



**0-6623-P2**

## **OPTIMIZING RESOURCE ALLOCATIONS FOR ROUTINE HIGHWAY MAINTENANCE: WORKSHOP SUMMARY**

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*TxDOT Project 0-6623: Optimizing Resource Allocations for Routine Highway  
Maintenance*

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Research Supervisor: Zhanmin Zhang



## **MEETING AGENDA**

**November 8, 2010  
1:30 – 4:30 p.m.**

**Opening Remarks.....**Tammy Sims  
**Brief Overview of Project Objectives and Scope .....**Zhanmin Zhang  
**Workshop Goal .....**Zhanmin Zhang  
**Identification of Maintenance Objectives .....**James O'Connor  
**Development of Weights for Maintenance Objectives .....**James O'Connor  
**Maintenance Activities to Be Considered .....**Mike Murphy  
**Discussion on Optional Discrete Frequency Adjustments to Maintenance Activities**  
**Adjourn**

# **1. BACKGROUND INFORMATION**

## **1.1. Introduction to TxCAP**

The Texas Department of Transportation (TxDOT) has established four systems to measure road inventory conditions:

- 1) The Pavement Management Information System (PMIS) is an automated system for storing, retrieving, analyzing, and reporting pavement condition information. It can be used to retrieve and analyze pavement information to compare maintenance and rehabilitation treatment alternatives, monitor current pavement conditions, and estimate total pavement needs. PMIS contains pavement evaluation data on all major pavement types used in Texas, including asphalt surfaced pavement, continuously reinforced concrete pavement, and jointed concrete pavement. PMIS data is used to determine the statewide “Good” or better pavement condition score. These types of data include
  - Visual distress data
  - Ride quality data
  - Skid resistance data
  - Deflection data
- 2) The Texas Maintenance Assessment Program (TxMAP) is a manual, visual condition survey that documents the overall maintenance condition of the state highway system. The TxDOT executive administration sets the annual goal of an overall condition score of 80. TxMAP inspections consist of the evaluation of 10% of the Interstate Highway System and 5% of all other highways on the state system. For each one-mile section of highway, TxMAP raters assess twenty-three elements separated into three highway components: pavements, traffic operations, and roadside. The program categorizes each element and assigns a weighted multiplier to each element as follows: pavements (50%), traffic operations (25%), and roadside (25%).
- 3) The Texas Traffic Assessment Program (TxTAP) is used by TxDOT to evaluate the department’s progress in the consistency, quality, and uniformity of traffic control devices on the state highway system. The TxDOT Traffic Operations Division conducts the annual evaluation of the various types of traffic control devices in each of TxDOT's 25 field districts. Each district review consists of 20–30 randomly selected segments on the state highway system, 5–16 signalized intersections, 3–4 work zones, and 2–6 railroad crossings.
- 4) The Texas Condition Assessment Program (TxCAP) combines information from PMIS, TxMAP, and TxTAP to get an overall picture of state roads. Currently, TxDOT uses TxCAP together with PMIS, TxMAP, and TxTAP to measure and compare overall road inventory condition among its 25 Districts, which provide a comprehensive assessment of the Interstate and Non-Interstate highway system.

## 1.2. Average Routine Maintenance Expenditures (TxDOT)

Table 2-1 presents the FY08–10 average costs for each function.

**Table 2-1. FY 08–FY 10 Average Cost and Work Units Performed for Each Function**

2008-2010 AVERAGE FUNCTION CODE WORK UNITS AND COST					
FUNCTION CODE	FUNCTION CODE DESCRIPTION	UNIT OF MEASURE	AVG TOTAL COST	AVG. TOTAL WORK UNITS	UNIT COST
712	HIGH PERFORMANCE STRIPING	LF	\$30,182,173.94	110592408	\$0.27
711	PAINT & BEAD STRIPING	LF	\$9,672,764.73	69291483	\$0.14
455	RESHAPING UNPAVED SHOULDERS	SY	\$8,563,017.14	29383625	\$0.29
265	TREAT BLEEDING PAVEMENT	SY	\$817,729.34	29038174	\$0.03
233	FOG SEAL	SY	\$4,167,535.08	18987985	\$0.22
212	LEVELING/OVERLAY W/ MAINTAINER	SY	\$81,126,651.49	18720046	\$4.33
562	RESHAPING DITCHES	LF	\$5,437,527.33	18040774	\$0.30
270	EDGE REPAIR	LF	\$16,460,070.77	17451734	\$0.94
231	SEAL COAT	SY	\$35,259,354.60	16793293	\$2.10
211	LEVELING/OVERLAY W/ LAYDOWN	SY	\$76,609,378.38	9629662	\$7.96
232	STRIP/SPOT SEAL	SY	\$12,668,898.77	5821494	\$2.18
252	MILLING/PLANING	SY	\$12,877,671.68	5511297	\$2.34
750	INSTALL/REMOVAL PAVEMENT MARKERS	EA	\$6,701,234.36	3653811	\$1.83
523	DEBRIS	MI	\$18,825,403.58	2619543	\$7.19
245	ADDING/WIDENING PAVEMENT	SY	\$12,549,110.51	2462032	\$5.10
548	SEEDING/SODDING/HYDROMULCHING	SY	\$377,607.54	2249107	\$0.17
561	DITCH MAINTENANCE	CY	\$12,976,482.73	1876625	\$6.91
521	LITTER	AC	\$24,212,732.51	1808880	\$13.39
214	LEVELING/OVERLAY WITH DRAG BOX	SY	\$4,245,875.29	1703002	\$2.49
511	MOWING	AC	\$48,902,558.34	1604988	\$30.47
325	CLEANING/SEALING JOINTS & CRACKS	LF	\$1,652,598.54	1520270	\$1.09
120	BASE IN PLACE REPAIR	CY	\$30,647,483.72	1456932	\$21.04
145	UNPAVED ROAD MAINTENANCE	SY	\$544,901.47	1383712	\$0.39
732	INSTALL/REINSTALL LARGE SIGN	SF	\$10,038,616.76	1099759	\$9.13
595	GUARD FENCE	LF	\$19,703,214.40	1052873	\$18.71
731	INSTALL/REINSTALL SMALL SIGN	EA	\$34,897,882.08	913875	\$38.19
480	SIDE ROAD APPROACHES/CROSSOVER/TURNOUTS	SY	\$3,639,962.47	839793	\$4.33
563	SLOPE REPAIR / STABILIZATION	SY	\$2,513,883.32	822225	\$3.06
721	DELINEATORS	EA	\$8,858,670.52	799398	\$11.08
110	BASE REMOVAL/REPLACEMENT	CY	\$38,551,266.92	761020	\$50.66
530	REMOVAL OF GRAFFITI	SF	\$723,327.85	716942	\$1.01
235	MICROSURFACING	SY	\$1,677,707.38	623329	\$2.69
241	POTHOLE, SEMI-PERMANENT REPAIR	EA	\$9,103,107.58	492369	\$18.49
593	CABLE MEDIAN BARRIER	LF	\$1,904,997.80	399429	\$4.77
213	LEVELING BY HAND	SY	\$7,635,088.47	316391	\$24.13
522	ROUTINE STREET SWEEPING	MI	\$23,522,143.47	294744	\$79.81
594	CONCRETE BARRIER	LF	\$1,896,049.73	287964	\$6.58
542	CHEMICAL VEG. CONTROL OVERSPRAY	AC	\$10,905,658.59	266840	\$40.87
253	SPOT MILLING	SY	\$1,321,018.57	261388	\$5.05
620	BRIDGE CHANNEL MAINTENANCE	CY	\$2,513,602.76	217297	\$11.57
560	RIPRAP INSTALLATION AND MAINTENANCE	SY	\$3,470,150.35	179291	\$19.35
495	PARKING AREA MAINTENANCE	SY	\$639,092.19	170619	\$3.75
650	BRIDGE DECK	SF	\$1,978,007.73	153180	\$12.91
488	CONCRETE APPURTENANCE INSTALLATION/MAINTENANCE	SY	\$1,870,903.41	141727	\$13.20
524	SPOT LITTER	AC	\$2,407,566.18	129795	\$18.55
597	MAILBOX INSTALLATION/MAINT.	EA	\$4,187,057.19	123215	\$33.98
360	FULL DEPTH REMOVAL/REPLACEMENT	SY	\$15,096,316.22	119710	\$126.11
680	BRIDGE PAINTING	SF	\$3,168,593.08	101806	\$31.12
628	BRIDGE RAIL	LF	\$2,637,243.46	93019	\$28.35
585	DRIVEWAY INSTALL/REMOVAL&MAINT	SY	\$1,210,231.00	90000	\$13.45
645	BRIDGE JOINT MAINTENANCE	LF	\$1,345,228.80	88733	\$15.16
541	CHEMICAL VEG. CONTROL EDGES	AC	\$7,198,826.24	82038	\$87.75
670	BRIDGE SUBSTRUCTURE, CONCRETE	SF	\$2,371,342.22	64632	\$36.69
580	REMOVAL OF ILLEGAL SIGN (TEMP)	EA	\$492,830.85	52682	\$9.35
733	VANDALIZED SIGNS	EA	\$2,283,321.95	51750	\$44.12
225	SEALING CRACKS	LM	\$17,109,497.30	31915	\$536.09
596	GUARDRAIL END TREATMENT SYSTEMS	EA	\$11,574,622.61	30088	\$384.70
513	SPOT MOWING	AC	\$1,395,346.92	20335	\$68.62
660	BRIDGE SUPERSTRUCTURE, CONCRETE	SF	\$1,189,643.23	17175	\$69.27
345	REPAIR SPALLING	SY	\$2,539,415.61	16820	\$150.97
242	POTHOLE, PERMANENT REPAIR	EA	\$537,074.14	15456	\$34.75
135	INSTALL/MAINTAIN UNDER-DRAINS	LF	\$91,664.03	9677	\$9.47

