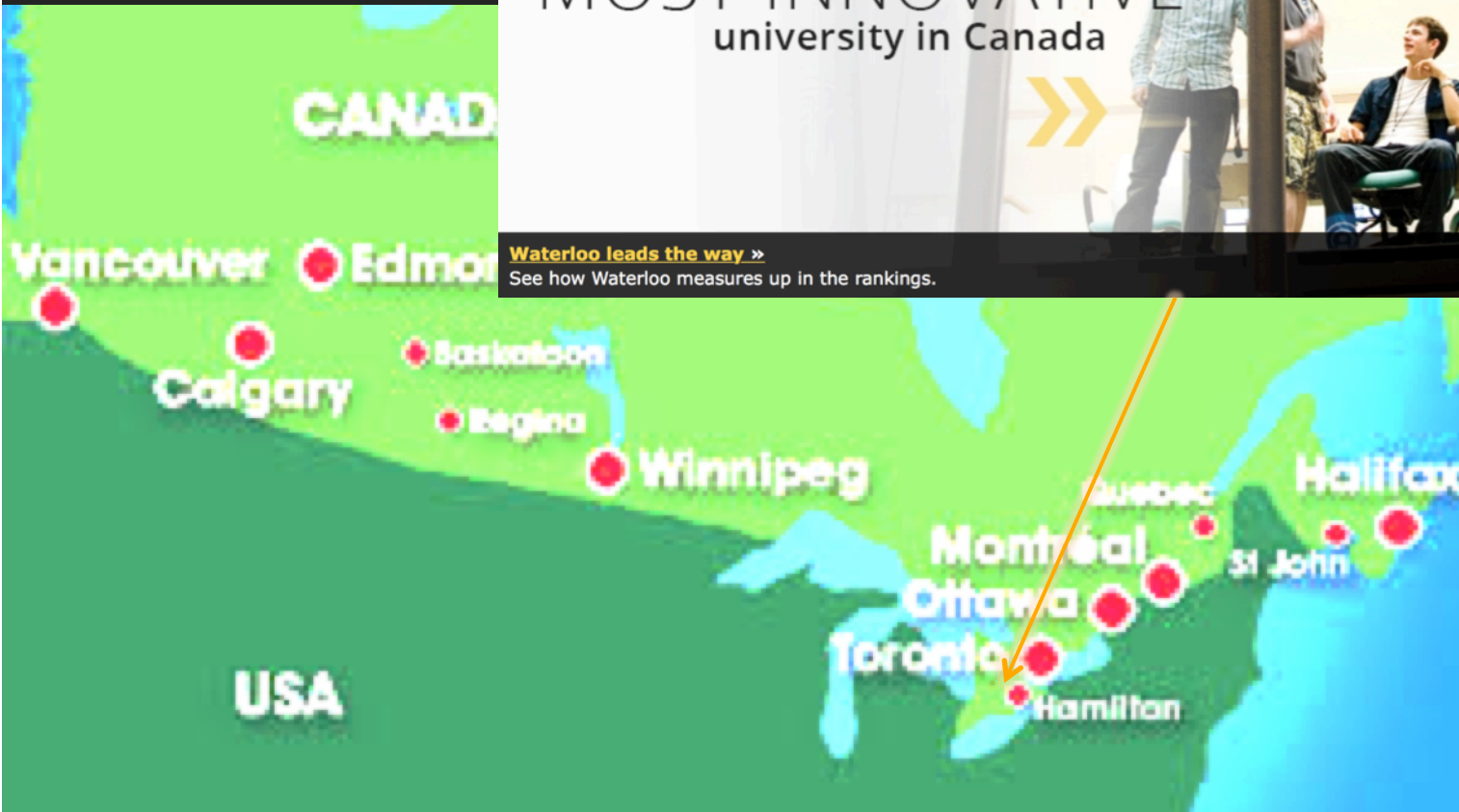


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MOST INNOVATIVE
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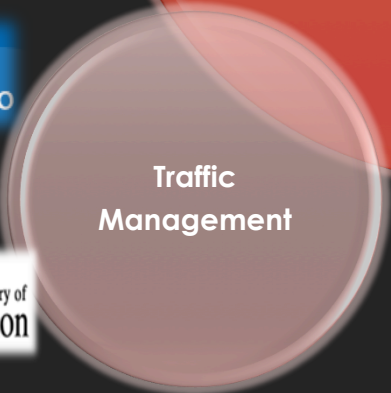


Transportation Safety



Division of METROLINK

iTSS Lab
UNIVERSITY OF
Waterloo



QUANTIFICATION OF WINTER DRIVING RISK: MODELS AND APPLICATIONS

Liping Fu, PhD, Professor,
Civil & Environmental Engineering, University of Waterloo

