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Introduction and Background

This technical memorandum describes the calibration, testing, and refinements made to the Ski Corridor Travel Time Model during Phase 2A of the project. It describes the specific components of the spreadsheet model and provides general instructions on how to create a base case scenario. Findings and recommendations on next steps are also provided.

The Southern Windsor County Regional Planning Commission (SWCRPC), the Rutland Regional Planning Commission (RRPC), and the Two Rivers-Ottauquechee Regional Commission (TRORC), working in partnership with the Vermont Agency of Transportation (VTrans) and two major ski areas, are working to develop a new analytical tool for assessing the impact of development-related traffic growth in regionally significant highway corridors. Phase 1 of the study was completed by Wilbur Smith Associates (WSA) and is documented in the "Ski Corridor Traffic Management Study" (April 2001). Phase 1 provides the overall context for the study as it relates to Act 250, includes an assessment of existing conditions in the study area, and reviews and assesses the applicability of various traffic impact assessment methodologies based on a set of goals agreed upon by the project steering committee.

One potential measure that survived the screening process involves the calculation of the total change in vehicle hours of travel that would be caused by new development. According to study participants, application of this technique appeared most promising at the "micro" segment or intersection level but was less appropriate in other respects. As a consequence, the measure was refined to produce point-to-point travel time changes within a corridor for a single vehicle. Study participants later agreed that the revised technique fulfilled the requirements of the study and requested that the technique be developed to a full-scale area-wide system for application.

The performance measure proposed in Phase 1 is best described as the average time it would take for a vehicle to travel between two points within a given corridor during peak traffic conditions. A spreadsheet model was developed to estimate point-to-point travel time that accounts for delay encountered along road segments and at intersections.

