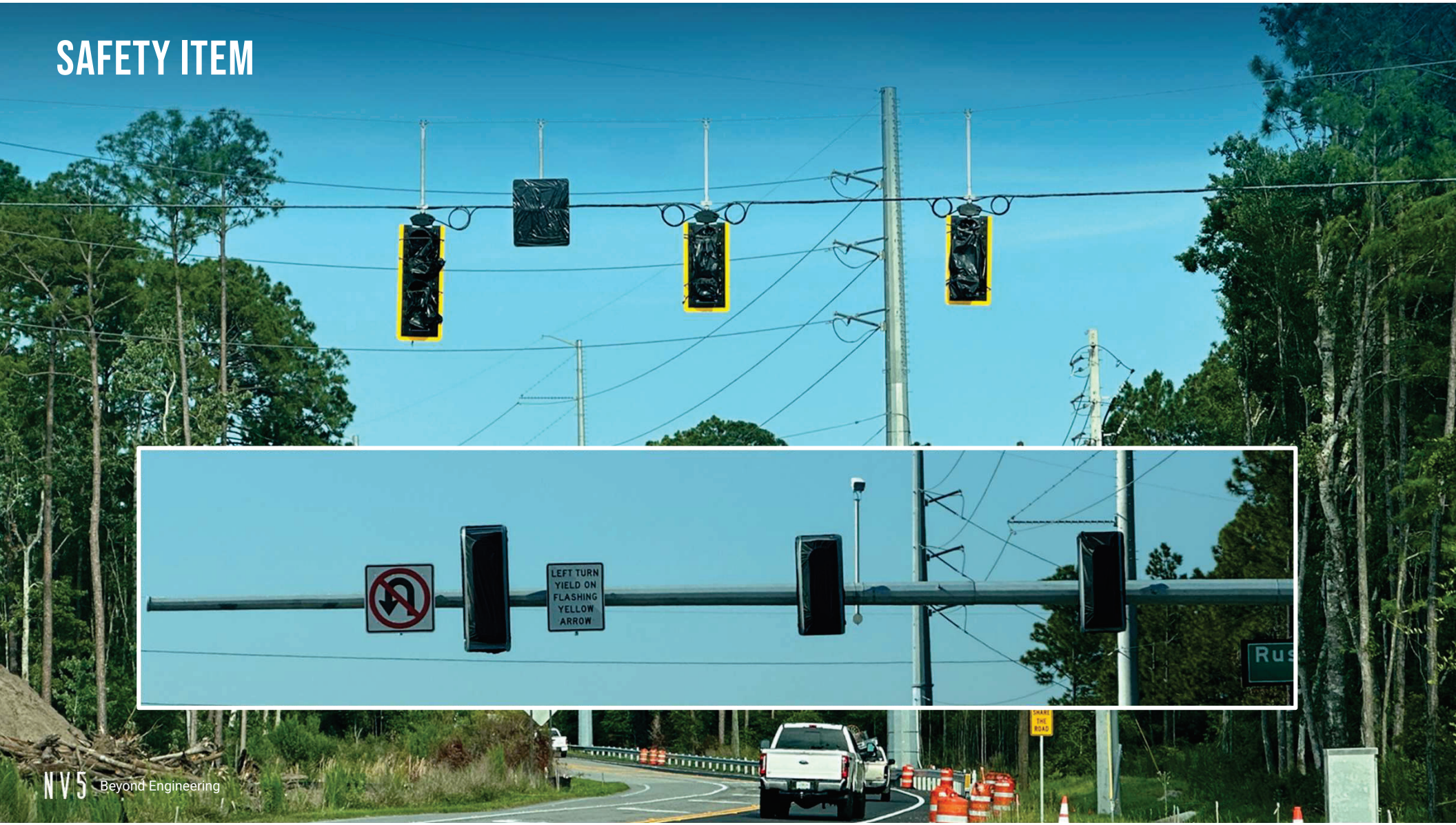
NV5

TRAFFIC SIGNAL OPERATIONS & MAXIMIZING SIGNALIZED INTERSECTION CAPACITY

November 20, 2025

SAFETY ITEM



MAXIMIZING SIGNALIZED INTERSECTION CAPACITY

Intersection capacity: the maximum rate at which vehicles can pass through an intersection in an hour under prevailing conditions.

Often estimated based on assumed values for saturation flow with consideration to the number and width of lanes, grades, lane use, vehicle types, & traffic control.

- Critical lane capacity at signalized intersections:
  - Historical value: 1,400 vehicles per hour (according to 1985 HCM).
  - Current estimation: 1,900 passenger cars per hour per lane (pc/h/ln). This base is often adjusted for specific conditions.

Operational measures of effectiveness:

- Capacity and Volume-to-Capacity Ratio
- Delay per Vehicle, Movement, Approach and Overall Intersection
- Queue Length

CAPACITY FORMULA:

$$c = s\,(g/C)$$

c - capacity

s - saturation flow

g - effective green time

C - cycle length, sec

CAPACITY AND VOLUME/CAPACITY RATIO

Volume to Capacity (v/c) Ratio	Description
< 0.85	Intersection is operating under capacity. Minimal delays, if any.
0.85 – 0.95	Intersection is operating near its capacity. Higher delays may be expected, but continuously increasing queues should not occur.
0.95 – 1.00	Unstable flow results in a wide range of delay. Intersection improvements will be required soon to avoid exacerbating delays.
> 1.00	The demand exceeds the available capacity of the intersection. Long delays and long queues are anticipated.

