MARYLAND DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

Safety Evaluation of **Dilemma Zone Protection System (DZPS)** at High Speed Rural Intersections in Maryland

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Majority of Intersection Crashes

Red Light Running Vehicles

Source: http://www.sheepsheadbites.com/2012/09/while-dot-studies-another-accident-on-bedford-avenue-and-emmons-avenue/v

-OR-

53.6%

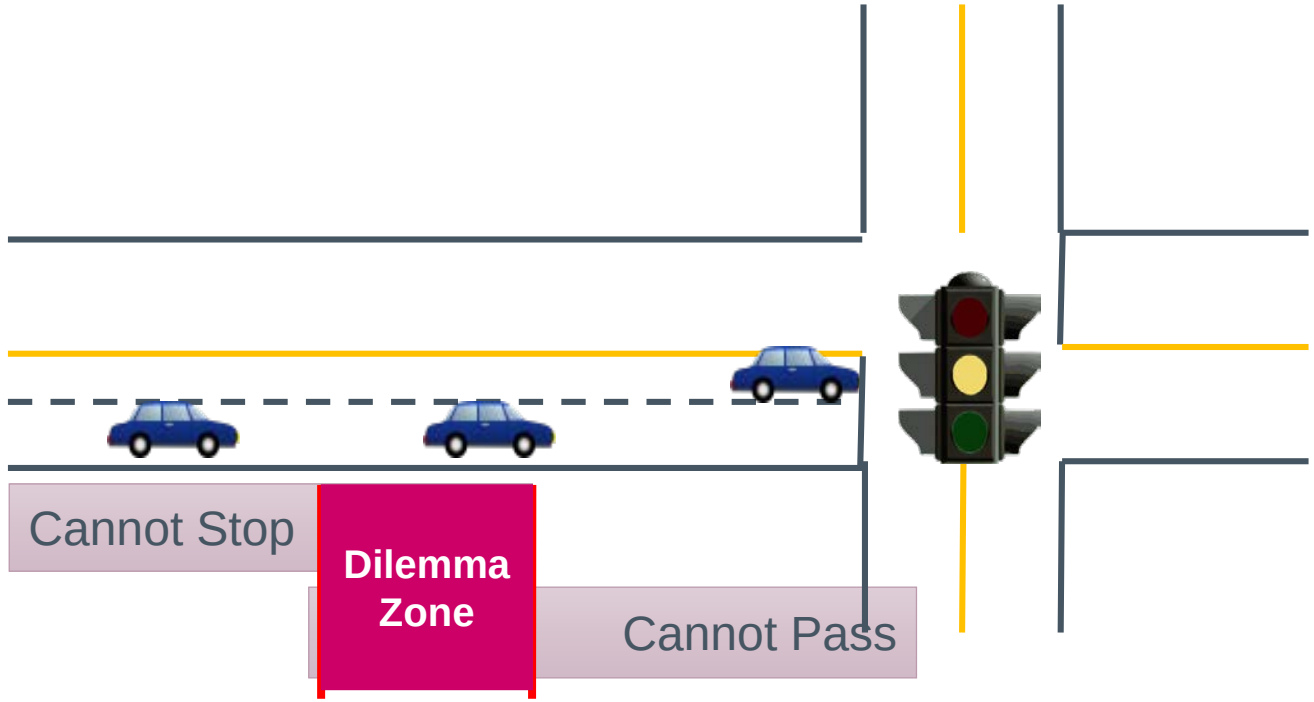
(Source: U.S. DOT, NHTSA.)

Hard Breaking Vehicles

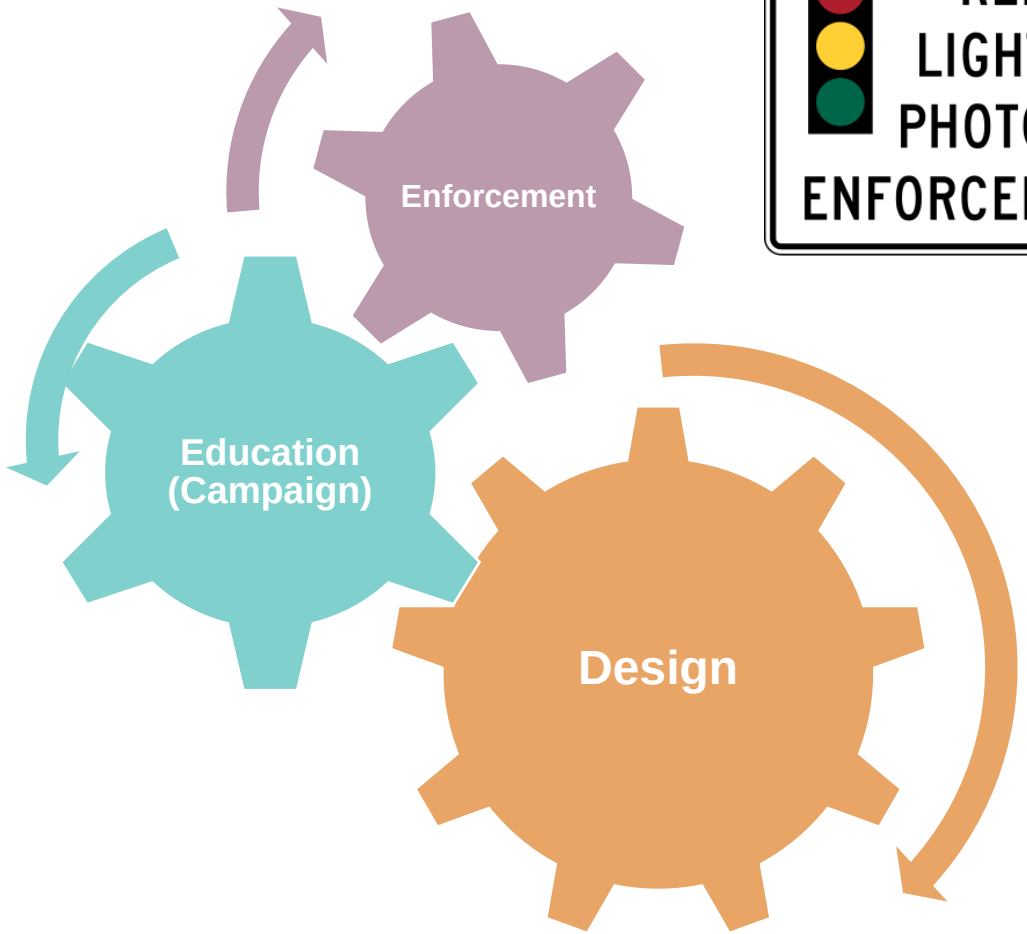
Source: http://crownheights.info/accidents/page/4/