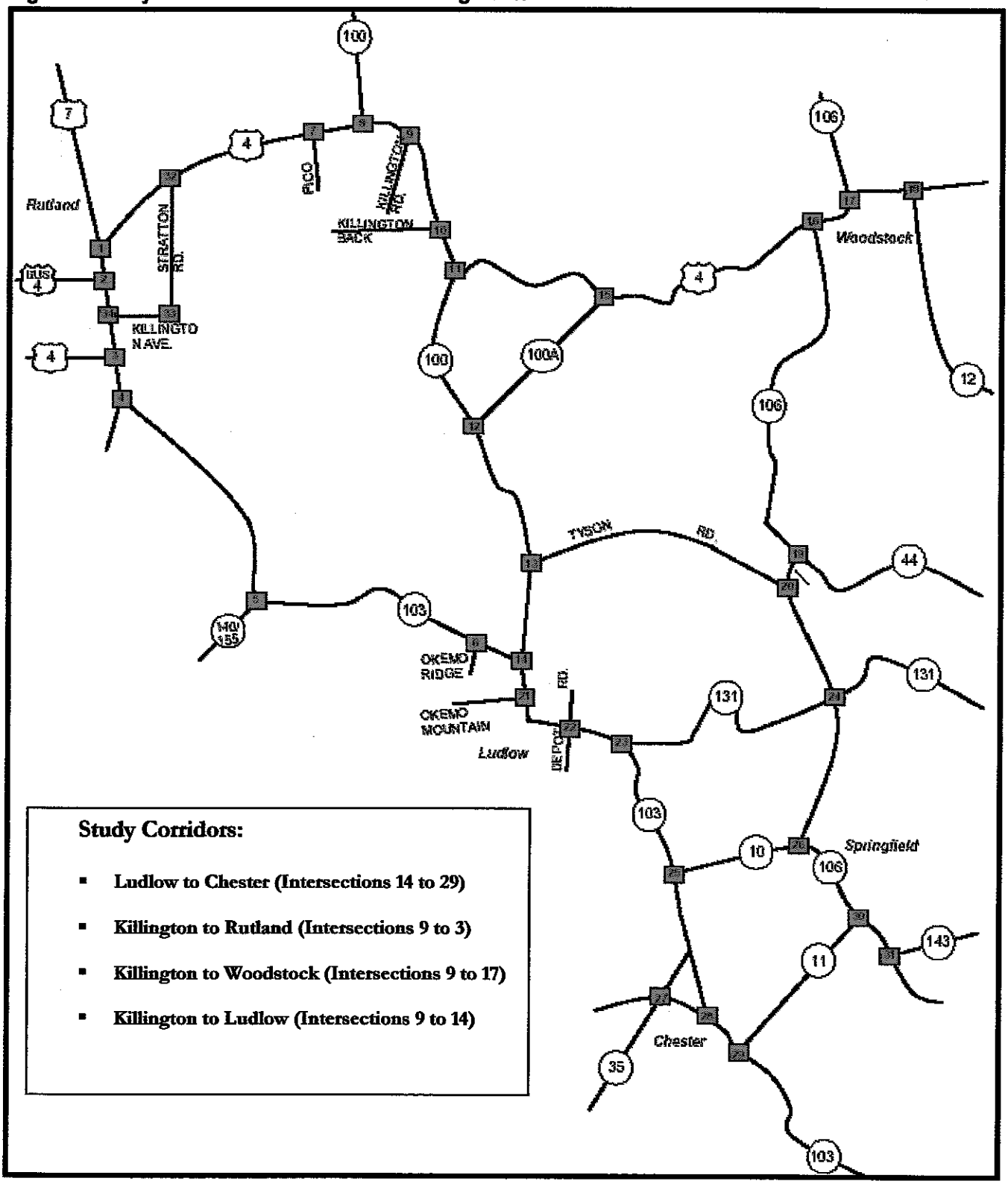
Phase 2A Tasks

Although the spreadsheet model was constructed and functional at the end of Phase 1, it had not been tested or calibrated using real data. Therefore, the purpose of Phase 2A was to:

- Populate the model with real world data (collected by the RPCs, VTans, and ski areas during January, February, and March of 2001);
- Test the model's performance by comparing its estimate of travel time to travel times measured in the field; and
- Refine the model as required to achieve acceptable performance.

Turning movement counts at the major intersections and field travel time runs are necessary to populate, test, and calibrate the model. Based on the data available, it was agreed by the project steering committee that the model would be tested within the four corridors listed and shown in **Figure 1**.

Figure 1. Study Area Intersections and Road Segments



Model Overview

At the conceptual level, the model is very simple. It estimates travel time between intersections along a corridor by adding the delay encountered at intersections to the travel time along the road segments which are both affected by traffic volumes and highway/intersection operational and physical characteristics. The delay encountered at intersections is estimated outside of the spreadsheet model using software based on the 2000 Highway Capacity Manual. Highway Capacity Software is used for stop-controlled intersections. During model testing and calibration, delay at signalized intersections was calculated using the Synchro 5, Traffic Signal Coordination Software. Other software packages could also be used to estimate delay at signalized intersections including the Highway Capacity Software and SIGNAL2000. Estimated intersection delays are manually entered into the spreadsheets where they are automatically added to road segment travel times to develop the total corridor travel time. The road segment travel times are estimated within the spreadsheet model using formulas developed from *Planning Techniques to Estimate Speeds and Service Volumes for Planning Applications, NCHRP 387.* Refer to the Phase 1 Final Report for a detailed description of the intersection delay and road segment travel time methodologies.

The model can be used to estimate travel times for any hour of any day as long as intersection turning movement counts are available during the hour and day being analyzed. The critical time period within the study area is Sunday evenings as skiers depart and travel home. In order to model this critical period, the project steering committee directed WSA to populate and test the model with data for Sunday, February 18, 2001 between 5:00-6:00 PM.

Calibration Targets

The model's performance is based on a comparison between its estimate of travel time within a corridor and the actual travel time measured in the field. It is reasonable to expect some difference between the actual and estimated travel times. In establishing a reasonable calibration target, the project steering committee considered (1) the differences between actual travel time runs made on different days and (2) calibration guidelines published by the Federal Highway Administration (FHWA) for transportation models.

