Reducing Speeding by Removing Speeding Opportunities:
Field Test of Safe Waves Traffic Signal Timing

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Why Speed Control on Arterials?

- **Vision Zero** principles: cities feel a stronger need to reduce extreme speeding on arterial roads.
- **Safety**, According to NHTSA (National Highway Traffic Safety Administration)
  - 28% of the traffic fatalities in the United States in 2021 were speeding-related.
  - 65% of non-freeway traffic fatalities in urban areas occur on **arterial roads**

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How Can We Control Speed on Multilane Arterials?

- **Local street treatments:**
  - ~~horizontal~~
  - ~~and vertical deflection~~ cannot be applied on multilane arterials
- **Other speed control methods:**
  - ~~Road diet~~ (Not always work)
  - ~~Automated enforcement~~ (Illegal in many states)
  - ~~Mandatory intelligent speed limiters~~ (not politically acceptable)
  - ~~Lowering the speed limit~~ (not effective)
  - **What other method can be effective for reducing speeding?**
    - Traffic Signals (???)

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Fully Actuated Control is an effective means of speed control

- Green automatically terminates when the platoon clears
  - Can't speed when in the discharge platoon
  - Excess green is cut off!
- Sweden, Netherlands: 80+% of urban traffic signals use fully actuated signal control
  - One of the reasons engineers give is to remove opportunities to speed
- HOWEVER, the distance between intersections is short in US cities, and the queues will spillback to the next intersection.

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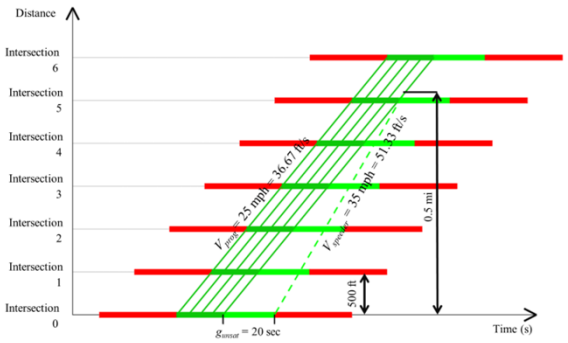
HOW Coordinated Signal Timing Allow Speeding?

- **One-way coordination**
  - Offsets for a safe progression speed prevents speeding at the head of the platoon
  - Long cycle → **Excess Green** creates speeding opportunities at the end of green



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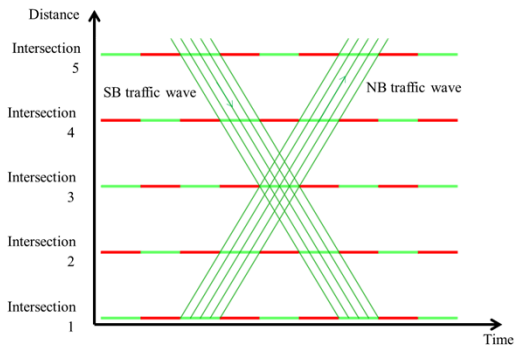
HOW Coordinated Signal Timing Allow Speeding Opportunities?

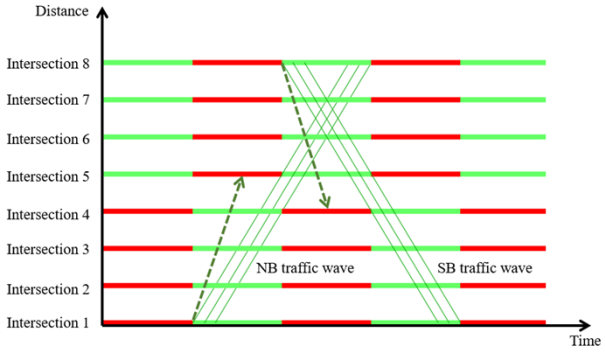
Two-Way Coordination

Ideal spacing = 0.5 cycle length – same speed control as one-way coordination



Ideal two-way coordination

- BUT in most urban situations, intersection spacing is much smaller
- Result: intersections are clustered into sets such that
  - middle of one cluster to another = 0.5C
- Driver sees **multiple green lights** – an incentive to speed!



