

**TIME-OF-RETURN (TOR) ANALYSIS USING THE  
“NON-TRUNKLINE TOR FY 2018” EXCEL WORKSHEET**

- 1) Please contact Pam Blazo of Local Agency Programs, Development Services Division, at (517) 335-2224, if you have questions concerning this worksheet. For more information on the MDOT Local Agency Programs, Safety Program please visit [http://www.michigan.gov/mdot/0,4616,7-151-9625\\_25885\\_40552---,00.html](http://www.michigan.gov/mdot/0,4616,7-151-9625_25885_40552---,00.html)
- 2) If a dialogue box appears which states, “Macros in this workbook are disabled...”, click “OK”.
- 3) The “**Info**” tab’s orange shaded fields must be filled out completely to obtain a TOR value.
- 4) Information in the “**TOR\_MAIN**” tab should be completed to obtain a TOR value. The cells will change color when completed. At least one group of related crashes must be filled out with at least three years of data.
- 5) To gain information on the crash reduction factors (CRF) for the “**TOR\_MAIN**” tab, use the “**Intersection CRF**” and “**Segment CRF**” tabs. If you would like to use a CRF or improvement not listed, please contact Pam Blazo at (517) - 335-2224. Also, reference the CMF (Crash Modification Factors) Clearing house at <http://www.cmfclearinghouse.org/>
- 6) Save the TOR analysis under the desired name using the “SAVE AS” command. Use the original Non-TL\_TOR\_18 for each project location.
- 7) The default tables are left blank. The appropriate crash types and crash reduction factors may be entered into these tables as needed to accurately analyze a variety of potential countermeasures and/or proposed safety improvements.
- 8) A. Enter the number of total crashes. B. Enter the total number of PDO and type C-injury crashes, combined. C. Enter the total number of type B-injuries. D. Enter the total number of type A-injuries and fatalities, combined.
- 9) Enter project cost estimate, ADT information, number of years of crash data used, inflation rate, and area type in the appropriate fields. For the ADT, either enter the current and the projected 10-year volumes, or assign a flat 10% growth factor by entering the numbers “1.0” and “1.1” in the ADT(before) and ADT(after) fields, respectively. For the inflation rate, a default rate of 2.50% should be used.
- 10) 1 single crash may only be applied to 1 CRF. Example: When upgrading to a box span signal and installing a center left turn lane, a head on left turn crash can only be applied to either the box span upgrade (10% CRF) or a center left turn lane install (65% CRF), but not to BOTH CRF’s.
- 11) To print a copy of the “**TOR\_MAIN**” and respective output report sheet, go to the “**Print**” Tab, then select print.

Prepared by	Ann Marie Kerby
Project Name	Example 1
Location	Road 1
City / Township	Main City
County	Genesee County
PR Number(s)	1497102, 1498309, 1498310
PR Milepoint(s) Range	0-4.043
Type of Improvement	Install Center-Left Turn lane
Date	3/16/2011
Cost(\$)	\$400,000

*NOTE: All shaded cells need to be completed to obtain a TOR result.*

TOR 2011 (Local Agency)

ENTERACCs

INSTRUCTIONS:

Fill in the number of 1) Minor Crashes, which are Property Damage with or without B and C injuries ("PDO+Minor"), and 2) Number of Persons A-injured (disabled) or killed. Put each number in the appropriate cell for the crash type and year. You may change the crash types, the percent reductions, and/or the calendar years, as needed. Please refer to the bottom of the following table for further instructions and input requirements.

NUMBER OF CRASHES OR INJURED PERSONS.

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
	2005	2006	2007	2008	2009
<b>Center Left-turn lane - Rear -End, Left Turn</b>					
	80%	%REDUCTION			
Number of Crashes	8	4	5	3	6
PDO+C Injury Crashes	6	3	2	1	3
B-Injured Persons	2	5	7	2	4
A-Injured or Killed Persons	0	0	1	0	0
<b>Center Left-turn lane - Head On, Angle, Other</b>					
	20%	%REDUCTION			
Number of Crashes	8	7	5	6	4
PDO+C Injury Crashes	9	4	6	4	5
B-Injured Persons	0	4	6	3	2
A-Injured or Killed Persons	0	0	0	1	0
<b>Blank Section 1</b>					
		%REDUCTION			
Number of Crashes					
PDO+C Injury Crashes					
B-Injured Persons					
A-Injured or Killed Persons					
<b>Blank Section 2</b>					
		%REDUCTION			
Number of Crashes					
PDO+C Injury Crashes					
B-Injured Persons					
A-Injured or Killed Persons					
<b>Blank Section 3</b>					
		%REDUCTION			
Number of Crashes					
PDO+C Injury Crashes					
B-Injured Persons					
A-Injured or Killed Persons					