Table 1 on the following page shows the differences in travel times in the four study corridors for the January, February, and March 2001 data collection days during many different time periods. The average difference between all of the time periods among the three data collection days is 7%. As shown in Table 1, the percent difference for individual time periods varies widely from 0% to 23%.

Table 2 on page 5 presents the FHWA calibration guidelines for transportation models. The calibration guidelines relate to the percent difference between traffic volumes measured in the field and traffic volumes predicted by a transportation model. Different calibration targets are provided for the region as a whole, and by functional class. Most of the highways in this study area are principal arterials suggesting a calibration target of +/- 10%.

Table 1. Differences between Travel Time Runs Conducted in the Field

Killington to Rutland
Intersections 9-4

Start Time	Travel Time Runs			Average Trav Time	% Diff Relative to Average			Average % Difference
	1-Jan	18-Feb	4-Mar		28-Jan	18-Feb	4-Mar	
3:30	0:24:26	0:25:31	0:23:35	0:24:31	0.32%	4.10%	3.79%	3%
3:45	0:28:05	0:25:00	0:36:30	0:29:52	5.95%	16.28%	22.23%	15%
4:00	0:27:10	0:25:02	0:27:20	0:26:31	2.47%	5.57%	3.10%	4%
4:15	0:27:07	0:23:55	0:24:27	0:25:10	7.77%	4.95%	2.83%	5%
4:30	0:25:46	0:25:13	0:23:14	0:24:44	4.15%	1.93%	6.09%	4%
5:00	0:24:00	0:26:00	0:22:00	0:24:00	0.00%	8.33%	8.33%	6%
6:00	0:26:16	0:25:10	0:23:15	0:24:54	5.51%	1.09%	6.61%	4%

Killington to Ludlow
Intersections 9 - 14

Start Time	Travel Time Runs			Average Trav Time	% Diff Relative to Average			Average % Difference
	1-Jan	18-Feb	4-Mar		28-Jan	18-Feb	4-Mar	
4:30	0:26:10	0:26:00	0:25:00	0:25:43	1.73%	1.08%	2.81%	2%
4:45	0:27:02	0:37:00	0:24:00	0:29:21	7.88%	26.09%	18.21%	17%

Route: Okemo to Rockingham
Intersection 14-29

Start Time	Travel Time Runs			Average Trav Time	% Diff Relative to Average			Average % Difference
	1-Jan	18-Feb	4-Mar		28-Jan	18-Feb	4-Mar	
3:00	0:33:32	0:32:58	0:32:45	0:33:05	1.36%	0.35%	1.01%	1%
3:15	0:34:36	0:34:23	0:34:52	0:34:37	0.05%	0.67%	0.72%	0%
3:30	0:34:02	0:35:51	0:33:36	0:34:30	1.34%	3.93%	2.59%	3%
3:45	0:36:00	0:39:51	0:38:45	0:38:12	5.76%	4.32%	1.44%	4%
4:00	0:37:02	0:44:25	0:42:41	0:41:23	10.50%	7.34%	3.16%	7%
4:15	0:41:06	0:42:00	0:39:41	0:40:56	0.42%	2.62%	3.04%	2%
4:30	0:41:27	0:40:17	0:32:00	0:37:55	9.33%	6.26%	15.59%	10%
4:45	0:37:23	0:36:00	0:34:40	0:36:01	3.79%	0.05%	3.75%	3%
5:00	0:32:50	0:45:47	0:34:13	0:37:37	12.70%	21.73%	9.03%	14%
5:15	0:31:44	0:51:51	0:31:59	0:38:31	17.62%	34.60%	16.97%	23%
5:30	0:32:00	0:51:24	0:32:35	0:38:40	17.23%	32.95%	15.72%	22%
5:45	0:34:20	0:47:37	0:32:14	0:38:04	9.79%	25.11%	15.31%	17%
6:00	0:38:48	0:39:56	0:37:02	0:38:35	0.55%	3.48%	4.03%	3%