Coordination with short urban blocks

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Background

- **Safe Waves Approach Principles (Used 2018 in a simulation study for the first time)**:
  - Short cycle lengths,
  - Moderately low progression speeds,
  - Break arterial into small coordination zones, with cycle tailored to each zone's need,
  - No more than two intersections with simultaneous offset,
  - Pedestrian phases on recall unless there is very low pedestrian demand.
- Only what's measured counts
- A need for a performance measure!
  - **A Speeding Opportunity**: *an event of a vehicle arrival on a stale green with no vehicle ahead of it (in its lane) for at least 5 s.*

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Previous Studies

- Furth and Halawani (2018)
  - **Simulation model**
    - Massachusetts Avenue in Boston with 7 intersections
    - Melnea Cass Boulevard in Boston with 6 intersections

Arterial	Period of the Day	Percent change in speeding opportunities	Change in average vehicle delay networkwide (s)
Melnea Cass Blvd, Boston	midday	-66%	-3.0
	PM peak	-30%	1.0
Massachusetts Av, Boston	AM peak	-37%	-7.0
Huntington Av, Boston	AM peak	-34%	0.1
	midday	-51%	5.6

- Furth and Lippman (2024)
  - **Simulation model**
    - Huntington Ave in Boston with 9 signalized intersections

Promising results!
A need for field test to examine the effect on drivers' behavior (speeding)!

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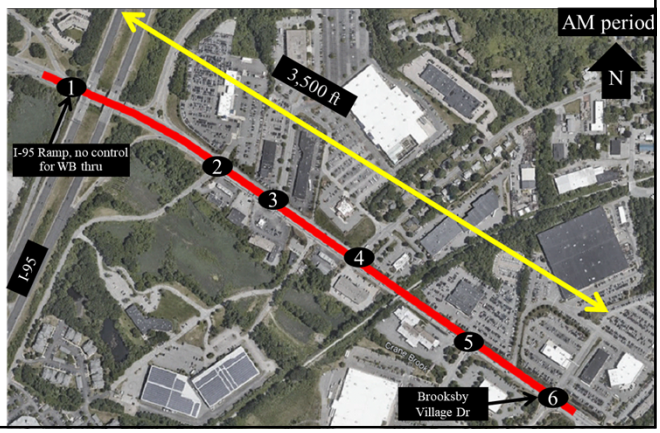
Field Test: Route 114, Danvers, MA

Hypothesis

- Safe Waves signal timing approach will reduce speeding with little or no increase in average vehicle delay.
- HOW much will it reduce speeding?

Characteristics of Rt-114:

- 5-lane (2+2 thru lanes plus one left turn lane at intersections)
- Undivided
- With 6 signalized intersections
- Intersection spacing = 450 ft to 1000 ft
- AADT = more than 36,000 Veh/day



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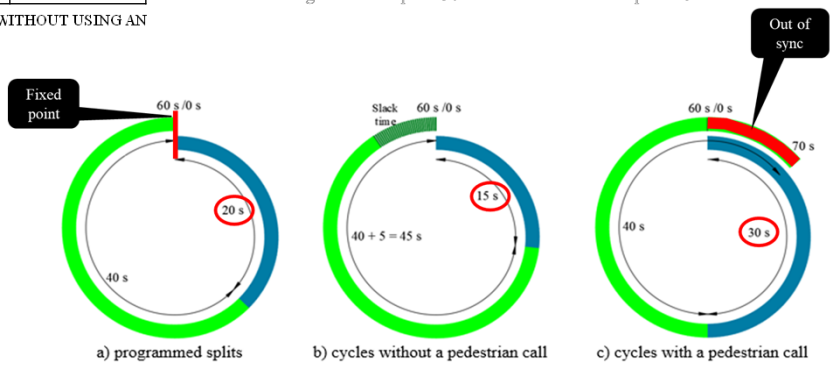
Safe Waves Signal Timing Approach

Cycle length (s)

PERIOD	EXISTING	NEEDED	PROPOSED
AM	120	54-66 (78) *	66
MIDDAY	120	65-72 (84) *	72
PM	95	78-84 (110) *	84

*: VALUES IN PARENTHESES ARE CYCLE LENGTH WITHOUT USING AN UNDERSIZED PHASE

- **Short cycles, HOW?**
  - Concurrent ped instead of exclusive ped
  - Undersized phase technique
  - Designed for the peak 30-minute rather than the peak 15-minute



a) programmed splits b) cycles without a pedestrian call c) cycles with a pedestrian call

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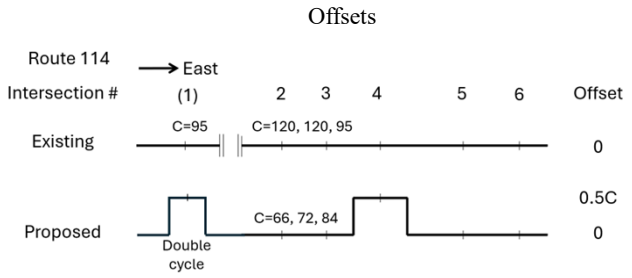
Safe Waves Signal Timing Approach



- **Offsets!**
  - No more than two consecutive intersections with simultaneous green

