Evaluation of Scottsdale 101 Photo Enforcement Demonstration Program

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Presentation Outline

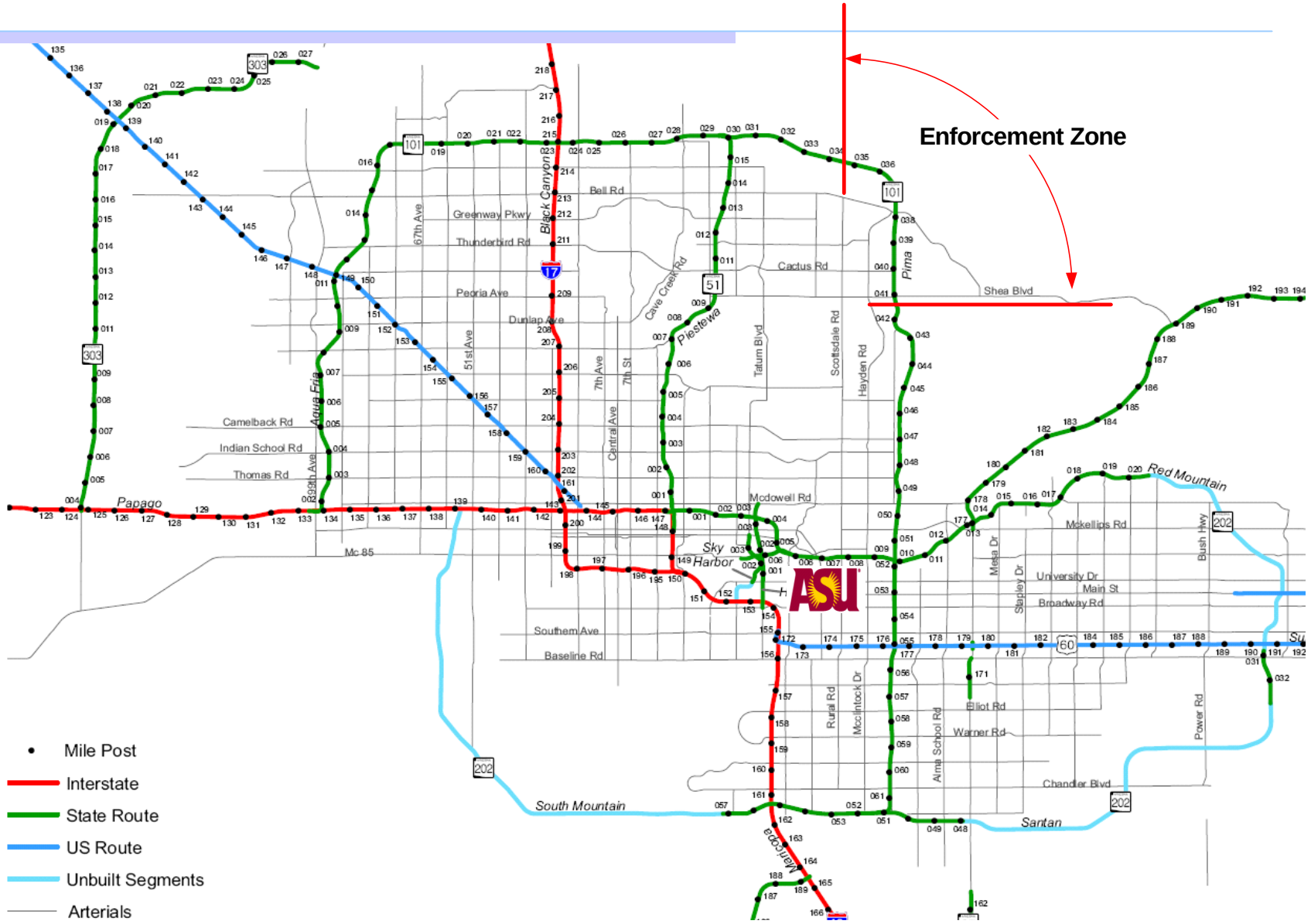
- Program summary
- Summary of findings
  - Impact of the speed enforcement camera demonstration program (SEP) on **speeding** behavior
  - Impact of the SEP on **mean speeds**
  - Impact of the SEP on **traffic safety**
- Conclusions

Program Summary

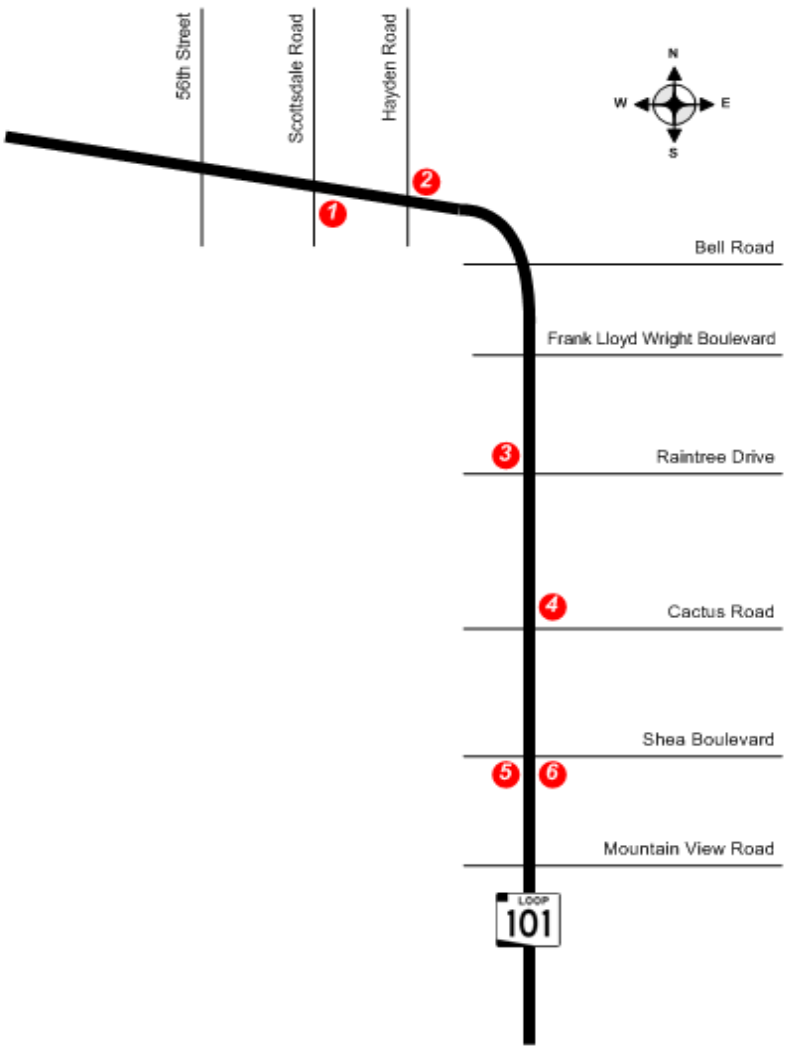
Background

- Speeding is recognized as a major contributing factor in traffic crashes
- Photo radar technologies are used in 75 counties throughout the world to enforce speeding
- Until 2006, the US had not seen an permanent installation of photo enforcement on limited access freeways
- In order to reduce speed-related crashes, city of Scottsdale implemented **the first fixed photo speed enforcement camera demonstration program (SEP)** in the US
  - January 22, 2006 – October 23, 2006 (9 months)
  - 6.5 mile stretch of Arizona SR 101 in Scottsdale