Route: Killington to Woodstock
Intersection 9-18

Start Time	Travel Time Runs			Average Trav Time	% Diff Relative to Average			Average % Difference
	1-Jan	18-Feb	4-Mar		28-Jan	18-Feb	4-Mar	
4:00	0:35:00	0:34:09	0:31:55	0:33:41	3.89%	1.37%	5.26%	4%
4:15	0:33:00	0:36:00	0:37:32	0:35:31	7.07%	1.38%	5.69%	5%
4:30	0:26:00	0:26:00	0:34:10	0:28:43	9.48%	9.48%	18.96%	13%
5:00	0:34:30	0:33:00	0:32:00	0:33:10	4.02%	0.50%	3.52%	3%
5:15	0:35:00	0:35:00	0:31:00	0:33:40	3.96%	3.96%	7.92%	5%
5:30	0:37:00	0:37:20	0:35:33	0:36:38	1.02%	1.93%	2.94%	2%

Note: Travel Time Data Collected in 2001

Average of All	7%

Table 2. FHWA Model Calibration Guidelines

Functional Class/Area	Guideline
Region-wide	+/- 5.0%
Freeways	+/- 7.0%
Principal Arterials	+/- 10%
Minor Arterials	+/- 15%
Collectors	+/- 25%

The steering committee agreed with WSA's recommendation to use the FHWA guideline of +/- 10% as a reasonable performance target for the ski corridor travel time model. The 10% target is reasonable because it applies to principal arterials and is based on accepted national modeling practice. The 7% difference measured in the field is a less reasonable target because of the wide variations in travel times that exist for specific time periods.

Model Refinements

Elimination of the Intersection Queue Delay Adjustment Factor. The spreadsheet model developed in Phase 1 included an adjustment to the delay encountered at intersections to account for the effect of long vehicle queues (back-ups). The adjustment converted the HCM estimated average delay to the delay experienced by a vehicle that arrives when the queue is at its worst. It was agreed by WSA and the project steering committee that this adjustment was not necessary or appropriate. First, it is unlikely that the vehicles making the travel time runs in the field (which were used to test and calibrate the model) arrived at every intersection within a corridor when the vehicles queues were at their worst. Second, building in the extra delay into model calculations will create a worse case condition that will bias future runs of the model when testing development proposals and mitigation strategies. And finally, since the road segment travel time estimate is an average, the intersection delay should also be an average for consistency.

Estimating Road Segment Travel Times. An initial test of the model in the Killington to Ludlow corridor using actual data indicated that the estimated travel time was very sensitive road segment travel time, and in particular, to the free flow speeds assumed for the roadway segments. Free flow speed is defined as the speed traveled under uncongested conditions and is often greater than the posted speed. However, the model developed in Phase 1 defined free flow speed as the average posted speed limit for a roadway segment. Using an average was reasonable because the posted speeds varied along each road segment as structured in the model. However, using posted speeds underestimated the actual free flow speeds. In fact, traffic engineers often assume that the free flow speed is 5 mile per hour higher than the posted speed limit.

Because the road segment travel time estimate had such a significant impact on a corridor's overall travel time estimate, the refinements focused on that component of the model. A suggested refinement was to replace the NCHRP formulas used to estimate travel times in the spreadsheet

with a recently updated methodology contained in the 2000 Highway Capacity Manual for two lane highways.

Chapter 20 of the 2000 Highway Capacity Manual describes the procedures for two lane highways. A two-lane highway may be evaluated as either a two-way segment or as an individual segment for one direction of travel (directional segments). For the Ski Corridor Travel Time Model, it is necessary to be able to calculate the travel time in a particular direction. Therefore, the directional segment methodology was investigated in more detail. The formula used to calculate average travel speed for directional segments is shown below.

