CROSS/ROADS\
LINKING MOBILITY SOLUTIONS

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Performance-based Asset Management Framework to Forecast Roadway Infrastructure Preservation Needs in India

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Roadway/Bridge Design/Construction

New Highway Infrastructure Projects

- Economy driver
  - "Expected to create 2.5 million jobs over the next couple of years"
- Cost intensive
  - "Investment worth Rs. 914,000 crores in Roads & bridges"
- Fast pace
  - 30 km/day

New Highway Infrastructure Projects

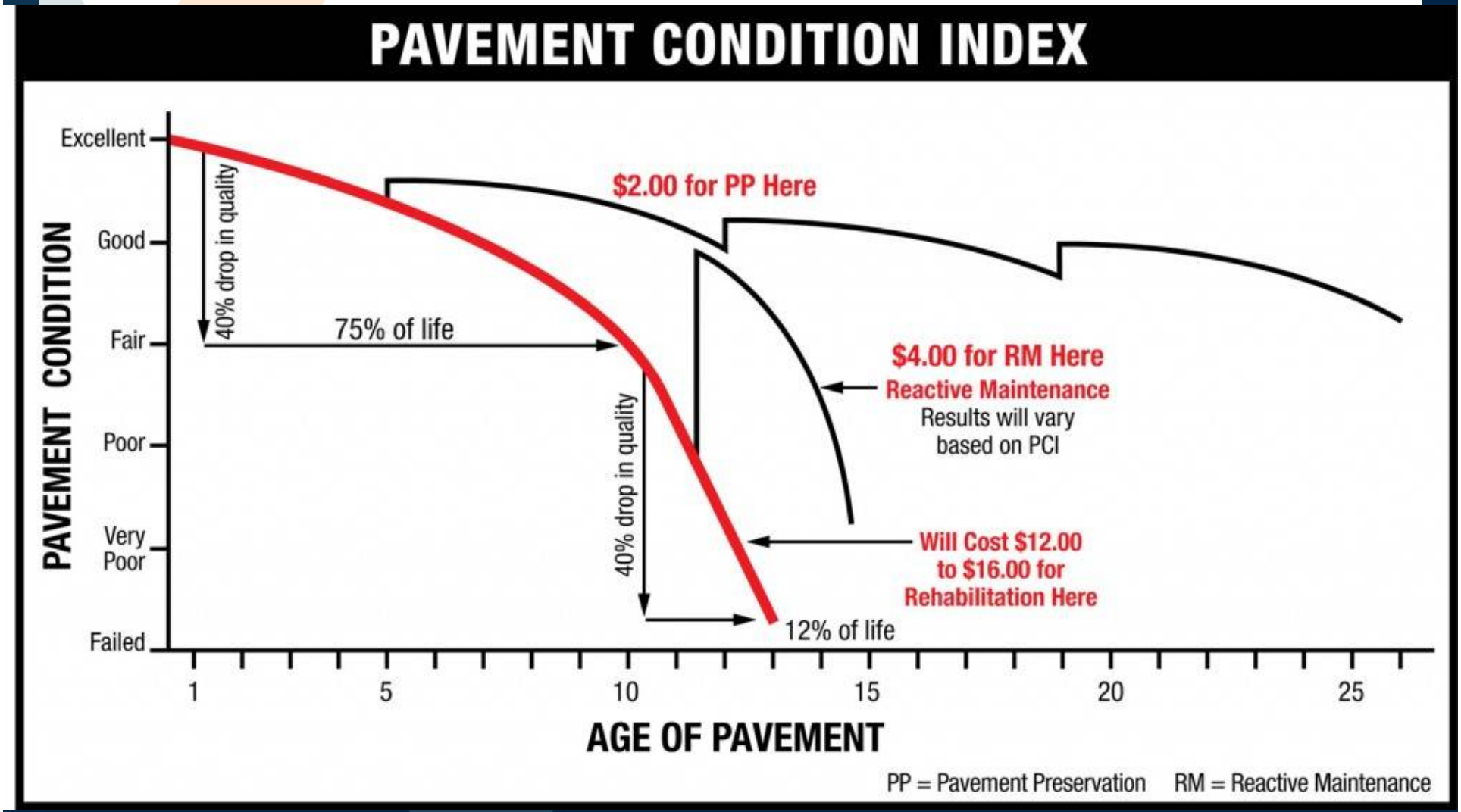
- Habitat destruction/disturbance
  - Land acquisitions
- Congestion
  - Induced demand
- Pollution
  - Air and water
- Climate change
  - Vehicular emissions

Highway Maintenance Anyone?