Enforcement zone: MP 34.51– MP 41.06 (Approximately 6.5 miles)



Location of 6 Enforcement Stations



Station ID	Station	Direction
1	Scottsdale Rd. and Hayden Rd.	East Bound
2	Hayden Rd. and Bell Rd.	West Bound
3	Frank Lloyd Wright Blvd. and Raintree Dr.	South Bound
4	Raintree Dr. and Cactus Rd.	North Bound
5	Shea Blvd. and Mountain View Rd.	South Bound
6	Shea Blvd. and Mountain View Rd.	North Bound

- Three cameras per direction
- Posted speed limit: 65 mph
- Infraction speed ≥ 76 mph
- Criminal speeding > 85 mph

Typical Equipment Set-up

Front Camera and Flash Unit

Rear Camera and Flash Unit

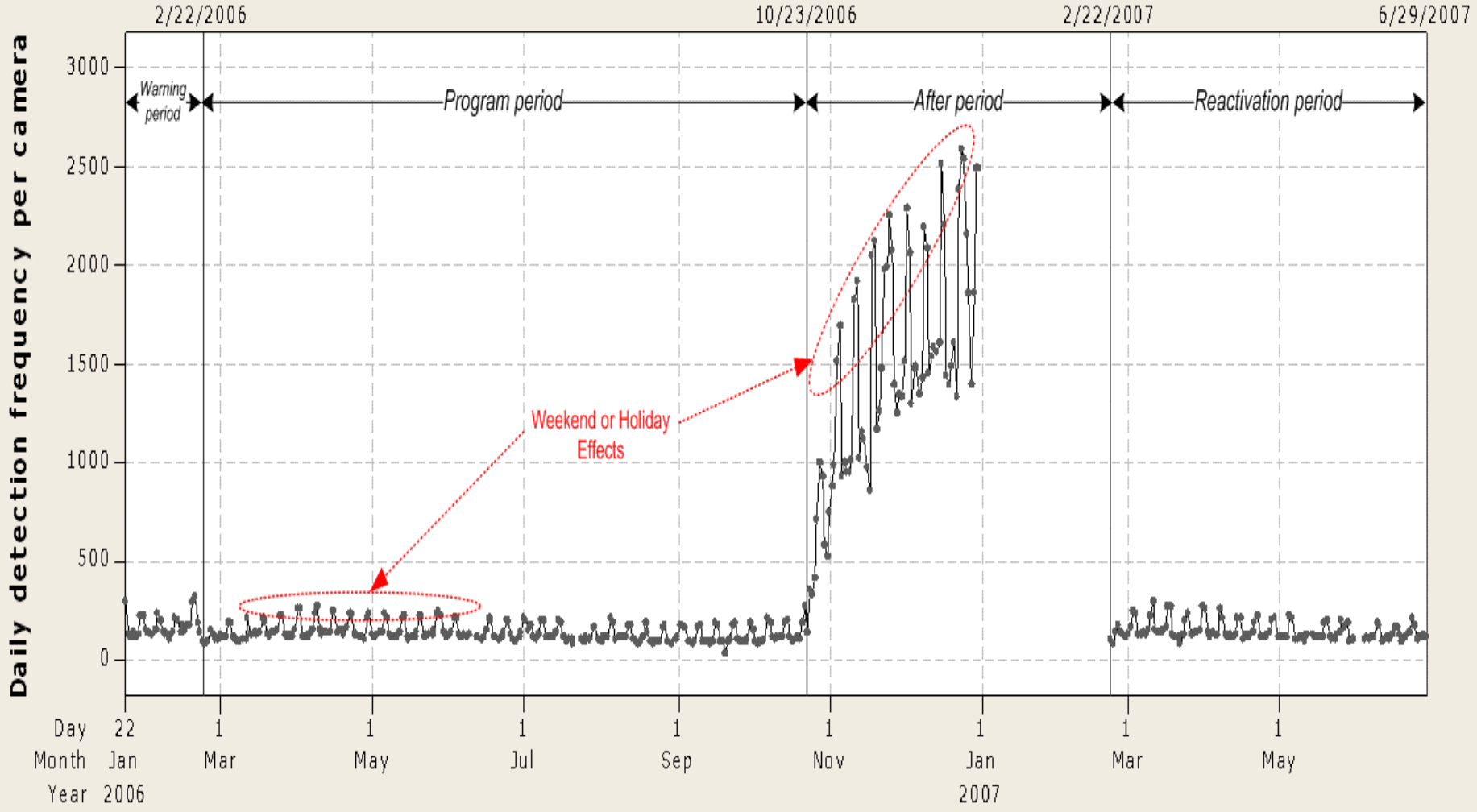
Analysis Preliminaries:

Periods of observation:

- *Before period: 2001 to 2005*
- *warning* period: 1/22/2006 – 2/21/2006 (31 days)
- *program* period: 2/22/2006 –10/23/2006 (244 days)
- *after* period: 10/24/2006 – 12/31/2006 (69 days)
- *reactivation* period: 2/22/2007– 6/29/2007 (128 days))

