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# *RealCost* Enhancement and Version 2 Life-Cycle Cost Analysis Manual for Caltrans

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Partnered Pavement Research Program (PPRC) Contract Strategic Plan Element 4.28: Version 2 Caltrans Life Cycle Cost Analysis Manual

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Abstract: The work detailed in this te Highway Administration (R enhancements to its function estimate procedures for state The work derives from Task Strategic Plan Element 4.28. analyzed, four standard hour Selected interfaces were then users to input a site-specific through the California Freew and days (weekdays and we four types of distribution pat	chnical a FHWA) hality an ewide im 3.1 ("Tr After tra ly traffic develop traffic pa ay Perfo ekends).	memorandum conce life-cycle cost an d user interfaces, e plementation by th affic Data") in the affic data from a ra distribution pattern bed. In addition, a co ttern along with its rmance Measureme Traffic hourly dist Weekday Single-	erns customization alysis (LCCA) seespecially in its tra- e California Depar work plan of the P nge of California f as were established ustomized pattern i availability. The C ent System (PeMS) ributions in Califor Peak Weekday Do	of the new oftware <i>Rec</i> affic distribution rtment of Tr Partnered Pay freeway sect as represent input option California tra Web site an pornia freeway	version of the Federal alCost 2.5, which has ution patterns and cost- cansportation (Caltrans). vement Research Center tions were collected and tative ones for the state. was developed to allow affic data were collected and analyzed by locations y were categorized into Weekend Flat-Peak and	

Weekend Skew-Peak). A new traffic pattern selection function has been incorporated into *RealCost 2.5*, resulting in an interim version, *RealCost 2.5CA* (California Edition) that can be used for subsequent development tasks. In the next phase of the project, details of the "Alternative" section interface will be enhanced.

#### **Keywords:**

Highway reconstruction; Life-cycle Cost Analysis, RealCost

#### **Proposals for implementation:**

Continue use of the approach described in this report for planning, designing and executing long-life reconstruction projects. Monitor and document results from at least several more projects with different scenarios to develop database and knowledge that will lead to future cost savings.

#### **Related documents:**

Work Plan: RealCost Enhancement and Version 2 Life-Cycle Cost Analysis Manual for Caltrans (UCPRC-WP-2009-01)

#### Signatures:

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AADT	Annual Average Daily Traffic
CBD	Central Business District
LCCA	Life Cycle Cost Analysis
РАТН	California Partners for Advanced Transit and Highways
PeMS	Freeway Performance Measurement System
UCPRC	University of California Pavement Research Center
VDS	Vehicle Detector Station
VOC	Vehicle Operation Cost

## LIST OF ABBREVIATIONS

### **1 INTRODUCTION**

Life-Cycle Cost Analysis (LCCA) is an analytical technique that uses economic principles in order to evaluate long-term alternative investment options. LCCA accounts for relevant costs to the sponsoring agency, owner, facility operator, and roadway user that will occur throughout the life of an alternative. Relevant costs include initial construction (including project support), future maintenance and rehabilitation, and user costs (time and vehicle costs). The LCCA analytical process helps to identify the lowest cost alternative that accomplishes a project's objectives by providing critical information for the overall decision-making process.

A California Department of Transportation (Caltrans) memorandum dated March 7, 2007, states that LCCA for pavements shall be performed and documented for all projects that include pavement work on the State Highway System, regardless of funding source, with the exception of the following projects:

- Major Maintenance
- Minor A and Minor B
- Projects using Permit Engineering Evaluation Reports
- Maintenance Pullouts
- Landscaping paving

This new policy applies to projects that have a project approval date of July 1, 2007, or later. Projects with documented approval prior to July 1, 2007, do not need to include life-cycle costs unless a supplemental report is needed due to a change in project scope.

The Caltrans *Highway Design Manual (HDM)* was updated in June 2006 to incorporate the use of LCCA to determine the optimum pavement design for new construction, widening, and rehabilitation projects (Chapter 610, Topic 612 "Pavement Design Life" and Topic 619 "Life-Cycle Cost Analysis" of the *HDM.*) Chapters 8, 9, and 10 of the Caltrans *Project Development Procedures Manual (PDPM)* were also updated to reflect this new policy.

Since publication of the first state LCCA procedures manual in November 2007, Caltrans has chosen *RealCost 2.2* (California Edition) as its official LCCA tool to support the application of LCCA in the pavement project-level decision-making process.

The Caltrans Office of Pavement Engineering maintains the Caltrans LCCA Web site for district users at *www.dot.ca.gov/hq/esc/Translab/ope/LCCA.html*.

The University of California Pavement Research Center (UCPRC) has been working with Caltrans on the development and implementation of the department's LCCA policy since 2006, and assisted Caltrans with the development and publication of the first state LCCA procedures manual in November 2007.