Average Travel Speed = Free Flow Speed – .0076(V_d + V_o) – f_{np} (HCM Formula 20-15)

V_d = Peak hour traffic flow in the direction analyzed adjusted for grade and percent of trucks

V_o = Peak hour traffic flow in the opposing direction adjusted for grade and percent of trucks

f_{np} = Adjustment for percent of "no-passing" zones

Replacing the NCHRP formulas with HCM formula 20-15 was not recommended for the following reasons:

- Formula 20-15 does not account for the effect of highway physical characteristics such as number of travel lanes, lane widths, or shoulder widths on travel time. The ability to model the effect of these characteristics will be necessary when the model is used to test mitigation measures;
- The factor f_{np} must be calculated manually using tables contained in the 2000 Highway Capacity Manual; and
- As indicated in **Table 3**, travel time estimates using the HCM methodology produced worse results than travel times estimated using the NCHRP methodology. Table 3 shows the travel times estimated for the Killington-Rutland and Killington-Ludlow corridors using both methods.

Table 3. Comparison between Road Segment Travel Times Estimated with NCHRP and HCM Methodologies

Corridor	Field Measured Travel Time (Minutes)	NCHRP Method		HCM Method	
		Travel Time	% Difference	Travel Time	% Difference
Killington to Rutland	23	26.46	15%	27.67	20%
Killington to Ludlow	25	26.01	4%	29.87	19%

After deciding that the NCHRPC formulas would be used, the refinement effort focused on collecting accurate base information. WSA conducted a field inventory to document the posted speed limits for each road segment in the study corridor. Each road segment contained several different speed limit zones. Free flow speeds were determined for each speed limit zone by adding 5 miles per hour to the posted speed limit. Data on the length of each speed zone was also collected and used to calculate a weighted average free flow speed for each road segment in the model.

Truck Percentages. The Phase 1 model assumed that 4% of the traffic stream consisted of heavy trucks. This assumption was changed to 2% based on class counts available from VTrans, which showed average weekday peak hour truck percentage of 2.6% in the study area.

Model Performance with Refinements

Table 4 compares field measured and model estimated travel times. Detailed results for each corridor are contained in **Attachment A**. With the exception of the Ludlow-Chester Corridor, the performance is well within the calibration target of +/-10%. The Ludlow-Chester corridor is the only corridor where the model significantly underestimated travel time. This difference is due to the rather large delays experienced at the Depot Street intersection (Intersection #22 in Figure 1) by the travel time data collection vehicles. On the day of the travel time run (February 18, 2001), the test vehicle was stopped at the Depot Street intersection for over 3 minutes. In situations where congestion is severe enough to cause excessive delays, the Ski Corridor Travel Time Model cannot accurately predict the travel time. In fact, no existing methodology is available to predict the type of delay that results when levels of congestion are severe. The project steering committee agreed that the model works well outside of the most severely congested areas, but is not appropriate in the most congestion areas. In the most congested areas, a problem already exists. Therefore, a model is not necessary.

Table 4. Model Performance Using February 18, 2002 Data Between 5:00 – 6:00 PM

Corridor	Field Measured Travel Time (Minutes)	Model Estimated Travel Time (Minutes)	Percent Difference
Killington to Rutland *(Intersections 9 to 3)*	23.00	24.44	+ 6.3%
Killington to Ludlow *(Intersections 9 to 14)*	25.00	24.77	-0.1%
Killington to Woodstock *(Intersections 9 to 17)*	28.00	28.10	+ 1.1%
Ludlow to Chester *(Intersections 22 to 29)*	21.43	19.17	-10.6%

Tables 5 and 6 compare field and model estimated travel times for different dates in the Killington-Ludlow and Ludlow-Chester corridors. The purpose of the comparisons was to determine whether or not the model's performance was reliable when different data sets were analyzed. As shown, the model's performance remained within acceptable limits within both corridors.

