Nothing Compares
NORTH CAROLINA

Executive Committee for Highway Safety
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Dynamic All-Red Extension Preliminary Results

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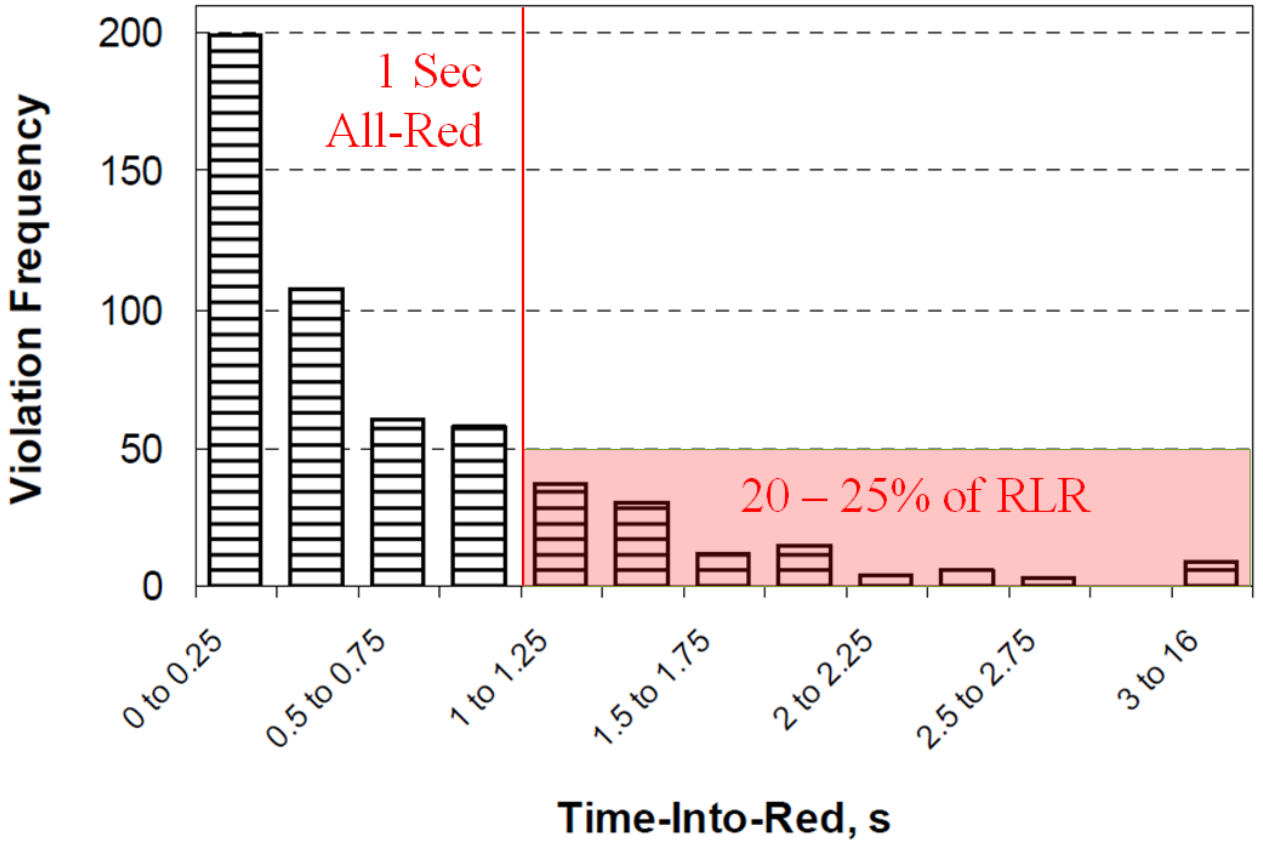
Dynamic All Red Extension

The Problem

Frequency of Red-Light Violations as a Function of Time-Into-Red
(Bonneson & Zimmerman 2004)



