Yellow Change Interval and All Red Clearance Interval Review

City of St. Petersburg

Interval Review for the "Stop on Red" Campaign

Prepared for:

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Introduction

The City of St. Petersburg is continually evaluating the "Stop on Red" campaign, which includes metrics such as crash analysis as well as traffic signal operational characteristics like yellow change intervals and all red clearance intervals. This document provides a review of the yellow change interval and all red clearance intervals for each phase of the traffic signal operating plan at the 10 intersections that are included in the "Stop on Red" campaign, which are:

- 4th Street & Gandy Boulevard
- 4th Street & 54th Avenue North
- 4th Street & 22nd Avenue North
- 34th Street & 38th Avenue North
- 34th Street & 1st Avenue North
- 34th Street & 1st Avenue South
- 34th Street & 22nd Avenue South
- 66th Street & 38th Avenue North
- 66th Street & Tyrone Boulevard
- 66th Street & 22nd Avenue North

The specific evaluation of intersection yellow change intervals and the all red clearance intervals at the 10 intersections that comprise the "Stop on Red" campaign has been prepared to provide the City staff and officials with an analysis of the existing intervals based on the legal driving speed, which is the Florida Department of Transportation (FDOT) District 7 policy. A review of the existing intervals was also conducted using the observed vehicular speed (85^{th} percentile) data collected at the specific intersection approaches. This analysis follows the yellow change interval and all red clearance interval calculation requirements defined by the FDOT within the FDOT *Traffic Engineering Manual.* The intersections included in this evaluation are under the jurisdiction of the FDOT, and therefore any adjustments identified as a recommendation for revision must be submitted to FDOT staff as a request for update, with the final decision resting with the FDOT reviewer. This request and review procedure is consistent with the agreement for traffic signal maintenance between the City of St. Petersburg and the FDOT, which is included as Appendix A.

FDOT Guidelines

The *Traffic Engineering Manual* provides guidance and equations for calculating the yellow change interval and all red clearance interval, which are shown below. The yellow signal indication warns traffic of an impending change in right-of-way. It is displayed following every green signal indication. The amount of time that the yellow signal is displayed is referred to as the yellow change interval. The duration of this interval is based on the driver's perception-reaction time and deceleration rate, the approach posted speed limit, and the approach grade. The duration of the yellow interval should allow, at a minimum, for a driver to comfortably decelerate to a stop prior to entering the intersection. The yellow clearance interval equation with the input variables defined is provided below:

Formula 3.6-1

$$Y = t + \frac{1.47v}{2(a + Gg)}$$

Where:

Y = length of yellow interval, sec.
t = perception-reaction time, (Use 1 sec.).
v = speed of approaching vehicles, in mph.
a = deceleration rate in response to the onset of a yellow indication. (Use 10 ft/sec^2)
g = acceleration due to gravity. (Use 32.2 ft/sec^2)
G= grade, with uphill positive and downhill negative. (percent grade /100)

A red clearance interval is a period when a red signal indication is displayed to most, if not all, vehicular traffic approaches. The duration of the red clearance interval is based on intersection width, vehicle length, and the approach posted speed limit. The duration of the red clearance interval allows additional time as a safety factor for a driver that legally enters the intersection at the very last instant of the yellow change interval to avoid a conflict with opposing traffic. The all red clearance interval equation with the input variables defined is provided below:

Formula 3.6-2

$$R = \frac{W + L}{1.47v}$$

Where:

R = length of all-red interval, sec.
W = total traversed width, from the approach stop bar to the far side of no-conflict point.
L = Length of vehicle (Use 20 ft.)
v = speed of approaching vehicles, in mph.

Data Collection

Existing vehicular speed data was obtained for the intersection approaches at the 10 intersections that comprise the "Stop on Red" campaign. The through movements speed was collected by a traffic count consultant and the City of St. Petersburg utilized their equipment to obtain the speed data for left turn movements which have a protected left turn phase. The speed data was collected for a 24-hour period.

The through movements' speed datum were collected upstream of the intersections, to reduce the likelihood of a red signal indication to influence the vehicle speed data collected. In some cases another signalized intersection was spaced close to a study location (for example, 66th Street & Tyrone Boulevard, 66th Street & 22nd Avenue N, 34th Street & 1st Avenue N, 34th Street & 1st Avenue S), which would affect the approaching vehicles' speed. The vehicle speed data was then collected upstream of the closely spaced intersection(s) to provide a more clear estimation of free flow vehicular speed for the intersection approach.

The left turn movements' speed datum were collected near the stop line of the left turn lane, more specifically on the far side of the crosswalk just in front of the turn lanes' stop line, which provides a reasonable recording of vehicular speed during the turning maneuver. The observed speed data collected is provided in Appendix B.

Yellow Change Interval

The yellow signal indication warns traffic of an impending change in right-of-way. A yellow change interval is important for intersection safety by providing sufficient warning time for drivers to safely stop at the intersection for the impending red indication. The enforcement of red light running, whether by camera or by on-site patrol officers, depends on the yellow interval being appropriate to meet safety goals thus reducing the opportunity for citations to be issued erroneously.

The existing yellow change intervals were implemented with the collaboration of FDOT District 7, as the FDOT has jurisdiction over these 10 intersections. The FDOT *Traffic Engineering Manual* (Chapter 3, section 6.2(4)) discusses the speed used to calculate left turn movements' yellow change interval and all red clearance interval, and states:

> "Through lane and turn lane approach speeds on an approach may be different. According to Section 5.3 of the Federal Highway Administration's *Signal Timing Manual*, "When applying Equation 5-2 to left-turn movement phases, the speed used should reflect that of the drivers that intend to turn. This speed can equal that of the adjacent through movement but it can also be slower as left-turn drivers inherently slow to a comfortable turning speed.""

This flexibility for setting the intervals for left turn movements indicates that engineering judgment was applied when establishing the existing yellow change interval and all red clearance intervals. Currently, the FDOT District 7 policy is to implement the yellow interval for left turn movements using the adjacent through movement's posted speed. Correspondence with the FDOT District 7 Traffic Operations staff member, Mark Hall, is attached as Appendix C.