Table 2-1. FY 08–FY 10 Average Cost and Work Units Performed for Each Function (continued)

2008-2010 AVERAGE FUNCTION CODE WORK UNITS AND COST					
FUNCTION CODE	FUNCTION CODE DESCRIPTION	UNIT	AVG TOTAL COST	AVG. TOTAL WORK UNITS	UNIT COST
520	ILLEGAL DUMPSTIE REMOVAL/DISPOSAL	CY	\$272,853.82	9368	\$29.13
665	BRIDGE SUPERSTRUCTURE, STEEL	SF	\$458,660.71	8925	\$51.39
581	REMOVAL OF ILLEGAL SIGN (PERM)	EA	\$67,074.80	8277	\$8.10
544	CHEMICAL VEG. CONTROL ROPE-WICK	AC	\$121,555.39	5948	\$20.44
526	SWEEPING ICE ROCK	EA	\$367,380.88	4071	\$90.24
646	BRIDGE JOINT REPLACEMENT	LF	\$367,706.57	3725	\$98.71
675	BRIDGE SUBSTRUCTURE, STEEL AND TIMBER	SF	\$70,356.51	1220	\$57.69
695	FENDER SYSTEMS	EA	\$990,857.68	988	\$1,003.23
611	BRIDGE, PORTABLE	EA	\$8,312.27	64	\$129.88
799	TRAFFIC CONTROL PLAN	***	\$35,532,590.43	0	\$0.00
742	ILLUMINATION	***	\$26,351,921.07	0	\$0.00
533	REST AREA MAINT THRU REGIONAL CONTRACTS	***	\$19,093,440.99	0	\$0.00
570	CULVERT AND STORM MAINTENANCE	***	\$18,308,309.58	0	\$0.00
743	MAINT OF ISOLATED TRAFFIC SIGNALS	***	\$17,489,633.97	0	\$0.00
552	TREE AND BRUSH CONTROL	***	\$16,491,891.62	0	\$0.00
745	TRAFFIC MANAGEMENT SYSTEM	***	\$15,502,334.21	0	\$0.00
811	ASSISTANCE TRAFFIC (SNOW AND ICE)	***	\$13,386,009.58	0	\$0.00
810	ASSISTANCE TO TRAFFIC (DEBRIS REMOVAL)	***	\$12,996,977.99	0	\$0.00
744	MAINT OF COORDINATED TRAFFIC SIGNALS	***	\$11,304,166.61	0	\$0.00
531	PICNIC AREA MAINTENANCE	***	\$7,830,893.14	0	\$0.00
713	SPECIALTY MARKINGS	***	\$7,449,011.92	0	\$0.00
738	INSTALL/MAINT FLASHING BEACON	***	\$7,147,206.87	0	\$0.00
725	VEHICLE ATTENUATORS	***	\$6,511,589.34	0	\$0.00
826	EMERGENCY REPAIRS TO BRIDGES	***	\$6,479,312.72	0	\$0.00
825	EMERGENCY REPAIRS TO ROADSIDES	***	\$6,378,783.45	0	\$0.00
807	ASSISTANCE TO TRAFFIC (ACCIDENTS AND INCIDENTS)	***	\$6,308,027.90	0	\$0.00
591	UTILITIES/DRIVEWAY INSPECTION	***	\$5,227,009.53	0	\$0.00
551	LANDSCAPING	***	\$4,186,420.55	0	\$0.00
827	EMERGENCY REPAIRS TO SIGNALS	***	\$4,013,329.62	0	\$0.00
790	MISCELLANEOUS TRAFFIC SERVICES	***	\$3,566,164.76	0	\$0.00
532	REST AREA MAINTENANCE	***	\$2,572,334.09	0	\$0.00
540	HAND VEGETATION CONTROL	***	\$2,429,118.20	0	\$0.00
831	HAZARDOUS MATL CLEAN-UP (ABANDONED)	***	\$2,267,215.24	0	\$0.00
571	STORM WATER PUMP STATION MAINT	***	\$2,076,260.28	0	\$0.00
821	EMERGENCY REPAIRS TO BASE & SUBGRADE	***	\$1,889,850.95	0	\$0.00
809	ASSISTANCE TO TRAFFIC (FLOOD WATER REMOVAL)	***	\$1,442,173.23	0	\$0.00
724	ROADWAY ACCESS CONTROL	***	\$1,322,394.52	0	\$0.00
315	SLAB STABILIZATION/JACKING	***	\$1,289,924.23	0	\$0.00
822	EMERGENCY REPAIRS TO ASPHALTIC SURFACES	***	\$1,227,795.64	0	\$0.00
525	ADOPT-A-HIGHWAY	***	\$997,279.59	0	\$0.00
610	BRIDGES MOVABLE SPAN	***	\$929,008.22	0	\$0.00
527	HAND SWEEPING	***	\$867,874.07	0	\$0.00
558	STORM WATER POLLUTION PROTECT	***	\$862,904.70	0	\$0.00
830	HAZARDOUS MATL CLEAN-UP (ACCIDENT)	***	\$759,939.61	0	\$0.00
545	CHEMICAL VEG. CONTROL BASAL APP	***	\$617,069.85	0	\$0.00
330	BLOWUPS AND STRESS RELIEF	***	\$474,387.32	0	\$0.00
536	CENTRAL TURNPIKE SYSTEM OPS	***	\$467,078.53	0	\$0.00
715	REMOVAL OF PAVEMENT STRIPING	***	\$374,183.71	0	\$0.00
535	MAINTENANCE OF SPECIALTY FACILITIES	***	\$361,459.79	0	\$0.00
690	BRIDGE, MECHANICAL AND ELECTRICAL	***	\$215,179.34	0	\$0.00
598	BOAT RAMP MAINTENANCE	***	\$187,746.63	0	\$0.00
582	REMOVAL OF ENCROACHMENTS, OTHER THAN SIGNS	***	\$178,596.37	0	\$0.00
823	EMERGENCY REPAIRS TO CONCRETE PAVEMENT	***	\$163,088.99	0	\$0.00
828	EMERGENCY REPAIRS TO SIGNS AND DELINEATORS	***	\$105,527.38	0	\$0.00
806	ASSISTANCE TRAFFIC SPEC. EVENT	***	\$92,483.26	0	\$0.00
814	ASSISTANCE TO TRAFFIC (EROSION CONTROL)	***	\$58,616.32	0	\$0.00
538	PEST CONTROL	***	\$57,046.96	0	\$0.00
824	EMERGENCY REPAIRS TO GUARD FENCE	***	\$18,831.04	0	\$0.00
813	ASSISTANCE TO TRAFFIC (FIRE CONTROL)	***	\$7,667.99	0	\$0.00
829	EMERGENCY REPAIRS TO ILLUMINATION SYSTEMS	***	\$3,364.43	0	\$0.00
820	EMERGENCY REPAIRS TO FERRY SYSTEMS	***	\$487.61	0	\$0.00
			\$998,275,607.76		



