuel.

Arneill Rd corridor, Camarillo CA — weekdays 07:00–19:00, Aug 14–Sep 14 2026; cycle-level signal performance data.

HOW WE GOT THAT NUMBER

Every second of delay is a second of idling

2,353,000
vehicle-seconds of delay avoided
from the delay results

→

654
vehicle-hours of idling
divide by 3,600

→

163
gallons of fuel not burned
× 0.25 gal per idling hour

→

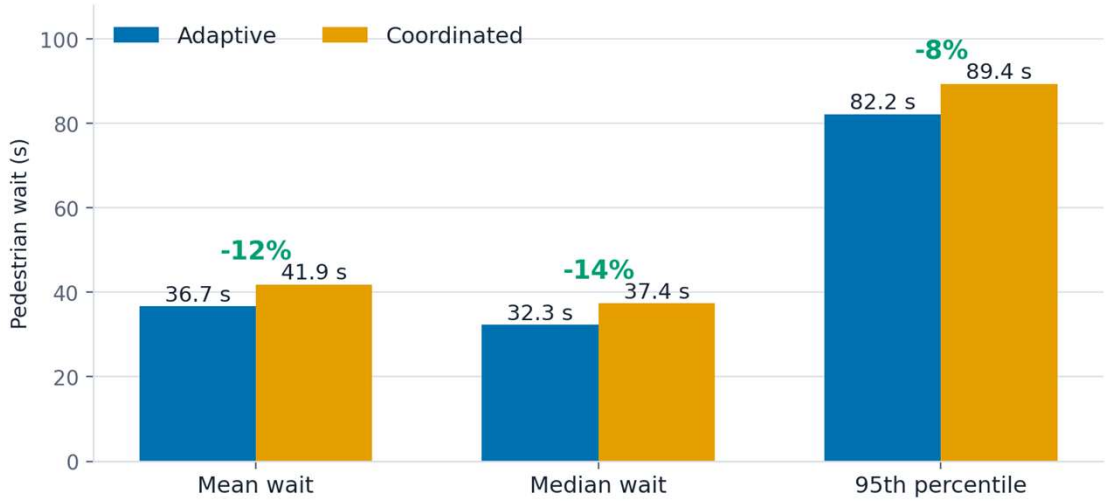
1,453 kg
of CO_2 not emitted
× 8,887 g CO_2 per gallon

Same arithmetic, minor street only: 23% less idling. Major street: 11%. Weighted across the vehicles actually served, 15.2%.

What it leaves out: the extra stops on the arterial. Acceleration burns fuel too, so treat 15% as the optimistic end.

PEDESTRIANS

12% less waiting, and a shorter worst case



−5.2 s Mean wait
41.9 s → 36.7 s

−5.1 s Median wait
37.4 s → 32.3 s

−7.2 s 95th percentile
89.4 s → 82.2 s

17,757 pedestrian walk phases across the four signals.

Arneill Rd corridor, Camarillo CA — weekdays 07:00–19:00, Aug 14–Sep 14 2026; cycle-level signal performance data.

PER-INTERSECTION RESULTS

Every location improved. Daily Dr gained the most.

Intersection	Delay, s adaptive	Delay, s coord.	Change	Relative change
Arneill & Barry	22.2	26.2	**–4.0 s**	**–15.3%**
Arneill & Pickwick	28.4	32.3	**–3.9 s**	**–12.1%**
Arneill & Daily	36.1	45.0	**–8.9 s**	**–19.8%**
Arneill & Ponderosa	50.0	55.2	**–5.2 s**	**–9.4%**

■ **Green = adaptive better**

Daily Dr gains most on both counts, 8.9 s per vehicle per cycle and 19.8%. Ponderosa carries the highest baseline delay of the four and improves least in relative terms.

Arneill Rd corridor, Camarillo CA — weekdays 07:00–19:00, Aug 14–Sep 14 2026; cycle-level signal performance data.

CONCLUSIONS

Adaptive earned its keep on the Arneill test bed.

- **Net delay and pedestrian benefits are real.**

  Delay fell in all six street-class and period comparisons; pedestrian wait fell 12%.

- **Side-street users gained most.**

  19–29% less delay on minor approaches, and 23% less idling CO_2 there.

- **Emissions follow the delay.**

  15.2% less signal-attributable CO_2, about 1,453 kg and 163 gallons of fuel over the month.

Questions. And if you run adaptive, check your own fallback hours.