Adaptive Traffic Signals Overview

Kevin Fehon, P.E., PTOE

Principal

DKS Associates

What is "adaptive" anyway?

- Signal timing is adapted to the measured traffic in real time
- Traffic is measured and/or predicted, calculations are made and timing is implemented
- "Adaptive" systems do not pick the best stored plan to match the measured traffic – that is "Traffic Responsive" (TRPS)

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Why Bother with Adaptive Control?

- Pre-stored plans accommodate variations in traffic, therefore never optimal
- Time of day selection also sub-optimal
- Pre-stored plans age quickly
- TRPS difficult to optimize, most successful on arterials, often abandoned
- 1.5 Generation updates plans but suffers from shortcomings of TRPS

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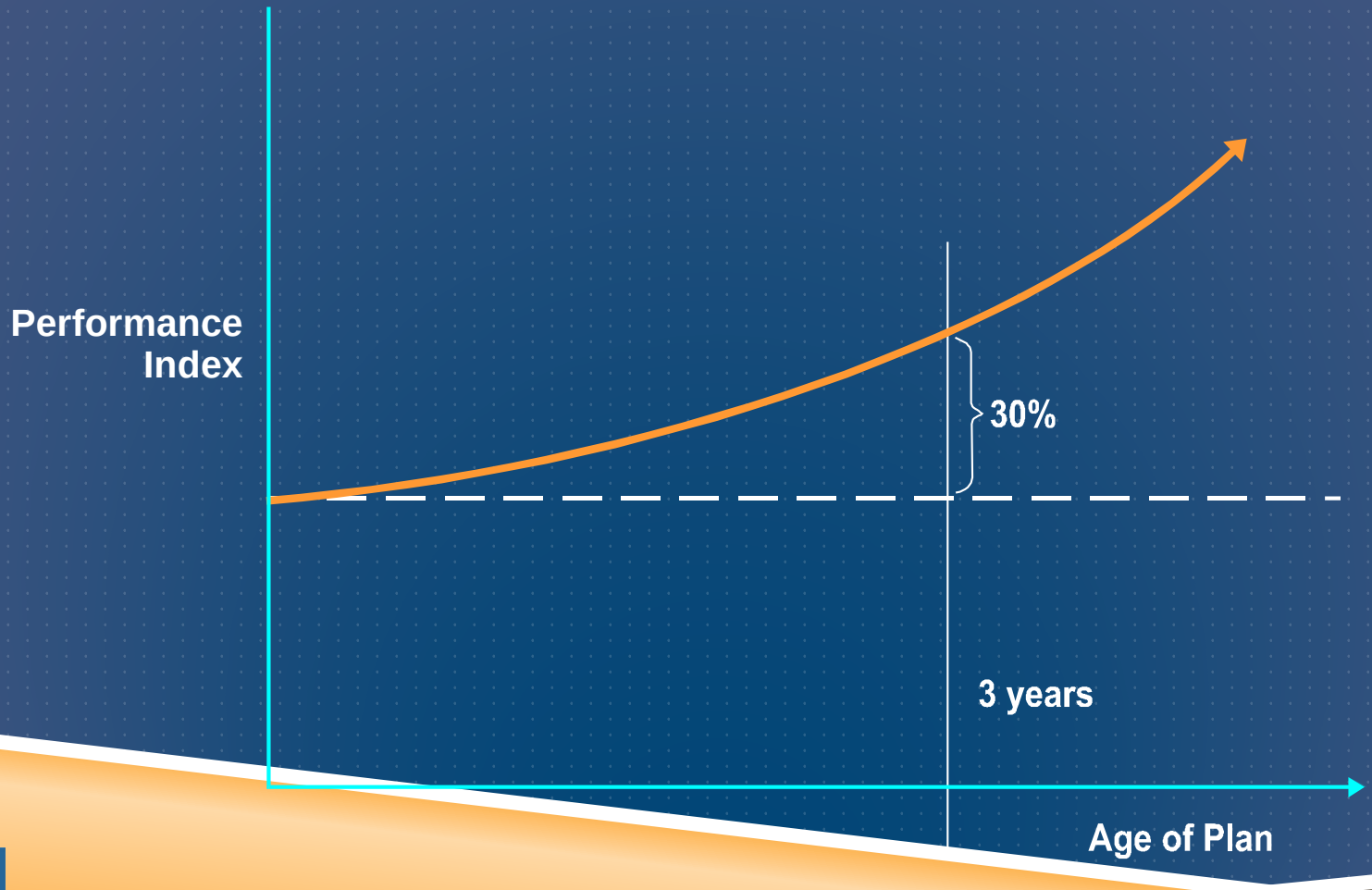
Performance of fixed time plans deteriorates



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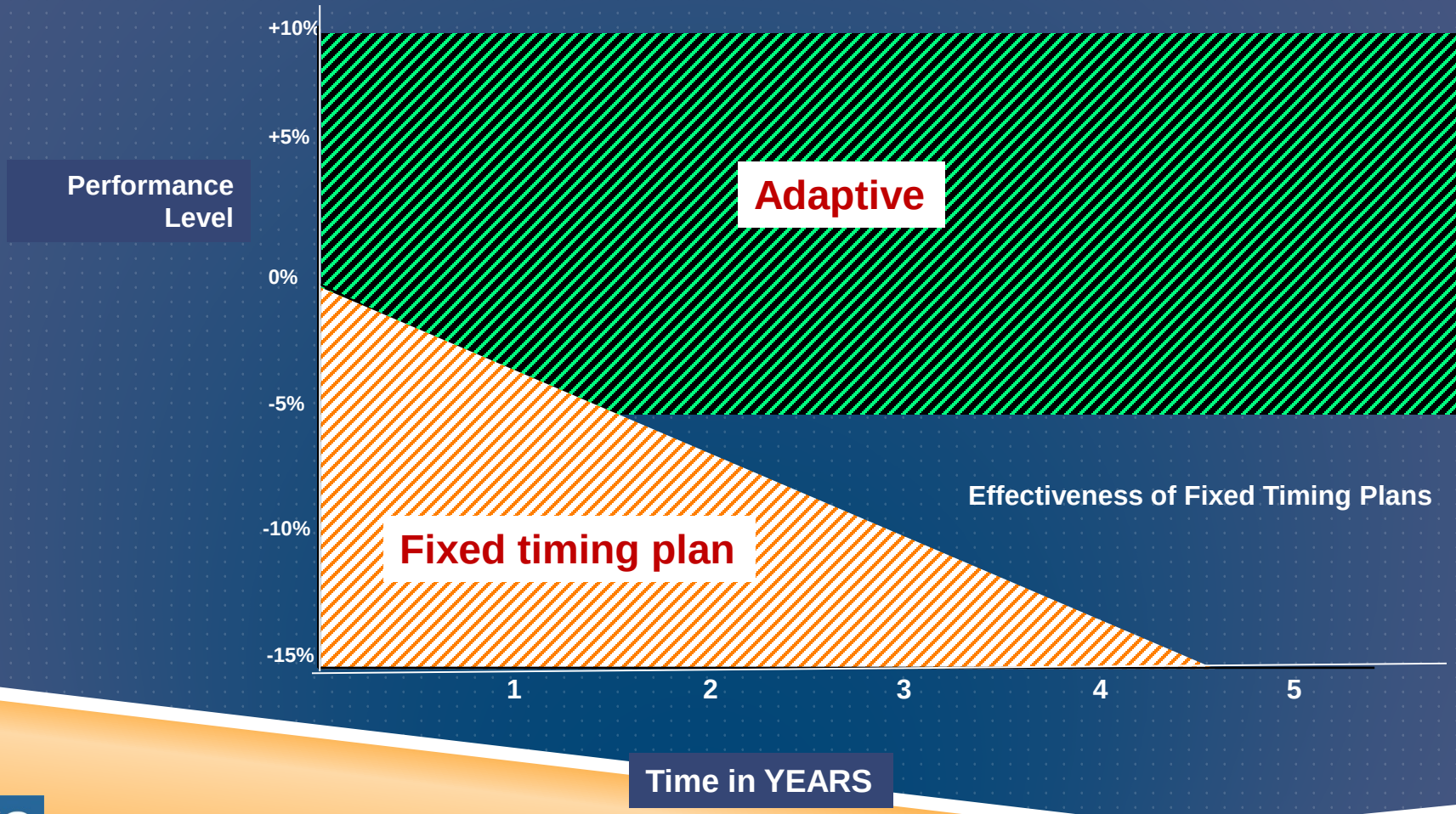
Performance of adaptive systems more stable