SEP Impact on Speeding

Detection Frequencies per camera per day



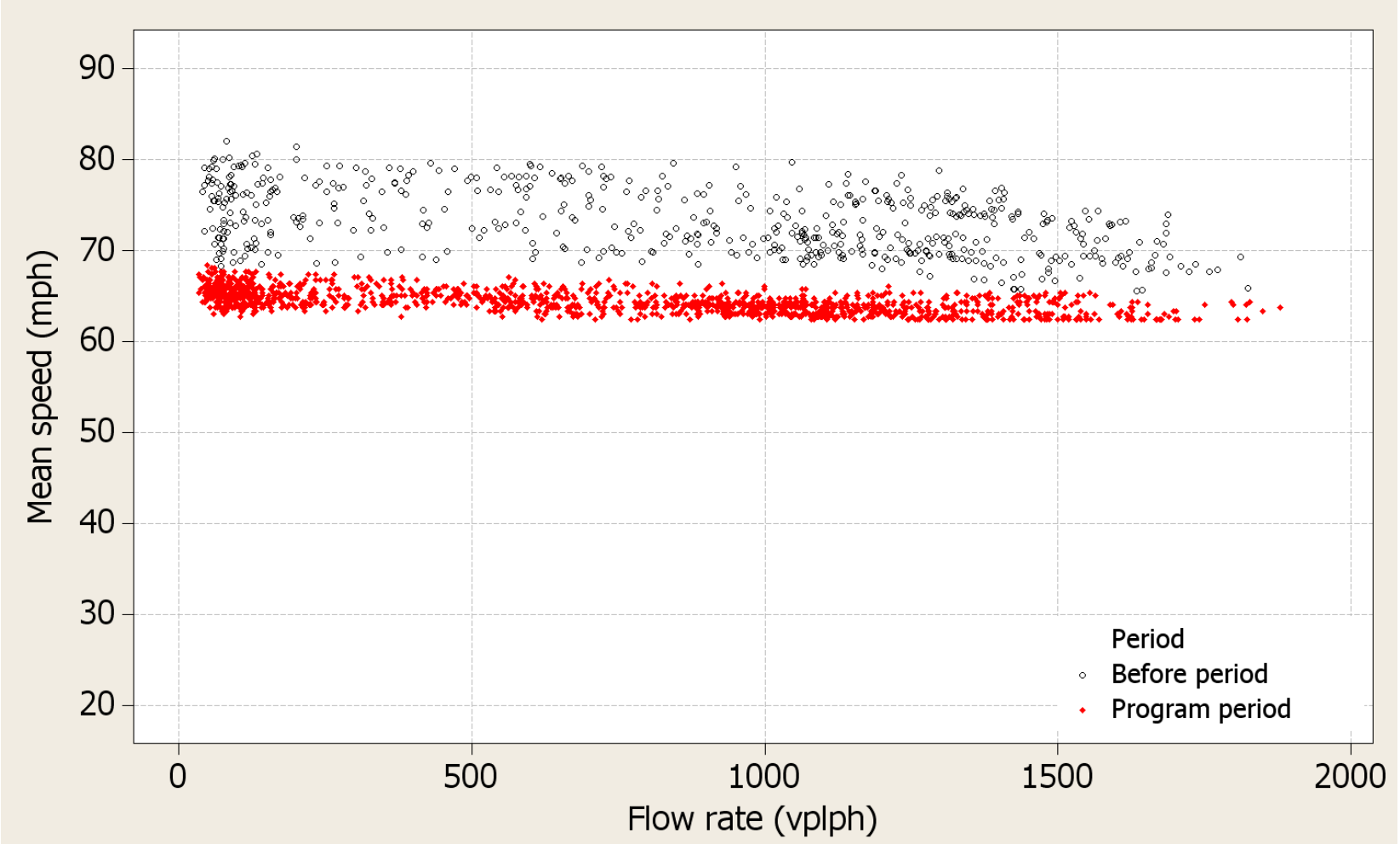
Conclusions: Impact on Detection Frequency

Differences in Daily Speeding Detections per Camera by Period and the Day of the Week

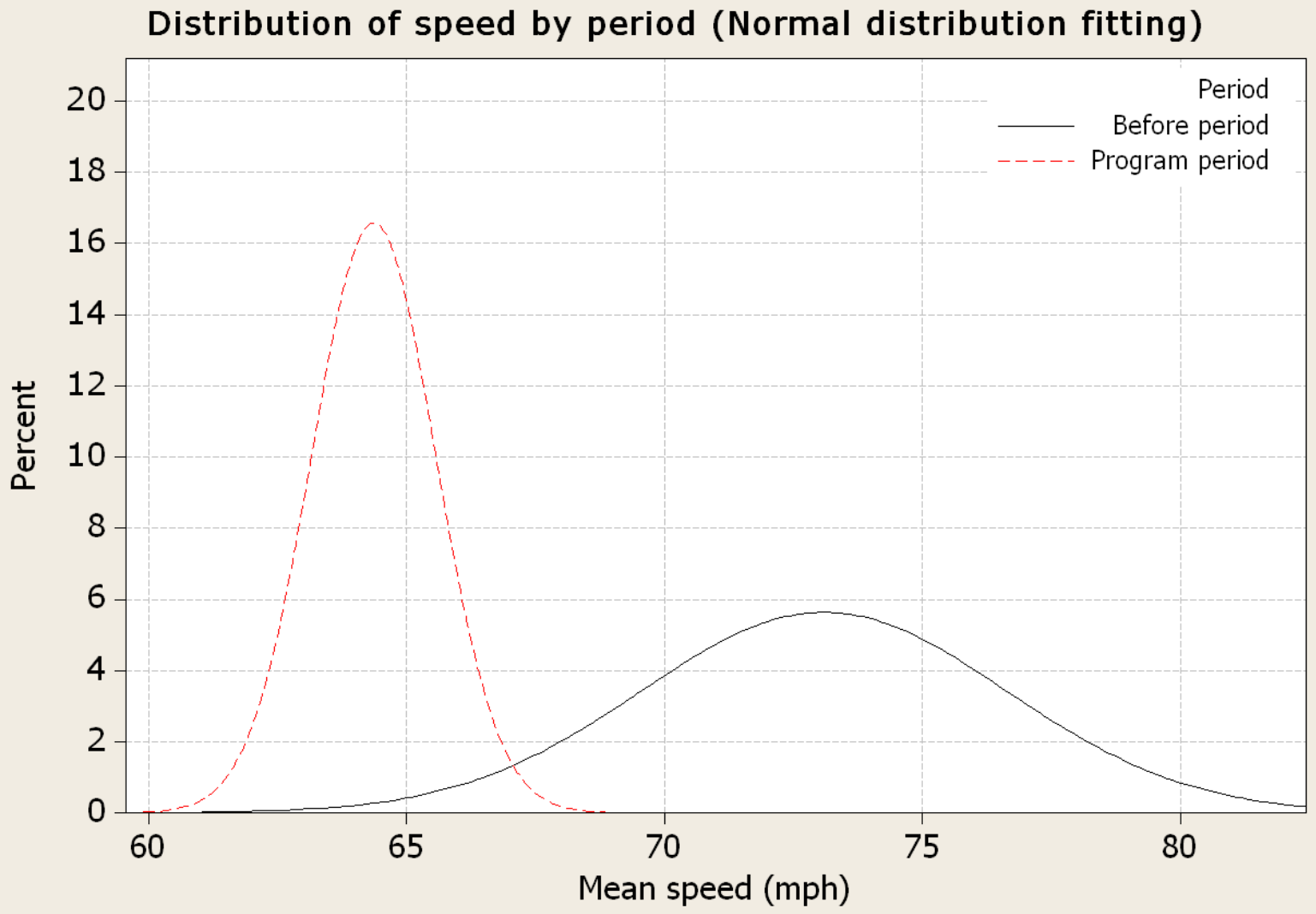
Day of Week	Period Pair	Difference in Daily Speeding Detection (p-value)	95% C.I.s	
			Lower	Upper
Weekdays	Warning–Program	27.33 (<0.001)	15.17	39.49
	After– Program	1096.04 (<0.001)	998.01	1194.06
	Reactivation– Program	5.81 (0.072)	–0.53	12.16
Weekends and Holidays	Warning–Program	50.98 (<0.001)	19.86	82.11
	After– Program	1860.66 (<0.001)	1689.91	2031.42
	Reactivation– Program	9.13 (0.241)	–6.14	24.41