CAPACITY FORMULA:

$$c = s\,(g/C)$$

c - capacity

s - saturation flow

g - effective green time

C - cycle length, sec

HIGHWAY CAPACITY MANUAL LEVEL OF SERVICE

Level of service criteria for signalized intersection:

Level of Service	Average Control Delay (sec)	Description
A	< 10	Free flow
B	> 10 - 20	Stable flow (occasional delays)
C	> 20 - 35	Stable flow (typical signal delays)
D	> 35 - 55	Approaching unstable flow (delays to next cycle service)
E	> 55 - 80	Unstable flow (delay to more than one cycle)
F	> 80	Forced flow (jammed)

Level of Service
- Movement (LT, Thru, RT)
- Approach (NB, SB, EB WB)
- Overall Intersection LOS

TYPES OF TRAFFIC SIGNALS

- **Fixed Time:**
  Set time at predetermined cycle length.
- **Pre-Timed Control:**
  Similar to fixed time, but set in phases, and cycle is programmed by time of day. Duration of green intervals differ by time of day.
- **Semi-Actuated Control:**
  Vehicle detection on side street and mainline left turn lanes. Service on demand and by program.
- **Fully Actuated Control:**
  Vehicle detection on all lanes. Presence and systems detection. Service by demand and program
- **Traffic Actuated Control:**
  Duration of green intervals for all approaches vary according to detected vehicle demand or program.

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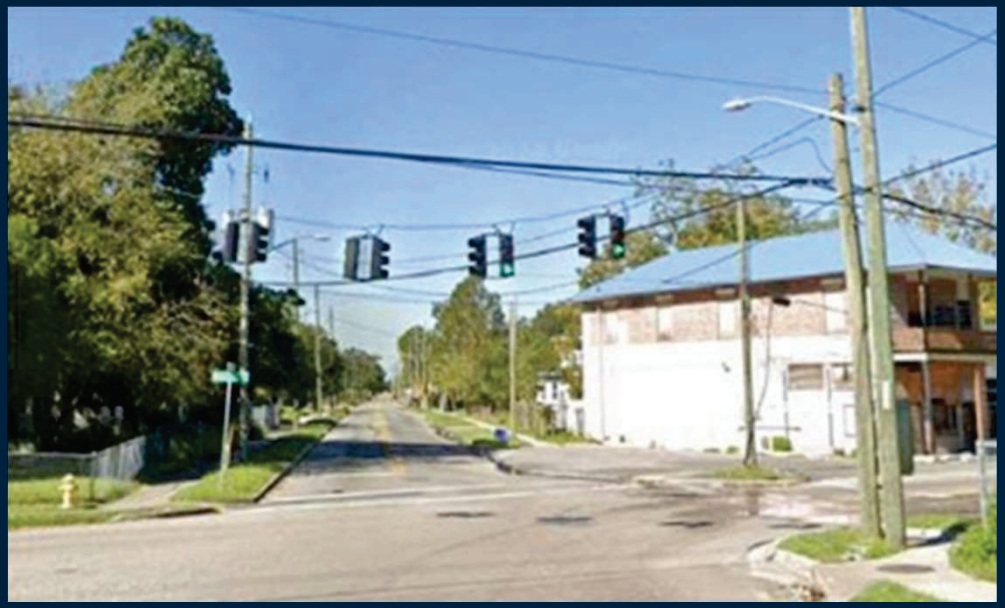

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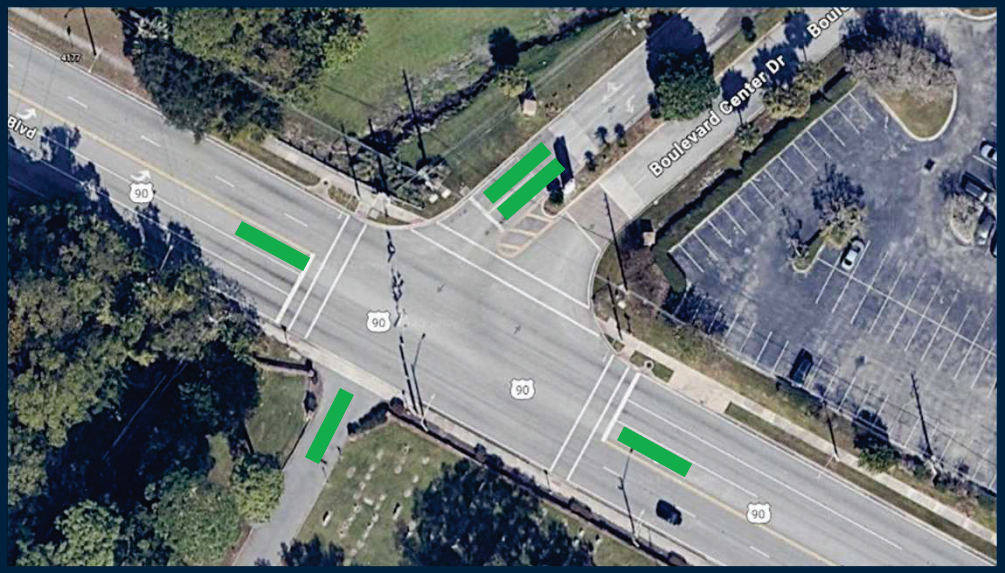