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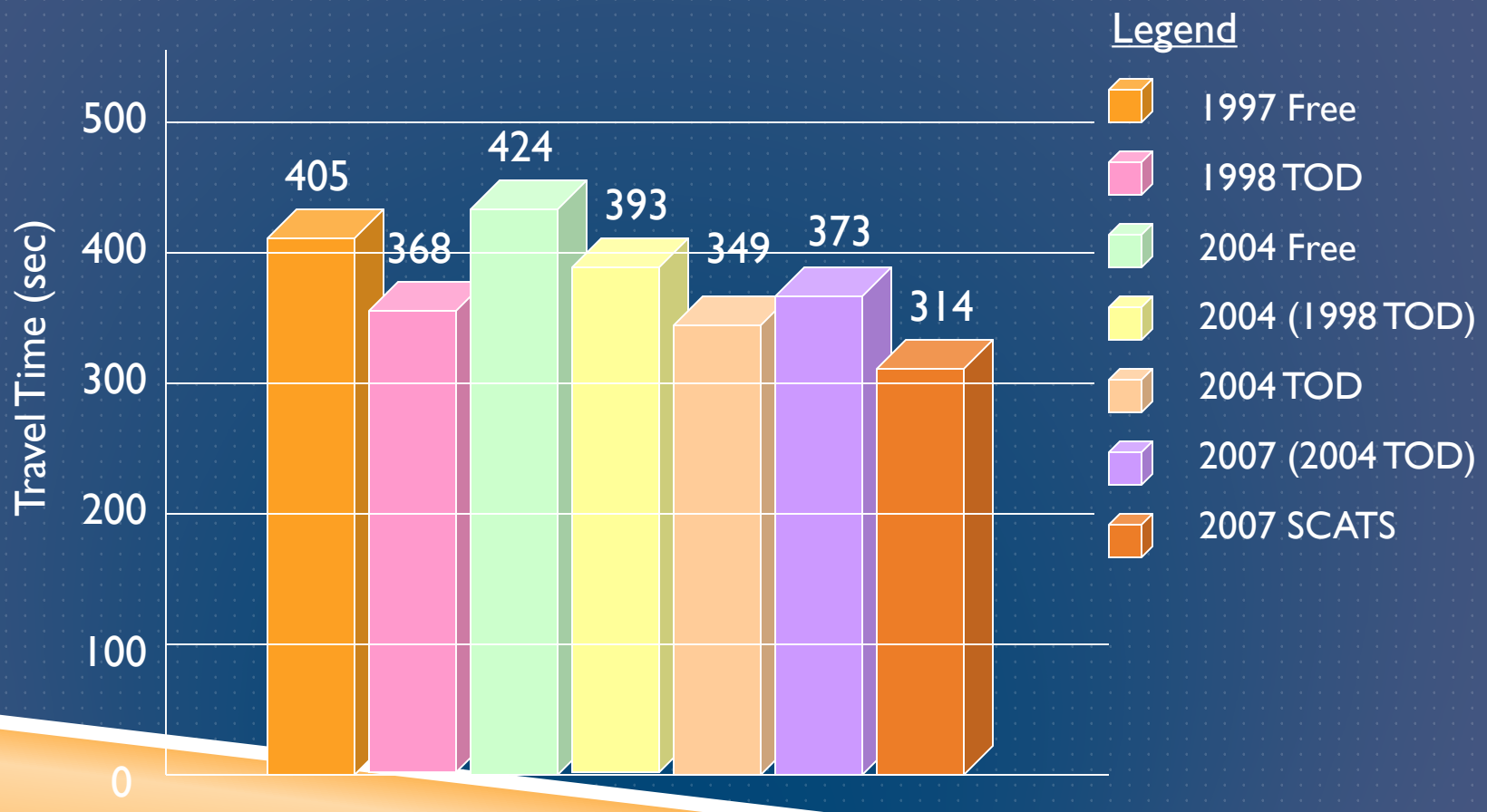
CAN ADAPTIVE SYSTEMS REALLY IMPROVE TRAFFIC OPERATIONS?

Gresham PM Peak TT (Eastbound Burnside)



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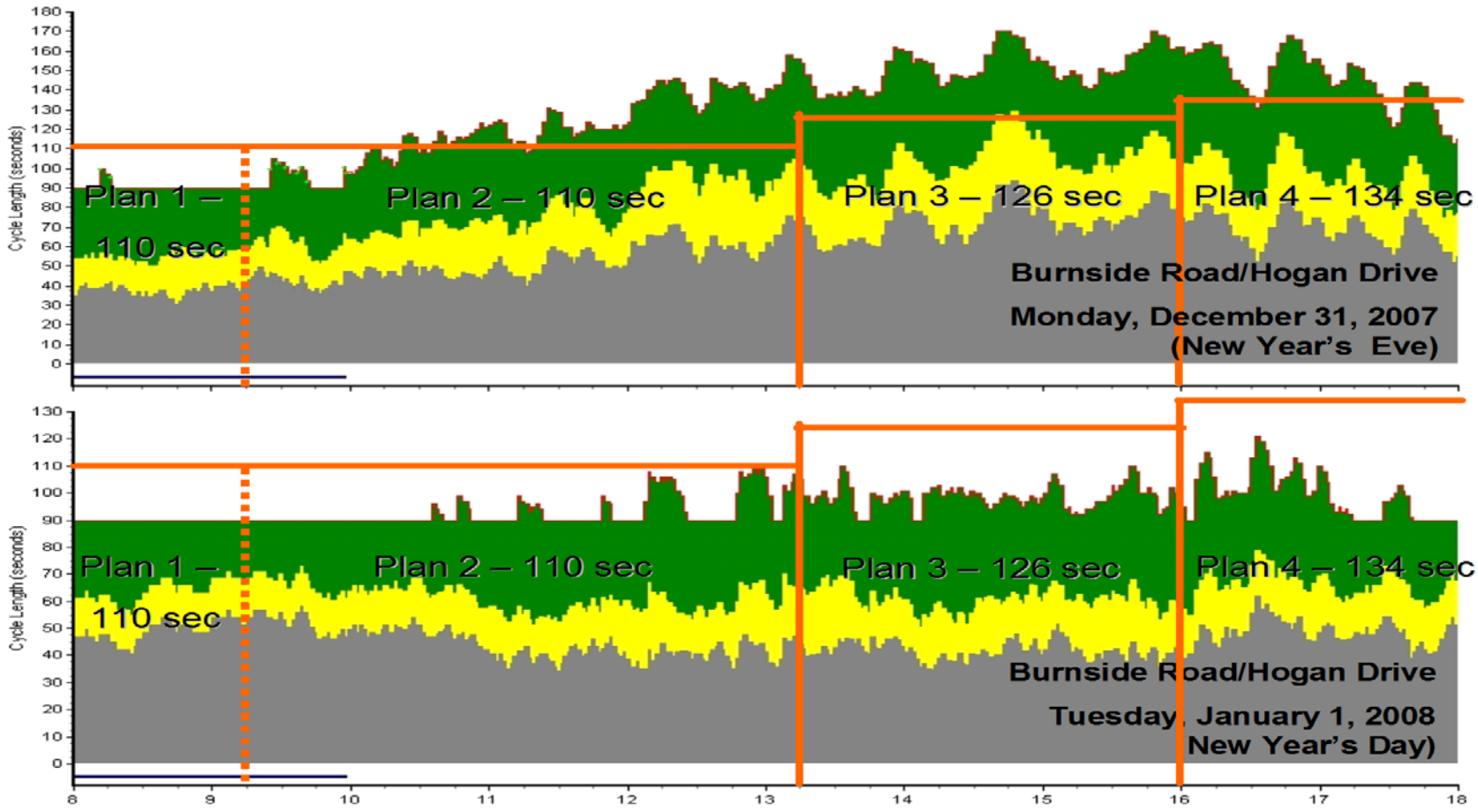
Adaptive Systems Respond to Significant Changes in Demand



HOW DO THEY WORK?