Impact on Mean Speeds

Estimate the Impact on Mean Speeds (cont'd)



Impact on Mean Speeds (cont'd)



Conclusion: Impact on Mean Speeds

- The reduction in speed due to the SEP depends on traffic volumes.
  - It also reflects the well-known relationship between speed and traffic flow in the stable regime.
- The following impacts are estimated:
  - The reduction in speed increases as traffic volume decreases
  - The mean speed decreased by 9.97 mph when traffic volume was 206 vplph (Q1).
  - The mean speed decreased by 9.04 mph when traffic volume was 800 vplph (Q2).
  - The mean speed decreased by 8.47 mph when traffic volume was 1,169 vplph (Q3).

Safety Impacts

Defining Target Crashes

- We start by defining which crashes are *materially affected* by the speed enforcement cameras ("target" crashes)
  - Using *all crashes* would under-estimate the impact of the program
- Since the crashes during the peak periods are unlikely to be significantly affected by the photo enforcement cameras (speeds are constrained), *target crashes* are crashes that occurred during non-peak period.
- We use time-of-day as a surrogate to determine whether crashes occurred 'peak' or 'off-peak'

Target Crashes

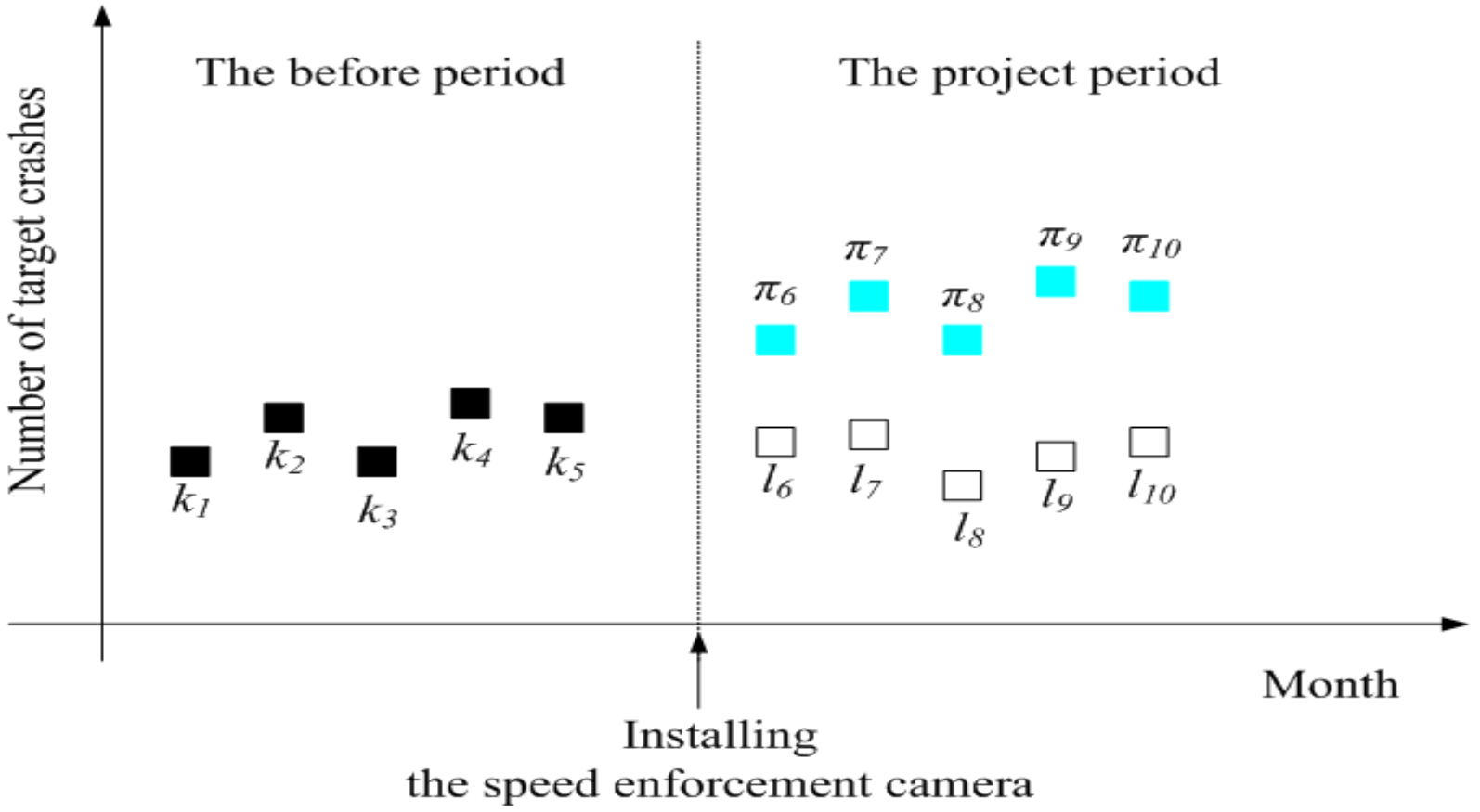
- Occur on **the mainline** within the enforcement zone during the **non-peak periods** defined by TOD
- Peak periods (6 hours): constrained speed
  - 06:00 AM — 09:00 AM
  - 16:00 PM — 19:00 PM
- Non-peak period: unconstrained speeds
  - The remaining 18 hours for weekdays
  - 24 hours for weekends and holidays

Evaluation Methods

- Before-and-after (hereafter BA) studies are used to estimate the impact of the SEP on safety.