In March 2009, *RealCost 2.5* was released, incorporating many upgrade requests submitted by various transportation agencies. Caltrans subsequently decided to customize the software, with assistance from the University of California Pavement Research Center (UCPRC), into *RealCost 2.5CA* (California Edition), with the UCPRC from March 2009 to March 2011.

The *RealCost* enhancement project consists of five definitive tasks and one optional task as shown below (the task numbers originated in the Work Plan: UCPRC-WP-2009-01):

Task 3.1: Traffic Data
Task 3.2: Alternative Interface
Task 3.3: Cost Estimates for Initial Construction
Task 3.4: Cost Estimates for Future Maintenance/Rehab
Task 3.5: M&R Menu Selection
Task 4.1: M&R Sequencing-Automation (Option)

This technical memorandum mainly describes the steps and changes made so far to accomplish *Task 3.1* and the plan for the remainder of the work.

Figure 1.1 shows the steps taken to in Task 3.1, the modification of Traffic Data. First, the UCPRC team collected traffic data from PeMS Web site (*pems.eecs.berkeley.edu*) and analyzed the traffic hourly distribution patterns to determine four standard distribution patterns and one customization function. Second, the team produced the corresponding interfaces of *RealCost 2.5* to incorporate the new traffic distribution patterns. Third, the team replaced the user cost calculation module with corresponding ones for the respective alternative activities. With completion of this task, an enhanced interim version of *RealCost 2.5CA* became available in September 2009. Completion of subsequent tasks will result in further enhancements.



Figure 1.1: Flow chart of changes made in *Task 3.1*, enhancement of Traffic Data.

### **2 TRAFFIC DATA COLLECTION**

In life-cycle cost analysis, traffic data is required to calculate road user delay cost (road user cost) for each activity of every alternative. Traffic delay is calculated using lane closure parameters such as the number of lanes closed, lane closure duration, work zone length, work zone capacity, and work zone speed limit, and either annual average daily traffic (AADT) with hourly traffic distribution pattern or average hourly volume for both directions.

The AADT on most California highways are updated every year and the hourly traffic volumes are collected and released through the California Freeway Performance Measurement System (PeMS) for the major urban highways.

In the original *RealCost 2.5* (FHWA Version), the "traffic hourly distribution" window allows user to input four different traffic hourly distributions and provides one default hourly distribution (1). The traffic hourly distribution input option for four different patterns can only be used when users have the traffic distribution information. When users lack traffic distribution information, the default distribution should be used regardless of the real traffic patterns and weekdays/weekends. The default values are taken from *MicroBENCOST*, software produced by the Texas Transportation Institute. *MicroBENCOST* is used to calculate benefits and costs of transportation improvements. The traffic hourly distribution included in *MicroBENCOST* has been adopted as a default traffic distributions for urban and rural highways in the original *RealCost 2.5* (FHWA Edition). These distributions are inadequate for California implementation for both weekday and weekend analysis. The traffic patterns in California highways show more diverse types than the *MicroBENCOST* defaults. This section describes traffic data collection and analysis for establishing California standard traffic patterns for efficient and accurate implementation.

### 2.1 Traffic Data Download from PeMS

The traffic data for Task 3.1 was acquired from the California Freeway Performance Measurement System (PeMS). As of August 2009, the State of California collects traffic data from 8,622 vehicle detector stations (VDS) with 27,449 loop detectors on 30,573 directional miles of freeways, including California interstate freeways and state routes. The PeMS covers 9 out of 12 districts in California (except Districts 1, 2, and 9). The traffic data are available—with a user name and password—through the PeMS Web site (*pems.eecs.berkeley.edu*), a cooperative effort of the departments of Electrical Engineering and

Computer Sciences at the University of California at Berkeley, Caltrans, California Partners for Advanced Transit and Highways (PATH), and Berkeley Transportation Systems (2).



Figure 2.1: Default Traffic Hourly Distribution (Urban) for the Original *RealCost 2.5* (FHWA Edition).



Figure 2.2: Default Traffic Hourly Distribution (Rural) for the Original *RealCost 2.5.* (FHWA Edition)

During the period of traffic data collection (February and March 2009), the locations for traffic data download were carefully investigated and selected based on the detectors' health condition and observation performance. The traffic data includes the averaged traffic hourly volumes for 24 hours of the day during weekday and the same during weekend.

The information (i.e., district, freeway, direction, location, period, and VDS identification number) of the selected locations is listed in Table 2.1.

#### 2.2 Traffic Data Analysis

Traffic data were analyzed to establish standard traffic hourly distribution patterns and investigate traffic patterns for weekdays versus weekends, inbound versus outbound.

