

Secondary Crashes and Causal Factors: A Quantitative Investigation

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ATTIKES DIADROMES

Incidents in Freeways

- Incidents or “non recurrent events” in freeways significantly
 - decrease freeway network efficiency
 - increase the risk for secondary crashes



Secondary Crashes

- Crashes that occur in the temporal and spatial vicinity of a primary crash
 - for example in the back of a queue formed as a consequence of a primary crash



Secondary Crashes

- Secondary Crash likelihood can be lowered by
 - efficient incident management systems should
 - apply well defined protocols for the rapid incident response, system clearance and congestion alleviation.



Previous Research

Fixed spatial and temporal thresholds

- 15 min duration plus clearance time and less than 1,6 km upstream from the primary accident

a comprehensive definition of secondary accident involving queues

- no investigation of causal factors

logistic regression models for causal investigation of factors influencing secondary crashes likelihood

- using fixed threshold
- no traffic related information for extracting secondary accident data



The scope

- Define the upstream influence area from a crash by taking into account crash and traffic related information
 - Identify crash and traffic determinants that increase the likelihood of a secondary accidents

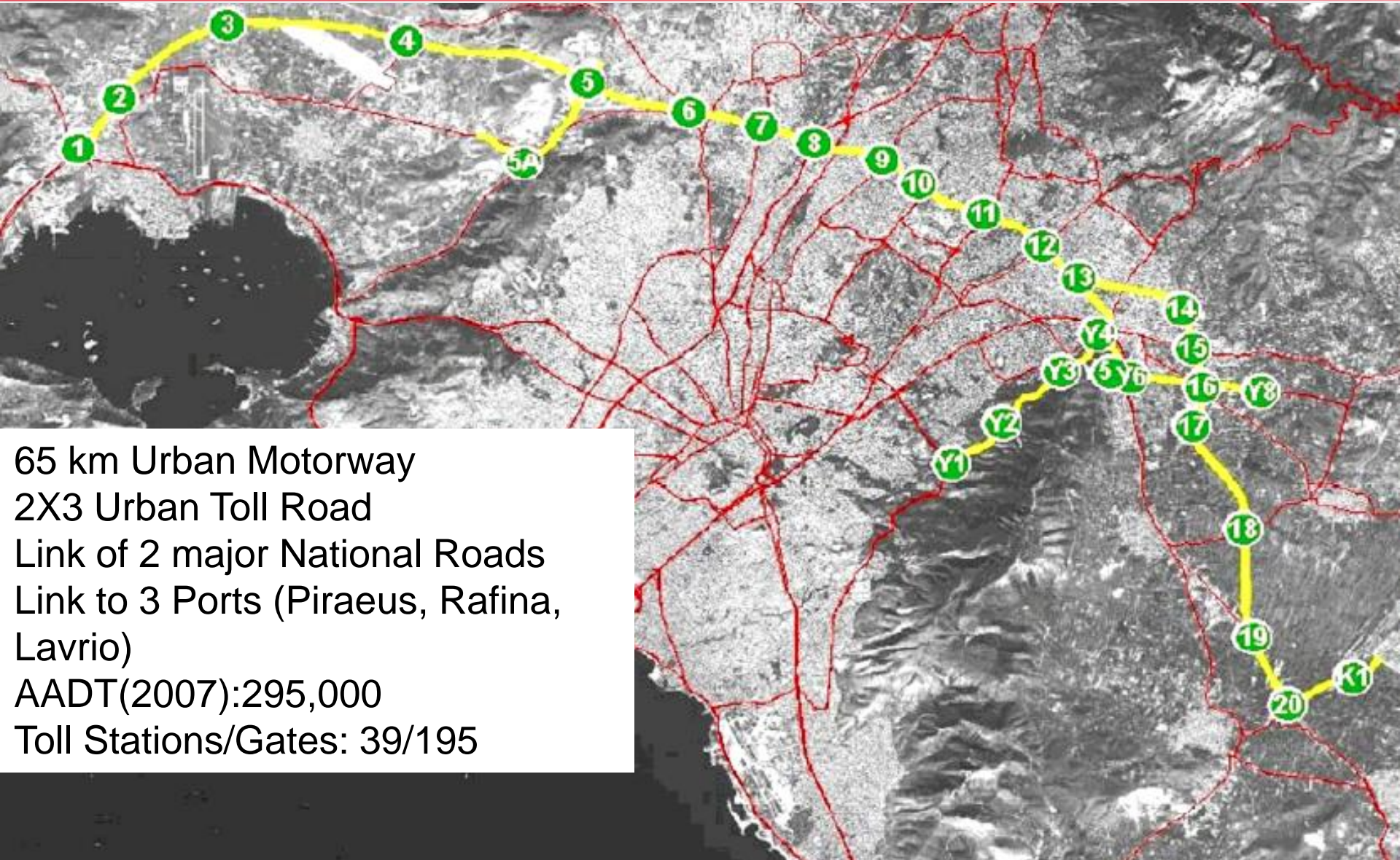


Methodology

- Scope:
 - reveal relations between the characteristics of a primary crash and different distance ranges of secondary from the primary crash.
- Bayesian Networks
 - account for the uncertainty in the defining the spatio-temporal influence of incidents in freeways.



Attica Tollway



65 km Urban Motorway
2X3 Urban Toll Road
Link of 2 major National Roads
Link to 3 Ports (Piraeus, Rafina,
Lavrio)
AADT(2007):295,000
Toll Stations/Gates: 39/195

Attica Tollway

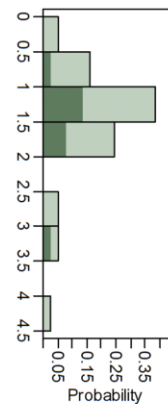
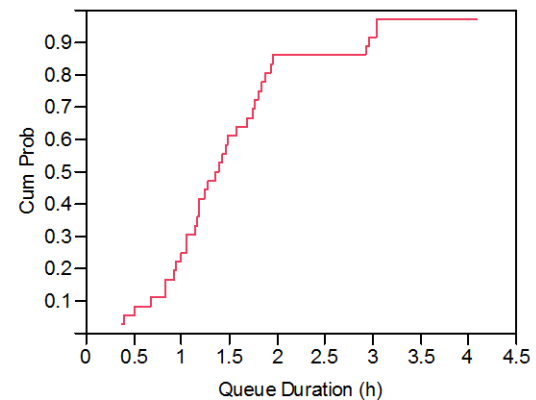
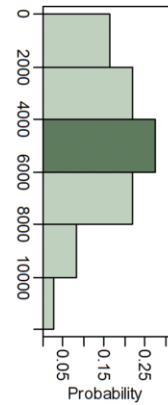
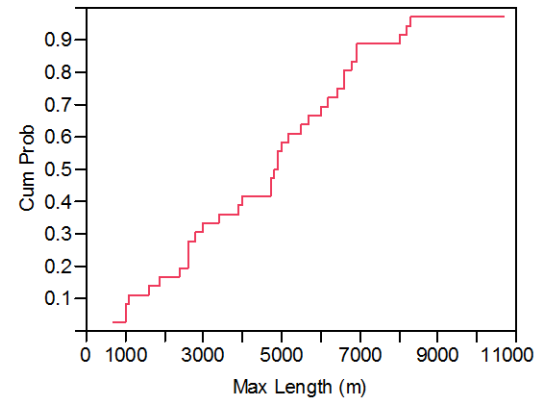
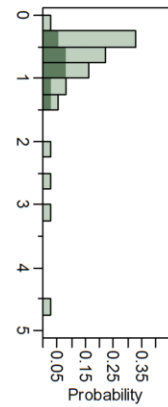
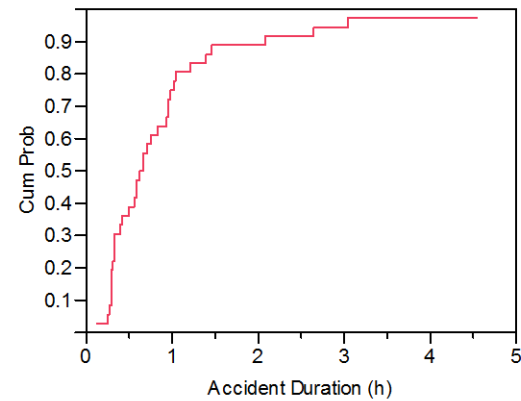
Incident Detection Systems

- Over 200 Color CCTV cameras controlled by TMC
- Inductive loops (traffic volume, occupancy, speed)
- Algorithms for automatic detection of incidents, queues, travel time estimation
- ERT (Emergency Roadside Telephones)
- Full mobile telephone coverage
- Emergency phone number (“1866”)
- Over-height vehicle detection system at entrance points
- CO/opacity detectors in tunnels and cut & covers
- 11 Meteorological Stations (temperature, wind, humidity etc.)