Dilemma Zone

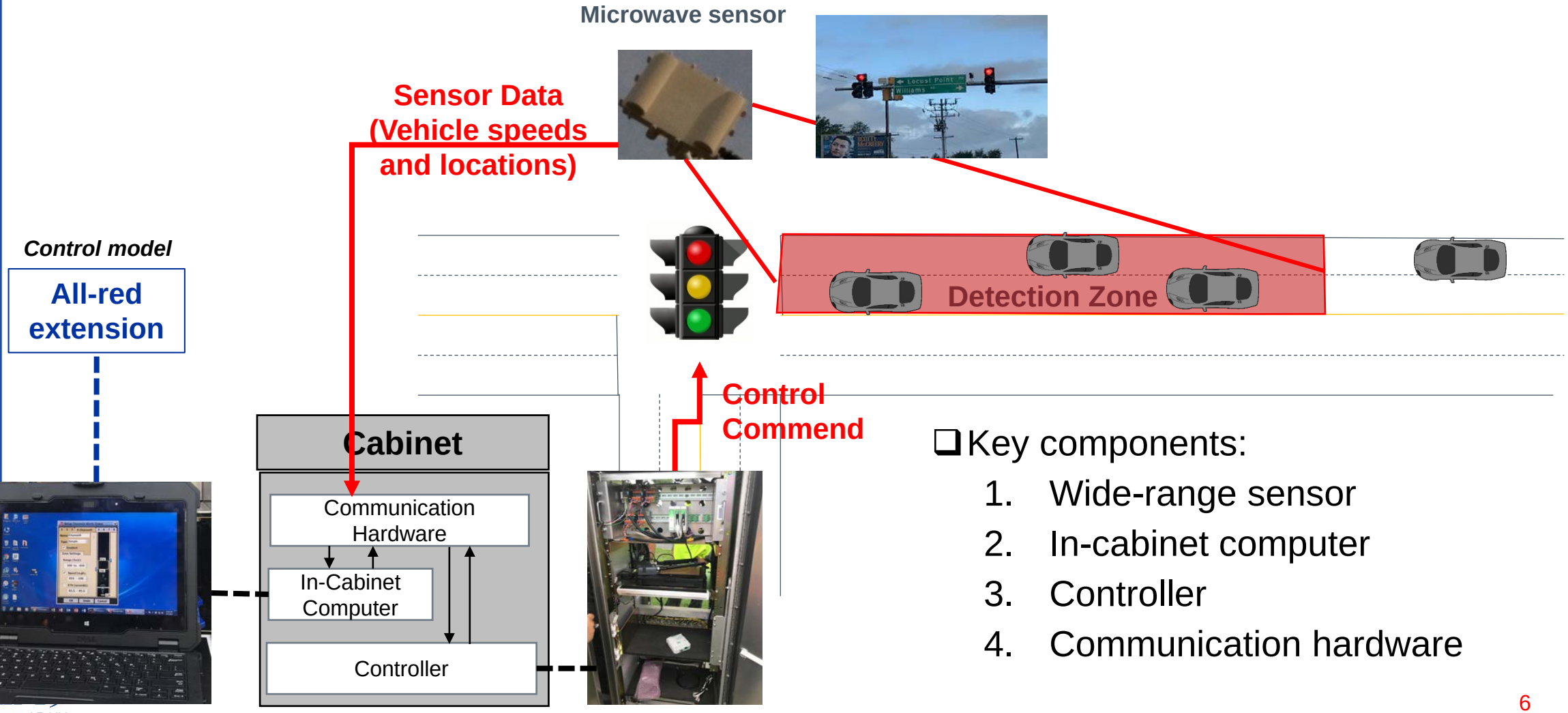
- **Potential contributors to Dilemma Zone related collisions**
  - **Insufficient duration of the yellow phase**
  - **Aggressiveness of drivers**
    - **High speed**
  - **Short sight distance**
  - **Driver's characteristics**
    - **PRT, age, gender**
  - **Deceleration rate of vehicles**



How to Prevent Crashes?

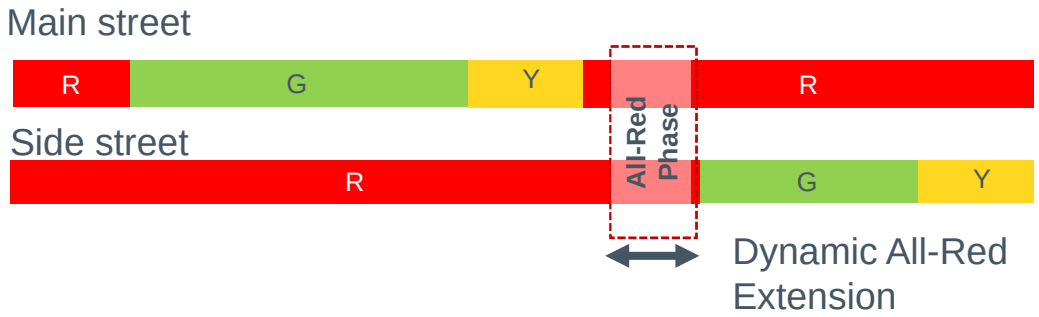


Dilemma Zone Protection System (DZPS) System Configuration

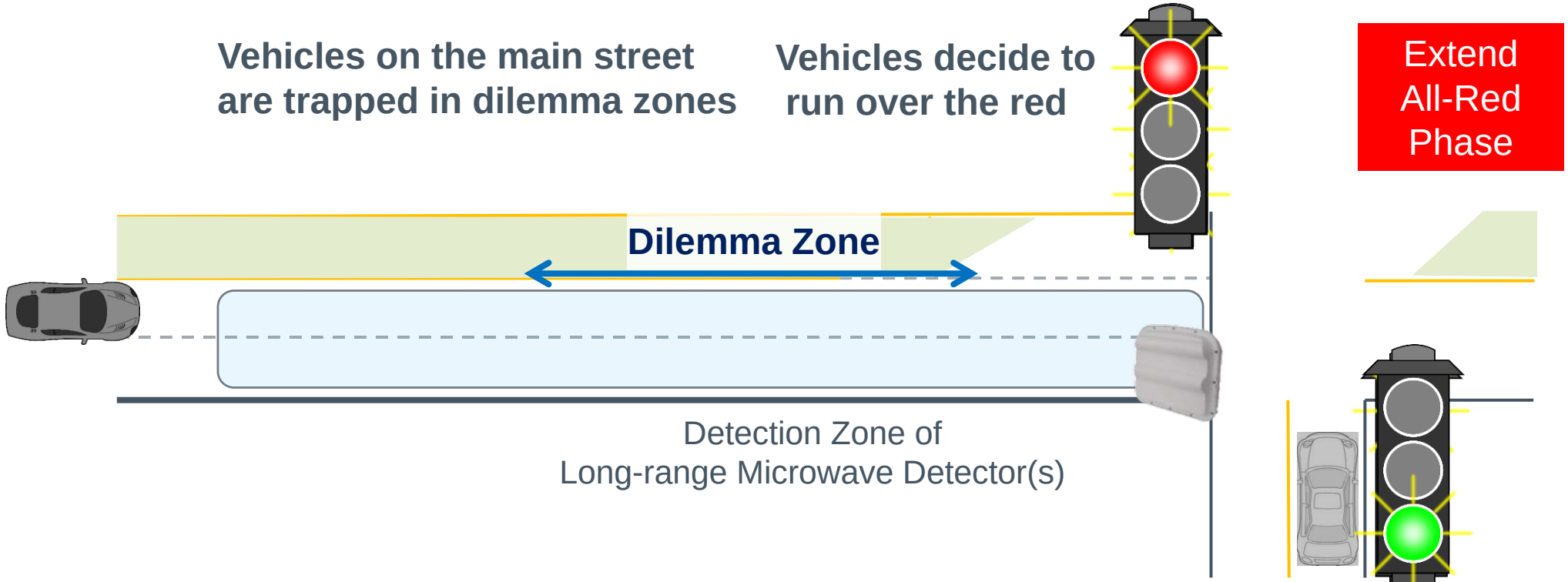


- Key components:
  1. Wide-range sensor
  2. In-cabinet computer
  3. Controller
  4. Communication hardware

DZPS Control Strategy
All-Red Extension



Give an additional clearance time to red-light running vehicle to prevent angled crash



DZPS Deployment in Maryland
High speed rural intersections

Site 1) US 40 @ Red Toad Rd.
- **DZPS in EB and WB** approaches along US 40
- Posted speed limit: 55mph

Site 3) US 40 @ Western Maryland Pkwy
- **DZPS in EB approach** along US 40
- T intersection
- Posted speed limit: 55mph

Site 2) MD 213 @ Locus Point Rd
- **DZPS in NB and SB** approaches along MD 213
- Posted speed limit: 55mph

Before-and-after crash patterns
Site 1) US 40 at Red Toad Rd. (EB)