Dynamic All Red Extension

How It Works

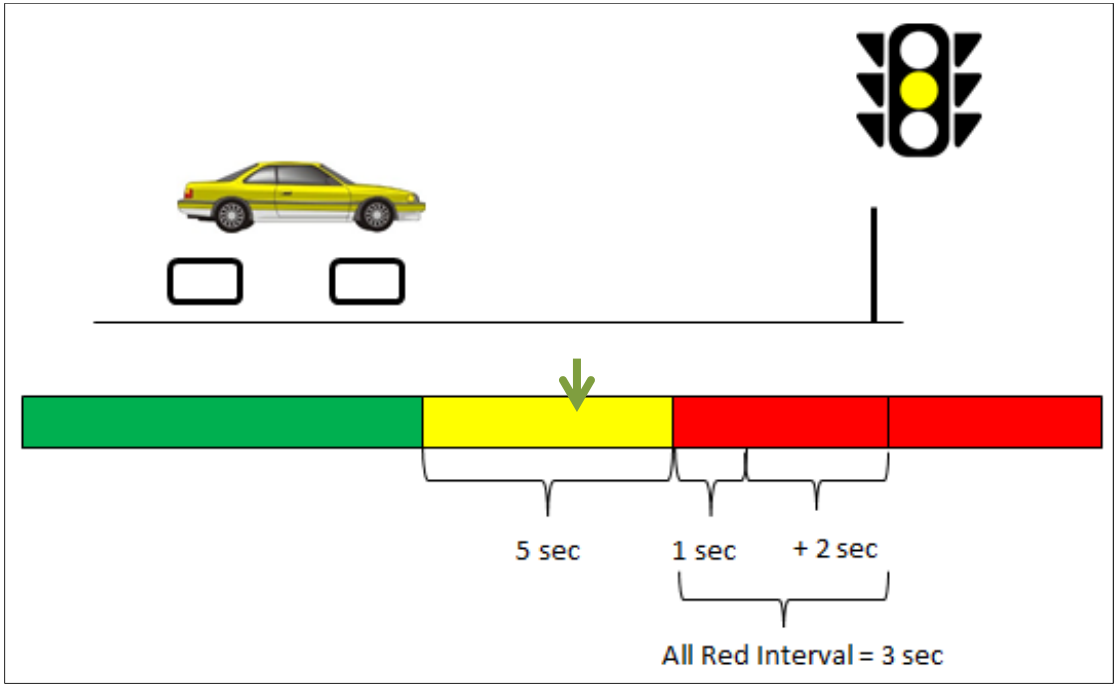
Signalized Intersection with:

- Yellow Interval: 5 seconds
- Default Red Interval: 1 second
- Alarm Time: 5 seconds
- Closest Loop is 240’ from Stop Bar

Example Scenario:

1. Vehicle below crosses the loops at 3 seconds into the yellow interval
2. 5 second stop time is placed on the red interval
3. Vehicle has remaining 2 seconds of yellow, 1 second of default red, and 2 seconds of red extension = 5 seconds from the time they cross the loops.

Total All-Red Time: 3 sec



http://www.shutterstock.com/pic-104301266/stock-photo-d-renderings-of-an-all-red-traffic-light.html

Inductive Loop

http://cronkitezine.asu.edu/specialprojects/photoenforcement/pages/technology.html

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Equipment

- Signal Controller: Oasis/2070
- Detection method – Two 6’ X 6’ inductive loops spaced 10’ apart
- Northstar Controls Model NQ4 Speed Advisory System
  - Unit is typically placed in separate cabinet next to inductive loops
  - Loop outputs feed into inputs of NQ4 logic unit and determines if preset speed threshold has been violated (threshold varies by location – typically 5 mph below design speed)
  - We tweaked outputs from our NQ4 detector systems to get the controller to handle the necessary “holds”
  - Duration of alarm output is 5 sec

Costs

- Estimate $5,000 per approach, using our detection method

First Installation: NC 11 @ NC 561 – Ahoskie

Dynamic All Red Extension

Project Timeline

February 2011

- Ahoskie Test Site Installed (Case Study Only – Not Included in Aggregated Results)

Fall 2012

- Eight Pilot Sites Selected & Signal Designs Completed
- Before Period Compliance Data Collected at Eight Pilot Sites

January – October 2013

- Eight Pilot Sites Installed

February 2013 - October 2014

- After Period Compliance Data Collected at Eight Pilot Sites (1, 3, 6 and 12-Mo.)