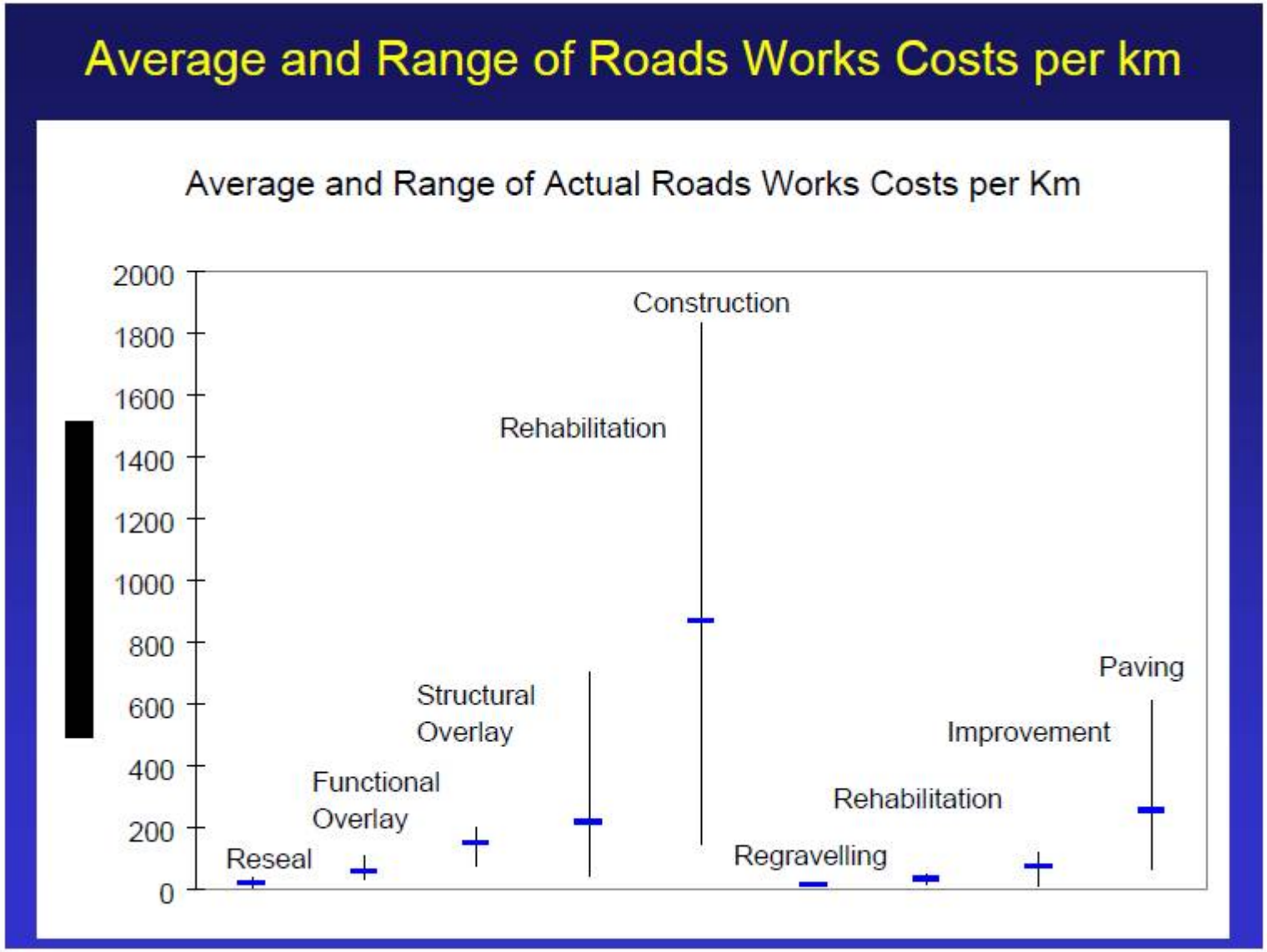
Maintenance Mindset

- Maintenance is mostly reactive in nature, and often inadequate
  - "If it is not broken, don't mend it"
  - For most rural roads in India, annual costs of routine maintenance is less than 4% of the construction cost of the road
  - Only 30% of maintenance requirements are met for PMGSY road network

