Adoption of a Management System Approach to Geometric Design Process for Better and Safer Roads

By

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ABSTRACT

Transportation agencies are moving toward the development of enterprise-wide transportation infrastructure system (TIMS) or Transportation Asset Management System (TAMS). This is an opportune time to include geometric design and safety-based applications within the overall TIMS development. Alberta Transportation commenced the development of TIMS in 1996. As part of TIMS development, Network Expansion System Support (NESS) and Collision Information Application (CIA) were developed and implemented in 2007. NESS/CIA are geometric design and safety-based applications that are used for analysis in various phases of project development including capital planning, programming, planning, design, and rehabilitation phases. NESS/CIA performs highway network screening on roadway geometrics and roadway safety annually. Traditionally, geometric design and safety analysis are separate functions. Moreover, geometric design and safety applications are mainly considered at project level during the detailed design phase. The development of NESS/CIA applications enable geometry design and safety analysis to be assessed concurrently at various phases of project management. Over the past eight years, NESS/CIA demonstrated wide use applications in various phases of project development that would result in overall better and safer roads.

Contents

INTRODUCTION

Geometric design of highways and streets is a complex process. In the design stage, designers typically use various geometric design guides and other documents to make design choices. However, geometric design activities and geometric design decisions may vary over time because many design choices are assessed throughout the project development stages through capital planning, preliminary engineering and programming prior to the detailed design stage. For better and safer roads, it is prudent to incorporate geometric design and safety analysis in the early stages of project development. With greater emphasis on safety, evidence-based and performance-based approaches, transportation agencies are seeking ways of incorporating geometric design and safety-based decisions in each phase of the project development. To accomplish this goal at the network level, an enterprise-wide management system that incorporates geometric design standards and safety information is required; the overall goal would be to plan, program and design better and safer roads.

Many transportation agencies are adopting enterprise-wide transportation infrastructure management systems (TIMS) to support achieving organization objectives in accessibility, mobility, reliability, safety and quality of service. In general, TIMS enable organizations to:

- improve infrastructure reliability and accessibility;
- plan and determine best life-cycle investment strategies to minimize missed opportunity costs;
- increase efficiency and transparency in decision-making through enterprise-wide road and bridge inventory and their roadway geometric and safety conditions;
- manage road and bridge projects more collaboratively, and;
- improve the organization’s ability to perform risk management.

BACKGROUND

Development of NESS And CIA Within TIMS

In 1995, Alberta Transportation decided to outsource all highway maintenance and engineering services to the private sectors; staff complements were reduced from over 3200 to 780 staff. It was determined that remaining staff would focus on developing standards and policies and managing outcomes while the private sector would performing design, construct and maintenance services. Alberta Transportation was to be viewed as a knowledgeable owner so that it could maintain a balance between public interests and private initiatives. As a result, it was decided that an enterprise-wide Transportation Infrastructure Management System (TIMS) was needed to enable staff to plan and manage Alberta’s highways and bridges. Moreover, existing legacy pavement and bridge management systems required major upgrading and integration in order to share data and information within and outside of Alberta Transportation; these functions would be rolled into the TIMS system as well.

Alberta Transportation commenced the development of TIMS in 1996. One of its modules, the Network Expansion Support System (NESS) was a geometric design-based decision support tool within TIMS. During the NESS concept definition phase, it was determined that safety information was needed as well to fulfill the safety aspect of Alberta Transportation's mission of providing a safe and efficient transportation network for movement of goods and people. Consequently, another module, the Collision Information Analysis (CIA), a safety-based information support tool, was being developed concurrently with NESS. Both were implemented in 2007. NESS is capable of producing various analytical reports for uses in planning, programming, design, rehabilitation and safety projects. Overall, the application of NESS/CIA in an integrated manner has enabled Alberta Transportation to plan, program and design better and safer roads to meet performance measures and performance management objectives.

NESS' Functional Role in TIMS

Alberta has nearly 31,000 km of provincial highways and over 3,800 bridges (*3*, *4*). TIMS is a web-based knowledge system to manage highway assets and capital improvement investments. The overall objective is to deliver the maximum lifetime socio-economic value for investments by measures of safety, economics, environmental sustainability and innovativeness. As shown *Figure 1*, it has different applications, among which, NESS/CIA assists staff and engineering consultants to identify deficient highway segments based on capacity, geometric design standards, safety and performance measures.

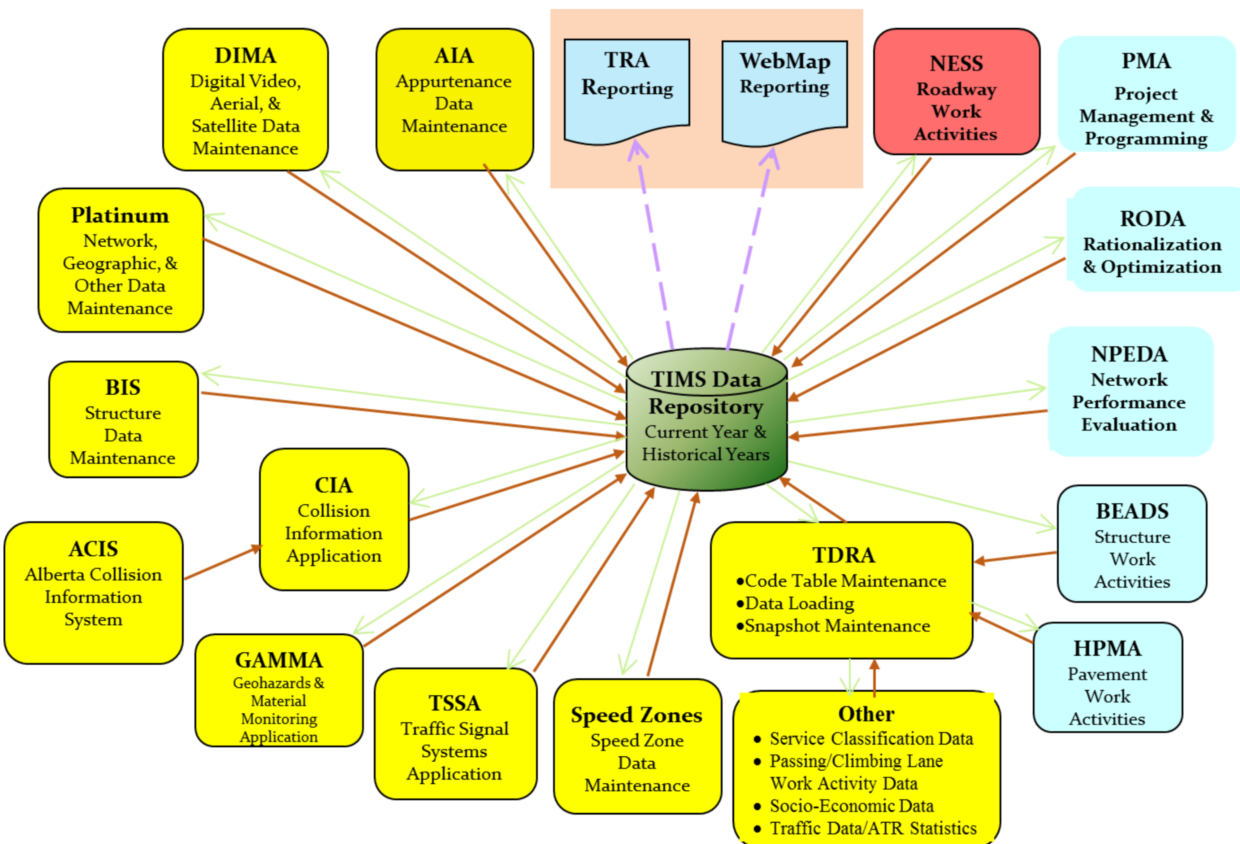


Figure 1, TIMS Applications (*14*)

Performance Measures and Performance Management

In the early 2000s, the Alberta Government aimed to develop a long term capital plan for all government owned infrastructure in Alberta. Performance measures were to be used to determine capital investment requirements for various government departments. Common corporate infrastructure performance measures were developed that would be applicable to both vertical infrastructures (hospital, school, senior housing) and horizontal infrastructures (roads and bridges). They were (1) physical condition, (2) utilization and (3) functional adequacy. For Alberta Transportation, (1) IRI (pavement smoothness), (2) level of service and (3) 3R/4R roadway width, speed reduction and road ban were chosen for physical condition, utilization and functional adequacy respectively. Level of service, 3R/4R roadway width and speed reduction were related to geometric design and safety. Annually, Alberta Transportation would report overall highway network performance in accordance to these performance measures as shown in Figure 2. Utilization was dropped subsequently from annual reporting but it was still being used at the programming level.

Core Businesses/Goals/Measure (s)			Prior years' Results			Target	Actual 2010-11
			2007-08	2008-09	2009-10		
Goal 1: *Alberta's provincial highway network connects communities and supports social and eceonomic growth.*							
Measure 1.a:	Physical Condition of Provincial Highways. *	Good	59.0%	58.6%	58.1%	58.0%	58.4%
		Fair	25.9%	26.3%	26.8%	26.0%	26.7%
		Poor	15.1%	15.1%	15.1%	16.0%	14.9%
Measure 1.b:	Functional Adequacy of Highways: Percentage of provincial highways that meet current engineering standards.		81.1%	82.2%	83.9%	80.0%	84.2%
Measure 1.c:	Construction Progress on the North-South Trade Corridor: Percentage of four-laning open to travel.		90.4%	90.4%	91.1%	92.0%	92.2%
Measure 1.d:	Ring Roads in Edmonton and Calgary: Percentage of ring roads open to travel.		36.4%	38.0%	58.5%	56.0%	58.5%

Figure 2, Highway Performance Measures in Alberta Transportation's Annual Report (15)

For utilization, Level of Service (LOS) of each highway segments would be rated based on HCM's Capacity Manual methodology for rural highways. For example, Alberta Transportation aimed to have its highway network level operating at LOS C or better. Highway segments operating below LOS C would be candidates for assessment for capital improvement. Geometric improvements such as provision of passing lanes, access management, grade widening to 3R/4R or new construction standards and four-laning would contribute to LOS improvement.