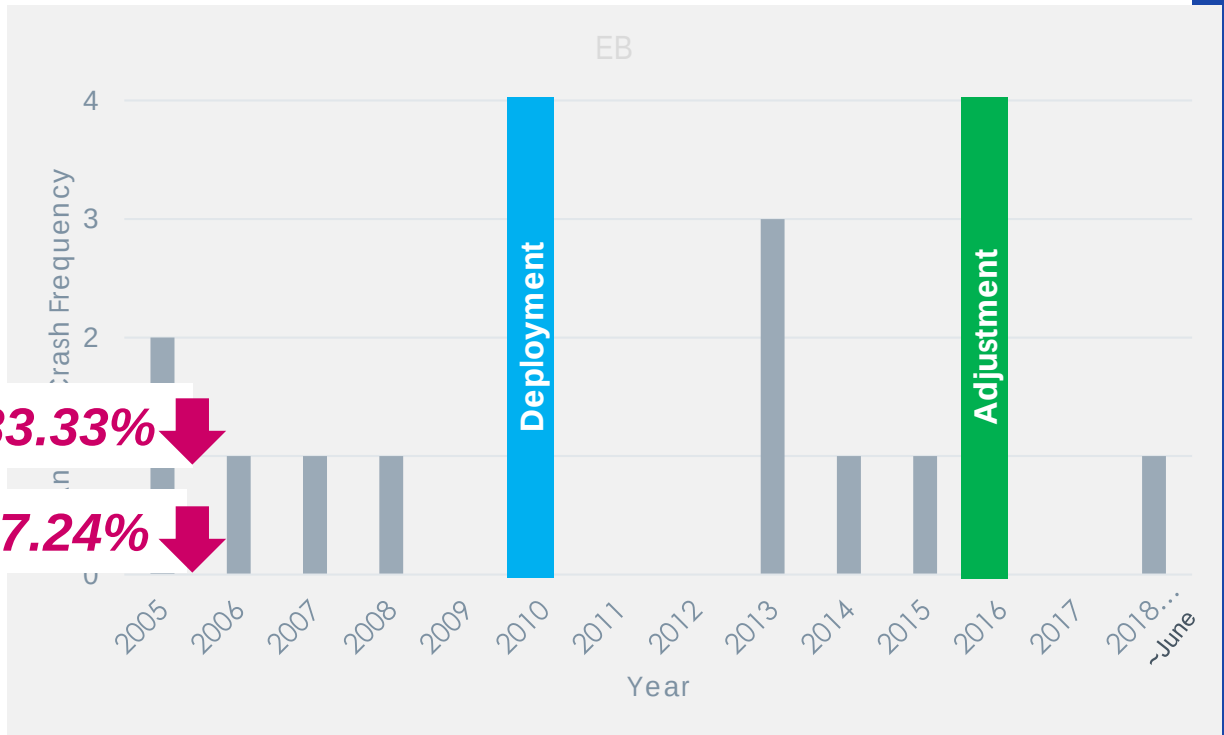
- **EB DZPS Deployed in 2010**
- **EB DZPS Adjusted in 2016**

❑ ***Before-and-after angled crashes***

Angled Crash	2005-2009	2011-2015	2017-2018
Annual Average Frequency	1.00	1.00	0.67
% EB Angled crashes	17.9%	16.7%	14.3%

After period: 18 month

[EB Angled Crash Frequency]



** without drug/alcohol related crash*

Before-and-after crash patterns
Site 1) US 40 at Red Toad Rd. (WB)

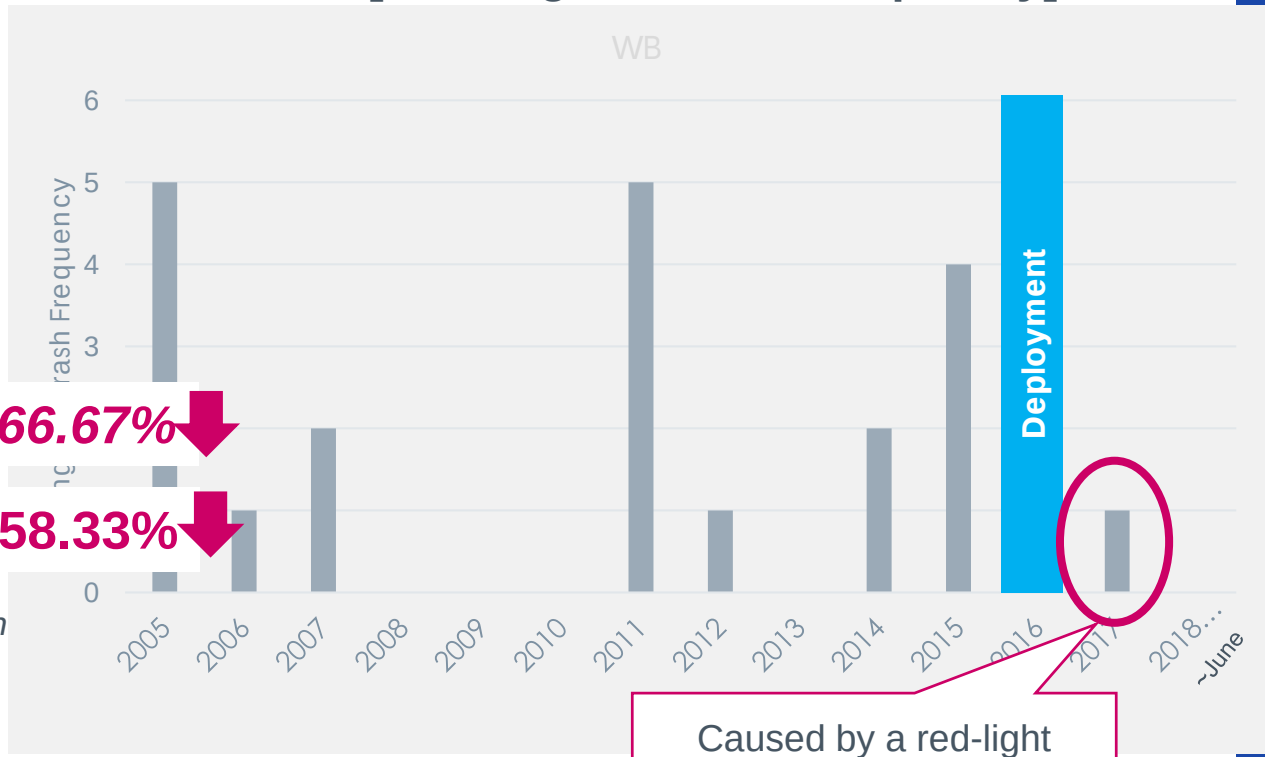
- **WB DZPS Deployed in 2016**

❑ ***Before-and-after angled crashes***

Angled Crash	2005-2009	2011-2015	2017-2018
Annual Average Frequency	1.60	2.40	0.67
% WB Angled crashes	28.6%	40.0%	14.3%

After period: 18 month

[WB Angled Crash Frequency]



66.67%

58.33%

** without drug/alcohol related crash*

Caused by a red-light running vehicle from the side street w/o DZPS

Before-and-after crash patterns
Site 1) US 40 at Red Toad Rd.