1. BA study with traffic flow correction
   (*assumes only change B to A is traffic flow*)
2. BA study with comparison zone
   (*assumes changes in safety reflected at comparison site*)
3. Empirical Bayes BA study (not presented here)
   (*corrects for possible regression-to-the-mean*)

BA Study Design



k_i : The observed target crash frequency during the before period
l_j : The observed target crash frequency during the project period
π_j: The expected number of target crash frequency during the project period if the treatment had not been installed

Analysis I: BA Study with Traffic Flow Correction

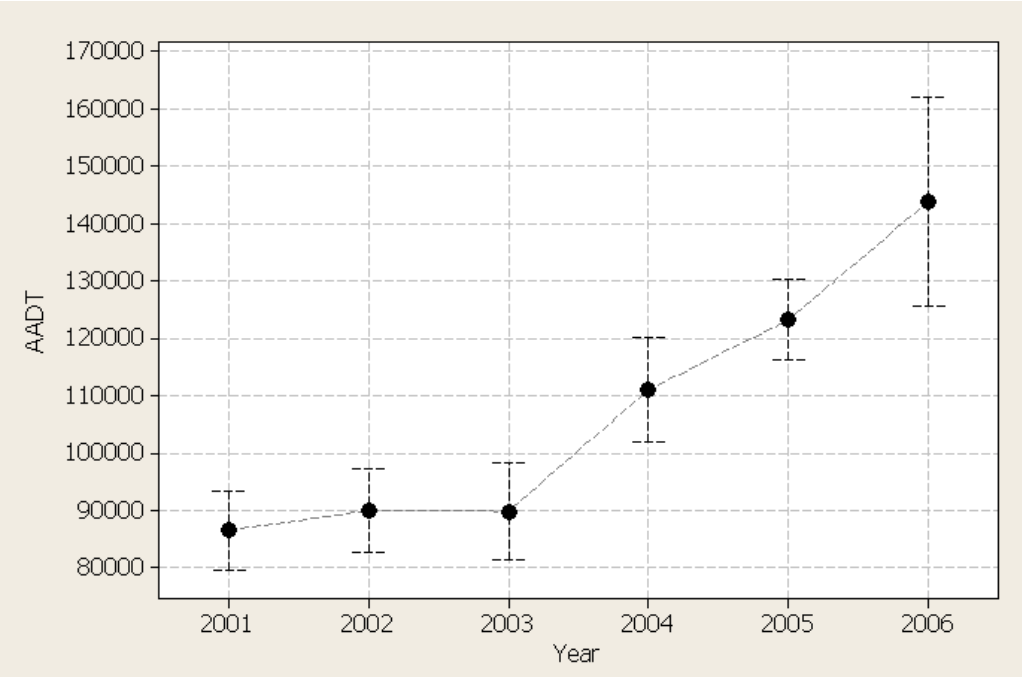
- Traffic flow is one of the most important factors affecting safety.

- We modify predictions of safety 'before' by accounting for differences in traffic flow (denoted r*tf*)

- 100 crashes/yr with 100,000 AADT, for example, might be worth 200 crashes/yr with 200,000 AADT

Change in Exposure

- On average, 42% increase in AADT from 2001 to 2006
- 66.2% increase from 2001 to 2006
- 60.1% increase from 2003 to 2006
- 16. 7% increase from 2005 to 2006



Therefore, the observed crashes (K) is not suitable for prediction.

Analysis I: How we 'quantify' the impact of the SEP on safety

- π (pi) is the predicted number of crashes after had the SEP not been installed
- λ (lambda) is the observed number of crashes after
- Θ (theta) is the estimated index effectiveness of the SEP

Example: theta = 0.70 means that there is a 30% reduction in crashes, or Crashes (after) = 0.70*Crashes (before)

