

STV
SUMMER SCHOOL SIIV 2012 - ROAD SAFETY MANAGEMENT
Theoretical principles and practical application in the framework of the European Directive 2008/96/CE
Catania 24-28 September 2012

Safety Impact Assessment at the Program and System Level

Jake Kononov, Ph.D., P.E.

Italy 2012

STV

In Order to Manage Safety Effectively, We Need to be Able to Measure it

Italy 2012

STV

How much Safety can we Expect?
How Many Crashes are too Many?
How much Safety for how much Money
can we Obtain?
What is Normal and what is Abnormal?



Italy 2012




How To Measure Safety?

Accident Rate is the Most Common Measure of Safety



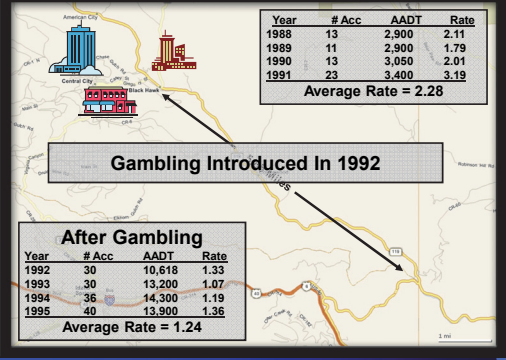
Italy 2012

$$\text{Rate} = \frac{\# \text{Acc} \times 1,000,000}{\text{AADT} \times 365 \times \text{Length}}$$

Let's Examine Its Application...

Italy 2012

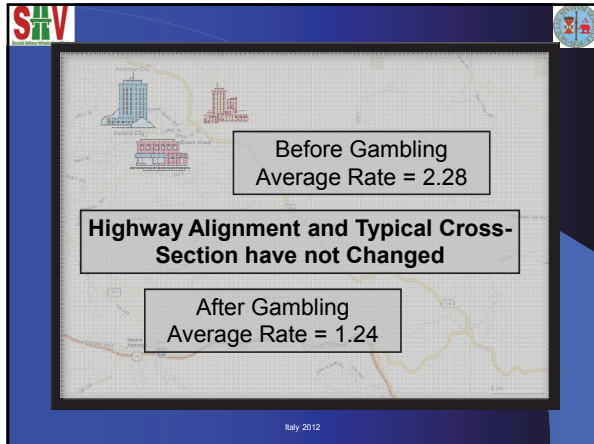




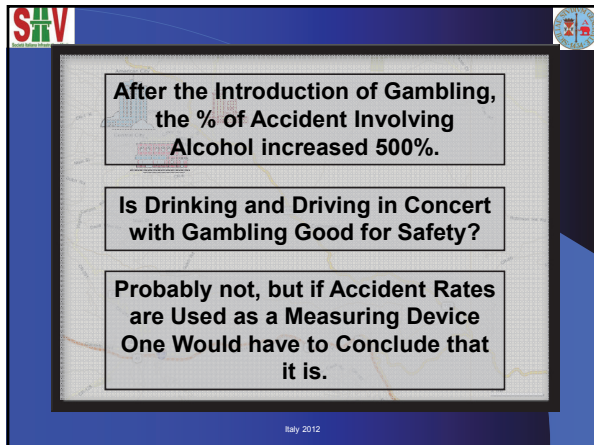
Gambling Introduced In 1992

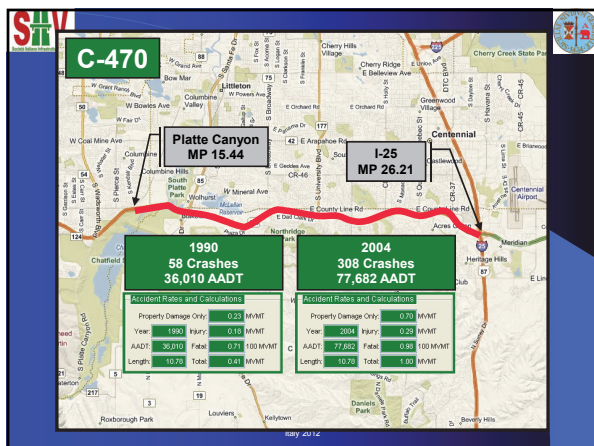
Year	# Acc	AADT	Rate
1988	13	2,900	2.11
1989	11	2,900	1.79
1990	13	3,050	2.01
1991	23	3,400	3.19
Average Rate = 2.28			

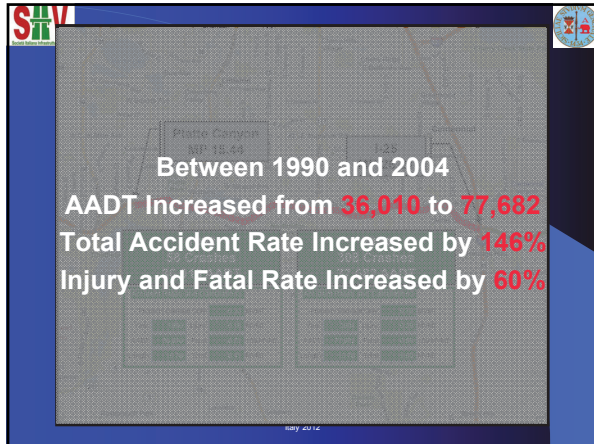
After Gambling			
Year	# Acc	AADT	Rate
1992	30	10,618	1.33
1993	30	13,200	1.07
1994	36	14,300	1.19
1995	40	13,900	1.36
Average Rate = 1.24			

Italy 2012









Clearly the Rate is Changing with
AADT

In Order to Understand how the Crash
Rate is Changing, We need to
Develop a Relationship between
Safety and Traffic Exposure

Italy 2012

The slide has a blue background with a white and light blue abstract shape on the right side. It contains text explaining the relationship between crash rate and traffic exposure. The text is: 'Clearly the Rate is Changing with AADT' and 'In Order to Understand how the Crash Rate is Changing, We need to Develop a Relationship between Safety and Traffic Exposure'. There is a logo in the top left and a small inset map in the top right.

This Relationship is Reflected by,
Safety Performance Function
(SPF)

Italy 2012

The slide has a blue background with a white and light blue abstract shape on the right side. It contains text about the Safety Performance Function (SPF). The text is: 'This Relationship is Reflected by, Safety Performance Function (SPF)'. There is a logo in the top left and a small inset map in the top right.

SHV

Calibration of Safety Performance Functions in Rural and Urban Environments

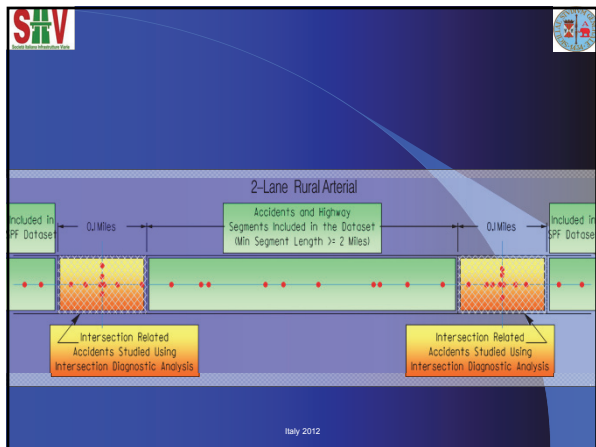
Jake Kononov, Ph.D., P.E.
Bryan K. Allery, P.E.