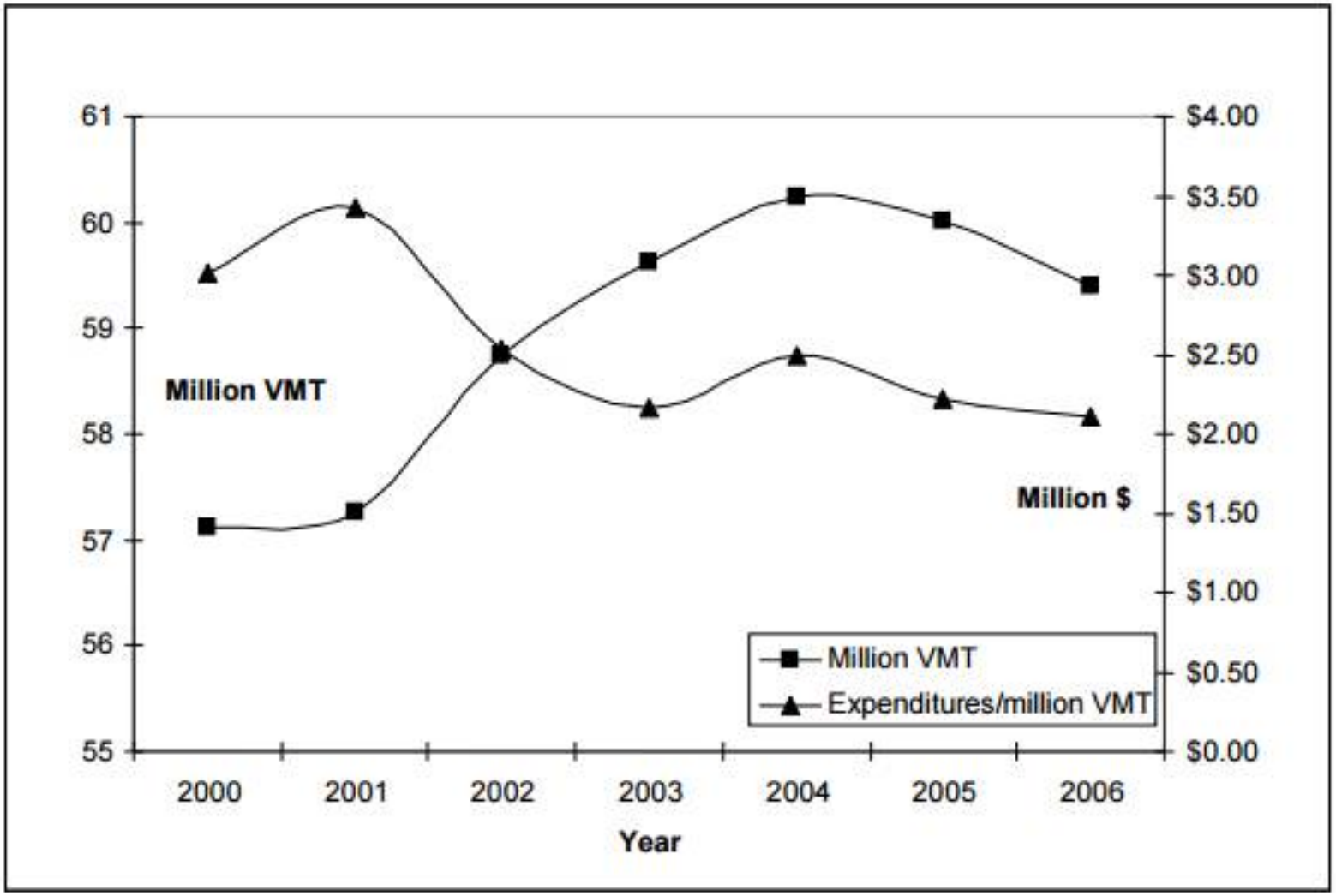
Timely Vs. Untimely Maintenance



Road Construction vs. Maintenance Cost

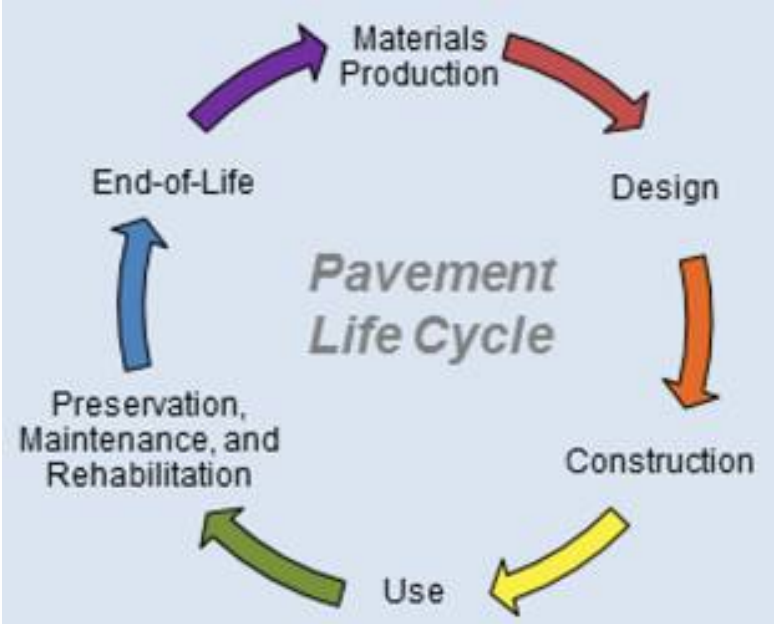


Traffic Growth Vs. Highway Maintenance



Asset Management

"*Transportation Asset Management is a strategic and systematic process of operating, maintaining, upgrading, and expanding physical assets effectively throughout their lifecycle. It focuses on business and engineering practices for resource allocation and utilization, with the objective of better decision-making based upon quality information and well-defined objectives*"