### 1.3. Combined Routine Maintenance Functions by Category

Some maintenance functions were combined to obtain a total cost for similar types of work. For example, mowing was combined with spot mowing to obtain a total cost for these two functions. In addition, the functions were grouped into categories such as pavement, roadside, bridge, traffic operations, and emergency operations. Tables 2-2 through 2-6 represent the grouped functions along with their corresponding costs and total group expenditures.

**Table 2-2. Pavement Related Functions**

Routine Highway Maintenance Functions Prioritizing Using Delphi Process				
Pavement Related Functions (Series 100, 200, 300, and 400)				
2008–2010 AVERAGE FUNCTION CODE, WORK UNITS AND COST				PERCENT COST USE
FUNCTION CODE	FUNCTION CODE DESCRIPTION	UNIT	AVG. TOTAL COST	
211-214	LEVELING/OVERLAY	SY	\$169,616,993.63	16.9910
231-232	SEAL COAT & STRIP/SPOT SEAL	SY	\$47,928,253.37	21.7921
110	BASE REMOVAL/REPLACEMENT	CY	\$38,551,266.92	25.6539
120	BASE IN PLACE REPAIR	CY	\$30,647,483.72	28.7239
225	SEALING CRACKS	LM	\$17,109,497.30	30.4378
270	EDGE REPAIR	LF	\$16,460,070.77	32.0867
360	FULL DEPTH REMOVAL/REPLACEMENT	SY	\$15,096,316.22	33.5989
252-253	MILLING/PLANING & SPOT MILLING	SY	\$14,198,690.25	35.0212
245	ADDING/WIDENING PAVEMENT	SY	\$12,549,110.51	36.2783
241-242	POTHoles, SEMI-PERMANENT & PERMANENT REPAIR	EA	\$9,640,181.71	37.2440
455	RESHAPING UNPAVED SHOULDERS	SY	\$8,563,017.14	38.1018
233	FOG SEAL	SY	\$4,167,535.08	38.5193
480	SIDE ROAD APPROACHES/CROSSOVER/TURNOUTS	SY	\$3,639,962.47	38.8839
345	REPAIR SPALLING	SY	\$2,539,415.61	39.1383
488	CONCRETE APPURTENANCE INSTALLATION/MAINTENANCE	SY	\$1,870,903.41	39.3257
235	MICROSURFACING	SY	\$1,677,707.38	39.4937
325	CLEANING/SEALING JOINTS & CRACKS	LF	\$1,652,598.54	39.6593
315	SLAB STABILIZATION/JACKING	***	\$1,289,924.23	39.7885
265	TREAT BLEEDING PAVEMENT	SY	\$817,729.34	39.8704
495	PARKING AREA MAINTENANCE	SY	\$639,092.19	39.9344
145	UNPAVED ROAD MAINTENANCE	SY	\$544,901.47	39.9890
330	BLOWUPS AND STRESS RELIEF	***	\$474,387.32	40.0365
135	INSTALL/MAINTAIN UNDER-DRAINS	LF	\$91,664.03	40.0457
Sub-Total (Pavement Related Functions):			\$399,766,702.61	

**Table 2-3. Roadside Related Functions**

Routine Highway Maintenance Functions Prioritizing Using Delphi Process				
Roadside Related Functions (Series 500)				
2008–2010 AVERAGE FUNCTION CODE, WORK UNITS AND COST				PERCENT COST USE
FUNCTION CODE	FUNCTION CODE DESCRIPTION	UNIT	AVG. TOTAL COST	
511-513	MOWING & SPOT MOWING	AC	\$50,297,905.26	5.0385
521-524	LITTER & SPOT LITTER	AC	\$26,620,298.69	7.7051
522	ROUTINE STREET SWEEPING	MI	\$23,522,143.47	10.0614
532-533	REST AREA MAINTENANCE & THRU REGIONAL CONTRACTS	***	\$21,665,775.08	12.2317
540-545	HAND & CHEMICAL VEG. CONTROL	***	\$21,272,228.28	14.3626
595	GUARD FENCE	LF	\$19,703,214.40	16.3363
523	DEBRIS	MI	\$18,825,403.58	18.2221
570	CULVERT AND STORM MAINTENANCE	***	\$18,308,309.58	20.0561
552	TREE AND BRUSH CONTROL	***	\$16,491,891.62	21.7082
561	DITCH MAINTENANCE	CY	\$12,976,482.73	23.0080
596	GUARDRAIL END TREATMENT SYSTEMS	EA	\$11,574,622.61	24.1675
531	PICNIC AREA MAINTENANCE	***	\$7,830,893.14	24.9519
562	RESHAPING DITCHES	LF	\$5,437,527.33	25.4966
591	UTILITIES/DRIVEWAY INSPECTION	***	\$5,227,009.53	26.0202
597	MAILBOX INSTALLATION/MAINT.	EA	\$4,187,057.19	26.4397
551	LANDSCAPING	***	\$4,186,420.55	26.8590
560	RIPRAP INSTALLATION AND MAINTENANCE	SY	\$3,470,150.35	27.2066
563	SLOPE REPAIR / STABILIZATION	SY	\$2,513,883.32	27.4585
571	STORM WATER PUMP STATION MAINT	***	\$2,076,260.28	27.6665
593	CABLE MEDIAN BARRIER	LF	\$1,904,997.80	27.8573
594	CONCRETE BARRIER	LF	\$1,896,049.73	28.0472
585	DRIVEWAY INSTALL/REMOVAL&MAINT	SY	\$1,210,231.00	28.1684
525	ADOPT-A-HIGHWAY	***	\$997,279.59	28.2683
527	HAND SWEEPING	***	\$867,874.07	28.3553
558	STORM WATER POLLUTION PROTECT	***	\$862,904.70	28.4417
530	REMOVAL OF GRAFFITI	SF	\$723,327.85	28.5142
580-581	REMOVAL OF ILLEGAL SIGN (TEMP)&(PERM)	EA	\$559,905.64	28.5703
536	CENTRAL TURNPIKE SYSTEM OPS	***	\$467,078.53	28.6171
548	SEEDING/SODDING/HYDROMULCHING	SY	\$377,607.54	28.6549
526	SWEEPING ICE ROCK	EA	\$367,380.88	28.6917
535	MAINTENANCE OF SPECIALTY FACILITIES	***	\$361,459.79	28.7279
520	ILLEGAL DUMPSITE REMOVAL/DISPOSAL	CY	\$272,853.82	28.7552
598	BOAT RAMP MAINTENANCE	***	\$187,746.63	28.7740
582	REMOVAL OF ENCROACHMENTS, OTHER THAN SIGNS	***	\$178,596.37	28.7919
538	PEST CONTROL	***	\$57,046.96	28.7976
Sub-Total (Roadside Related Functions):			\$287,479,817.89	