Types of algorithms

- Sequence based
  - Use a cycle length, like most coordinated signal systems
  - Have a pre-defined sequence of phases (some with flexibility)
- Non sequence based
  - Do not use a cycle length
  - Do not use a pre-defined sequence of phases

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Types of systems

- Complete, stand-alone, with full management system capabilities
- Module within proprietary signal management system
- External to proprietary signal management system

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Examples of current systems

- Complete, stand-alone
  - SCATS, SCOOT, LA ATCS
- Modules for proprietary system
  - Synchro Green (TrafficWare/Naztec), Centracs Adaptive, McCain QuicTrac, Intelight, OPAC (MIST)
- External
  - ACS-Lite, InSync, Rhodes

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Various architectures

- Centralized
  - All strategic and tactical decisions at central
- Distributed
  - Strategic at central, tactical at local
- Peer-to-peer
  - No central supervisor

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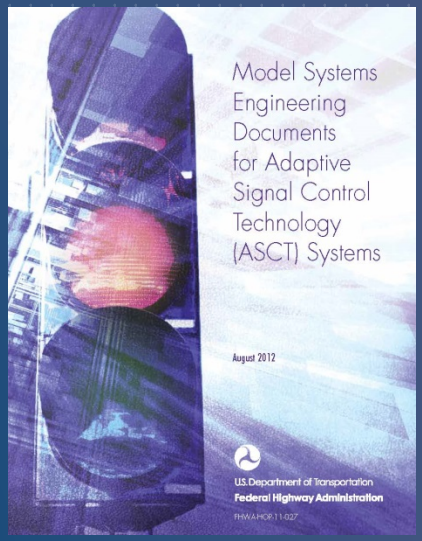
How do they work?

- Implement one or more operational strategy (See FHWA guidebook)
  - Pipeline to **maximize throughput** (appropriate with oversaturation)
  - Pipeline to **provide smooth flow** (appropriate with undersaturation)
  - **Equitably distribute green** times (appropriate with many turning movements)
  - **Manage queues**



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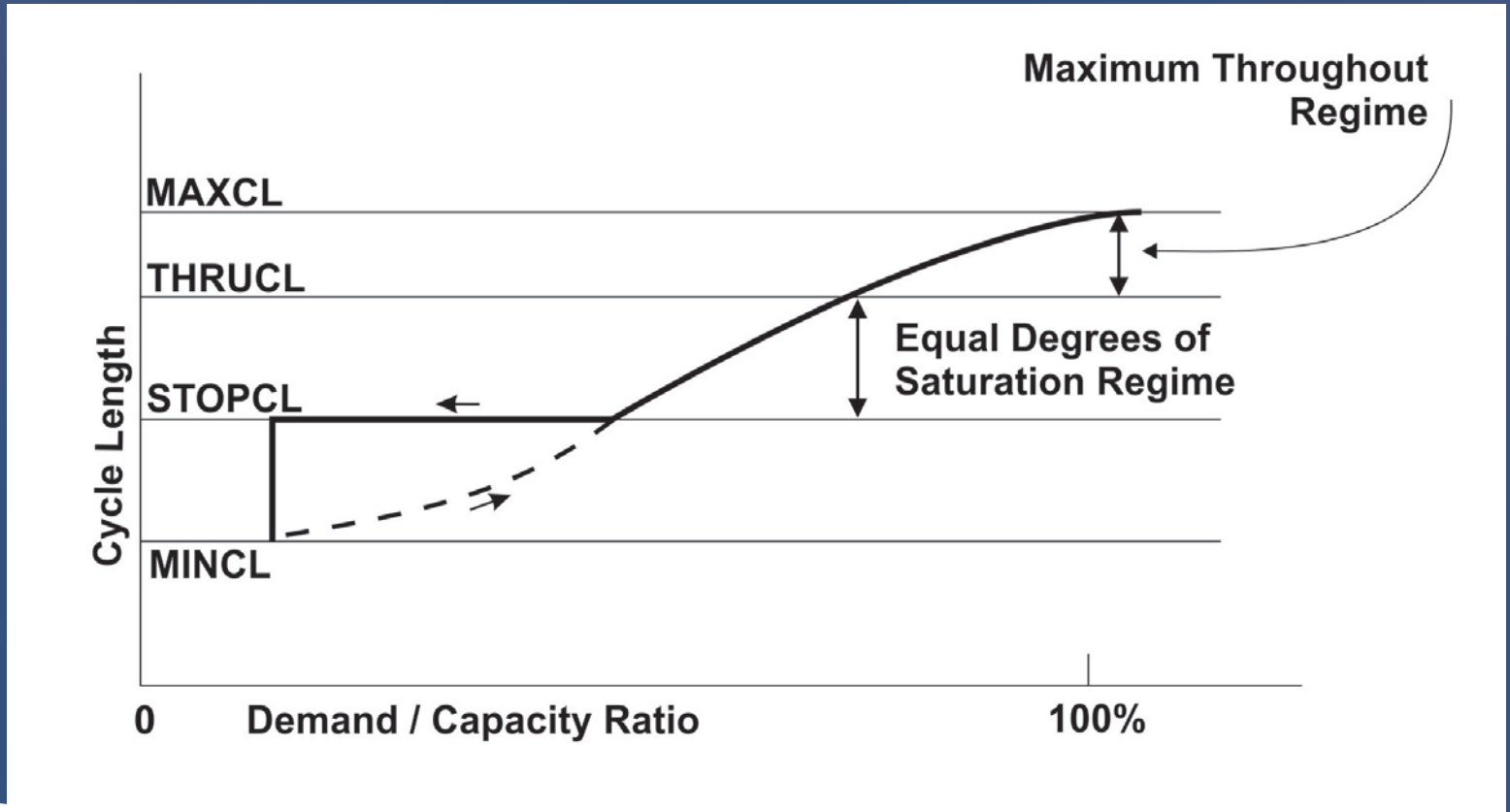
Fixed or variable objective function?



