

PHYSICS OF THE YELLOW SIGNAL LIGHT ITE'S FIRST RECOMMENDED PRACE

National Society of Professional Engineers, September 23, 2020 http://talussoftware.com/docs/nspe/pspe-nation.pptx



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MOVIECLIPS.com

Yellow change and clearance intervals

At the termination of a green phase, motorists approaching a signalized intersection are advised by a yellow signal indication that the red interval is about to commence³⁵. The

speed and location of some approaching vehicles will be such that they can stop safely at the stop line; others will have to continue at their speed or even accelerate into or through the intersection. The minimum length of the clearance interval (which may include an all-red interval after the yellow indication) should accommodate both situations and eliminate the possibility of a dilemma zone in which a driver can neither stop safely nor legally proceed into or through the intersection. See Table 24-7.





Institute of Transportation Engineers, Transportation and Traffic Engineering Handbook 1982



MARCH 2020

Guidelines for Determining Traffic Signal Change and Clearance Intervals

A Recommended Practice of the Institute of Transportation Engineers



Critical Distance





ITE Extended Kinematic Equation - First Recommended Practice (Järlström, 2016)





Constant Maximum Velocity – Old ITE Kinematic Equation (Gazis, Herman, Maradudin 1959)















Red Light Camera Safety Report - 2015

NSPE



Suffolk County, NY 2017





Fastest Turn (Ceccarelli, 2010)



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PE NSPE

Turn with Constant Deceleration – Chiu Liu, 2002

NSPE





Greenville, NC







Omissions



Impeded Traffic



Vehicles Egressing/Entering Nearby Businesses





Close-By Intersections





Solution – Includes Impeded Traffic @ Isolated Intersection This changes the definition of a yellow light.





Tolerances









By Plugging In Boundary Values

			Boundary									
Comfortable and Safe	NCDOT	ITE	Value		NCDOT (North (arolina Departm	nent of Transport	ation) uses the E	mergency Stop	ping Values from	the American A	Association
Perception-Reaction Time (s)	1.5	1.0	2.5		ITE (Institute of	Transportation I	Engineers) Perce	ption-Reaction Ti	me and Decele	ration for the 50	h Percentile Pa	ssenger Ve
Decleration (ft/s2)	11.2	10.0	8.0		Boundary Value	s: Drivers exhib	oit a range of vali	d behavior. 2.5 s	and 8.0 ft/s/s	represent the ma	ximum and min	imum bou
			Minimum Yello	w Change Interv	rals			Mnimum Yellow	Change Interva	als		
			Going Staight a	t Constant Appro	ach Speed			Turning or Imped	led Thru-Move	ments		
			(Unimpeded Th	ru-Movements)	Read Facts 4-9.		(Unimpeded Turning Movements) Read Facts 4-9.				ι	
										Boundary	Red Light	
	Vo				Boundary	Red Light	Ve	NCDOT	ITE	Value	Camera	NCDOT
	Approach		NCDOT	ITE	Value	Camera	Intersection	Turn	Turn	Turn	Turn	Braking
	Speed	Grade	Y	Y	Y	Grace Period	Entry Speed	Y	Y	Y	Grace Period	Time
	(mph)	(%)	(s)	(s)	(s)	(s)	(mph)	(s)	(s)	(s)	(s)	(s)
	15	0	2.5	2.1	3.9	1.8	15	2.5	2.1	3.9	1.8	_
	20	0	2.9	2.5	4.4	1.9	20	2.9	2.5	4.4	1.9	
	25	0	3.2	2.9	4.8	1.9	20	3.5	3.2	5.3	2.1	
	30	U	3.5	3.2	5.3	2.1	20	4.2	4.0	6.2	2.2	
	35	0	3.8	3.6	5.8	2.2	20	4.8	4./	/.1	2.4	_
	40	0	4.2	4.0	6.2	2.2	20	5.5	5.4	8.0	2.0	
	45	0	4.5	4.3	7.1	2.4	20	6.0	6.0	9.0	2.0	
	55	0	4.0	5.1	7.5	2.4	20	7.4	0.9	10.8	3.0	-
	60	0	5.5	5.4	8.0	2.6	20	81	8.4	11.7	3.3	-
	65	0	5.8	5.8	85	2.0	20	8.8	91	12.6	3.5	
			5.0	5.0		27	20	0.0	5.2	11.0	3.3	
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By Error Propagation