Lalita Thakli, Taimur Usman, Tae Kwon, Max Perchanok







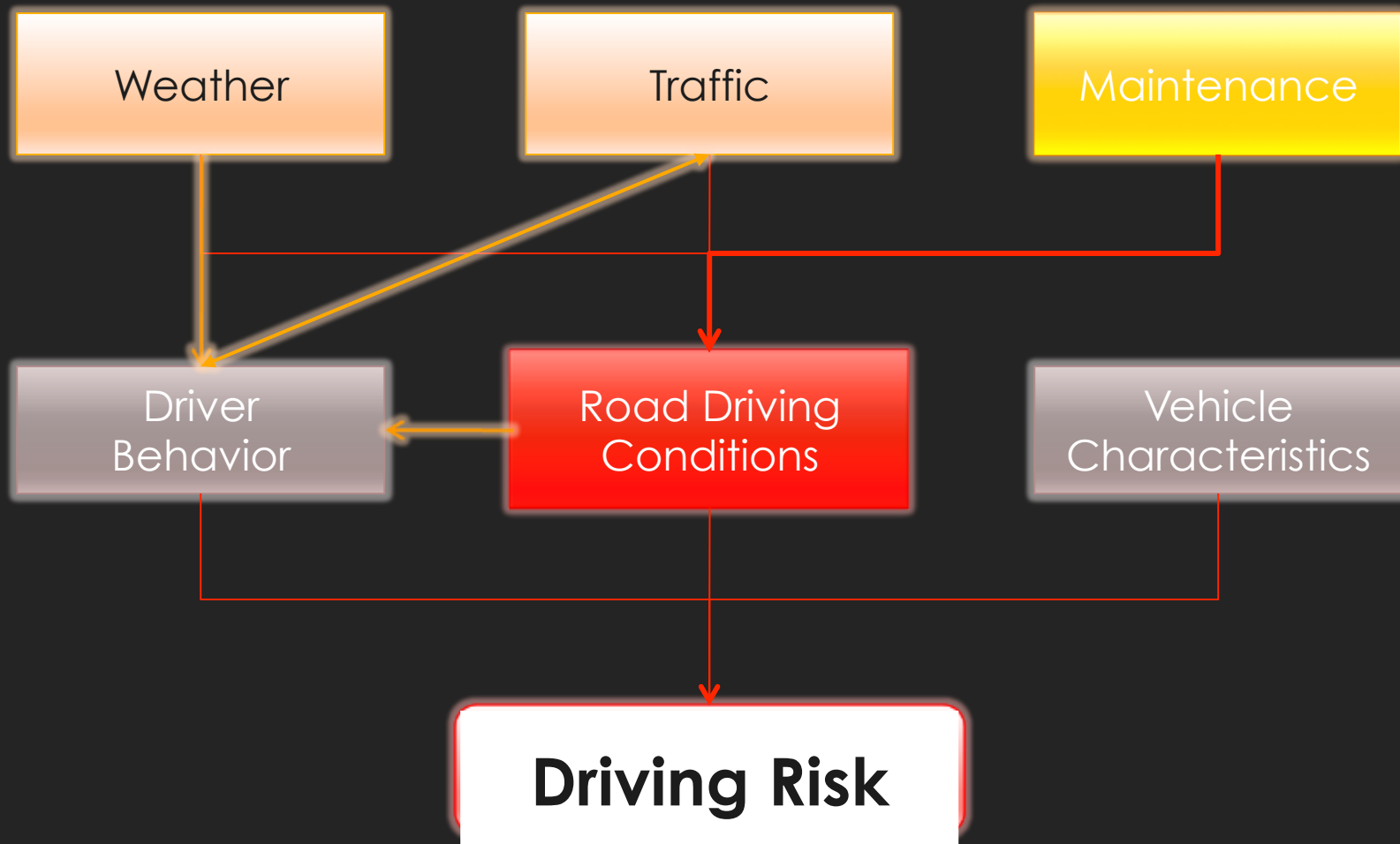
{Winter Driving} Risk?

“ The possibility that something bad or unpleasant (such as an injury or a loss) will happen ” - Webster