April 2015

- Preliminary Crash Results

2017

- Final Crash Results (3 years of After Data)
  – consider waiting for additional Crash Data….

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Pilot Study Locations

Site	Location Description	Treated Approaches	Distance to Loop (ft)	Yellow Interval (sec)	Default Red Interval (sec)	Signal Phase	Mainline Cross Section	Mainline AADT	Mainline Speed Limit (mph)
1	US 17 at US 158 and SR 1416, Pasquotank County	US 17 - Both	290	5.5-5.6	1.0-1.1	5	4 Lane Divided	17,000	60
2	US 17 at SR 1300, Perquimans County	US 17 - Both	290	5.5	2.0	6	4 Lane Divided	15,500	55
3	US 17/158 at SR 1333), Pasquotank County	US 17 - Both	290	5.5	1.0	2	4 Lane Divided	8,000	60
4	NC 24 at SR 1141/SR 1144, Carteret County	NC 24 - Both	240	5.3	1.1	3	5 Lane Undivided	18,500	55
5	US 17 at NC 904, Brunswick County	US 17 - Both	240	5.2-5.3	1.0-1.2	5	4 Lane Divided	22,000	55
6	US 70 Business at SR 2558, Wake County	US 70 Bus - Eastbound	240	5.2	1.2	6	4 Lane Divided	29,500	55
7	US 601 at NC 268, Surry County	US 601 - Both	155	4.3	1.0	2	2 Lane	4,800	45
8	US 52 at US 52 Business and SR 2011, Surry County	US 52 - Westbound	240	5.1	2.0	6	4 Lane Divided	14,500	55

Site 5

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Study Design

Compliance Data:

- Video collected by Quality Counts, LLC at Eight Pilot Sites
- Collected 1-2 Days @ Before, 1 Mo After, 3 Mo After, 6 Mo After & 1 Yr After Period
- **OBSERVING CHANGES IN DRIVER BEHAVIOR/ADAPTATION OVER TIME**
- **CHECKING SYSTEM OPERATION**

Measures of Effectiveness

- Average Yellow Light Runners (YLR)
- Average Red Light Runners (RLR)
- Average Target* RLR

* Target RLR consists of vehicles we assume should receive an all-red extension, excluding vehicles entering the intersection during the default all-red clearance interval.

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Study Design

Crash Data:

- 3 Years of Before & After Data at Test Site (Case Study Only – Not Included in Aggregated Results)
- Preliminary Results at Eight Pilot Sites - Currently 1-2 years of After Period Crash Data (Wait until 3 years of After Period Crash Data for Final Results)
- Selected sites with moderate Red Light Running crash patterns (1-3 crashes per year) – Expect Regression to the Mean to be a factor
- **EXPECT A DECREASE IN RED LIGHT RUNNING CRASHES**