Usually, weekday AADT data is collected for most California freeway facilities and weekend AADT data is collected rarely, on an as needed basis. Therefore, when weekend AADT data is needed (and measurement is not feasible) for weekend construction/maintenance analysis, it is commonly derived by conversion from weekday AADT data. In order to accurately accomplish this conversion, a trend analysis of weekday and weekend AADT was conducted to generate a guideline for a conversion factor.

For identical locations and periods, weekday and weekend traffic data were compared to investigate the relationship of the traffic patterns for weekdays and weekends. Based on the results of the comparison, the observed weekend AADT was between 70 percent and 105 percent of the weekday AADT (Table 2.2). The weekend conversion factor is calculated as:

Weekend AADT Conversion Factor =  $\frac{\text{Weekend AADT}}{\text{Weekday AADT}}$ .

The average of the weekend AADT conversion factor from weekday traffic was 0.84.

Figure 2.3 shows that there is no significant relationship for the weekday AADT and the weekend AADT. High conversion factor values are observed in freeways with high AADT and as well those with low AADT. Weekend AADT depends upon freeway functionality more than traffic volume. For example, Interstate 15 in San Bernardino shows higher weekend AADT than weekday AADT because the freeways carries higher portion of weekend leisure travelers.

District	Freeway	Direction	Location	Period	VDS	
1	No PeMS VDS de	eployed				
2	No PeMS VDS deployed					
3	5	NB	Sacramento	Weekday	314923	
	5	NB	Sacramento	Weekday	315054	
	5	NB	Sacramento	Weekend	315054	
	80	EB	Placer	Weekend	316214	
	80	WB	Placer	Weekend	316222	
4	80	EB	Pinole	Weekday	400660	
	80	WB	Pinole	Weekday	400301	
	880	NB	Oakland	Weekday	400949	
	880	SB	Oakland	Weekday	400498	
	80	EB	Berkeley	Weekend	400679	
	80	WB	Berkeley	Weekend	400809	
	80	WB	Pinole	Weekend	400301	
	80	EB	Pinole	Weekend	400660	
5	17	NB	Scotts Valley	Weekday	500006	
6	41	NB	Fresno	Weekday	600405	
	41	NB	Fresno	Weekend	600405	
	41	SB	Fresno	Weekday	600281	
	41	SB	Fresno	Weekend	600281	
7	5	NB	Burbank	Weekday	716971	
	5	NB	Burbank	Weekend	716971	
	5	SB	Los Angeles	Weekday	763748	
	110	SB	Los Angeles	Weekday	759418	
	110	SB	Los Angeles	Weekend	759418	
8	15	NB	Ontario	Weekday	811156	
	15	NB	San Bernardino	Weekday	811246	
	15	SB	Ontario	Weekday	811162	
	15	SB	San Bernardino	Weekday	811232	
	15	NB	San Bernardino	Weekend	811246	
	15	SB	San Bernardino	Weekend	811232	
	91	EB	Riverside	Weekend	801502	
	91	WB	Riverside	Weekend	801505	
9	No PeMS VDS de	eployed				
10	33	SB	Merced	Weekday	1008510	
	33	SB	Merced	Weekend	1008510	
11	5	NB	San Diego	Weekday	1118348	
	5	NB	San Diego	Weekend	1113976	
	5	NB	San Diego	Weekday	1113976	
	5	NB	San Diego	Weekend	1118348	
12	57	NB	Fullerton	Weekday	1202365	
	57	NB	Fullerton	Weekend	1202365	
	57	SB	Fullerton	Weekday	1213106	
	57	SB	Fullerton	Weekend	1213106	
	405	SB	Irvine	Weekday	1209161	
	405	SB	Irvine	Weekend	1209161	

Table 2.1: Traffic Data Loca
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District	Location	Freeway	Weekend AADT Conversion Factor
3	Sacramento	5	0.72
1	Pinole	80	0.94
4	Pinole	80	0.95
6	Fresno	41	0.67
0	Fresno	41	0.77
7	Los Angeles	110	0.80
/	Burbank	5	0.86
0	San Bernardino	15	1.02
8	San Bernardino	15	0.89
10	Merced	33	1.04
11	San Diego	5	0.89
11	San Diego	5	0.72
	Irvine	405	0.78
12	Fullerton	57	0.78
	Fullerton	57	0.81
	Average		0.84

 Table 2.2:
 Conversion Factor from Weekday to Weekend



Figure 2.3: Relationship for Weekday AADT and Weekend Conversion Factor

Based on the investigation of relationship of weekday AADT and weekend AADT, the weekend AADT conversion factors can be chosen by the respective freeway functionality as shown in Table 2.3.

Freeway Functionality	Weekend AADT Conversion Factor		
Shopping, Leisure, and Tours Routes	0.90–1.00		
Rural and Intercity Freeways	0.80–0.90		
Commute Routes and Office Building Areas	0.70–0.85		

 Table 2.3: Weekend AADT Conversion Factor by Freeway Functionality

Among other factors, inbound and outbound traffic hourly distribution patterns are affected by freeway functionality and location. Details are described in the following sections.