$$\Delta Y = \left| \frac{\partial Y}{\partial t_p} \Delta t_p \right| + \left| \frac{\partial Y}{\partial a} \Delta a \right| + \left| \frac{\partial Y}{\partial v_c} \Delta v_c \right| + \left| \frac{\partial Y}{\partial v_i} \Delta v_i \right|$$
$$= \left| \Delta t_p \right| + \left| \frac{(v_i - 2v_c)}{2a^2} \Delta a \right| + \left| \left(\frac{1}{a} \right) \Delta v_c \right| + \left| \left(\frac{1}{2a} \right) \Delta v_i \right| \approx \pm 3 \text{ sec}$$

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for a 45 mph v_c and 20 v_i



TIMING CHART											
2070N Controller											
Phase	01	02	03	04	05	06	07	08			
Minimum Green	7 sec	12 sec	7 sec	7 sec	7 sec	12 sec	7 sec	7 sec			
Passage Gap	1.0 sec	2.0 sec	1.0 sec	2.0 sec	1.0 sec	2.0 sec	1.0 sec	2.0 sec			
Max 1	25 sec	45 sec	20 sec	35 sec	25 sec	45 sec	20 sec	35 sec			
Yellow Change Int.	6.2 sec	4.3 sec	6.2 sec	4.3 sec	6.2 sec	4.3 sec	6.2 sec	4.3 sec			
Enforcement Delay [*]	2.8 sec	2.4 sec	2.8 sec	2.4 sec	2.8 sec	2.4 sec	2.8 sec	2.4 sec			
Red Clearance	3.4 sec	2.1 sec	3.6 sec	1.3 sec	2.8 sec	2.1 sec	2.9 sec	1.4 sec			
Recall Position	None	Min Recall	None	None	None	Min Recall	None	None			
Vehl Call Memory	Nonlock	Lock	Nonlock	Nonlock	Nonlock	Lock	Nonlock	Nonlock			
Walk	-	7 sec	-	7 sec	-	-	-	-			
Flashing Don't Walk	-	29 sec	-	16 sec	-	-	-	-			

*Enforcement Delay: Red-light camera delay/grace periods cannot be set to values less than this. Also the police cannot enforce red-light running until the driver enters the intersection after this length of time. Because the Yellow Change Int. is set for the average driver, good drivers (half the driving population is slower than average) may inadvertently run the red light up to this time into the red.



Perception-reaction time and deceleration are not constants. Good allowed drivers on the road exhibit a well-defined range of valid values. The curve of valid perception-reaction times has a range which tops at 2.6 seconds. The curve of deceleration has a range starting at 7.4 ft/s/s.

Errors





Vc or Deceleration Measured at the Wrong Location



Critical Distance





Dynamics of Emergency Stopping Misapplied to Comfortable Stopping



$$Y \ge t_p + \left[\frac{v_c - v_i}{a + Gg}\right] + \frac{v_i}{2(a + Gg)}$$

where G = y/x = grade and g = gravitational acceleration







History of the Yellow Light







London, England

The First Red-Green Traffic Light

> J.P. Knight 1828 - 1886





William Potts 1883 – 1947 Detroit Policeman

1920







Traffic "Towers"

Fifth Avenue New York, NY



Schenectady, NY

NSPE





The Henry Ford Dearborn, MI

The Yellow Change Interval Formula









Denos Gazis 1930 - 2004 Solid State Physicist and Traffic Scientist Robert Herman 1914 – 1997 Physicist Known for Research on Big Bang Theory: Microwave Radiation Alexei Maradudin 1931 – Physics Professor UC Irvine



For vehicles traversing the critical distance at a constant speed which is the maximum allowable speed.





Institute of Transportation Engineers The Yellow Change Interval Equation

1985 $Y = t_p + \frac{1}{2(a + gG)}$

Applied Universally





Mats Järlström Beaverton, OR 2013 Brian Ceccarelli Apex, NC 2009

2020

Jay Beeber Los Angeles, CA 2012





PHYSICS OF THE YELLOW SIGNAL LIGHT ITE'S FIRST RECOMMENDED PRACE

National Society of Professional Engineers, September 23, 2020 http://talussoftware.com/docs/nspe/pspe-nation.pptx



Brian Ceccarelli, P.E., M.NSPE