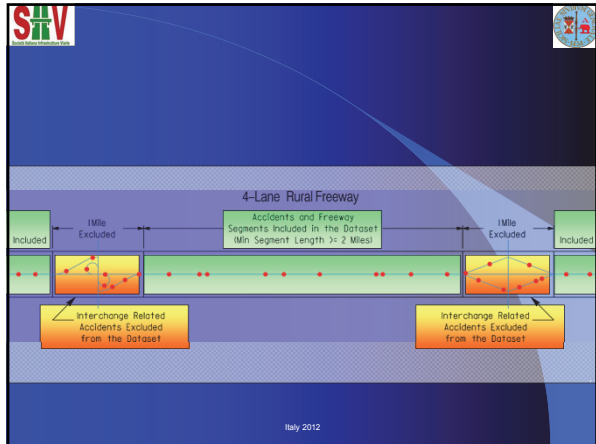
Italy 2012

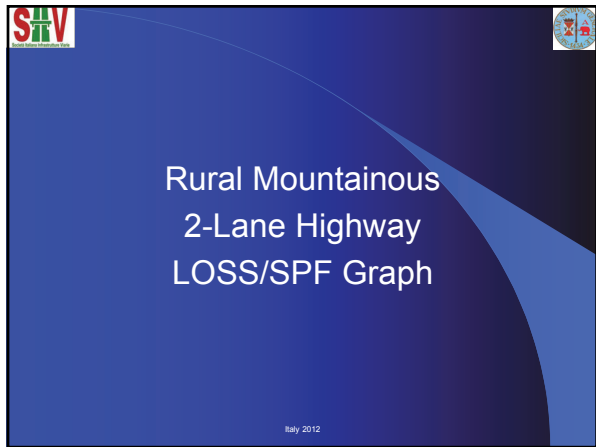
SHV

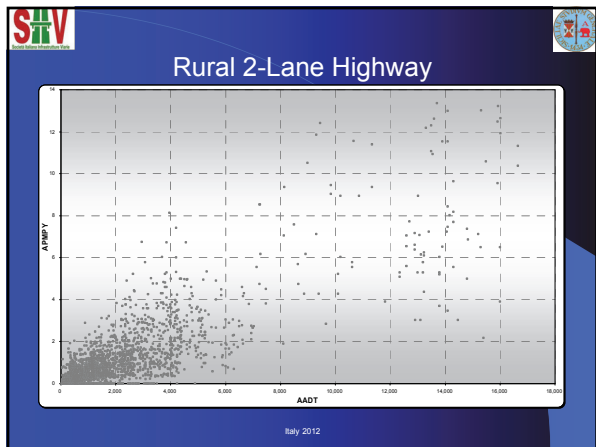
Dataset Preparation

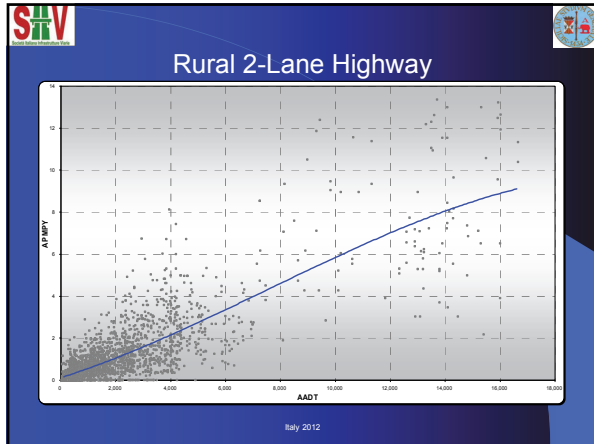
Italy 2012

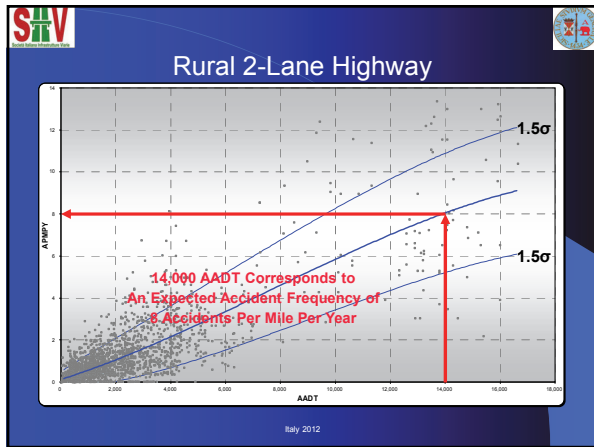


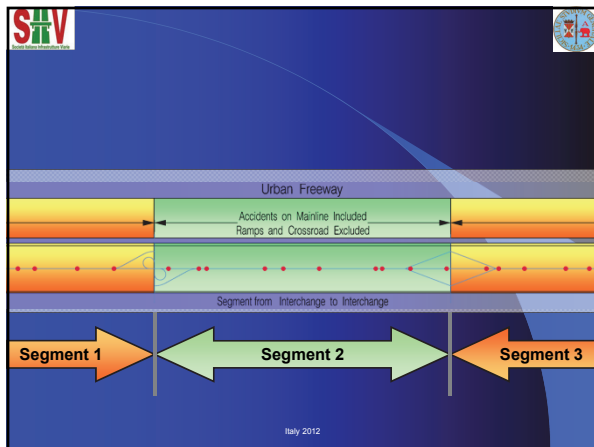








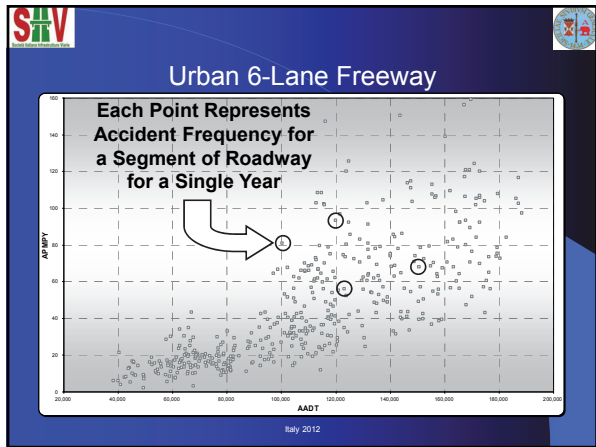


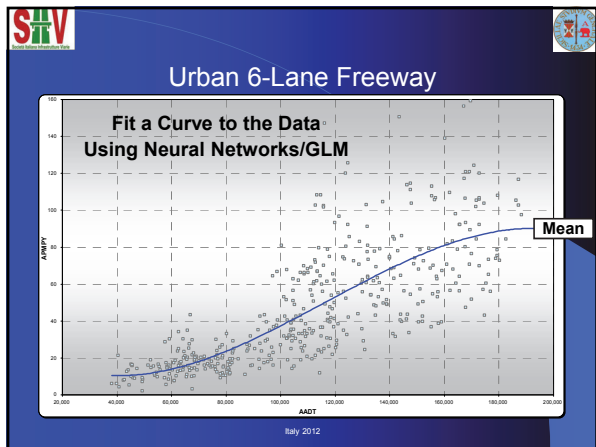


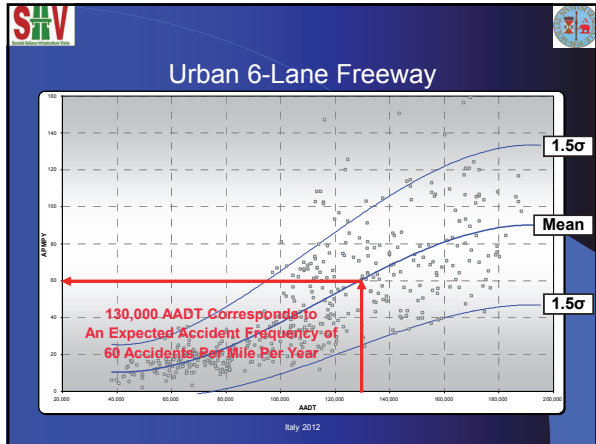
STV

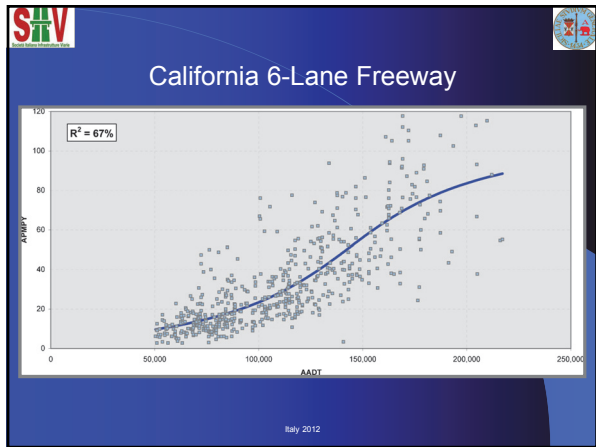
Urban 6-Lane Freeway SPF Graph

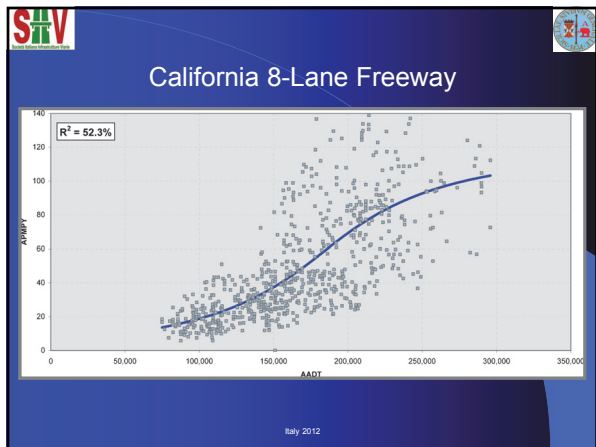
Italy 2012

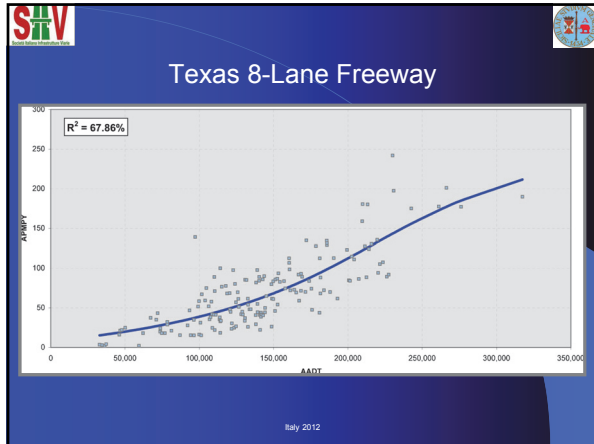


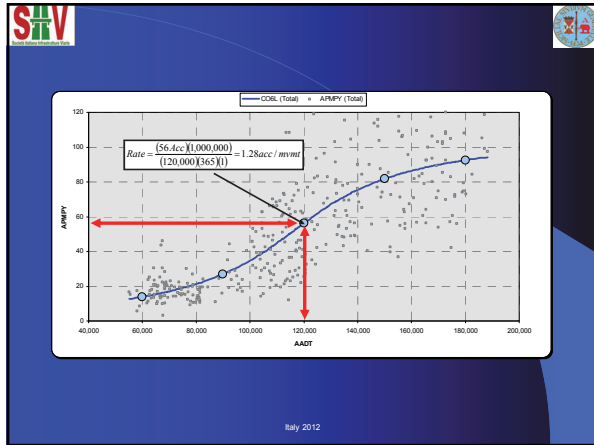


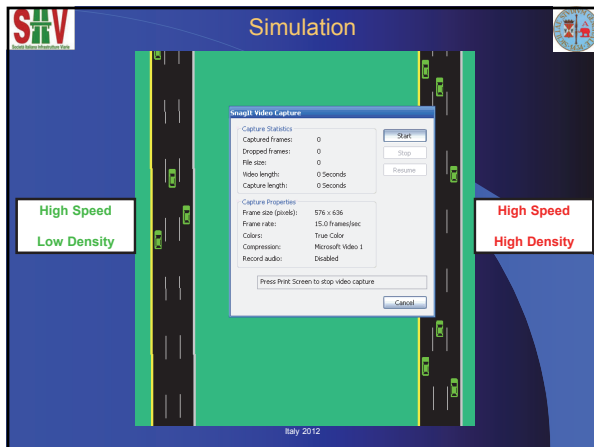


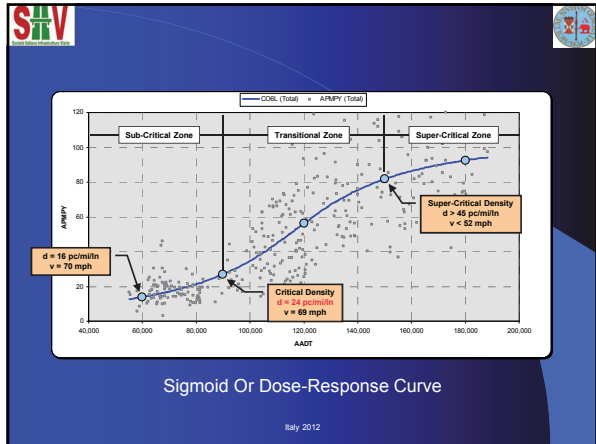


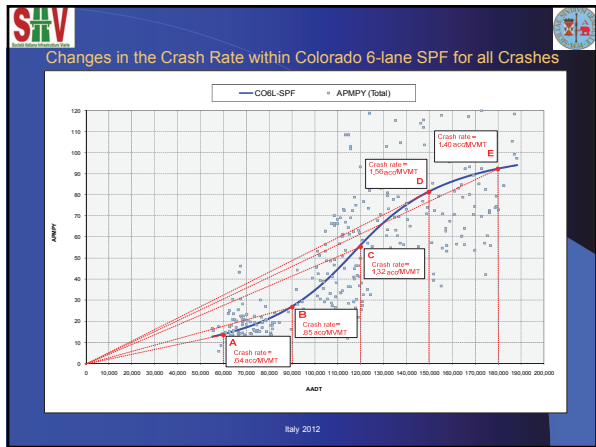


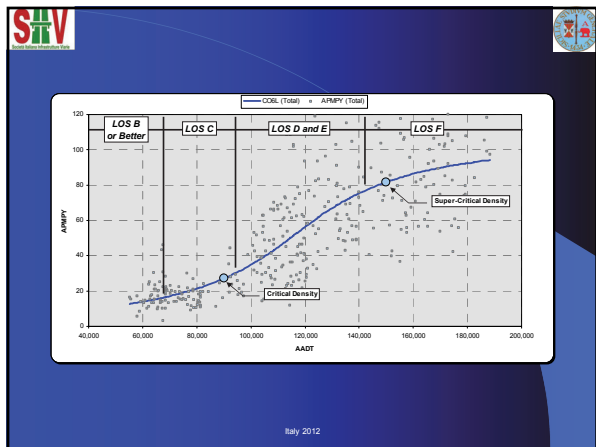


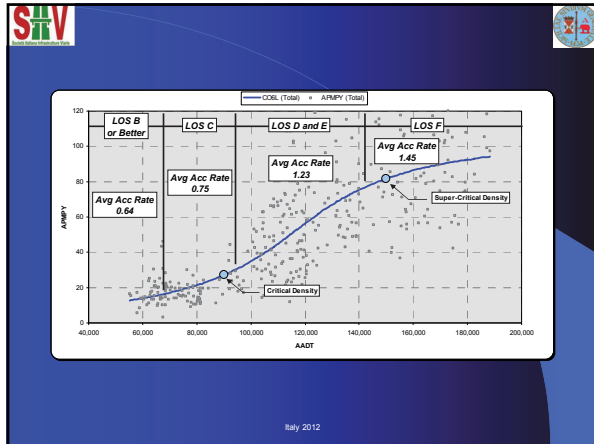


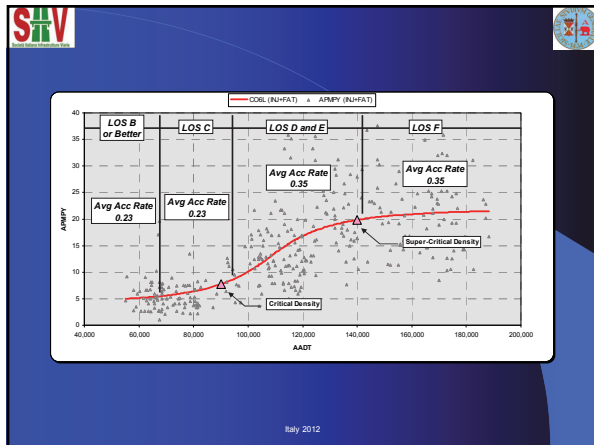








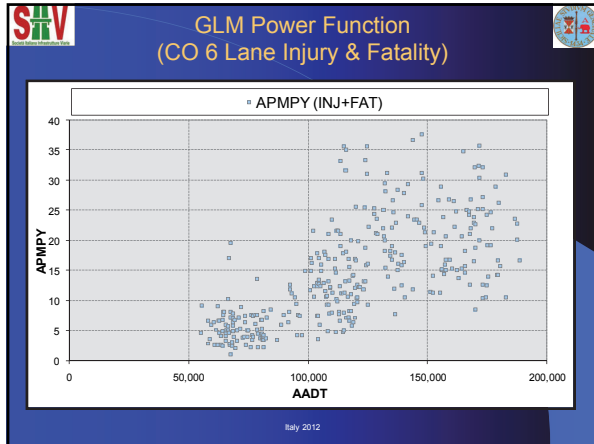


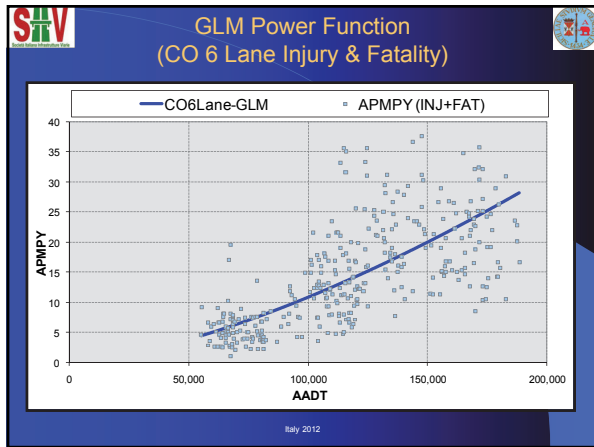


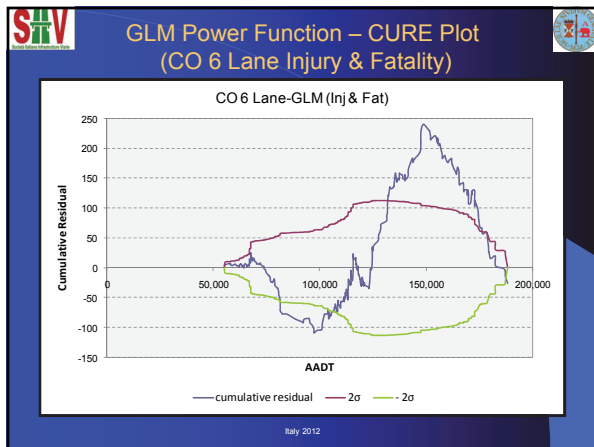
Functional Form of Colorado's 6-Lane and California 8-Lane Urban Freeway SPFs

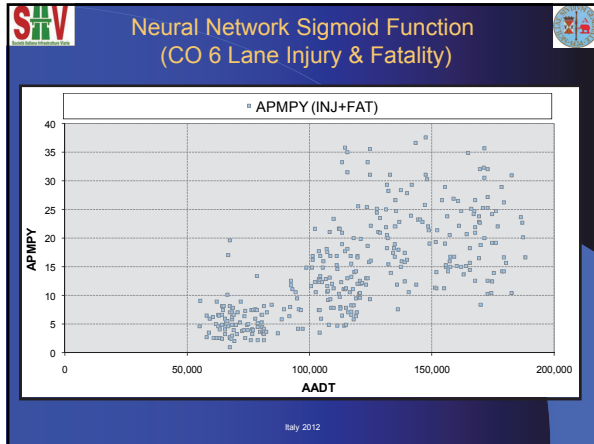
- Generalized Linear Modeling (GLM) Power Function
- GLM Sigmoid and Neural Network (NN) Sigmoid

