

Adapting Roadside Safety Analysis Program for Localized Conditions in Alaska

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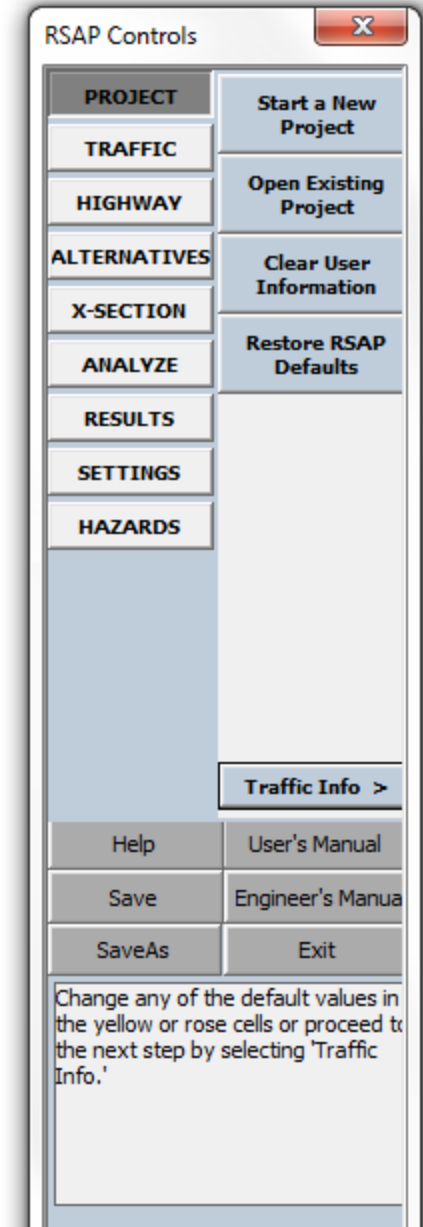
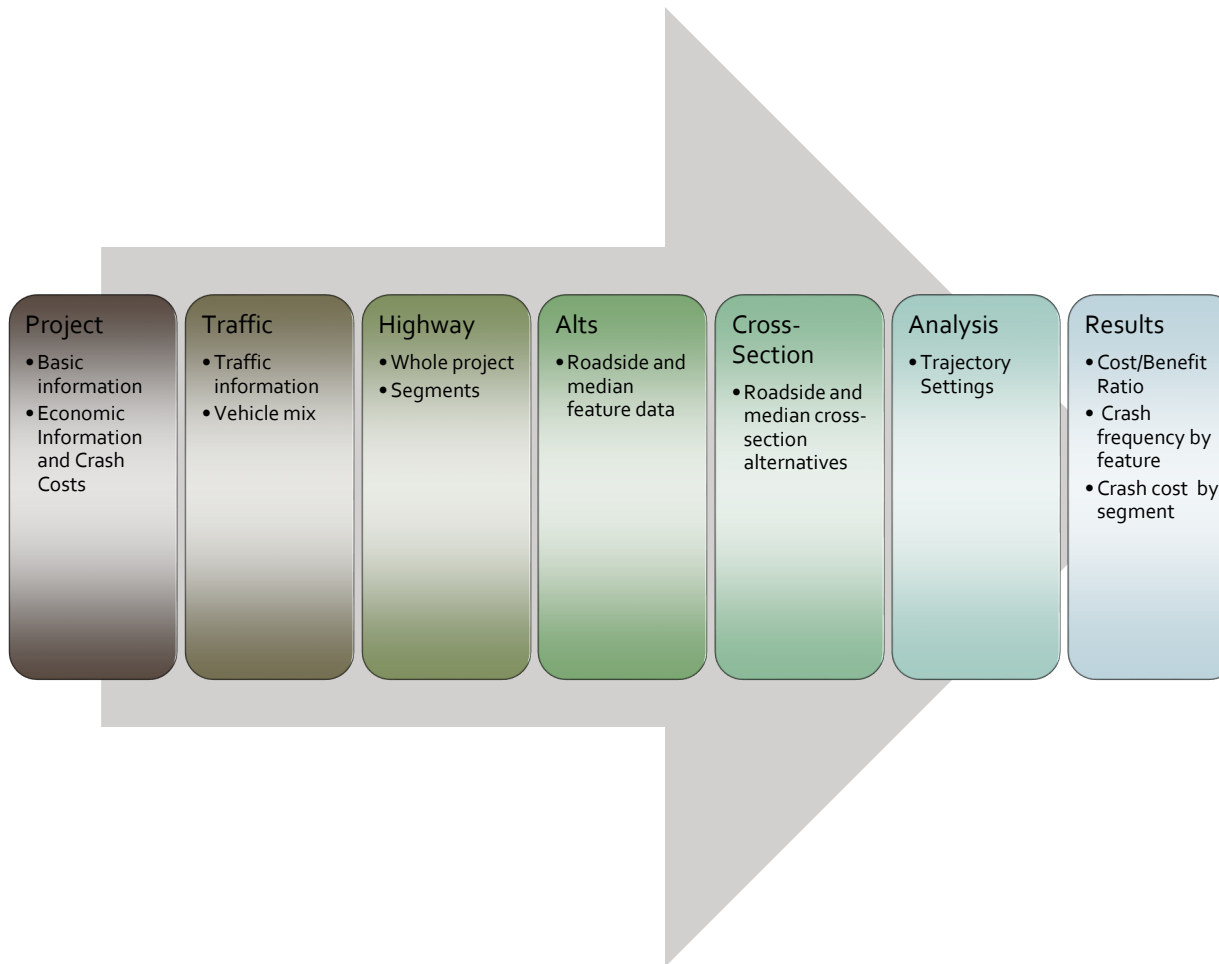
Roadside Safety Analysis Program