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A FEW EXAMPLES…

InSync

- Theory
  - Seeks to minimize a weighted delay objective function at one critical intersection
  - Picks next phase (state) that will minimize short term delay function
  - Inserts non-coordinated phases at other intersections outside platoon bands (tunnels)
- Practical limitations
  - Maximum wait times, overlapping tunnels, driver expectations
  - Effectively runs fixed cycles at critical intersection
  - Best with short sections of arterial

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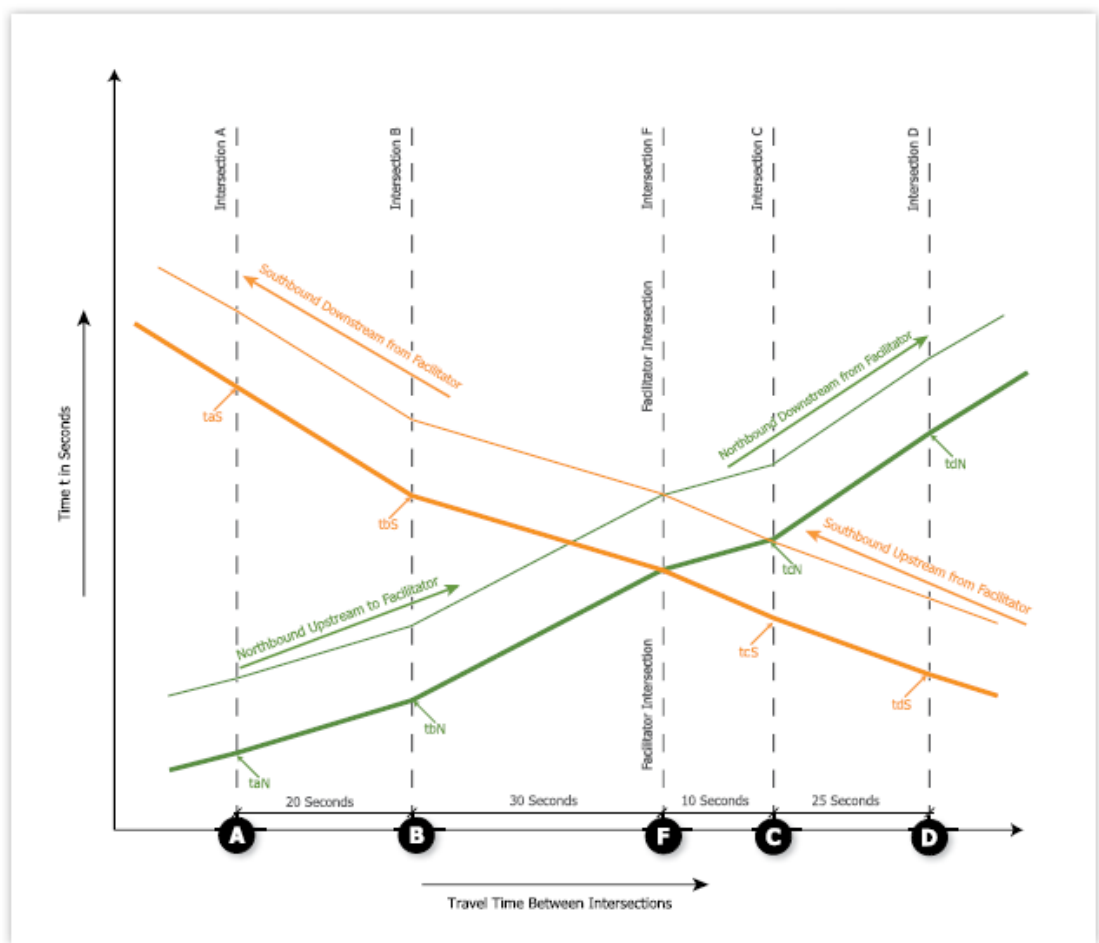
InSync "time tunnels"



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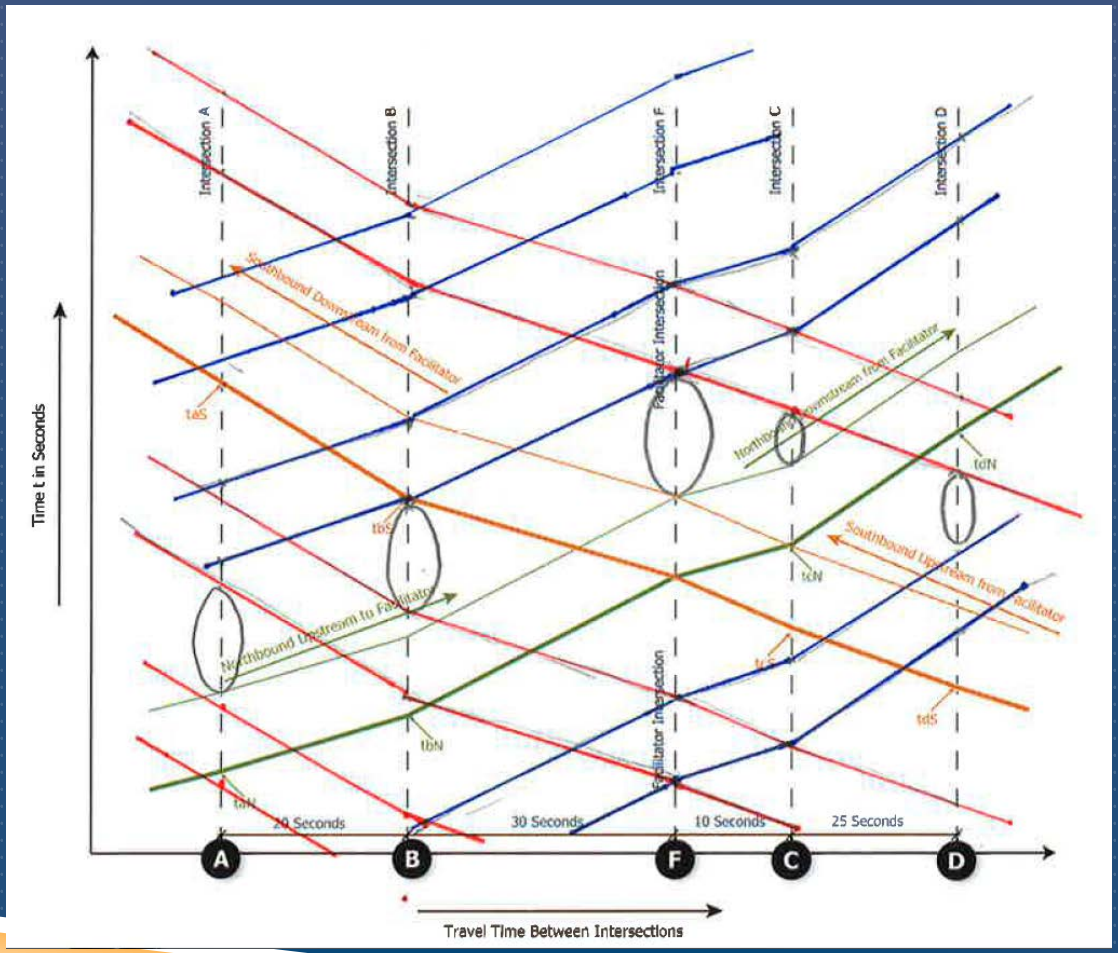
Success depends on spacing & speed



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ACS-Lite

- Theory
  - Start with a standard TOD pattern
  - Modify offsets based on detection of arrivals during green
  - Modify phase splits (based on maxouts?)
  - Modify TOD schedule
- Practical limitations
  - Cannot adjust cycle length
  - Cannot accommodate traffic markedly different from pattern basis