when driving under adverse winter weather conditions

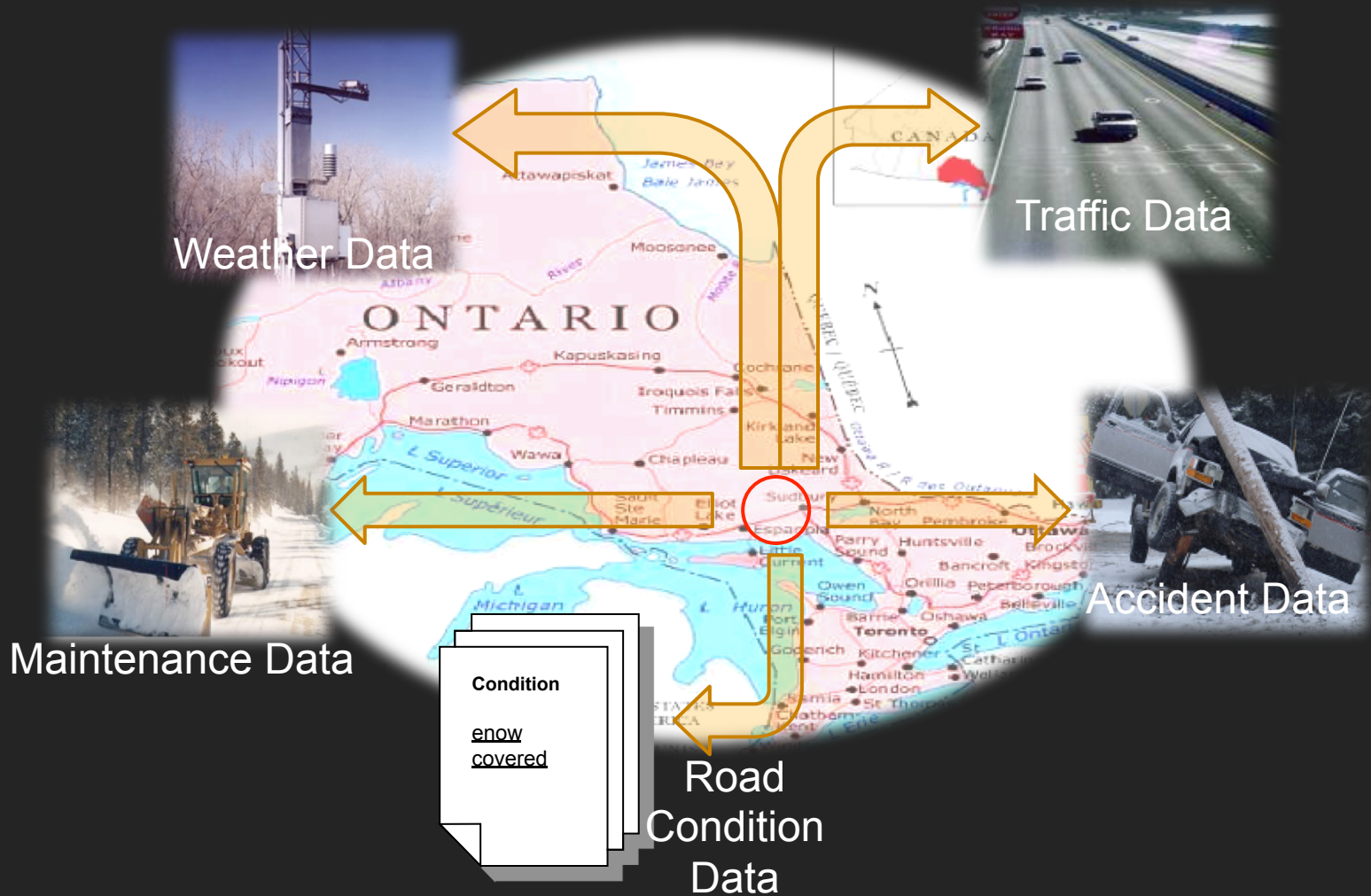


Factors Affecting Winter Road Driving Risk



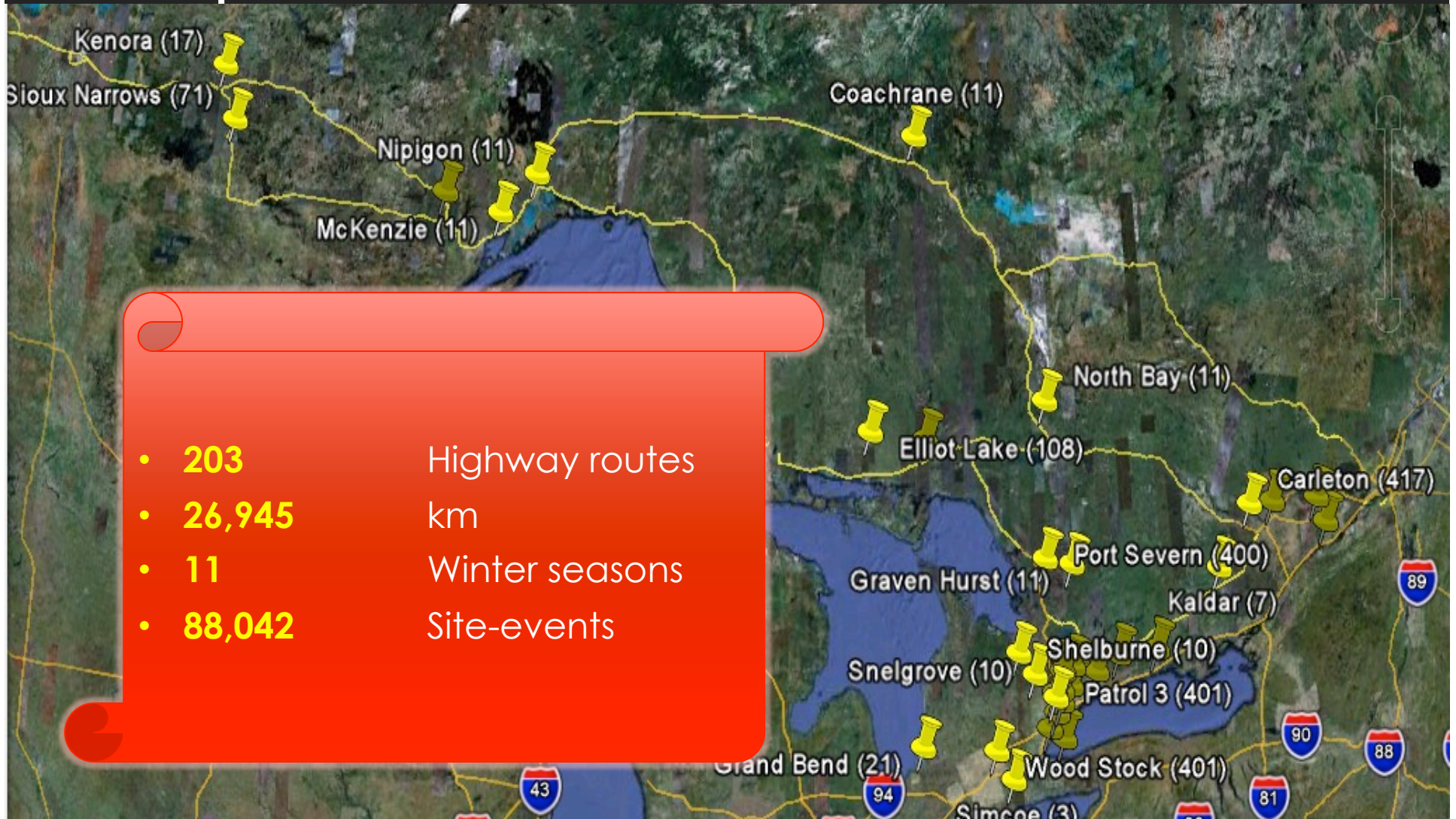


Quantification of Risk: Observational Study...





Observational Study: Study Sites ...