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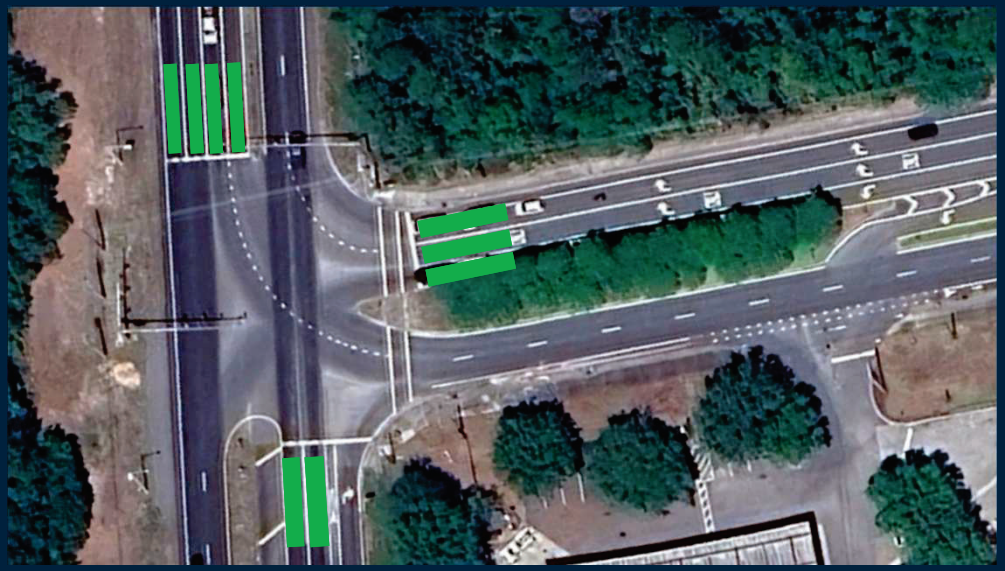