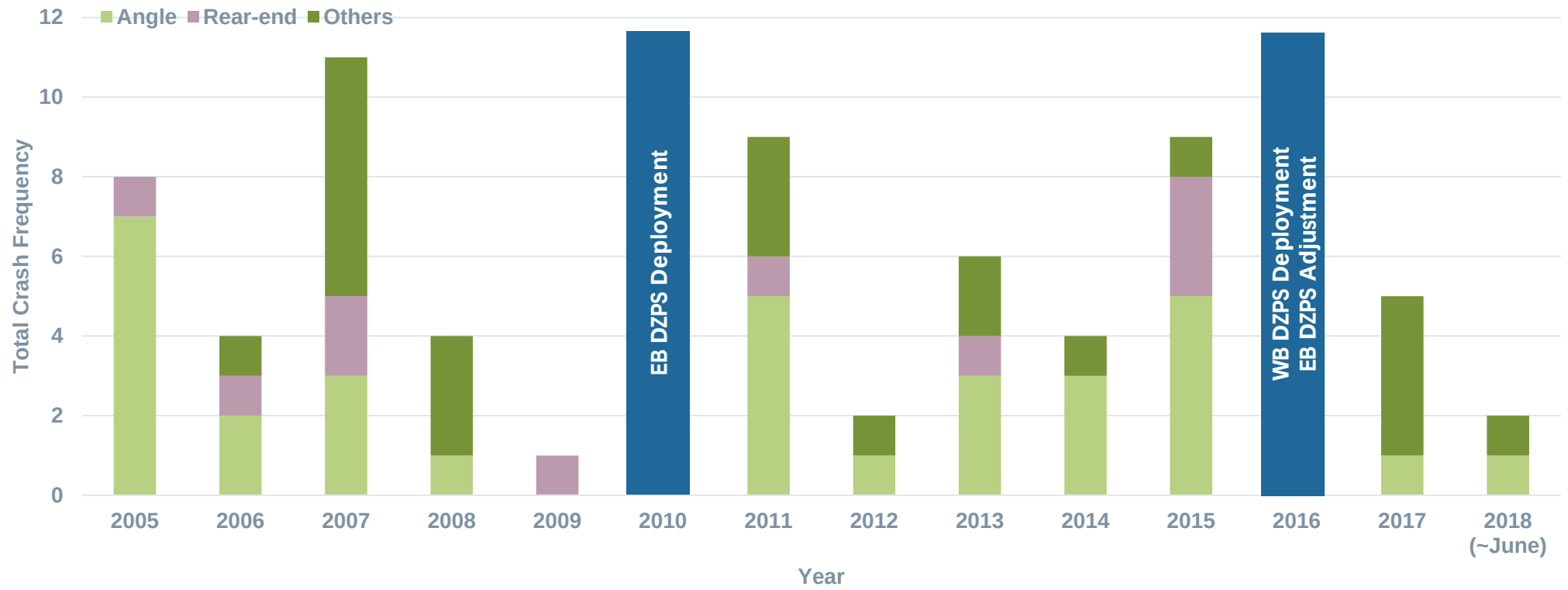
Angled Crash	2005-2009	2011-2015	2017-2018
Annual Average Frequency	2.60	3.40	1.33
% Angled crashes	46%	57%	29%

55.56%

44.57%

[Total Crash Frequency]

After period: 18 month



** without drug/alcohol related crash*

Before-and-after crash patterns

Site 2) MD 213 at Locust Point Rd.

- **NB and SB DZPS Deployed in 2016**

❑ ***Before-and-after angled crashes***

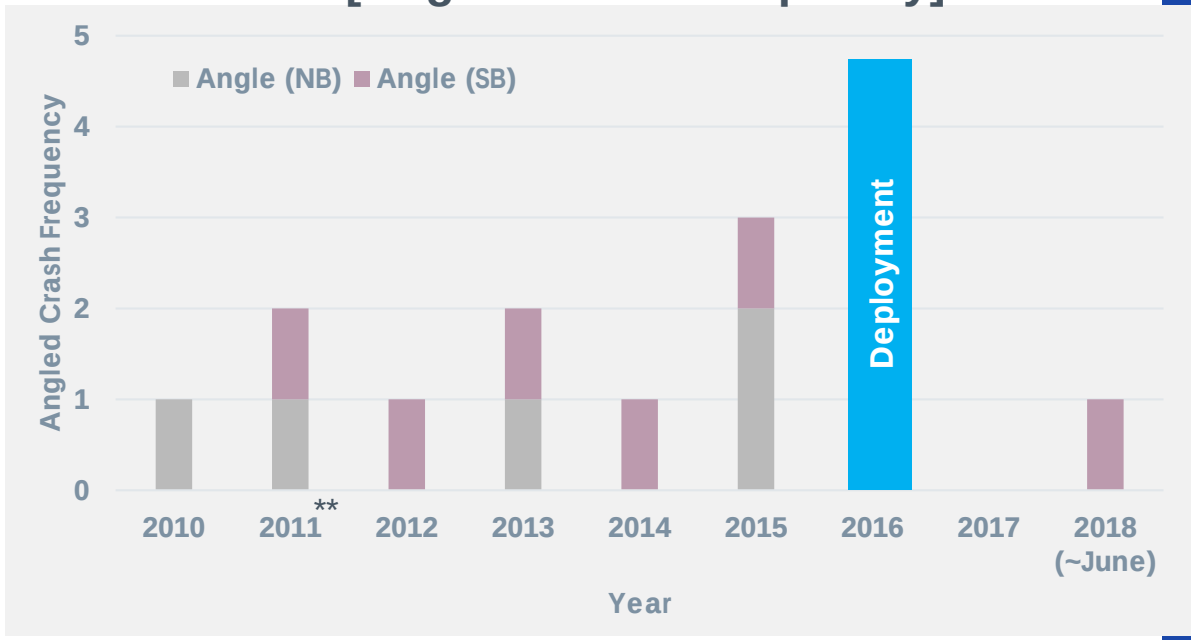
Angled Crash	2010-2015	2017-2018
Annual Average Frequency	1.67	0.67
% Angled crashes	62.5%	25.0%

After period: 18 month

60%

60%

[Angled Crash Frequency]



[Total Crash Frequency]