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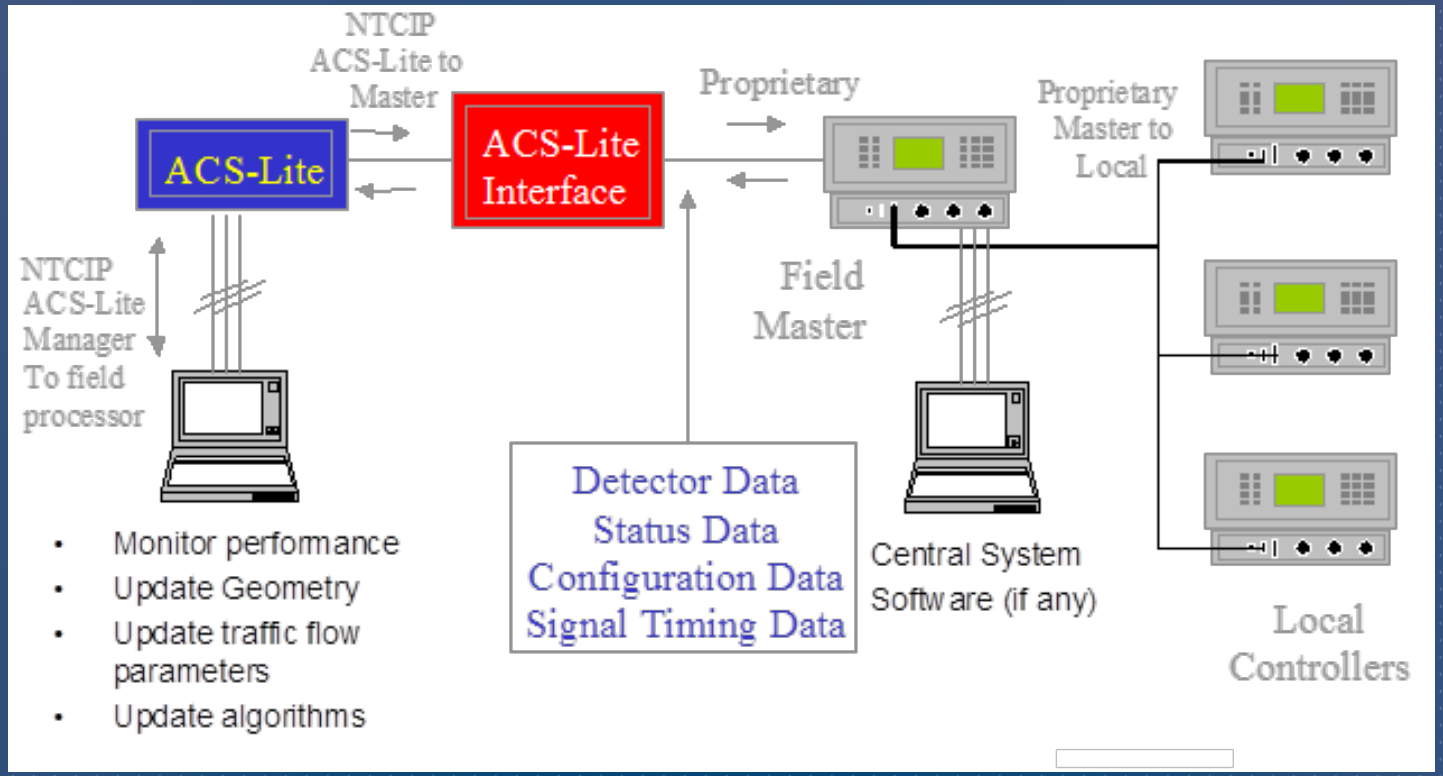
ACS-Lite architecture



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Synchro Green

- Calculation engine like Synchro
- Like Gen 1.5, traffic responsive with regular recalculation of background pattern

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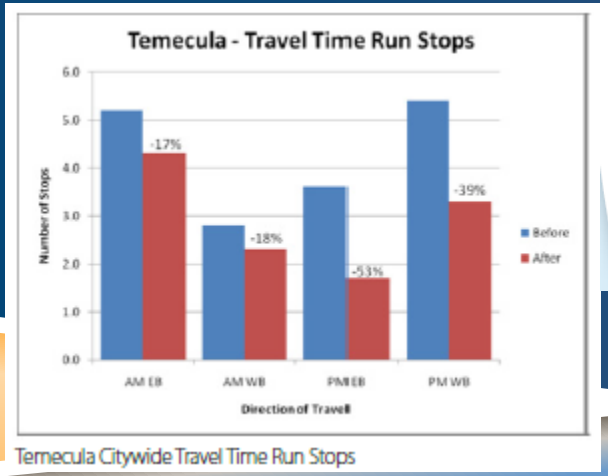
QuicTrac

- Estimate platoon speed with system detectors and calculate offsets at master
- Calculate cycle length at master based on local volumes
- Calculate splits at local



Temecula Citywide Travel Time Run Stops

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SCOOT

- Calculation engine similar to TRANSYT/7F
- Based on signal timing theory
- Measures volumes entering a link
- Calculates cycle length, splits and offsets
- Makes regular small steps to follow changing traffic patterns
- Coordinated groups fixed. Usually some VA

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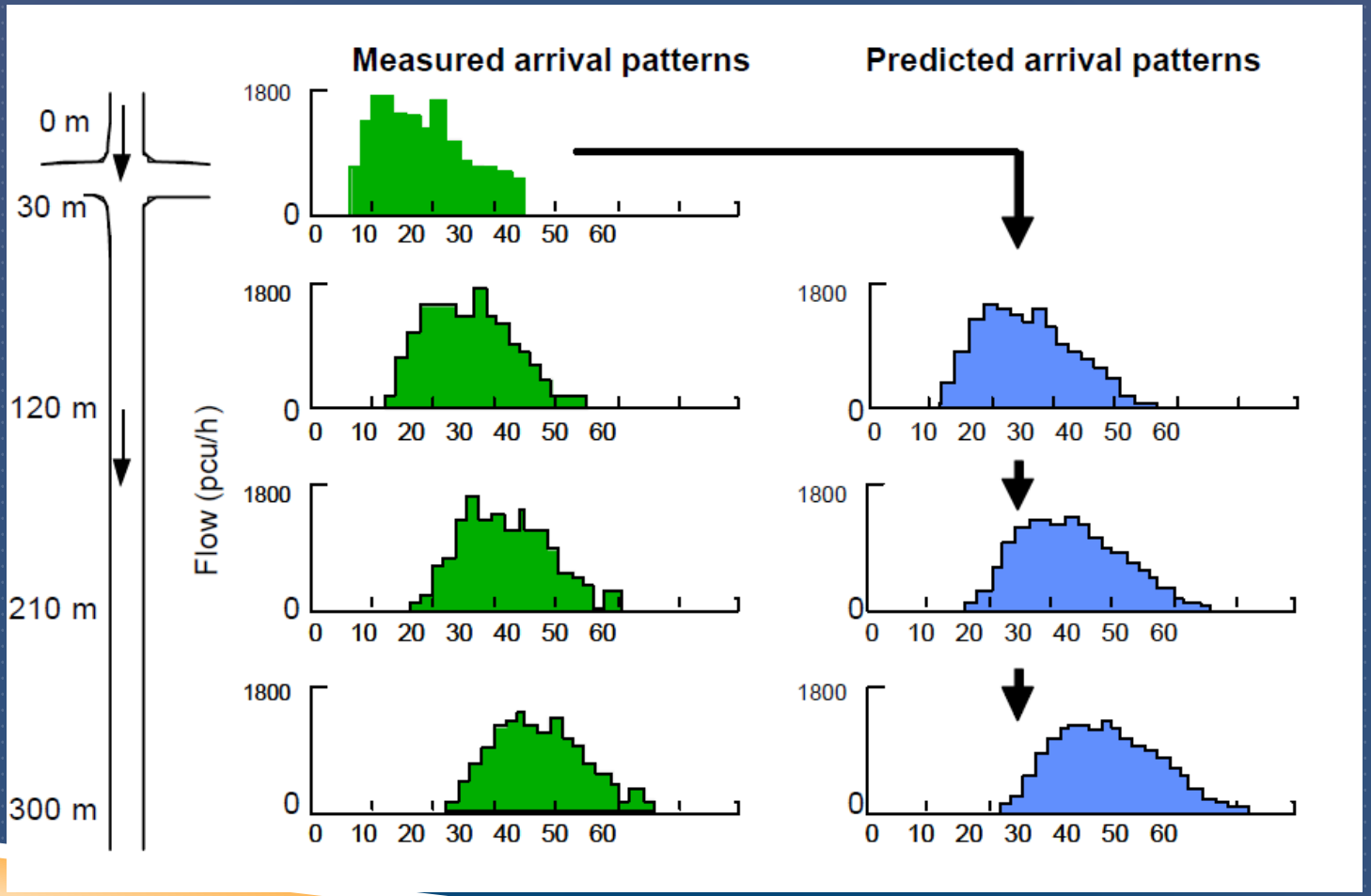
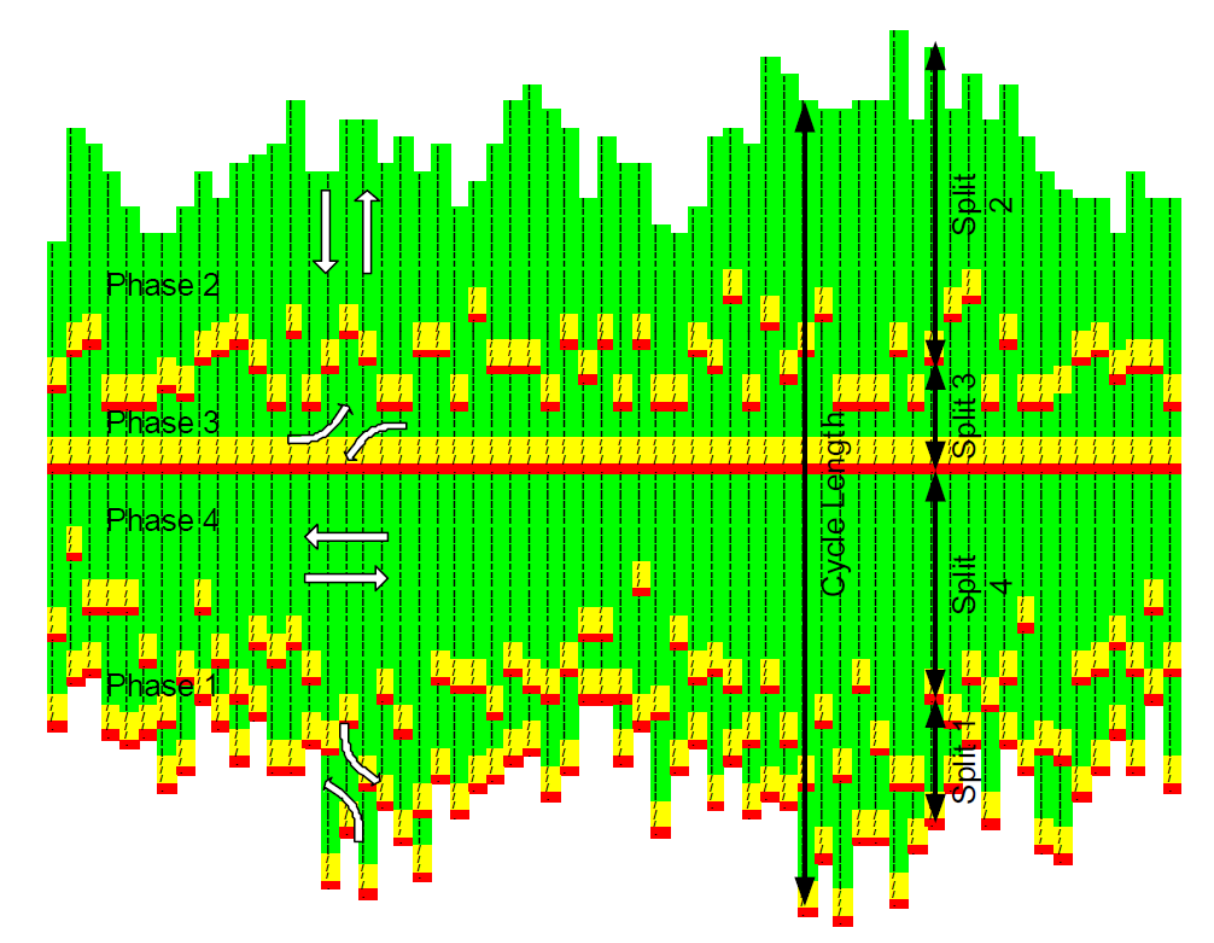
SCOOT platoon arrivals