For functional adequacy, 3R/4R width was chosen for safety and speed reduction zones was selected for speed management. Figure 3 illustrates the relationship amongst road width, traffic volumes and roadway safety. Through cost-benefit analysis, Alberta Transportation established 3R/4R traffic volumes that would require road widening or four laning. Speed reduction zones were identified that were due to poor horizontal and vertical geometric design such as sharp horizontal curves with inadequate superelevation, inadequate sight distances, poor access management and congested intersections. Accordingly, geometric improvements to these segments could restore its original functional adequacy to a posted speed of 100 km/hr on rural highways.

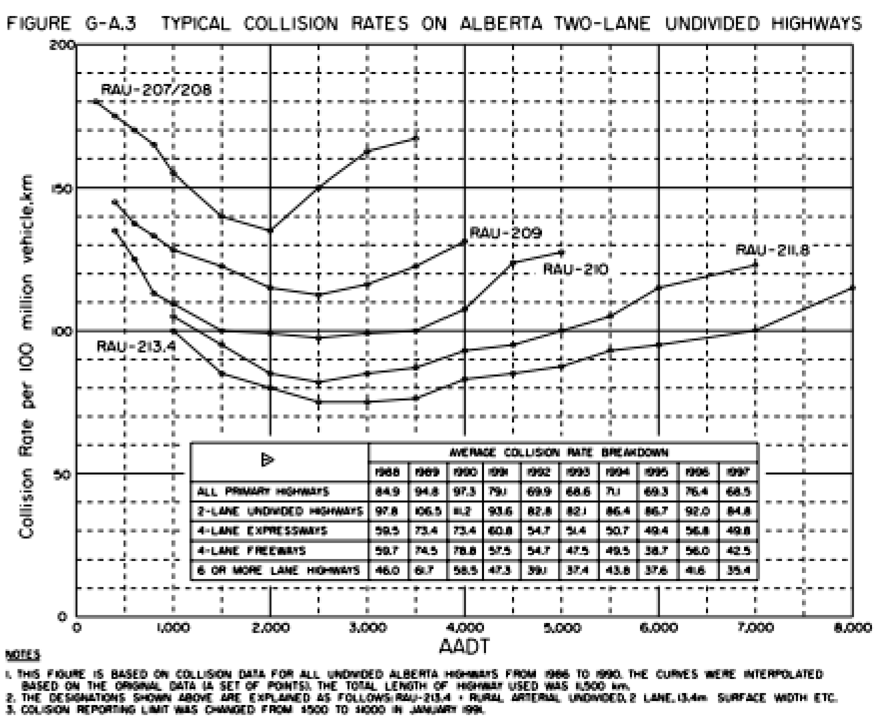


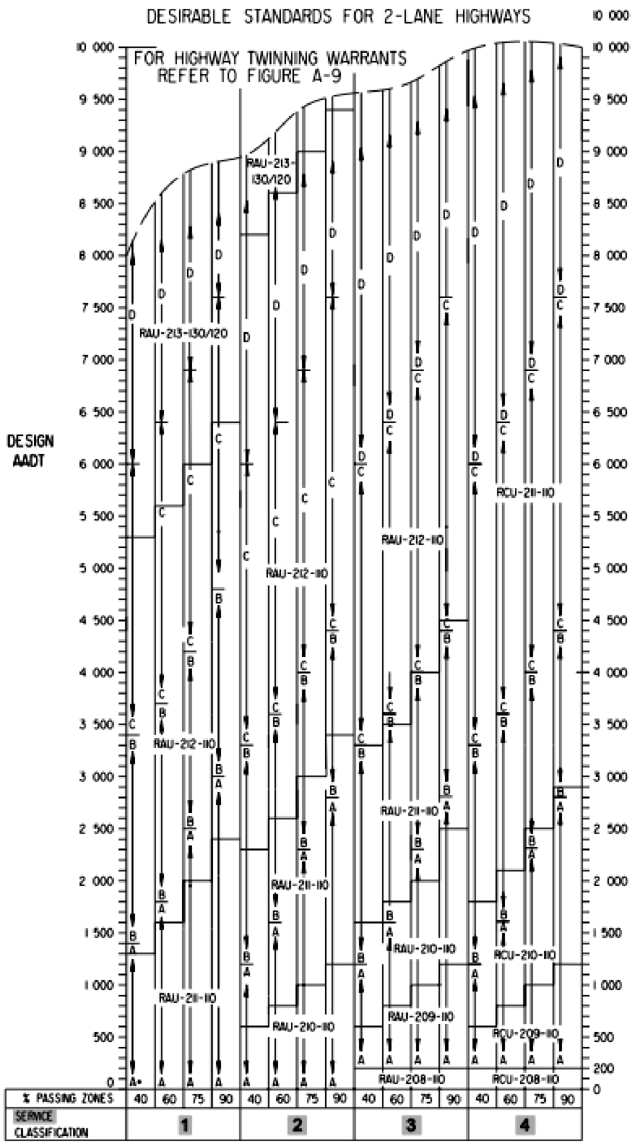
Figure 3, Interrelationship amongst AADT, Collision Rate and Road Widths

Performance management is related to activities that maintain highway integrity relative to highway safety and compliance with Highway Geometric Design Guide and other technical requirements. These activities may not have a short-term impact on overall highway network performance measures as corporate performance measures are high-level indicators at the network level. For example, Alberta Transportation undertakes geometric assessment and improvement of all highway pavement rehabilitation projects in the three-year pavement rehabilitation program. As such, removal of redundant accesses according to access management design guidelines and intersection improvements based on future traffic volumes and future safety performance will not have immediate impact on overall highway network performance measures.

With the use of geometric design and safety based metrics and performance measures during the early stage of project development, it will bring smarter decision-making for better and safer roads. These measures also provide quantitative evidence and transparency for safety and/or operation improvements within the current highway network; it assists highway agencies' performance management process in a forward-looking way.

Geometric Design, Capacity and Safety Thresholds in NESS

NESS is capable of identifying and reporting highway segments' and intersections' deficiencies in terms of geometric design, capacity and safety thresholds. Geometric design thresholds on vertical and horizontal alignments and intersections are based on Alberta Transportation's Highway Geometric Design Guide. Capacity thresholds in terms of new construction and 3R/4R guidelines are shown in Figure 4a.and Figure 4b. As shown, capacity thresholds were further categorized in accordance to Alberta Transportation's service classification of Level 1 (National Highways), Level 2 (Intra Provincial), Level 3 (Intra-Regional) and Level 4 (Collectors (local)).



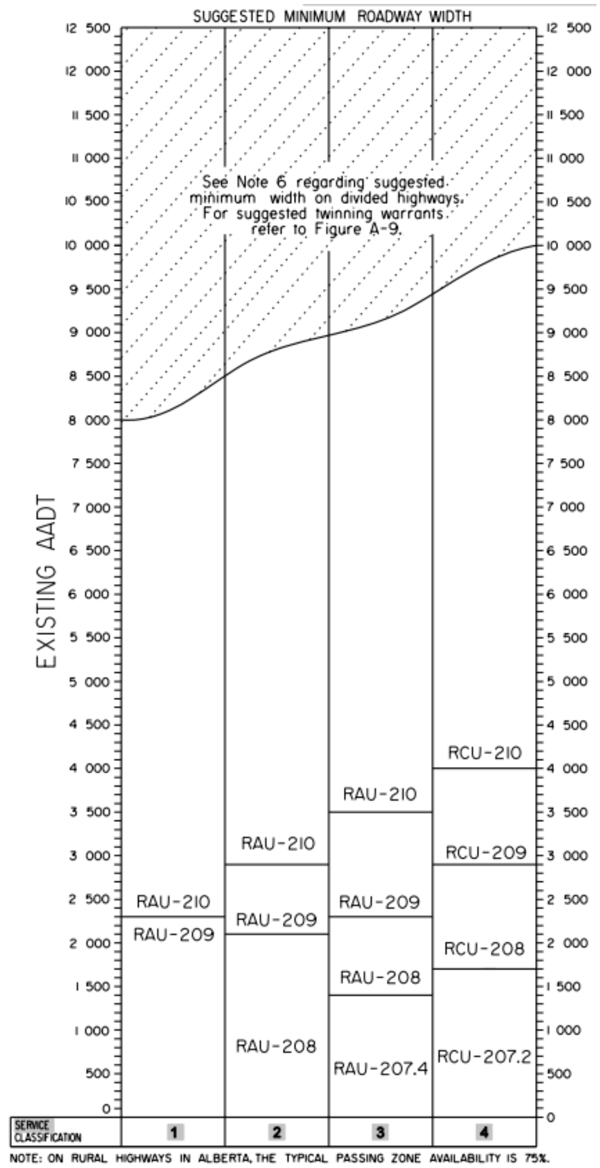


Figure 4a, Road Sizing Chart, New Construction   Figure 4b: 3R/4R Road Sizing Chart

For safety thresholds, provincial non-animal collision rates for road widths and intersections were calculated in CIA for usage on each highway segment, intersection and other highway geometric features. Based on these safety thresholds in CIA, NESS would identify highway segments, intersections, horizontal and vertical curves with ‘negative delta’ values to alert the users on safety deficiencies.