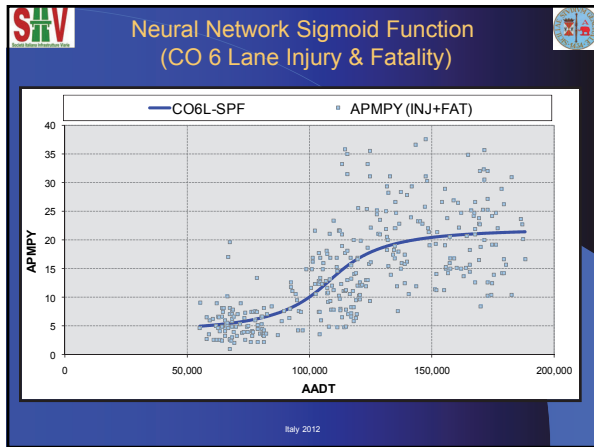
Italy 2012

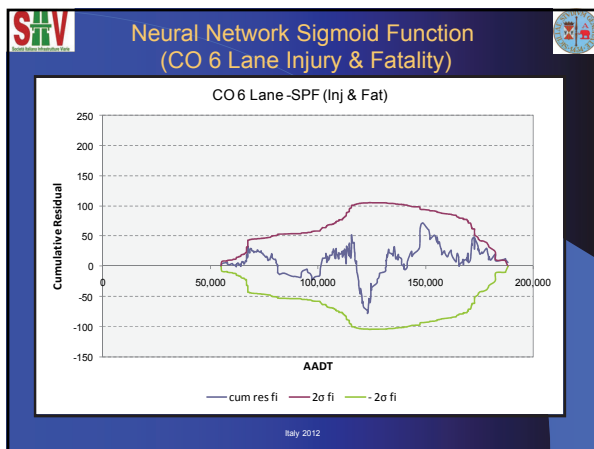


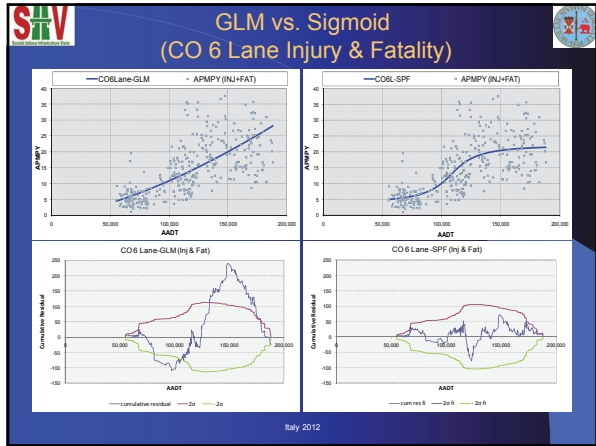


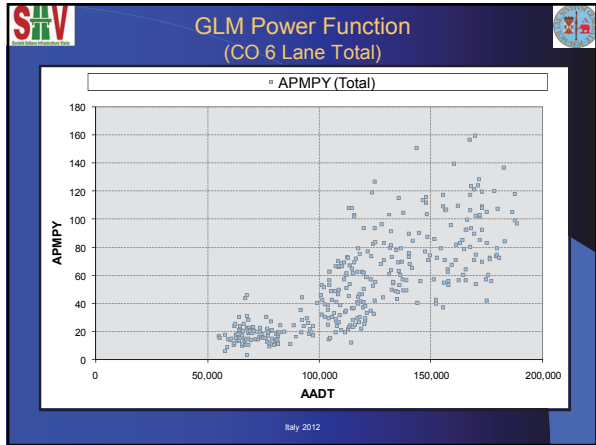


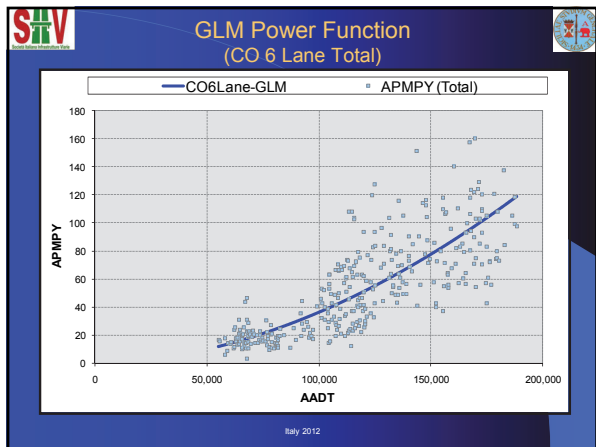


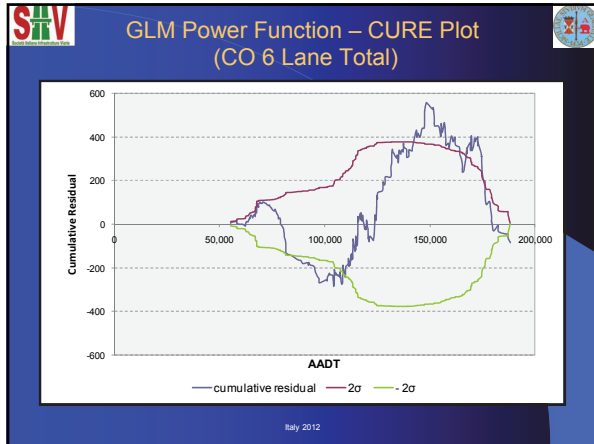


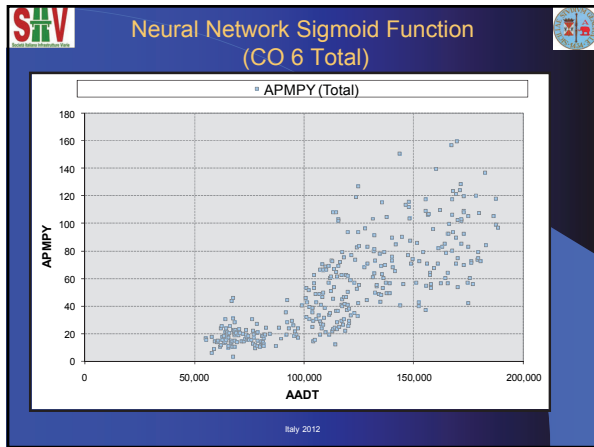


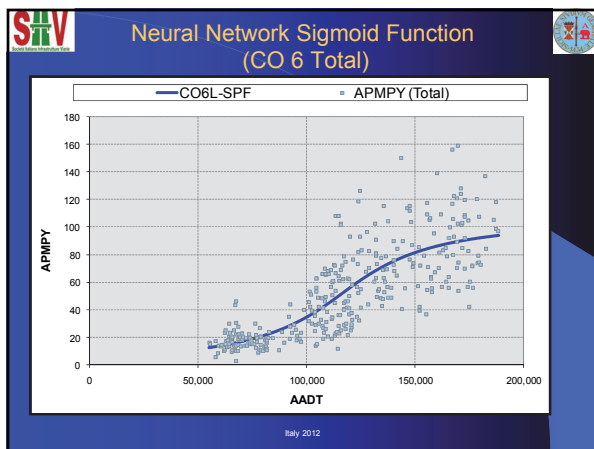


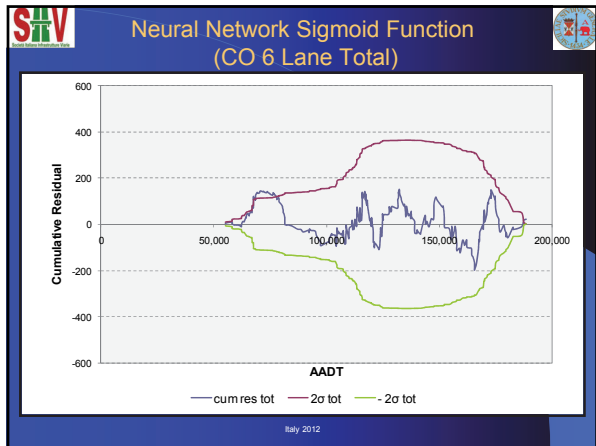


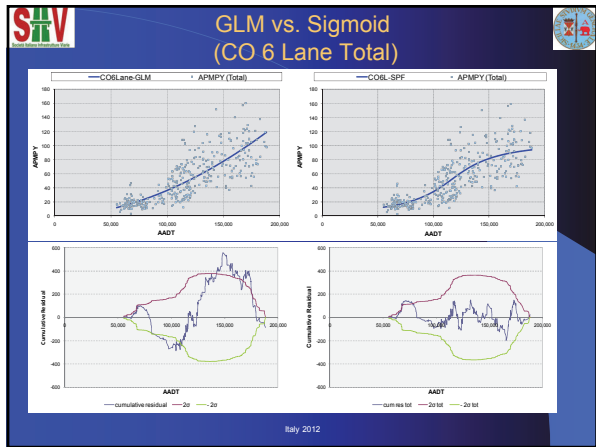


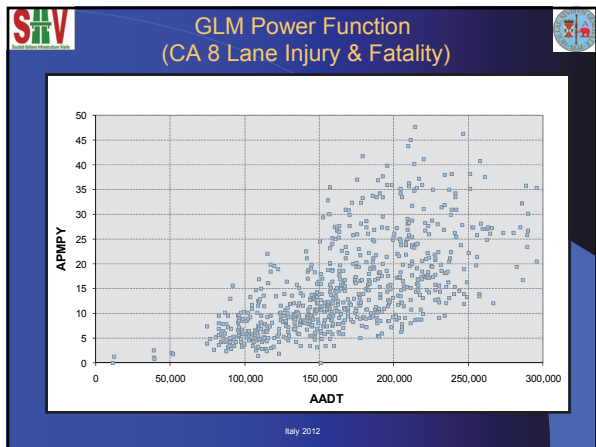


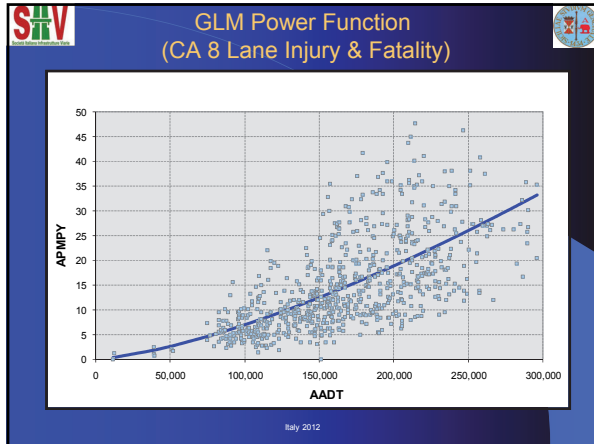


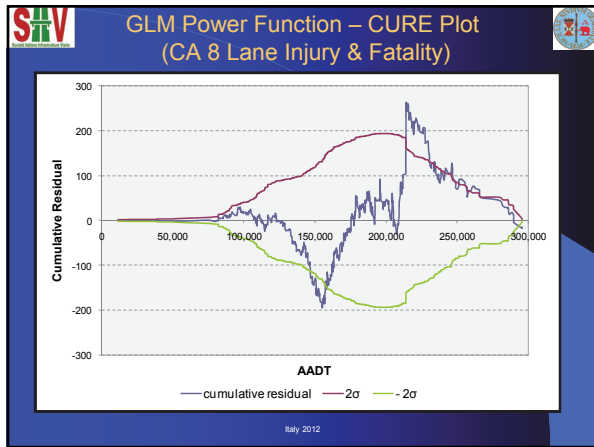


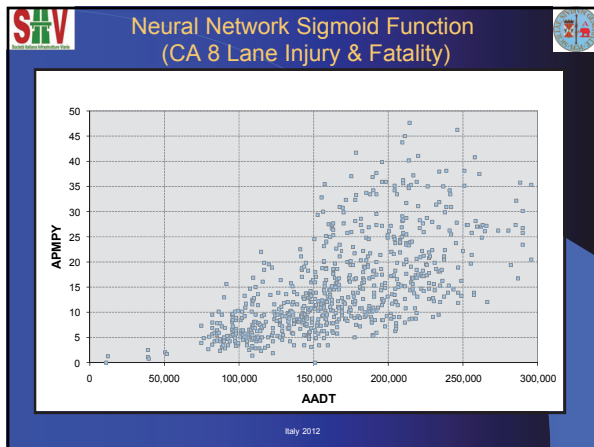


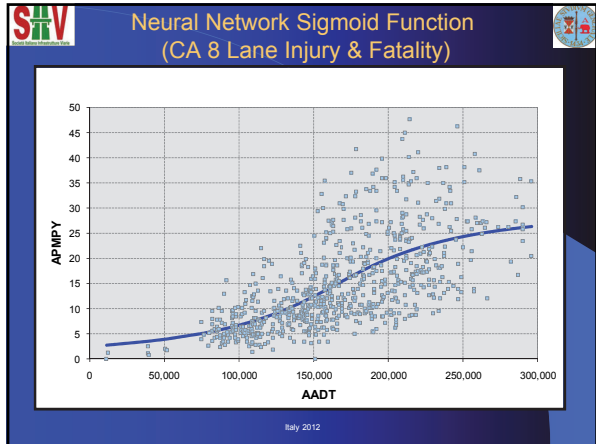


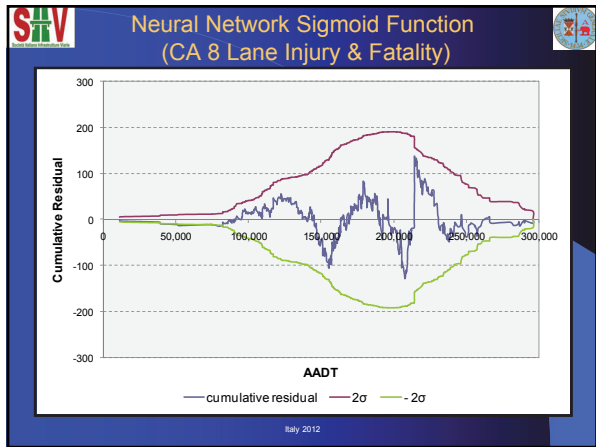


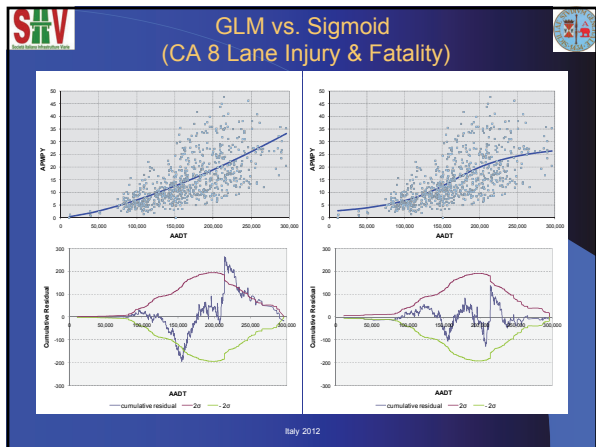


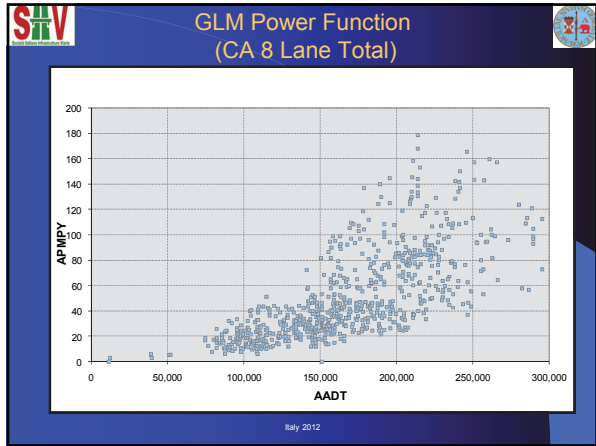


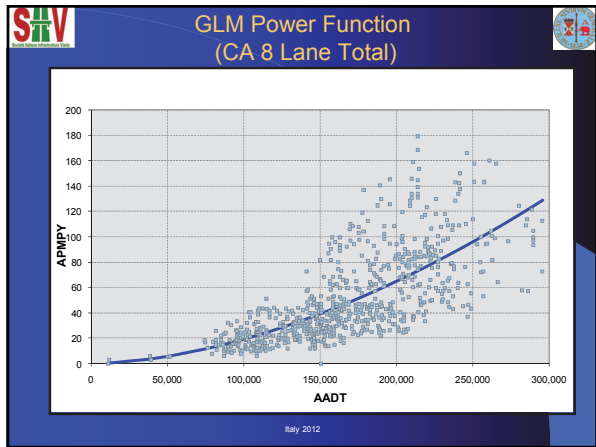


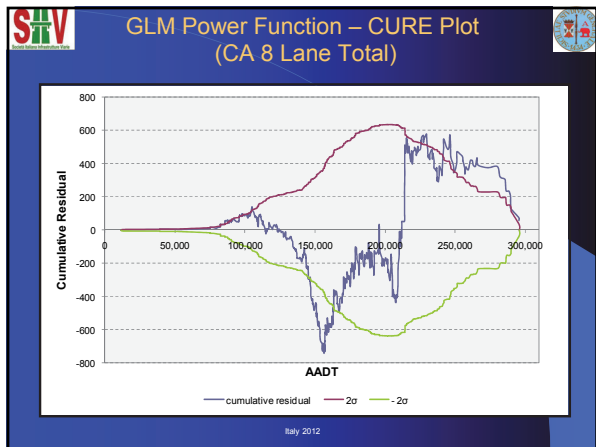


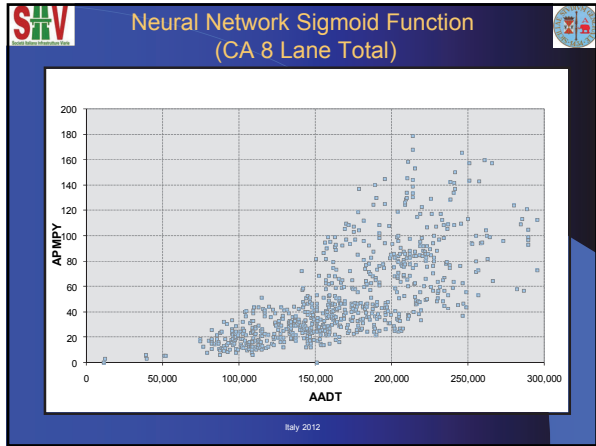


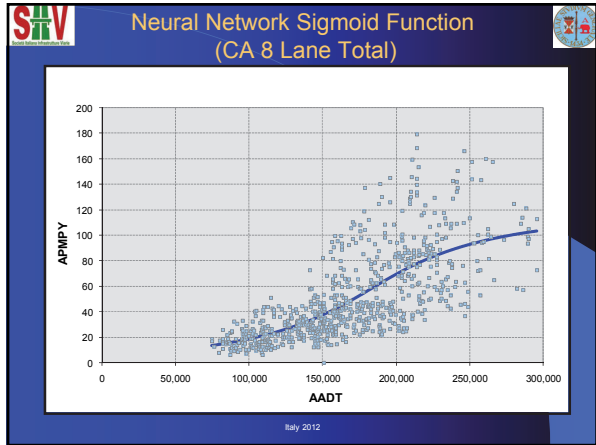


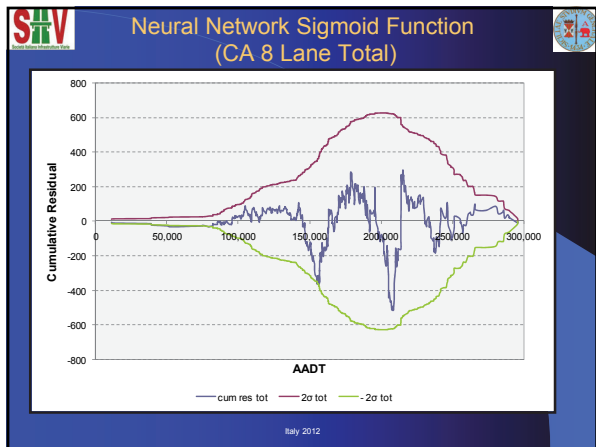


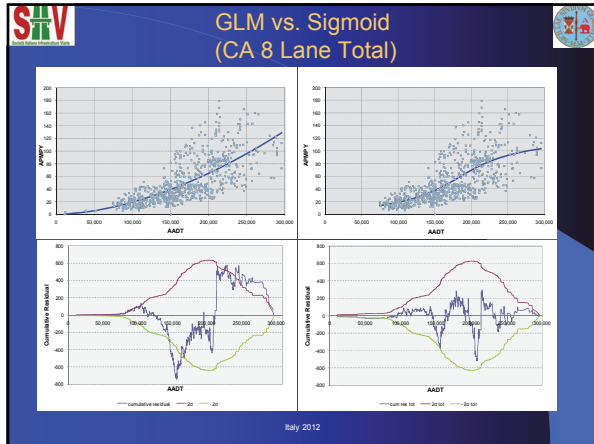






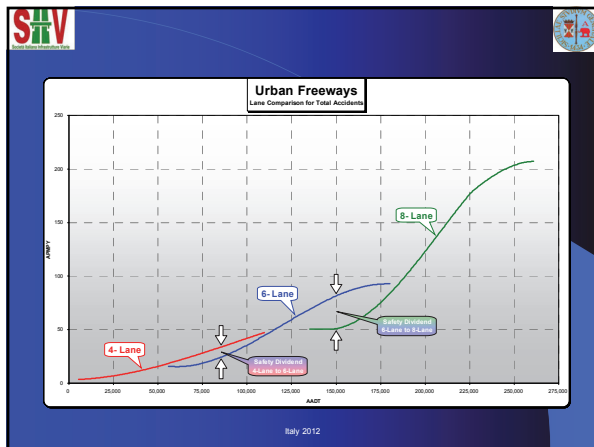


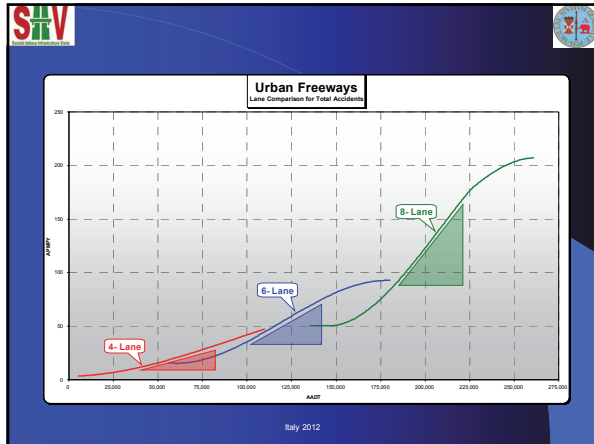


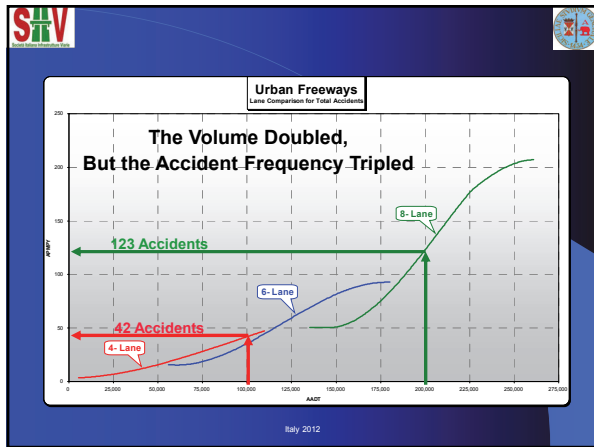


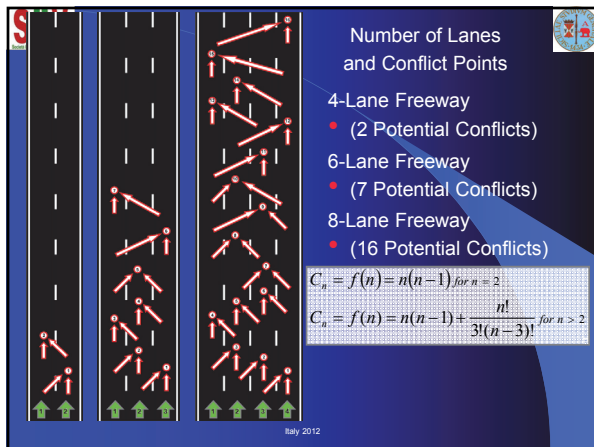