- Primary tool used to evaluate the need for roadside improvements in Alaska
- Evaluates existing roadside treatment and treatment alternatives to determine most cost-effective treatment
 - Crash costs: simulation of roadside encroachments that interact with hazards, resulting range of severities
 - Minimization of life-cycle costs, including cost of crashes, construction costs, repair costs, and annual maintenance costs

Roadside Safety Analysis Program

- Encroachment Module
 - Does a vehicle leave the roadway?
 - What is its trajectory and speed?
- Crash Prediction Module
 - Are there hazards on the roadside?
 - Does the vehicle strike the hazard, given the trajectory?
 - Does the vehicle continue on past the hazard?
- Severity Module
 - If the vehicle strikes the hazard, what is the severity of the crash?
- Benefit-Cost Module

Process for RSAPv3



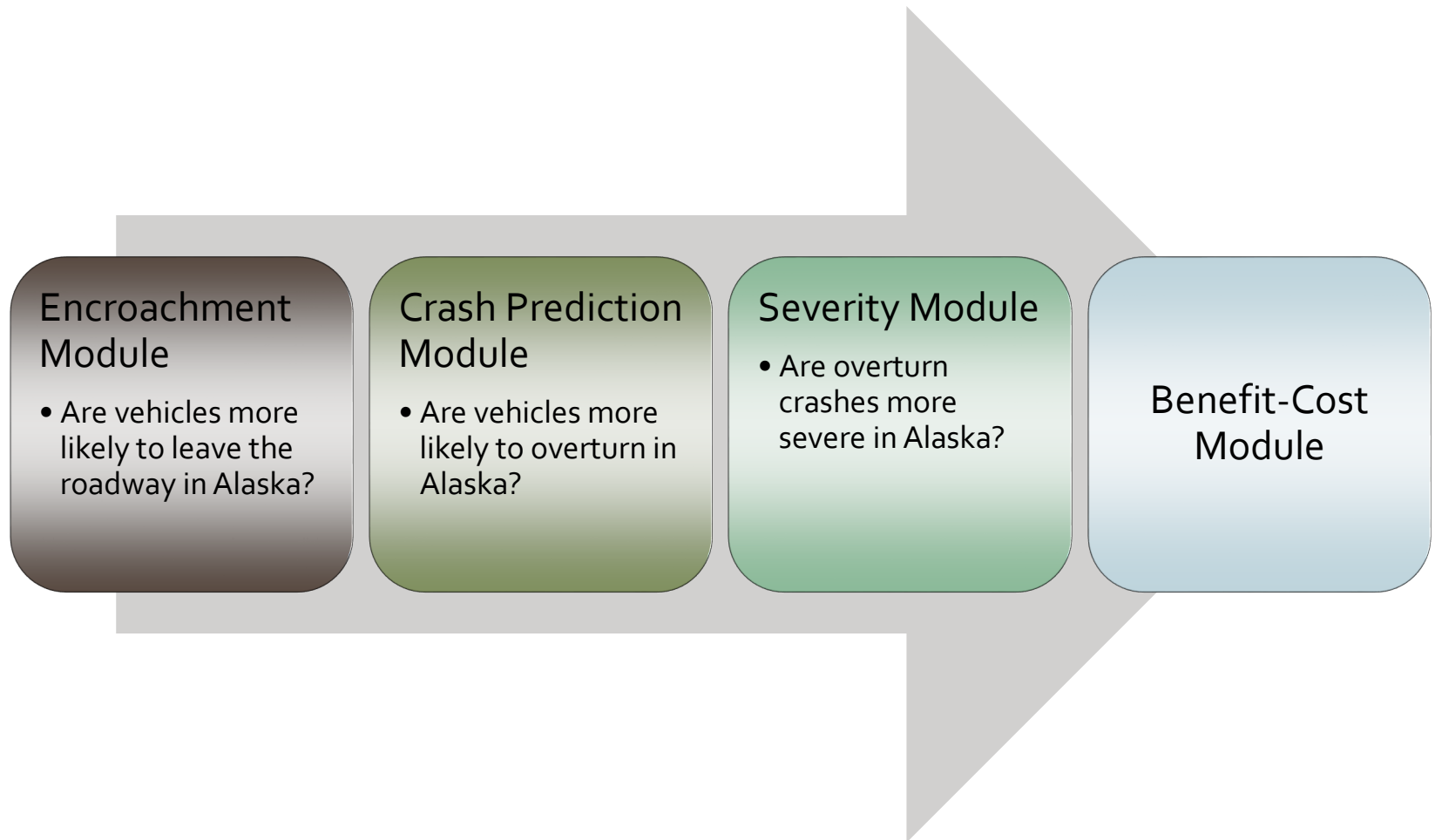
Problem of Steep Slopes

- If no barrier, crash occurs
 - Only if vehicle travels beyond traveled way and
 - strikes hazard on slope or at toe of slope
 - overturns
 - No injury or damage if vehicle stops on slope without striking anything and without overturning
- With barrier (guardrail), crash occurs
 - If vehicle travels beyond edge of traveled way
 - Always results in damage
- RSAP **nearly always** selects no barrier, as most cost effective