Accident duration, maximum queue length and queue duration distributions and cumulative distributions

accidents of up to 1.5 hours duration may have negative traffic impacts reflected to queue formation upstream of the primary accident location.

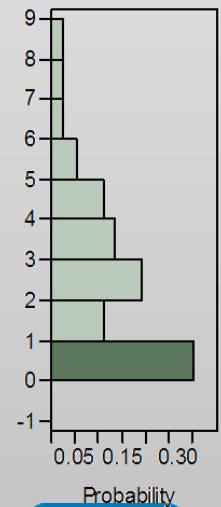
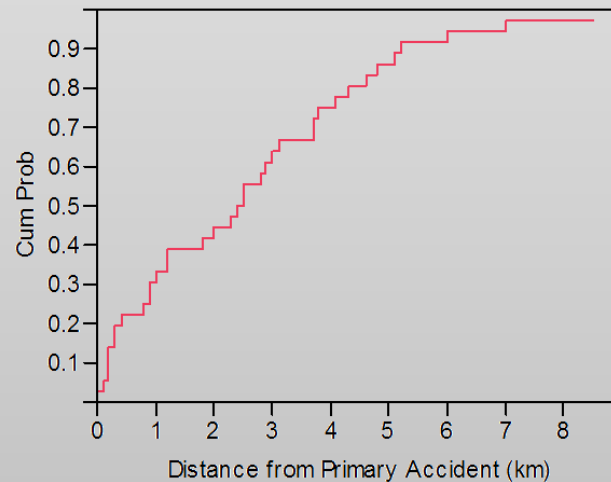
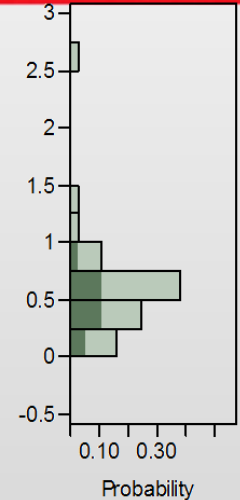
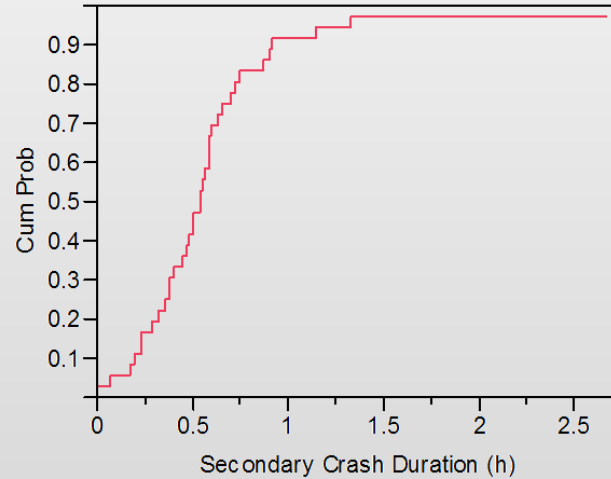
This queue may last up to 3.5 hours and has a maximum length ranging from 4 km to 6 km.



Secondary Crashes in Attica Tollway

16% of the crashes may be attributed to a primary crash and thus be characterized as secondary.

This percentage is relative high when compared to the one observed in Los Angeles freeways; previous research have reported that up to 8.8% of the crashes may be confirmed as secondary (Moore et al. 2004).