Table 5. Killington to Ludlow Corridor (Intersections 9 to 14) Model Performance Comparison between two Dates

Date	Field Measured Travel Time (minutes)	Model Estimated Travel Time (minutes)	Percent Difference
February 18, 2001	25.00	24.77	-0.1%
January 28, 2001	25.20	24.38	-2.8

Table 6. Ludlow to Chester Corridor (Intersections 22 to 29) Model Performance Comparison between Two Dates

Date	Field Measured Travel Time (minutes)	Model Estimated Travel Time (minutes)	Percent Difference
February 18, 2001	21.43	19.17	-10.6%
March 4, 2001	19.47	18.06	-7.3%

Model Instructions

This section describes the structure of the Ski Corridor Travel Time model and how to create a base-case scenario for a specific corridor.

The Ski Corridor Travel Time Model (the "model") is built upon a Microsoft Excel spreadsheet. A user should be familiar with this software before utilizing this model and will also need to be proficient in the use of highway capacity software. The spreadsheet contains over twenty-five separate worksheets (similar to a page). These worksheets contain tables for entering data or contain the formulas and organizational relationships necessary to automatically generate travel time estimates for a given corridor. **Attachment B** describes the name of each worksheet, its purpose, links it contains to other worksheets in the spreadsheet, and other important notes.

The model is organized to provide a travel time estimate in one direction, for one corridor and scenario at a time. Corridors can be defined by a user as any contiguous chain of road segments between the intersections shown in **Figure 1** on page 2. Examples of scenarios include a base-case, a development-case, and a development-with-mitigation-measures-case. A separate Excel spreadsheet file must be created for each corridor and scenario combination. The steps below define the general process a user will follow to estimate the travel time within a specific corridor for a specific scenario. For a base case scenario, the user will need intersection turning movement count data from one

Synchro 5, Traffic Signal Coordination Software. Other software packages may also be used to estimate delay at the signalized intersections including the Highway Capacity Software and SIGNAL2000.

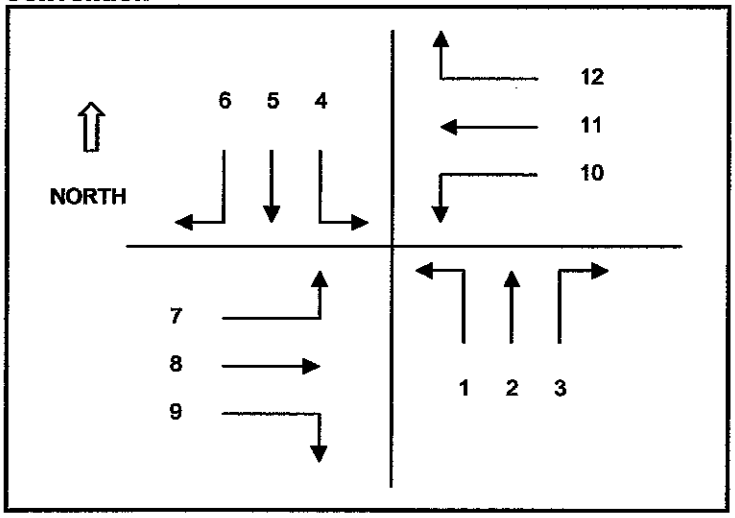
Figure 3. Example of Intersection Delay Entry Table

Intersection #	1			Intersection:			US 7 & US 4 East					
Location:	Center Rutland											
Approach:	Northbound			Southbound			Eastbound			Westbound		
Street:	US 7			US 7						US 4 East		
Movement:	1	2	3	4	5	6	7	8	9	10	11	12
Direction:	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right
Delay	x	55	11	41	57	x	x	x	x	56	x	36

"x" indicates that a particular movement is not possible

Enter average delay per vehicle in seconds

Figure 4. Intersection Turning Movement Numbering Convention



3. Define the Corridor and Generate Final Travel Time Calculation

In this final step, a user identifies the road segments and intersections that comprise a corridor and the spreadsheet model generates the total travel time. The ID numbers of the beginning and ending intersections for each road segment of the corridor being analyzed are entered into the table shown in **Figure 5**, which is located in the "Total_Travel_Time" worksheet. The user must also enter the turning movement number (using the convention shown in **Figure 4** above) corresponding to the turn that a vehicle would make as it travels trough the ending intersection of one road segment to the next road segment in the corridor. The spreadsheet model will use this information to automatically extract the relative intersection delays and road segment travel times from the appropriate worksheets and will sum the travel time for the entire corridor.