** without drug/alcohol related crash*

*** one fatality crash: angled crash between SB Thru, WB Thru.*

Before-and-after crash patterns

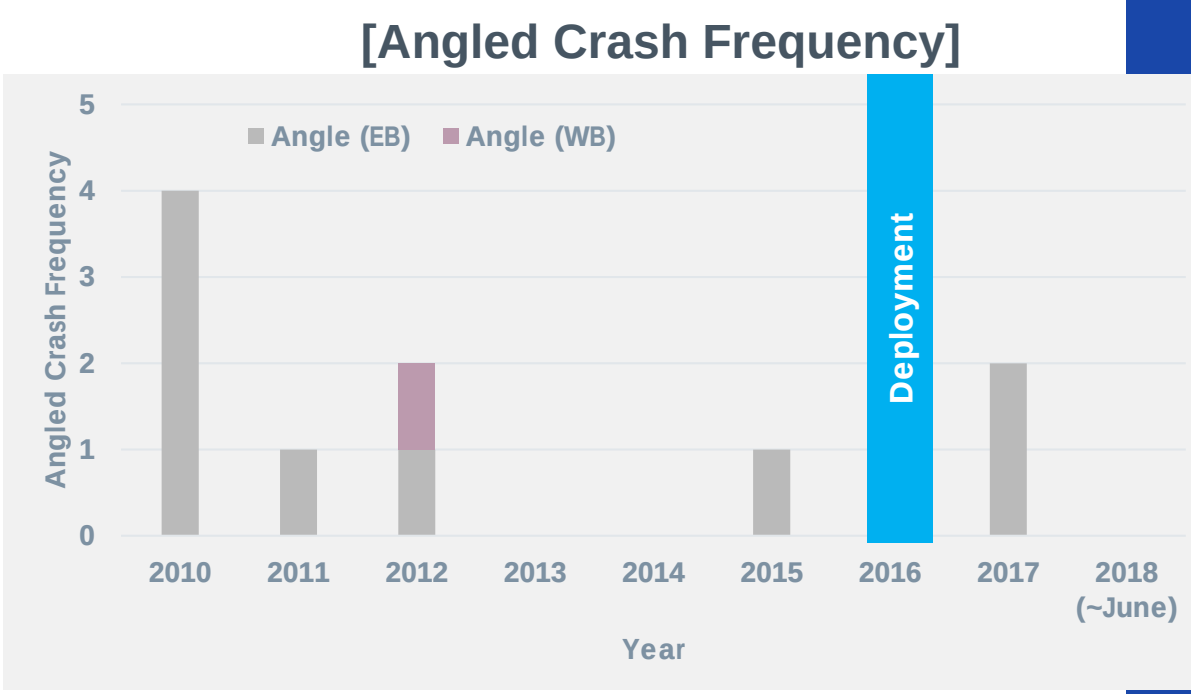
Site 3) US 40 at MD 910 C

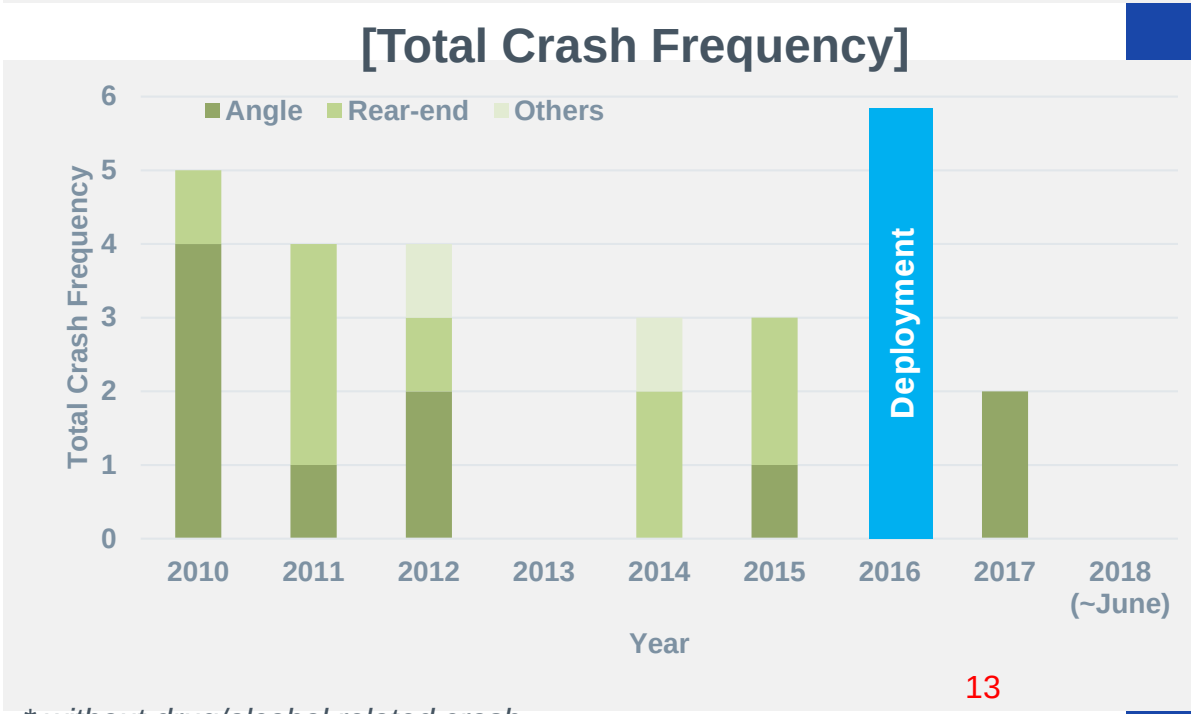
- **EB DZPS Deployed in 2016**

❑ ***Before-and-after angled crashes***

Angled Crash	2010-2015	2017-2018
Annual Average Frequency	1.33	1.33
% Angled crashes	36.4%	100%

After period: 18 month

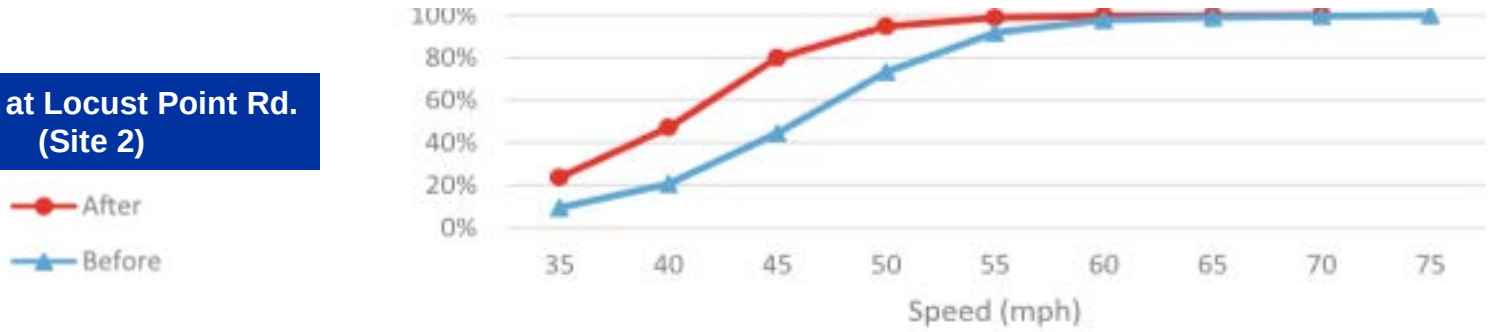




** without drug/alcohol related crash*

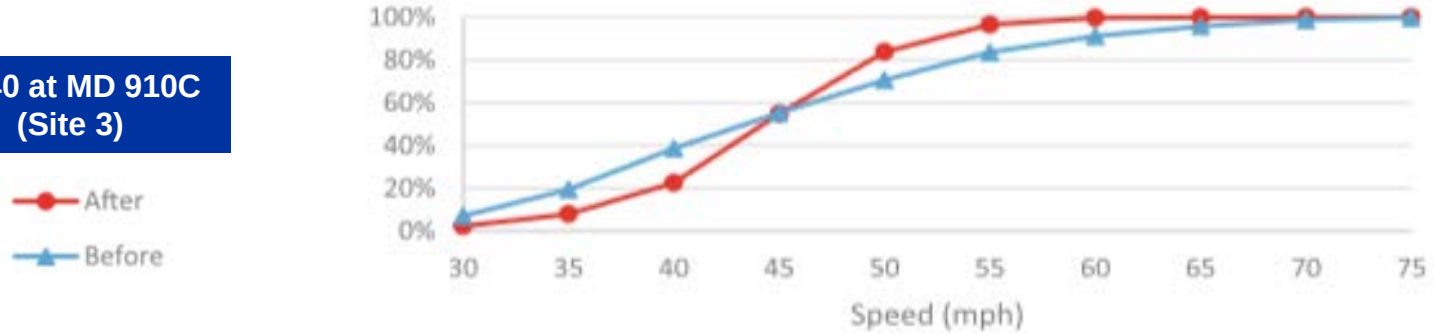
Field Observation on Driving Behavior
Cumulative distribution of approaching speeds and detection rate

MD 213 at Locust Point Rd. (Site 2)



Distance of 500 ft

US 40 at MD 910C (Site 3)



Distance of 900 ft

Source: Sung Park. et al, Field Evaluation of the Dilemma Zone Protection System at Suburban Intersections, Transportation Research Record 2018, Vol. 2672(21) 51–62

Field Observation on distribution of speeds and detection rates

Speed (mph)	MD 213 (Site 2)				US 40 (Site 3)			
	Before		After		Before		After	
	Frequency	Percent (%)	Frequency	Percent (%)	Frequency	Percent (%)	Frequency	Percent (%)
75+	N/A	N/A	N/A	N/A	14	1%	0	0%
70-75	3	0%	0	0%	36	3%	3	0%
65-70	3	0%	2	0%	58	5%	6	0%
60-65	8	1%	0	0%	92	7%	94	3%
55-60*	37	6%	7	1%	160	13%	375	13%
50-55	113	18%	32	5%	189	15%	850	29%
45-50	177	29%	115	17%	206	17%	951	32%
40-45	147	24%	254	38%	236	19%	432	15%
35-40	69	11%	182	27%	153	12%	166	6%
30-35	58	9%	77	12%	87	6%	66	2%
Over the Speed Limit (total)	51 (615)	8%	9 (669)	1%	360 (1231)	29%	478 (2943)	16%