Roadside Safety Analysis Program Inner Workings

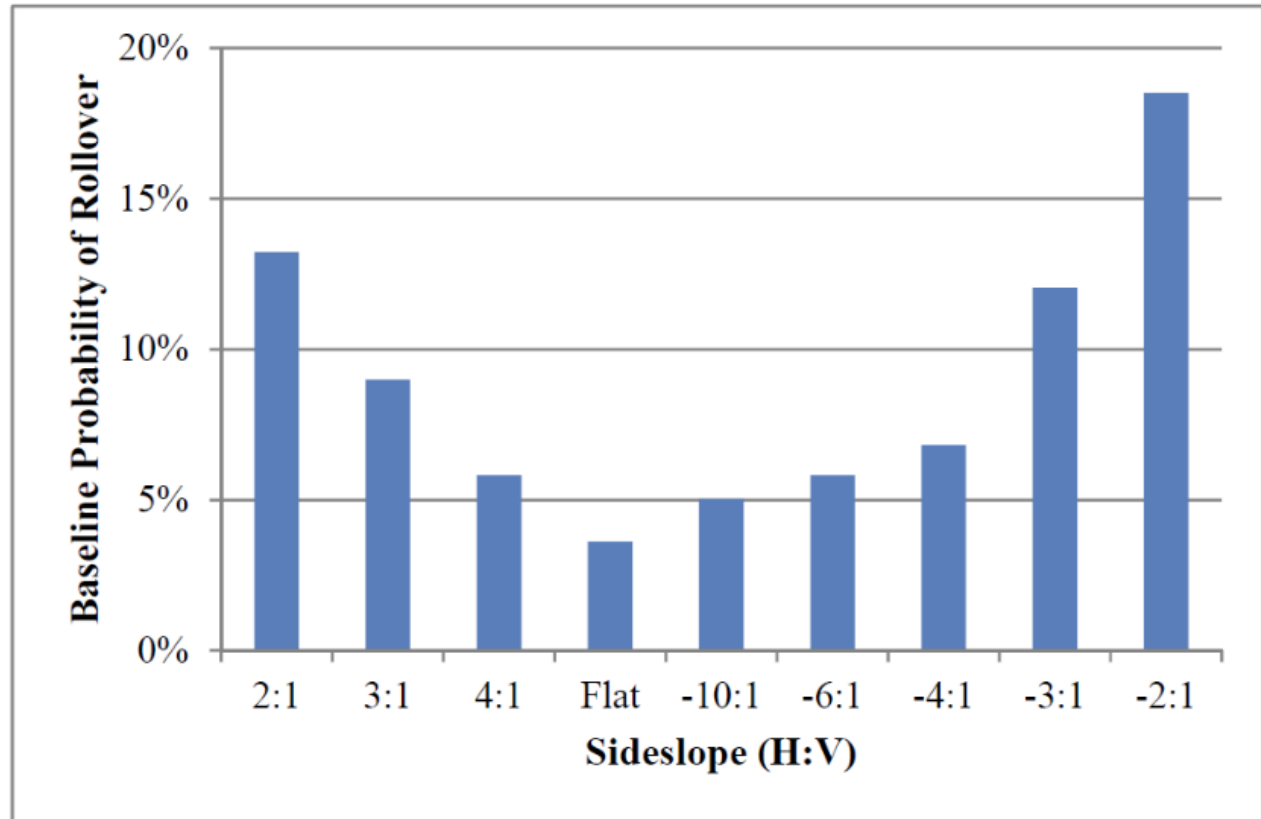


Departure Angle and Speed

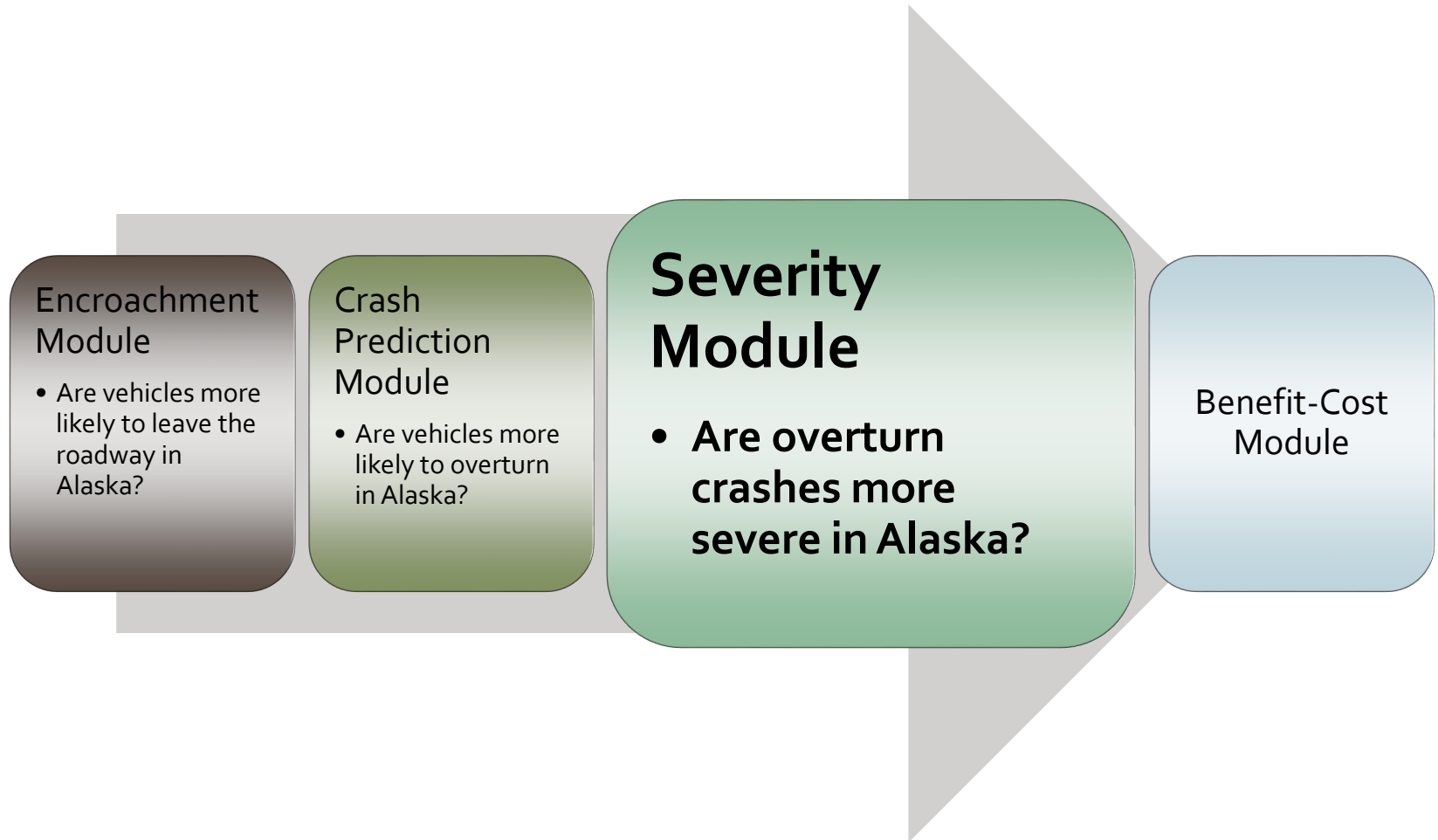
- NCHRP 665: Identification of Vehicle Impact Conditions Associated with Serious Ran-Off Road Crashes
 - Combined database of 877 crashes from 1997 to 2001, statistical sample of crashes throughout US
 - Use for distribution of departure angles and speeds, among other attributes

RSAP v3, Probability of a Rollover

Sideslope H:V	Probability of Rollover (%)
2:1	13.23%
3:1	8.99%
4:1	5.82%
Flat	3.61%
-10:1	5.03%
-6:1	5.82%
-4:1	6.82%
-3:1	12.04%
-2:1	18.52%



Roadside Safety Analysis Program Inner Workings



Hazard Module

X

RSAP Controls

PROJECT	Start a New Project
TRAFFIC	Open Existing Project
HIGHWAY	Clear User Information
ALTERNATIVES	Restore RSAP Defaults
X-SECTION	
ANALYZE	
RESULTS	
SETTINGS	
HAZARDS	

Traffic Info >

Help	User's Manual
Save	Engineer's Manual
SaveAs	Exit

Change any of the default values in the yellow or rose cells or proceed to the next step by selecting 'Traffic Info.'