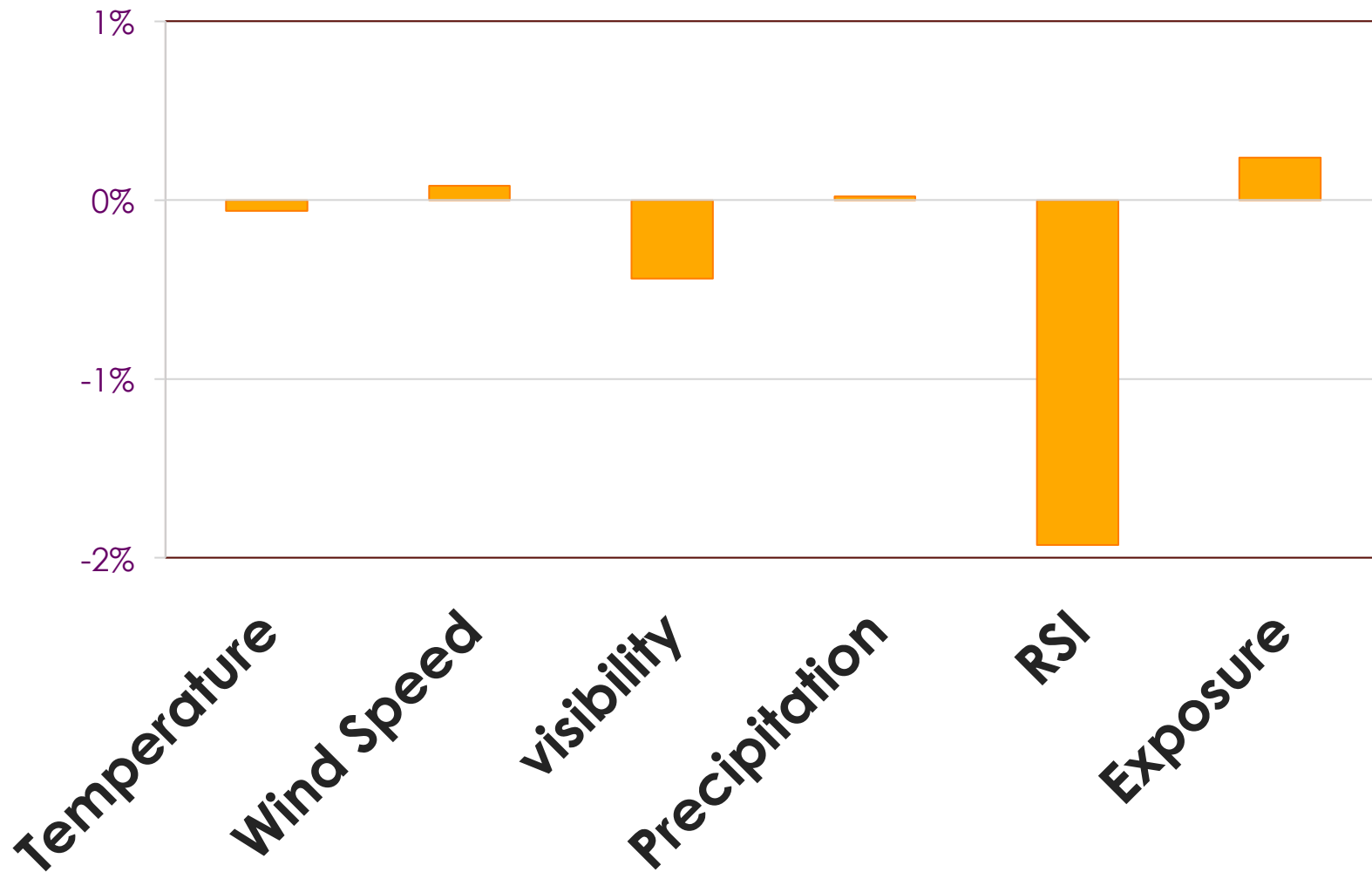
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	
1	Date	EventDura	Viskm	WindSpee	Air_temp	Ppt (0.1 cr	Weather_c	Road_surf	AccuCode	OperCode	Anti_icing	Accidents	DAYWEK	LIGHT	Patrol_Nur	Patrol_Len	Traffic_Vol	No_Sandir	No_Salting	No_Sandir	No_Plows	No_Sandir	No_Salting	No_Sandir	Exposure	LnEx	
2	14/11/2003	19	12.9	37.68	-0.54	28.37	2	0.942	0	0	0	9	4	8	2	28	386462	0	0	0	0	0	0	0	0	10.82094	2.38
3	14/11/2003	6	11.4	15	1.2	7	2	0.9205	0	0	0	5	5	1	2	28	181250	0	0	0	0	0	0	0	0	5.075	1.62
4	25/11/2003	5	14.5	20.6	-0.52	4	2	0.8938	0	0	0	12	2	8	2	28	23912	0	0	0	0	0	0	0	0	0.669536	-0.4
5	28/11/2003	3	9.67	18	2.1	10	2	0.897	0	0	0	0	0	0	2	28	85756	0	0	0	0	0	0	0	0	2.401168	0.87
6	29/11/2003	13	2.62	29.15	0.2	17.69	2	0.896	0	0	0	0	0	0	2	28	11161	0	1	0	0	0	0	0	0	4.624508	1.5
7	01/12/2003	2	20.1	16	0.9	10	2	0.9299	0	0	0	0	0	0	2	28	378	0	0	0	0	0	0	0	0	1.186584	0.17
8	01/12/2003	2	21.7	19	1	10	2	0.9539	0	0	0	0	0	0	2	28	947	0	0	0	0	0	0	0	0	1.426516	0.35
9	02/12/2003	20	13.62	14.75	-5.06	27	2	0.6961	0	0	0	24	3	3	2	28	3059	1	0	1	0	0	0	4	0	9.885652	2.29
10	12/12/2003	4	24.1	17.25	-3.1	2	2	0.9871	0	2	0	0	0	0	2	28	65344	0	1	0	0	0	0	0	0	1.829632	0.60
11	12/12/2003	8	15.09	13.5	-2.48	4	2	0.946	0	1	0	3	5	1	2	28	161247	0	2	0	0	0	0	0	0	4.514916	1.50
12	13/12/2003	7	14.13	1.71	-7.44	2	2	0.8	0	2	1	0	0	0	2	28	63285	0	1	0	0	0	0	0	0	1.77198	0.57
13	13/12/2003	2	24.1	0	-7.75	2	2	0.8	0	2	0	0	0	0	2	28	26426	0	0	0	0	0	0	0	0	0.739928	-0
14	15/12/2003	26	5.37	12.5	-2.62	49.08	2	0.4	0	4	0	2	6	2	2	28	375894	0	0	0	0	2	3	0	0	10.52503	2.35
15	17/12/2003	2	10.5	17	1.15	24	2	0.918	0	0	0	0	0	0	2	28	60093	0	0	0	0	0	0	0	0	1.682604	0.52
16	17/12/2003	3	11.8	19.33	1.43	24	2	0.9453	0	0	0	0	0	0	2	28	84873	0	0	0	0	0	0	0	0	2.376444	0.86
17	18/12/2003	12	15.61	18.83	-1.13	15.67	2	0.41	0	2	0	0	0	0	2	28	210778	1	2	0	0	0	0	0	0	5.901784	1.77
18	18/12/2003	2	21.7	23	-4.05	4	2	0.9435	0	0	0	0	0	0	2	28	60266	0	0	0	0	0	0	0	0	1.687448	0.52
19	19/12/2003	4	10.85	11	-0.6	4	2	0.9279	0	6	0	4	5	5	2	28	124739	0	0	0	0	0	0	1	0	3.492692	1.25

Statistical Modelling of Risk

$$\begin{aligned}
 \ln(\text{Risk}) = & \beta_0 + \beta_1 \text{RoadSurface} \\
 & + \beta_2 \text{Visibility} \\
 & + \beta_3 \text{Precipitation} \\
 & + \beta_4 \text{Temperature} \\
 & + \beta_5 \text{WindSpeed} \\
 & + \beta_6 \text{TrafficExposure}
 \end{aligned}$$