Highway Network Screening For Deficiencies and Work Activities

NESS performs network screening annually after updating of data on traffic projection, collisions and newly constructed highway segments and intersections. Geometric design elements are all considered, such as design speed, lane width, horizontal alignment, vertical alignment, grade, superelevation etc. After network screening, it identifies the segments deficiencies and provides recommended 'work activities' such as planning study and safety assessment, intersection and roadway improvements relative to the established geometric design and safety thresholds.

To illustrate, some NESS reports on Highway 754 in Alberta are shown in the following figures:

Roadway Summary Page 1 of 126

Segments included within the Report

LRS	Length
754:02 C1 0.000 - 19.607	19.607
754:04 C1 0.000 - 41.162	41.162
754:06 C1 0.000 - 35.039	35.039
Total	95.808

Length of Roadway (in Km) by Service Class

Service Class	Length
LV 3	89.501
LV 4	6.307

Length of Paved and Gravel Roads (in Km)

Surface	Length
PAVED	95.808
Total	95.808

Collision Summary for years 2008-2012

	Total	Non Animal
Collision Rate in C/100MVKM	98.48	49.24
# of Fatal Collisions	3	3
# of Injury Collisions	35	32
# of Property Damage Only Collisions	178	73
Total # of collisions	216	108

Existing Width and Curve Summary

	Typical	Weighted	Max	Min	Total
Existing Width	9.00	8.8	9.20	8.00	
Existing WAADT	920.00	1,328	2,670.00	920.00	
Growth Rate %	1.8	1.8	1.8	1.8	
Speed	100		100	60	
Horizontal Curve Radius			3,500	131	57
Vertical Curve k (Crest)			740	24	124
Vertical Curve k (Sag)			620	28	108

Figure 5a, Highway 754 – NESS Roadway Summary Report

Width Safety Report Page 7 of 12(

Report Notes

Number of results found 6

Collision Cost in $/km (M) over 5 years

Collision Rate in C/100MVKM

Collision rate is calculated as (sum total collisions over 5 years * 100 Mil) / (sum of AADT history for the same 5 years * 365.25 * length (km))

Collision cost is calculated as (sum of collisions involving a fatality * $1,345,068) + (sum of collisions involving a serious injury * $100,000) + (sum of collisions involving a minor injury * $100,000) + (sum of the property damage only collisions * $12,000)

		Existing			Collision Frequency				Total Rate			Non Animal Rate			Collision Cost (M)			Safety	
LRS	Len	WAADT	Width	Paved Y/N	Total	Fatal	Injury	Non Animal	Actual	BM	Δ	Actual	BM	Δ	Actual	BM	Δ	Assess Year	Region
754:02 C1 0.000 - 19.607	19.607	1,020	8.90	Y	43	1	8	14	139.3	155.4	16.0	45.4	48.3	2.9	0.130	0.804	0.674	~~No~~	5
754:04 C1 0.000 - 29.348	29.348	920	9.00	Y	44	0	6	22	102.1	177.9	75.8	51.1	53.5	2.5	0.036	0.804	0.768	~~No~~	5
754:04 C1 29.348 - 41.162	11.814	920	9.00	Y	19	1	1	3	109.5	177.9	68.3	17.3	53.5	36.2	0.140	0.804	0.665	~~No~~	
754:06 C1 0.000 - 13.800	13.8	920	9.00	Y	21	0	1	7	105.5	177.9	72.3	35.2	53.5	18.3	0.025	0.804	0.780	~~No~~	
754:06 C1 13.800 - 19.590	5.79	2,670	9.00	Y	17	1	1	7	57.7	115.9	58.2	23.7	43.8	20.1	0.281	0.804	0.523	~~No~~	
754:06 C1 19.590 - 35.039	15.449	2,670	8.00	Y	64	0	16	48	81.4	115.9	34.5	61.0	48.5	-12.5	0.141	0.990	0.849	~~Yes~~	

Figure 5b, Highway 754 – NESS Width Safety Report (partial)

Report Notes

Number of results found 41

The number of collisions in this report are collisions at and near the intersection and are collisions within the intersection polygon in TIMS

For details on individual collisions, see the "Collision Details" section within Excel report

The Signalization Work Activity Trigger is Traffic Score (TS) > 79 or TS >= 60 with 5 or more angle collisions

Interchange Trigger - Signalization trigger met on Level 1 divided highway with 100+ km/h, or left turn volume >= 700 vehicles per hour

Collision Cost in $ (M) over 5 years

Collision Rate in C/100MEV

Intersection collision rate is calculated as (sum of intersection collisions over 5 years * 100 Mil) + (sum of AADT entering over 5 years * 365.25)

Collision cost is calculated as (sum of collisions involving a fatality * $1,345,068) + (sum of collisions involving a serious injury * $100,000) + (sum of collisions involving a minor injury * $100,000) + (sum of the property damage only collisions * $12,000)

Va, Vo and Vl in VPH

LT & RT Length in m

Pk = Peak Hour

Year LT = Scheduled Year of Left Turn Lane Construction

Year LTR = Scheduled Year of Left Turn Lane Reconstruction

Year RT = Scheduled Year of Right Turn Lane Construction

Year RTR = Scheduled Year of Right Turn Lane Reconstruction

INT #:469 LRS: 754:02 C1 0.000

Location: HIGHWAY 88:02 AND 88:04 AND 754:02

Lv 2 Work Activity Summary | Lv 3 Work Activity Summary

2014 INTERSECTION SAFETY ASSESSMENT

Major Road Details

Int. Type: TYPE 4C
Service Class: LV 2

Posted Speed: 100
Lit: N Sig: N Div: N Radius:

TMD Ref: 62750
Maj Rd: 88-SB/NB
Min Rd: 754-EB/WB

	Veh/day	Growth
Maj Rd	1,770	1.8%
Min Rd	1,020	1.8%

Collision Frequency				Collision Rate				Collision Cost	
Total	Fatal	Inj	Non-An	Total	BM	Non-An	BM	Cost (in $M)	BM
5	0	2	4	166.2	111.4	133.0	105.1	0.236	0.460

Approach	LT Lane	LT Len	LT BM	RT Lane	RT Len	RT BM	Chan	Yr LT	Vo	Vl	BM	Va	Undiv BM	Pk	Yr RT	RT AADT	Yr Chan
88-SB				Y	235	190	N		181	2		7	179	am		10	
88-NB				Y	269	190	N									450	

Yr Signal	TS	Ang. Coll	Yr IC	TS	LT vph	Yr Light.	Day	Night	N/D Col%	Near VC
	9	0					2	3	150.00	Y

Figure 5c, Highway 754 – NESS Intersection Report

LRS	Access Type	Access Count	Road Side	Int #	Int Type	Speed	Roadside Class	MD Name	Distance Last Access	Distance Last Public
754:02 C1 0.000	HWY			469	TYPE 4C	100	major art	M.D. OF LESSER SLAVE RIVER NO. 124		
754:02 C1 0.382	BUSINESS/INDUSTRIAL	1	L			100	major art	M.D. OF LESSER SLAVE RIVER NO. 124	0.382	
754:02 C1 0.396	MUNICIPAL ROAD			22676	AG	100	major art	M.D. OF LESSER SLAVE RIVER NO. 124	0.014	0.396
754:02 C1 1.760	UTILITY/RESOURCE	1	L			100	major art	M.D. OF LESSER SLAVE RIVER NO. 124	1.364	
754:02 C1 1.846	UTILITY/RESOURCE	1	L			100	major art	M.D. OF LESSER SLAVE RIVER NO. 124	0.086	
754:02 C1 3.514	MUNICIPAL ROAD	2	R&L	22677	AG	100	major art	M.D. OF LESSER SLAVE RIVER NO. 124	1.668	3.118
754:02 C1 3.656	UTILITY/RESOURCE	1	L			100	major art	M.D. OF LESSER SLAVE RIVER NO. 124	0.142	
754:02 C1 4.152	MUNICIPAL ROAD	1	R	22678	AG	100	major art	M.D. OF LESSER SLAVE RIVER NO. 124	0.496	0.638
754:02 C1 5.085	UTILITY/RESOURCE	1	R			100	major art	M.D. OF LESSER SLAVE RIVER NO. 124	0.933	
754:02 C1 5.967	UTILITY/RESOURCE	1	R			100	major art	M.D. OF LESSER SLAVE RIVER NO. 124	0.882	
754:02 C1 12.865	MUNICIPAL ROAD	1	L	22679	AG	100	major art	M.D. OF LESSER SLAVE RIVER NO. 124	6.898	8.713
754:02 C1 14.749	FIELD	1	L			100	major art	M.D. OF LESSER SLAVE RIVER NO. 124	1.884	
754:02 C1 16.732	MUNICIPAL ROAD	2	R&L	22680	AG	100	major art	M.D. OF LESSER SLAVE RIVER NO. 124	1.983	3.867
754:02 C1 17.991	FIELD	1	R			100	major art	M.D. OF LESSER SLAVE RIVER NO. 124	1.259	
754:02 C1 18.356	FIELD					100	major art	M.D. OF LESSER SLAVE RIVER NO. 124	0.365	
754:04 C1 0.626	FIELD	1	L			100	major art	M.D. OF LESSER SLAVE RIVER NO. 124	1.877	
754:04 C1 0.922	MUNICIPAL ROAD			22681	AG	100	major art	M.D. OF LESSER SLAVE RIVER NO. 124	0.296	1.922
754:04 C1 0.932	UTILITY/RESOURCE	1	L			100	major art	M.D. OF LESSER SLAVE RIVER NO. 124	0.010	
754:04 C1 2.448	FIELD	1	L			100	major art	M.D. OF LESSER SLAVE RIVER NO. 124	1.516	
754:04 C1 3.527	MUNICIPAL ROAD	1	L	22682	AG	100	major art	M.D. OF LESSER SLAVE RIVER NO. 124	1.079	2.605
754:04 C1 5.536	FIELD	1	R			100	major art	M.D. OF LESSER SLAVE RIVER NO. 124	2.009	
754:04 C1 7.448	MUNICIPAL ROAD	1	L	22683	AG	100	major art	M.D. OF LESSER SLAVE RIVER NO. 124	1.912	3.921
754:04 C1 8.924	UTILITY/RESOURCE	1	R			100	major art	M.D. OF LESSER SLAVE RIVER NO. 124	1.476	
754:04 C1 9.294	MUNICIPAL ROAD	1	R	22684	AG	100	major art	M.D. OF LESSER SLAVE RIVER NO. 124	0.370	1.846