Relationship Between the Number of Lanes and Safety

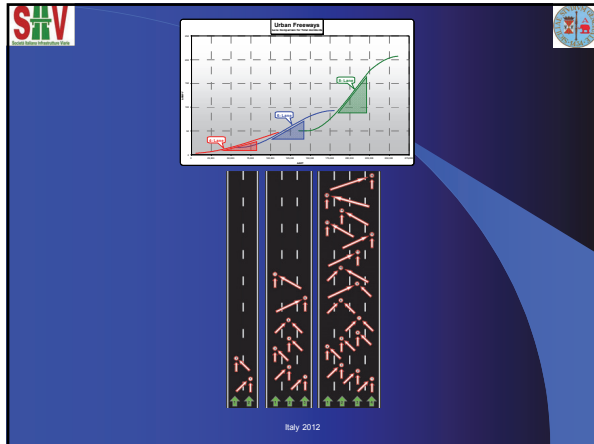
*Jake Kononov, P.E. Ph.D.
Bryan K. Allery, P.E.*





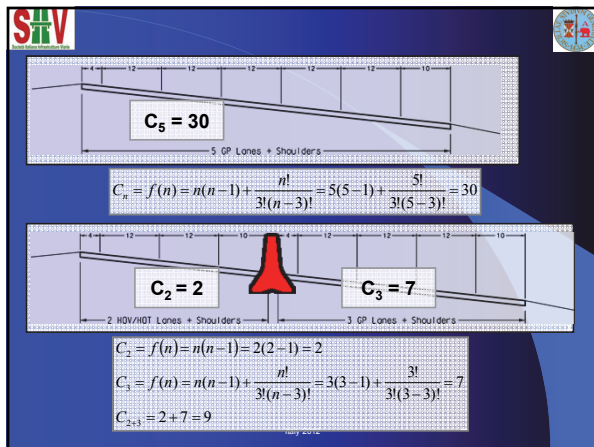






As the Number of Lanes Increases,
the Degree of Freedom for Things
to go Wrong also Increases

Italy 2012







9 is Less Than 30






Italy 2012



SPFs for Intersections

Jake Kononov, Ph.D., P.E.
Bryan K. Allery, P.E.

Italy 2012






26 Year Old Male
164 Lbs

Blood Pressure
110 Systolic
65 Diastolic

Does he have High Blood Pressure?

Italy 2012







43 Year Old Male
264 Lbs

Blood Pressure
180 Systolic
100 Diastolic

Does he have High Blood Pressure?

Italy 2012

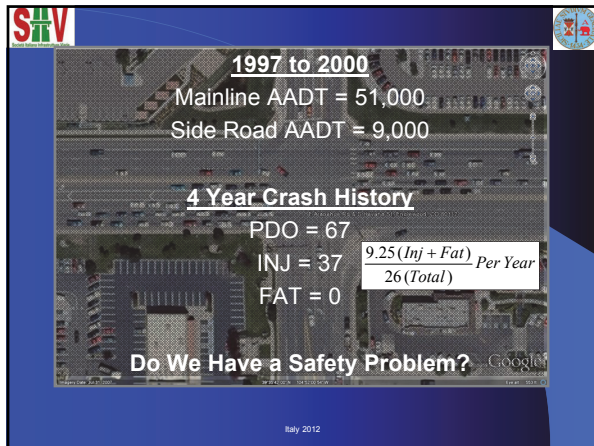
Does anyone here have Training in Internal Medicine or Cardiology?

Italy 2012




Urban
4 Leg
6-Lane
Signalized
Fully Actuated
Mast Arm Signal Layout
Lighted

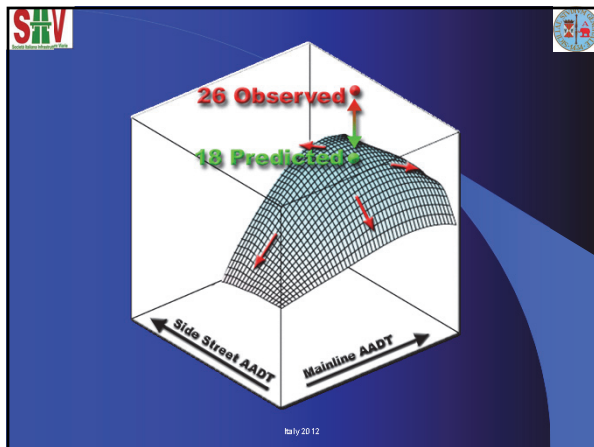
Italy 2012





The Safety Performance Function of an Intersection can be viewed Mathematically as a 3-Dimensional Response Surface, where:

$$\# \text{ Crashes/Year} = f(ADT_{\text{Mainline}}, ADT_{\text{Side Road}})$$

Italy 2012



LOSS Analysis

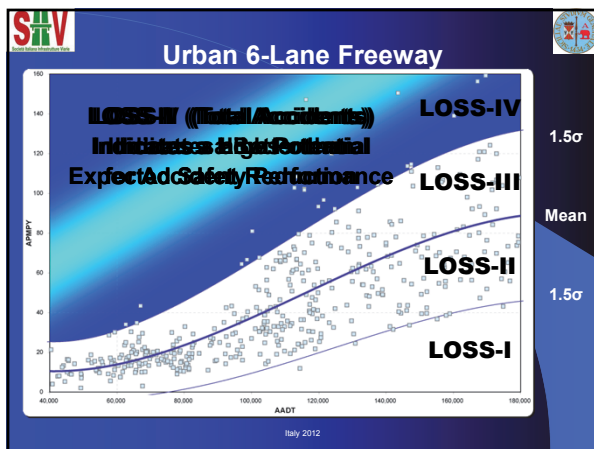
Jake Kononov, P.E. Ph.D.
Bryan K. Allery, P.E.