HAZARD CHARACTERISTICS								
HAZARD NAME	TYPE	ANNUAL MAINT. COST	TYPICAL REPAIR COST / CRASH	EFCR65	PENETRATION			
GenericBR	L	\$ -	\$ -	0.0035				
TL2LowProfileBR	L	\$ -	\$ 100	0.0035				
TL3+FShapeBR	L	\$ -	\$ 100	0.0035				
TL3+NShapeBR	L	\$ -	\$ 100	0.0035				
TL3+SingleSlpBR	L	\$ -	\$ 100	0.0035				
TL3+VertWallBR	L	\$ -	\$ 100	0.0085				
TL3FShapeBR	L	\$ -	\$ 100	0.0035				
TL3NShapeBR	L	\$ -	\$ 100	0.0035				
TL3VertWallBR	L	\$ -	\$ 100	0.0085				
TL4FShapeBR	L	\$ -	\$ 100	0.0035				
TL4NShapeBR	L	\$ -	\$ 100	0.0035				
TL4SingleSlpBR	L	\$ -	\$ 100	0.0035				
TL4VertWallBR	L	\$ -	\$ 100	0.0085				
TL5FShapeBR	L	\$ -	\$ 100	0.0035				
TL5NShapeBR	L	\$ -	\$ 100	0.0035				
TL5VertWallBR	L	\$ -	\$ 100	0.0085				
GenericAttenuator	P	\$ -	\$ 0.0120	7.00				
TL3HTCableGR	L	\$ 100.00	\$ 800	0.0018	7.00	0.50	40,000	110,000
TL3LTcableGR	L	\$ 100.00	\$ 800	0.0009	11.00	0.50	40,000	110,000
TL3+FshapeGR	L	\$ -	\$ 100	0.0035	0.00	1.50	47,000	94,000
TL3+NShapeGR	L	\$ -	\$ 100	0.0035	0.00	2.00	47,000	86,400
TL3FShapeGR	L	\$ -	\$ 100	0.0035	0.00	1.50	47,000	90,000
TL3NShapeGR	L	\$ -	\$ 100	0.0035	0.00	2.00	47,000	43,200
TL5FShapeGR	L	\$ -	\$ 100	0.0035	0.00	1.50	47,000	264,000
TL5NShapeGR	L	\$ -	\$ 100	0.0035	0.00	2.00	47,000	256,000
TL3WbeamGR	L	\$ -	\$ 1,000	0.0047	4.00	0.10	40,000	110,000
TL3HTCableMB	L	\$ 100.00	\$ 800	0.0018	4.00	0.50	40,000	110,000
TL3LTcableMB	L	\$ 100.00	\$ 800	0.0009	6.00	0.50	40,000	110,000
TL3+FShapeMB	L	\$ -	\$ 100	0.0035	0.00	1.50	47,000	94,000
TL3+NShapeMB	L	\$ -	\$ 100	0.0035	0.00	2.00	47,000	86,400
TL3FShapeMB	L	\$ -	\$ 100	0.0035	0.00	1.50	47,000	90,000
TL3NShapeMB	L	\$ -	\$ 100	0.0035	0.00	2.00	47,000	43,200
TL5FShapeMB	L	\$ -	\$ 100	0.0035	0.00	1.50	47,000	264,000
TL5NShapeMB	L	\$ -	\$ 100	0.0035	0.00	2.00	47,000	256,000
TL3WbeamMB	L	\$ -	\$ 1,200	0.0047	2.00	0.10	110,000	40,000
BridgePierColumn	P	\$ -	\$ -	0.1784	2.00	0.00	1,000,000,000	1,000,000
Delinicator	P	\$ -	\$ -	0.0020	15.00	0.00	34,000	
Generic Fixed Obj	P	\$ -	\$ -	0.0300	0.00	0.00		
Luminaire	P	\$ -	\$ -	0.0130	30.00	1.00	34,000	
Mailbox	P	\$ -	\$ -	0.0170	40.00	1.00	34,000	
SignsBrkwy	P	\$ -	\$ -	0.0030	7.00	0.00	34,000	
SmallWoodSign	P	\$ -	\$ -	0.0030	7.00	0.00	34,000	
TrafficSignal	P	\$ -	\$ 2,000	0.0367	4.00	0.00	34,000	
Tree	P	\$ -	\$ -	0.0320	5.00	0.00		
UtilityPole	P	\$ -	\$ 5,000	0.0310	11.00	0.00		
BridgeEdge_HighHa	L	\$ -	\$ -	1.0000	100.00	0.00	1,000,000,000	
BridgeEdge_LowHaz	L	\$ -	\$ -	0.0584	100.00	0.00	1,000,000,000	
BridgeEdge_MedHa	L	\$ -	\$ -	0.1584	100.00	0.00	1,000,000,000	
ClearZoneFence	L	\$ -	\$ -	0.0060	15.00	0.00	300,000	
EdgeOfMedian	L	\$ -	\$ -	0.0425	100.00	0.00	-	
GenericRigidWall	P	\$ -	\$ -	0.0035	0.10	1.00	100,000	
Rock Ledge	L	\$ -	\$ -	0.0300	0.00	0.00		
TreeLine	L	\$ -	\$ -	0.0300				
Water	L	\$ -	\$ -	0.0300				
GenericEnd	P	\$ -	\$ -	0.0168				
Rollover	A	\$ -	\$ -	0.0220				
Rock Ledge	L	\$ -	\$ -	0.0300				
TreeLine	L	\$ -	\$ -	0.0300				
Water	L	\$ -	\$ -	0.0300				
GenericEnd	P	\$ -	\$ -	0.0168				
Rollover	A	\$ -	\$ -	0.0220				

TL3NShapeBR. Only the barrier is scaled by 1.6 based on comparison of Yield-Limit capacity(42kips) scaled by 1.6=256kips; Assume 1.5% redirection r

Guardrails_Rigid
Load capacity(42kips) scaled by 1.6=256kips; Assume 2% redirection r
Load capacity(42kips) scaled by 1.6=256kips; Assume 0.5% redirection r

Guardrails_Flexible
Load capacity(71,000 lb) scaled by 1.6 based on comparison of Yield-Limit capacity(71,000 lb) scaled by 1.6 based on comparison of Yield-Limit

Guardrails_SemiRigid
1.2 times TL3 Impact Severity ... load capacity based on Olson's equation

MedianBarriers_Flexible
Load capacity(54kips) scaled by 1.6=86.4kips; Assume 1.5% redirection r
Load capacity(54kips) scaled by 1.6=86.4kips; Assume 2% redirection r

MedianBarriers_Rigid
Load capacity(71,000 lb) scaled by 1.6 based on comparison of Yield-Limit capacity(71,000 lb) scaled by 1.6 based on comparison of Yield-Limit