The values for vehicle operation cost (VOC) and user time for passenger cars and commercial vehicles in 2009 have not been released as of this writing but they will be updated in subsequent tasks.

### 3 NEW TRAFFIC HOURLY DISTRIBUTION PATTERNS ADDED IN TASK 3.1

The customized version of *RealCost 2.5CA* contains a pair of key enhancements that allow users to estimate life cycle costs for California projects. Specifically, the customized version of *RealCost 2.5CA* contains traffic hourly distribution patterns specific to California freeways. There are four standard patterns represented: Weekday Single Peak, Weekday Double Peak, Weekend Flat Peak, and Weekend Skew Peak. Traffic data analysis indicates that weekday traffic patterns differ from weekend traffic patterns. The annual average daily traffic volumes (AADT) for weekends are smaller than those for weekdays. In addition, users have the option to further customize this traffic pattern data by inputting site-specific traffic hourly distribution percentages or traffic hourly volumes.

Two dominant patterns are observed in the traffic data for weekdays. The Weekday Single Peak distribution shows a morning-peak period for one direction and an afternoon-peak period for the opposite direction. The Weekday Double Peak pattern shows a morning-peak and an afternoon-peak period for both directions. Two prevailing patterns are also observed in the traffic data for weekends. The Weekend Flat Peak shows a single flat afternoon-peak period; the shape of the Weekend Skew Peak is a single, relatively sharp afternoon-peak period.

The interface of Traffic Data Window was revised for implementing the new California standard traffic patterns. In *RealCost 2.5CA* this window opens (Figure 3.3) when users click the Traffic Hourly Distribution button on the Switchboard.

In configuring their analysis, users can select the user cost computation method by clicking the the Switchboard's Analysis Option button. In the User Cost Computation section of the window that opens, users can choose between calculated or specified values. When the Calculated option is selected, a road user cost for each activity of each alternative is presented based on the corresponding hourly traffic distribution and lane closure parameters entered in every Alternative window (which is opened by clicking the Alternative button on the Switchboard). If users have a road user cost value for each activity of their respective alternatives, or intend to use specific user cost amounts instead of the calculated values based on the traffic data, then they select Specified in the User Cost Computation Method (Figure 3.4) and type each user cost value in the Alternative window.

As noted earlier, *RealCost 2.5CA* contains standard values for traffic hourly distribution percentages. However, modifications in this version of the software also allow users to provide traffic hourly proportion and directional spilt percentages (or traffic hourly volumes for both directions) when they are known. This is accomplished using the new customization function available by clicking the Switchboard's (Figure 3.1) Traffic Hourly Distribution button, and the Input Traffic button next to the Customized input pattern (Figure 3.2).

*Note:* Users distinguish the *RealCost V2.5* California Edition by the title of the switchboard. The title bar shows "California Edition" and the right upper side of the switchboard shows "Build: 2.5.0 (CA)" (Figure 3.1).

The original *RealCost 2.5* (FHWA edition) has four default values of traffic hourly distribution patterns (Weekday 1, Weekday 2, Weekend 1, and Weekend 2) for each urban and rural highway. The default values can be changed by users when the specific distribution data is available (Figure 3.3).

The details for each traffic distribution pattern are described in the following sections.



Figure 3.1: The new Switchboard of *RealCost 2.5* California Edition.

California 4 standard tra and customized pattern	affic distribution input.
Weekday Single-Peak	View Traffic
Weekday Double-Peak	View Traffic
Weekend Flat-Peak	View Traffic
Weekend Skew-Peak	View Traffic
Customized	Input Traffic

Figure 3.2: The new Traffic Hourly Distribution window of *RealCost 2.5CA*.

istribution Nar	ne: W	/eek Day 1		•		
Hour	AADT Rural (%)	Inbound Rural (%)	Outbound Rural (%)	AADT Urban (%)	Inbound Urban (%)	Outbound Urban (%)
0 - 1	1.8	48	52	1.2	47	53
1 - 2	1.5	48	52	0.8	43	57
2-3	1.3	45	55	0.7	46	54
3-4	1.3	53	47	0.5	48	52
4 - 5	1.5	53	47	0.7	57	43
5-6	1.8	53	47	1.7	58	42
6-7	2.5	57	43	5.1	63	37
7 - 8	3.5	56	44	7.8	60	40
8-9	4.2	56	44	6.3	59	41
9 - 10	5	54	46	5.2	55	45
10 - 11	5.4	51	49	4.7	46	54
11 - 12	5.6	51	49	5.3	49	51
12 - 13	5.7	50	50	5.6	50	50
13 - 14	6.4	52	48	5.7	50	50
14 - 15	6.8	51	49	5.9	49	51
15 - 16	7.3	53	47	6.5	46	54
16 - 17	9.3	49	51	7.9	45	55
17 - 18	7	43	57	8.5	40	60
18 - 19	5.5	47	53	5.9	46	54
19 - 20	4.7	47	53	3.9	48	52
20 - 21	3.8	46	54	3.3	47	53
21 - 22	3.2	48	52	2.8	47	53
22 - 23	2.6	48	52	2.3	48	52
23 - 24	2.3	47	53	1.7	45	55
Total	100			100		

Figure 3.3: Old traffic hourly distribution of *RealCost 2.5* (FHWA Edition).