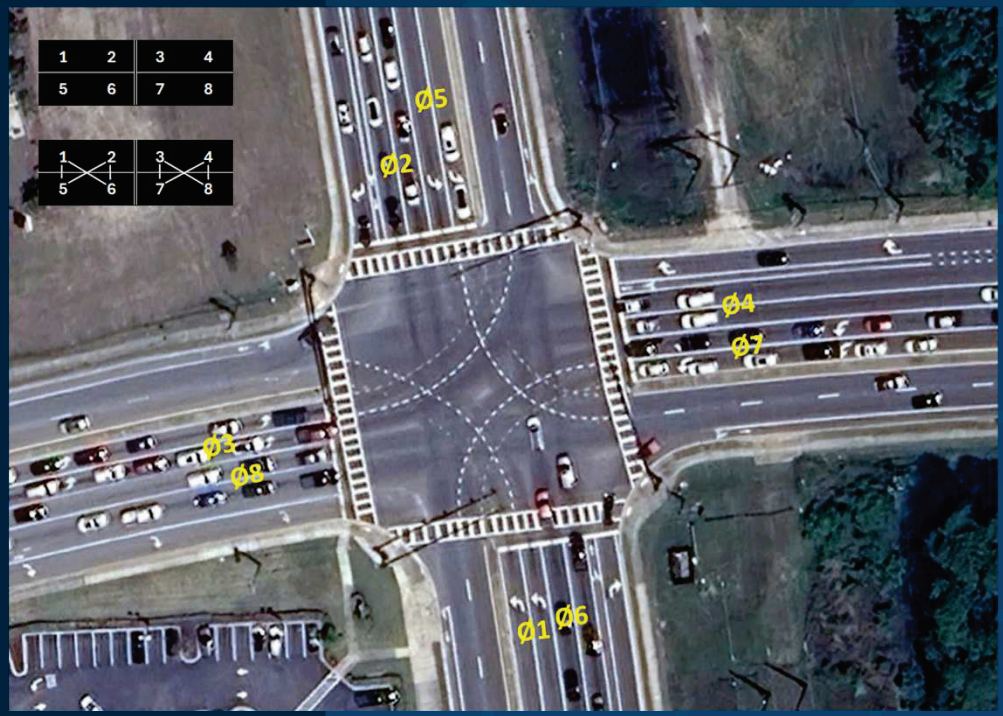
Typical Vehicle Detections in Use

- Induction Loop
- Video
- Microwave

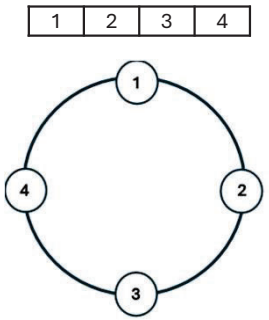
SIGNAL PHASING

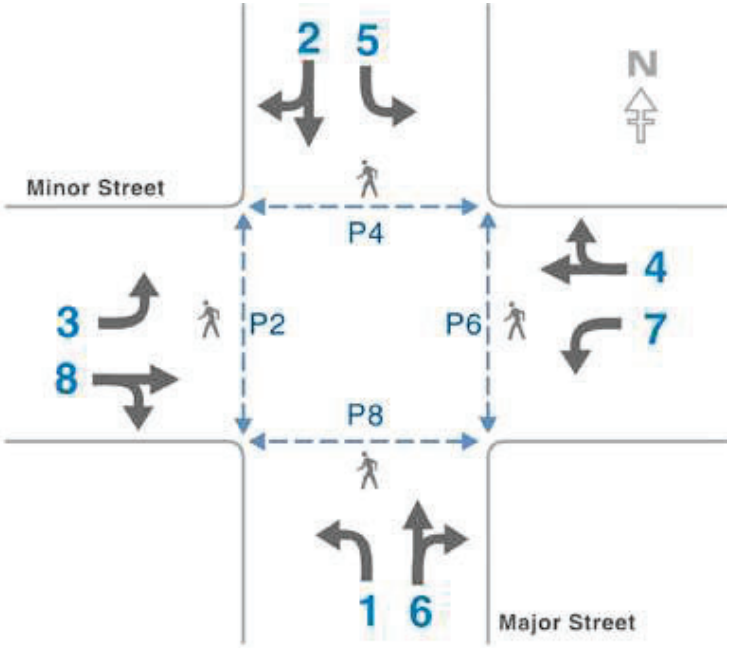
To organize and describe the movements at signalized intersections, each movement is assigned a phase number.

This phase number may represent a single lane, multiple lanes, or in some cases just a movement from a shared lane. For the most part, North America has standardized the NEMA method for assigning phases to movements.