Figure 5. Example of Total Travel Time Input and Output Table

Model Run Information

Scenario Description:	Existing Highway Conditions
Corridor:	Killington to Ludlow
Model Period:	Friday, February 18, 2001
Time Period	5:00 - 6:00 PM

See Figure 4

Model Estimate:

INPUTS			***OUTPUTS***				
Road Segment							
Beginning Intersection ID Number	Ending Intersection ID Number	Turn Movement from Ending Intersection to Next Intersection (1)	Travel Time Row (2)	Intersection Delay (Seconds)	Segment Travel Time (Minutes)	Road Segment Travel Time Plus Intersection Delay (Minutes)	Running Total (Minutes)
	9	3	NA	10.7	NA	0.18	0.18
9	10	8	18	0.0	5.9	5.93	6.11
10	11	9	20	0.0	1.4	1.39	7.50
11	12	5	22	7.4	6.1	6.27	13.77
12	13	5	25	7.6	5.0	5.16	18.93
13	14	4	28	8.0	6.1	6.22	25.15

See Figure 1 for Intersection ID Numbers

☐ Shaded cell indicates location for entering information

Total Estimated Travel Time:	**25.15**

Summary

- The Ski Corridor Travel Time Model has been successfully tested and calibrated. It produces reasonably accurate estimates of travel times within the study corridors with consistency and reliability.

- The model is limited in its ability to predict travel times in the segments of corridors that are extremely congested. It should only be applied in the corridors outside of these areas.

- The model is most sensitive to road segment travel time, which in turn, is very sensitive to the free flow speeds assumed.

Recommended Next Steps

Model Development and Testing

1) Test model's sensitivity to a development proposal

2) Develop impact action thresholds
   a) April 2001 Ski Corridor Traffic Management Study recommends conducting a survey of residents, day skiers, and weekend skiers.

3) Develop methodologies for mitigation measures and test model's sensitivity to these measures.
   a) Roadway Mitigation Strategies
   b) Intelligent Transportation System Strategies
   c) Transportation Demand Management Strategies

Strategy	Model Inputs That Can Be Changed to Test A Strategy
Roadway Mitigation	• Intersection Features – Number and type of turning lanes – Signal timing plans • Road Segment Features – Number of lanes – Lane and shoulder width
ITS	• Estimated traffic volume changes
TDM	• Estimated traffic volume changes

Model Management and Application

1) Develop protocol for applying the model in the permitting process
2) Public policy discussion
3) Develop model management protocol
   a) Responsibility for housing the base model
   b) Process for sharing refinements and updates
   c) Scheduling complete updates

ATTACHMENT A

Study Corridor Travel Time Estimates
and
Model Performance

Corridor: Killington to Rutland

Intersections 9 to 3

Model Period: Friday, February 18, 2001
5:00 - 6:00 PM

Model Estimate:

Segment From	Segment Through	Next Turn Movement	Travel Time Row	Intersection Delay (s)	Segment Travel Time (min)†	Seg + Inter Sec TT	Running Total
	9	11		0.0		0.00	0.00
9	8	11	17	0.0	0.1	0.14	0.14
8	7	11	15	0.0	3.4	3.40	3.54
7	32	11	14	24.3	11.4	11.79	15.32
32	1	10	75	56.2	2.6	3.55	18.87
1	2	5	1	17.5	0.3	0.58	19.46
2	34	5	4	7.0	1.0	1.15	20.61
34	3	5	81	3.0	3.8	3.83	24.44
					Total Estimated Travel Time 9 -3		24.44