Measures of Effectiveness

- Total Crashes
- Fatal and Injury Crashes
- Angle Crashes
- Rear End Crashes

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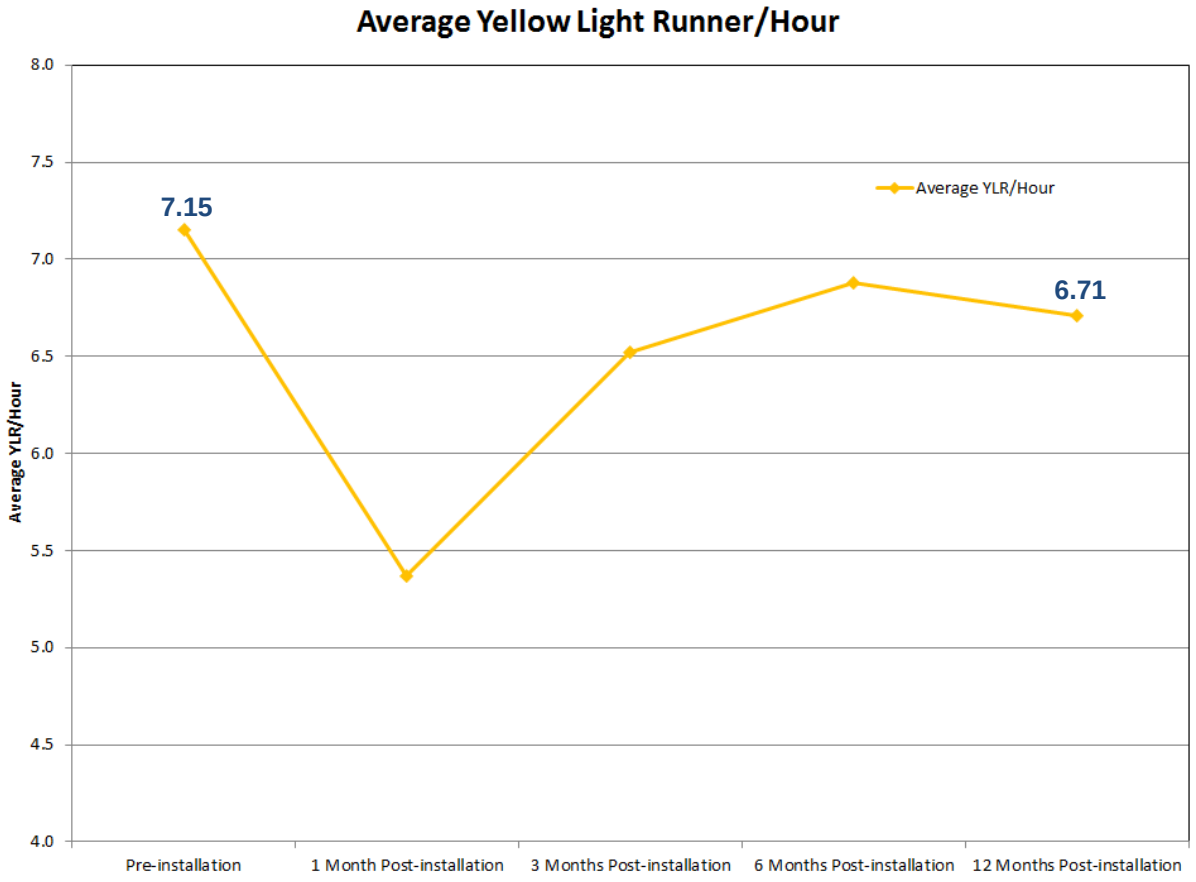
Overall Results

Compliance Study

YLR



[a] *Denotes a statistically significant ($p<0.05$) change from pre installation to post-installation conditions using a two-tailed unpaired t-test.*

Yellow Light Runner Data

Time Period	Observation Period (hours)	Number of Observations	Average YLR/Hour	Average YLR/ 1,000 veh	Average YLR/ Cycle
Pre-installation	304	2173	7.15	22.36	0.186
1 Month Post-installation	255	1370	5.37[a]	17.13[a]	0.127[a]
3 Month Post-installation	155	1010	6.52	20.32	0.147[a]
6 Months Post-installation	155	1067	6.88	19.75	0.158
12 Months Post-installation	193	1295	6.71	22.35	0.141[a]