* Speed limit for US 40 and MD 213

› **System influences drivers to slow down**

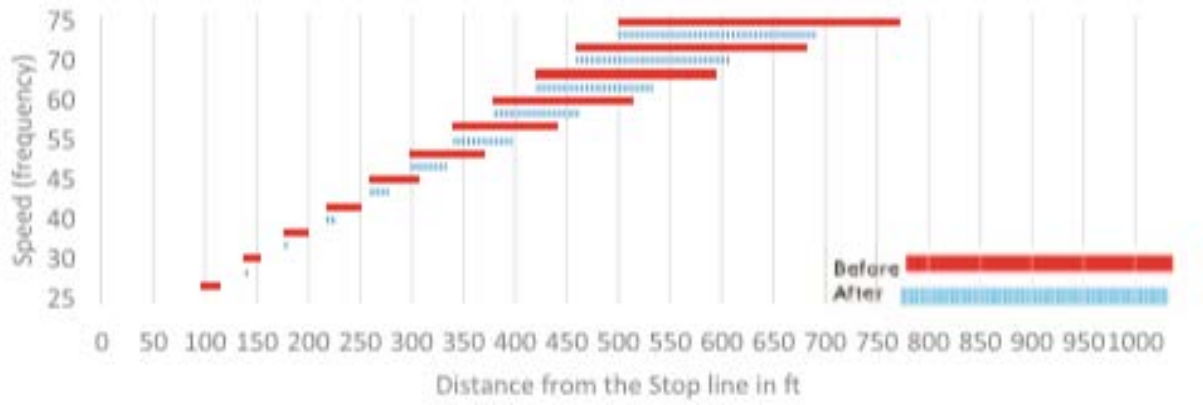
MOE	Field Operation (US 213, site 2)	Field Operation (MD 40, site 3)
Red-light-running rate (RLR) (RLR / cycle)	1.6%	1.6%
Extension call rate (extension call / cycle)	17.6%	31.7%
Detection rate (protected RLR)	100.0%	100.0%
False alarm rate (false alarm / cycle)	16.0%	30.0%

› **System detects all red-light running vehicles and provides all-red extension**

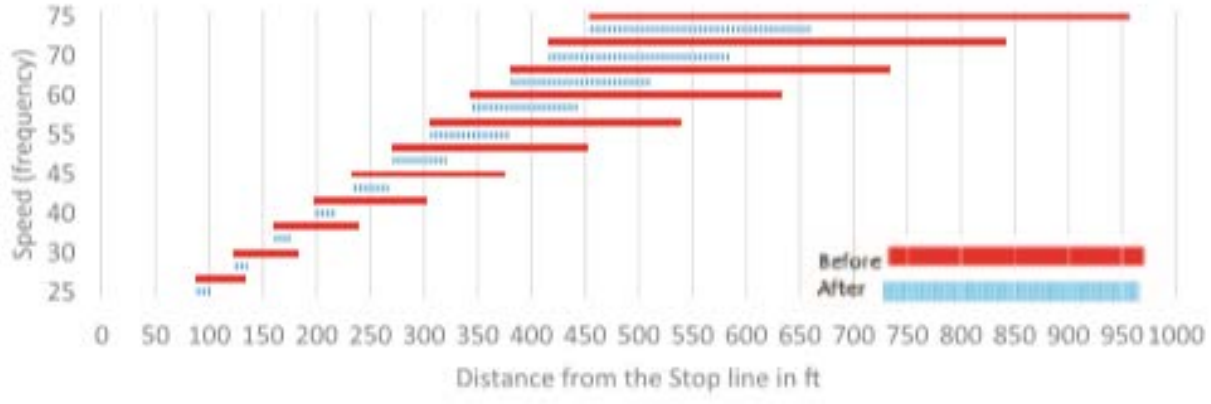
Source: Sung Park. et al, Field Evaluation of the Dilemma Zone Protection System at Suburban Intersections, Transportation Research Record 2018, Vol. 2672(21) 51–62

Field Observation on Driving Behavior
Distribution of dilemma zone

MD 213 at Locust Point Rd. (Site 2)



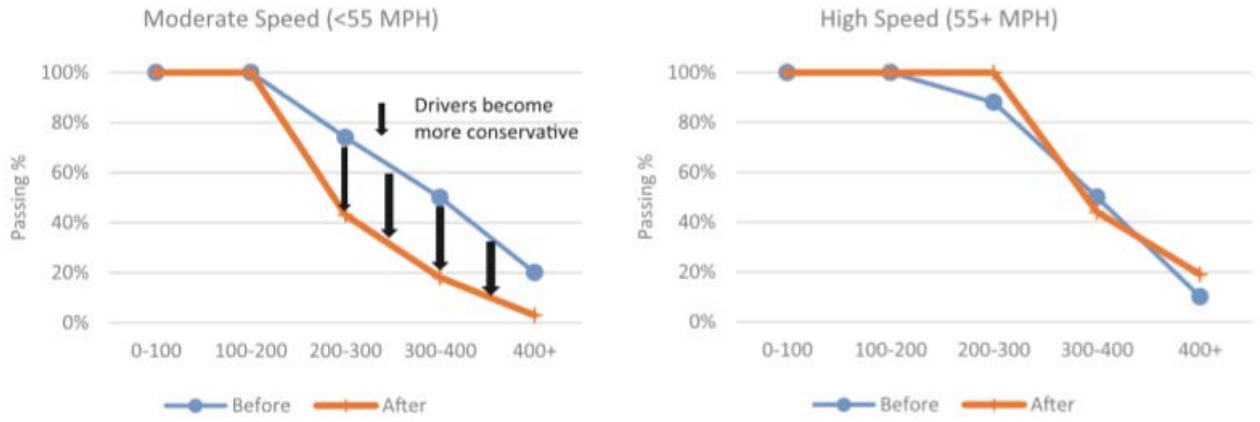
US 40 at MD 910C (Site 3)



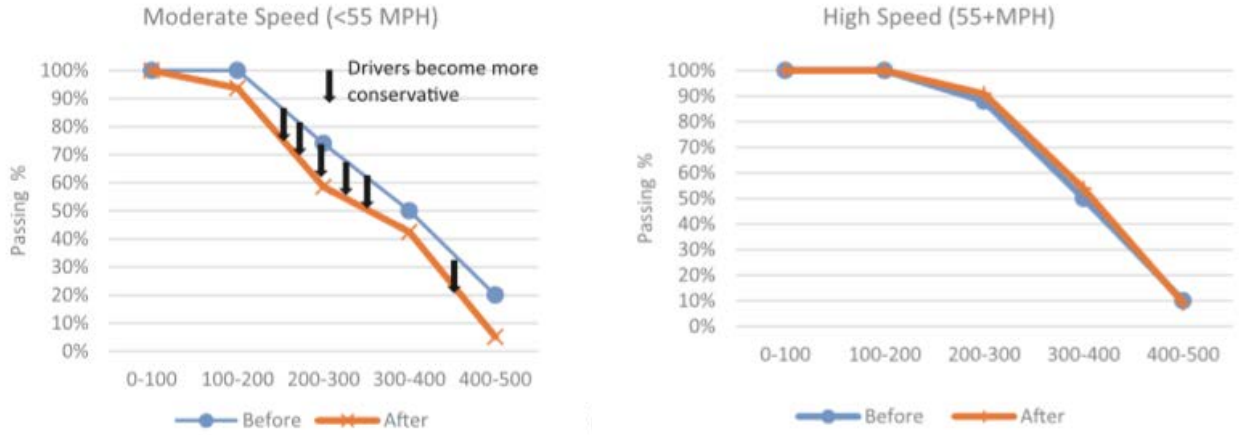
Source: Sung Park. et al, Field Evaluation of the Dilemma Zone Protection System at Suburban Intersections, Transportation Research Record 2018, Vol. 2672(21) 51–62

Field Observation on Driving Behavior
Drivers taking the ‘pass’ decision during the yellow

MD 213 at Locust Point Rd. (Site 2)