STANDARD SIGNAL PHASING



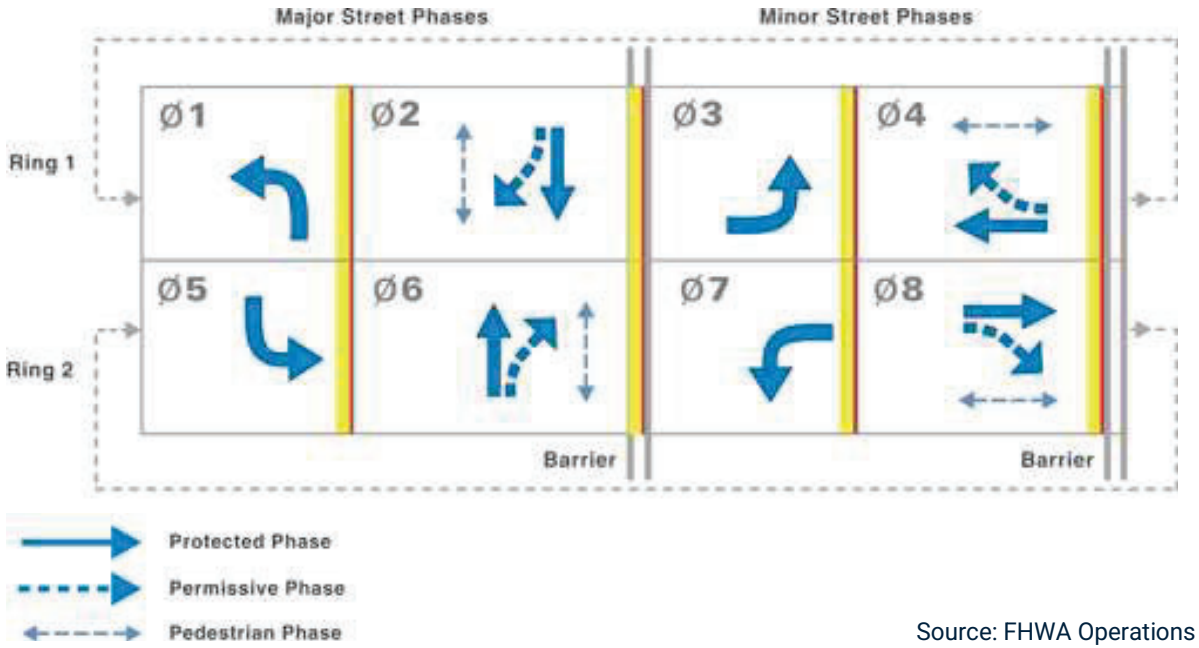


Vehicle Movements

Pedestrian Movements

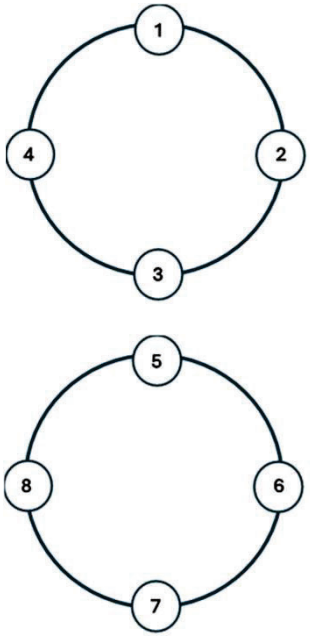
Source: FHWA Operations

NEMA STANDARD SEQUENCE SIGNAL PHASING

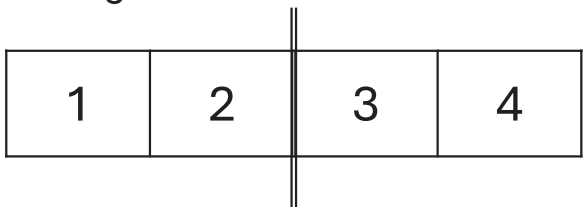


Source: FHWA Operations

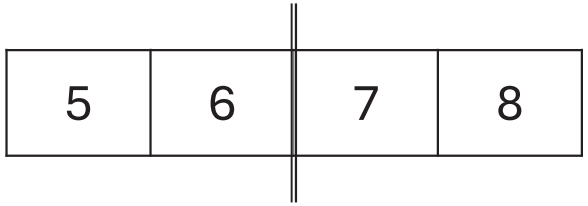
TRAFFIC SIGNAL PHASING

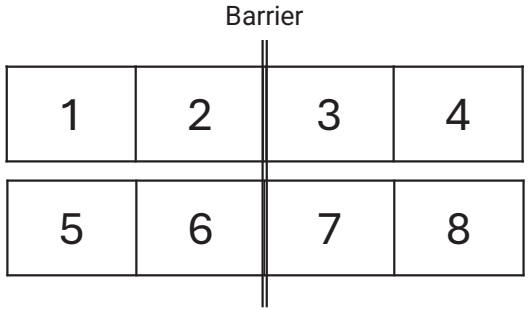


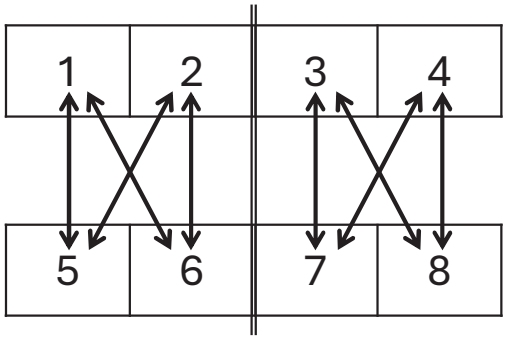
Ring 1



Ring 2



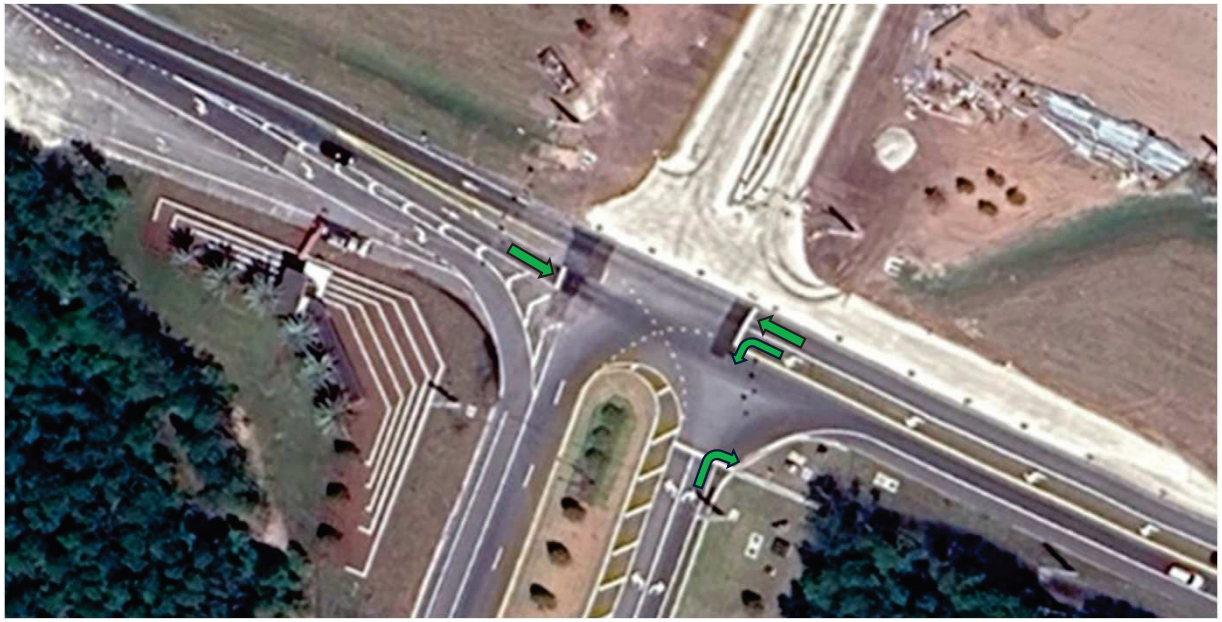




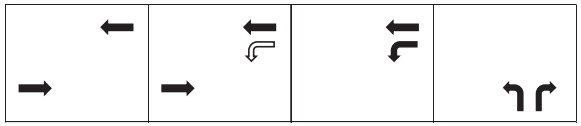
IMPROVEMENTS

- **Overlaps:** Non-conflicting phases programmed concurrently.
- **Unused Capacity:** Hash lined pavement modified to designated lane use.
- **Side Street Pedestrian Signal With Mainline Green - No Ped Actuation:** Duration of green intervals for all approaches vary according to detected vehicle demand or program.
- **Restrictive Phasing Pattern/Phase Number:**
  - **Minimum Green:** The initial period serving as the shortest amount of green time allocated to the beginning of a phase.
  - **Maximum Green:** Maximum limit to which the green time is programmed to be extended on a phase in the presence of a call on a conflicting phase.
  - **Early Release:** Short offset to release downstream queue early and provide receiving lanes space for arriving vehicles.
- **Coordination:** During off-peak, no progression patterns & random flows.
- **Review** before implementing traffic signal timing & phasing plans from the construction plans