- Δ is the reduction in accidents

Example: delta = 10, means 10 crashes reduced by the program

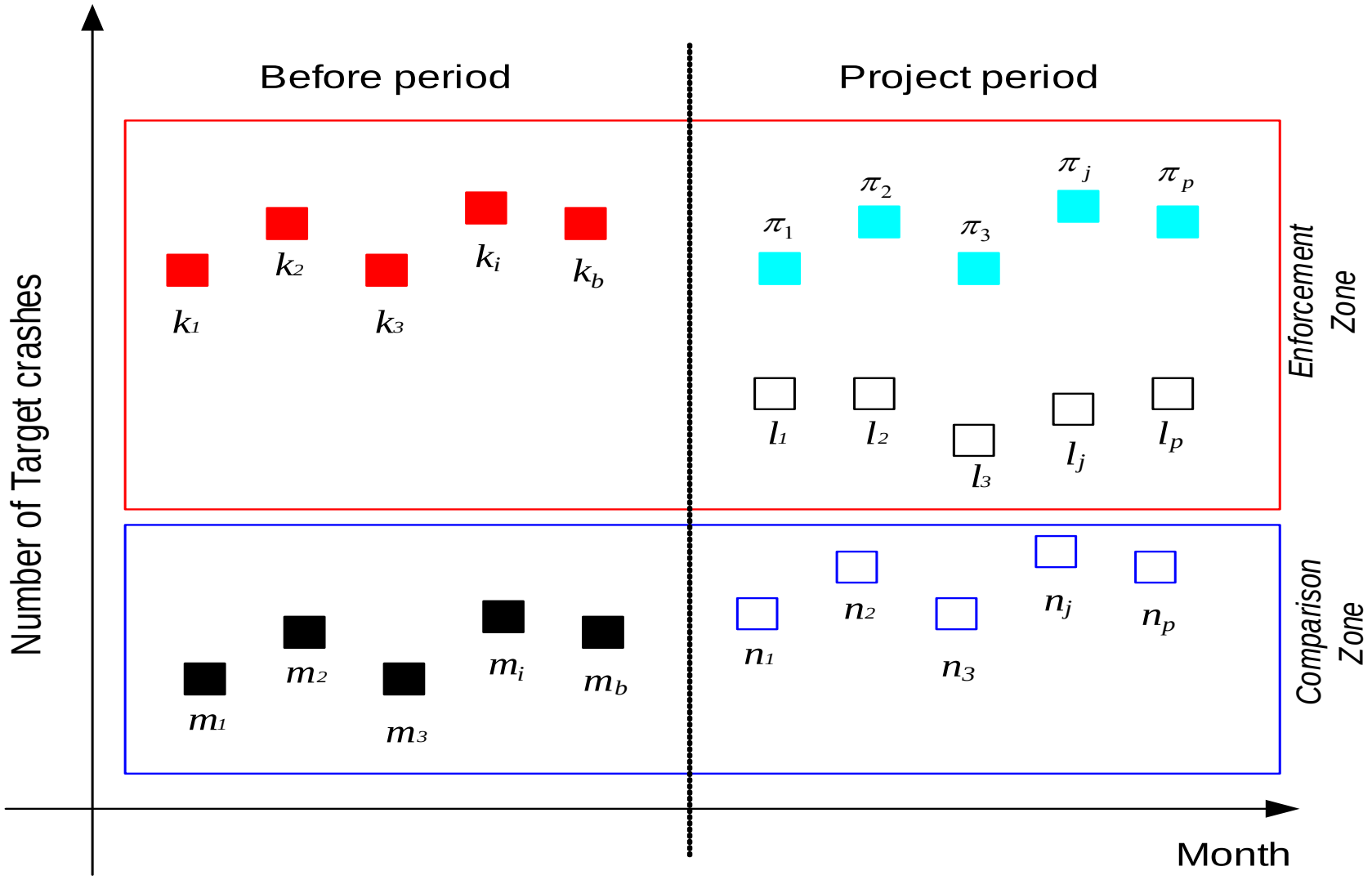
Results of the BA Study with r_{tf}

Crash type and severity		Crash estimates		Impact estimates	
		$\hat{\pi}$	$\hat{\lambda}$	$\hat{\theta}$ [1]	$\hat{\delta}$ [2]
All target crashes	Single Vehicle	51.18	19	0.37 (0.09) [3***]	32.18 (5.88)***
	Side-swipe (same)	21.85	12	0.54 (0.17)**	9.85 (4.55)**
	Rear-end	30.43	23	0.74 (0.18)*	7.43 (6.41)*
	Other	15.28	2	0.13 (0.09)***	13.28 (2.79)***
Injury crashes	Single Vehicle	10.37	6	0.56 (0.24)*	4.37 (3.02)*
	Side-swipe (same)	4.83	2	0.39 (0.27)*	2.83 (1.89)*
	Rear-end	9.30	8	0.82 (0.33)	1.30 (3.57)
	Other	6.61	1	0.14 (0.13)***	5.61 (2.11)**
PDO crashes	Single Vehicle	39.60	13	0.33 (0.09)***	26.60 (4.97)***
	Side-swipe (same)	16.82	10	0.58 (0.20)**	6.82 (4.13)**
	Rear-end	21.01	15	0.69 (0.21)*	6.01 (5.33)*
	Other	9.19	1	0.10 (0.10)***	8.19 (2.02)***
Total target crashes		118.74	56	0.47 (0.07)***	62.74 (10.50)***
Total injury crashes		31.12	17	0.54 (0.14)**	14.12 (5.43)**
Total PDO crashes		86.62	39	0.45 (0.08)***	47.62 (8.93)***

Analysis II: BA Study with Comparison Zone

- In addition to the change in *traffic flow* between the two periods, it is often necessary to account for other changes as well (e.g. drivers, weather, enforcement, etc.)
- The BA study with comparison group is routinely used to accomplish this…
  - The comparison group is selected based on its similarity to the treatment group

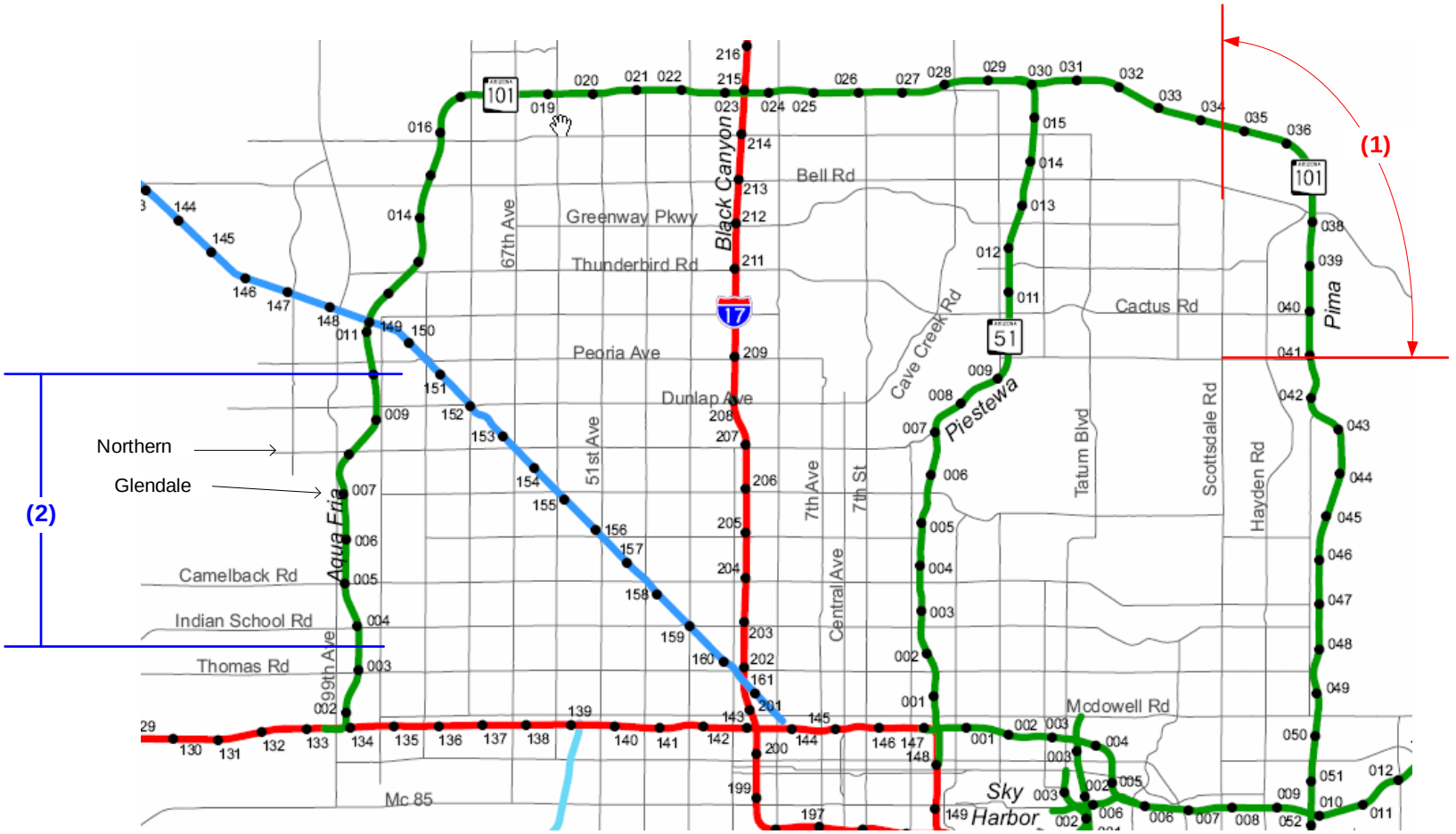
BA Analysis with Comparison Zone



Installing the Speed enforcement cameras

Location of Comparison Zone

(1) Enforcement zone: MP 34.51– MP 41.06 (Approximately 6.5 miles)
(2) Comparison zone: MP 3.5 – MP 10 (6.5 miles)