The yellow change interval was reviewed at the intersection movements for the 10 intersections that comprise the "Stop on Red" campaign. The approach grades were assumed to be flat. Intersection approaches with and without camera enforcement were reviewed to provide a better understanding of the whole intersection, as safety at an entire intersection is the desired outcome instead of only intersection approaches with camera enforcement. Table 1 provides a summary of the yellow change interval using the legal driving speed (posted speed limit).

Table 1:
Yellow Change Interval Summary Using the Legal Driving Speed

Intersection	Movement	Legal Driving Speed (mph)	Modified Left Turn Speed (mph)	Existing Yellow Interval (seconds)	Calculated Yellow Interval (w/ legal speed)	Calculated Yellow Interval* (w/ modified left turn speed)	Adequate Yellow? (w/ legal speed)
4th Street & Gandy Boulevard	**NB**(1)	40	-	4.5	3.9	-	Yes
	NBL(2)	40	30	4.5	3.9	3.2	Yes
	SB	40	-	4.5	3.9	-	Yes
	SBL	40	30	4.5	3.9	3.2	Yes
	EB	40	-	4.5	3.9	-	Yes
	EBL	40	30	4.5	3.9	3.2	Yes
	WB	40	-	4.5	3.9	-	Yes
	WBL	40	30	4.5	3.9	3.2	Yes
4th Street & 54th Avenue North	**NB**	45	-	4.3	4.3	-	Yes
	NBL	45	35	4.0	4.3	3.6	No
	SB	45	-	4.3	4.3	-	Yes
	SBL	45	35	4.0	4.3	3.6	No
	EB	35	-	4.0	3.6	-	Yes
	EBL	35	35			Permissive Only Lefts	
	WB	35	-	4.0	3.6	-	Yes
	WBL	35	35			Permissive Only Lefts	
4th Street & 22nd Avenue North	**NB**	35	-	4.0	3.6	-	Yes
	NBL	35	25	4.0	3.6	2.8	Yes
	SB	35	-	4.0	3.6	-	Yes
	SBL	35	25	4.0	3.6	2.8	Yes
	EB	35	-	4.0	3.6	-	Yes
	EBL	35	25	4.0	3.6	2.8	Yes
	WB	35	-	4.0	3.6	-	Yes
	WBL	35	25	4.0	3.6	2.8	Yes
34th Street & 38th Avenue North	NB	40	-	4.0	3.9	-	Yes
	NBL	40	30	4.0	3.9	3.2	Yes
	SB	40	-	4.0	3.9	-	Yes
	SBL	40	30	4.0	3.9	3.2	Yes
	EB	40	-	4.0	3.9	-	Yes
	EBL	40	30	4.0	3.9	3.2	Yes
	WB	40	-	4.0	3.9	-	Yes
	WBL	40	30	4.0	3.9	3.2	Yes
34th Street & 1st Avenue North	**NB**	35	-	4.0	3.6	-	Yes
	NBL	35	25	4.0	3.6	2.8	Yes
	SB	35	-	4.0	3.6	-	Yes
	NA (1st Ave S is One-Way EB)	-	-	-	-	-	-
		-	-	-	-	-	-
		-	-	-	-	-	-
	WB	40	-	4.0	3.9	-	Yes
	WBL	40	30	4.0	3.9	3.2	Yes

Notes:
Bold and Underline: indicates the intersection movement is enforced through the "Stop on Red" campaign.
Asterisk (*): See the FDOT *Traffic Engineering Manual* for guidance on left turn yellow change intervals. Discretion is afforded for applying a speed to an intersection left turn movement.
(1) Northbound
(2) Northbound Left

Table 1 (Continued):
Yellow Change Interval Summary Using the Legal Driving Speed

Intersection	Movement	Legal Driving Speed (mph)	Modified Left Turn Speed (mph)	Existing Yellow Interval (seconds)	Calculated Yellow Interval (w/ legal speed)	Calculated Yellow Interval (w/ modified left turn speed)	Adequate Yellow? (w/ legal speed)
34th Street & 1st Avenue South	NB	35	-	4.0	3.6	-	Yes
	NA (1st Ave S One-Way)	-	-	-	-	-	-
	SB	35	-	4.0	3.6	-	Yes
	SBL	35	25	4.0	3.6	2.8	Yes
	EB	40	-	4.0	3.9	-	Yes
	EBL	40	-	Permissive Only Lefts			
	NA (1st Ave S One-Way)	-	-	-	-	-	-
		-	-	-	-	-	-
34th Street & 22nd Avenue South	**NB**	45	-	4.3	4.3	-	Yes
	NBL	45	35	3.5	4.3	3.6	No
	SB	45	-	4.3	4.3	-	Yes
	SBL	45	35	3.5	4.3	3.6	No
	EB	40	-	4.0	3.9	-	Yes
	EBL	40	30	3.5	3.9	3.2	No
	WB	40	-	4.0	3.9	-	Yes
	WBL	40	30	3.5	3.9	3.2	No
66th Street & 38th Avenue North	NB	45	-	5.0	4.3	-	Yes
	NBL	45	35	4.0	4.3	3.6	No
	SB	45	-	5.0	4.3	-	Yes
	SBL	45	35	4.0	4.3	3.6	No
	EB	40	-	5.0	3.9	-	Yes
	EBL	40	30	4.0	3.9	3.2	Yes
	WB	40	-	5.0	3.9	-	Yes
	WBL	40	30	4.0	3.9	3.2	Yes
66th Street & Tyrone Boulevard	**NB**	45	-	4.3	4.3	-	Yes
	NBL	45	35	3.6	4.3	3.6	No
	SB	45	-	4.3	4.3	-	Yes
	SBL	45	35	3.6	4.3	3.6	No
	EB	45	-	4.3	4.3	-	Yes
	EBL	45	35	3.6	4.3	3.6	No
	WB	45	-	4.3	4.3	-	Yes
	NA (WBL not permitted)	-	-	-	-	-	-
66th Street & 22nd Avenue North	**NB**	45	-	4.3	4.3	-	Yes
	NBL	45	35	4.3	4.3	3.6	Yes
	SB	45	-	4.3	4.3	-	Yes
	SBL	45	35	4.0	4.3	3.6	No
	EB	35	-	4.0	3.6	-	Yes
	EBL	35	25	4.3	3.6	2.8	Yes
	WB	35	-	4.0	3.6	-	Yes
	WBL	35	25	4.3	3.6	2.8	Yes

Notes:
Bold and Underline: indicates the intersection movement is enforced through the "Stop on Red" campaign.