SCOOT cycle by cycle changes



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SCATS

- Measures degree of saturation at stop line to calculate cycle length and splits
- Measures volumes entering links to select best direction of offset
- Practical implementation of how traffic engineers set up coordination patterns
- Determines which intersections need coordination – flexible grouping
- Selects appropriate objective function based on V/C regime

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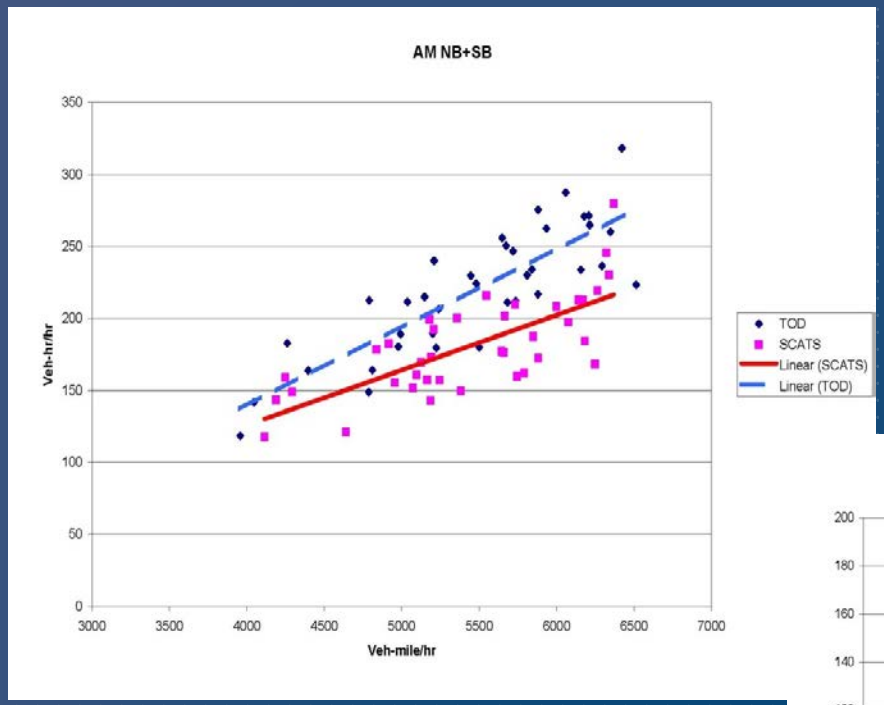
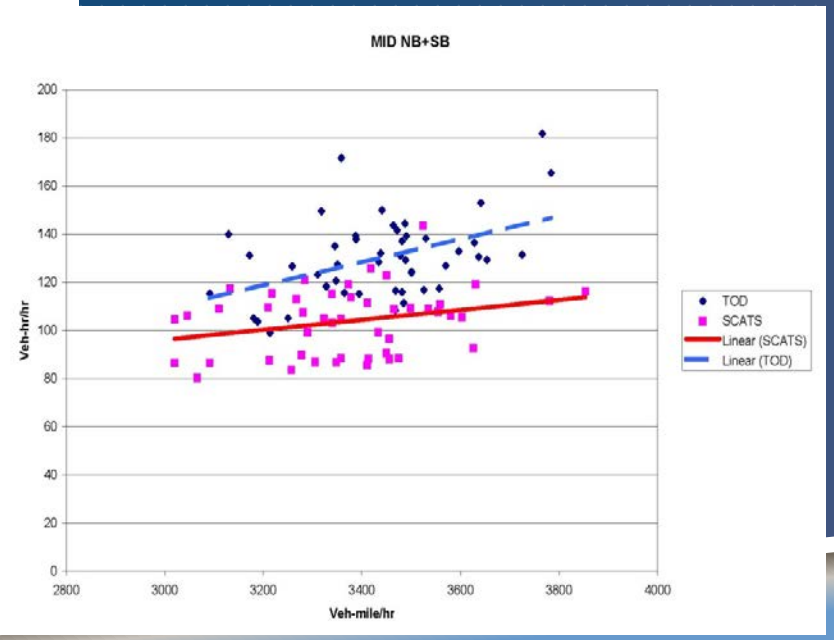
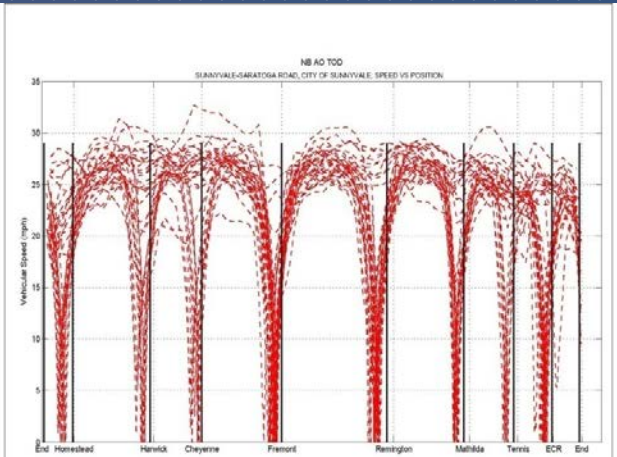
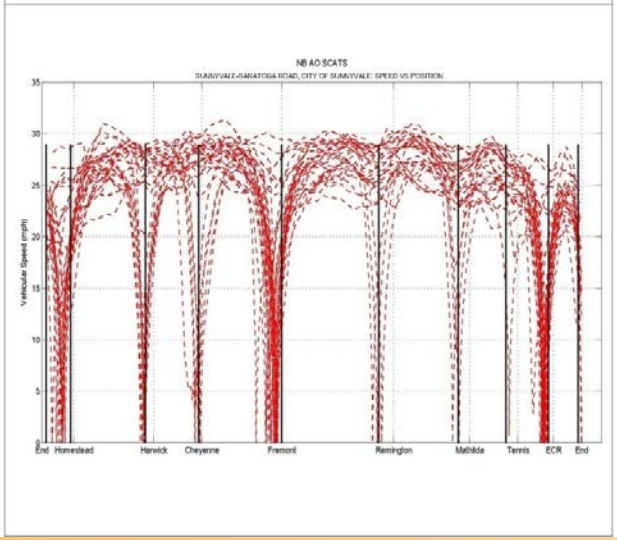
Sunnyvale: Extension of SCATS