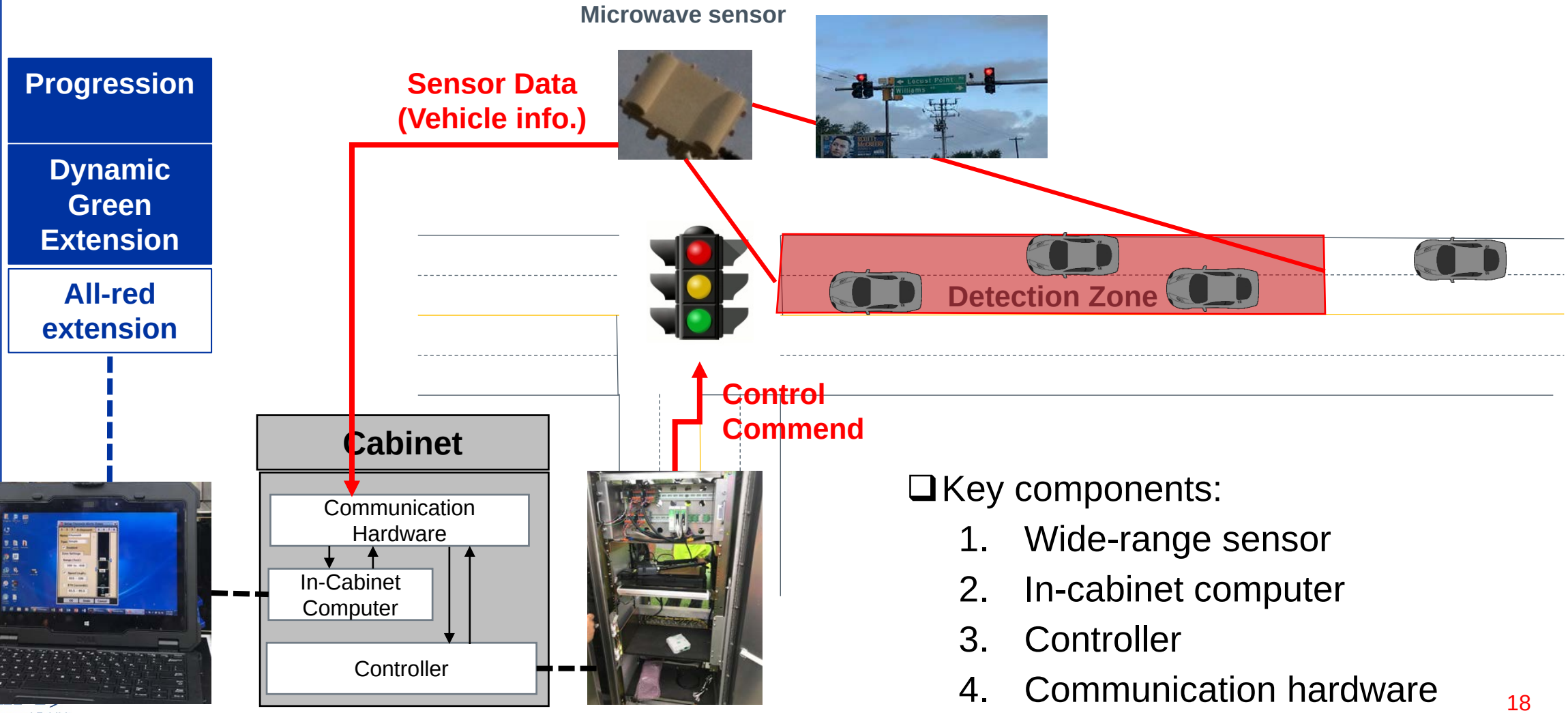


US 40 at MD 910C (Site 3)



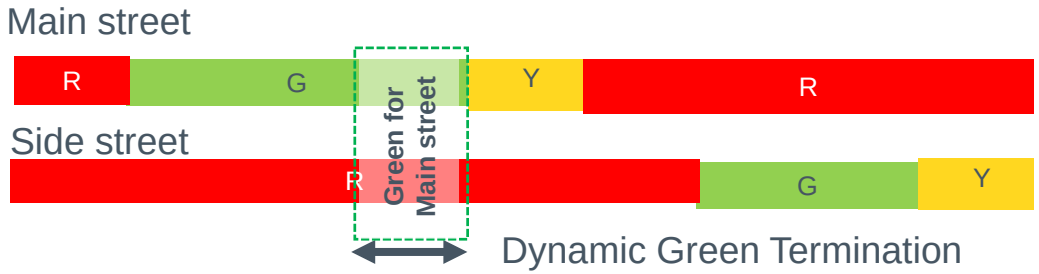
Source: Sung Park. et al, Field Evaluation of the Dilemma Zone Protection System at Suburban Intersections, Transportation Research Record 2018, Vol. 2672(21) 51–62

Potential Extension of the DZPS



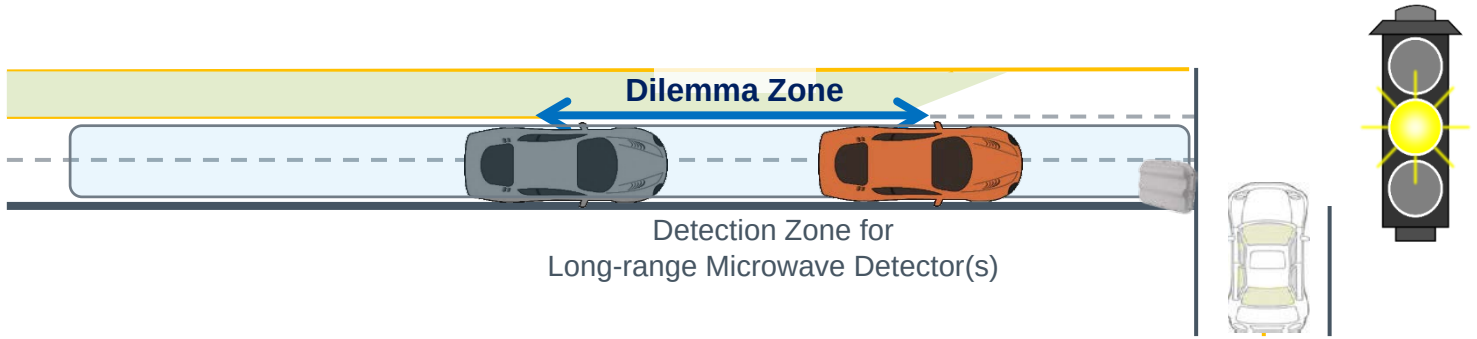
- Key components:
  1. Wide-range sensor
  2. In-cabinet computer
  3. Controller
  4. Communication hardware

Potential Extension of the DZPS

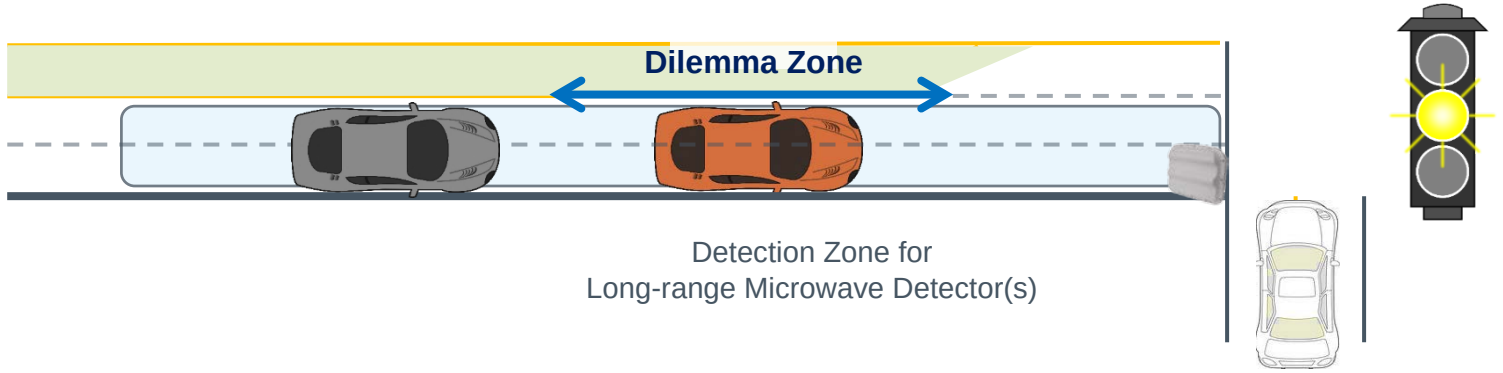


› Before the green phase becomes max-out
  – **Find the safest time to terminate green** for **minimizing the number of vehicles trapped in the DZ**