The FDOT Traffic Engineering Manual provides the ability to use a slower speed than the posted speed limit for left turning vehicles (therefore a shorter yellow change interval). Vehicles generally do not make left turns at the legal posted speed limit unless uncommon intersection skew or other geometric factors provide the ability to do so. Many jurisdictions use lower speeds to calculate yellow intervals. In general, 20 mph to 30 mph is used as a rule of thumb in some states. For demonstration purposes, a modified left-turn speed column and calculated yellow interval (based on modified left-turn speed) column have been included in table 1. The modified left-turn speed is conservatively calculated by assuming vehicles will traverse a left-turn while traveling at least 10 mph below the posted speed limit. For example, this methodology assumes a vehicle making a left-turn on a roadway with a speed limit of 45 mph will slow to at least 35 mph while making the turn. These two additional columns provide insight into the yellow interval required for safe passage through the intersection. However, when the current FDOT District 7 policy is used as guidance, the left turn movements must have yellow change interval(s) that correspond with the legal driving speed (posted speed limit) of the adjacent through movement. To maintain consistency with FDOT District 7 policy, it is recommended the yellow change intervals for the left turn movements be updated to meet the current policy.

In addition to reviewing the yellow change intervals for each intersection movement using the legal driving speed (posted speed limit), a review was also conducted using the observed (85th percentile) vehicle speed for these intersection movements. Table 2 provides a summary of the yellow change interval using the observed vehicular speed.

Table 2:
Yellow Change Interval Summary Using the 85th Percentile Speed

Intersection	Movement	Rounded 85th Percentile Speed (mph)	Legal Driving Speed (mph)	Existing Yellow Interval (seconds)	Calculated Yellow Interval (w/ 85th % speed)	Adequate Yellow? (w/ 85th % speed)
4th Street & Gandy Boulevard	**NB**	48	40	4.5	4.5	Yes
	NBL	27	40	4.5	3.0	Yes
	SB	44	40	4.5	4.3	Yes
	SBL	32	40	4.5	3.4	Yes
	EB	38	40	4.5	3.8	Yes
	EBL	25	40	4.5	2.9	Yes
	WB	45	40	4.5	4.4	Yes
	WBL	28	40	4.5	3.1	Yes
4th Street & 54th Avenue North	**NB**	46	45	4.3	4.4	No (1)
	NBL	19	45	4.0	2.5	Yes
	SB	43	45	4.3	4.2	Yes
	SBL	21	45	4.0	2.6	Yes
	EB	34	35	4.0	3.5	Yes
	EBL	Permissive Only Lefts				
	WB	34	35	4.0	3.5	Yes
	WBL	Permissive Only Lefts				
4th Street & 22nd Avenue North	**NB**	34	35	4.0	3.5	Yes
	NBL	26	35	4.0	2.9	Yes
	SB	24	35	4.0	2.8	Yes
	SBL	25	35	4.0	2.9	Yes
	EB	24	35	4.0	2.8	Yes
	EBL	27	35	4.0	3.1	Yes
	WB	27	35	4.0	3.0	Yes
	WBL	23	35	4.0	2.8	Yes
34th Street & 38th Avenue North	NB	35	40	4.0	3.6	Yes
	NBL	28	40	4.0	3.1	Yes
	SB	38	40	4.0	3.8	Yes
	SBL	24	40	4.0	2.8	Yes
	EB	33	40	4.0	3.5	Yes
	EBL	23	40	4.0	2.7	Yes
	WB	34	40	4.0	3.5	Yes
	WBL	24	40	4.0	2.8	Yes
34th Street & 1st Avenue North	**NB**	38	35	4.0	3.8	Yes
	NBL	43	35	4.0	4.2	No (1)
	SB	35	35	4.0	3.6	Yes
	NA (1st Ave S is One-Way EB)	-	-	-	-	-
		-	-	-	-	-
		-	-	-	-	-
	WB	36	40	4.0	3.7	Yes
	WBL	22	40	4.0	2.6	Yes

Notes:

Bold and Underline: indicates the intersection movement is enforced through the "Stop on Red" campaign.

(1) See the FDOT *Traffic Engineering Manual* for guidance on left turn yellow change intervals. This yellow interval does comply with FDOT guidance; however we recommend the "Stop on Red" campaign be coordinated with law enforcement agencies to enforce the legal driving speed.

Table 2 (Continued):
Yellow Change Interval Summary Using the 85th Percentile Speed