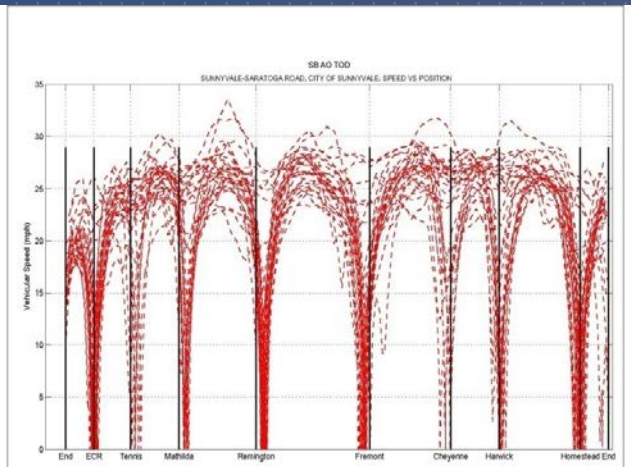


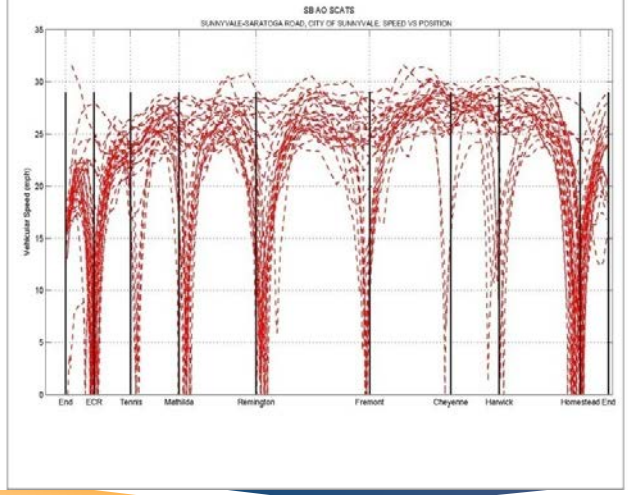


Sunnyvale SCATS









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LA ATCS

- Over 3500 intersections under control
- System being expanded
- Apparently operates well, but not really as adaptive as it sounds
- Not well documented
- Better supported in last few years

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Other systems

- Intelight adaptive (new)
- Surtrac (experimental – Carnegie Mellon)
- OPAC
- Rhodes
- SPOT

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What is good? What is not?

- SCOOT – well proven in many countries, variable in USA
- SCATS – well proven in many countries, generally good in USA
- InSync – rapidly growing, variable results
- Synchro Green – steadily growing, satisfactory
- ACS-Lite – slow progress, several vendors
- Centracs Adaptive – integrated and improved ACS-Lite
- QuicTrac – several successful deployments
- RHODES – development continues, practical results patchy
- OPAC – variable results, not growing
- LA ATCS – apparently good, little published data, expanding beyond City of LA.

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Is an adaptive system right for you

- Do you have a corridor or closed network
- Does demand exceed the theoretical and practical capacity of your corridor

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Should I consider adaptive control?

Should I consider ASCT?

I manage a large city, with over 1000 traffic signals, I'm considering adaptive signal control for some intersections, but how do I determine the right place for adaptive?

I need to improve my network to comply with new air quality standards. Is it time to consider adaptive control?

I'm a technologist and want to use the latest and greatest. I just heard about adaptive control and it sounds great; I want one! What do I do next to get it?

I been working with my consultant/vendor for many years and they have been telling me about new adaptive traffic control systems that I should consider. What locations would be the best fit for an adaptive control system?

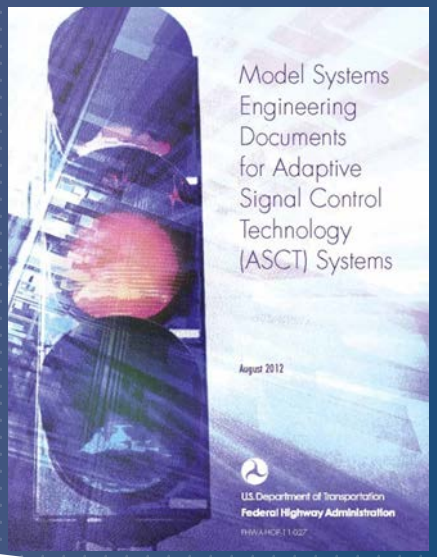
I am getting calls on a couple of my intersections and I cannot solve the cycle/phase issues. Will adaptive control help?

I have a very old traffic control system and with my recent grant I think I can afford a new system. Is it time to consider adaptive control?

I have a corridor on which I run time of day coordination, but occasionally diverting traffic overwhelms the corridor. Could adaptive control provide a better solution?

I have tried time of day coordination and even traffic responsive plan selection, but I feel there could be something better. Could adaptive control be a better solution?

The planners are telling me that in the next ten years there will be 50% growth along the main corridor in the city. The current traffic signal system will not handle the traffic based on the current capacity. Is it time to consider an adaptive control?



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What do the opponents say?

- I know exactly what will happen on my street on Monday morning.
- The transitions cause too much disruption and are counter productive
- The detection costs too much and is not reliable
- The communication costs too much or is unreliable
- I don't believe the claims
- I have too much investment in my current system

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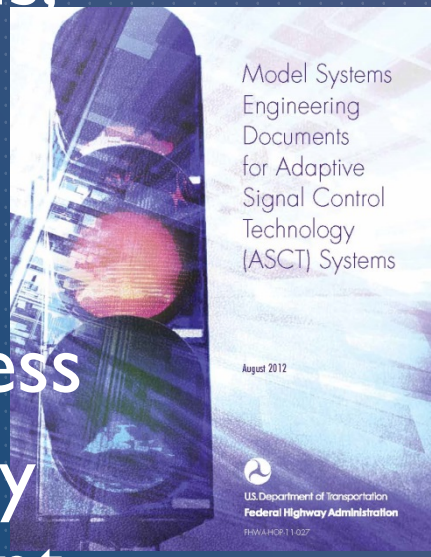
How should I get an adaptive system?