Estimates of the Comparison Ratios

- Comparison ratio is the ratio of crashes that occurred within the comparison zone 'before' to 'program' (e.g. rear-ends before/rear-ends program)
- Comparison ratios greater than 1 indicate an increase while ratios less than 1 indicate a decrease (e.g. overall crashes increased 54% at comparison site)

Collision type	Comparison ratio (r_C)	SE (r_C)
Single-vehicle	1.03	0.21
Side-swipe (same)	1.67	0.48
Rear-end	1.28	0.37
Other	3.80	0.67
Total	1.54	0.18

Results of the BA Study with r_c

Crash type and severity		Crash estimates		Impact estimates	
		$\hat{\pi}$	$\hat{\lambda}$	$\hat{\theta}$ [1]	$\hat{\delta}$ [2]
All target crashes	Single Vehicle	46.53	19	0.41 (0.10)[3]***	27.53 (5.62) ***
	Side-swipe (same)	17.68	12	0.67 (0.21) *	5.68 (4.19) *
	Rear-end	23.36	23	0.96 (0.24)	0.36 (5.85)
	Other	12.47	2	0.16 (0.11) ***	10.47 (2.40) ***
Injury crashes	Single Vehicle	9.42	6	0.62 (0.27) *	3.42 (2.93) *
	Side-swipe (same)	3.44	2	0.55 (0.39)	1.44 (1.67)
	Rear-end	6.67	8	1.14 (0.46)	-1.33 (3.23)
	Other	3.94	1	0.24 (0.23) **	2.94 (1.48) **
PDO crashes	Single Vehicle	35.56	13	0.36 (0.10) ***	22.56 (4.71) ***
	Side-swipe (same)	13.38	10	0.73 (0.25)	3.38 (3.78)
	Rear-end	16.23	15	0.90 (0.27)	1.23 (4.84)
	Other	7.46	1	0.13 (0.13) **	6.46 (1.74) **
Total target crashes		100.03	56	0.56 (0.08) ***	44.03 (8.95) ***
Total injury crashes		23.47	17	0.72 (0.19) *	6.47 (4.73) **
Total PDO crashes		72.63	39	0.54 (0.09) ***	33.63 (7.56) ***

Estimated Benefit of Photo Enforcement on Traffic Safety (Crash Costs)

Economic Analysis

- Crash costs obtained from extensive national research (NHTSA, 2000; Economic Impact of Motor Vehicle Crashes)
- Reflect AZ-specific costs: hospital charges by injury severity category (from AZ high-speed freeways)
- Utilize inflation adjusted costs from
  - National Hospital Discharge Survey
  - National Health Interview Survey
  - AZ hospital cost/charge information
  - CHAMPUS data on physician costs
  - National Medical Expenditure Survey
  - National Council on Compensation Insurance
  - Crashworthiness Data System.

AZ Unit Crash Costs

KABCO Scale

K = Killed

A = disabling injury

B = evident injury

C = possible injury

O = property damage only (no apparent injury)

Collision type	Crash severity	Final Medical Cost	Total Other Cost	Quality of Life Cost	Total Cost
Single-vehicle	K	$162,870	$1,340,063	$2,111,828	$3,614,761
	A	$122,790	$200,291	$361,020	$684,101
	B	$24,104	$61,295	$88,104	$173,503
	C	$13,545	$34,771	$45,343	$93,659
	O	$15,527	$41,402	$50,277	$107,206
Side-swipe (same direction)	K	$119,065	$1,651,039	$2,496,842	$4,266,946
	A	$133,636	$301,959	$442,205	$877,801
	B	$27,504	$80,482	$86,291	$194,277
	C	$16,354	$65,398	$64,673	$146,425
	O	$15,826	$62,247	$50,530	$128,604
Rear-end	K	$71,037	$1,608,206	$2,441,687	$4,120,929
	A	$70,820	$162,469	$239,725	$473,013
	B	$39,899	$100,244	$152,827	$292,971
	C	$28,785	$77,037	$113,695	$219,517
	O	$30,643	$77,278	$117,022	$224,942
Other Crashes	K	$77,949	$1,200,900	$1,784,243	$3,063,092
	A	$97,374	$236,524	$310,713	$644,611
	B	$15,431	$62,216	$60,957	$138,604
	C	$8,557	$42,965	$43,917	$95,439
	O	$3,421	$34,919	$11,019	$49,359

Annualized Estimated Crash Benefits

Analysis method	Collision type	Crash severity					
		Fatal Crashes (K)	Disabling Injury (A)	Evident Injury (B)	Possible Injury (C)	Property Damage (O)	Total
BA study with traffic flow correction	Single Vehicle	$1,503	$134	$1,370	-$184	$4,266	$7,088
	Side-swipe (same)	$1,651	$0	$476	$204	$1,312	$3,643
	Rear-end	$0	-$859	$1,018	$63	$2,021	$2,243
	Other	$1,748	$368	$369	$438	$605	$3,529
	Total	$4,902	-$358	$3,234	$521	$8,204	$16,503
EB BA study with time-varying κ	Single Vehicle	$1,471	$87	$1,341	-$192	$4,273	$6,980
	Side-swipe (same)	$1,803	$0	$520	$263	$1,373	$3,960
	Rear-end	$0	-$822	$1,145	$155	$2,064	$2,543
	Other	$1,762	$371	$372	$443	$618	$3,565
	Total	$5,036	-$364	$3,379	$669	$8,328	$17,048

KABCO Scale

K = Killed

A = disabling injury

B = evident injury

C = possible injury

O = property damage only (no apparent injury)

Conclusions

Scottsdale 101 Program Conclusions

- Speeding **detection frequency (speeds ≥ 76 mph) increased by a factor of 10.5 after the SEP was temporarily terminated**. During this termination the cameras were "bagged" and advertising and news media advertised the end of the program.
- The Scottsdale 101 SEP appears to be an **effective deterrent to speeding in excess of 75 mph**.
- The SEP not only **reduced the average speed at the enforcement camera sites by about 9 mph**, but also contributed to **reducing the speed dispersion** at the enforcement camera sites. Thus, as prior research has revealed, both the prerequisites for crash reduction (safety improvement) are met with the SEP.
- The reduction in the mean and variance of speed resulting from the SEP depends on traffic flow.