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	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
	2005	2006	2007	2008	2009
<b>All-Red Clearance Interval - All Crash Types</b>					
	10%	%REDUCTION			
Number of Crashes	10	12	14	16	18
PDO+C Injury Crashes	8	10	12	14	16
B-Injured Persons	2	1	2	1	2
A-Injured or Killed Persons	0	2	0	1	0

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<b>TOR</b>
1.96

# A-Injuries: 2 For reference only  
 # Fatalities: 0 For reference only; "Q" accounts for the risk of a fatality.  
 PROJECT COST ESTIMATE: \$400,000 If unknown, enter "0" (zero).  
 ADTb (before-volume) 1.0 You may change these  
 ADTa (after-volume) 1.1 default ADT values.  
 NUMBER OF YEARS OF DATA: 5.00 3 to 5 years should be used.  
 RATE OF INFLATION: 2.50%  
 AREA TYPE: 2 (1 = RURAL, 2 = URBAN, 3 = BETWEEN)

REMARKS:	Example 1 Road 1 1497102, 1498309, 1498310 0-4.043 Install Center-Left Turn lane
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The worksheet calculates the Time of Return (TOR) for you. To view the results, go to REPORT page. Then Save, Print, and/or Start Over.

**NUMBER OF CRASHES OR INJURED PERSONS.**

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
	2005	2006	2007	2008	2009
<b>Center Left-turn lane - Rear -End, Left Turn</b>					
	<b>80% %REDUCTION</b>				
Number of Crashes	8	4	5	3	6
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A-Injured or Killed Persons	0	0	1	0	0
+					
<b>Center Left-turn lane - Head On, Angle, Other</b>					
	<b>20% %REDUCTION</b>				
Number of Crashes	8	7	5	6	4
PDO+C Injury Crashes	9	4	6	4	5
B-Injured Persons	0	4	6	3	2
A-Injured or Killed Persons	0	0	0	1	0
+					
<b>0</b>					
	<b>0% %REDUCTION</b>				
Number of Crashes	0	0	0	0	0
PDO+C Injury Crashes	0	0	0	0	0
B-Injured Persons	0	0	0	0	0
A-Injured or Killed Persons	0	0	0	0	0
+					
<b>0</b>					
	<b>0% %REDUCTION</b>				
Number of Crashes	0	0	0	0	0
PDO+C Injury Crashes	0	0	0	0	0
B-Injured Persons	0	0	0	0	0
A-Injured or Killed Persons	0	0	0	0	0
+					
<b>0</b>					
	<b>0% %REDUCTION</b>				
Number of Crashes	0	0	0	0	0
PDO+C Injury Crashes	0	0	0	0	0
B-Injured Persons	0	0	0	0	0
A-Injured or Killed Persons	0	0	0	0	0

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 # Fatalities: 0 For reference only; "Q" accounts for the risk of a fatality.  
 PROJECT COST ESTIMATE: \$400,000 If unknown, enter "0" (zero).  
 ADTb (before-volume): 1.0 You may change these  
 ADTa (after-volume): 1.1 default ADT values.  
 NUMBER OF YEARS OF DATA: 5.00 3 to 5 years should be used.  
 RATE OF INFLATION: 2.50%  
 AREA TYPE: 2 (1 = RURAL, 2 = URBAN, 3 = BETWEEN)

REMARKS:  
 0 Example 1  
 Road 1  
 1497102, 1498309, 1498310  
 0-4.043  
 Install Center-Left Turn lane

**COMPUTED BENEFITS DERIVED THROUGH CRASH REDUCTION**

TOR 2011 (Local Agency) Date: 16-Mar-11  
 Proj: Example 1 City/Twp.: Main City  
 Prepared by: Ann Marie Kerby County: Genesee County  
 PR Number: 1497102, 1498309, 1498 PR MP: 0-4.043

The method of evaluating crash costs, used below, is given on page 67 of Roy Jorgensen's report of Highway Safety Improvement Criteria 1966 edition. This same method is given in the Bureau of Public Roads IM21-3-67. In 1994 we have adapted the Q formula to blend Fatalities and A-injuries only. In the following analysis the costs provided by the National Safety Council (NSC) are:

**2008 NSC VALUES:**

Death	\$1,300,000	=FATCOST
Disabling (A) injury:	\$67,200	=ACOST
B-injury	\$21,800	=BCOST
PDO and/or Minor Injury Crash:	\$8,300	=PDOCCST

BTOTAL = ADTa/ADTb\*(QxR1+(BCOSTxR2)+(PDOCCSTxR3))