Intersection	Movement	Rounded 85th Percentile Speed (mph)	Legal Driving Speed (mph)	Existing Yellow Interval (seconds)	Calculated Yellow Interval (w/ 85th % speed)	Adequate Yellow? (w/ 85th % speed)
34th Street & 1st Avenue South	NB	38	35	4.0	3.8	Yes
	NA (1st Ave S One-Way)		-	-	-	-
	SB	35	35	4.0	3.6	Yes
	SBL	33	35	4.0	3.5	Yes
	EB	40	40	4.0	4.0	Yes
	EBL	36	40	Permissive Only Lefts		
	NA (1st Ave S is One-Way EB)	-	-	-	-	-
		-	-	-	-	-
34th Street & 22nd Avenue South	**NB**	37	45	4.3	3.8	Yes
	NBL	22	45	3.5	2.7	Yes
	SB	41	45	4.3	4.1	Yes
	SBL	22	45	3.5	2.6	Yes
	EB	33	40	4.0	3.5	Yes
	EBL	22	40	3.5	2.7	Yes
	WB	40	40	4.0	4.0	Yes
	WBL	19	40	3.5	2.4	Yes
66th Street & 38th Avenue North	NB	45	45	5.0	4.4	Yes
	NBL	19	45	4.0	2.5	Yes
	SB	40	45	5.0	4.0	Yes
	SBL	22	45	4.0	2.7	Yes
	EB	36	40	5.0	3.7	Yes
	EBL	20	40	4.0	2.5	Yes
	WB	37	40	5.0	3.8	Yes
	WBL	19	40	4.0	2.5	Yes
66th Street & Tyrone Boulevard	**NB**	37	45	4.3	3.8	Yes
	NBL	28	45	3.6	3.1	Yes
	SB	42	45	4.3	4.1	Yes
	SBL	27	45	3.6	3.0	Yes
	EB	47	45	4.3	4.5	No (1)
	EBL	27	45	3.6	3.0	Yes
	WB	42	45	4.3	4.1	Yes
	NA (WBL not permitted)		-	-	-	-
66th Street & 22nd Avenue North	**NB**	37	45	4.3	3.8	Yes
	NBL	20	45	4.3	2.5	Yes
	SB	42	45	4.3	4.1	Yes
	SBL	17	45	4.0	2.3	Yes
	EB	37	35	4.0	3.8	Yes
	EBL	20	35	4.3	2.5	Yes
	WB	27	35	4.0	3.0	Yes
	WBL	19	35	4.3	2.5	Yes

Notes:
Bold and Underline: indicates the intersection movement is enforced through the "Stop on Red" campaign.
(1) See the FDOT *Traffic Engineering Manual* for guidance on left turn yellow change intervals. This yellow interval does comply with FDOT guidance; however we recommend the "Stop on Red" campaign be coordinated with law enforcement agencies to enforce the legal driving speed.

The yellow change interval summary using the 85th percentile speed data shows that sixty-four (64) intersection movements have a yellow change interval greater than the calculated value, and three (3) movements with a yellow interval equal to the calculated value. In addition, three (3) movements, which have observed intersection movement speeds that exceed the legal driving speed, result in yellow interval calculations that are greater than the existing yellow interval when the observed speed is an input to the calculation. The yellow clearance interval may not be sufficient to accommodate drivers who exceed the legal driving speed; therefore we recommend the "Stop on Red" campaign be coordinated with law enforcement agencies to enforce the legal driving speed.

All Red Clearance Interval

The all red clearance interval is a safety measure that is not associated with the "Stop on Red" campaign. The "Stop on Red" campaign is a tool that includes enforcing the law prohibiting drivers from entering the intersection on a red indication. The all red clearance interval is designed to allow drivers who entered the intersection legally during the yellow indication, to safely continue through the intersection before conflicting traffic receives a green indication. The all red clearance interval is important for intersection safety as it provides the time for drivers to vacate the intersection and significantly reduce the likelihood of conflicts within the intersection.

The existing all red clearance intervals were implemented with the collaboration of FDOT District 7, as the FDOT has jurisdiction over these 10 intersections. The FDOT *Traffic Engineering Manual* (Chapter 3, section 6.2(4)) discusses the speed used to calculate left turn movements' yellow change interval and all red clearance interval, and states:

> Through lane and turn lane approach speeds on an approach may be different. According to Section 5.3 of the Federal Highway Administration's Signal Timing Manual, "When applying Equation 5-2 to left-turn movement phases, the speed used should reflect that of the drivers that intend to turn. This speed can equal that of the adjacent through movement but it can also be slower as left-turn drivers inherently slow to a comfortable turning speed."

This flexibility for setting the intervals for left turn movements indicates that engineering judgment was applied when establishing the existing all red clearance intervals. Currently, the FDOT District 7 policy is to implement the all red clearance interval for left turn movements using the adjacent through movement's posted speed. Correspondence with the FDOT District 7 Traffic Operations staff member, Mark Hall, is attached as Appendix C.

The all red clearance interval was reviewed at the intersection approaches for the 10 intersections that comprise the "Stop on Red" campaign. The approach grades were assumed to be flat. As with the yellow change interval review, the intersection approaches with and without camera enforcement were reviewed to provide a better understanding of the whole intersection, as safety at an entire intersection is the desired outcome instead of only intersection approaches with camera enforcement. A summary of the all red clearance interval review is provided in Table 3.

Table 3:
All Red Clearance Interval Summary Using the Legal Driving Speed

Intersection	Movement	Legal Driving Speed (mph)	Existing All Red Interval (seconds)	Calculated All Red Interval (w/ legal speed)	Adequate Red? (w/ legal speed)
4th Street & Gandy Boulevard	**NB**	40	7.0	6.0	Yes
	NBL	40	7.0	4.2	Yes
	SB	40	7.0	5.6	Yes
	SBL	40	7.0	3.7	Yes
	EB	40	6.0	2.6	Yes
	EBL	40	6.0	3.9	Yes
	WB	40	6.0	2.6	Yes
	WBL	40	6.0	4.2	Yes
4th Street & 54th Avenue North	**NB**	45	2.0	1.8	Yes
	NBL	45	2.0	2.0	Yes
	SB	45	2.0	1.8	Yes
	SBL	45	2.0	2.0	Yes
	EB	35	2.0	2.5	No
	EBL	Permissive Only Lefts			
	WB	35	2.0	2.7	No
	WBL	Permissive Only Lefts			
4th Street & 22nd Avenue North	**NB**	35	1.0	1.9	No
	NBL	35	0.0	2.1	No
	SB	35	1.0	1.9	No
	SBL	35	0.0	2.2	No
	EB	35	1.0	2.0	No
	EBL	35	0.0	2.0	No
	WB	35	1.0	2.1	No
	WBL	35	0.0	2.2	No
34th Street & 38th Avenue North	NB	40	2.4	2.3	Yes
	NBL	40	2.4	2.3	Yes
	SB	40	2.4	2.3	Yes
	SBL	40	2.4	2.2	Yes
	EB	40	2.7	2.1	Yes
	EBL	40	2.2	2.1	Yes
	WB	40	2.7	2.2	Yes
	WBL	40	2.2	2.4	No
34th Street & 1st Avenue North	**NB**	35	1.0	2.4	No
	NBL	35	1.0	2.4	No
	SB	35	1.0	2.5	No
	NA (1st Ave S is One-Way EB)	-	-	-	-
		-	-	-	-
		-	-	-	-
	WB	40	1.0	2.2	No
	WBL	40	1.0	1.8	No

Notes:
Bold and Underline: indicates the intersection movement is enforced through the "Stop on Red" campaign.