**Table 2-4. Bridge Related Functions**

Routine Highway Maintenance Functions Prioritizing Using Delphi Process				
Bridge Related Functions (Series 600)				
2008–2010 AVERAGE FUNCTION CODE, WORK UNITS AND COST				PERCENT COST USE
FUNCTION CODE	FUNCTION CODE DESCRIPTION	UNIT	AVG. TOTAL COST	
680	BRIDGE PAINTING	SF	\$3,168,593.08	0.3174
628	BRIDGE RAIL	LF	\$2,637,243.46	0.5816
620	BRIDGE CHANNEL MAINTENANCE	CY	\$2,513,602.76	0.8334
670	BRIDGE SUBSTRUCTURE, CONCRETE	SF	\$2,371,342.22	1.0709
650	BRIDGE DECK	SF	\$1,978,007.73	1.2691
645	BRIDGE JOINT MAINTENANCE	LF	\$1,345,228.80	1.4038
660	BRIDGE SUPERSTRUCTURE, CONCRETE	SF	\$1,189,643.23	1.5230
695	FENDER SYSTEMS	EA	\$990,857.68	1.6222
610	BRIDGES MOVABLE SPAN	***	\$929,008.22	1.7153
665	BRIDGE SUPERSTRUCTURE, STEEL	SF	\$458,660.71	1.7613
646	BRIDGE JOINT REPLACEMENT	LF	\$367,706.57	1.7981
690	BRIDGE, MECHANICAL AND ELECTRICAL	***	\$215,179.34	1.8196
675	BRIDGE SUBSTRUCTURE, STEEL AND TIMBER	SF	\$70,356.51	1.8267
611	BRIDGE, PORTABLE	EA	\$8,312.27	1.8275
Sub-Total (Bridge Related Functions):			\$18,243,742.57	

**Table 2-5. Traffic Operation Related Functions**

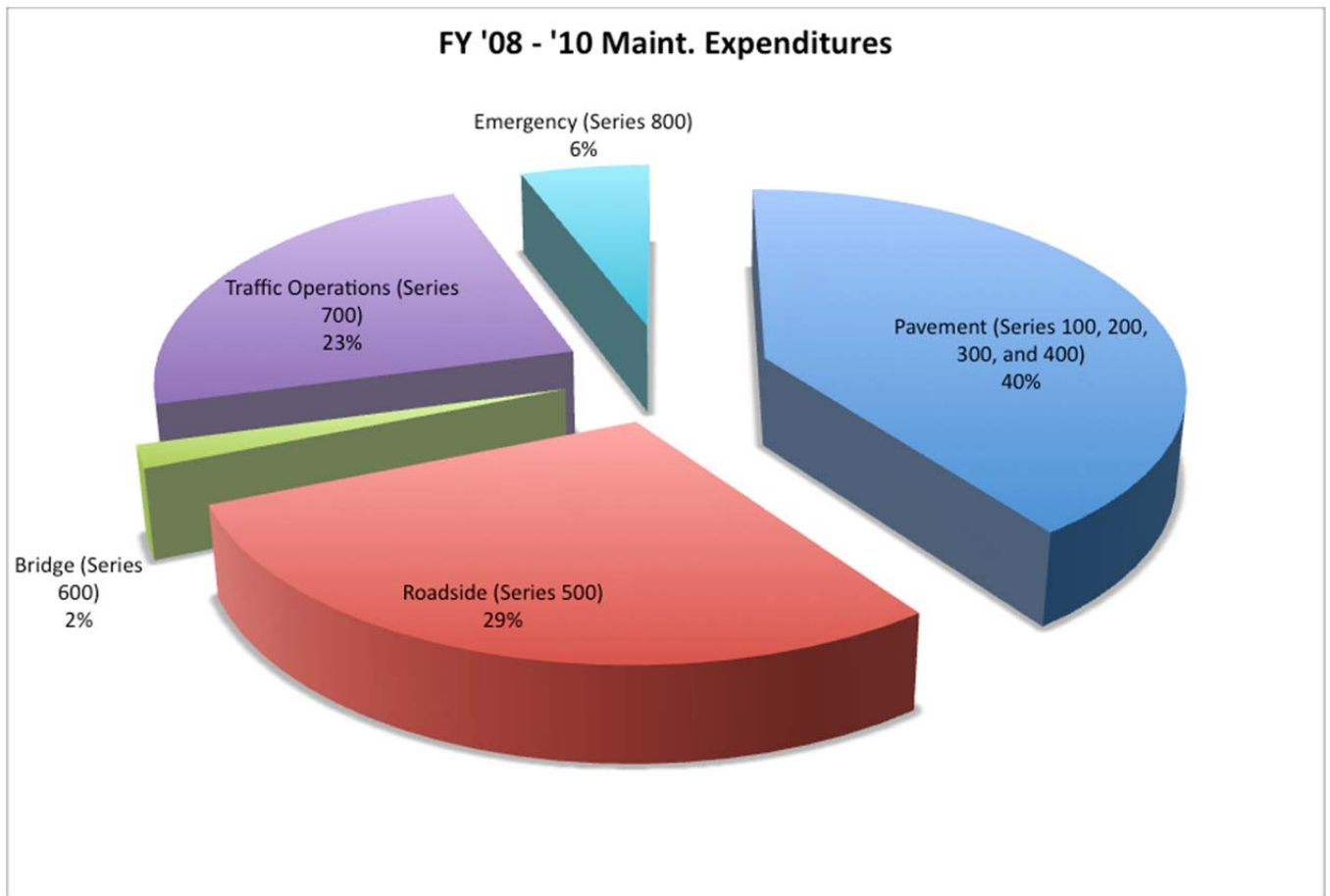
Routine Highway Maintenance Functions Prioritizing Using Delphi Process				
Traffic Operations Related Functions (Series 700)				
2008–2010 AVERAGE FUNCTION CODE, WORK UNITS AND COST				PERCENT COST USE
FUNCTION CODE	FUNCTION CODE DESCRIPTION	UNIT	AVG. TOTAL COST	
731-733	INSTALL/REINSTALL SMALL, LARGE & VANDALIZED SIGNS	EA	\$47,219,820.78	4.7301
799	TRAFFIC CONTROL PLAN	***	\$35,532,590.43	8.2895
712	HIGH PERFORMANCE STRIPING	LF	\$30,182,173.94	11.3130
743-744	MAINT OF ISOLATED & COORDINATED TRAFFIC SIGNALS	***	\$28,793,800.58	14.1973
742	ILLUMINATION	***	\$26,351,921.07	16.8371
745	TRAFFIC MANAGEMENT SYSTEM	***	\$15,502,334.21	18.3900
711	PAINT & BEAD STRIPING	LF	\$9,672,764.73	19.3589
721	DELINEATORS	EA	\$8,858,670.52	20.2463
713	SPECIALTY MARKINGS	***	\$7,449,011.92	20.9925
738	INSTALL/MAINT FLASHING BEACON	***	\$7,147,206.87	21.7085
750	INSTALL/REMOVAL PAVEMENT MARKERS	EA	\$6,701,234.36	22.3797
725	VEHICLE ATTENUATORS	***	\$6,511,589.34	23.0320
790	MISCELLANEOUS TRAFFIC SERVICES	***	\$3,566,164.76	23.3893
724	ROADWAY ACCESS CONTROL	***	\$1,322,394.52	23.5217
715	REMOVAL OF PAVEMENT STRIPING	***	\$374,183.71	23.5592
Sub-Total (Traffic Operations Functions):			\$235,185,861.75	