PoleTreeSign
10*9 ensures that no trajectory continues once it has crossed this hazard
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Equivalent Fatal Crash Cost Ratio at 65 mph (EFCCR65)

- Value of Statistical Life: \$10.1 Million
 - K, fatal = $1 \times \text{VSL} = \$10.1 \text{ Million}$
 - A, incapacitating injury = $0.07 \times \text{VSL} = \$707,000$
 - B, non-incapacitating injury = $0.014 \times \text{VSL} = \$141,400$
 - C, possible injury = $0.007 \times \text{VSL} = \$70,700$
 - O, property damage only = $0.0008 \times \text{VSL} = \$8,080$
- In RSAPv3, EFCCR65 for rollover crashes is **0.022**
 - $0.022 \times \text{VSL} = \$222,200$
 - Between non-incapacitating and incapacitating injury

Alaska Historical Crashes

- Desire severity levels for rollover crashes at 65 mph using crashes and these surrogate attributes:
 - Functional Classification: Interstate
 - 2-lane
 - AADT 2,000 vpd
 - Area Type: Rural
 - Number of Vehicles: Single Vehicle
 - Damage to Vehicle: Total or Disabling
 - Location of Crash: Shoulder and Roadside (not in median, pathway, parking lot, etc)

Alaska Historical Crashes 2010 to 2014

- Crash Database: 2000 to 2012
 - Run off road – most frequent
 - Overturn
 - 4 levels of severity
- Crash Database: 2013
 - Overturn/Rollover
 - 5 levels of severity
- Crash Database: 2014
 - Overturn/Rollover
 - 5 levels of severity

Filtered Crashes by Severity

Severity Class- 2016 Values	2010	2011	2012	2013	2014
K- \$10.1 Million	4	3	5	2	2
A- \$707,000	5	5	0	8	9
*B&C- Avg.= \$106,050	40	20	8	24	23
O- \$8,080	46	43	25	30	32
Total	95	71	38	64	66

Combine 2000 to 2012, 2013, 2014?

- Two-way Analysis of Variance:
 - Significant difference between number of crashes in each severity level (rows), $p = 9.7 \times 10^{-6}$
 - Not significant difference between crashes by year (columns), $p = 0.09$
- Crashes can be combined by year

Alaska Severity Experience for Rollover Crashes, 65 mph estimate

Class	2010 to 2014 Crashes	Severity Cost	2010 to 2014 Class Cost
K	16	\$10,100,000	\$161,600,000
A	27	\$707,000	\$19,089,000
B&C	115	\$106,050	\$12,195,750
O	176	\$8,080	\$1,422,080
Total	334		\$194,306,830
		Average	\$ 581,757
		Average Severity	0.0575

Confidence Interval for Severity Experience

						5-year Expected Based on:			
Severity Class	5-year mean	Standard Deviation	95% confidence interval	Lower Confidence Limit (mean-CI)	Upper Confidence Limit (mean+CI)	Mean	Lower	Upper	
K	3.20	1.30	1.62	1.58	4.82	16.00	7.91	24.09	
A	5.40	3.51	4.35	1.05	9.75	27.00	5.23	48.77	
B&C	23.00	11.45	14.21	8.79	37.21	115.00	43.94	186.06	
O	35.20	8.93	11.08	24.12	46.28	176.00	120.58	231.42	

Class	Severity Cost	LCL frequency	LCL Costs by Class	UCL frequency	UCL Cost by Class
K	\$9,500,000.00	7.91	\$ 75,100,740	24.09	\$ 228,899,260
A	\$660,000.00	5.23	\$ 3,449,543	48.77	\$ 32,190,457
B&C	\$100,000.00	43.94	\$ 4,394,253	186.06	\$ 18,605,747
C	\$7,300.00	120.58	\$ 880,200	231.42	\$ 1,689,400
Total		177.65	\$ 83,824,736	490.35	\$ 281,384,864
		Average	\$ 471,854	Average	\$ 573,845
EFCCR65 Severity Value					
		471.85K/\$9.5 M	0.0497	573.84K/\$9.5 M	0.0604

$$0.0497 < EFCCR65 < 0.0604$$

Case Study – Expected Conditions for Crashes in Study

- 1,000-foot segment, 65 mph
- 2-lane highway
 - 12-foot lanes
 - 10-foot shoulders
- Vehicle composition (estimated from 2010-2014 crash history)
 - 4% Commercial Trucks
 - 48% Passenger Cars
 - 48% Pick up or SUVs
- 4 embankment scenarios including 2:1, 3:1, 4:1, and barnroof (6:1&2:1)
- Multiple AADT values

Average Crash Severity, 65 mph

- Using default EFCCR65 of 0.022
 - Average severity under Case Study conditions of 0.0077
- EFCCR65 of 0.167
 - Average severity under Case Study conditions of 0.058 (Statewide overturn severity)
- Outcome highly dependent upon truck composition
 - With 10% trucks, EFCCR65 of 0.145 results in average severity of 0.058
- Outcome is not sensitive to AADT.