Table 3 (Continued):
All Red Clearance Interval Summary Using the Legal Driving Speed

Intersection	Movement	Legal Driving Speed (mph)	Existing All Red Interval (seconds)	Calculated All Red Interval (w/ legal speed)	Adequate Red? (w/ legal speed)
34th Street & 1st Avenue South	NB	35	1.0	2.3	No
	NA (1st Ave S One-Way)	-	-	-	-
	SB	35	1.0	2.2	No
	SBL	35	1.0	2.1	No
	EB	40	1.0	2.0	No
	EBL	40	Permissive Only Lefts		
	NA (1st Ave S is One-Way EB)	-	-	-	-
		-	-	-	-
34th Street & 22nd Avenue South	**NB**	45	2.3	2.3	Yes
	NBL	45	1.0	2.3	No
	SB	45	2.3	2.2	Yes
	SBL	45	1.0	2.3	No
	EB	40	3.0	2.5	Yes
	EBL	40	1.0	2.6	No
	WB	40	3.0	2.6	Yes
	WBL	40	1.0	2.8	No
66th Street & 38th Avenue North	NB	45	2.0	2.1	No
	NBL	45	2.0	2.3	No
	SB	45	2.0	2.0	Yes
	SBL	45	2.0	2.2	No
	EB	40	2.0	2.4	No
	EBL	40	2.0	2.2	No
	WB	40	2.0	2.4	No
	WBL	40	2.0	2.4	No
66th Street & Tyrone Boulevard	**NB**	45	3.5	3.8	No
	NBL	45	4.9	4.0	Yes
	SB	45	3.5	4.0	No
	SBL	45	5.7	3.7	Yes
	EB	45	3.2	3.3	No
	EBL	45	3.0	2.2	Yes
	WB	45	3.2	3.3	No
	NA (WBL not permitted)	-	-	-	-
66th Street & 22nd Avenue North	**NB**	45	2.0	2.3	No
	NBL	45	2.0	2.1	No
	SB	45	2.0	2.1	No
	SBL	45	2.0	2.1	No
	EB	35	2.0	2.9	No
	EBL	35	2.0	2.7	No
	WB	35	2.0	2.7	No
	WBL	35	2.0	2.9	No

Notes:
Bold and Underline: indicates the intersection movement is enforced through the "Stop on Red" campaign.

The FDOT *Traffic Engineering Manual* provides the ability to use a slower speed for left turning vehicles. When the current FDOT District 7 policy is used as guidance, both the through movements and the left turn movements would have all red clearance interval(s) that correspond with the legal driving speed (posted speed limit) of the through movement. It is recommended that the all red clearance intervals for the through movements and the left turn movements be updated to meet the current FDOT District 7 policy.

In addition to reviewing the all red clearance intervals for each intersection movement using the legal driving speed (posted speed limit), a review was also conducted using the observed (85^{th} percentile) vehicle speed for these intersection movements. Table 4 provides a summary of the all red clearance interval review using the observed vehicular speed.

Table 4:
All Red Clearance Interval Summary Using the 85th Percentile Speed

Intersection	Movement	Rounded 85th Percentile Speed (mph)	Legal Driving Speed (mph)	Existing All Red Interval	Calculated All Red Interval (w/ 85th % speed)	Adequate Red? (w/ 85th % speed)
4th Street & Gandy Boulevard	**NB**	48	40	7.0	5.0	Yes
	NBL	27	40	7.0	6.3	Yes
	SB	44	40	7.0	5.2	Yes
	SBL	32	40	7.0	4.6	Yes
	EB	38	40	6.0	2.8	Yes
	EBL	25	40	6.0	**6.2**	No (1)
	WB	45	40	6.0	2.4	Yes
	WBL	28	40	6.0	5.9	Yes
4th Street & 54th Avenue North	**NB**	46	45	2.0	1.8	Yes
	NBL	19	45	2.0	**4.6**	No (1)
	SB	43	45	2.0	1.9	Yes
	SBL	21	45	2.0	**4.4**	No (1)
	EB	34	35	2.0	**2.7**	No (1)
	EBL	-	-	Permissive Only Lefts		
	WB	34	35	2.0	**2.9**	No (1)
	WBL	-	-	Permissive Only Lefts		
4th Street & 22nd Avenue North	**NB**	34	35	1.0	**2.1**	No (1)
	NBL	26	35	0.0	**3.0**	No (1)
	SB	24	35	1.0	**2.9**	No (1)
	SBL	25	35	0.0	**3.2**	No (1)
	EB	24	35	1.0	**3.0**	No (1)
	EBL	27	35	0.0	**2.7**	No (1)
	WB	27	35	1.0	**2.8**	No (1)
	WBL	23	35	0.0	**3.4**	No (1)
34th Street & 38th Avenue North	NB	35	40	2.4	**2.7**	No (1)
	NBL	28	40	2.4	**3.3**	No (1)
	SB	38	40	2.4	**2.5**	No (1)
	SBL	24	40	2.4	**3.7**	No (1)
	EB	33	40	2.7	**2.6**	Yes
	EBL	23	40	2.2	**3.8**	No (1)
	WB	34	40	2.7	**2.7**	Yes
	WBL	24	40	2.2	**4.0**	No (1)
34th Street & 1st Avenue North	**NB**	38	35	1.0	**2.3**	No (1)
	NBL	43	35	1.0	**2.0**	No (1)
	SB	35	35	1.0	**2.6**	No (1)
	NA (1st Ave S is One-Way EB)	-	-	-	-	-
		-	-	-	-	-
		-	-	-	-	-
	WB	36	40	1.0	**2.5**	No (1)
	WBL	22	40	1.0	**3.4**	No (1)