**Table 2-6. Emergency Related Functions**

Routine Highway Maintenance Functions Prioritizing Using Delphi Process				
Emergency Related Functions (Series 800)				
2008–2010 AVERAGE FUNCTION CODE, WORK UNITS AND COST				PERCENT COST USE
FUNCTION CODE	FUNCTION CODE DESCRIPTION	UNIT	AVG. TOTAL COST	
811	ASSISTANCE TRAFFIC (SNOW AND ICE)	***	\$13,386,009.58	1.3409
810	ASSISTANCE TO TRAFFIC (DEBRIS REMOVAL)	***	\$12,996,977.99	2.6429
826	EMERGENCY REPAIRS TO BRIDGES	***	\$6,479,312.72	3.2919
825	EMERGENCY REPAIRS TO ROADSIDES	***	\$6,378,783.45	3.9309
807	ASSISTANCE TO TRAFFIC (ACCIDENTS AND INCIDENTS)	***	\$6,308,027.90	4.5628
827	EMERGENCY REPAIRS TO SIGNALS	***	\$4,013,329.62	4.9648
830-831	HAZARDOUS MATL CLEAN-UP (ACCIDENT) & (ABANDONED)	***	\$3,027,154.85	5.2680
821	EMERGENCY REPAIRS TO BASE & SUBGRADE	***	\$1,889,850.95	5.4574
809	ASSISTANCE TO TRAFFIC (FLOOD WATER REMOVAL)	***	\$1,442,173.23	5.6018
822	EMERGENCY REPAIRS TO ASPHALTIC SURFACES	***	\$1,227,795.64	5.7248
823	EMERGENCY REPAIRS TO CONCRETE PAVEMENT	***	\$163,088.99	5.7412
828	EMERGENCY REPAIRS TO SIGNS AND DELINEATORS	***	\$105,527.38	5.7517
806-814	ASSISTANCE TRAFFIC	***	\$92,483.26	5.7610
814	ASSISTANCE TO TRAFFIC (EROSION CONTROL)	***	\$58,616.32	5.7669
824	EMERGENCY REPAIRS TO GUARD FENCE	***	\$18,831.04	5.7687
813	ASSISTANCE TO TRAFFIC (FIRE CONTROL)	***	\$7,667.99	5.7695
829	EMERGENCY REPAIRS TO ILLUMINATION SYSTEMS	***	\$3,364.43	5.7698
820	EMERGENCY REPAIRS TO FERRY SYSTEMS	***	\$487.61	5.7699
Sub-Total (Emergency Related Functions):			\$57,599,482.93	
Total Cost (All Functions):			\$998,275,607.75	

#### 1.4. Expenditure Breakdown by Category

Figure 2-1 presents the maintenance expenditure totals by function.



**Figure 2-1. Total maintenance expenditure by function categories**

#### 1.5. Delphi Process Guidelines

The Delphi Process is an iterative technique used to reach a consensus and is especially suited for group decision-making. The Delphi Process is used to reach a consensus about the priorities of the activity groups. Once the individual members complete their judgments, the responses are averaged and presented to the panel. The Delphi Process is essentially iterative, and the iteration may occur through the submission of questionnaire or group results over a series of rounds, allowing the members to modify their opinions and reach a consensus.

The importance of each objective was evaluated using a 1 to 5 scale, with 1 representing the lowest importance and 5 representing the highest importance. This Delphi process went through three iterations when needed.

#### 1.6. Brief Introduction to AHP

Analytic Hierarchy Process (AHP) is a multi-criterion decision analysis technique based on interactive elicitation of preferences from the decision-maker. It is especially useful for complex

multi-dimensional problems. AHP reduces the complexity of the decision by breaking the problem down into manageable levels and hierarchical components. A hierarchy composed of goals, objectives, and alternatives is formed to accurately model the complex problem. However, with too many components the comparison and synthesis of the results can become extremely difficult. AHP overcomes this difficulty by employing pair-wise comparisons between alternatives for each level of the hierarchy, something that is more intuitive for the human mind. One of the major strengths of AHP is that it has a built-in mechanism to check the consistency of the judgment provided by the decision-maker. In the case of multiple attributes and alternatives, the pair-wise comparisons can be susceptible to certain degree of inconsistency in judgment. However, AHP provides a check on this to ensure that an acceptable level of consistency is maintained. The concept of consistency in judgment implies not just the traditional requirement of the transitivity of preference (that if alternative A is preferred to alternative B and alternative B is preferred to alternative C, then alternative A should be preferred to alternative C). It also means that the actual intensity with which the preference is expressed should follow through the sequence of objects in comparison. For instance, if activity group “General Administrative Activities” is preferred to the “Engineering and Economic Analysis” group by a factor of 2 and “Engineering and Economic Analysis” group is preferred to activity group “Quality Control Related Activities” by a factor of 3, then ideally, following the transitivity of preference, the judgment between “General Administrative Activities” and “Quality Control Related Activities” is already known and should be equal to  $2 \times 3 = 6$ , i.e., “General Administrative Activities” are strongly preferred over “Quality Control Related Activities.” However, this ideal situation might not always occur. Usually, some level of inconsistency exists in the pair-wise comparisons (based on the subjective preferences of the decision-maker) and a limit of 0.1 has been prescribed as the acceptable limit. As long as the judgments are not random, the consistency is fairly easy to achieve. The worst-case scenario leading to inconsistency can be that even though alternative A is preferred to B and B is preferred to C, when it comes to comparing A and C, C is preferred to A. Judgments of this kind would result in the greatest inconsistency in the matrix.

## 2. WORKSHEETS

### 2.1. Prioritizing Routing Maintenance Objectives Using Delphi Process

Table 3-1 presents the template used during the workshop.

**Table 3-1. Template for Prioritizing Routing Maintenance Objectives  
ITERATION 1-3**

Objective	Score
Safety	
Pavement Preservation	
Aesthetics	
Operations	

**Note:** The importance of objectives should be ranked using a 1 to 5 scale, with 1 representing the least important and 5 representing the most important.

### 2.2. Guidelines for Conducting Objectives Comparisons Using AHP

#### 2.2.1. Layout of the Comparisons Spreadsheet

The spreadsheet consists of a preference matrix and two output tables. The preference matrix is for comparisons between the objectives of efficient pavement management. Comparing each objective against the other with respect to the goal of efficient pavement management will lead to their relative weights or importance towards the goal of efficient pavement management.

In the bottom right corner of the matrix, a cell displays the Consistency Ratio (CR). This represents the consistency of the judgments for the matrix, as shown in Table 3-3. This value changes dynamically depending on the consistency of the judgments entered in the cells and preferably should be less than 0.1. Table 3-4 shows the relative weights calculated based on Table 3-3 using AHP.

#### 2.2.2. Steps for Filling Matrices

The following guidelines were included to assist the decision-makers in completing the pair-wise comparisons:

- 1) Each matrix is an independent entity and the consistency ratio displayed below the bottom right corner of the matrix depends only on the values entered for that particular matrix.
- 2) Each cell of a matrix represents a pair-wise comparison between the alternative in the row and the alternative in the corresponding column. For any cell in the first matrix, start by comparing the objectives in the lower half of the matrix row and the corresponding column

with respect to the goal of efficient pavement management. Based on your judgment, using the ratio scale provided in Table 3-2, enter the corresponding value.

- 3) Only the lower half of the matrix needs to be filled out as the top half of the matrix is a reciprocal of the lower part. As you complete the lower half of the matrix, you will see a reciprocal value being entered in the corresponding cell in the upper half of the matrix.
- 4) The diagonal row is unity as each alternative is being compared to itself, leading to a judgment value of 1 or no preference.
- 5) If the alternative in the row is preferred to the alternative in the column, a direct value is entered. For instance, a direct value of 5 implies that alternative in the row is preferred to the alternative in the corresponding column. However, a value of 1/5 would mean that alternative in the column is preferred to the one in the corresponding row.
- 6) Once the judgments are complete, the CR cell in the lower right corner of the matrix will be automatically computed.
- 7) If the CR is greater than 0.1, it means that the inconsistency needs to be reduced. To do so, review the judgments that border on the extremes of the ratio scale being used (i.e., values in the range of 5–9) and make the appropriate adjustments as needed.
- 8) For the two activity groups involved in the extreme preference case (in step 7), separately analyze and review the rest of their comparisons with other activity groups and make the appropriate adjustments as needed.
- 9) Repeat steps 7 and 8 until the CR falls below 0.1. Follow the same procedure for the rest of the matrices.