Analysis Options	×
Analysis Units:	English
Analysis Period (years):	65
Discount Rate (%):	4
Beginning of Analysis Period:	2007
Include Agency Cost Remaining	Service Life Value: 🔽
Include User Costs in Analysis:	
User Cost Computation Method:	Specified -
Traffic Direction:	Calculated Specified
Include User Cost Remaining Se	rvice Life Value:
Number of Alternatives:	4 💌
Ok	Cancel

Figure 3.4: The Analysis Options window of RealCost 2.5CA.

### 3.1 Weekday Single-Peak

The Weekday Single Peak pattern contains one peak period for each direction. A morning-peak appears in one direction, and an afternoon-peak appears in the other (Figure 3.5). The morning peak starts at 5:00 hrs (5 A.M.), reaches its maximum between 7:00 and 8:00 hrs (7 and 8 A.M.), and begins to diminish at 10:00 hrs (10 A.M.). The afternoon peak starts around at 15:00 hrs (3:00 P.M.), reaches its maximum between 17:00 and 18:00 hrs (5:00 and 6:00 P.M.), and diminishes at 20:00 hrs (8:00 P.M.). This pattern is often observed in the boundary areas of central business districts (CBDs) or perimeters of downtown areas.



Figure 3.5: The Weekday Single Peak traffic distribution pattern.

#### 3.2 Weekday Double Peak

The Weekday Double Peak pattern contains two peak periods for both directions. The first peak appears and diminishes in the morning for both directions, and the second peak appears and diminishes in the afternoon for both directions. The morning-peak starts at 5:00 hrs (5 A.M.), reaches its maximum between 7:00 and 8:00 hrs (7 and 8 A.M.), and begins diminishing at 10:00 hrs (10 A.M.). The afternoon-peak starts around at 15:00 hrs (3:00 P.M.), reaches its maximum between 5:00 and 6:00 hrs (5 and 6 P.M.), and ends at 8:00 P.M. (Figure 3.6). This pattern is often observed on urban freeways inside CBDs or downtown areas during weekdays.



Figure 3.6: The Weekday Double Peak traffic distribution pattern.

### 3.3 Weekend Flat Peak

The Weekend Flat Peak pattern contains one flat peak period for each direction. The flat peak starts at 10:00 hrs (10 A.M.) and diminishes around at 20:00 hrs (8 P.M.). The curve shape is gentle and flat during the peak period (Figure 3.7). This pattern is mostly observed on urban freeways inside CBDs or downtown areas during Saturdays and Sundays.

Hour	AADT (%)	Inbound (%)	Outbound (%)	Traffic Distribution Pattern - Weekend Flat-Peak
0 - 1	2.25	55	45	Tanio Distributor Fatern Weekend Fat Feak
1 - 2	1.61	53	47	
2 - 3	1.41	54	46	8
3 - 4	0.99	43	57	8-
4 - 5	1.05	32	68	
5 - 6	1.39	35	65	
6 - 7	2.15	42	58	± O
7 - 8	3.07	46	54	≓ 5 — Directio
8 - 9	4.17	48	52	
9 - 10	5.18	50	50	
10-11	5.93	50	50	li internationali in
11 - 12	6.16	51	49	₩ 5 m
12-13	6.20	51	49	F. N. I
13-14	6.35	51	49	$\tilde{\epsilon}^2$
14-15	6.24	52	48	
15-16	6.30	51	49	ľ'
16-17	6.21	51	49	0
17-18	6.13	51	49	
18-19	5.92	51	49	1 3 5 7 9 11 13 15 17 19 21 23
19-20	5.57	51	49	Time of Day
20 - 21	4.88	50	50	
21 - 22	4.43	49	51	
22 - 23	3.70	50	50	OK
23-24	2.73	52	48	

Figure 3.7: The Weekend Flat Peak traffic distribution pattern.

### 3.4 Weekend Skew Peak

The Weekend Skew Peak pattern contains one sharp peak period for each direction. The skew peak starts at 14:00 hrs (2 P.M.) and diminishes around at 20:00 hrs (8 P.M.). The curve shape is skewed and narrow during peak period (Figure 3.8). This pattern is particularly observed on freeways connecting leisure sites, including amusement parks and tourist destinations.