Notes:
Bold and Underline: indicates the intersection movement is enforced through the "Stop on Red" campaign.
(1): All red clearance intervals are intended to accommodate drivers who are driving at the legal driving speed (posted speed limit). When the 85th percentile speed is lower than the legal driving speed, drivers would have adequate time to decelerate to a stop during the yellow indication. When the 85th percentile speed is higher than the legal driving speed, an all red clearance interval using the higher speed would not safely accommodate a driver traveling at the legal speed limit. Calculating the all red clearance with the 85th percentile speed is not recommended.

Table 4 (Continued):
All Red Clearance Interval Summary Using the 85th Percentile Speed

Intersection	Movement	Rounded 85th Percentile Speed	Legal Driving Speed	Existing All Red Interval	Calculated All Red Interval (w/ 85th % speed)	Adequate Red? (w/ 85th % speed)
34th Street & 1st Avenue South	NB	38	35	1.0	2.2	No (1)
	NA (1st Ave S One-Way)			-	-	-
	SB	35	35	1.0	2.3	No (1)
	SBL	33	35	1.0	2.3	No (1)
	EB	40	40	1.0	2.1	No (1)
	EBL	36	40	Permissive Only Lefts		
	NA (1st Ave S is One-Way EB)	-	-	-	-	-
		-	-	-	-	-
34th Street & 22nd Avenue South	**NB**	37	45	2.3	2.8	No (1)
	NBL	22	45	1.0	4.8	No (1)
	SB	41	45	2.3	2.5	No (1)
	SBL	22	45	1.0	4.8	No (1)
	EB	33	40	3.0	3.0	Yes
	EBL	22	40	1.0	4.9	No (1)
	WB	40	40	3.0	2.6	No (1)
	WBL	19	40	1.0	6.0	No (1)
66th Street & 38th Avenue North	NB	45	45	2.0	2.2	No (1)
	NBL	19	45	2.0	5.4	No (1)
	SB	40	45	2.0	2.3	No (1)
	SBL	22	45	2.0	4.5	No (1)
	EB	36	40	2.0	2.7	No (1)
	EBL	20	40	2.0	4.6	No (1)
	WB	37	40	2.0	2.6	No (1)
	WBL	19	40	2.0	5.0	No (1)
66th Street & Tyrone Boulevard	**NB**	37	45	3.5	4.6	No (1)
	NBL	28	45	4.9	6.6	No (1)
	SB	42	45	3.5	4.3	No (1)
	SBL	27	45	5.7	6.2	No (1)
	EB	47	45	3.2	3.2	Yes
	EBL	27	45	3.0	3.7	No (1)
	WB	42	45	3.2	3.6	No (1)
	NA (WBL not permitted)		-	-	-	-
66th Street & 22nd Avenue North	**NB**	37	45	2.0	2.9	No (1)
	NBL	20	45	2.0	4.9	No (1)
	SB	42	45	2.0	2.3	No (1)
	SBL	17	45	2.0	5.5	No (1)
	EB	37	35	2.0	2.8	No (1)
	EBL	20	35	2.0	4.9	No (1)
	WB	27	35	2.0	3.6	No (1)
	WBL	19	35	2.0	5.3	No (1)

Notes:
Bold and Underline: indicates the intersection movement is enforced through the "Stop on Red" campaign.
(1): All red clearance intervals are intended to accommodate drivers who are driving at the legal driving speed (posted speed limit). When the 85th percentile speed is lower than the legal driving speed, drivers would have adequate time to decelerate to a stop during the yellow indication. When the 85th percentile speed is higher than the legal driving speed, an all red clearance interval using the higher speed would not safely accommodate a driver traveling at the legal speed limit. Calculating the all red clearance with the 85th percentile speed is not recommended.

The all red clearance interval summary using the 85th percentile speed data shows that ten (10) intersection movements have an all red clearance interval greater than the calculated value, three (3) movements have a red interval equal to the calculated value, and fifty-seven (57) movements have all red clearance intervals that are less than the calculated value. Increasing the all red clearance intervals should be considered for the movements with current red intervals less than the calculated values using the legal driving speed (posted speed limit). When the current FDOT District 7 policy is used as guidance, the all red clearance intervals are intended to accommodate drivers who are driving at or below the legal driving speed (posted speed limit). Drivers who are slower than the legal driving speed would have adequate time to decelerate to a stop under the yellow indication. As stated earlier, we recommend the all red clearance intervals for the through movements and the left turn movements to be updated to meet the current FDOT District 7 policy, which is calculated using the legal driving speed (posted speed limit).

The City of St. Petersburg staff has confirmed that the red clearance intervals used within the City comply with the requirements within the FDOT *Traffic Engineering Manual.*, which states:

> "All new signals installations, intersections with Traffic Infraction Devices, signal phasing changes, geometric changes affecting the timing or phasing, or corridor re-timing projects must comply with these guidelines [in the November 2012 edition] immediately upon implementing timing changes. All other existing signalized intersections on the state highway system must be in compliance with guidelines of this Section by January 1, 2015."

City of St. Petersburg staff has confirmed that updating the red clearance intervals across the City are scheduled to meet the January 1, 2015 date as required by the FDOT.