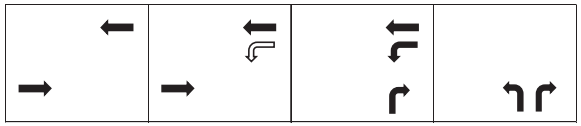
PHASE OVERLAPS



Existing:

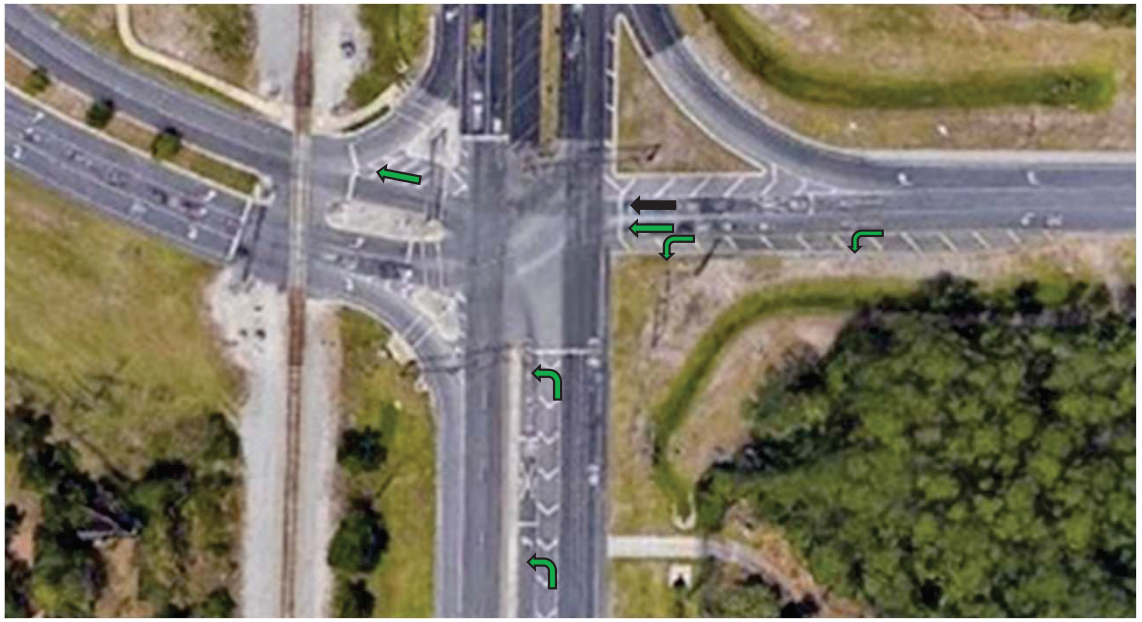


Revision:

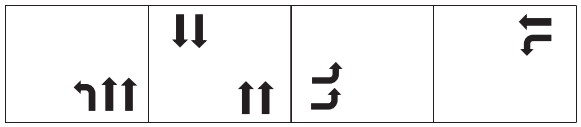


= High Volume Movements

HASHED PAVEMENT TO DESIGNATED USE LANE



Existing:



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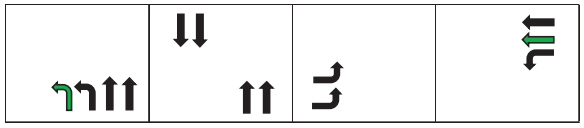
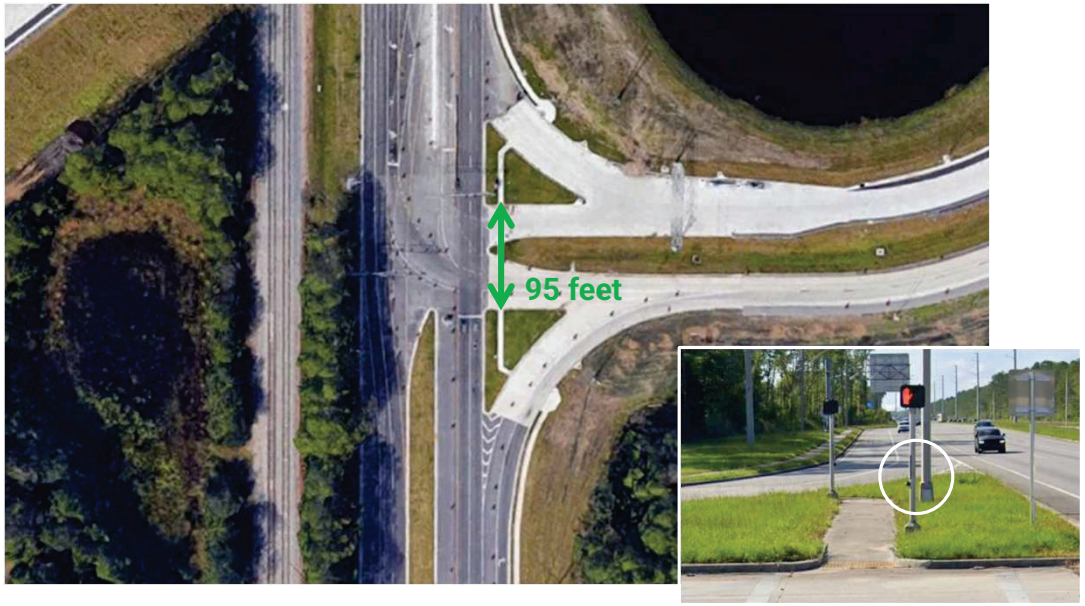


= Use existing lanes currently hashed

PEDESTRIAN SIGNALS WITH MAINLINE GREEN



Existing:

- WALK and FLASHING DON'T WALK (FDW) signals overlapped with mainline (NB & SB) Green without a pedestrian.
- Holds mainline Green indications after gap-out to the end of FDW.
- Pedestrian push buttons are installed.