Figure 5d, Highway 754 – NESS Intersection Report (partial)

Horizontal Curve Report Page 31 of 126

Report Notes

Number of results found 57

Collision Cost in $/km (M) over 5 years

Collision Rate in C/100MVKM

Collision rate is calculated as (sum total collisions over 5 years * 100 Mil) / (sum of AADT history for the same 5 years * 365.25 * length (km))

Collision cost is calculated as (sum of collisions involving a fatality * $1,345,068) + (sum of collisions involving a serious injury * $100,000) + (sum of collisions involving a minor injury * $100,000) + (sum of the property damage only collisions * $12,000)

e in %

Deflection Angle in degrees

			Geometric Analysis						Collision Frequency				Safety Analysis				Work Activity Year		Region
LRS	Len	Exist WAADT	Type	Actual	BM	Δ	Defl Angle	Int On Curve	Total	Fatal	Injury	Non Animal	Type	Actual	BM	Δ	Safety Assess	Recon	
Reg																			
754:02 C1 1.951 - 2.187	0.236	1,020	R	1,760			8.4 R	N	1	0	1	1	Total Rate	269.2	329.4	60.2	2014		5
			e Max	2.3									Non Animal Rate	269.2	279.1	9.90			
			e Min	2.3									Coll Cost	0.424	0.205	-0.219			
754:02 C1 3.747 - 4.314	0.567	1,020	R	580	600	-20	57.3 L	Y	1	0	1	0	Total Rate	112	385	272.9		2014	5
			e Max	3.7	7.9	4.2							Non Animal Rate	0	360.9	360.90			
			e Min	3.7	5.9	-2							Coll Cost	0.176	0.395	0.219			
754:02 C1 5.241 - 5.673	0.432	1,020	R	1,740			14.2 R	N	1	0	0	0	Total Rate	147	329.4	182.4			5
			e Max	2.2									Non Animal Rate	0	279.1	279.10			
			e Min	2.2									Coll Cost	0.028	0.205	0.177			
754:02 C1 6.678 - 7.008	0.33	1,020	R	590	600	-10	33.2 L	N	1	0	1	1	Total Rate	192.5	385	192.5		2014	5
			e Max	3.7	7.9	4.2							Non Animal Rate	192.5	360.9	168.40			
			e Min	3.7	5.9	-2							Coll Cost	0.303	0.395	0.092			
754:02 C1 8.660 - 9.006	0.346	1,020	R	1,730			11.6 R	N	0	0	0	0	Total Rate	0	329.4	329.4			5
			e Max	2.5									Non Animal Rate	0	279.1	279.10			
			e Min	2.5									Coll Cost	0	0.205	0.205			
754:02 C1 9.645 - 9.993	0.348	1,020	R	940	600	340	21.7 R	N	0	0	0	0	Total Rate	0	288.4	288.4			5
			e Max	3.8	6.9	3.1							Non Animal Rate	0	254.3	254.30			
			e Min	3.8	4.5	-1							Coll Cost	0	0.255	0.255			
754:02 C1 12.380 - 12.708	0.328	1,020	R	880	600	280	21.3 R	N	0	0	0	0	Total Rate	0	304.2	304.2			5
			e Max	3.2	7.2	4.0							Non Animal Rate	0	277.3	277.30			
			e Min	3.2	4.7	-2							Coll Cost	0	0.279	0.279			

Figure 5e, Highway 754 – NESS Horizontal Report (partial)

Vertical Curve Report Page 37 of 126

Report Notes

Number of results found 0

Gradient in %

Collision Rate for horizontal curve in C/100MVKM; intersection in C/100MEV

Horizontal curve collision rate is calculated as (sum segment collisions over 5 years * 100 Mil) / (sum of AADT 5 years * 365.25 * length (km))

Intersection collision rate is calculated as (sum of intersection collisions over 5 years * 100 Mil) + (sum of AADT entering over 5 years * 365.25)

Collision cost is calculated as (sum of collisions involving a fatality * $1,345,068) + (sum of collisions involving a serious injury * $100,000) + (sum of collisions involving a minor injury * $100,000) + (sum of the property damage only collisions * $12,000)

					K-Value					Running Speed			Total Collision Rate				Region
LRS	Len	Existing WAADT	Type	Grad	k	3R4R BM	Δ	NC BM	Δ	Estimated	Design	Δ	H Curve	INT	WA Year	Heavy Truck %	
754:02 C1 0.003 - 0.195	0.192		TAN	0.70													5
754:02 C1 0.195 - 0.346	0.151		SAG		84												5
754:02 C1 0.346 - 0.480	0.134		TAN	2.50													5
754:02 C1 0.480 - 0.668	0.188	1,020	CREST		98	50	48	100	-2	110	110	0				35.3	5
754:02 C1 0.668 - 1.051	0.383		TAN	0.60													5
754:02 C1 1.051 - 1.254	0.203	1,020	SAG		57	31	26	60	-3	115	110	5				35.3	5
754:02 C1 1.254 - 1.354	0.10		TAN	4.20													5
754:02 C1 1.354 - 1.672	0.318	1,020	CREST		87	50	37	100	-13	105	110	-5				35.3	5
754:02 C1 1.672 - 2.024	0.352		TAN	0.50													5

Figure 5f, Highway 754 – NESS Vertical Report (partial)

Posted Speed Summary Page 48 of 126

LRS	Length	Speed Km/Hr
754:02 C1 0.000 - 19.607	19.607	100
754:04 C1 0.000 - 41.162	41.162	100
754:06 C1 0.000 - 18.513	18.513	100
754:06 C1 18.513 - 19.623	1.11	80
754:06 C1 19.623 - 35.039	15.416	60

Figure 5g, Highway 754 – NESS Posted Speed Report

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Report Notes

For details on individual collisions, see 'Collision Details' section within the Collision Summary worksheet in the Excel version of this report

	Total				Roadway				Intersection			
Event	Fatal	Injury	Property Damage Only	Total	Fatal	Injury	Property Damage Only	Total	Fatal	Injury	Property Damage Only	Total
BACKING	0	1	0	1	0	1	0	1	0	0	0	0
HEAD ON	0	1	0	1	0	1	0	1	0	0	0	0
LEFT TURN - ACROSS PATH	0	0	0	0	0	0	0	0	0	0	0	0
OFF ROAD LEFT	2	10	18	30	1	8	17	26	1	2	1	4
OFF ROAD RIGHT	1	7	29	37	1	7	26	34	0	0	3	3
OTHER	0	1	1	2	0	0	1	1	0	1	0	1
PASSING - LEFT TURN	0	0	0	0	0	0	0	0	0	0	0	0
PASSING - RIGHT TURN	0	0	0	0	0	0	0	0	0	0	0	0
REAR END	0	7	8	15	0	2	2	4	0	5	6	11
RIGHT ANGLE	0	0	4	4	0	0	0	0	0	0	4	4
SIDESWIPE - OPPOSITE DIRECTION	0	3	10	13	0	2	7	9	0	1	3	4
SIDESWIPE SAME DIRECTION	0	0	1	1	0	0	1	1	0	0	0	0
STRUCK OBJECT	0	2	2	4	0	1	1	2	0	1	1	2
UNKNOWN	0	0	0	0	0	0	0	0	0	0	0	0
ANIMAL	0	3	105	108	0	3	104	107	0	0	1	1
TOTAL	3	35	178	216	2	25	159	186	1	10	19	30