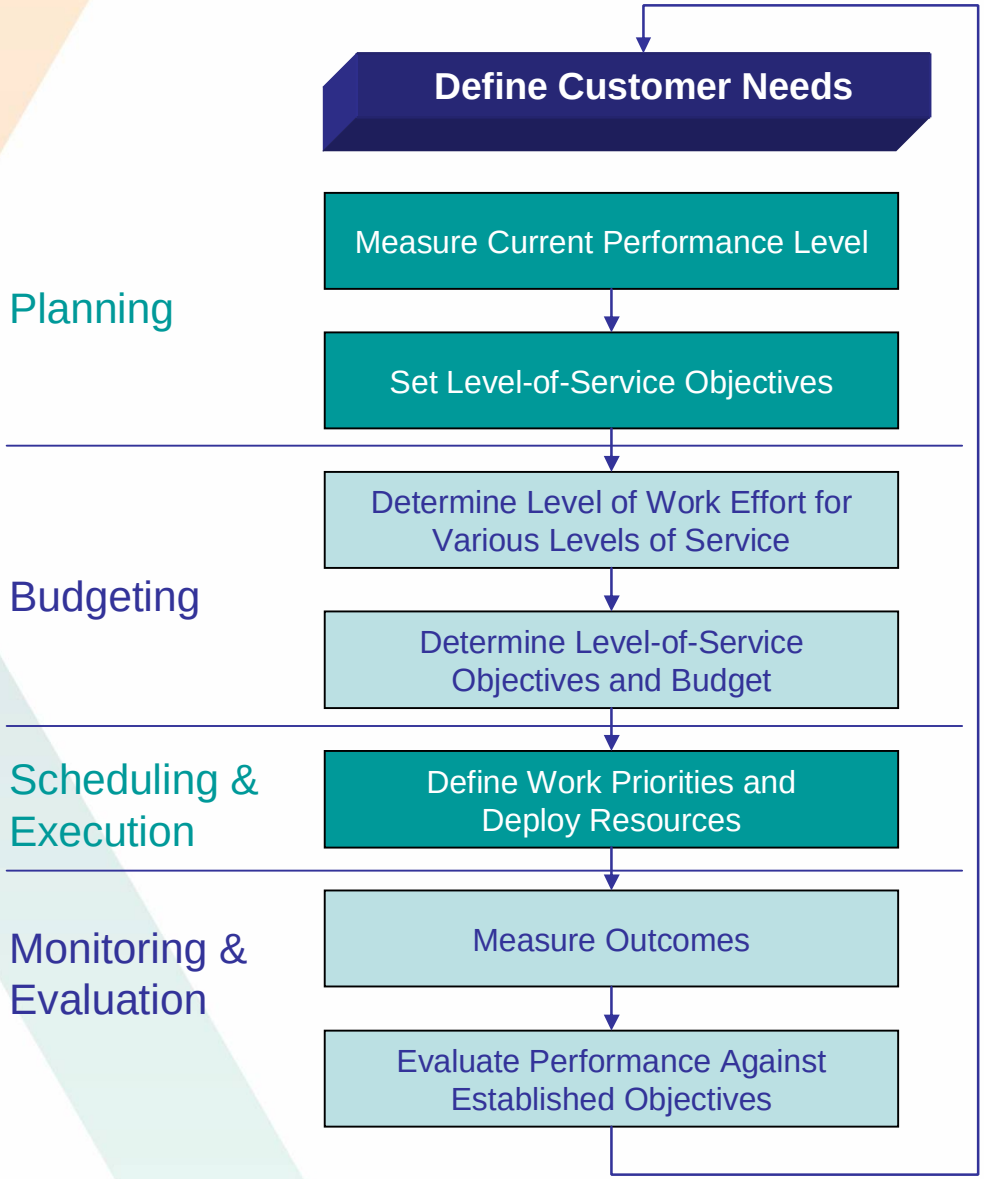
Highway Maintenance Management

- DeLeuw & Roy Jorgensen model of 1960s in United States of America (USA)
  - State departments of transportation (DOT) have implemented and improved upon this model
- United Kingdom (UK)
  - County Councils including Hertfordshire, Hampshire, etc.
- International Organization for Standards (ISO)
  - Specifications – ISO 55000, 55001, 55002

Highway Maintenance Management

- India
  - National Highways Road Asset Management System (RAMS)
    - Initiated by NHAI is 2014
    - Automated inventory and condition data along NHs
  - Indian Bridge Management System (IBMS)
    - Launched by MoRTH in 2016
    - Detailing structural condition of bridges

Highway Asset Management



Highway Preservation - Citizen Input

Condition 5. No contiguous drop-off, which is in excess of 2 inches, along the roadway. Vehicles and travelers experience no discomfort while pulling onto and off the shoulder.

Condition 4. Contiguous drop-off in excess of 2 inches stretching for only about 500 feet along the roadway. Travelers may experience a moderate bump when they leave the paved surface

Condition 3. Contiguous drop-off in excess of 2 inches stretching for less than 1/4-mile along the roadway. Noticeable bump when pulling onto the shoulder