Review of Other Agencies' Yellow Interval Documentation

The Federal Highway Administration (FHWA) provides a resource titled *Red-Light Camera Q & A* to answer frequently asked questions regarding red light cameras and their operation. This resource also includes numerous links to supplemental documents and reports associated with the various red light camera questions FHWA is attempting to answer. These secondary references include information relating to yellow change intervals in general and in conjunction with red light cameras. The FHWA resource and the available secondary resources are provided in the Appendix. Some of the information gathered from the FHWS resource includes:

- **Federal Highway Administration, *Red-Light Camera Systems Operational Guidelines*, 2005**
  This document is a non-regulatory requirement that is intended to foster initiatives to improve intersection safety and reduce red light running crashes. With regard to yellow intervals, the document defines the purpose as allowing enough time for a vehicle to comfortably decelerate to a stop before entering the intersection or to proceed through the intersection at a constant speed prior to the signal indication changing to red. Lengthening the yellow interval, within appropriate guidelines, can reduce the number of inadvertent red light violations. Yellow intervals should be established in accordance with the MUTCD and the ITE Proposed Recommended Practice (1985).

- **Institute of Transportation Engineers (ITE), *Making Intersections Safer: A Toolbox of Engineering Countermeasures to Reduce Red-Light Running*, ITE Report 115, 2003**
  This document focuses on explaining the behavior and characteristics behind red light running to provide solutions for engineering intersections that discourage red light running. Some of the contributing factors in red light running include 1) a higher number of approaching vehicles yielding a higher exposure, 2) a higher number of signal cycles and therefore a higher number of yellow intervals, and 3) suboptimal signal coordination leading to a yellow interval beginning in the middle of a platoon of approaching vehicles. Additionally, excessively long yellow intervals can decrease capacity, violate driver expectancy, and cause frustration when a vehicle comes to a complete stop at the intersection before the signal indication changes to red. The adjustment of driver behavior to account for known excessive yellow intervals is referred to as "habituation" and can result in drivers intentionally disregarding the yellow indication. However, further research into this phenomenon is needed to obtain reliable statistical data. Conversely, yellow intervals below the ITE recommended values can also violate driver expectancy and lead to a

higher number of red light violations. Several studies cited that increasing the yellow interval to meet ITE recommended values decreased the chance of red light running.

- **Federal Highway Administration, *Guidance Memorandum on Consideration and Implementation of Proven Safety Countermeasures*, 2008, Revision July 1, 2009**
  This policy summarizes the nine proven safety countermeasures identified by FHWA and provides guidance for implementation. With regard to yellow change intervals, the background reiterates that numerous studies support the ITE recommended values as a means to reduce crashes resulting from red light running. The guidance statement and application for this countermeasure states that the yellow interval should be adequate to allow a motorist traveling at the prevailing speed of traffic to comfortably stop at the intersection before the signal indication changes to red.

In addition to FHWA resources, documentation from the State of Georgia and City of Winnipeg, Canada outlining their evaluation of local yellow intervals were also reviewed.

- **State of Georgia House Bill 77, 2008**
  The State of Georgia passed House Bill 77 in 2008 mandating that "The duration of the yellow or red light of any traffic-control device at which a traffic-control signal monitoring device is installed shall not be decreased prior to the installation of a device or during the time for which the device is operated. The Department of Transportation shall establish minimal yellow light change interval times for traffic-control devices at intersections where a traffic-control signal monitoring device is utilized. The minimal yellow light change interval time shall be established in accordance with nationally recognized engineering standards, and any such established time shall not be less than the recognized national standard plus one additional second." This language is part of the larger bill which sets forth guidelines for local governments to follow prior to installing red light cameras and the procedures that must be followed for violations. Detailed research supporting the "plus one additional second" of yellow interval time was not discovered.

- **City of Winnipeg, Canada, *Review the Adequacy of Amber Time Duration at Signalized Intersections*, 2011 Administrative Report**
  The City of Winnipeg, Canada issued an administrative report titled *Review the Adequacy of Amber Time Duration at Signalized Intersections* in 2011. The report evaluated the City's existing yellow change intervals in response to media coverage regarding Georgia's House Bill 77. The report concludes that the City's existing policy of a consistent 4-second yellow interval at

all intersections is adequate and should be retained with no calculation based on the ITE formulas. It did, however, conclude that the existing policy on the all-red change interval should be updated to include the use of the ITE formulas given certain speed limits and intersection characteristics.

Research, case studies and a political document were also reviewed from the Texas Transportation Institute, Virginia Tech, the City of Albuquerque, and the U.S. Congress Majority Leader's office.

- **Office of the Majority Leader U.S. House of Representatives, *The Red Light Running Crisis Is it Intentional*?, 2001**

  This document incorrectly indicates that intersection width is a factor in determining the yellow change interval (page 4, Adlard & Murphy TV interview). The intersection width is used in determining the all red clearance interval, but not the yellow change interval. This document also indicates that since 1976 the updates/revisions to yellow change interval calculations and the addition of all red clearance intervals were made to "specifically accommodate camera enforcement." This document appears to weave together a theory of a movement to conspire between engineering standards and red light running photo enforcement.

- **Texas Transportation Institute, *Effect of Yellow Interval Timing on Red-Light Violation Frequency at Urban Intersections*, 2003**

  The technical study performs a before and after study at 8 signalized intersections focusing on the effect that adjusting the yellow change interval has on Red Light Running. Of the 8 study locations, 4 have substandard yellow change intervals in the before scenario. The sample set is contaminated with these 4 study locations which do not provide the appropriate yellow interval to allow drivers to safely come to a stop, thus these drivers are "trapped" into running the red light in the before scenario. With the contaminated sample set, the red light running was reduced from 113 in the before scenario to 58 in the after scenario (approximately 49%). This study cites potential engineering countermeasures to reduce red light running, such as:

  - Signal coordination
  - Signal operation improvements
  - Improve visibility of signal through use of backplates
  - Improve signal conspicuity through LED indications (bulbs)

  The City of St. Petersburg has previously implemented these countermeasures through the Intersection Public Safety Program. Furthermore, this study recommends that increasing a yellow interval that is shorter than standard engineering practices (the ITE formula) "will provide the

greatest return… Therefore, it is recommended that agencies consider timing the yellow interval such that it at least equals the value obtained from [the ITE formula]." The City of St. Petersburg confirmed that their yellow change intervals were consistent with standard practices (using the posted speed limit as vehicular speed) at the 22 camera enforced intersection approaches prior to the Stop on Red campaign.