Figure 5h, Highway 754 – NESS Collision Summary Report

NESS Work Activity Summary Page 3 of 126

NESS Scheduled Year	PMA Programmed Year	LRS	Length	Int #	Location	Direction	Work
2031		754:04 C1 25.000 - 29.348	4.348		45 Km N of Hwy 88 - 41 Km S of Hwy 813		GRADE WIDENING
2031		754:04 C1 29.348 - 41.162	11.814		41 Km S of Hwy 813 - 29 Km S of Hwy 813		GRADE WIDENING
2031		754:06 C1 28.733 - 35.039	6.306		Hwy 813 - 6 Km N of Hwy 813		GRADE WIDENING
2038		754:02 C1 0.000 - 19.607	19.607		Hwy 88 - 20 Km N of Hwy 88		GRADE WIDENING
2043		754:04 C1 0.000 - 25.000	25		20 Km N of Hwy 88 - 45 Km N of Hwy 88		GRADE WIDENING
2043		754:06 C1 0.000 - 13.800	13.8		29 Km S of Hwy 813 - 15 Km S of Hwy 813		GRADE WIDENING
2014		754:02 C1 3.747 - 4.314	0.567		4 Km N of Hwy 88 - 4 Km N of Hwy 88		HORIZONTAL CURVE RECONSTRUCTION
2014		754:02 C1 6.678 - 7.008	0.33		7 Km N of Hwy 88 - 7 Km N of Hwy 88		HORIZONTAL CURVE RECONSTRUCTION
2014		754:04 C1 0.746 - 1.358	0.612		20 Km N of Hwy 88 - 21 Km N of Hwy 88		HORIZONTAL CURVE RECONSTRUCTION
2014		754:04 C1 14.501 - 14.980	0.479		34 Km N of Hwy 88 - 35 Km N of Hwy 88		HORIZONTAL CURVE RECONSTRUCTION
2014		754:04 C1 17.810 - 18.422	0.612		37 Km N of Hwy 88 - 38 Km N of Hwy 88		HORIZONTAL CURVE RECONSTRUCTION
2014		754:04 C1 24.385 - 24.939	0.554		44 Km N of Hwy 88 - 45 Km N of Hwy 88		HORIZONTAL CURVE RECONSTRUCTION
2014		754:06 C1 2.476 - 2.717	0.241		26 Km S of Hwy 813 - 26 Km S of Hwy 813		HORIZONTAL CURVE RECONSTRUCTION
2014		754:02 C1 3.747 - 4.314	0.567		4 Km N of Hwy 88 - 4 Km N of Hwy 88		INSTALL SPEED ADVISORY
2014		754:02 C1 6.678 - 7.008	0.33		7 Km N of Hwy 88 - 7 Km N of Hwy 88		INSTALL SPEED ADVISORY
2014		754:04 C1 14.501 - 14.980	0.479		34 Km N of Hwy 88 - 35 Km N of Hwy 88		INSTALL SPEED ADVISORY
2014		754:04 C1 17.810 - 18.422	0.612		37 Km N of Hwy 88 - 38 Km N of Hwy 88		INSTALL SPEED ADVISORY
2014		754:04 C1 24.385 - 24.939	0.554		44 Km N of Hwy 88 - 45 Km N of Hwy 88		INSTALL SPEED ADVISORY
2014		754:06 C1 2.476 - 2.717	0.241		26 Km S of Hwy 813 - 26 Km S of Hwy 813		INSTALL SPEED ADVISORY
2014		754:06 C1 14.000 - 16.000	2		15 Km S of Hwy 813 - 13 Km S of Hwy 813		PASSING LANE
2014		754:06 C1 16.000 - 18.000	2		13 Km S of Hwy 813 - 11 Km S of Hwy 813		PASSING LANE
2014		754:02 C1 3.747 - 4.314	0.567		4 Km N of Hwy 88 - 4 Km N of Hwy 88		SUPERELEVATION ADJUSTMENT
2014		754:02 C1 6.678 - 7.008	0.33		7 Km N of Hwy 88 - 7 Km N of Hwy 88		SUPERELEVATION ADJUSTMENT
2014		754:02 C1 9.645 - 9.993	0.348		10 Km N of Hwy 88 - 10 Km N of Hwy 88		SUPERELEVATION ADJUSTMENT
2014		754:02 C1 12.380 - 12.708	0.328		12 Km N of Hwy 88 - 13 Km N of Hwy 88		SUPERELEVATION ADJUSTMENT
2014		754:02 C1 14.529 - 14.796	0.267		15 Km N of Hwy 88 - 15 Km N of Hwy 88		SUPERELEVATION ADJUSTMENT
2014		754:04 C1 14.501 - 14.980	0.479		34 Km N of Hwy 88 - 35 Km N of Hwy 88		SUPERELEVATION ADJUSTMENT
2014		754:04 C1 35.799 - 36.502	0.703		34 Km S of Hwy 813 - 33 Km S of Hwy 813		SUPERELEVATION ADJUSTMENT
2014		754:06 C1 0.068 - 0.222	0.154		29 Km S of Hwy 813 - 29 Km S of Hwy 813		SUPERELEVATION ADJUSTMENT
2014		754:06 C1 2.476 - 2.717	0.241		26 Km S of Hwy 813 - 26 Km S of Hwy 813		SUPERELEVATION ADJUSTMENT
2014		754:06 C1 7.240 - 7.383	0.143		21 Km S of Hwy 813 - 21 Km S of Hwy 813		SUPERELEVATION ADJUSTMENT
2014		754:06 C1 18.403 - 18.646	0.243		10 Km S of Hwy 813 - 10 Km S of Hwy 813		SUPERELEVATION ADJUSTMENT
2014		754:06 C1 23.977 - 24.102	0.125		5 Km S of Hwy 813 - 5 Km S of Hwy 813		SUPERELEVATION ADJUSTMENT
2014		754:06 C1 24.705 - 24.815	0.11		4 Km S of Hwy 813 - 4 Km S of Hwy 813		SUPERELEVATION ADJUSTMENT
2014		754:06 C1 28.780 - 29.031	0.251		Hwy 813 - Hwy 813		SUPERELEVATION ADJUSTMENT
2014		754:06 C1 29.274 - 29.372	0.098		1 Km N of Hwy 813 - 1 Km N of Hwy 813		SUPERELEVATION ADJUSTMENT
2014		754:06 C1 29.859 - 30.007	0.148		1 Km N of Hwy 813 - 1 Km N of Hwy 813		SUPERELEVATION ADJUSTMENT
2014		754:06 C1 31.699 - 31.806	0.107		3 Km N of Hwy 813 - 3 Km N of Hwy 813		SUPERELEVATION ADJUSTMENT
2014		754:06 C1 33.788 - 33.955	0.167		5 Km N of Hwy 813 - 5 Km N of Hwy 813		SUPERELEVATION ADJUSTMENT
2014		754:06 C1 34.199 - 34.309	0.11		5 Km N of Hwy 813 - 6 Km N of Hwy 813		SUPERELEVATION ADJUSTMENT
2014		754:06 C1 34.471 - 34.582	0.111		6 Km N of Hwy 813 - 6 Km N of Hwy 813		SUPERELEVATION ADJUSTMENT
2014		754:04 C1 1.018 - 1.207	0.189		21 Km N of Hwy 88 - 21 Km N of Hwy 88		VERTICAL CURVE RECONSTRUCTION

Figure 5i: Highway 754 – NESS Work Activity Summary Report

NESS produces Work Activity Summary as illustrated in the above table. There are three levels of work activities in NESS. Level 1 is data collection. Level 2 is engineering studies or safety assessment. Level 3 is remedial measures such as installation of speed advisory sign, superelevation improvement, horizontal and vertical alignment reconstruction, grade widening, intersection improvement and passing lanes.

NESS generates a high level report on geometric design and safety recommendations. In general, these reports are further used as reference for engineering studies or for programming of capital improvement projects.

NESS' Output for Decision Support in Planning, Programming, Design and Safety Analysis

After performing network screening and processing, information on geometric design and safety analysis and associated work activities are stored in Transportation Infrastructure Management System (TIMS) Inventory.

As shown previously, users could generate various types of NESS reports on roadway geometric conditions with associated safety analysis. Customize reporting could be generated for planning, programming, design and safety analysis.

NESS outputs are used for different aspects:

- Infrastructure planning engineers use information from NESS to identify and prioritize highway sections that require geometric and safety improvements.
- NESS reports form the basis as terms of reference for preliminary engineering and detailed design for each project.
- NESS information can assist to analyze impacts from changes in standards and policies.
- Safety engineers use NESS information for development of various Traffic Safety Plan programs such as catch-up shoulder rumble strips program and black spot program.
- Geometric designers use NESS for scoping of 3R/4R geometric and safety improvements for incorporation into pavement rehabilitation projects.
- Safety engineers use NESS reports to conduct in-service road safety review.
- Planning and geometric design engineers use NESS reports with geometric design and safety information to assist in highway corridor planning and access management studies.
- As shown in Figure 2, the performance measures are listed on the annual report; it shows the department's effort in highway performance management.
- The output is used for capital funding requests to Treasury Board, Government of Alberta's statutory Cabinet committee.

Geometric Design Decisions and Project Development Process

Geometric design and safety decisions are interdependent and they should be considered in all phases of the project development process with intended outcomes or target performance. Geometric design and safety decisions will evolve throughout the project development process. In this regard, geometric and safety engineers should be undertaken geometric and safety analysis and provide appropriate input to influence final outcomes and performance related to safety, mobility, accessibility and quality of service in all stages of the development process.

Figure 6 shows the highway capital planning and project development processes. Through this ten year cycle, projects are being identified for planning, preliminary engineering, survey and design, right-of-way acquisition, environmental assessment and finally construction programming. Traditionally, geometric design has limited roles in capital planning and programming of highway projects. System planning or long range planning may consider the role of geometric design at a rudimentary level in terms of geometric design relative to service classification. As projects advance to the preliminary engineering and planning study phases, geometric design and safety would be given stronger consideration. The application of NESS and CIA in Alberta enable geometric design decisions and safety are taking into strong consideration in the capital planning stage that ultimately will result in better and safer roads.