20	19/12/2003																										792	0.58	
21	20/12/2003																											108	0.30
22	30/12/2003																											032	1.21
23	02/01/2004																											578	0.14
24	02/01/2004																											424	0.87
25	05/01/2004																											266	2.33
26	06/01/2004																											412	1.00
27	08/01/2004																											084	2.16
28	08/01/2004																											912	1.70
29	12/01/2004																											775	2.83
30	12/01/2004																											616	1.3
31	13/01/2004																											988	1.78
32	13/01/2004																											648	0.35
33	16/01/2004																											191	3.48
34	18/01/2004																											796	1.95
35	18/01/2004																											692	-1.0
36	20/01/2004																											938	1.51
37	23/01/2004																											715	2.42
38	23/01/2004																											448	0.7
39	28/01/2004																											492	3.08
40	29/01/2004																											256	1.47
41	29/01/2004																											756	2.10
42	01/02/2004																											896	3.35
43	04/02/2004																											702	2.35
44	06/02/2004																											624	2.2
45	07/02/2004																											292	-0.4
46	10/02/2004																											596	1.51
47	10/02/2004																											006	0.80
48	11/02/2004	24	15.11	15.12	-4.32	1.5	2	0.9388	0	0	0	9	4	9	2	28	389728	0	0	0	0	0	0	0	0	0	14.78816	2.65	
49	12/02/2004	18	9.96	4.06	-3.11	6	2	0.9384	0	0	0	7	4	1	2	28	388317	0	0	0	0	0	0	0	0	0	10.87288	2.36	
50	14/02/2004	8	14.82	21.25	-5.45	6	2	0.9474	0	0	0	5	6	1	2	28	232554	0	0	0	0	0	0	0	0	0	6.511512	1.87	
51	20/02/2004	15	4.35	11.2	0.26	17.6	1	0.9635	0	0	0	4	5	1	2	28	210295	0	0	0	0	0	0	0	0	0	5.88826	1.77	
52	20/02/2004	3	4.27	18.33	-0.6	22	1	0.897	0	2	1	0	0	0	2	28	41449	0	2	0	0	0	0	0	0	0	1.160572	0.14	
53	21/02/2004	2	4.8	17	1.75	22	1	0.897	0	0	0	0	0	0	2	28	27544	1	0	0	0	0	0	0	0	0	0.771232	-0.2	
54	21/02/2004	3	8.57	22.67	1.7	22	2	0.897	0	1	0	0	0	0	2	28	41068	1	0	0	0	0	0	0	0	0	1.149904	0.13	
55	21/02/2004	9	4.48	26.89	-0.12	22	2	0.897	0	0	0	7	6	1	2	28	122175	0	0	0	0	0	0	0	0	0	3.4209	1.22	
56	22/02/2004	11	18.28	21.45	-1.74	7.45	2	0.8947	0	0	0	0	0	0	2	28	147787	0	0	0	0	0	0	0	0	0	4.138036	1.42	

Risk Effects of Some Major Factors





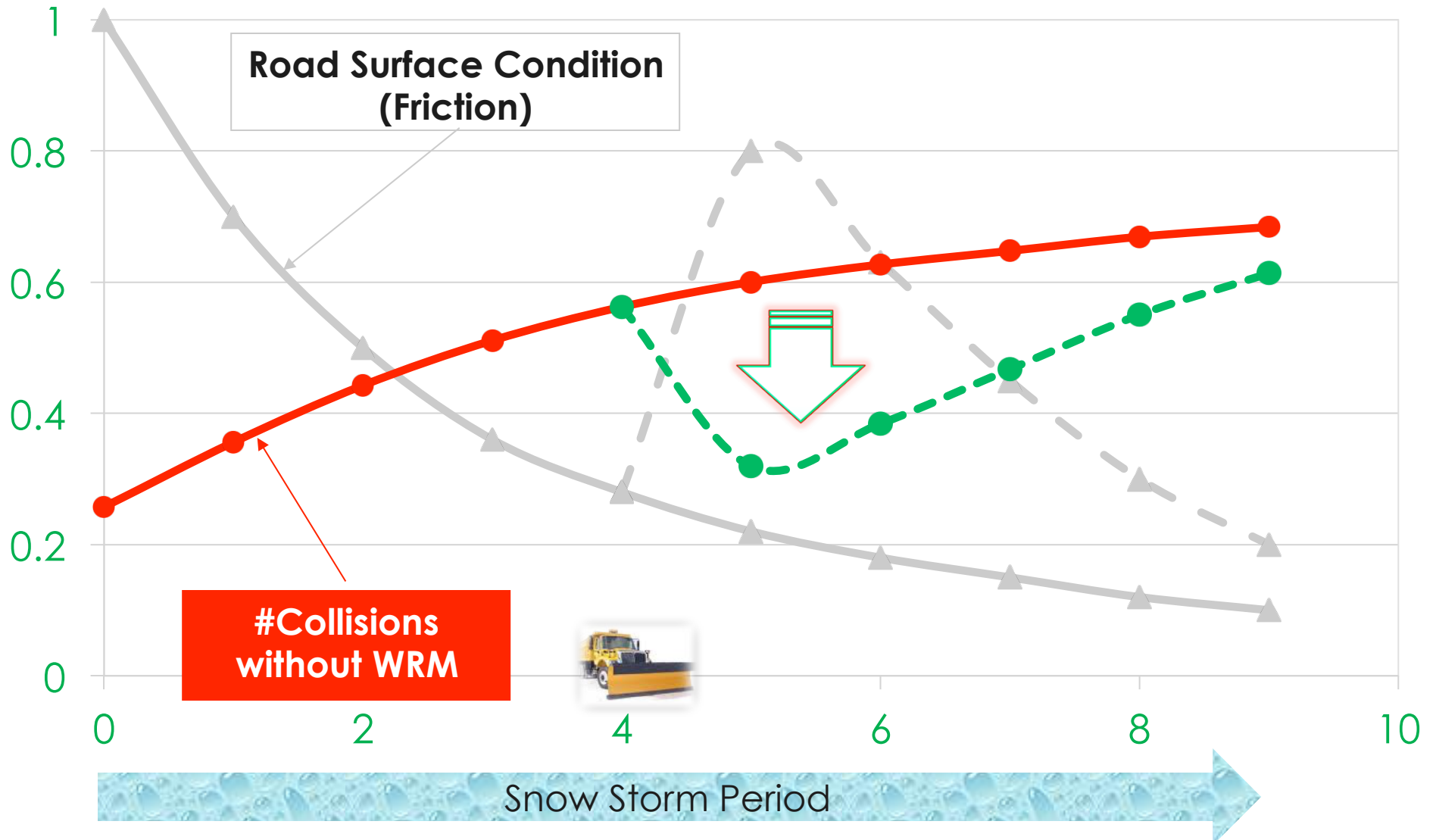
Applications of Driving Risk Models

- What-if Analysis of Alternative WRM Policies, Strategies, Methods
- Classification of RSC
- Setting Variable Speed Limits