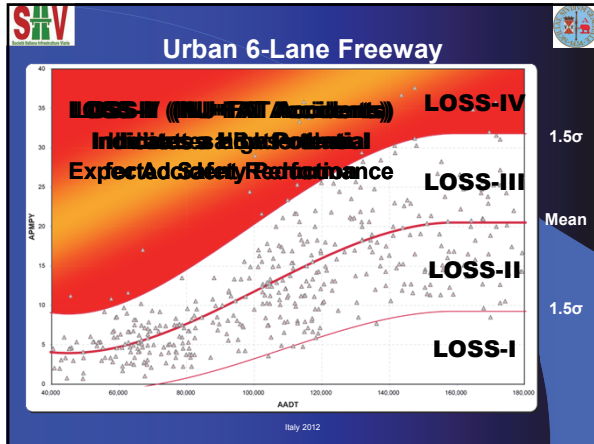
Italy 2012




Level of Service of Safety (LOSS) on Every Segment is Described from the Perspective of Both Frequency and Severity

Italy 2012





Why is Level of Service of Safety (LOSS) Concept Needed?

- Qualitatively and Quantitatively Describe the Degree of Safety or Un-Safety of a Roadway Segment
- Communicate the Magnitude of Safety Problem of a Roadway Segment to Other Professionals or Elected Officials

Italy 2012

Why is Level of Service of Safety (LOSS) Concept Needed?

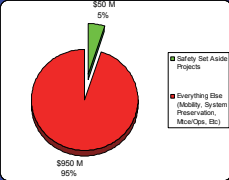
- Bring Perception of Roadway Safety in Line with Reality of Safety Performance Reflecting a Specific Facility

Italy 2012

STV

Why is Level of Service of Safety (LOSS) Concept Needed?

- Provide a Frame of Reference for Decision Making on Non-Safety Motivated Projects (Resurfacing or Reconstruction)



Italy 2012

STV

Why is Level of Service of Safety (LOSS) Concept Needed?

- Provide a Frame of Reference from a Safety Perspective for Planning Corridor Improvements


Italy 2012

STV

Correcting for Regression to the Mean Bias Using Empirical Bayes Method

Jake Kononov, P.E. Ph.D.
Bryan K. Allery, P.E.

Italy 2012


STV Regression to the Mean Phenomenon 

The best guess about the future is usually obtained by computing the average of past events.

In road safety (as well as other disciplines) the precision of this estimate however can be improved upon by correcting it for the Regression To the Mean (RTM) bias.

RTM phenomenon reflects the tendency of random events such as vehicle crashes to move toward the average over time.

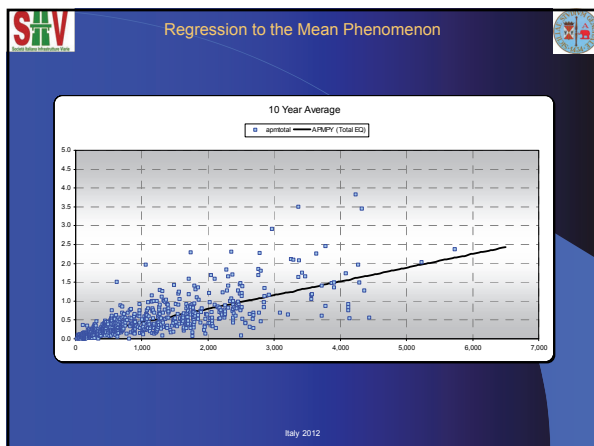
Italy 2012

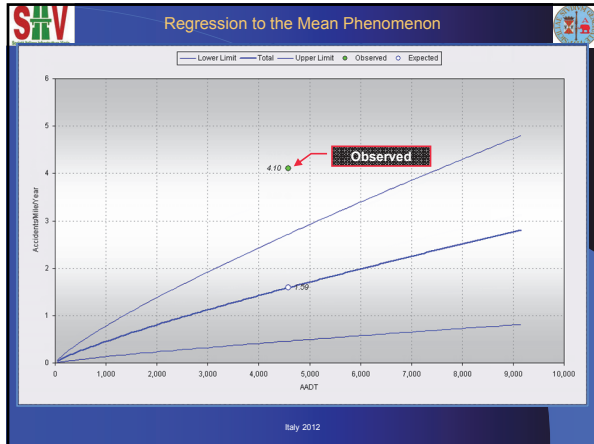
STV Regression to the Mean Phenomenon 

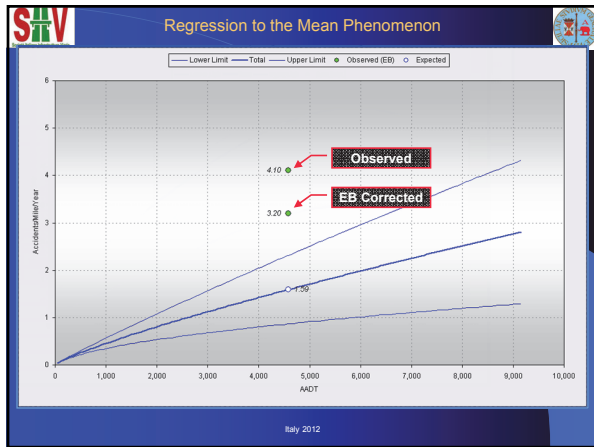
The RTM bias has been long recognized , and is now effectively addressed by using the Empirical Bayes (EB) method.

The EB method increases the precision of the estimation and corrects for the RTM bias.

Italy 2012







System Level Planning and Program Development (SPF Based)

Jake Kononov, P.E. Ph.D.
Bryan K. Allery, P.E.

Italy 2012

Locations with Potential for Accident Reduction														
Hwy	Bcd	Begin	End	From	To	ADT	APMPY (Total)	APMPY (Total)	% SO Day	LOSS I	LOSS II	LOSS III	LOSS IV	Location
10A	72.40	75.90	01/01/04	12/31/08	1.450	1,188	0.852	194.00%					YES	10A MP 72.4-75.9
10A	89.00	97.99	01/01/04	12/31/08	4.978	4,989	2.712	541.00%					YES	10A MP 89.0-97.99
10A	111.62	118.78	01/01/04	12/31/08	4.280	2,879	2.384	558.00%					YES	10A MP 111.62-118.78
10A	180.24	184.43	01/01/04	12/31/08	1.145	2,323	1.955	206.40%					YES	10A MP 180.24-184.43
11A	38.15	42.64	01/01/04	12/31/08	886	8,889	0.574	231.73%					YES	11A MP 38.15-42.64
12A	85.44	108.43	01/01/04	12/31/08	1,622	1,626	1.366	282.40%					YES	12A MP 85.44-108.43
13A	83.25	84.45	01/01/04	12/31/08	2,134	2,276	1.550	344.62%					YES	13A MP 83.25-84.45
13A	87.87	92.75	01/01/04	12/31/08	2,538	1,899	1.468	188.79%					YES	13A MP 87.87-92.75
13A	92.65	95.48	01/01/04	12/31/08	3,034	3,989	1.741	200.00%					YES	13A MP 92.65-95.48
13A	97.05	98.40	01/01/04	12/31/08	3,418	2,362	1.914	180.40%					YES	13A MP 97.05-98.4
13A	106.29	110.42	01/01/04	12/31/08	2,479	1,756	1.756	240.00%					YES	13A MP 106.29-110.42
13A	123.69	128.69	01/01/04	12/31/08	1,866	1,406	1.060	172.03%					YES	13A MP 123.69-128.69
15A	2.31	8.31	01/01/04	12/31/08	4,300	2,763	2,313	108.31%					YES	15A MP 2.31-8.31
16A	27.29	28.39	01/01/04	12/31/08	562	9,727	0.369	372.24%					YES	16A MP 27.29-28.39
17A	67.11	68.28	01/01/04	12/31/08	964	8,874	0.798	279.76%					YES	17A MP 67.11-68.28
17A	532.27	537.03	01/01/04	12/31/08	964	9,758	4.404	341.31%					YES	17A MP 532.27-537.03
17A	537.03	541.74	01/01/04	12/31/08	964	1,019	0.469	631.73%					YES	17A MP 537.03-541.74
18A	49.42	51.41	01/01/04	12/31/08	1,370	1,425	0.775	153.20%					YES	18A MP 49.42-51.41
21A	40.87	44.54	01/01/04	12/31/08	2,432	1,824	1.410	188.81%					YES	21A MP 40.87-44.54
21A	52.00	57.20	01/01/04	12/31/08	1,918	1,426	1.060	168.60%					YES	21A MP 52.00-57.2
22A	21.29	24.72	01/01/04	12/31/08	1,908	1,341	0.941	224.89%					YES	22A MP 21.29-24.72
23A	34.73	38.15	01/01/04	12/31/08	3,116	1,113	0.796	182.40%					YES	23A MP 34.73-38.15
23B	100.69	104.12	01/01/04	12/31/08	422	8,510	0.288	280.61%					YES	23B MP 100.69-104.12
23B	110.11	113.52	01/01/04	12/31/08	326	1,381	0.288	280.61%					YES	23B MP 110.11-113.52
23B	113.25	113.15	01/01/04	12/31/08	352	0,311	0.173	228.20%					YES	23B MP 113.25-113.15
23A	287.84	282.07	01/01/04	12/31/08	490	0,818	0.287	388.69%					YES	23A MP 287.84-282.07
23A	272.28	276.53	01/01/04	12/31/08	721	0,450	0.203	233%					YES	23A MP 272.28-276.53
23A	280.77	283.48	01/01/04	12/31/08	684	0,590	0.412	161.74%					YES	23A MP 280.77-283.48
23A	298.42	298.92	01/01/04	12/31/08	706	0,496	0.144	60.6%					YES	23A MP 298.42-298.92
23A	421.62	424.89	01/01/04	12/31/08	3,208	3,034	2,259	318.68%					YES	23A MP 421.62-424.89
24A	13.20	17.73	01/01/04	12/31/08	630	1,758	0.399	370.54%					YES	24A MP 13.20-17.73
24A	17.81	22.11	01/01/04	12/31/08	489	0,489	0.313	183.93%					YES	24A MP 17.81-22.11
24A	22.41	27.28	01/01/04	12/31/08	470	0,438	0.291	199.94%					YES	24A MP 22.41-27.28
24A	30.47	34.85	01/01/04	12/31/08	503	0,694	0.269	175.00%					YES	24A MP 30.47-34.85
24A	22.04	26.29	01/01/04	12/31/08	1,308	0,998	0.743	153.00%					YES	24A MP 22.04-26.29
27A	12.03	14.31	01/01/04	12/31/08	2,096	1,491	1.164	160.90%					YES	27A MP 12.03-14.31
28A	7.64	10.61	01/01/04	12/31/08	4,492	5,342	3.999	498.22%					YES	28A MP 7.64-10.61
29A	10.62	13.68	01/01/04	12/31/08	4,924	10,741	4,244	195.00%					YES	29A MP 10.62-13.68
29A	33.92	37.82	01/01/04	12/31/08	800	3,333	1,018	183.24%					YES	29A MP 33.92-37.82
29A	1.00	3.00	01/01/04	12/31/08	2,207	2,071	0,859	203.84%					YES	29A MP 1-3
33A	4.11	6.10	01/01/04	12/31/08	1,442	3,324	0.914	234.40%					YES	33A MP 4.11-6.1
33A	64.20	67.26	01/01/04	12/31/08	1,880	1,889	1,291	350.00%					YES	33A MP 64.20-67.26
34A	11.52	15.54	01/01/04	12/31/08	1,352	1,497	1,054	191.38%					YES	34A MP 11.52-15.54

APPLICATION OF METHODOLOGY

- System Level Planning and Program Development
- Corridor Level Planning (E/A/EIS)
- Project Level Decision Support Analysis
- Supporting Research Papers and Information

July 2012

Research Papers by Kononov and Allery

Methodology for System Level Planning and Program Development

Methodology for Corridor Level Planning (E/A/EIS)

Methodology for Project Level Decision Support Analysis

Methodology for Supporting Research Papers and Information

Safety performance functions reflect the complex relationship between exposure, usually measured in average daily traffic, and accident count for each of road sections over a unit of time. One of the main goals of the safety performance functions is to identify locations that experience more accidents than expected, thus indicating a potential for accident reduction.

Comprehension of the number of accident events can be achieved by general procedure provided by the safety performance functions. This study presents a methodology for the analysis of accident data to identify locations that experience more accidents than expected, thus indicating a potential for accident reduction. Accident type, severity, road condition, traffic distribution of accidents, and lighting conditions are only a few of the many important components of the accident problem. Some methodologies are identified for identification of locations that are potential for accident reduction. Point estimates and confidence intervals are used to analyze the data. The methodology presented that estimates of accident pattern concepts to correlation may or may not be accompanied by the interpretation of accident frequency detected by the safety performance functions.

There is a conceptual relationship among traffic safety measures that a comprehensive matrix between traffic exposure and safety. This concept is indicated by the safety performance functions (SPF) utilized for analysis of road and transportation. One of the main goals of SPF is to identify locations with potential for accident reduction. This study presents a methodology for the analysis of accident data to identify locations that experience more accidents than expected, thus indicating a potential for accident reduction. Accident type, severity, road condition, traffic distribution of accidents, and lighting conditions are only a few of the many important components of the accident problem. Some methodologies are identified for identification of locations that are potential for accident reduction. Point estimates and confidence intervals are used to analyze the data. The methodology presented that estimates of accident pattern concepts to correlation may or may not be accompanied by the interpretation of accident frequency detected by the safety performance functions.