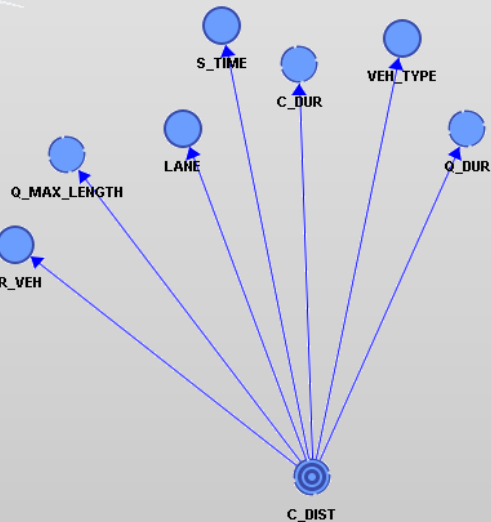
Crash and Queue characteristics

Characteristic	Values	Description
<i>S_TIME</i>	hour	Start time of the primary crash occurrence
<i>NR_VEH</i>	1, 2 , more than 2	Number of vehicles involved to the crash
<i>C_DIST</i>	km	Distance between consecutive crashes
<i>C_DUR</i>	hour	Total duration of the crash
<i>VEH_TYPE</i>	(a) passenger cars (PC), (b) power-two-wheelers (PTW), (c) Taxis and (d) Trucks/Buses.	Type of the vehicle that caused the crash
<i>LANE</i>	left lane (LL), the middle (ML), right (RL), emergency (EL), more than one (MTL)	Location of the crash
<i>Q_MAX_LENGTH</i>	km	
<i>Q_DUR</i>	hour	
<i>D_WEEK</i>	Weekday(WD), weekend(WE)	



Results

Overall relationship between the traffic related and accident related characteristics (children) and distance of the secondary to the primary crash (parent).



Parent	Child	Mutual information	Relative Significance
C_DIST	Q_MAX_LENGTH	0.69	1.00
	Q_DUR	0.639	0.92
	C_DUR	0.458	0.66
	VEH_TYPE	0.261	0.37
	S_TIME	0.211	0.30
	NR_VEH	0.143	0.20
	LANE	0.111	0.11



Results

Type I C_Dist <=1.4 (41.18%)					Type II C_Dist <=4.079 (20.59%)				
Node	Mutual Information(%)	Relative significance	Modal Value		Node	Mutual Information (%)	Relative significance	Modal Value	
Q_MAX_LE NGTH	26.68%	1	<=1948.333	35.71%	Q_MAX_LE NGTH	39.38%	1	<=4391.667	28.57%
Q_DUR	16.87%	0.63	<=1.071	28.57%	Q_DUR	26.20%	0.67	<=1.071	28.57%
C_DUR	14.11%	0.53	<=0.36	21.43%	VEH_TYPE	25.52%	0.65	PC	57.14%
LANE	7.84%	0.29	LL	72.73%	C_DUR	20.65%	0.52	<=0.36	42.86%
VEH_TYPE	5.30%	0.20	PC	71.43%	NR_VEH	4.83%	0.12	more than 2	71.43%
S_TIME	3.53%	0.13	Off peak	42.86%	S_TIME	4.70%	0.12	Morning peak	42.86%
NR_VEH	0.22%	0.01	more than 2	53.85%	LANE	3.30%	0.08	LL	71.43%
Type III C_Dist >4.079 (20.59%)					Type IV C_Dist <=2.768 (17.65%)				
Node	Mutual Information(%)	Relative significance	Modal Value		Node	Mutual Information (%)	Relative significance	Modal Value	
Q_DUR	45.03%	1	<=1.41	28.57%	Q_DUR	27.79%	1	<=1.796	33.33%
Q_MAX_LE NGTH	26.37%	0.59	<=7780	28.57%	S_TIME	27.32%	0.98	Off peak	66.67%
C_DUR	24.25%	0.54	<=0.36	57.14%	Q_MAX_LE NGTH	23.40%	0.84	<=3315	33.33%
VEH_TYPE	6.28%	0.14	PC	71.43%	C_DUR	20.90%	0.75	>2.007	33.33%
NR_VEH	4.83%	0.11	more than 2	71.43%	NR_VEH	14.83%	0.53	2	66.67%
LANE	4.02%	0.09	LL	42.86%	VEH_TYPE	12.13%	0.44	PC	66.67%
S_TIME	3.87%	0.08	Afternoon peak	42.86%	LANE	2.09%	0.075	LL	50.00%



Results

- the most significant determinants
 - queuing conditions information, as described by the maximum queue length and queue duration
 - the primary crash duration
- secondary crash likelihood is strongly related to primary crashes involving 2 or more vehicles in the left lane, caused by PCs



Results

- 4 types of influence areas upstream of a crash
- traffic conditions when the primary crash occurs are a crucial determinant during peak periods
- crash duration is significant, especially during off peak periods