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Data Collection Methods

- **Radar: Speed, [lane, headway]**
  - Speed data is valid
  - Lane was often misassigned, making headway data unreliable
    - Thus, field measurement of speeding opportunities was not reliable
- **Camera: Signal state (green or not)**
  - Used to filter out vehicles detected during red
- **INRIX: Travel time, [speed]**
  - Travel time data is valid; change in travel time agrees closely with SWAT
  - Speed data is questionable – we want each vehicle's peak speed within a segment, not average speed

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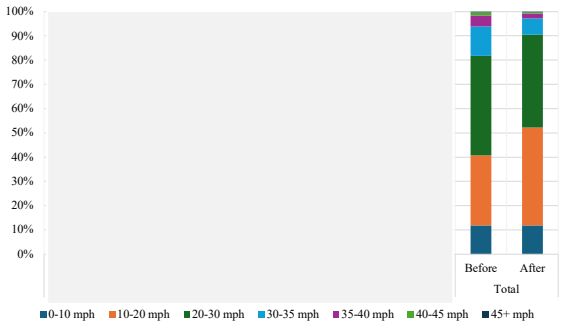
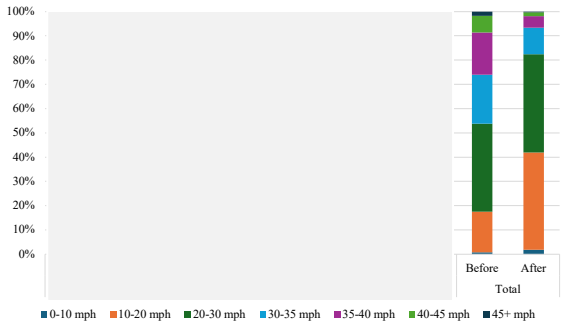
Results: Changes in Speed Distribution

- **AM Peak** (7:00-9:00 a.m.)



Eastbound



Westbound

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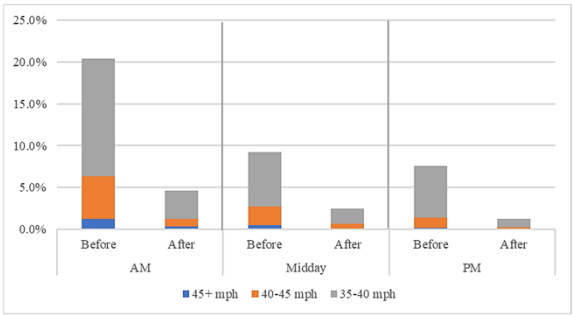
Results: Changes in Speeding from Field collected Data

The posted speed limit is 40 mph.



Speed	Reduction
35+ mph	78%
40+ mph	79%
45+ mph	74%

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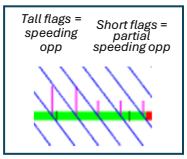
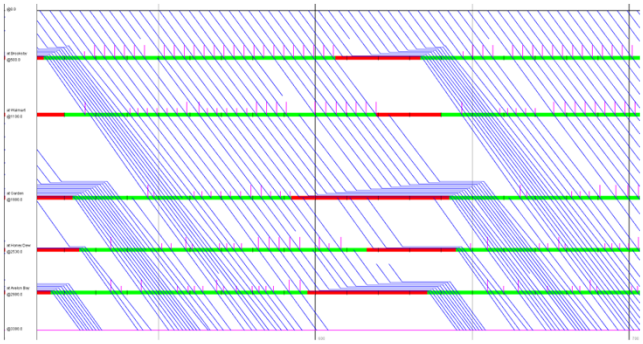
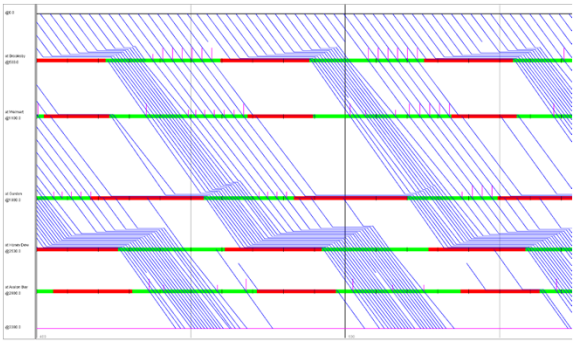
AM Peak Westbound (light direction)



Before, C = 120 s



After, C = 66 s



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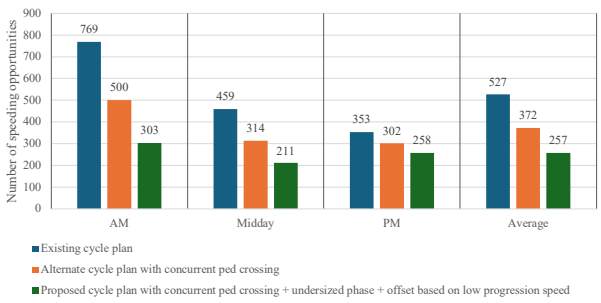
Results: Change in Speeding Opportunities from Safe Waves Analysis Tool (SWAT)

Speeding opportunity = An event in which a car arrives at stale green with a gap of at least 5 seconds to the car ahead.