Condition 2. Contiguous drop-off in excess of 2 inches stretching for about 1/3-mile along the roadway. Vehicle may be damaged when pulling onto the shoulder

Condition 1. Contiguous drop-off in excess of 2 inches stretching for more than ½-mile along the roadway. Driver might lose control of the vehicle

Typology

- Asset Class
- Asset Elements
- Deficiency Criteria
- Level of Service (LOS)
- LOS Indicator
- LOS Measure

Highway Preservation – Asset Class

Pavement

Structures

Drainage

Traffic Control Devices

Roadside Vegetation

Highway Preservation – Asset Class & Elements

Asset Class

- Pavement
- Drainage
- Traffic control devices

Asset Elements

- Fatigue cracking; faulting; rutting; surface roughness
- Side/cross drains; ditches; drop inlets/catch basin
- Striping; guardrails; delineators; signs

Asset Elements and LOS Measure

Asset Class	Asset Elements	Level of Service Condition	Level of Service Indicator	Deficiency Criteria	Level of Service Measure
Drainage Systems	Point features: Drop Inlets/Catch Basins	Functioning as designed	Blocked/damaged	Percent blocked/damaged	Percentage of elements blocked/damaged (number of elements deficient divided by total number of surveyed elements)
	Linear features: All cross and side drainage structures, and ditches				