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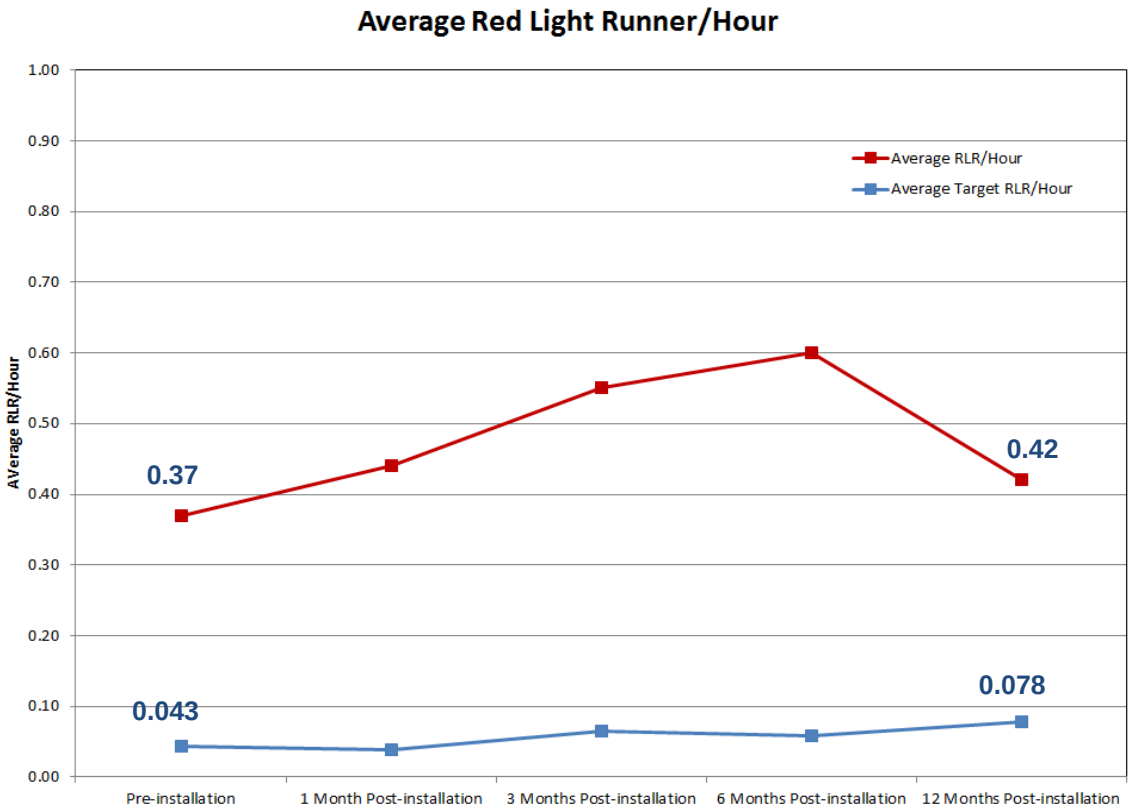
Overall Results

Compliance Study

RLR



[a] *Denotes a statistically significant ($p<0.05$) change from pre installation to post-installation conditions using a two-tailed unpaired t-test.*

Target RLR consist of vehicles that based on our assumptions should receive an all-red extension, excluding vehicles entering the intersection during the default all-red clearance interval. The side street movement (4+8) is the next phase served for Target RLR. We assume RLR hit loops traveling at/above the set speed, and maintain speeds at the posted speed limit.

Red Light Runner Data

Time Period	Observation Period (hours)	Number of Observations	Average RLR/Hour	Average RLR/ 1,000 veh	Average RLR/ Cycle
Pre-installation	304	111	0.37	1.21	0.0089
1 Month Post-installation	255	113	0.44	1.30	0.0102
3 Month Post-installation	155	86	0.55[a]	1.79	0.0121
6 Months Post-installation	155	93	0.60[a]	1.74	0.0125[a]
12 Months Post-installation	193	82	0.42	1.40	0.0088

Target Red Light Runner Data

Time Period	Observation Period (hours)	Number of Observations	Average RLR/Hour	Average RLR/ 1,000 veh	Average RLR/ Cycle
Pre-installation	304	13	0.043	0.139	0.0010
1 Month Post-installation	255	10	0.039	0.145	0.0008
3 Month Post-installation	155	10	0.065	0.240	0.0012
6 Months Post-installation	155	9	0.058	0.159	0.0012
12 Months Post-installation	193	15	0.078	0.275	0.0016