Results- Analysis based on Detail Page

RSAP Controls

PROJECT

TRAFFIC

HIGHWAY

ALTERNATIVES

X-SECTION

ANALYZE

RESULTS

SETTINGS

HAZARDS

REPORTS

Seq. Detail

B/C

Include Terrain Rollovers in

Print Reports

Check boxes for reports you want to print.

Input Summary

Analysis Settings

Feature Collision and Cost Report

Segment Report

Benefit Cost Report

Export to Wrksht

Preview Printout

Help User's Manual

Save Engineer's Manual

SaveAs Exit

Change any of the values in the yellow or rose cells. If they are ok proceed to 'Highway Info'

DETAILED COLLISION AND COST SUMMARY											
Randy Road (High Fill)											
Based on Analysis Run on 5/1/2014 8:41:50 PM											
RSAP 3.0.1 (release 140130XL14) running in Excel Version 14.0 on Windows (32-bit) NT 6.0.1											
Analysis Time = 184.5859 sec.											
Alternative	Segment	FEATURE		EXPECTED ANNUAL CRASHES			ANNUAL COST OF CRASHES				
		Feature Number	Feature Type	Encroachment and Vehicle Type	Total Feature Crashes	Penetrated or Vaulted	Rolled Over after Redirection	Annual Feature Crash Cost	Feature Maintenance Cost	Feature Repair Cost	
1			ALTERNATIVE 1								
1	1	1	TreeLine	PR - PU	0.0227	0.0227	\$ -	\$ -	1,327	\$ 0	\$ 0
1	1	1	TreeLine	PR - M	0.0011	0.0011	\$ -	\$ -	21	\$ 0	\$ 0
1	1	1	TreeLine	PR - HTT	0.0010	0.0010	\$ -	\$ -	28	\$ 0	\$ 0
1	1	1	TreeLine	PR - C	0.0784	0.0784	\$ -	\$ -	4,577	\$ 0	\$ 0
1	1	1	TreeLine	PL - PU	0.0000	0.0000	\$ -	\$ -	-	\$ 0	\$ 0
1	1	1	TreeLine	PL - M	0.0000	0.0000	\$ -	\$ -	-	\$ 0	\$ 0
1	1	1	TreeLine	PL - HTT	0.0000	0.0000	\$ -	\$ -	-	\$ 0	\$ 0
1	1	1	TreeLine	PL - C	0.0000	0.0000	\$ -	\$ -	-	\$ 0	\$ 0
1	1	1	TreeLine	OR - PU	0.0000	0.0000	\$ -	\$ -	-	\$ 0	\$ 0
1	1	1	TreeLine	OR - M	0.0000	0.0000	\$ -	\$ -	-	\$ 0	\$ 0
1	1	1	TreeLine	OR - HTT	0.0000	0.0000	\$ -	\$ -	-	\$ 0	\$ 0
1	1	1	TreeLine	OR - C	0.0000	0.0000	\$ -	\$ -	-	\$ 0	\$ 0
1	1	1	TreeLine	OL - PU	0.0219	0.0219	\$ -	\$ -	1,038	\$ 0	\$ 0
1	1	1	TreeLine	OL - M	0.0011	0.0011	\$ -	\$ -	16	\$ 0	\$ 0
1	1	1	TreeLine	OL - HTT	0.0000	0.0000	\$ -	\$ -	-	\$ 0	\$ 0
1	1	1	TreeLine	OL - C	0.0754	0.0754	\$ -	\$ -	3,582	\$ 0	\$ 0

Example -Export to a spreadsheet and use pivot tables to extract alternative crash frequency and cost (VSL=\$10.1 M)