**WHERE:**

BTOTAL=	Total Benefit in Dollars Over Years Used	798820
ADTa =	Average traffic volume after the improvement	1.1
ADTb =	Average traffic volume before the improvement	1.0
R1 =	Reduction in fatalities and A-injuries Combined.	1.0
R2 =	Reduction in B-injury crashes:	19.0
R3 =	Reduction in PDO and C-injury crashes	17.6
Q =	[FATCOST+((1/F)xACOST)]/[1+(1/F)]	
=	[1,210,000+(8.63 x 62,500)] / [1+8.63]	195,200.0
	for AREA TYPE ERR	
1/F =		8.63

Q-Reference	Q	A-Injuries	Fatalities	1/F
RURAL	238800	9041	1462	6.1839945
URBAN	195200	12881	1493	8.6275954
BETWEEN	213600	21922	2955	7.4186125

Data from Safety Programs Unit, E. Line  
 5-Year, Statewide, Non-Trunkline crash figures.  
 (From 1-1-05 through 12-31-09) used. See DATA 2009.

Time of Return (T.O.R.) is based on .... 5.0 years of data.

NOINF = No-Inflation Annual Benefit=BTOTAL/years 159764

With an inflation rate of ..... 2.50%

B=Annual Benefit=Present Value (with Inflation) \$204,511

C = Project Cost \$400,000

TOR=C/B=COST/ANNUAL BENEFIT= 1.96

<b>INTERSECTION CRASH REDUCTION FACTORS</b>		
<b>Proposed Improvement</b>	<b>% Reduction</b>	<b>Associated Crash Types</b>
<b>Signal Timing / Hardware Enhancements</b>		
<b>Center Left-Turn Lane - Install</b>	80%	Rear-End Left-Turn
	50%	Head-On Left-Turn
	20%	Head-On, Sideswipe Opposite, Angle
	15%	Non Left-Turn Rear-End, Other Applicable Crashes
<b>Install Reflectorized Backplates</b>	15%	All Applicable Crashes
<b>Add All-Red Clearance Interval - Add per ITE</b>	20%	Head-On Left-Turn, Angle
<b>Yellow-Change Interval - Increase</b>	10%	All Crash Types
<b>Box Span Signal - Upgrade from Stop Control</b>	65%	Angle
	-25%	Rear-End (Increases Crashes)
	20%	All Other Non Rear-End Crashes
<b>Box Span Signal - Upgrade from Diagonal Span</b>	10%	All Applicable Crashes
<b>Protected Left-Turn Signal Phase - Add</b>	30%	Left-Turn
<b>Signal Head Size - Increase to 12 "</b>	10%	All Applicable Crashes
<b>Signal Optimization &amp; Timing Updates</b>	10%	All Applicable Crashes
<b>Pedestrian / Bicycle Enhancements</b>		
<b>Bump Out / Curb Extension - Remove Parking / Install</b>	30%	All Applicable Crashes
<b>Bicycle Lanes</b>	25%	Bicycle Crashes
<b>Intersection Lighting - Install</b>	75%	Pedestrian Fatal - Dark Unlighted Crashes
	40%	Pedestrian A-Injury - Dark Unlighted Crashes
	30%	All Applicable Dark Unlighted Crashes
<b>Ped. Countdown Signals - Install new Pedestrian signal</b>	30%	Pedestrian Crashes
<b>Ped. Countdown Signals - Upgrade from existing Pedestrian signal</b>	25%	Pedestrian Crashes
<b>Sidewalk - Install</b>	85%	Pedestrian Crashes
<b>Intersection Geometric Enhancements</b>		
<b>Intersection Improvements (Realignment, Sight-Distance Improvements, Radii Improvements, Etc.)</b>	30%	Angle
	15%	Rear-End
	10%	Head-On, Sideswipe, Pedestrian, Bicycle, Left-Turn Related
<b>Offset Left-Turn Lane - Install</b>	65%	Angle-Turn, Head On Left Turn
	20%	Rear-End Left Turn
<b>Offset Right-Turn Lane - Install</b>	65%	Angle-Turn
	50%	Other Applicable Crashes
	20%	Rear-End Right Turn
<b>Right-Turn Lane - Install</b>	65%	Rear-End Right-Turn
	20%	Applicable Rear End Crashes, Sideswipe Same Direction
<b>Roundabout - Refer to Roundabout TOR</b>		
<b>General Intersection Enhancements</b>		
<b>All-Way Stop Control - New Installation</b>	60%	All Applicable Crashes
<b>Ground Mounted Flashing Beacons (Red)- Install*</b>	30%	All Crashes On Install Approach
<b>Ground Mounted Flashing Beacons(Amber) - Install*</b>	20%	All Crashes On Install Approach
<b>Signing - Improve/Upgrade</b>	30%	Angle, Rear-End Crashes
<b>Pavement Markings - Improve/Upgrade</b>	30%	Angle, Rear-End Crashes
<b>Reflective Sheeting on Sign Posts (lollipops)</b>	15%	All Applicable Crashes

\* applies to new installation or with removal of existing overhead flashing beacon

#### **REFERENCES:**

The references listed below are the sources recognized by MDOT for obtaining crash reduction factors. If you have a situation that none of these sources can provide a crash reduction factor for, please contact Lynnette Firman 517.335.2224.