Asset Class	Asset Elements	LOS Condition	LOS Indicator	Deficiency Criteria	LOS Measure
Roadside	Front and Back Slopes	Functioning as intended	Erosion, slides	Depth of washouts, depth of accumulated material	Percent of slopes deficient (measured longitudinally along roadway)
	Right-of-Way Fences	Functioning as intended	Missing/damaged	Height reduction, openings	Percent of length deficient
	Vegetation Management	Condition of mowable areas	Motorist visibility, aesthetics	Height of vegetation in mowable areas	Average height of vegetation (inches)
	Rest Areas	Open and functioning as intended	Closed; damaged facilities; non-functioning facilities; not sanitary; unsightly	Rest area rating	Average rest area rating (five-point scale)

LOS Measure Example

- Service Level Indicator: Condition
  - Drainage elements: Blockage/damaged
- Deficiency Criteria: Deficiency extent
  - Drainage elements: >30% blocked
- Level of Service Measure:
  - Drainage elements: % blocked

Data Collection – Example

Asset Group: Asphalt Pavement	
Asset Element: Rutting	
Definition: Ruts are defined as vertical deformations in the pavement surface along the wheel tracks that can hold ¾ inch or more of water. In severe cases, pavement uplift may occur along the sides of the rut, but in most instances, only a depression is noticeable. Rutting can cause water accumulation, which poses a hazardous condition.	
Measurement Unit: Inventory: Asphalt lane-miles. Condition: Linear feet of rutting per asphalt lane-mile.	
Inspection Procedure: The average linear feet of rutting per asphalt lane-mile will be obtained from PMS data from the MDOT Research Division, for each District and road class. Should PMS data not be available, the data will be collected at the sample sites in the field. For each sample on asphalt-surfaced pavements, inspect the surface area for rutting. Measure and record the total length of rutting in all lanes that will cause water accumulation, using a straightedge and ¾ inch shim to determine the depth and the measuring wheel to determine the length.	

Current LOS

Asset		A	B	C	D	F
Asphalt	Potholes		B			
	Rutting		B-			
	Stripping		B+			
	Alligator Cracking		B			
	Block Cracking			C		
	Linear Cracking			C-		
	Edge Raveling	A+				
	Shoving		B			
	Sweeping					F
Concrete	Spalling / Potholes					F
	Faulting		B-			
	Joint Sealing		B-			
	Crack Sealing		B+			
	Punchouts		B+			
	Pumping	A				
	Sweeping	A+				
Paved Shoulder	Potholes				D	
	Edge Raveliing				D-	
Unpaved Shoulder	Dropoff		B-			
	High Shoulder		B+			

LOS – Current and Desired

Maintenance Element	LOS Measure	LOS Classes					Current LOS Measure	Current LOS	Desired LOS
		A	B	C	D	F			
Asphalt Cracking	Linear ft. of unfilled cracks per lane mile	0-250	250.01-500	500.01-1000	1000.01-2500	>2500	900.0	C-	B
Concrete Spalling	Number of spalls per lane mile	0	0.01-2	2.01-5	5.01-10	>10	12.0	F	B
Shoulder Drop off	Linear feet per shoulder mile	0	0.01-500	500.01-1000	1000.01-2500	>2500	800.0	B-	B
Paved Ditches	% of ditch length defective	0	0.01-5	5.01-10	10.01-15	>15	5.5	C+	B
Litter Control	Number of fist-size objects per shoulder mile	0-50	50.01-100	100.01-300	300.01-500	>500	320.0	D+	B
Guardrail	% of guardrail length defective	0-1	1.01-3	3.01-5	5.01-10	>10	2.4	B-	B
Bridge Pier/Caps	% deficient	0-5	5.01-10	10.01-15	15.01-20	>20	9.5	B-	B