Network screening is the first step in the safety performance process. The product of network screening is a list of sites that are ranked by priority for the conduct of detailed engineering studies. In order to determine which sites to examine first, the product of network screening is a list of sites that are ranked by priority for the conduct of detailed engineering studies. In order to determine which sites to examine first, the product of network screening is a list of sites that are ranked by priority for the conduct of detailed engineering studies. In order to determine which sites to examine first, the product of network screening is a list of sites that are ranked by priority for the conduct of detailed engineering studies.

This study presents a methodology for the analysis of accident data to identify locations that experience more accidents than expected, thus indicating a potential for accident reduction. Accident type, severity, road condition, traffic distribution of accidents, and lighting conditions are only a few of the many important components of the accident problem. Some methodologies are identified for identification of locations that are potential for accident reduction. Point estimates and confidence intervals are used to analyze the data. The methodology presented that estimates of accident pattern concepts to correlation may or may not be accompanied by the interpretation of accident frequency detected by the safety performance functions.

The relationship between traffic exposure and the number of lanes is necessarily well understood at present. In contrast to safety, the relationship between the number of lanes and safety is not well understood. This study presents a methodology for the analysis of accident data to identify locations that experience more accidents than expected, thus indicating a potential for accident reduction. Accident type, severity, road condition, traffic distribution of accidents, and lighting conditions are only a few of the many important components of the accident problem. Some methodologies are identified for identification of locations that are potential for accident reduction. Point estimates and confidence intervals are used to analyze the data. The methodology presented that estimates of accident pattern concepts to correlation may or may not be accompanied by the interpretation of accident frequency detected by the safety performance functions.

July 2012

SHV

Level of Service of Safety (LOSS) and Pattern Recognition Analysis

Example #1 Colorado State Highway 285

*Jake Kononov, P.E. Ph.D.
Bryan K. Allery, P.E.*

Italy 2012

SHV

**Step I
Define Study Limits**

Italy 2012

SHV

SH285D LOSS and Pattern Recognition Analysis

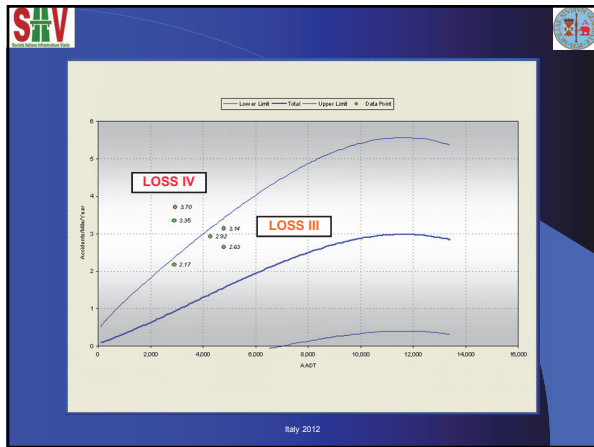
The map shows a section of Colorado State Highway 285. A grey box labeled "SH285D LOSS and Pattern Recognition Analysis" is positioned over the highway. Two arrows point to specific mileposts: "Begin MP 184" and "End MP 203". The map also shows surrounding terrain, roads, and the state boundary with "COLORADO" labeled at the bottom.

Italy 2012

Step I
Define Study Limits

Step II
LOSS Analysis

Italy 2012



Step I
Define Study Limits

Step II
LOSS Analysis

Step III
Select Diagnostic Menu

Italy 2012

Diagnostic Normative Percentages (Flat and Rolling 2-Lane Highway)

58.32% PDO	0.23% Bicycle	39.15% Total Fixed Objects
39.74% INJ	0.01% Motorized Bicycle	3.45% Total Other Objects
1.94% FAT	1.12% Domestic Animal	57.64% Daylight
N/A Persons Injured	9.64% Wild Animal	5.28% Dawn or Dusk
N/A Persons Killed	0.25% Light or Utility Pole	1.40% Dark - Lighted
70.04% Single Vehicle Accidents	0.00% Traffic Signal Pole	34.21% Dark - Unlighted
21.22% Two Vehicle Accidents	1.62% Sign	1.48% Unknown Lighting
2.70% Three or more Vehicle Accident	0.27% Bridge Rail	74.20% No Adverse Weather
0.05% Unknown Number of Vehicles	4.30% Guard Rail	3.93% Rain
33.79% On Road	0.04% Median Barrier	19.13% Snow or Sleet or Hail
24.42% Off Road Left	0.07% Bridge Abutment	0.27% Fog
36.63% Off Road Right	0.00% Column or Pier	0.01% Dust
0.05% Off Road at Tee	0.59% Culvert or Headwall	0.96% Wind
0.01% Off Road in Median	11.10% Embankment	1.50% Unknown Weather
0.10% Unknown Road Location	0.05% Curb	59.06% Dry Road
22.26% Overturning	5.98% Delineator Post	6.87% Wet Road
2.14% Other Non Collision	2.70% Fence	0.09% Muddy Road
0.02% School Age Pedestrians	5.30% Tree	6.96% Snowy Road
0.15% All Other Pedestrians	5.69% Large Boulder	16.44% Icy Road
0.69% Broadside	1.62% Rocks In Roadway	3.63% Slushy Road
4.49% Head On	0.04% Barricade	0.28% Foreign Material Road
7.16% Rear End	0.11% Wall or Building	0.74% With Road Treatment
1.39% Sideswipe (Same Direction)	0.03% Crash Cushion	0.08% Dry with Icy Road Treatment
4.63% Sideswipe (Opposite Direction)	0.24% Mailbox	0.01% Wet with Icy Road Treatment
0.92% Approach Turn	0.51% Other Fixed Object	0.03% Snowy with Icy Road Treatment
1.41% Overtaking Turn	0.11% Involving Other Object	0.12% Icy with Icy Road Treatment
1.07% Parked Motor Vehicle	0.51% Road Maintenance Equipment	0.05% Slushy with Icy Road Treatment
0.01% Railway Vehicle	0.06% Unknown Accident Type	3.63% Unknown Road Condition

Italy 2012



BLOOD TEST REFERENCE RANGE CHART

Reference Range (conventional units*)

17 Hydroxprogesterone (Men)	0.06-3.0 mg/L
17 Hydroxprogesterone (Women) Follicular phase	0.2-1.0 mg/L
25-hydroxyvitamin D (25(OH)D)	8-80 ng/mL
Acetate	<3 mg/dL
Acidity (pH)	7.35 - 7.45
Alcohol	0 mg/dL (more than 0.1 mg/dL normally indicates intoxication) (ethanol)
Ammonia	15 - 50 µg of nitrogen/dL
Amylase	53 - 123 units/L
Ascorbic Acid	0.4 - 1.5 mg/dL
Bicarbonate	18 - 25 mEq/L (carbon dioxide content)
Bilirubin	Direct: up to 0.4 mg/dL Total: up to 1.0 mg/dL
Blood Volume	8.5 - 9.1% of total body weight
Calcium	9.2 - 10.6 mg/dL (normally slightly higher in children)
Carbon Dioxide Pressure	35 - 45 mm Hg
Carbon Monoxide	Less than 5% of total hemoglobin
CD4 Cell Count	500 - 1500 cells/µL
Ceruloplasmin	15 - 60 mg/dL
Chloride	98 - 108 mEq/L
Complete Blood Cell Count (CBC)	Tests include: hemoglobin, hematocrit, mean corpuscular hemoglobin, mean corpuscular hemoglobin concentration, mean corpuscular volume, platelet count, white blood cell count.
Copper	Total: 70 - 150 µg/dL
Creatine Kinase (CK or CPK)	Male: 38 - 174 units/L Female: 96 - 140 units/L
Creatine Kinase Isoenzymes	0% MB or less
Creatinine	0.5 - 1.2 mg/dL
Electrolytes	Test includes: calcium, chloride, magnesium, potassium, sodium.
Erythrocyte Sedimentation Rate (ESR or Sed Rate)	Male: 1 - 13 mm/hr Female: 1 - 20 mm/hr
Glucose	Tested after fasting: 70 - 110 mg/dL

Italy 2012

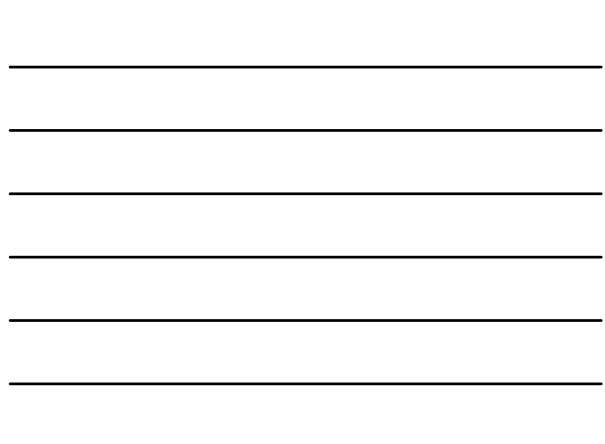


BLOOD TEST REFERENCE RANGE CHART

Reference Range (conventional units*)

Hematocrit	Male: 45 - 62% Female: 37 - 49%
Hemoglobin	Male: 13 - 18 gm/dL Female: 12 - 16 gm/dL
Iron	60 - 160 µg/dL (normally higher in males)
Iron-binding Capacity	250 - 460 µg/dL
Lactate (lactic acid)	Venous: 4.5 - 19.8 mg/dL Arterial: 4.5 - 14.4 mg/dL
Lactic Dehydrogenase	50 - 150 units/L
Triglycerides	10 - 29 years 53 - 104 mg/dL 30 - 39 years 55 - 115 mg/dL 40 - 49 years 66 - 139 mg/dL 50 - 59 years 75 - 163 mg/dL 60 - 69 years 78 - 158 mg/dL > 70 years 83 - 141 mg/dL
Lipids:	
Cholesterol	125 - 200 mg/dL
HDL cholesterol	35 - 65 mg/dL
LDL cholesterol	100 - 160 mg/dL
Very low density lipoprotein (VLDL) cholesterol	30 - 60 mg/dL
Non-HDL cholesterol	100 - 150 mg/dL
Triglycerides	100 - 150 mg/dL
Liver Function Tests	Tests include bilirubin (total), phosphatase (alkaline), protein (total and albumin), transaminases (alanine and aspartate), prothrombin (PTT).
Magnesium	1.9 - 2.7 mEq/L
Mean Corpuscular Hemoglobin (MCH)	27 - 32 pg/cell
Mean Corpuscular Hemoglobin Concentration (MCHC)	32 - 36% hemoglobin/cell
Mean Corpuscular Volume (MCV)	76 - 100 cu µm
Osmolality	280 - 290 mOsm/kg water
Oxygen Pressure	83 - 100 mm Hg
Oxygen Saturation (arterial)	96 - 100%
Phosphatase, Prostatic	0 - 3 units/dL (Bodansky units) (acid)

Italy 2012



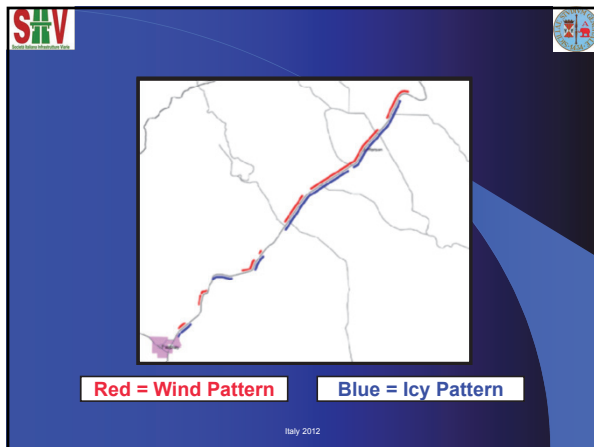
SIV

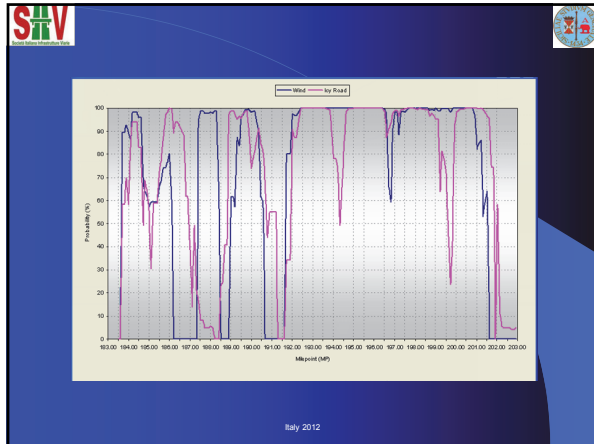
BLOOD TEST REFERENCE RANGE CHART

Test	Reference Range (conventional units*)
Phosphatase	50 - 160 units/L (normally higher in infants and adolescents) (alkaline)
Phosphorus	3.0 - 4.5 mg/dL (inorganic)
Platelet Count	150,000 - 350,000/mL
Potassium	3.5 - 5.4 mEq/L
Prostate Specific Antigen (PSA)	0 - 4 ng/mL (likely higher with age)
Proteins:	
Total	6.0 - 8.4 gm/dL
Albumin	3.5 - 5.0 gm/dL
Globulin	2.3 - 3.5 gm/dL
Prothrombin (PTT)	25 - 41 sec
Pyruvic Acid	0.3 - 0.9 mg/dL
Red Blood Cell Count (RBC)	4.2 - 6.9 million/ μ L/cu mm
Sodium	133 - 146 mEq/L
Thyroid-Stimulating Hormone (TSH)	0.5 - 6.0 μ units/mL
Transaminase:	
Alanine (ALT)	1 - 21 units/L
Aspartate (AST)	7 - 27 units/L
Urea Nitrogen (BUN)	7 - 18 mg/dL
BUN/Creatinine Ratio	5 - 35
Uric Acid	Male: 2.1 to 8.5 mg/dL (likely higher with age) Female: 2.0 to 7.0 mg/dL (likely higher with age)
Vitamin A	30 - 65 μ g/dL
WBC (leukocyte count and white Blood cell count)	4.3-10.8 $\times 10^3$ /mm ³
White Blood Cell Count (WBC)	4,300 - 10,800 cells/ μ L/cu mm

Italy 2012







Operational Considerations

Italy 2012

ACCORDING TO THE AASHTO POLICY ON GEOMETRIC DESIGN

- SHOULDERS ARE AN IMPORTANT ELEMENT OF A HIGHWAY DESIGN SYSTEM
- WELL-DESIGNED AND MAINTAINED SHOULDERS ARE ESSENTIAL FOR SAFE TRAFFIC OPERATION
- THE USABLE PAVED WIDTH OF RIGHT SHOULDER ON FREEWAYS SHOULD BE AT LEAST 10FT

Italy 2012


STV

- NOT PROVIDING SHOULDERS ON FREEWAYS SEEMS TO BE IN CONFLICT WITH AASHTO POLICY ON GEOMETRIC DESIGN!!!
- IS IT SAFE TO DEPEND ON SHOULDER RUNNING?
- IS REDUCING CONGESTION MORE IMPORTANT THAN SAFETY???
- IS IT SUFFICIENT FOR PROFESSIONAL ENGINEERS TO SAY "OTHERS ARE DOING IT SO WE WILL DO IT TOO"?