- 1) MDOT Safety Programs Unit - Crash Reduction Factors (As recommended by K. Kunde. P.E.); October, 1986
- 2) *Selection Process for Local High Safety Projects*, - Transportation Research Record 847: 1982
- 3) UKTRP - 85-6, University of Kentucky; March, 1985
- 4) *Desktop Reference for Crash Reduction Factor*, Federal Highway Administration. 2007
- 5) NCHRP Report 617: *Accident Modification Factors for Traffic Engineering and ITS Improvements*, TRB 2008
- 6) Crash Modification Factor Clearinghouse, <http://www.cmfclearinghouse.org/index.cfm>, 2008
- 5) NCHRP Report 617: *Accident Modification Factors for Traffic Engineering and ITS Improvements*, TRB 2008
- 6) Crash Modification Factor Clearinghouse, <http://www.cmfclearinghouse.org/index.cfm>, 2008

<b>SEGMENT CRASH REDUCTION FACTORS</b>		
<b>Proposed Improvement</b>	<b>% Reduction</b>	<b>Associated Crash Types</b>
<b>Geometric Safety Enhancements</b>		
<b>Center Left-Turn Lane - Construct</b>	80%	Rear-End Left-Turn
	50%	Head-On Left-Turn
	20%	Head-On, Sideswipe Opposite, Other*
	15%	Non Left-Turn Rear-End, Other Applicable Crashes*
<b>Horizontal Curve Flattening</b>	30%	Lane Departure***
<b>Curve Superelevation Modification</b>	20%	Lane Departure***
<b>Widen Pavement (Lane Plus Paved Shoulder)</b>	5% per foot**	Lane Departure***
<b>Vertical Curve Flattening</b>	20%	All Applicable Crash Types
<b>General Segment Enhancements</b>		
<b>Access Management - Improve</b>	15%	Driveway Related Crashes
<b>Lighting - Install on segment</b>	20%	Dark Unlighted Crashes
<b>High Friction Surface Treatment - Install</b>	35%	Wet Crashes
	20%	All Applicable Crash Types
<b>Pedestrian Refuge Island- Install</b>	50%	Pedestrian Crashes
<b>Recessed Durable Pavement Markings</b>	5%	All Applicable Crash Types
<b>Road Diet (4-3 Lane Conversion) - Install</b>	50%	Suburban - All Crash Types
	30%	Urban - All Crash Types
<b>Centerline Rumble Strips - Install</b>	44%	K and A injury Applicable Crashes
	46%	Single Vehicle Run off Road Left Crashes
	43%	Sideswipe Same Crashes
	55%	Sideswipe Opposite Crashes
<b>Shoulder Rumble Strips/Stripes - Install</b>	20%	Run-Off the Road Right Crashes
<b>Signing/Delineation on Horizontal Curves (Including Recessed Durable Pavement</b>	20%	Lane Departure***
<b>Roadside Enhancements</b>		
<b>Fixed Objects From Clear zone (Trees, Culverts, Headwalls, Etc.) - Removal</b>	75%	Fixed-Object
<b>Slope Flattening</b>	15%	Fixed-Object, Overturn
<b>Guardrail - Install</b>	55%	Lane Departure*** Related Fatalities and A Injuries
<b>Sidewalk for Pedestrians - Install</b>	85%	Pedestrian Crashes
<b>Bicycle Lanes</b>	50%	Bicycle Related Crashes
<b>Shared Use Path - Install</b>	33%	Bicycle and Pedestrian Related Crashes

\* "Other" includes and other crash which might be mitigate by the addition of a center left-turn lane in the judgment of the crash analyst

\*\* 5% per foot widened each side (i.e. 3 foot shoulder on each side = 15% reduction)

\*\*\*"Lane departure" crashes include the following types: Fixed Object, Overturn, Sideswipe Opposite, Sideswipe Same and Head-On

**REFERENCES:**

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- 6) Crash Modification Factor Clearinghouse, <http://www.cmfclearinghouse.org/index.cfm>, 2008