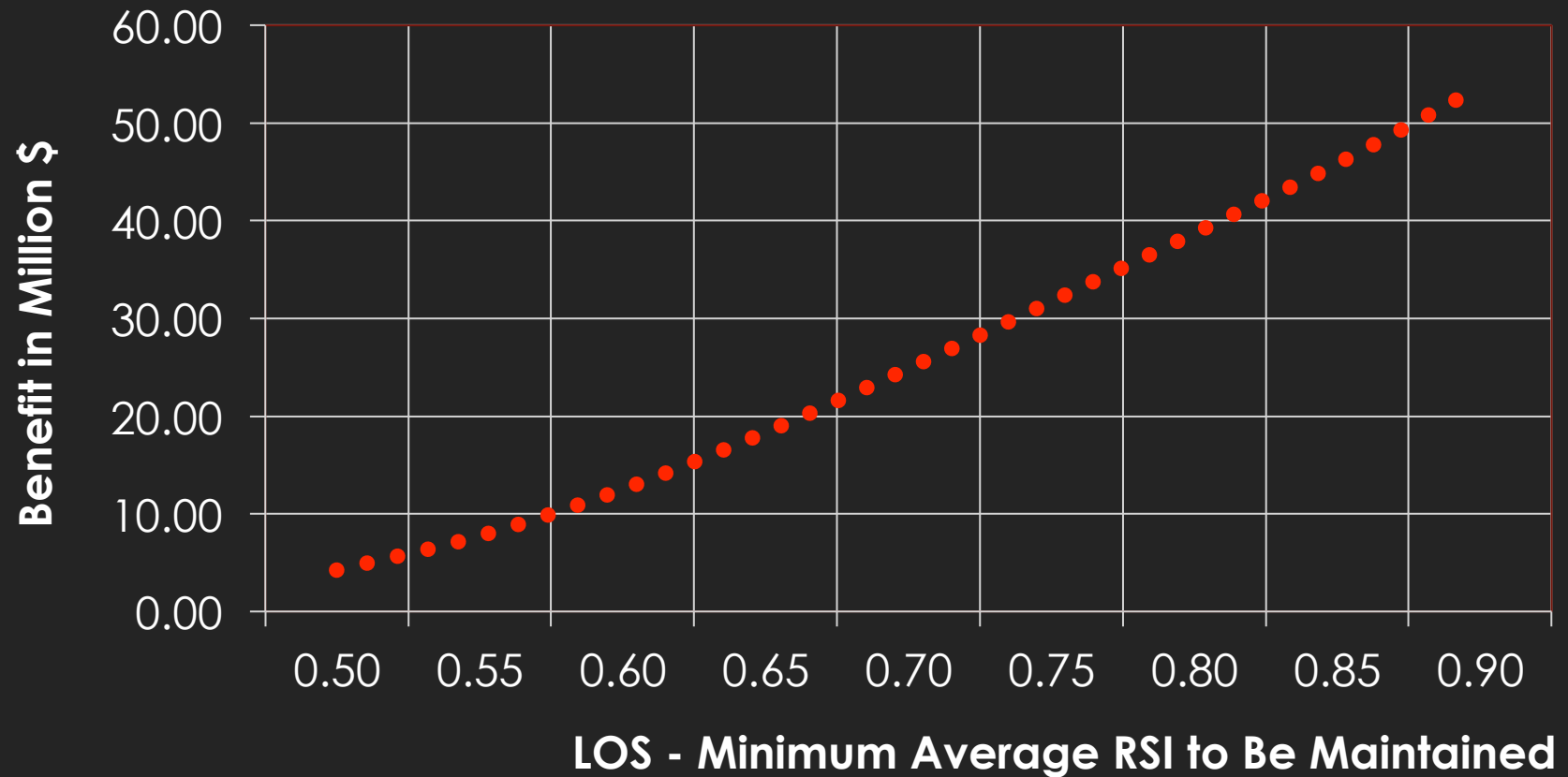
Application #1:

Effect of Treatment on Safety





Network Wide Safety Benefit of WRM (Ontario Network)





Application #2: Classification and Reporting of Road Surface Conditions

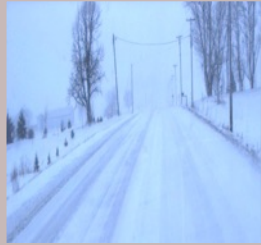


Winter RSC Classification/Reporting Practice

North Dakota



Compacted snow



Snow covered



Ice



Scattered snow



Frost



Wet/Slush



Dry

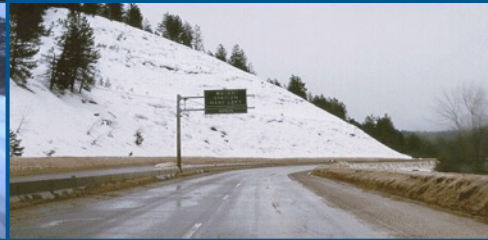
Missouri



covered



Partly covered



Wet



Dry

Ontario



Covered



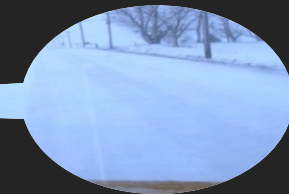
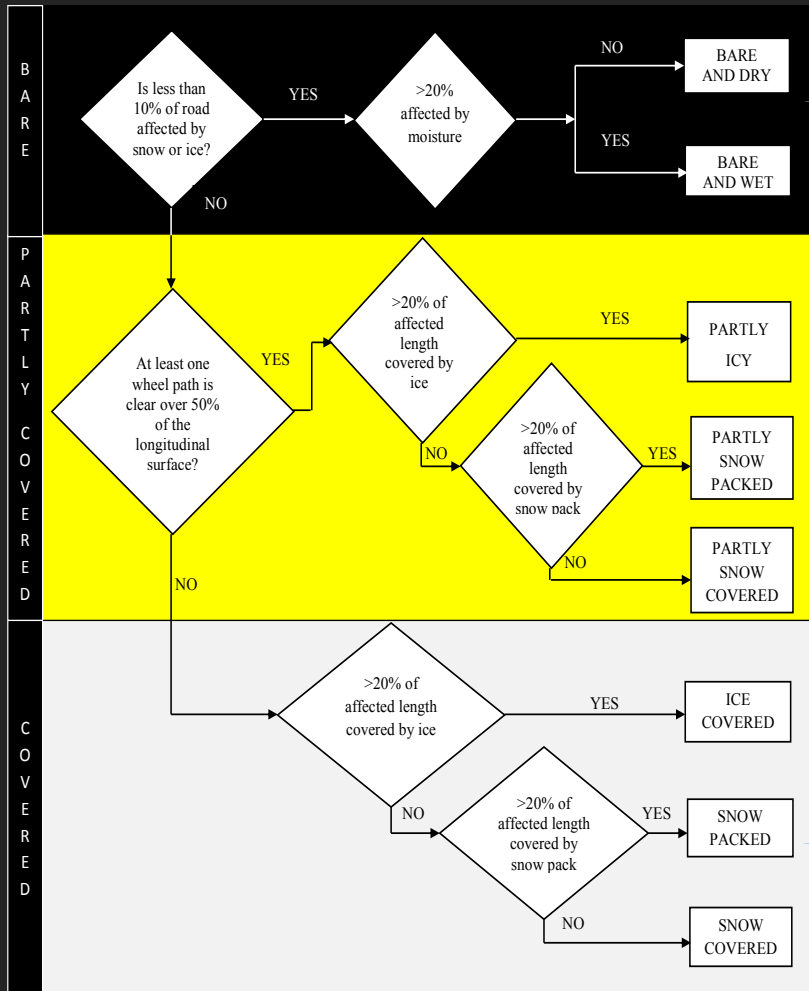
Partly covered