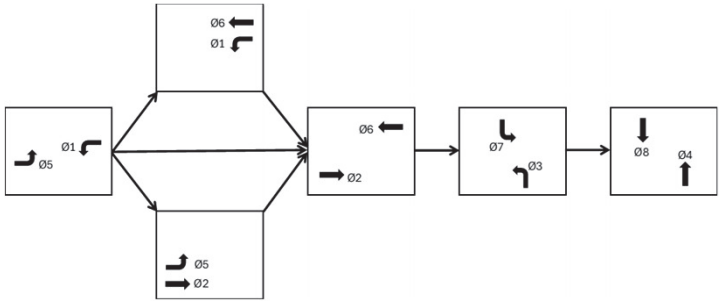
Revision:

- Assign phase to Pedestrian signals and only service with Ped actuation.

MUTCD Walking Speed for FDW:
95 ft / (3.5 ft/sec) = 27.1 sec

TRAFFIC SIGNAL PHASING PATTERN

Existing:



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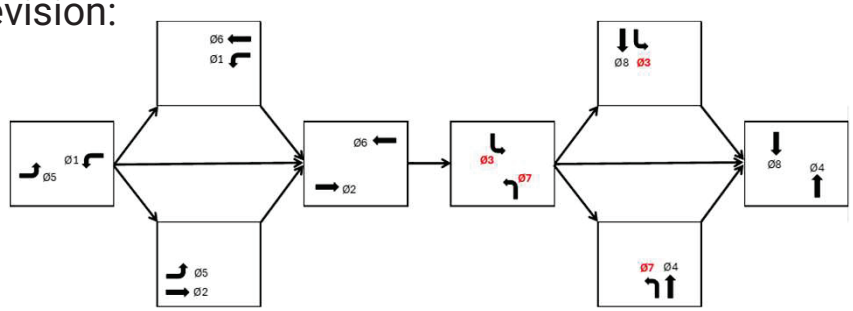


Timing Sheet 5/23/2025 11:51:29 AM

Station :

Phase [1.1.1]

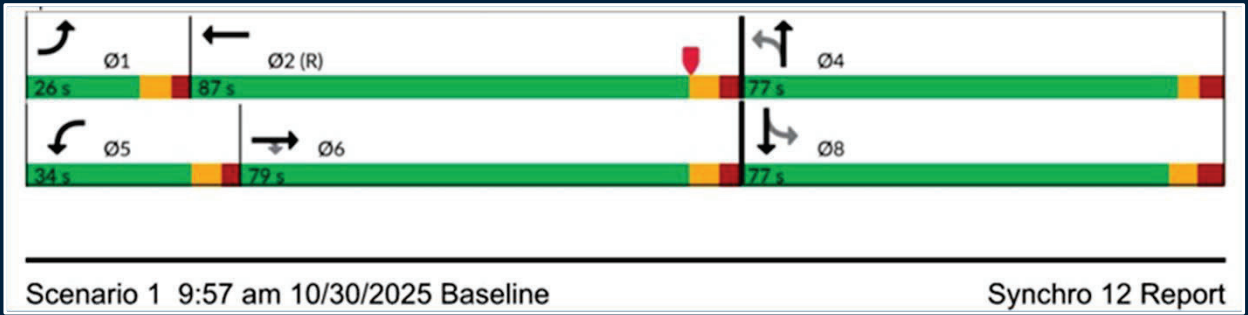
	WBLT	EBT	* NBLT	NBT	EBLT	WBT	* SBLT	SBT								
	ϕ1 (EL)	ϕ2 (WT)	ϕ3 (SL)	ϕ4 (ST)	ϕ5 (WL)	ϕ6 (ET)	ϕ7 (NL)	ϕ8 (NT)	ϕ9	ϕ10	ϕ11	ϕ12	ϕ13	ϕ14	ϕ15	ϕ16
Walk	0	7	0	7	0	7	0	7	0	0	0	0	0	0	0	0
Ped Clearance	0	32	0	35	0	31	0	34	0	0	0	0	0	0	0	0
Min Green	7	12	5	4	7	12	5	4	0	0	0	0	0	0	0	0
Gap Ext	2	3.5	2	3.5	2	3.5	2	3.5	0	0	0	0	0	0	0	0
Max1	25	50	20	40	25	55	20	35	0	0	0	0	0	0	0	0
Max2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Yellow Clr	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	0	0	0	0	0	0	0	0
Red Clr	2	2	2	2	2	2	2	2	0	0	0	0	0	0	0	0
Red Revert	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Added Initial	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Max Initial	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Time Before Reduce	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cars Before Reduce	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Time To Reduce	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Reduce By	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Min Gap	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dynamic Max Limit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dynamic Max Step	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auto Flash Entry				ON				ON								
Auto Flash Exit		ON				ON										
Non-Actuated 1																
Non-Actuated 2																
Bike Clear																
Safe Clear Min																
Enable	ON	ON	ON	ON	ON	ON	ON	ON								
Lock Call		ON				ON										
Min Recall		ON				ON										
Max Recall																
Ped Recall																
Soft Recall																
Dual Entry		ON		ON		ON		ON								
Sim Gap Enable																
Guar Passage																
Rest In Walk																
Cond Service																
Add Init Calc																

Close Loop Active	OFF

MINIMUM GREEN: TOO SHORT OR TOO LONG

Minimum Green:

The initial period serving as the shortest amount of green time allocated to the beginning of a phase.