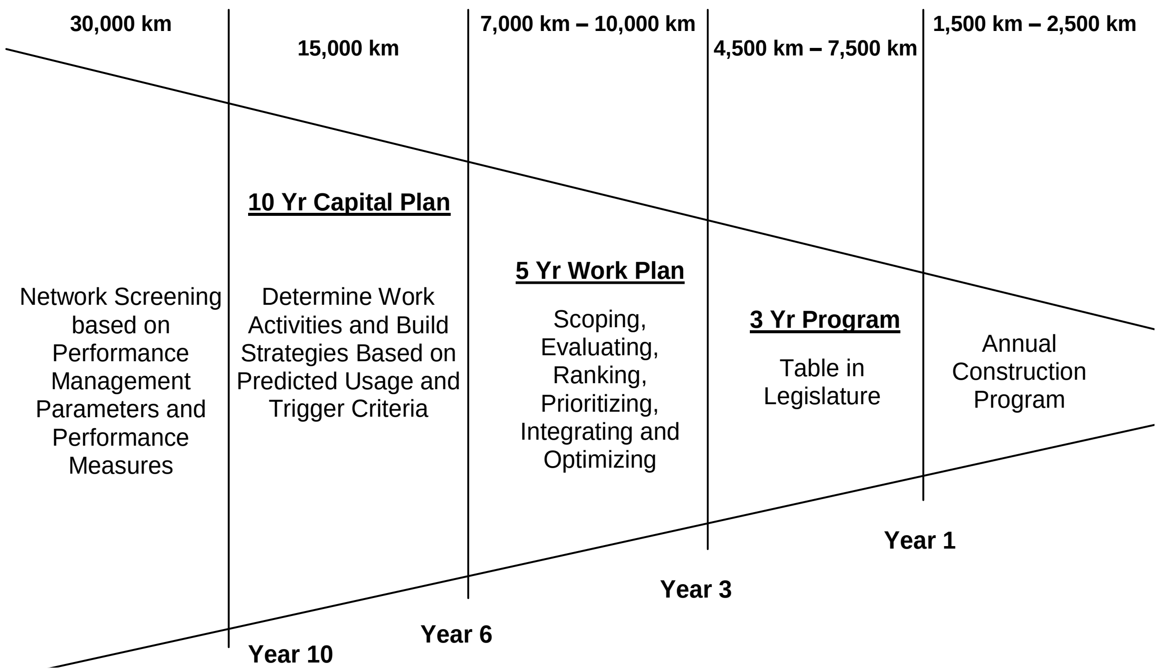

Figure 6, Highway Capital Plan and Project Development Process

CASE STUDIES

Three case studies are shown in this section to demonstrate the earlier application of geometric and safety considerations for project development. The case studies illustrate the functionality of NESS in terms of: (1) incorporating 3R/4R geometric and safety improvement to pavement rehabilitation projects; (2) developing geometric and safety improvement projects to eliminate safety inadequacy; and (3) developing geometric improvement projects to meet capacity requirements.

Geometric Improvement with Pavement Rehabilitation Project

Prior to NESS implementation, Alberta Transportation geometric designers and engineering consultants performed 3R/4R geometric and safety assessment of future pavement rehabilitation projects. The purpose of 3R/4R improvements is to extend the service life of existing paved highways and enhance highway safety on a network basis. Geometric assessment was a labour intensive and tedious process as most roadway geometric and safety data were not readily available. In 2007, geometric and safety assessment of planned pavement rehabilitation projects were automated through NESS. Suggested 3R/4R safety improvements generated by NESS would be assesses for inclusion in corresponding pavement rehabilitation projects scheduled in future years. Figure 7shows the general work flow of including geometric improvement projects to the pavement rehabilitation project.

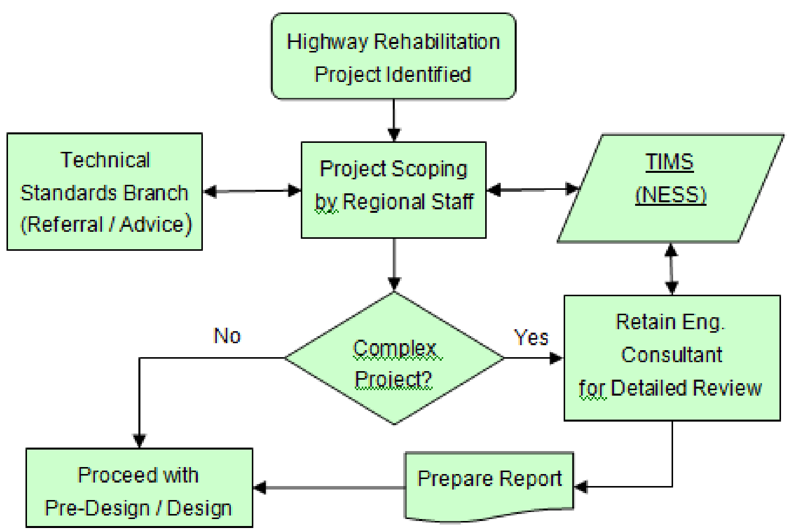

Figure 7, Work flow for Pavement Rehabilitation Scoping

As shown in *Figure 8*, a snapshot of work activities summary for Highway 36:26, NESS suggests grade widening, vertical curve reconstruction and turning lanes at two intersections be included with this pavement rehabilitation project. Further engineering studies were also suggested for other segments of Highway 36:26.

Alberta Transportation

TIMS Network Expansion Support System (NESS)
TIMS Geometric Report

Dave Hadfield
2014 Feb 10 13:19

Work Activity Summary

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Year	LRS	Length	Int #	Location	Direction	Work
2027	36:26 C1 55.275 - 60.306	5.031		1 Km N of Hwy 55 - 6 Km N of Hwy 55		GRADE WIDENING
2027	36:26 C1 61.750 - 71.594	9.844		7 Km N of Hwy 55 - 1 Km S of Hwy 881		GRADE WIDENING
2013	36:26 C1 72.731 - 72.813	0.082		1 Km N of Hwy 881 - 1 Km N of Hwy 881		VERTICAL CURVE RECONSTRUCTION
2013	36:26 C1 73.278 - 73.477	0.199		1 Km S of Hwy 55 - 1 Km S of Hwy 55		VERTICAL CURVE RECONSTRUCTION
2013	36:26 C1 73.721 - 73.791	0.07		1 Km S of Hwy 55 - 1 Km S of Hwy 55		VERTICAL CURVE RECONSTRUCTION
2013	36:26 C1 73.851 - 73.963	0.112		Hwy 55 - Hwy 55		VERTICAL CURVE RECONSTRUCTION
2026	36:26 C1 73.155		8712	Highway 36:26 And 2 Avenue	N	CONSTRUCT RIGHT TURN LANE
2029	36:26 C1 74.110		4734	Highway 36:26 And Vera Welch School Access	S	CONSTRUCT RIGHT TURN LANE
2062	36:26 C1 72.217		2499	Highway 36:26 And 881:18 And 55:13		INSTALL SIGNAL
2013	36:26 C1 72.731 - 72.813	0.082		1 Km N of Hwy 881 - 1 Km N of Hwy 881		GEOMETRIC STUDY - VERTICAL CURVE
2013	36:26 C1 73.278 - 73.477	0.199		1 Km S of Hwy 55 - 1 Km S of Hwy 55		GEOMETRIC STUDY - VERTICAL CURVE
2013	36:26 C1 73.721 - 73.791	0.07		1 Km S of Hwy 55 - 1 Km S of Hwy 55		GEOMETRIC STUDY - VERTICAL CURVE
2013	36:26 C1 73.851 - 73.963	0.112		Hwy 55 - Hwy 55		GEOMETRIC STUDY - VERTICAL CURVE
2023	36:26 C1 55.275 - 60.306	5.031		1 Km N of Hwy 55 - 6 Km N of Hwy 55		PLANNING STUDY (GRADE WIDENING)
2023	36:26 C1 61.750 - 69.500	7.75		7 Km N of Hwy 55 - 3 Km S of Hwy 881		PLANNING STUDY (GRADE WIDENING)
2023	36:26 C1 69.500 - 71.594	2.094		3 Km S of Hwy 881 - 1 Km S of Hwy 881		PLANNING STUDY (GRADE WIDENING)
2013	36:26 C1 61.750 - 71.594	9.844		7 Km N of Hwy 55 - 1 Km S of Hwy 881		SAFETY ASSESSMENT
2013	36:26 C1 72.830 - 72.977	0.147		1 Km N of Hwy 881 - 1 Km N of Hwy 881		SPEED STUDY (VERTICAL CURVE)
2013	36:26 C1 73.157 - 73.221	0.064		1 Km N of Hwy 881 - 1 Km N of Hwy 881		SPEED STUDY (VERTICAL CURVE)
2020	36:26 C1 61.648 - 62.043	0.395		7 Km N of Hwy 55 - 8 Km N of Hwy 55		SPEED STUDY (VERTICAL CURVE)
2020	36:26 C1 63.447 - 63.965	0.518		9 Km S of Hwy 881 - 8 Km S of Hwy 881		SPEED STUDY (VERTICAL CURVE)
2020	36:26 C1 66.329 - 66.756	0.427		6 Km S of Hwy 881 - 5 Km S of Hwy 881		SPEED STUDY (VERTICAL CURVE)
2020	36:26 C1 67.113 - 67.386	0.273		5 Km S of Hwy 881 - 5 Km S of Hwy 881		SPEED STUDY (VERTICAL CURVE)
2020	36:26 C1 67.967 - 68.211	0.244		4 Km S of Hwy 881 - 4 Km S of Hwy 881		SPEED STUDY (VERTICAL CURVE)
2021	36:26 C1 73.155		8712	Highway 36:26 And 2 Avenue	N	INTERSECTION ASSESSMENT
2024	36:26 C1 74.110		4734	Highway 36:26 And Vera Welch School Access	S	INTERSECTION ASSESSMENT
2013	36:26 C1 72.217		2499	Highway 36:26 And 881:18 And 55:13		INTERSECTION SAFETY ASSESSMENT
2013	36:26 C1 74.317		4269	Highway 36:26 And 881:19		INTERSECTION SAFETY ASSESSMENT

Figure 8, Work Activity Summary for Highway 36:26

Intersection Safety Improvement Project Development

The NESS intersection report (*Figure 9*) provides information on highway intersections. NESS gives a detailed report for the location description, intersection details, safety performance, turning lane analysis, traffic signal analysis, illumination analysis and summary of work activities.

The report includes reported collisions within the intersection area during the latest five years. Fatal, injury and property damage only (PDO) has their associated collision cost, which is used for calculate the total collision cost at the intersection. The benchmark is determined using the average collision cost per intersection having similar entering volumes. Turning lane warrant is conducted as per geometric design guidelines in Chapter D of the Highway Geometric Design Guide.

Based on the aforementioned studies, the work activities for an intersection are summarized (see *Figure 10*).