- If any Federal funds involved, must provide a systems engineering analysis, commensurate with the scale of the project
- Selection must be competitive, but recommend AGAINST low-bid process
- You are buying technology, with every product different, not buying pavement complying with a physical specification



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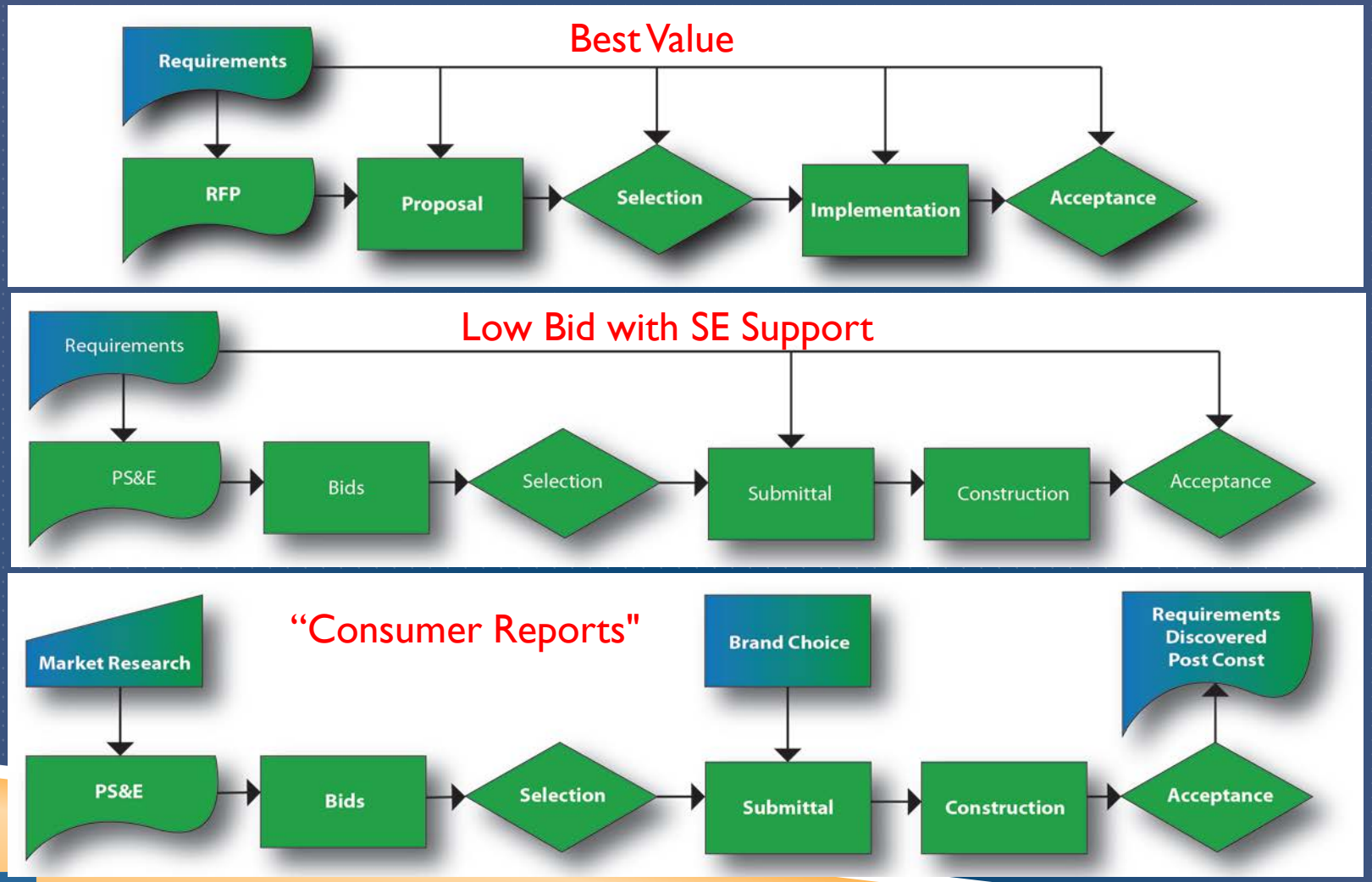
Procurement options



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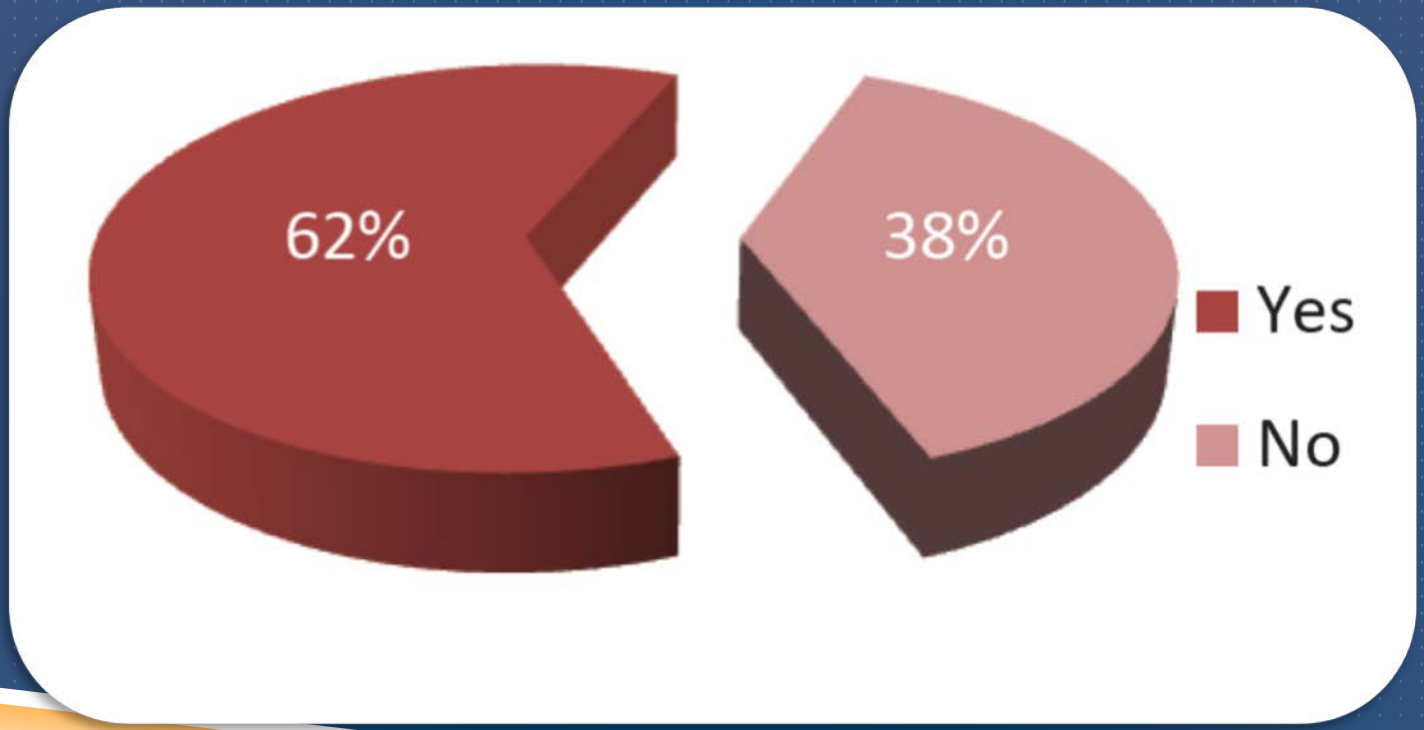
Would you do it again?



Source: Adaptive Traffic Control Systems in the United States, Matt Sellinger, HDR Engineering, Inc.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