Italy 2012

STV

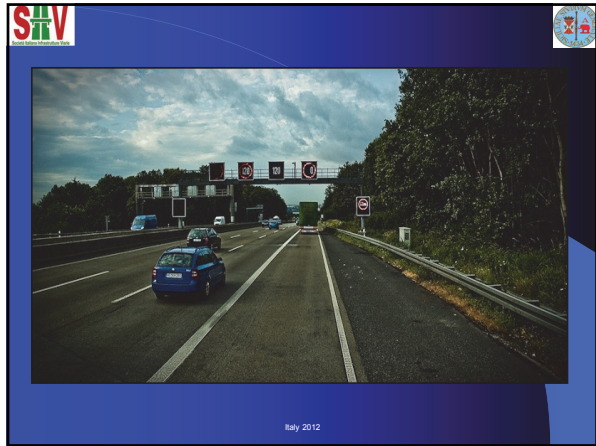


Italy 2012

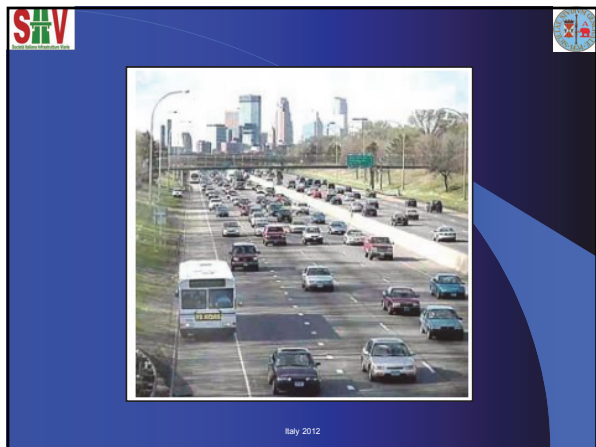
STV



Italy 2012







STV **Hard Shoulder Running**

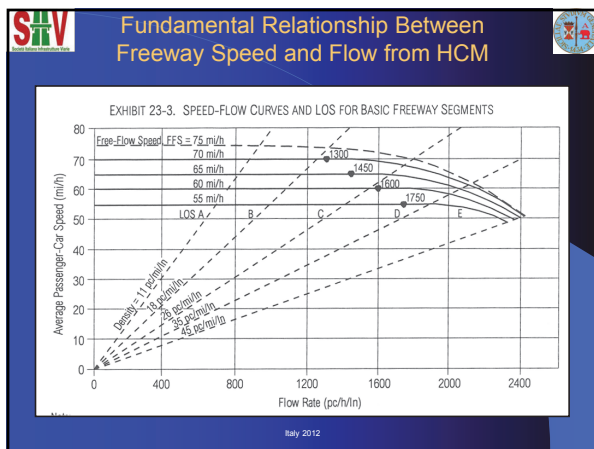
- Relationship between Mobility (LOS, Density, Speed, Travel Time etc.) and Number of Lanes is well understood at Present
- In contrast with Mobility, the Relationship between Congestion and Safety is not, especially when Hard Shoulder Running (HSR) is concerned

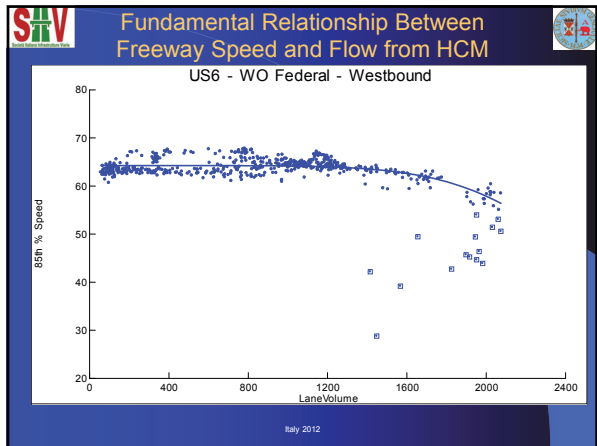
Italy 2012

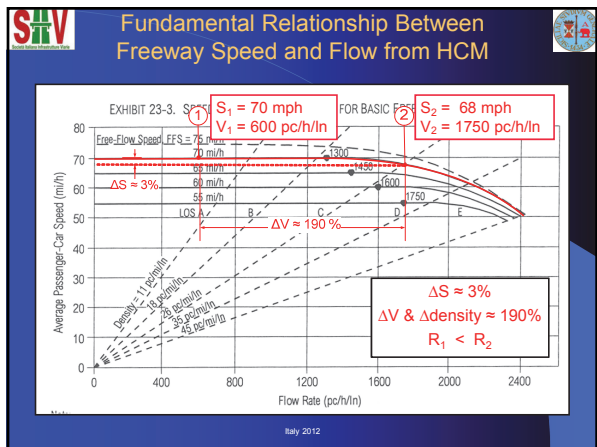
STV **Hard Shoulder Running**

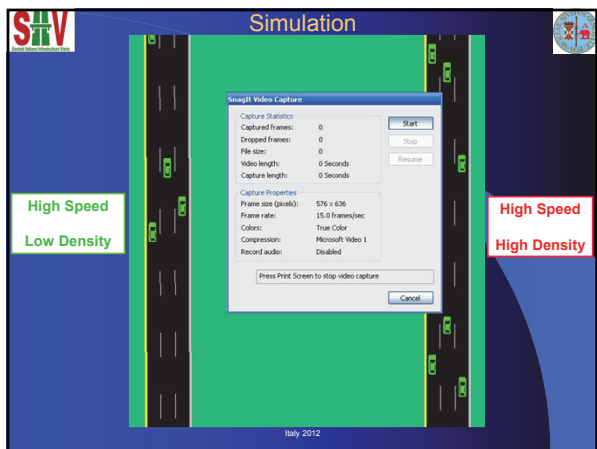
- The survey suggests that 89% of motorists feel safer on Freeways compared to other roads because full shoulder width is available
- Over 50% of drivers questioned in England said they would not feel confident driving on the motorway without shoulders