### 2.3. Scale of Relative Importance

**Table 3-2. Scale of Relative Importance [Saaty 80]**

<b>Intensity of Importance</b>	<b>Definition</b>	<b>Explanation</b>
1	Equal importance	Two activities contribute equally to the objective
3	Weak importance of one over the other	Experience and judgment slightly favor one over the other
5	Essential or strong importance	An activity is strongly favored and its dominance demonstrated in practice
7	Demonstrated importance	The evidence favoring over another is of highest possible order of affirmation
9	Absolute importance	When compromise is needed
2,4,6,8	Intermediate values	



## 2.4. Pair-wise Comparison of Maintenance Objective

**Table 3-3. Pair-wise Comparisons of Routine Maintenance Objectives**

		1	2	3	4
	<b>Criterion</b>	Pavement Preservation	Safety	Aesthetics	Operations
1	Pavement Preservation	1.00			
2	Safety		1.00		
3	Aesthetics			1.00	
4	Operations				1.00
				<b>Consistency Ratio =</b>	

## 2.5. Relative Weights of Maintenance Objectives

**Table 3-4. Relative Weights of Routine Maintenance Objectives**

<b>Objective</b>	<b>Relative Weight</b>
Pavement Preservation	
Safety	
Aesthetics	
Operations	

## 2.6. Maintenance Functions to Be Considered

To perform a proof of concept, only a limited number of maintenance functions are needed. Tables 3-5 through 3-7 provide the functions in each category. From each of the tables, the decision-makers were asked to select three maintenance functions that they considered the most important and put them in order in terms of their relative importance, with 1 being the most important and 3 being the least important.

**Table 3-5. Pavement Related Functions**

Routine Highway Maintenance Functions Prioritizing Using Delphi Process					
Pavement Related Functions (Series 100, 200, 300, and 400)					
2008–2010 AVERAGE FUNCTION CODE, WORK UNITS AND COST				PERCENT COST USE	TOP 3 FUNCTIONS
FUNCTION CODE	FUNCTION CODE DESCRIPTION	UNIT	AVG. TOTAL COST		
211-214	LEVELING/OVERLAY	SY	\$169,616,993.63	16.9910	
231-232	SEAL COAT & STRIP/SPOT SEAL	SY	\$47,928,253.37	21.7921	
110	BASE REMOVAL/REPLACEMENT	CY	\$38,551,266.92	25.6539	
120	BASE IN PLACE REPAIR	CY	\$30,647,483.72	28.7239	
225	SEALING CRACKS	LM	\$17,109,497.30	30.4378	
270	EDGE REPAIR	LF	\$16,460,070.77	32.0867	
360	FULL DEPTH REMOVAL/REPLACEMENT	SY	\$15,096,316.22	33.5989	
252-253	MILLING/PLANING & SPOT MILLING	SY	\$14,198,690.25	35.0212	
245	ADDING/WIDENING PAVEMENT	SY	\$12,549,110.51	36.2783	
241-242	POTHoles, SEMI-PERMANENT & PERMANENT REPAIR	EA	\$9,640,181.71	37.2440	
455	RESHAPING UNPAVED SHOULDERS	SY	\$8,563,017.14	38.1018	
233	FOG SEAL	SY	\$4,167,535.08	38.5193	
480	SIDE ROAD APPROACHES/CROSSOVER/TURNOUTS	SY	\$3,639,962.47	38.8839	
345	REPAIR SPALLING	SY	\$2,539,415.61	39.1383	
488	CONCRETE APPURTENANCE INSTALLATION/MAINTENANCE	SY	\$1,870,903.41	39.3257	
235	MICROSURFACING	SY	\$1,677,707.38	39.4937	
325	CLEANING/SEALING JOINTS & CRACKS	LF	\$1,652,598.54	39.6593	
315	SLAB STABILIZATION/JACKING	***	\$1,289,924.23	39.7885	
265	TREAT BLEEDING PAVEMENT	SY	\$817,729.34	39.8704	
495	PARKING AREA MAINTENANCE	SY	\$639,092.19	39.9344	
145	UNPAVED ROAD MAINTENANCE	SY	\$544,901.47	39.9890	
330	BLOWUPS AND STRESS RELIEF	***	\$474,387.32	40.0365	
135	INSTALL/MAINTAIN UNDER-DRAINS	LF	\$91,664.03	40.0457	
	Sub-Total (Pavement Related Functions):		\$399,766,702.61		

**Table 3-6. Roadside Related Functions**

Routine Highway Maintenance Functions Prioritizing Using Delphi Process					
Roadside Related Functions (Series 500)					
2008–2010 AVERAGE FUNCTION CODE, WORK UNITS AND COST				PERCENT COST USE	TOP 3 FUNCTIONS
FUNCTION CODE	FUNCTION CODE DESCRIPTION	UNIT	AVG. TOTAL COST		
511-513	MOWING & SPOT MOWING	AC	\$50,297,905.26	5.0385	
521-524	LITTER & SPOT LITTER	AC	\$26,620,298.69	7.7051	
522	ROUTINE STREET SWEEPING	MI	\$23,522,143.47	10.0614	
532-533	REST AREA MAINTENANCE & THRU REGIONAL CONTRACTS	***	\$21,665,775.08	12.2317	
540-545	HAND & CHEMICAL VEG. CONTROL	***	\$21,272,228.28	14.3626	
595	GUARD FENCE	LF	\$19,703,214.40	16.3363	
523	DEBRIS	MI	\$18,825,403.58	18.2221	
570	CULVERT AND STORM MAINTENANCE	***	\$18,308,309.58	20.0561	
552	TREE AND BRUSH CONTROL	***	\$16,491,891.62	21.7082	
561	DITCH MAINTENANCE	CY	\$12,976,482.73	23.0080	
596	GUARDRAIL END TREATMENT SYSTEMS	EA	\$11,574,622.61	24.1675	
531	PICNIC AREA MAINTENANCE	***	\$7,830,893.14	24.9519	
562	RESHAPING DITCHES	LF	\$5,437,527.33	25.4966	
591	UTILITIES/DRIVEWAY INSPECTION	***	\$5,227,009.53	26.0202	
597	MAILBOX INSTALLATION/MAINT.	EA	\$4,187,057.19	26.4397	
551	LANDSCAPING	***	\$4,186,420.55	26.8590	
560	RIPRAP INSTALLATION AND MAINTENANCE	SY	\$3,470,150.35	27.2066	
563	SLOPE REPAIR / STABILIZATION	SY	\$2,513,883.32	27.4585	
571	STORM WATER PUMP STATION MAINT	***	\$2,076,260.28	27.6665	
593	CABLE MEDIAN BARRIER	LF	\$1,904,997.80	27.8573	
594	CONCRETE BARRIER	LF	\$1,896,049.73	28.0472	
585	DRIVEWAY INSTALL/REMOVAL&MAINT	SY	\$1,210,231.00	28.1684	
525	ADOPT-A-HIGHWAY	***	\$997,279.59	28.2683	
527	HAND SWEEPING	***	\$867,874.07	28.3553	
558	STORM WATER POLLUTION PROTECT	***	\$862,904.70	28.4417	
530	REMOVAL OF GRAFFITI	SF	\$723,327.85	28.5142	
580-581	REMOVAL OF ILLEGAL SIGN (TEMP)&(PERM)	EA	\$559,905.64	28.5703	
536	CENTRAL TURNPIKE SYSTEM OPS	***	\$467,078.53	28.6171	
548	SEEDING/SODDING/HYDROMULCHING	SY	\$377,607.54	28.6549	
526	SWEEPING ICE ROCK	EA	\$367,380.88	28.6917	
535	MAINTENANCE OF SPECIALTY FACILITIES	***	\$361,459.79	28.7279	
520	ILLEGAL DUMPSITE REMOVAL/DISPOSAL	CY	\$272,853.82	28.7552	
598	BOAT RAMP MAINTENANCE	***	\$187,746.63	28.7740	
582	REMOVAL OF ENCROACHMENTS, OTHER THAN SIGNS	***	\$178,596.37	28.7919	
538	PEST CONTROL	***	\$57,046.96	28.7976	
Sub-Total (Roadside Related Functions):			\$287,479,817.89		