Performance-based Budget

oup	Feature	Current LOS	Target LOS	Activity	Crew-Days	Labor	Equipment	Materials	Subtotal	Contract	Total
Asphalt Pavement	Potholes	B	B	402	288.7	$ 178,974	$ 107,990	$ 40,424	$ 327,388	$ -	$ 327,388
				406	6.0	$ 6,525	$ 4,935	$ 6,018	$ 17,479	$ -	$ 17,479
						$ 185,499	**$ 112,925**	**$ 46,442**	**$ 344,867**	**$ -**	**$ 344,867**
	Rutting Depth	B-	B-	403	7.9	$ 20,789	$ 25,849	$ 230,241	$ 276,879	$ -	$ 276,879
						$ 20,789	**$ 25,849**	**$ 230,241**	**$ 276,879**	**$ -**	**$ 276,879**
	Stripping	B+	B+	401	1.7	$ 4,358	$ 2,965	$ 46,653	$ 53,976	$ -	$ 53,976
				403	51.8	$ 136,361	$ 169,551	$ 1,510,188	$ 1,816,100	$ -	$ 1,816,100
				404	1233.2	$ 2,293,122	$ 2,130,934	$ -	$ 4,424,056	$ -	$ 4,424,056
						$ 2,433,841	**$ 2,303,450**	**$ 1,556,841**	**$ 6,294,132**	**$ -**	**$ 6,294,132**
	Alligator Cracking	B	B	402	873.6	$ 541,519	$ 326,743	$ 122,310	$ 990,572	$ -	$ 990,572
				403	4.9	$ 12,786	$ 15,898	$ 141,603	$ 170,287	$ -	$ 170,287
				404	115.6	$ 215,015	$ 199,807	$ -	$ 414,823	$ -	$ 414,823
				406	245.7	$ 266,529	$ 201,592	$ 245,835	$ 713,956	$ -	$ 713,956
						$ 1,035,849	**$ 744,040**	**$ 509,748**	**$ 2,289,638**	**$ -**	**$ 2,289,638**
	Area Cracking	C	C	401	3.4	$ 8,846	$ 6,017	$ 94,694	$ 109,557	$ -	$ 109,557
				403	17.5	$ 46,130	$ 57,358	$ 510,884	$ 614,371	$ -	$ 614,371
				405	68.1	$ 73,851	$ 39,692	$ 2,544	$ 116,087	$ -	$ 116,087
						$ 128,826	**$ 103,067**	**$ 608,121**	**$ 840,015**	**$ -**	**$ 840,015**
	Long. / Trans. Cracking	C-	C-	405	38.2	$ 41,470	$ 22,289	$ 1,428	$ 65,187	$ -	$ 65,187
						$ 41,470	**$ 22,289**	**$ 1,428**	**$ 65,187**	**$ -**	**$ 65,187**
	Edge Raveling	A+	A+	402	40.4	$ 25,045	$ 15,112	$ 5,657	$ 45,813	$ -	$ 45,813
						$ 25,045	**$ 15,112**	**$ 5,657**	**$ 45,813**	**$ -**	**$ 45,813**
	Shoving	B	B	402	152.0	$ 94,236	$ 56,860	$ 21,285	$ 172,381	$ -	$ 172,381
				403	1.7	$ 4,450	$ 5,533	$ 49,284	$ 59,267	$ -	$ 59,267
				406	171.0	$ 185,528	$ 140,326	$ 171,123	$ 496,976	$ -	$ 496,976
						$ 284,214	**$ 202,719**	**$ 241,692**	**$ 728,625**	**$ -**	**$ 728,625**
	Sweeping	F	F	533	120.4	$ 55,977	$ 56,714	$ -	$ 112,692	$ -	$ 112,692
						$ 55,977	**$ 56,714**	**$ -**	**$ 112,692**	**$ -**	**$ 112,692**

Risk Management

- Risks of delayed or deferred maintenance
  - Identify
  - Evaluate
  - Manage

Risk = Likelihood x Consequence

LIKELIHOOD OF EVENT OCCURRING	CONSEQUENCE OF EVENT OCCURRING				
	NEGLIGIBLE	LOW	MEDIUM	HIGH	SEVERE
NEGLIGIBLE	1	2	3	4	5
VERY LOW	2	4	6	8	10
LOW	3	6	9	12	15
MEDIUM	4	8	12	16	20
HIGH	5	10	15	20	25
KEY TO RISKS					
LOW		MEDIUM		HIGH	

Thank you for your attention!