Alternatives:

- Existing plan
- Alternative cycle plan with concurrent ped crossings
- Proposed cycle plan based on Safe Waves Signal Timing Approach



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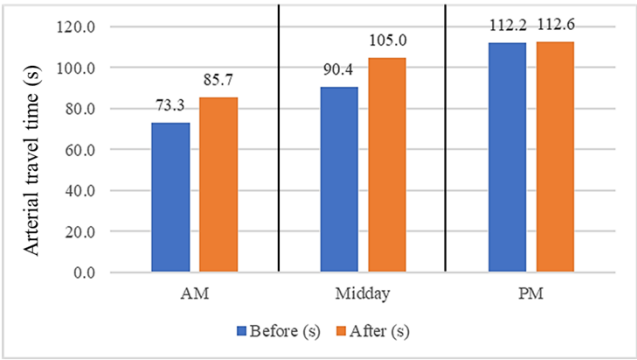
Results: Change in Travel Time

Travel time (delay) on average increased by 1.8 seconds per intersection (INRIX).



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Results: Changes in Pedestrian Delay

Concurrent ped crossing instead of exclusive ped crossing → Pedestrian delay, on average, decreased by 18.5 seconds.

Time of day	Before	After	Change
AM	60.0	33.0	-27.0
Midday	60.0	37.0	-23.0
PM	47.5	42.0	-5.5
Average	55.8	37.3	-18.5

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Safe Waves Analysis Tool (SWAT)

- **Purpose:** Enable engineers to evaluate a traffic signal timing plan in terms of *speeding opportunities* and *arterial delay*
  - ➢ Only what's measured counts
  - ➢ Visualization aids in refining a plan
- **Demo:** newton.neu.edu:8080/SafeWaves/
  - ➢ Resources offered:
    - User guide
    - Input file template
    - Sample input files
  - ➢ **Outputs**
    - Performance measures: speeding opportunities, arterial delay
    - Visualization aids in refining a plan

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SWAT: Output

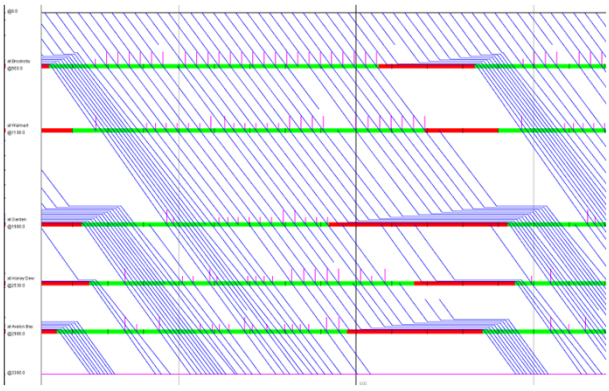
RESULTS

Route 114, EB, Weekday a.m. peak.

Base case, *

Safe Waves Analysis Tool / 2024-02-08 16:05:25

INTERSECTION	Speeding Opp's (per hr)	Thru Volume (Veh/h)	Speeding Opp's (% of thru veh's)	Thru Delay (s/veh)
1. at Brooksby	700	1041	67.3 %	4.1
2. at Walmart	706	1026	68.9 %	0.1
3. at Garden	281	991	28.4 %	13.4
4. at Honey Dew	389	1113	35.0 %	1.5
5. at Avalon Bay	264	1160	22.8 %	5.2
TOTAL	2340	5331	43.9 %	24.5
AVERAGE per intersection	468	1066	43.9 %	4.9



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SWAT Input File (Excel)

- Geometry (intersection spacing)
- Volumes
- Info from Synchro reports:
  - ➢Saturation flow rates
  - ➢Effective actuated green
- Signal timing info: Cycle, offset, green
  - Offset & green intervals are for effective actuated cycle
- One direction (e.g., EB) at a time
- Prep time ≈ (5-10) minutes per intersection
- Example

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Conclusions

Applying Safe Waves Signal Timing principles resulted in:

- Significant reduction in number of speeding (75%)
- Less than 2 seconds increase in arterial delay
- More than 18 seconds decrease in pedestrian delay

SWAT, a tool for estimating the number of speeding opportunities:

- newton.neu.edu:8080/SafeWaves/

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