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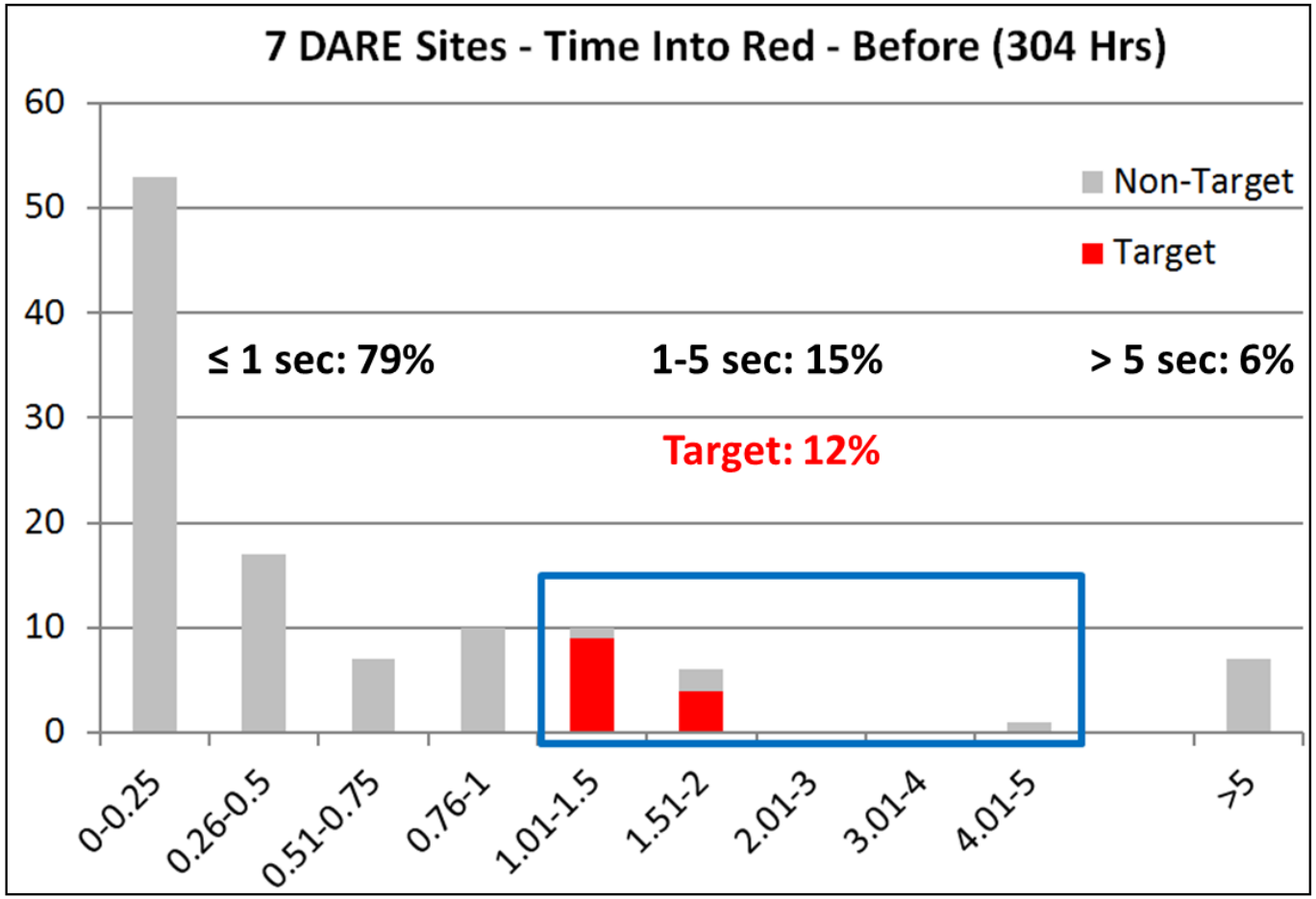
Overall Results