Intersection Report Page 6 of 32

Report Notes

Number of results found 1

The number of collisions in this report are collisions at and near the intersection and are collisions within the intersection polygon in TIMS

For details on individual collisions, see the "Collision Details" section within Excel report

The Signalization Work Activity Trigger is Traffic Score (TS) > 79 or TS >= 60 with 5 or more angle collisions

Interchange Trigger - Signalization trigger met on Level 1 divided highway with 100+ km/h, or left turn volume >= 700 vehicles per hour

Collision Cost in $ (M) over 5 years

Collision Rate in C/100MEV

Intersection collision rate is calculated as (sum of intersection collisions over 5 years * 100 Mil) + (sum of AADT entering over 5 years * 365.25)

Collision cost is calculated as (sum of collisions involving a fatality * $1,345,068) + (sum of collisions involving a serious injury * $100,000) + (sum of collisions involving a minor injury * $100,000) + (sum of the property damage only collisions * $12,000)

Va, Vo and Vl in VPH

LT & RT Length in m

Pk = Peak Hour

Year LT = Scheduled Year of Left Turn Lane Construction

Year LTR = Scheduled Year of Left Turn Lane Reconstruction

Year RT = Scheduled Year of Right Turn Lane Construction

Year RTR = Scheduled Year of Right Turn Lane Reconstruction

INT #:599 LRS: 55:18 C1 18.898

Location: HIGHWAY 55:18 AND 892:02 AND 892:04

Lv 2 Work Activity Summary	Lv 3 Work Activity Summary
2013 INTERSECTION ASSESSMENT **2013** INTERSECTION SAFETY ASSESSMENT	**2013** CONSTRUCT RIGHT TURN LANE

Int. Type: RND
Service Class: LV 2

Major Road Details
Posted Speed: 100
Lit: Y Sig: N Div: N Radius:

TMD Ref: 135640
Maj Rd: 55-EB/WB
Min Rd: 892-NB/SB

	Veh/day	Growth
Maj Rd: 55-EB/WB	3,290	2.23%
Min Rd: 892-NB/SB	2,370	2.23%

Collision Frequency				Collision Rate				Collision Cost	
Total	Fatal	Inj	Non-An	Total	BM	Non-An	BM	Cost (in $M)	BM
15	1	8	15	208.5	151.1	208.5	120.6	2.217	0.500

Approach	LT Lane	LT Len	LT BM	RT Lane	RT Len	RT BM	Chan	Yr LT	Vo	Vl	BM	Va	Undiv BM	Pk	Yr RT	RT AADT	Yr Chan
55-EB																110	
55-WB															2012	620	

Yr Signal	TS	Ang. Coll	Yr IC	TS	LT vph	Yr Light.	Day	Night	N/D Col%	Near VC
2062		4					7	7	100.00	Y

Figure 9, Intersection Report that Identifies Safety Deficiencies

Work Activity Summary Page

Year	LRS	Length	Int #	Location	Direction	Work
2052	55:18 C1 28.538 - 35.900	7.362		Hwy 897 - CITY of Cold Lake		4-LANE
2024	55:18 C1 0.000 - 0.374	0.374		Hwy 41 - Hwy 41		GRADE WIDENING
2042	55:18 C1 0.374 - 18.360	17.986		Hwy 41 - Hwy 892		GRADE WIDENING
2062	892:02 C1 16.976 - 20.949	3.973		4 Km S of Hwy 55 - Hwy 55		GRADE WIDENING
2062	892:04 C1 0.155 - 8.750	8.595		Hwy 55 - 8 Km N of Hwy 55		GRADE WIDENING
2016	55:18 C1 8.909 - 9.488	0.579		9 Km E of Hwy 41 - 9 Km W of Hwy 892		HORIZONTAL CURVE RECONSTRUCTION
2016	55:18 C1 10.869 - 11.412	0.543		8 Km W of Hwy 892 - 7 Km W of Hwy 892		HORIZONTAL CURVE RECONSTRUCTION
2013	55:18 C1 8.909 - 9.488	0.579		9 Km E of Hwy 41 - 9 Km W of Hwy 892		INSTALL SPEED ADVISORY
2013	55:18 C1 10.869 - 11.412	0.543		8 Km W of Hwy 892 - 7 Km W of Hwy 892		INSTALL SPEED ADVISORY
2016	55:18 C1 8.909 - 9.488	0.579		9 Km E of Hwy 41 - 9 Km W of Hwy 892		SUPERELEVATION ADJUSTMENT
2016	55:18 C1 10.869 - 11.412	0.543		8 Km W of Hwy 892 - 7 Km W of Hwy 892		SUPERELEVATION ADJUSTMENT
2016	55:18 C1 13.740 - 13.939	0.199		5 Km W of Hwy 892 - 5 Km W of Hwy 892		VERTICAL CURVE RECONSTRUCTION
2013	55:18 C1 18.898		599	Highway 55:18 And 892:02 And 892:04	W	CONSTRUCT RIGHT TURN LANE
2052	55:18 C1 13.499		5018	Highway 55:18 And Happy Hollow Road	W	CONSTRUCT RIGHT TURN LANE
2052	55:18 C1 0.000		1214	Highway 55:16 And 55:18 And 41:24		INSTALL SIGNAL
2062	55:18 C1 18.898		599	Highway 55:18 And 892:02 And 892:04		INSTALL SIGNAL
2013	55:18 C1 8.909 - 9.488	0.579		9 Km E of Hwy 41 - 9 Km W of Hwy 892		GEOMETRIC STUDY - HORIZONTAL CURVE
2013	55:18 C1 10.869 - 11.412	0.543		8 Km W of Hwy 892 - 7 Km W of Hwy 892		GEOMETRIC STUDY - HORIZONTAL CURVE
2013	55:18 C1 13.740 - 13.939	0.199		5 Km W of Hwy 892 - 5 Km W of Hwy 892		GEOMETRIC STUDY - VERTICAL CURVE
2013	55:18 C1 8.909 - 9.488	0.579		9 Km E of Hwy 41 - 9 Km W of Hwy 892		PERFORM BALL BANK INDICATOR
2013	55:18 C1 10.869 - 11.412	0.543		8 Km W of Hwy 892 - 7 Km W of Hwy 892		PERFORM BALL BANK INDICATOR
2014	55:18 C1 0.000 - 0.374	0.374		Hwy 41 - Hwy 41		PLANNING STUDY (GRADE WIDENING)
2013	55:18 C1 0.374 - 18.360	17.986		Hwy 41 - Hwy 892		SAFETY ASSESSMENT
2013	55:18 C1 18.898 - 28.538	9.64		Hwy 892 - Hwy 897		SAFETY ASSESSMENT
2013	55:18 C1 28.538 - 35.900	7.362		Hwy 897 - CITY of Cold Lake		SAFETY ASSESSMENT
2013	892:02 C1 16.976 - 20.949	3.973		4 Km S of Hwy 55 - Hwy 55		SAFETY ASSESSMENT
2013	55:18 C1 8.909 - 9.488	0.579		9 Km E of Hwy 41 - 9 Km W of Hwy 892		SAFETY ASSESSMENT - HORIZONTAL CURVE
2013	55:18 C1 24.590 - 24.706	0.116		4 Km W of Hwy 897 - 4 Km W of Hwy 897		SPEED STUDY (VERTICAL CURVE)
2016	55:18 C1 2.928 - 3.170	0.242		3 Km E of Hwy 41 - 3 Km E of Hwy 41		SPEED STUDY (VERTICAL CURVE)
2016	55:18 C1 7.654 - 7.835	0.181		8 Km E of Hwy 41 - 8 Km E of Hwy 41		SPEED STUDY (VERTICAL CURVE)
2016	55:18 C1 9.045 - 9.249	0.204		9 Km E of Hwy 41 - 9 Km E of Hwy 41		SPEED STUDY (VERTICAL CURVE)
2016	55:18 C1 13.941 - 14.274	0.333		5 Km W of Hwy 892 - 4 Km W of Hwy 892		SPEED STUDY (VERTICAL CURVE)
2016	55:18 C1 17.854 - 18.038	0.184		1 Km W of Hwy 892 - 1 Km W of Hwy 892		SPEED STUDY (VERTICAL CURVE)

Figure 10, Intersection Safety Improvement Work Activity Summary

Multi-lane Project Development

The NESS multilane report shows road segments that require more driving lanes to accommodate future traffic demand and address safety performance. The Weighted Annual Average Daily Traffic (WAADT) is the latest traffic data in the TIMS data repository. Using the growth rate for the road segment, traffic volume in year 20 is projected. The level of service is computed for road segments at year 0 and year 20. The year in which the 4-lane, 6-lane or 8-lane work activity is triggered, as shown in the work summary (see *Figure 11*).