Hour	AADT (%)	Inbound (%)	Outbound (%)	Traffic Distribution Pattern - Weekend Skew-Peak
0 - 1	1.88	47	53	
1 - 2	1.32	46	54	10 r · · · · · · · · · · · · · · · · · ·
2 - 3	1.11	48	52	
3 - 4	0.96	47	53	89
4 - 5	1.05	45	55	
5 - 6	1.52	46	54	₽ 7
6 - 7	2.16	44	56	
7 - 8	2.90	47	53	臣 6 Directio
8 - 9	3.88	46	54	👸 5 – Directio
9 - 10	4.91	46	54	
10-11	5.73	46	54	₩ 4
11-12	6.14	47	53	≝ 3
12-13	6.32	50	50	
13-14	6.54	51	49	<u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u></u>
14-15	6.62	52	48	₽ 1 - <b>-</b>
15-16	6.73	53	47	
16-17	6.82	52	48	0
17-18	6.66	53	47	1 3 5 7 9 11 13 15 17 19 21 23
18-19	6.17	53	47	Time of Day
19-20	5.69	52	48	Time of Day
20 - 21	4.90	52	48	
21 - 22	4.16	51	49	
22 - 23	3.40	49	51	
23-24	2.45	50	50	OK

Figure 3.8: The Weekend Skew Peak traffic distribution pattern.

### 3.5 Customized A Traffic Pattern

In addition to the four California standard traffic hourly distribution patterns, the customization function allows users to input a site-specific traffic hourly distribution pattern by selecting the customized Input Traffic button in the Traffic Hourly Distribution window (Figure 3.2). In the Traffic Hourly Distribution—Customized Pattern window that appears (Figure 3.9), users directly input either hourly proportions and directional split proportions or hourly volumes for inbound and outbound. By clicking the relevant View Graph button after inputting either traffic pattern by AADT or hourly traffic volumes, users can obtain a corresponding graph of the customized traffic patterns (Figure 3.10), which can then be selected for each activity of the respective alternative.

Hour	AADT (%)	Inbound (%)	Outbound (%)		Hour	Volume (Inbound)	Volume (Outbound)		
0 - 1	1.00	50	50		0 - 1	2000	1000		
1 - 2	1.40	50	50		1 - 2	2000	1000		
2 - 3	1.40	50	50	2 - 3	2000	1000			
3-4	1.40	50	50		3-4 4-5 5-6	2000	1000		
4 - 5	1.10	50	50			2000	1000		
5 - 6	3.4	50	50			1000	1000		
6 - 7	5.6	50	50		6 - 7	1000	1000		
7 - 8	7.8	50	50		7 - 8	1000	1000		
8 - 9	6.5	50	50		8 - 9	1000	1000		
9 - 10	3.5	50	50		9 - 10	1000	1000		
10 - 11	2.6	50	50		10 - 11	1000	1000		
11 - 12	4.3	46	54	OR	R 11 - 12	1000	1000		
12 - 13	4.2	48	52		12 - 13	1000	1000		
13 - 14	6.8	51	49		13 - 14	1000	1000		
14 - 15	7.9	52	48		14 - 15	1000	1000		
15 - 16	8.6	54	46		15 - 16	1000	1000		
16 - 17	8.6	48	52		16 - 17	1000	1000		
17 - 18	4.6	49	51		17 - 18	1000	1000		
18 - 19	6.7	50	50			18 - 19	1000	1000	
19 - 20	7.3	50	50		19 - 20	1000	1000		
20 - 21	2.3	50	50		20 - 21	1000	1000		
21 - 22	1.00	50	50		21 - 22	1000	1000		
22 - 23	1.00	50	50		22 - 23	1000	1000		
23 - 24	1.00	50	50		23 - 24	1000	1000		
SUM	100				SUM	29000	24000		

Figure 3.9: The Traffic Distribution—Customized Pattern input window.



Figure 3.10: The customized pattern generated by using AADT Graph window.

#### 3.6 Incorporation with Alternative Window

The new traffic hourly distribution patterns with the customization function are incorporated in the Alternative window, which is accessed by clicking the Alternative button in the Switchboard. When users click the Traffic Hourly Distribution menu-drop button in the Alternative window, five choices of traffic patterns appear (Figure 3.11). When one traffic hourly distribution pattern among the five is chosen, the tool calculates the user cost with the other given traffic condition (i.e., Work Zone Duration, Work Zone Speed Limit, and Closure Hours) for the corresponding activity of the respective alternative.