**Table 3-7. Traffic Operations Related Functions**

Routine Highway Maintenance Functions Prioritizing Using Delphi Process					
Traffic Operations Related Functions (Series 700)					
2008–2010 AVERAGE FUNCTION CODE, WORK UNITS AND COST				PERCENT COST USE	TOP 3 FUNCTIONS
FUNCTION CODE	FUNCTION CODE DESCRIPTION	UNIT	AVG. TOTAL COST		
731-733	INSTALL/REINSTALL SMALL, LARGE & VANDALIZED SIGNS	EA	\$47,219,820.78	4.7301	
799	TRAFFIC CONTROL PLAN	***	\$35,532,590.43	8.2895	
712	HIGH PERFORMANCE STRIPING	LF	\$30,182,173.94	11.3130	
743-744	MAINT OF ISOLATED & COORDINATED TRAFFIC SIGNALS	***	\$28,793,800.58	14.1973	
742	ILLUMINATION	***	\$26,351,921.07	16.8371	
745	TRAFFIC MANAGEMENT SYSTEM	***	\$15,502,334.21	18.3900	
711	PAINT & BEAD STRIPING	LF	\$9,672,764.73	19.3589	
721	DELINEATORS	EA	\$8,858,670.52	20.2463	
713	SPECIALTY MARKINGS	***	\$7,449,011.92	20.9925	
738	INSTALL/MAINT FLASHING BEACON	***	\$7,147,206.87	21.7085	
750	INSTALL/REMOVAL PAVEMENT MARKERS	EA	\$6,701,234.36	22.3797	
725	VEHICLE ATTENUATORS	***	\$6,511,589.34	23.0320	
790	MISCELLANEOUS TRAFFIC SERVICES	***	\$3,566,164.76	23.3893	
724	ROADWAY ACCESS CONTROL	***	\$1,322,394.52	23.5217	
715	REMOVAL OF PAVEMENT STRIPING	***	\$374,183.71	23.5592	
Sub-Total (Traffic Operations Functions):			\$235,185,861.75		

### 3. RESULTS AND FEEDBACKS

#### 3.1. Relative Weights of Maintenance Objectives

During the workshop, we found out it would be very difficult to ask the expert panel to assign scale of relative importance when comparing two objectives. So instead of using AHP to determine the relative weight of maintenance objectives, we used three different prioritization methods and came up with different relative weights. See Tables 4-1 through 4-3.

- Method 1: Assign each objective a percentage to indicate the weight.
- Method 2: Use 1.0 to indicate the lowest importance, and assume the importance scale among the objectives is linear.
- Method 3: The importance of objectives should be ranked using a 1 to 5 scale, with 1 representing the least important and 5 representing the most important.

**Table 4-1. Method 1 (Percentage Allocation)**

OBJECTIVES	PARTICIPANT NUMBER										Average	Standard Deviation	Minimum Value	Maximum Value	Relative Weights
	1	2	3	4	5	6	7	8	9	10					
Safety	40	45	30	35	30	35	40	20	30	35	34.000	6.992	20	45	0.336634
System Preservation	30	20	40	30	30	30	25	55	40	25	32.500	10.069	20	55	0.321782
Aesthetics	10	15	15	15	15	20	10	10	10	15	13.500	3.375	10	20	0.133663
System Operation	20	20	15	20	25	15	25	15	30	25	21.000	5.164	15	30	0.207921
	$\Sigma$										101.000				$\Sigma$ 1.000000

**Table 4-2. Method 2 (Incremental Ranking Base 1)**

OBJECTIVES	PARTICIPANT NUMBER										Average	Standard Deviation	Lowest Value	Highest Value	Relative Weights
	1	2	3	4	5	6	7	8	9	10					
Safety	2.5	5	4	2	4	3	4	5	3	5	3.750	1.087	2	5	0.364964
System Preservation	2	4	3	3	3	2.5	3	4	4	3	3.150	0.669	2	4	0.306569
Aesthetics	1	1	1	1	1	1	1	1	1	2	1.100	0.316	1	2	0.107056
System Operation	1.75	3	2	1	2	2	2	2	3	4	2.275	0.837	1	4	0.221411
	$\Sigma$										10.275				$\Sigma$ 1.000000

**Table 4-3. Method 3 (Ranking: 1 = Least Important, 5 = Most Important)**

OBJECTIVES	PARTICIPANT NUMBER										Average	Standard Deviation	Minimum Value	Maximum Value	Relative Weights
	1	2	3	4	5	6	7	8	9	10					
Safety	5	5	5	5	5	4	5	5	4	5	4.800	0.422	4	5	0.369231
System Preservation	4	3	4	4	4	5	4	4	5	4	4.100	0.568	3	5	0.315385
Aesthetics	1	1	1	2	1	2	1	2	1	3	1.500	0.707	1	3	0.115385
System Operation	2	2	3	4	3	1	3	3	3	2	2.600	0.843	1	4	0.200000
	$\Sigma$										13.000				$\Sigma$ 1.000000

The results show that, although we used different methods to prioritize the objectives, the relative weights obtained from all three methods are very close. This finding also indicates the consent among the participants. Tables 4-4 through 4-6 provide the related functions.

### 3.2. Ranked Maintenance Activities

**Table 4-4. Pavement Related Functions (Series 100, 200, 300, 400)**

FUNCTION CODE	FUNCTION CODE DESCRIPTION	WEIGHT BASED ON PARTICIPANT MEMBER'S RANKING										SUM	RANK
		1	2	3	4	5	6	7	8	9	10		
231-232	SEAL COAT & STRIP/SPOT SEAL	1	2	4	5	4	4	2	0	5	5	32	1
241-242	POTHoles, SEMI-PERMANENT & PERMANENT REPAIR	5	5	5	1	0	5	5	5	1	0	32	2
211-214	LEVELING/OVERLAY	3	4	3	4	5	1	1	0	4	4	29	3
110-120	BASE REMOVAL/REPLACEMENT/BASE IN PLACE REPAIR	2	3	2	2	3	2	4	0	3	3	24	4
270	EDGE REPAIR	4	0	0	0	2	3	3	0	0	1	13	5
225	SEALING CRACKS	0	1	1	3	0	0	0	2	2	0	9	
345	REPAIR SPALLING	0	0	0	0	0	0	0	4	0	0	4	
252-253	MILLING/PLANING & SPOT MILLING	0	0	0	0	1	0	0	0	0	2	3	
325	CLEANING/SEALING JOINTS & CRACKS	0	0	0	0	0	0	0	3	0	0	3	
360	FULL DEPTH REMOVAL/REPLACEMENT	0	0	0	0	0	0	0	1	0	0	1	
245	ADDING/WIDENING PAVEMENT	0	0	0	0	0	0	0	0	0	0	0	
455	RESHAPING UNPAVED SHOULDERS	0	0	0	0	0	0	0	0	0	0	0	
233	FOG SEAL	0	0	0	0	0	0	0	0	0	0	0	
480	SIDE ROAD APPROACHES/CROSSOVER/TURNOUTS	0	0	0	0	0	0	0	0	0	0	0	
488	CONCRETE APPURTENANCE INSTALLATION/MAINTENANCE	0	0	0	0	0	0	0	0	0	0	0	
235	MICROSURFACING	0	0	0	0	0	0	0	0	0	0	0	
315	SLAB STABILIZATION/JACKING	0	0	0	0	0	0	0	0	0	0	0	
265	TREAT BLEEDING PAVEMENT	0	0	0	0	0	0	0	0	0	0	0	
495	PARKING AREA MAINTENANCE	0	0	0	0	0	0	0	0	0	0	0	
145	UNPAVED ROAD MAINTENANCE	0	0	0	0	0	0	0	0	0	0	0	
330	BLOWUPS AND STRESS RELIEF	0	0	0	0	0	0	0	0	0	0	0	
135	INSTALL/MAINTAIN UNDER-DRAINS	0	0	0	0	0	0	0	0	0	0	0	