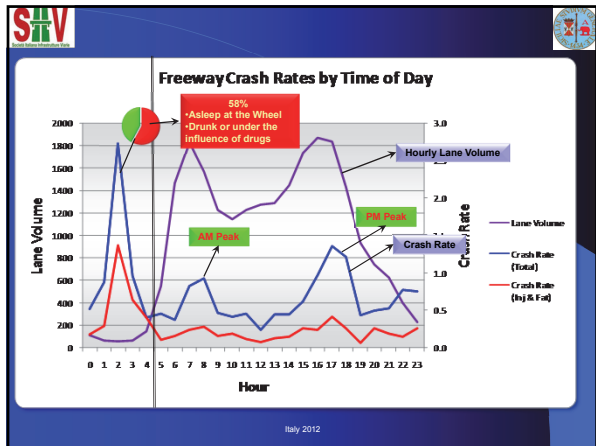
Italy 2012

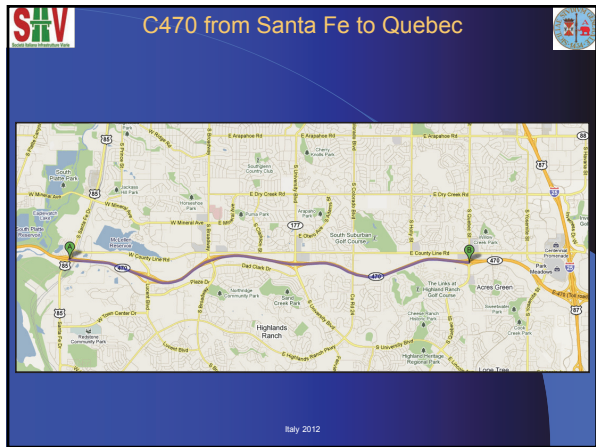


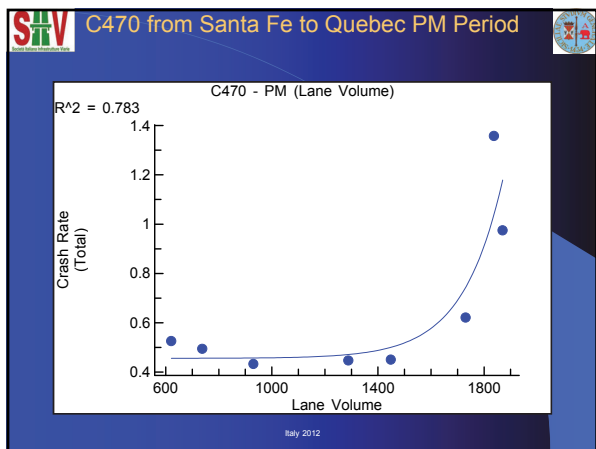


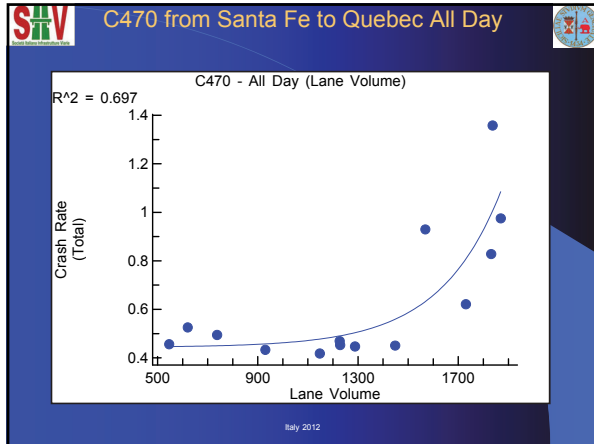


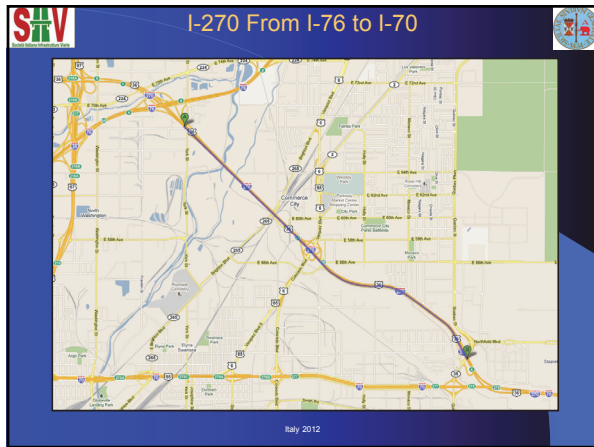


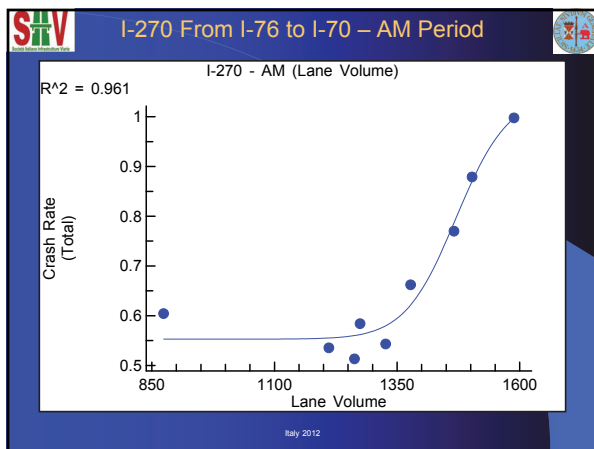


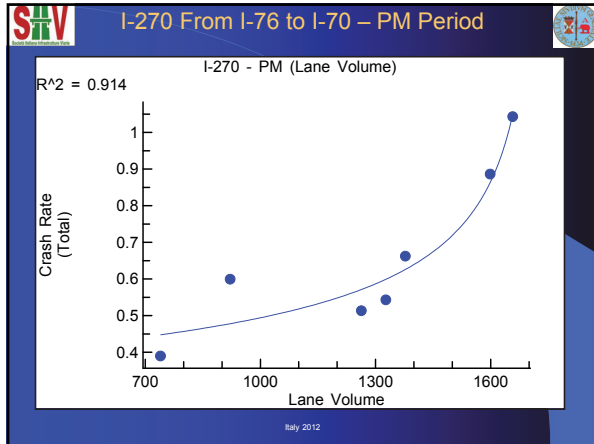


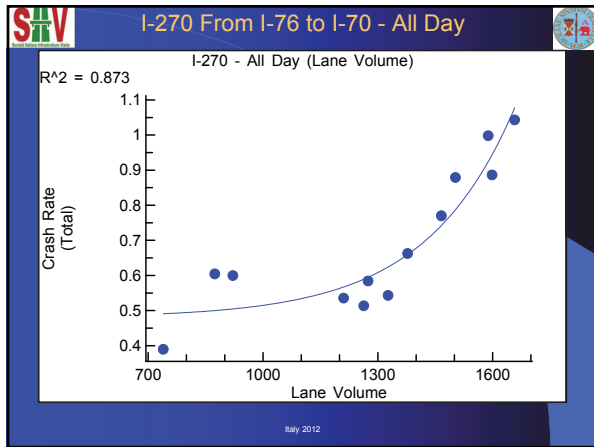


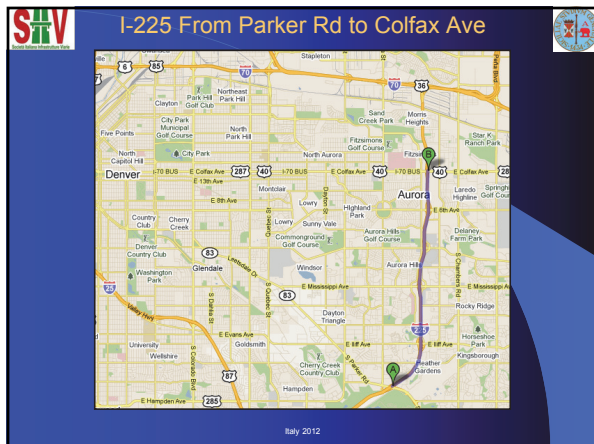


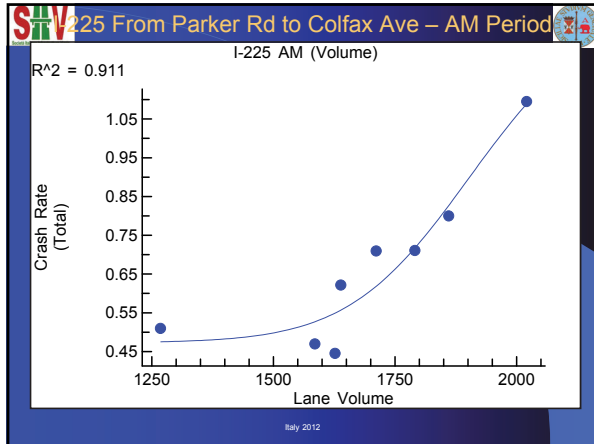


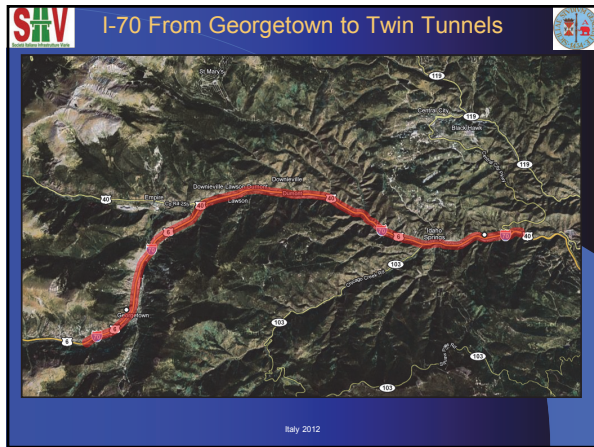


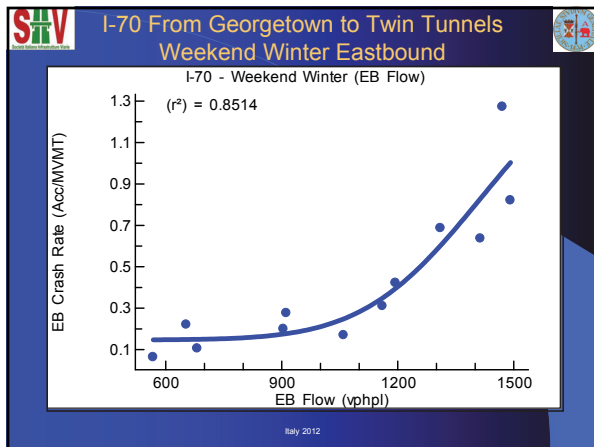


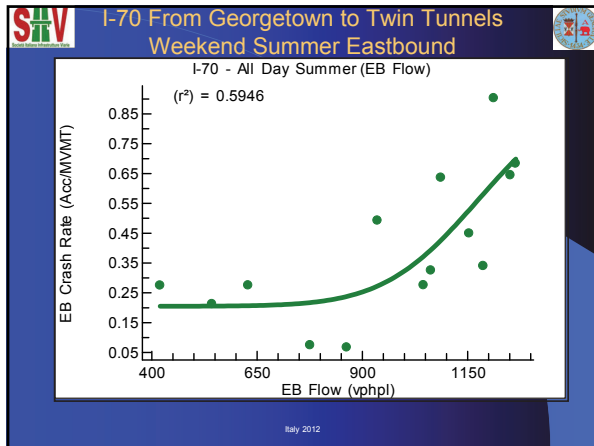


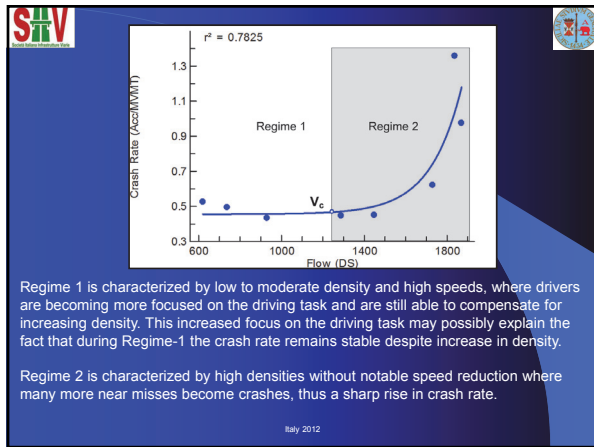






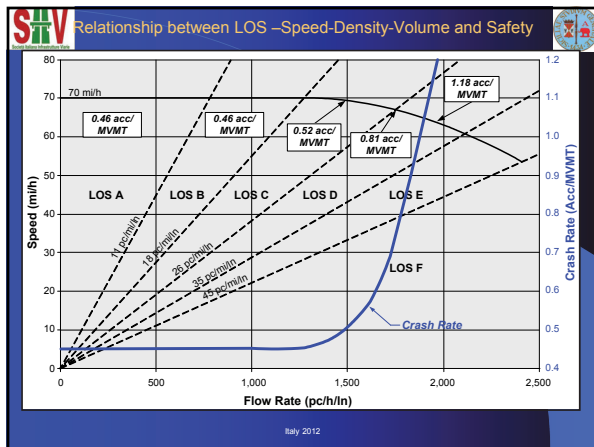


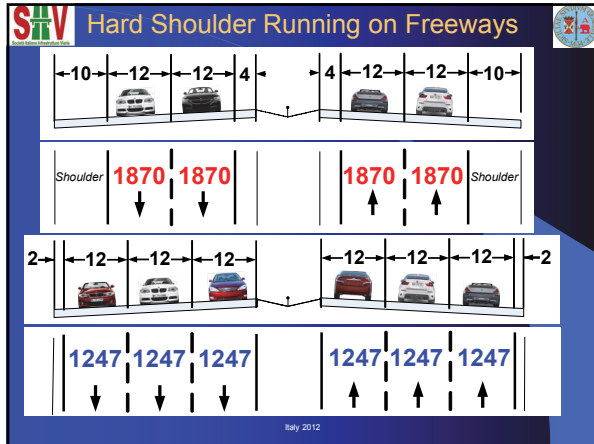


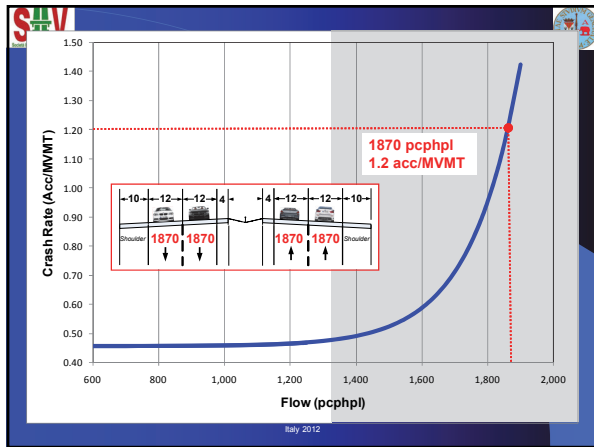


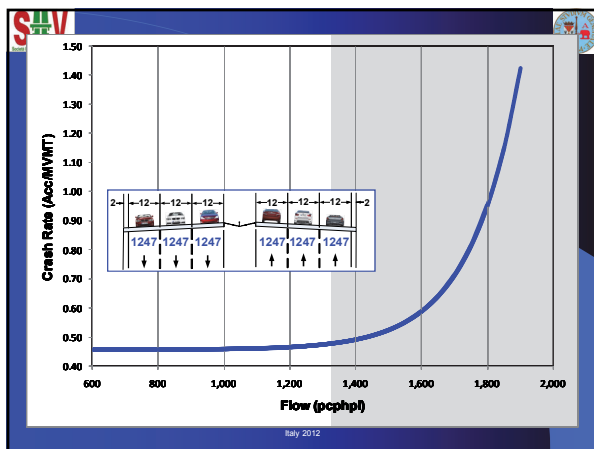
Regime 1 is characterized by low to moderate density and high speeds, where drivers are becoming more focused on the driving task and are still able to compensate for increasing density. This increased focus on the driving task may possibly explain the fact that during Regime-1 the crash rate remains stable despite increase in density.

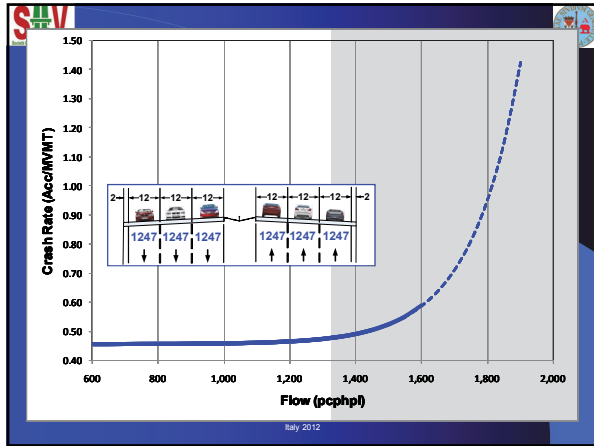
Regime 2 is characterized by high densities without notable speed reduction where many more near misses become crashes, thus a sharp rise in crash rate.

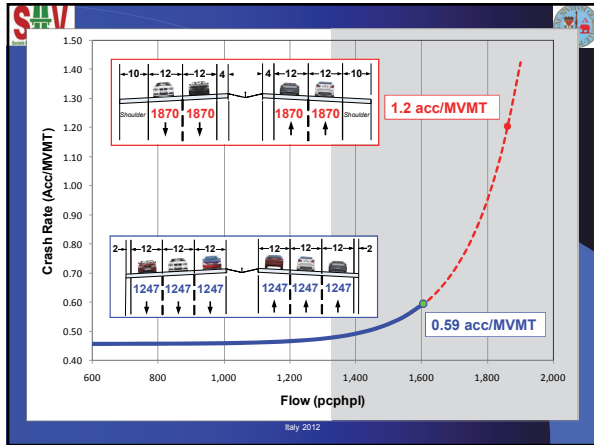


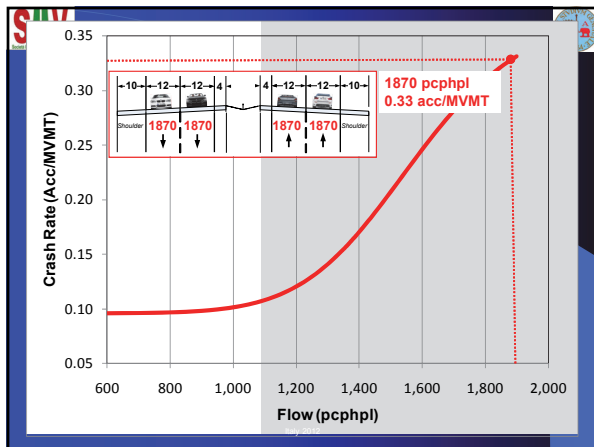


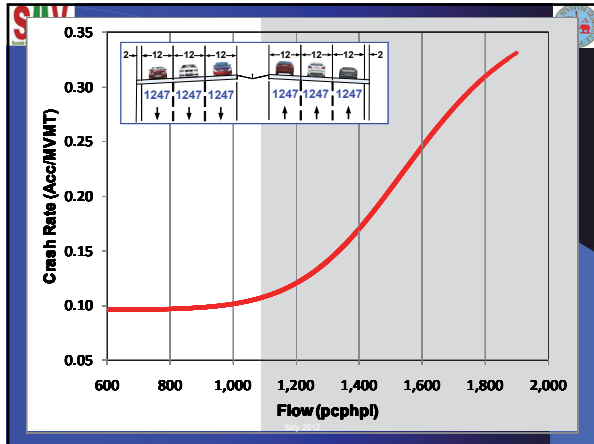


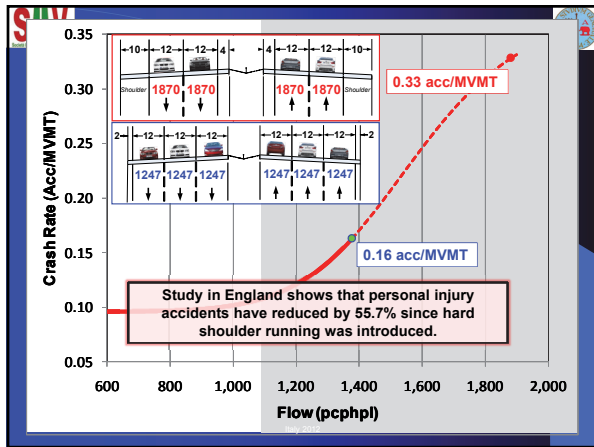












STV

Deployment of Hard Shoulder Running on Freeways

- HSR deployment consists of gantries, loops in pavement, VMS boards and cameras
- Formalized incident management plan
- Intensified presence of courtesy patrol
- Construct pull-outs at strategic locations
- Public education campaign
- Lower speed limit during peak periods

Italy 2012

STV Expected Safety, Mobility and Environmental Benefits from Hard Shoulder Running on 4-Lane Freeways

- Significant travel time reduction in the 30-50% range during congested periods due to lower density
- Travel time savings due to fewer incidents
- Improved Travel Time Reliability
- Significant crash reduction in the 50% range during peak periods
- Air quality improvements:
 - Due to shorter travel times
 - Less idling in traffic
 - More efficient vehicle use at free-flow rather than stop and go traffic.

Italy 2012