Alternative:			1		Þ			
Alternative Description:	12" PC	C & 6" ACB	(35 YR) Full-d	lepth Recon	struction	Number of Act	ivities:	2
tivity 1 Activity 2								
Activity Description:	12" PCC	+ 6" AC Ba:	se Reconstruc	tion (Week	end)			
Activity Cost and Serv	ice Life In	puts						
Agency Construction Cost	: (\$1000):	19106	Cost	Acti	vity Service Life (	years):	35	
User Work Zone Costs (\$1	.000):	2000		Acti	vity Structural Life	e (years):	35	
Maintenance Frequency (years):				Age	Cost (\$1000):	0		
Activity Work Zone In	puts							
Work Zone Length (miles)		4		Wor	k Zone Duration (	(days):	40	
Work Zone Capacity (vph	pl):	1500		Wor	'k Zone Speed Lim	nit (mph):	55	
No of Lanes Open in Each During Work Zone:	Direction	1		Traf	fic Hourly Distribu	ution: Week	day Single	-Pea 💌
Work Zone Hours						Week	day Single day Double	Peak e-Peak
			nbound	End	Outbound -	Fod Week	end Flat-Pe end Skew-I	eak Peak
First Period of	Lane Closu	re:	o	24	0	24 Custo	Dimized Paste A	rtivity
Second Period	d of Lane Clo	osure:	— ř					
Third Period o	f Lane Closu	ure:		(Tr				
-								

Figure 3.11: Alternative window.

### 4 FUTURE TASKS

The *RealCost* enhancement for Caltrans began in March 2009 and will be completed in March 2011. Figure 4.1 shows the detailed schedule for the tasks, including optional Task 4.1.

Task 3.1 (Traffic Data) was completed in September 2009, and Task 3.2 (Alternative Interface), which began in July 2009, is expected to be completed by December 2009. Task 3.3 (Cost Estimates for Initial Construction) began in September 2009 and will be continued until March 2010 with *Task 3.4* (Cost Estimates for Future Maintenance/Rehab) concurrently. Task 3.5 (M&R Menu Selection) is planned to begin in March 2010 and will be completed by September 2010. Task 4.1 (M&R Sequencing-Automation) is an optional task and will be conducted from October 2010 to March 2011 after additional approval.

Tasks	Mar. 2009	Jun. 2009	Sep. 2009	Dec. 2009	Mar. 2010	Jun. 2010	Sep. 2010	Dec. 2010	Mar. 2011
<i>Task 3.1:</i> Traffic Data		Completed							
<i>Task 3.2:</i> Alternatives Interfaces			Planned						
<i>Task 3.3</i> : Cost Estimates for Initial Construction				Planned					
<i>Task 3.4</i> : Cost Estimates for Future Maintenance/ Rehab				Plan	ned				
Task 3.5: M&R Menu Selection						Planned			
Task 4.1 (Option): M&R Sequencing- Automation							P	lanned in Op	tion

The details and deliverables for each task are described in the following sections.

Figure 4.1: Schedule of the *RealCost* enhancement for Caltrans.

### 4.1 Task 3.2: Alternative Interface

- 1. Develop a procedure to incorporate new hourly traffic distribution patterns from the Traffic Data input window, and improve the interfaces for activation and interaction in the Alternative window (The current version has preset traffic types (2 weekend and 2 weekday, and they are properly working when the hourly traffic distribution pattern is changed).
- 2. Add/change the first activity title to Activity 1 (Initial Construction).

- 3. Insert a calculator button and develop the code to link it to the Cost Module.
- 4. Insert a button and develop the code to link the Cost Estimate to the each Activity tab in Alternative Window.
- 5. Provide integration interface between *RealCost* and the Cost Estimate module.
- 6. Provide more automatic calculation procedures of the working-day estimate input for future M&R activities with preset design cross sections, based on typical *CA4PRS* production rates.
- 7. The main tasks of Alternatives will be completed and a technical memorandum will be submitted by November 30, 2009.

### 4.2 Task 3.3: Cost Estimates for Initial Construction

- 1. Produce a prototype of cost from *CA4PRS* based on the latest Appendix AA of the *Caltrans Project Development Procedures Manual* (PDPM) to be used in the "Initial Construction Estimate."
- 2. Insert percentage calculation when total dollar amount is entered.
- 3. Develop the code to input the construction duration calculated from *CA4PRS* and link the Cost Estimate module to the Construction Schedule Analysis module.
- 4. Produce calculation of user inputs.
- 5. Delete Net Project Value (NPV) in main window of Cost Estimate module.
- 6. Simplify calculation of supporting cost by PY.
- 7. Insert a user input window including lane-mile and unit cost.
- 8. Include a simplified function to determine traffic handling cost
- 9. Determine a process to input Road User Cost (RUC) from the two different ways (calculated and specified).
- 10. Decide on a process and develop the code to incorporate RUC into *RealCost*.
- 11. The main tasks of Cost Estimates for Initial Construction will be completed and its technical memorandum will be submitted by March 31, 2010.