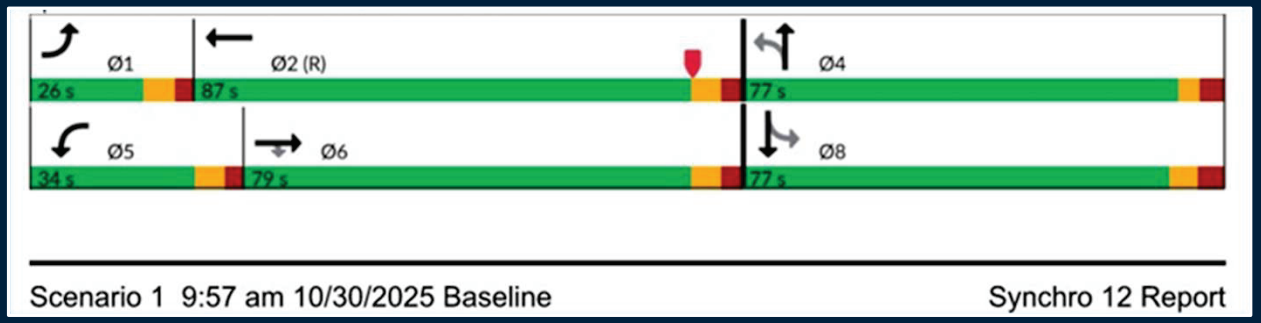
MAXIMUM GREEN: TOO LONG OR TOO SHORT

Maximum Green:

Maximum limit to which the green time is programmed to be extended on a phase in the presence of a call on a conflicting phase.

Passage Time/Gap/Vehicle Extension/Unit Extension:

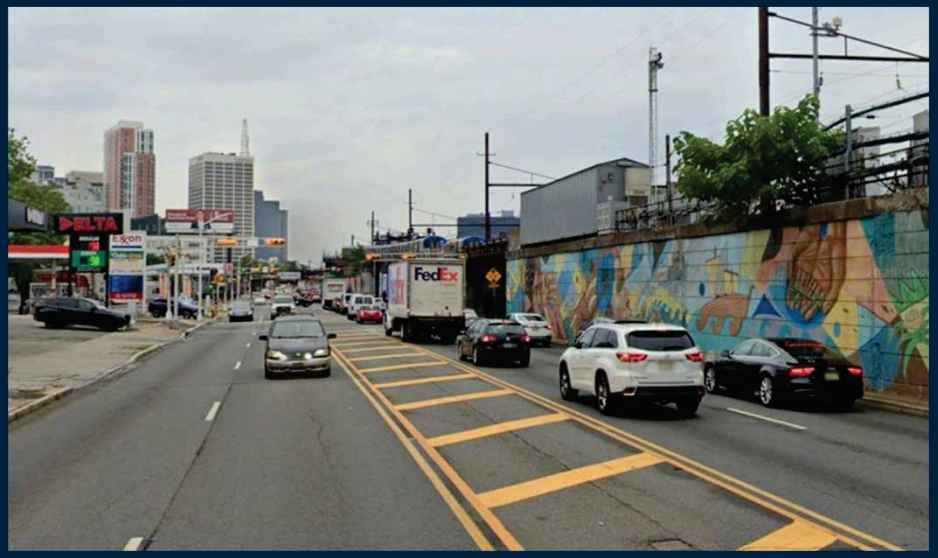
The time it takes a vehicle to travel from the detector to the stop line and is used to extend the green indication for a phase as long as cars are continuously detected.



EARLY GREEN/RELEASE DOWNSTREAM: COORDINATED PLAN

Early Release:

Early green to downstream intersection to release link occupancy, a coordinated plan, and provide receiving lanes space for arriving vehicles.



COORDINATION DURING OFF-PEAK PERIODS

Coordination within progression patterns:

- Coordinated plan has a preferred or desired traffic flow progression.
- Maximizes corridor or network throughput by providing a green band or green indication to targeted traffic flow.
- Synchronizes traffic movements to manage progression speed.

A progression pattern during off peak periods will hold the green signal for the assigned approaches without consideration to any traffic volumes entering the corridor or network. It will increase vehicular delays to the approaches that are not in the progression pattern.

REVIEW TRAFFIC SIGNAL TIMING & PHASING PLANS ON CONSTRUCTION PLANS BEFORE IMPLEMENTION

- Review supporting documentations including Turning Movement Counts and Highway Capacity Software reports or Synchro reports that should be included in with the construction plans.
- Report should include explanation to the minimum green, maximum green, and offsets for each Time of Day plans.
- A follow-up field review of the timing and phasing plan should be conducted in 4 to 6 months.

TRAFFIC SIGNAL OPERATIONS& MAXIMIZING SIGNALIZED INTERSECTION CAPACITY

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