**Table 4-5. Roadside Related Functions (Series 500)**

FUNCTION CODE	FUNCTION CODE DESCRIPTION	WEIGHT BASED ON PARTICIPANT MEMBER'S RANKING										SUM	RANK
		1	2	3	4	5	6	7	8	9	10		
511-513	MOWING & SPOT MOWING	5	3	1	5	1	2	4	0	5	2	28	1
561-562	DITCH MAINTENANCE/RESHAPING DITCHES	0	5	0	4	0	5	3	4	2	0	23	2
540-545	HAND & CHEMICAL VEG. CONTROL	1	4	2	1	2	0	5	0	4	3	22	3
521-524	LITTER & SPOT LITTER	4	2	0	2	3	0	1	0	0	0	12	4
595	GUARD FENCE	0	0	0	3	0	4	0	0	0	4	11	5
570	CULVERT AND STORM MAINTENANCE	0	0	0	0	5	1	0	5	0	0	11	5
563	SLOPE REPAIR / STABILIZATION	0	0	4	0	0	0	0	0	0	5	9	
552	TREE AND BRUSH CONTROL	2	0	5	0	0	0	0	0	0	1	8	
596	GUARDRAIL END TREATMENT SYSTEMS	0	0	3	0	0	3	0	0	0	0	6	
523	DEBRIS	3	1	0	0	0	0	0	0	1	0	5	
522	ROUTINE STREET SWEEPING	0	0	0	0	4	0	0	0	0	0	4	
562	RESHAPING DITCHES											0	
560	RIPRAP INSTALLATION AND MAINTENANCE	0	0	0	0	0	0	0	3	0	0	3	
532-533	REST AREA MAINTENANCE & THRU REGIONAL CONTRACTS	0	0	0	0	0	0	2	0	0	0	2	
593	CABLE MEDIAN BARRIER	0	0	0	0	0	0	0	2	0	0	2	
580-581	REMOVAL OF ILLEGAL SIGN (TEMP)&(PERM)	0	0	0	0	0	0	0	1	0	0	1	
531	PICNIC AREA MAINTENANCE	0	0	0	0	0	0	0	0	0	0	0	
591	UTILITIES/DRIVEWAY INSPECTION	0	0	0	0	0	0	0	0	0	0	0	
551	LANDSCAPING	0	0	0	0	0	0	0	0	0	0	0	
571	STORM WATER PUMP STATION MAINT	0	0	0	0	0	0	0	0	0	0	0	
594	CONCRETE BARRIER	0	0	0	0	0	0	0	0	0	0	0	
585	DRIVEWAY INSTALL/REMOVAL&MAINT	0	0	0	0	0	0	0	0	0	0	0	
525	ADOPT-A-HIGHWAY	0	0	0	0	0	0	0	0	0	0	0	
527	HAND SWEEPING	0	0	0	0	0	0	0	0	0	0	0	
558	STORM WATER POLLUTION PROTECT	0	0	0	0	0	0	0	0	0	0	0	
530	REMOVAL OF GRAFFITI	0	0	0	0	0	0	0	0	0	0	0	
536	CENTRAL TURNPIKE SYSTEM OPS	0	0	0	0	0	0	0	0	0	0	0	
548	SEEDING/SODDING/HYDROMULCHING	0	0	0	0	0	0	0	0	0	0	0	
526	SWEEPING ICE ROCK	0	0	0	0	0	0	0	0	0	0	0	
535	MAINTENANCE OF SPECIALTY FACILITIES	0	0	0	0	0	0	0	0	0	0	0	
520	ILLEGAL DUMPSITE REMOVAL/DISPOSAL	0	0	0	0	0	0	0	0	0	0	0	
598	BOAT RAMP MAINTENANCE	0	0	0	0	0	0	0	0	0	0	0	
582	REMOVAL OF ENCROACHMENTS, OTHER THAN SIGNS	0	0	0	0	0	0	0	0	0	0	0	
538	PEST CONTROL	0	0	0	0	0	0	0	0	0	0	0	

**Table 4-6. Traffic Operations Related Functions (Series 700)**

FUNCTION CODE	FUNCTION CODE DESCRIPTION	WEIGHT BASED ON PARTICIPANT MEMBER'S RANKING										SUM	RANK
		1	2	3	4	5	6	7	8	9	10		
731-733	INSTALL/REINSTALL SMALL, LARGE & VANDALIZED SIGNS	5	1	1	3	5	3	1	5	3	5	32	1
799	TRAFFIC CONTROL PLAN	0	5	5	5	3	2	5	0	1	1	27	2
712	HIGH PERFORMANCE STRIPING	0	3	4	4	4	0	4	4	4	0	27	3
743-744	MAINT OF ISOLATED & COORDINATED TRAFFIC SIGNALS	2	0	0	0	0	4	2	0	5	4	17	4
711	PAINT & BEAD STRIPING	4	2	0	1	0	5	0	0	0	3	15	5
742	ILLUMINATION	0	0	0	0	0	0	3	3	0	2	8	
725	VEHICLE ATTENUATORS	3	0	3	2	0	0	0	0	0	0	8	
750	INSTALL/REMOVAL PAVEMENT MARKERS	0	4	0	0	0	0	0	2	0	0	6	
721	DELINEATORS	1	0	0	0	1	1	0	0	0	0	3	
745	TRAFFIC MANAGEMENT SYSTEM	0	0	0	0	2	0	0	0	0	0	2	
713	SPECIALTY MARKINGS	0	0	2	0	0	0	0	0	0	0	2	
738	INSTALL/MAINT FLASHING BEACON	0	0	0	0	0	0	0	0	2	0	2	
724	ROADWAY ACCESS CONTROL	0	0	0	0	0	0	0	1	0	0	1	
790	MISCELLANEOUS TRAFFIC SERVICES	0	0	0	0	0	0	0	0	0	0	0	
715	REMOVAL OF PAVEMENT STRIPING	0	0	0	0	0	0	0	0	0	0	0	

It was discussed that the objective of maintenance functions ranking was to identify a short list of maintenance activities that will be used for the “proof of concept.” The concept has been established and approved by TxDOT, and a more extensive list of maintenance activities will be utilized for the pilot district(s).

### 3.3. Feedback During and After Workshop

The experts’ panel members provided a great deal of feedback during and after the workshop. Those comments involve almost every aspect of the project, from conceptual framework to maintenance function list, as listed below.

#### 1) Conceptual Framework:

- Objectives could also be the functions of average daily traffic (ADT), instead of using ADT as an exposure factor. We could pull ADT to upper layer in AHP.
- There should be more exposure factors.

#### 2) Pilot Study:

Austin is temporarily selected as the pilot district. In the workshop, some members suggested we should select a rural district for the pilot study. However, the pilot study is only a proof of concept; thus, it does not need to be complete at this stage.



**3) Ranked Maintenance Functions:**

We picked up the top five maintenance functions in each of the three categories (Pavement Related Functions, Roadside Related Functions, and Traffic Operations Related Functions). Some members suggested we could select the top 10 from each category. However, considering the total number of pair-wise comparisons in AHP would bloom and become unmanageable, we still recommend using only the top five maintenance functions in each category.

**4) Activity Frequency Increment:**

The increment of activity frequency would have an impact on the overall performance. But the relationship between frequency increment and performance increment would not be linear. Take ditch cleaning as an example: it is more like need based, not frequency based.