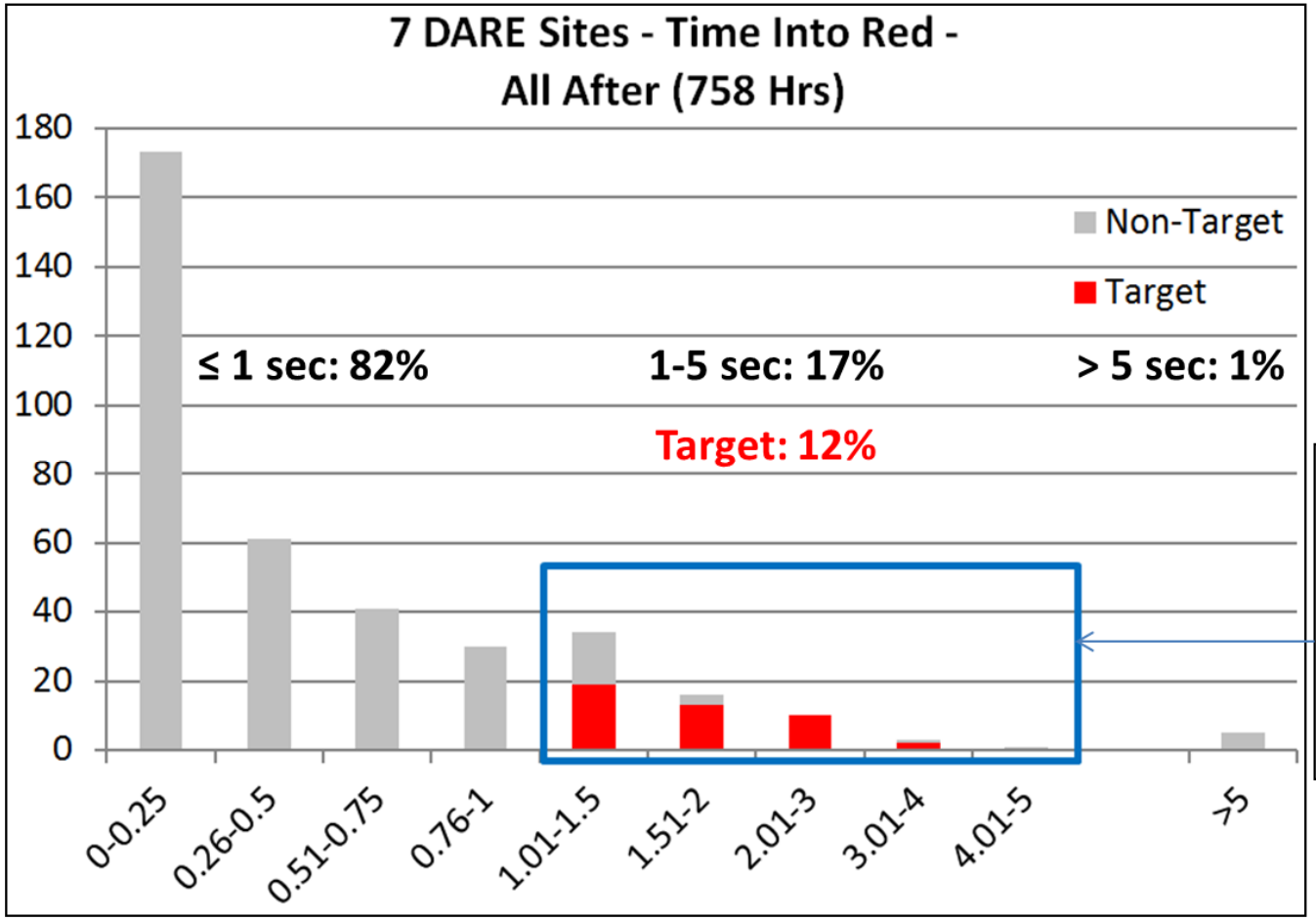
Compliance Study: ***Time into Red – Before*** *(111 RLR)*



Dynamic All Red Extension

Overall Results

Compliance Study: ***Time into Red – After*** *(374 RLR)*



89% of the 44 Target RLR received an extension. The average all-red interval for the Target RLR was 6 seconds

Dynamic All Red Extension

Overall Results

Usage Data (From Signal Logs)

Average Extensions/Hour range from 0.11 – 3.13
Average Length of Extension range from 1.4 – 3.2 seconds