ANNUAL SEGMENT SUMMARY											
Alternative	Segment	Feature Number	Feature Type	Encroachment and Vehicle Type	Total Feature Crashes	Penetrated or Vaulted	Rolled Over after Redirection	Annual Feature Crash Cost	Feature Maintenance Cost	Feature Repair Cost	
ALTERNATIVE 1											
2H:1V	1	1	TreeLine	PR - PU	0.0000	0.0000	\$ -	\$ -	\$ -	\$ -	
2H:1V	1	1	TreeLine	PR - C	0.0000	0.0000	\$ -	\$ -	\$ -	\$ -	
2H:1V	1	1	TreeLine	PR - ATT	0.0000	0.0000	\$ -	\$ -	\$ -	\$ -	
2H:1V	1	1	TreeLine	PR - ASUT	0.0000	0.0000	\$ -	\$ -	\$ -	\$ -	
2H:1V	1	1	TreeLine	PL - PU	0.0115	0.0115	\$ -	\$ 645	\$ -	\$ -	
2H:1V	1	1	TreeLine	PL - C	0.0115	0.0115	\$ -	\$ 645	\$ -	\$ -	
2H:1V	1	1	TreeLine	OR - ATT	0.0001	0.0001	\$ -	\$ 8	\$ -	\$ -	
2H:1V	1	1	TreeLine	OR - ASUT	0.0001	0.0001	\$ -	\$ 8	\$ -	\$ -	
2H:1V	1	1	TreeLine	OL - PU	0.0000	0.0000	\$ -	\$ -	\$ -	\$ -	
2H:1V	1	1	TreeLine	OL - C	0.0000	0.0000	\$ -	\$ -	\$ -	\$ -	
2H:1V	1	1	TreeLine	OL - ATT	0.0000	0.0000	\$ -	\$ -	\$ -	\$ -	
2H:1V	1	1	TreeLine	OL - ASUT	0.0000	0.0000	\$ -	\$ -	\$ -	\$ -	
2H:1V	1	2	TreeLine	PR - ASUT	0.0001	0.0001	\$ -	\$ 8	\$ -	\$ -	
2H:1V	1	2	TreeLine	PL - PU	0.0000	0.0000	\$ -	\$ -	\$ -	\$ -	
2H:1V	1	2	TreeLine	PL - C	0.0000	0.0000	\$ -	\$ -	\$ -	\$ -	
2H:1V	1	2	TreeLine	PL - ATT	0.0000	0.0000	\$ -	\$ -	\$ -	\$ -	
2H:1V	1	2	TreeLine	PL - ASUT	0.0000	0.0000	\$ -	\$ -	\$ -	\$ -	
2H:1V	1	2	TreeLine	OR - PU	0.0000	0.0000	\$ -	\$ -	\$ -	\$ -	
2H:1V	1	2	TreeLine	OR - C	0.0000	0.0000	\$ -	\$ -	\$ -	\$ -	
2H:1V	1	2	TreeLine	OR - ATT	0.0000	0.0000	\$ -	\$ -	\$ -	\$ -	
2H:1V	1	2	TreeLine	OR - ASUT	0.0000	0.0000	\$ -	\$ -	\$ -	\$ -	
2H:1V	1	2	TreeLine	OL - PU	0.0115	0.0115	\$ -	\$ 645	\$ -	\$ -	
2H:1V	1	2	TreeLine	OL - C	0.0115	0.0115	\$ -	\$ 645	\$ -	\$ -	
2H:1V	1	2	TreeLine	OL - ATT	0.0000	0.0000	\$ -	\$ 2	\$ -	\$ -	
2H:1V	1	2	TreeLine	OL - ASUT	0.0000	0.0000	\$ -	\$ 2	\$ -	\$ -	
2H:1V	1	3	Rollover	PR - PU	0.0033	0.0000	\$ -	\$ 1,793	\$ -	\$ -	
2H:1V	1	3	Rollover	PR - C	0.0033	0.0000	\$ -	\$ 1,793	\$ -	\$ -	
2H:1V	1	3	Rollover	PR - ATT	0.0000	0.0000	\$ -	\$ 237	\$ -	\$ -	
2H:1V	1	3	Rollover	PR - ASUT	0.0000	0.0000	\$ -	\$ 226	\$ -	\$ -	
2H:1V	1	3	Rollover	PL - PU	0.0028	0.0000	\$ -	\$ 1,569	\$ -	\$ -	
2H:1V	1	3	Rollover	PL - C	0.0028	0.0000	\$ -	\$ 1,569	\$ -	\$ -	
2H:1V	1	3	Rollover	PL - ATT	0.0000	0.0000	\$ -	\$ 149	\$ -	\$ -	
2H:1V	1	3	Rollover	PL - ASUT	0.0000	0.0000	\$ -	\$ 184	\$ -	\$ -	
2H:1V	1	3	Rollover	OR - PU	0.0034	0.0000	\$ -	\$ 1,807	\$ -	\$ -	
2H:1V	1	3	Rollover	OR - C	0.0034	0.0000	\$ -	\$ 1,807	\$ -	\$ -	
2H:1V	1	3	Rollover	OR - ATT	0.0000	0.0000	\$ -	\$ 237	\$ -	\$ -	
Annual Crashes											
Sum of Total Feature Crashes		Column Labels									
Row Labels		Rollover		TreeLine	Grand Total						
2H:1V				0.025	0.093						
3H:1V				0.020	0.054						
4H:1V				0.013	0.034						
Barnroof				0.017	0.074						
Annual Cost											
Sum of Annual Feature Crash Cost		Column Labels									
Row Labels		Rollover		TreeLine	Grand Total						
2H:1V				\$ 15,049	\$ 5,857						
3H:1V				\$ 10,559	\$ 2,079						
4H:1V				\$ 6,928	\$ 1,126						
Barnroof				\$ 11,129	\$ 3,310						
Cost/Crash											
Unit Cost per Crash											
Alternative		Rollover		TreeLine	Grand Total						
2H:1V				\$ 609,950	\$ 63,029						
3H:1V				\$ 540,890	\$ 38,634						
4H:1V				\$ 526,671	\$ 33,006						
Barnroof				\$ 643,378	\$ 44,759						
EFCCR/\$10.1 mil											
EFCCR=(Cost/Crash)/\$10.1 Mill											
Alternative		Rollover		TreeLine	Grand Total						
2H:1V				0.0604	0.0062						
3H:1V				0.0536	0.0038						
4H:1V				0.0521	0.0033						
Barnroof				0.0637	0.0044						
AK Standard				0.0575							0
Slopes Average				0.0554							

Recommendations

- For evaluating treatments for high, steep slopes, ensure that crash output severity falls within the confidence interval:
 - 0.0497 to 0.0601
- Alter EFCCR65 until severity within the confidence interval is achieved.
- Using an adjusted EFCCR65 in RSAP for rollover severity, RSAP computations align with engineering judgment and intuition (guardrail alternatives will prevail over steeper slopes!)