- **Texas Transportation Institute, *Development of Guidelines for Identifying and Treating Locations with a Red-Light-Running Problem*, 2004**

  The analysis shows graphs for crash frequency against the length of yellow change interval. There is no data to confirm whether or not the study intersections have yellow change intervals that meet the ITE formula based on speed or the slope of hill on the approach. This study and provided data, figures, and charts are not directly applicable to the City of St. Petersburg due to the unavailability of needed engineering data inputs. The Figures 2-4 and 2-6 tend to indicate that the All Red Clearance Interval can be expected to have a more significant impact on the Red Light Related Crash Frequency than the Yellow Change Interval.

  - +1 sec. of yellow predicts a reduction of +/- 0.3 crashes/3 years
  - +1 sec. of red predicts a reduction of +/- 0.8 crashes/3 years

  Another chapter entitled "Area Wide Red Light Related Crash Frequency and Enforcement Effectiveness" identifies the Camera Enforcement Effectiveness as:

  - Reducing Red Light violations by 40 to 59 percent
  - Reducing Red Light related crashes by 20 to 36 percent
  - Reducing city wide crashes by 7 percent (Halo Effect, also experienced by the City of St. Petersburg)

- **Virginia Tech Transportation Institute, *A Novel Stochastic Procedure for Designing yellow Intervals At Signalized Intersections*, Year Unknown**

  The perception reaction time of the (real person) 85th percentile study participant (design driver) was 0.92 seconds. The ITE formula assumes 1.0 second for the perception reaction time. The ITE formula is conservative by using a slower perception reaction time. The median deceleration of study participants (real persons) was:

  - 11.6 ft/sec2 for drivers at 45 mph
  - 12.5 ft/sec2 for drivers at 55 mph

  The ITE formula assumes 10 ft/sec2 for the deceleration rate. The ITE formula is conservative by using a less aggressive deceleration rate.

Further statistical evaluations were made with imaginary participants (not real persons), which yielded a different result than the data from human participants of varying age and gender. Although this evaluation of imaginary participants is interesting, the human participant data tends to support the standard practices found in the ITE formula for the Yellow Change Interval and the All Red Clearance Interval

- **City of Albuquerque*, Yellow Light Timing Change and All-Red Clearance Interval Timing Change Effectiveness Study Final Report,* 2012**

  The study performs a simple before and after study at 18 signalized intersections with the yellow change interval being adjusted. The study measures total intersection crashes before and after yellow change intervals were increased. Of the 18 study locations, 2 have substandard yellow change intervals in the before scenario. The sample set is contaminated with these 2 study locations which do not provide the appropriate yellow interval to allow drivers to safely come to a stop, thus these drivers are "trapped" into running the red light in the before scenario. With the contaminated sample set, the total crashes were reduced from 443 in the before scenario to 407 in the after scenario (a modest +/- 8% reduction). The study also performs a simple before and after study at 2 signalized intersections with the all red clearance interval being adjusted. The study measures total intersection crashes before and after all red clearance interval was increased. This sample size of 2 intersection locations appears wholly inadequate to draw any conclusions (crash rates increased). This study shows that at the 18 intersections with yellow time increased and the 2 intersections with all red increased, there was an increase of 9 angle injury crashes and a reduction of 25 angle crashes with no injuries. This indicates the severity of the crashes increased with the yellow and red time changes. For the 20 intersections with yellow or red time increased, this study cites only a slight statistically significant difference in non-injury crashes between the before and after scenario. No other crash types provided a statistically significant difference between the before and after scenario.

Conclusions

The City of St. Petersburg continues to evaluate the "Stop on Red" campaign using crash analysis as one metric of success, also using characteristics such as yellow change interval and all red clearance intervals that are a part of the Intersection Public Safety program.

The specific evaluation of intersection yellow change intervals and the all red clearance intervals at the 10 intersections that comprise the "Stop on Red" campaign has been prepared with an analysis of the existing intervals based on the legal driving speed, which is the Florida Department of Transportation (FDOT) District 7 policy. This analysis follows the yellow change interval and all red clearance interval calculation requirements defined by the FDOT within the *Traffic Engineering Manual*. An additional review of the existing intervals was also conducted using the observed vehicular speed (85th percentile) data collected at the specific intersection approaches.

The yellow signal indication warns vehicle traffic of an impending change in right-of-way. The duration of this yellow change interval is based on the driver's perception-reaction time and deceleration rate, the approach posted speed limit, and the approach grade. The duration of the yellow interval should allow, at a minimum, for a driver to comfortably decelerate to a stop prior to entering the intersection. A yellow change interval is important for intersection safety by providing sufficient warning time for drivers to safely stop at the intersection for the impending red indication. The enforcement of red light running, whether by camera or by on-site patrol officers, depends on the yellow interval being appropriate to meet safety goals thus reducing the opportunity for citations to be issued erroneously.

The yellow change intervals for the through movements currently meet the FDOT *Traffic Engineering Manual* guidelines as well as the FDOT District 7 policy. **It is recommended that the yellow change intervals for the left turn movements be updated to meet the current FDOT District 7 policy, which is calculated using the legal driving speed (posted speed limit) of the adjacent through movement.** The yellow clearance interval may not be sufficient to accommodate drivers who exceed the legal driving speed; therefore **it is recommended that the "Stop on Red" campaign be coordinated with law enforcement agencies to enforce the legal driving speed (posted speed limit).**

The all red clearance interval is a safety measure that is not associated with the "Stop on Red" campaign. The all red clearance interval is intended to allow drivers to safely cross an intersection after entering the intersection on a yellow indication. The all red clearance interval is designed to allow drivers who entered the intersection on the yellow indication, to safely continue through the intersection before conflicting traffic receives a green indication. **It is recommended that the all red clearance intervals for the through movements and the left turn movements be updated to meet the current FDOT District 7 policy, which is calculated using the legal driving speed (posted speed limit).**

Appendix