Dry



TAC's Method For RSC Classification

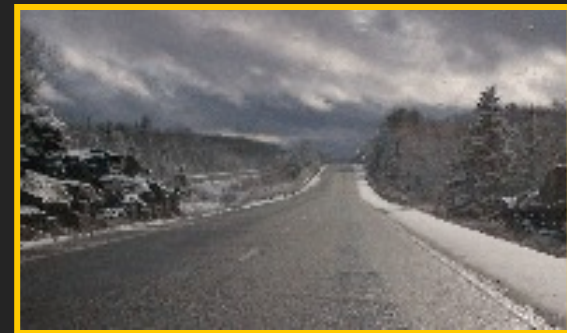




Risk-based Approach – Relative Risk Index (RRI)

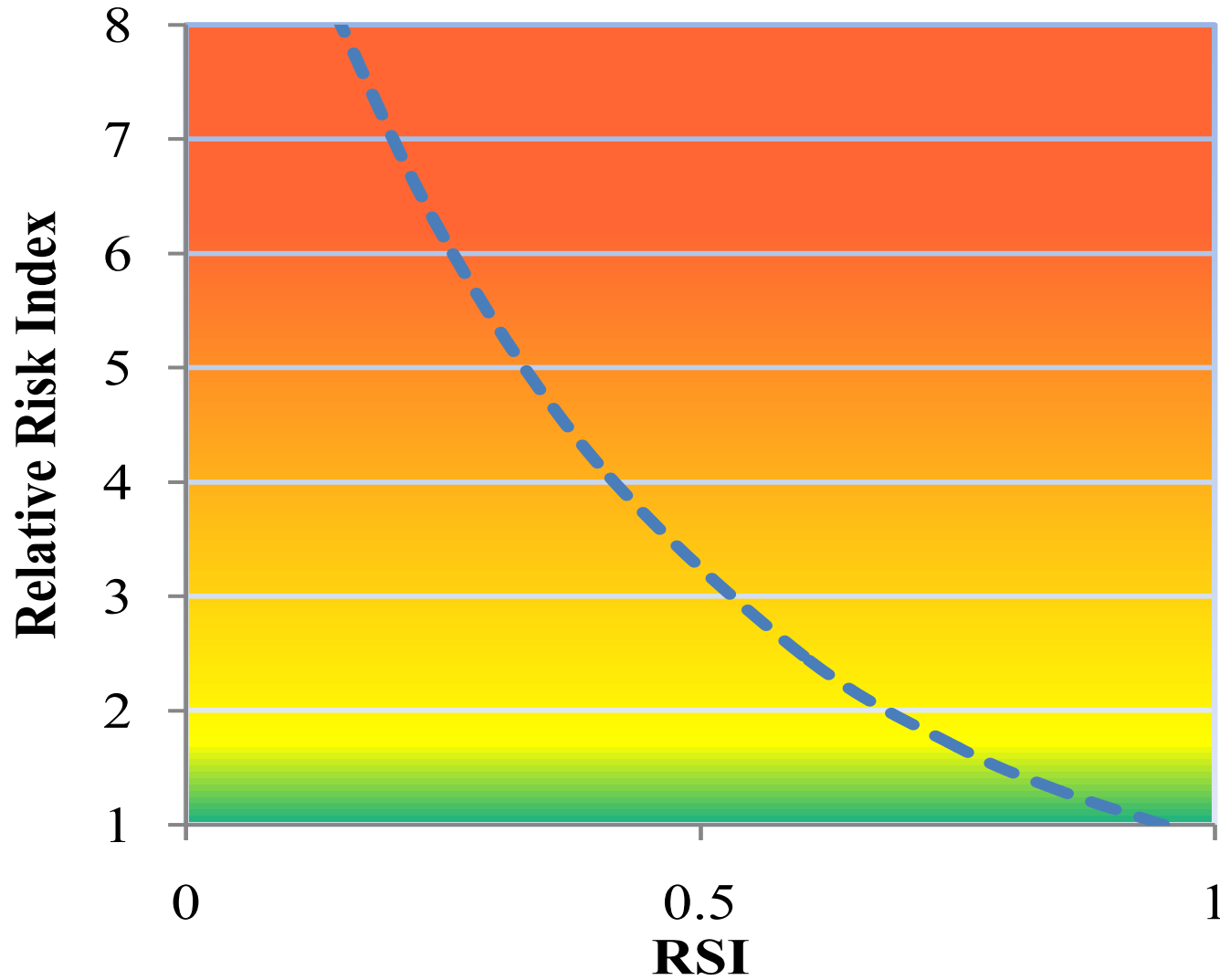
RRI =

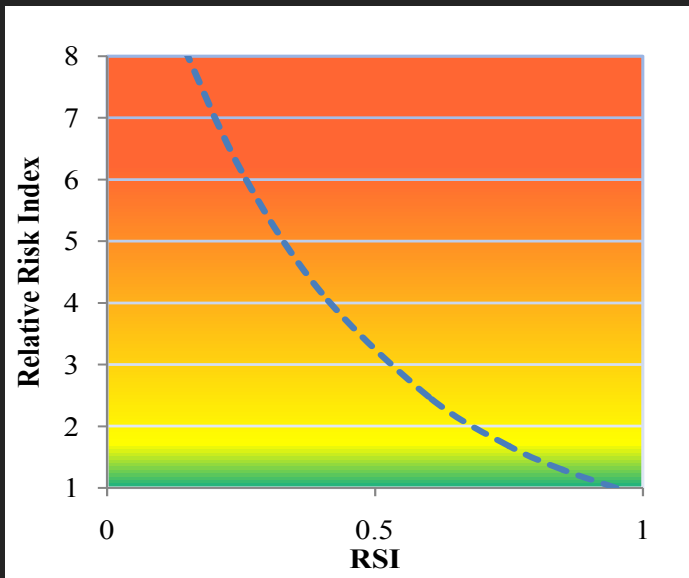
$$\frac{\text{Expected collisions in a given condition}}{\text{Expected collisions in a good condition}}$$