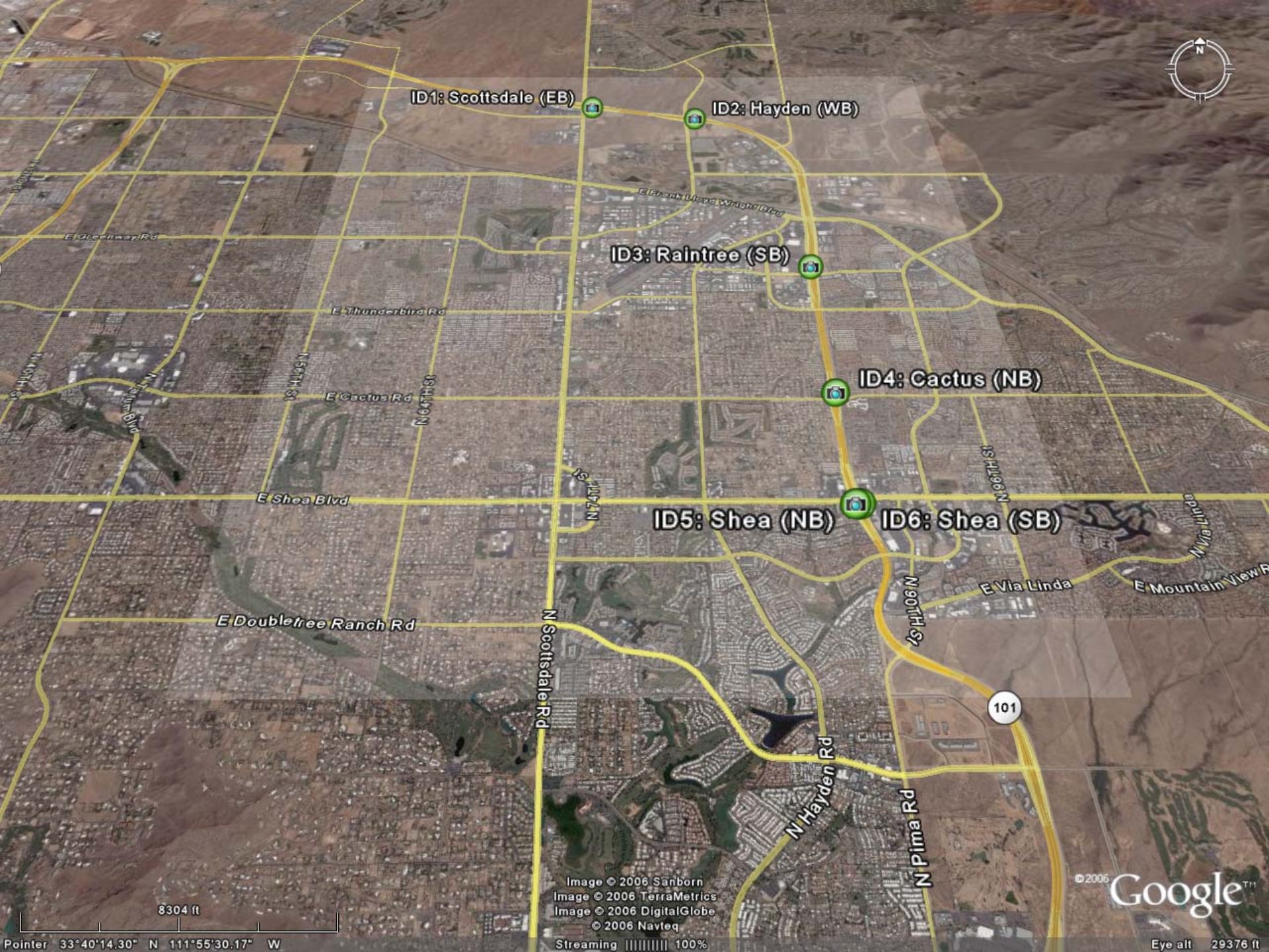
Scottsdale 101 Program Conclusions (cntd.)

- The total number of **target crashes was reduced by about 54%,** the total number of **injury crashes by about 48%,** and the total number of **PDO crashes decreased by about 56%.**
- **All but rear-end crashes types appear to have been reduced**. Although the changes in safety for rear-end crashes were inconsistent among evaluation methods, the increase in rear-end crashes was not significant.
- Swapping of crash types is common for safety countermeasures—many countermeasures exhibit the 'crash swapping' phenomenon observed in this study (left-turn channelization, red-light cameras, conversion of stop signs to signals, etc.).
- The total estimated SEP **benefits range from an estimated $16.5 M to $17.1 M per year**.
- The speed enforcement camera is a promising countermeasure to reduce crashes in Arizona, which is consistent with findings in other countries.

Thank you!

Scottsdale 101 Program Conclusions (cntd.)

- There is no significant difference in the total free-flow travel time with and without the SEP, suggesting that drivers can travel in the enforcement zone in the same acceptable amount of travel time regardless of the existence of the SEP.
- The insignificant difference in total free-flow travel time with and without the SEP conditions led to total travel time savings, which resulted from the reduction in crash frequency. The reduction was at least '569 vehicle-hours/year' when assuming the *1-lane block crash* state and at least '37,981 vehicle-hours/year' when assuming the *2-lane block crash* state.
- This research raises serious doubts as to the validity of arguments against photo speed enforcement on the grounds of reduced mobility; in fact we show that photo speed enforcement not only improves safety but also improves mobility through travel time savings, improved travel time reliability, and reduced travel time uncertainty in Arizona, which is consistent with findings in other countries.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ID2: Hayden (WB)
ID3: Raintree (SB)
ID4: Cactus (NB)
ID5: Shea (NB)
ID6: Shea (SB)
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E Cactus Rd
E Shea Blvd
E Doubletree Ranch Rd
E Via Linda
E Mountain View Rd
N 64TH St
N 68TH St
N 72TH St
N 90TH St
N Scottsdale Rd
N Hayden Rd
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