Alberta Transportation

TIMS Network Expansion Support System (NESS)
Multilane Report

Dave Hadfield
2014 Feb 07 13:26

				WAADT		LOS			NESS Sched		4 lane		6 lane		8 lane			
LRS	Len	Serv Class	# Lanes	Year 0	Year 20	Year 0	Year 20	Growth Rate	1st Work Year	WAADT	Need Year	WAADT	Need Year	WAADT	Need Year	WAADT	Notes	Region
2:20 L1 1.619 - 4.537	2.918	LV 1	6	29,400	40,450	B	C	1.88	2052	56,456			2024	36,084	2052	56,456		3
2:20 L1 4.537 - 9.713	5.176	LV 1	4	29,400	40,450	B	C	1.88	2052	56,456			2024	36,084	2052	56,456		3
2:20 L1 9.713 - 21.051	11.338	LV 1	4	29,420	40,480	B	C	1.88	2052	56,456			2024	36,084	2052	56,456		3
2:20 L1 21.051 - 35.570	14.519	LV 1	4	28,630	40,590	B	C	2.09	2052	56,456			2023	35,298	2052	56,456		3
2:22 L1 0.000 - 0.550	0.55	LV 1	5	28,780	40,800	B	C	2.09	2022	34,830			2022	34,830	2052	57,804		3
2:22 L1 0.550 - 16.040	15.49	LV 1	4	28,780	40,800	B	C	2.09	2022	34,830			2022	34,830	2052	57,804		3
2:22 L1 16.040 - 24.519	8.479	LV 1	4	30,740	43,580	B	C	2.09	2022	34,830			2022	34,830	2042	51,874		3
2:22 L1 24.519 - 27.938	3.419	LV 1	4	30,020	40,850	B	C	1.80	2021	36,015			2021	36,015	2052	55,576		3
2:24 L1 0.000 - 4.055	4.055	LV 1	4	32,050	43,610	B	C	1.80	2020	37,995			2020	37,995	2042	50,868		3
2:24 L1 4.055 - 8.239	4.184	LV 1	6	32,050	43,610	B	C	1.80	2020	37,995			2020	37,995	2042	50,868		3
2:24 L1 8.239 - 15.686	7.447	LV 1	4	32,050	43,610	B	C	1.80	2020	37,995			2020	37,995	2042	50,868		3
2:24 L1 15.686 - 21.638	5.952	LV 1	5	36,030	49,030	B	C	1.80	2020	37,995			2020	37,995	2037	52,952		3
2:24 L1 21.638 - 23.911	2.273	LV 1	4	37,070	51,190	C	D	1.90	2020	37,995			2020	37,995	~~2038~~			3
2:24 L1 23.911 - 25.021	1.11	LV 1	5	37,070	51,190	C	D	1.90	2020	41,855			2020	41,855	~~2039~~			3
2:24 L1 25.021 - 25.940	0.919	LV 1	5	26,460	36,540	B	C	1.90	2020	41,855			2020	41,855	2052	50,454		3
2:24 L1 25.940 - 28.158	2.218	LV 1	4	39,890	58,930	C	D	2.39	2030	59,432			2030	59,432	~~2029~~			3
2:24 L1 28.158 - 33.007	4.849	LV 1	4	50,360	69,540	C	D	1.90	2019	52,223			2019	52,223	~~2042~~			3
2:24 L1 33.007 - 36.372	3.365	LV 1	4	39,440	54,460	C	D	1.90	2019	52,223			2019	52,223	~~2026~~			3
2:26 L1 0.000 - 1.663	1.663	LV 1	4	38,690	53,420	C	D	1.90	2013	39,340			2013	39,340	~~2029~~			3
2:26 L1 1.663 - 1.864	0.201	LV 1	5	38,690	53,420	C	D	1.90	2013	39,340			2013	39,340	~~2028~~			3
2:26 L1 1.864 - 7.002	5.138	LV 1	4	38,690	53,420	C	D	1.90	2017	36,229			2017	36,229	~~2029~~			3
2:26 L1 7.002 - 17.498	10.496	LV 1	4	32,660	45,100	B	C	1.90	2025	35,524			2025	35,524	2042	52,996		3
2:26 L1 17.498 - 26.319	8.821	LV 1	4	27,810	38,400	B	C	1.90	2052	54,642			2025	35,524	2052	54,642		3
2:26 L1 26.319 - 27.567	1.248	LV 1	4	28,250	40,180	A	B	2.11	2028	33,336			2028	33,336	2052	54,642		3

Figure 11 Multi-lane Project Development for Future 20 Years

Review of Other Geometric Design and Safety Applications

Highway network expansion and rehabilitation is one of the key components in transportation asset management. From a geometric design and safety perspective, there were several policy initiatives to achieve optimum return on investments. In 1997, FHWA developed the national guidance document *Flexibility in Highway Design* (*5*). The "flexibility" means that design will not only meet the minimum requirements of geometric design standard, but also will achieve an optimum solution that balances conflicting interests from all stakeholders. In 1999, FHWA began the research on Context-Sensitive Design (CSD), now called Context-Sensitive Solutions (CSS) (*6*). The philosophy of CSD is to incorporate community impacts beyond the basic transportation considerations. CSD concept seeks a collaborative project development process that understands the design decisions' impacts and trade-offs for all the stakeholders. Recently, Transportation Research Board released a National Cooperative Highway Research Program (NCHRP) publication on Performance-Based Analysis of Geometric Design of Highways & Streets. This publication describes the proposed performance-based analysis framework for geometric design. The framework includes (1) the project initiation phase, which determines intended outcomes within the project context; and (2) the concept development, which analyzes the influence of discrete design decisions of a geometric element to generate a set of potential solutions for further evaluation; and (3) the evaluation and selection phase, which performs performance measure process and financial feasibility evaluation. The best alternatives are selected according to the whole process. Six case studies were demonstrated to showcase this analysis process (*7*, *8*).

The concept of using performance measures for geometric design is widely accepted in various agencies. Several state DOTs started to implement Practical Design policy, which was consistent with CSS principle. They identified target objectives for design alternatives. Missouri Department of Transportation (MoDOT) started to implement Practical Design policy from 2005. The related projects addressed insufficiency, corridor needs, and cost reduction (*9*). MoDOT suggested that Practical Design can apply to all projects, while it was most effective at the scoping level (*10*). Kentucky adopted the Practical Design procedure in 2007. They considered project investment to achieve optimal safety, mobility and utility return. The Practical Design was applied from planning through operations and maintenance (*11*). Idaho adopted CSS approach in 2005 and started their Practical Solutions in 2007. They considered safety benefits as the most important goal, and they also reported cost savings (*10*). Oregon incorporated Practical Design into their project delivery-cycle from 2009 (*12*). They considered system optimization from safety, corridor context, and public support perspective and found most cost efficiency design alternatives. Utah also adopted Practical Design concept from 2011, they set objectives and optimized the transportation system as a whole (*10*).

Safety Analyst (SA) is a system-wide safety analysis tool that applies Practical Design concept. It screens the roadway network to find the sites that potentially require safety improvements. It diagnoses the problems, assists selection of countermeasures, and prioritizes improvement projects based on benefit-cost analysis. Currently, 11 State DOTs, and Ontario in Canada are using SA for their capital improvement projects. FHWA also developed another web-based tool named Infrastructure Voluntary Evaluation Sustainability Tool (INVEST). This tool helps highway agencies evaluate highway projects from sustainability perspective, which includes three key principles: economic, social and environmental. In terms of life-cycle analysis, highway projects are evaluated through three stages: System Planning (SP), Project Development (PD) and Operations and Maintenance (OM). Six State DOT evaluated their projects with INVEST for sustainability (*13*).

For overall effectiveness, safety, level of service and capacity should be considered concurrently throughout the project development process. The analytical tools aforementioned only consider one perspective: safety or sustainability whereas NESS is capable of identifying and reporting highway segments' and intersections' deficiencies relative to geometric, capacity and safety thresholds. Its network screening incorporates the desired outcomes in performance measures and performance management. Within NESS, geometric design elements are considered, such as design speed, lane width, radius, superelevation, crest and sag curve, grade, intersection and access. Safety information for each geometric design element is analysed and evaluated relative to pre-determined thresholds. It determines both current and future technical requirements in the project development process, ahead of programming and construction activities.

CONCLUSIONS

NESS/CIA is a geometric design and safety-based decision support tool within Alberta's Transportation Infrastructure Management System (TIMS). Annually, the provincial highway network is analyzed to assess for sufficiency in capacity, geometric design and safety. NESS can determine network deficiencies based on capacity, geometric design and safety thresholds. By knowing when and where these future network needs are, geometric and safety improvements can be assembled effectively and efficiently for capital planning, preliminary engineering and programming prior to the detailed design stage. Ultimately, incorporation of geometric design and safety based decisions in all phases of project development process will lead to better and safer roads. Based on Alberta Transportation's experience, it is possible to develop an enterprise-wide transportation infrastructure management system that incorporates geometric design and safety-based applications.

The case studies shown in this paper demonstrate NESS' capability of addressing different transportation issues. Case Study One shows how it incorporates geometric improvements to pavement rehabilitation project. Case Study Two shows that NESS is able to conduct detailed intersection geometric analysis to address possible future safety inadequacy. Case Study Three shows the development of multi-lane projects to meet future capacity requirements.

The aforementioned NCHRP 15-34 project: Performance-Based Analysis of Geometric Design of Highways and Streets defines a process that geometric design and safety decisions and other considerations be assessed in more details at the preliminary engineering stage. It is worthwhile to note this process is only applicable at the project level, not at network nor programming level. It is anticipate that Performance-Based Analysis **System** of Geometric Design would be the next phase of development to enable geometric design consideration be included in earlier phases of project development.. NESS has been using the 'system' or network approach for over eight years. It performs an integrated analysis to identify desired outcomes and suggests cost-effective geometric design and safety work activities based on performance management metrics and performance measures. Geometric design standards for various geometric parameters and other related technical guidelines for traffic and safety analysis are included in the applications. In conjunction with roadway inventory and their conditions, NESS performs network screening and transfer the processed roadway information back into TIMS data/information repository for usage by users.

NESS is becoming an important tool to achieve Alberta Transportation's organizational excellence. To a large extent, the readily available roadway geometric and safety information and proposed work activities have successfully reduce costs and time in planning, programming and engineering analysis. It has gained around 300 users in total, both internal and external to the department. With NESS' outcome-driven principle, more and more professionals are using NESS to analsyse geometric and safety deficiencies within their planning and design projects, or to assess the health of the network.

Therefore, NESS has several unique features that made the analysis tool gains its user in a sustainable way:

1). NESS is within an enterprise-wide infrastructure management system such that data and information from traffic management, pavement management and bridge management are available for application.

2). NESS uses a sound performance-based analysis framework that includes geometric design and safety analysis at network, programming and project levels and.

3). NESS's web-based service enhances accessibility and reliability.

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