#### 4.3 Task 3.4: Cost Estimates for Future Maintenance/Rehab

- 1. Investigate typical rehabilitation thickness (including CAPM) provided by Caltrans' Division of Pavement Management to develop user inputs that will generate cost estimates for future activities.
- 2. Produce a function and develop the code to calculate total volume and select a number of closures automatically in the Future Maintenance/Rehab Activities.
- 3. Provide the factors in cost estimates for Future Maintenance/Rehab Activities.

4. The main tasks of Cost Estimates for Future Maintenance/Rehab will be completed and its technical memorandum will be submitted by March 31, 2010.

#### 4.4 Task 3.5: M&R Menu Selection

- 1. Coordinate and update the Maintenance and Rehab (M&R) sequence with Caltrans' Division of Pavement Management.
- 2. Produce a tracking function of classification.
  - A. Climate region
  - B. Final surface
  - C. Design life
  - D. Maintenance level
- Confirm the latest M&R sequencing with Division of Pavement Management, update the M&R sequencing, covert the M&R data to an *Excel* DB with a unique M&R ID code for tracking from *RealCost 2.5CA* with automatic interaction (this automation is optional Task 4.1).
- 4. Enhance accuracy of pavement maintenance and rehabilitation sequences included in the manual by investigating service lives of historical maintenance and rehabilitation strategies.
- 5. The intermediate progress summary of M&R Menu Selection will be submitted by May 31, 2010.
- 6. The main tasks of M&R Menu Selection will be completed and a technical report on *RealCost* and M&R Updates will be submitted by September 15, 2010.

### 4.5 Task 4.1: M&R Sequencing-Automation (Option)

- 1. Activate a function linking M&R data to the Activity menu in the Alternatives section of the Switchboard.
- 2. Produce a function to calculate activity service life, maintenance frequency, and agency maintenance cost in each activity of each alternative.
- 3. Develop a sequencing-automation function to place activity service life, maintenance frequency, and agency maintenance cost in each activity chosen when the number of activities is chosen.
- 4. Test the updated *RealCost* including M&R sequencing-automation function.
- 5. An intermediate progress summary will be submitted by December 15, 2010.
- 6. The main tasks of M&R Sequencing-Automation will be completed and its technical memorandum will submitted by March 15, 2011.

### **5 SUMMARY**

This technical memorandum summarizes Task 3.1: Traffic Data of the *RealCost* Enhancement and Version 2 Life-Cycle Cost Analysis Manual for Caltrans. Every task item in Task 3.1 has been consequently completed and the interim version of *RealCost 2.5CA* (California Edition) is available and ready for subsequent tasks. The major change accomplished in Task 3.1 was the addition of California-specific traffic patterns and input data selection.

First, four standard California-specific traffic hourly distribution patterns were generated using traffic data collected and analyzed from a number of state freeway sections. The traffic distribution patterns were categorized into four standard patterns—Weekday Single-Peak, Weekday Double-Peak, Weekend Flat-Peak, and Weekend Skew-Peak—regardless of freeway category (Urban/Rural).

Based on the comparison of AADT, no strong relationship was found between weekday AADT and weekend AADT, even. The weekend conversion factors were observed between 0.70 and 1.04, and their average was 0.84. Based on the comparative analysis of weekday and weekend AADT, weekend AADT conversion factors by freeway functionality were provided.

Second, the new traffic pattern selection option was incorporated into the *RealCost 2.5*. The interim *RealCost 2.5CA* contains the new interfaces for the traffic hourly distribution input and Alternative window. The corresponding modules for the traffic hourly distribution selection and calculation of user costs were replaced in the interim *RealCost 2.5CA*.

Third, the customization function for the user-specific input was generated and the interface windows were produced and incorporated with the relevant modules. When either hourly proportion of AADT or traffic hourly volume is known for a freeway section, a user can select the customization option to input directly the site-specific hourly traffic data instead of choosing one of the four standard traffic distribution patterns.

Fourth, the traffic pattern data input interfaces in the original FHWA's *RealCost V2.5* were modified and upgraded to customize the new traffic data pattern selection for Caltrans, especially in the Alternative and Activity menus.

The interfaces for the traffic, user cost, and cost estimates for each activity of the respective alternative in the Alternative window will be updated in subsequent project tasks.

### **6 REFERENCES**

- Office of Asset Management (2004), Life-Cycle Cost Analysis *RealCost* User Manual, U.S. Department of Transportation, *www.fhwa.dot.gov/infrastructure/asstmgmt/rc210704.pdf*. (Accessed August 2009.)
- 2. PATH at University of California, Berkeley and Caltrans (2009), California Freeway Performance Measurement System (PeMS), *pems.eecs.berkeley.edu*. (Accessed August 2009.)