Number of Extension Calls Per Approach

Signal ID	After Period	Hours Collected	Average Extensions Per Hour		Average Length of Extension (Sec)		Average Cycles Per Hour
			Phase 2	Phase 6	Phase 2	Phase 6	
01-0314	1 month	192	2.21*		n/a		46
	2 years	168	2.91*		n/a		45
01-0381	2 years	144	1.23	1.20	1.5	1.4	39
01-0658	1 month	336	0.33	0.93	n/a	n/a	47
	2 years	432	0.53	0.56	2.8	2.9	48
02-0470	1 month	240	1.11	0.93	n/a	n/a	41
03-0342	1 year	72	2.79	2.69	2.5	2.4	56
05-1142	6 months	168	2.93	-	2.9	-	32
	2 years	144	3.13	-	2.8	-	32
11-1090	3 months	1368	0.11	0.27	3.2	3.2	65
11-1093	2 months	192	2.54	-	2.7	-	55

*Average extensions for both approaches combined.

Dynamic All Red Extension

Conclusions – Compliance Study

- Comparing the before period to the final after period, there is **no statistically significant change in YLR and RLR/hour** in the overall sample
  - 1062 Hours (about 1.5 months) of video data is included from 7 sites
  - There were some significant increases in RLR at the 3 & 6 mo. marks
  - However, by final after period, appears to be minimal habituation…
- The system is **not going to capture all RLR crashes** - provides extra protection against angle crashes caused by a specific group of mainline RLR vehicles.
  - Of 374 observed RLR, 6 entered the intersection too late for an extension (3 of these were police or EMS with lights on)
- Vehicle conflicts are rare. Even with hundreds of hours of observation, there were **too few conflicts to evaluate.**
  - Observed 2 near misses in the after period. The vehicles were too late to receive the all red extension, entering the intersection at 6 sec and 9 sec.

Dynamic All Red Extension

Conclusions – Crash Analysis

- We need to **wait for more after crash data** before trying to draw conclusions.
- Preliminary results are **promising** for target angle crashes & severe injury crashes.
- If possible, we will try to draw a connection between system parameters and crash performance. Perhaps there is more benefit when the target window is larger and extends later in the red:
  - Larger Target Window - Design speed is closer to what drivers are actually traveling and the loops are placed further back (however, more False+)
  - Extends Later into Red – A longer default red clearance is used (1.5+ seconds) and later protection can be offered

Dynamic All Red Extension

Conclusions – Operations

- The system **can work** as designed.
  - There were 44 Target RLR in the after period sample – 89% (39 of 44) got an extension.
- The system **can remain in operation** for an extended period of time.
  - All sites were operating at the 2-year after mark
- Signals with Dynamic Red **require periodic monitoring.**
  - Like monitoring already required to maintain proper signal operation
  - 03-0342 @ 3 mo mark (relay switch failed – *unrelated* to DARE)
  - 01-0381 @ 3 & 6 mo mark (water backed up in conduit – *unrelated*)
  - 05-1142 @ 1 yr mark (signal phasing change/construction-*unrelated*)
  - Supervisor Circuit planned for future installations
- Minimal risk with system
  - If it's not working, the signal will revert to standard red interval
- More sites in development….

Dynamic All Red Extension

Video Clips

Target

http://youtu.be/LKCQvtPFMsQ

https://youtu.be/qJ52wMowehM?list=PLFPlSVRUEsJqDGOS458c2HfhYNy1QM4It

https://youtu.be/-pHBTlOoKEU?list=PLFPlSVRUEsJqDGOS458c2HfhYNy1QM4It

https://youtu.be/FwjAiPbKKwA?list=PLFPlSVRUEsJqDGOS458c2HfhYNy1QM4It

https://youtu.be/4kSvUbj4c5E?list=PLFPlSVRUEsJqDGOS458c2HfhYNy1QM4It

Non Target

https://youtu.be/uRsEUNWd7vQ?list=PLFPlSVRUEsJqDGOS458c2HfhYNy1QM4It