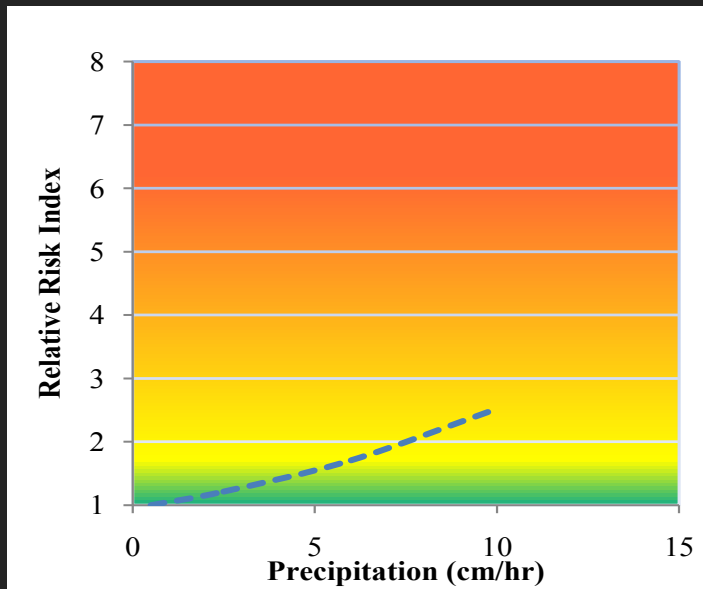
Risk Factor:

Relative Risk (RRI) vs. RSI

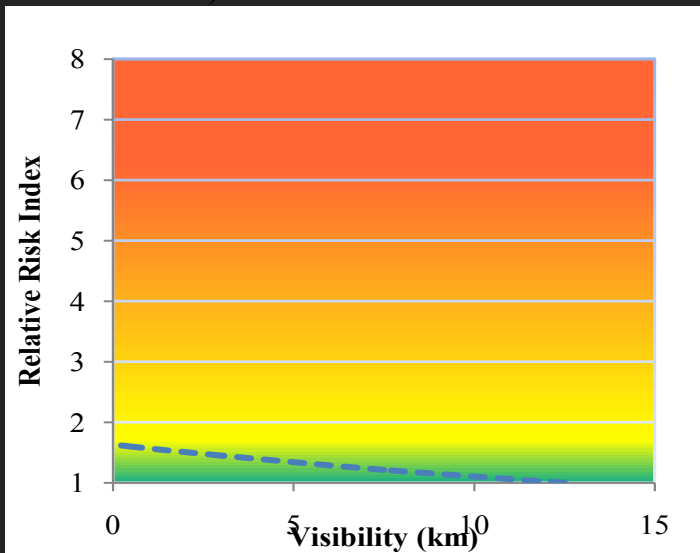




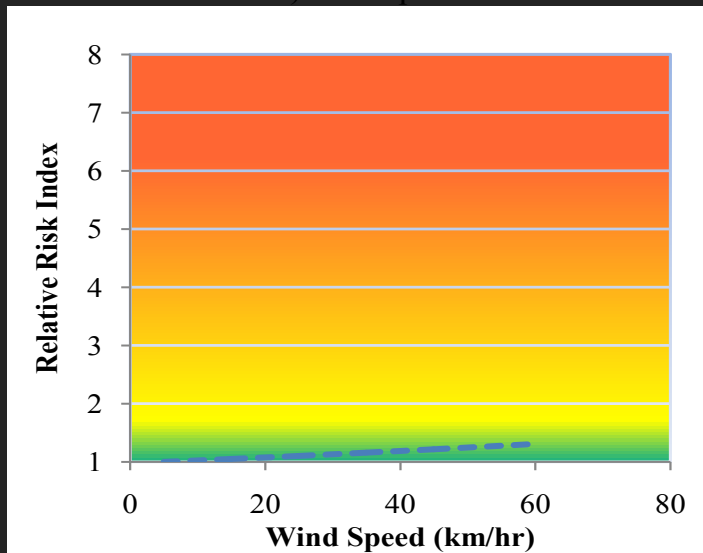
a) Road Surface Condition



b) Precipitation



c) Visibility



d) Wind Speed

Overall RSC of a Route



l_1, RRI_1

l_2, RRI_2

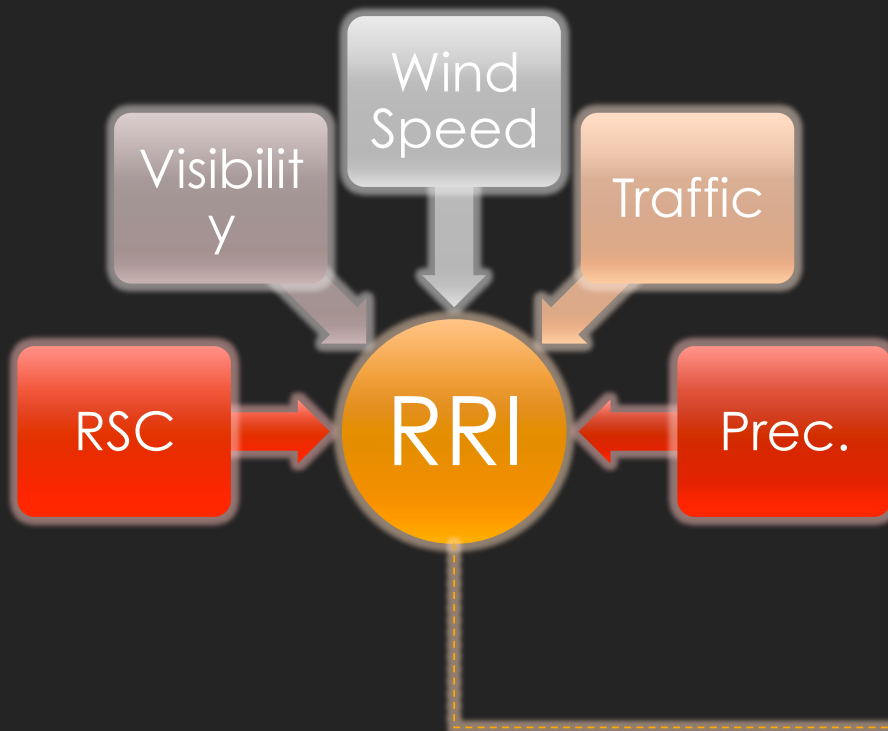
l_3, RRI_3

$$\overline{RRI} = \frac{\sum RRI_i * l_i}{\sum l_i}$$



Application #3:

Risk-based Approach to Setting Variable Speed Limit (VSL)





Remaining Challenges ...

- Improvement of risk models
- Transferability of risk models
- Driver's behavioral adaptation?
- Definition of risk thresholds