At max-out both vehicles trapped in the dilemma zone

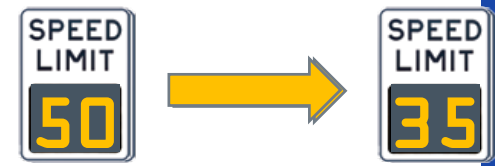


At max-out one vehicle trapped in the dilemma zone

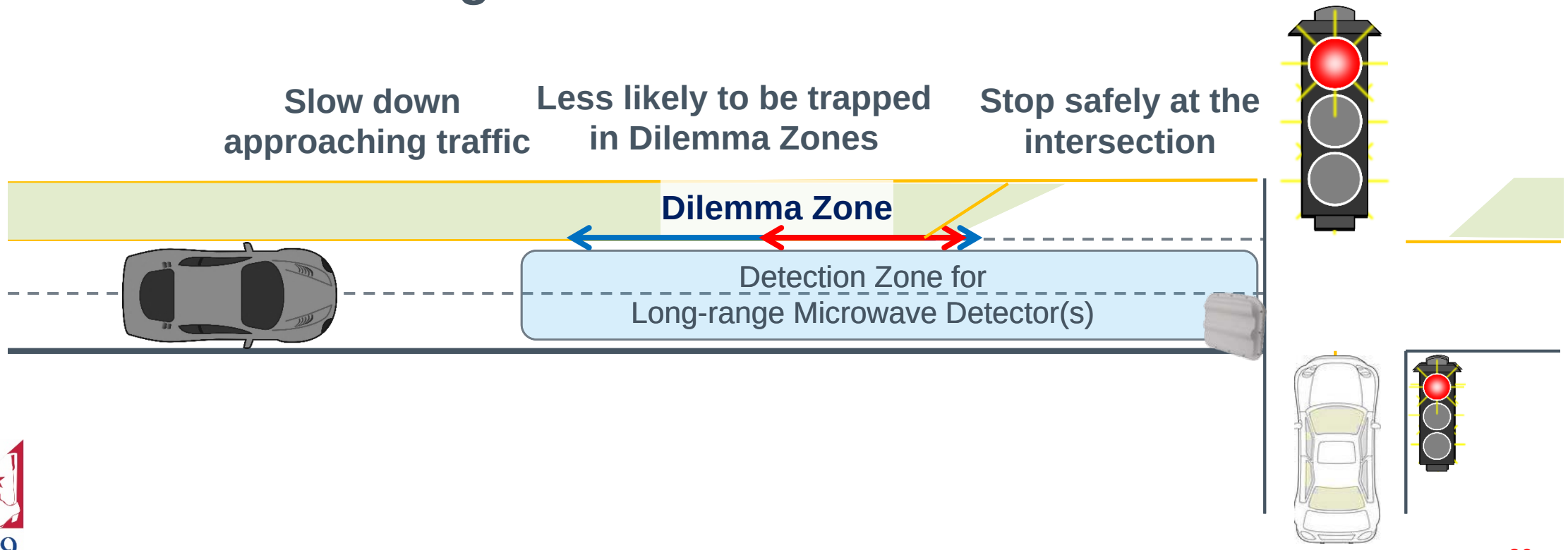


Potential Extension of the DZPS

Activate the advisory speed sign

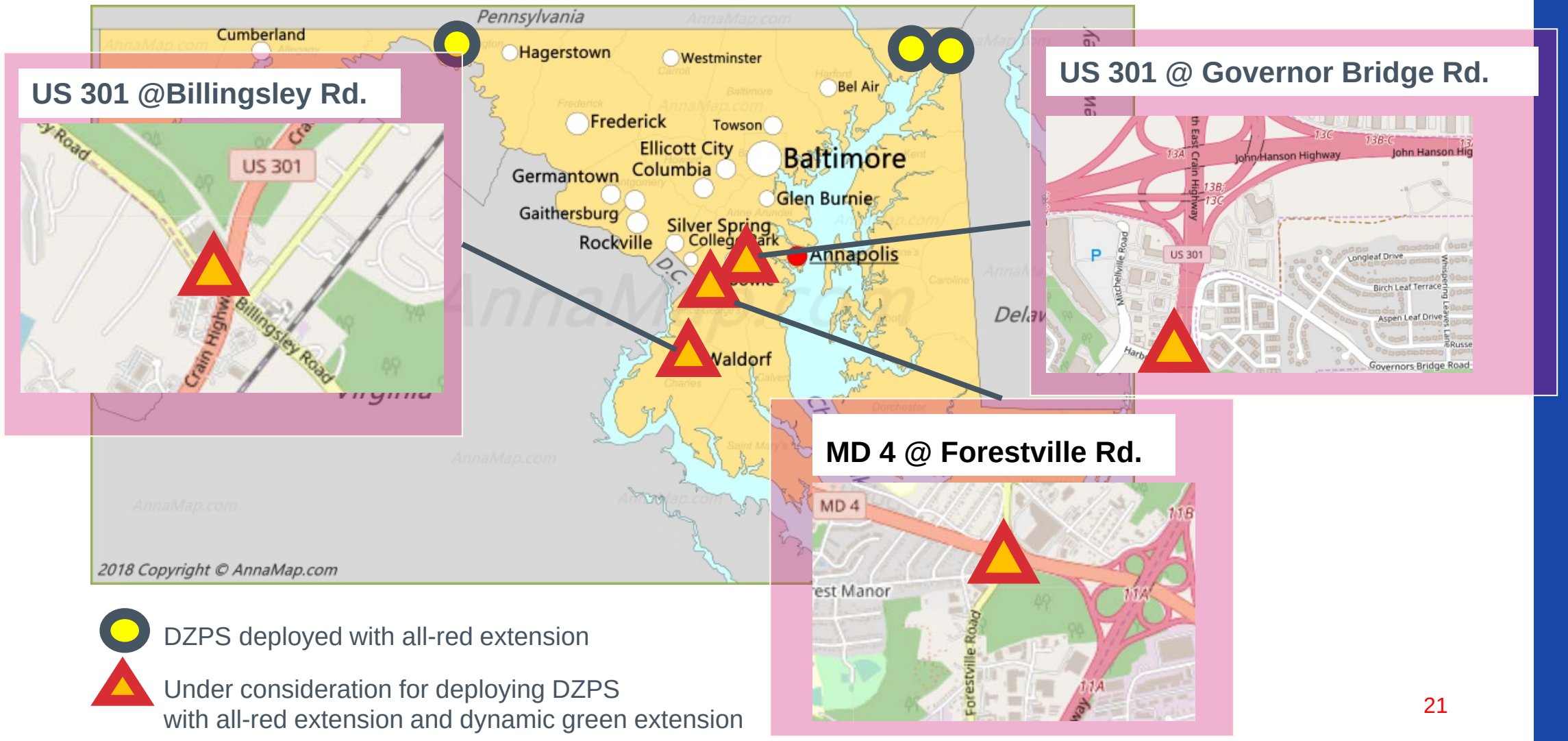


› **Reduce** both **angled** and **rear-ended** crashes



DZPS Deployment in Maryland

Under consideration for deploying DZPS with all-red extension and dynamic green termination



DZPS deployed with all-red extension

Under consideration for deploying DZPS with all-red extension and dynamic green extension

Summary of Findings

- Deployed DZPS can
  - Identify all red-light running vehicles and provide all-red extensions.
  - Reduce the annual average number of angle crashes.
  - Decrease overall total number of crashes.
- Deployed DZPS has potential to
  - Reduce the percentage of high-speed vehicles.
  - Reduce the range of dilemma zones.
  - Encourage drivers to take the “STOP” action during the yellow phase.

THANK YOU

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