Segment Comparison			Start Time 5:00		
From	To		Model Estimate	Field Travel Time	% Diff
9	7		3.5	4.0	-11.6%
7	32		11.4	9.7	17.7%
32	1		2.6	2.2	20.6%
1	2		0.29	0.33	-12.1%
2	34		1.0	1.7	-37.9%
34	3		3.8	2.0	88.9%

Version 5 Notes:

Includes revised free flow speeds based on posted speeds plus 5 mph
Includes corrections to speed formula and "no-pass" factor
Assumes 2% Trucks

Summary	5-6 PM
Travel Time Run	23.00
Model Estimate	24.44
% Difference	6.3%

Travel Time Run: Feb 18, 2001

Intersection No.	5:00	
time stopped 9	4:52:00	4:52:00
time through	4:53:00	0:01:00
7	4:57:00	0:04:00
	4:57:00	0:00:00
32	5:06:40	0:09:40
	5:07:00	0:00:20
1	5:09:10	0:02:10
	5:10:00	0:00:50
2	5:10:20	0:00:20
	5:11:20	0:01:00
34	5:13:00	0:01:40
	5:13:00	0:00:00
3	5:15:00	0:02:00
	5:15:00	0:00:00
4	5:18:00	0:03:00
	5:18:00	0:00:00

trip time 9 to 3 0:23:00

Corridor: Killington to Ludlow

Intersections 9 to 14

Model Period: Friday, February 18, 2001
5:00 - 6:00 PM

Model Estimate:

Segment From	Segment To	Next Turn Movement	Travel Time Row	Intersection Delay (s)	Segment Travel Time (min)†	Seg + Inter Sec TT	Running Total
	9	11		0.0		0.00	0.00
9	10	8	18	0.0	5.9	5.93	5.93
10	11	9	20	0.0	1.4	1.39	7.32
11	12	5	22	7.4	6.1	6.27	13.59
12	13	5	25	7.6	5.0	5.16	18.75
13	14	4	28	8.0	6.1	6.22	24.97
					Total Estimated Travel Time 9 -14:		24.97

Segment Comparison			Start Time 5:00			Start Time 5:30	
From	To		Model Estimate	Field Travel Time	% Diff	Field Travel Time	% Diff
9	10		5.9	5.0	19%	6.0	1.2%
10	11		1.4	6.0	-77%	2.0	43.5%
11	12		6.1	7.0	-12%	6.0	-2.4%
12	13		5.0	2.0	152%	6.0	19.2%
13	14		6.1	5.0	22%	5.0	-17.8%

Version 5 Notes:

Includes revised free flow speeds based on posted speeds plus 5 mph
Includes corrections to speed formula and "no-pass" factor
Assumes 2% Trucks

Summary	5:00 Start	5:30 Start
Travel Time Run	25.00	25.00
Model Estimate	24.97	24.97
% Difference	-0.1%	-0.1%

Travel Time Run: Feb 18, 2001

Intersection No.	Starte Time: 5:00:00		Start Time 5:30 PM	
time stopped 9	4:59:00	4:59:00	5:23:00	5:23:00
time through	4:59:00	0:00:00	5:23:00	0:00:00
10	5:04:00	0:05:00	5:29:00	0:06:00
	5:04:00	0:00:00	5:29:00	0:00:00
11	5:10:00	0:06:00	5:31:00	0:02:00
	5:10:00	0:00:00	5:31:00	0:00:00
12	5:17:00	0:07:00	5:37:00	0:06:00
	5:17:00	0:00:00	5:37:00	0:00:00
13	5:19:00	0:02:00	5:43:00	0:06:00
	5:19:00	0:00:00	5:43:00	0:00:00
14	5:24:00	0:05:00	5:48:00	0:05:00
	5:24:00	0:00:00	5:48:00	0:00:00
9 to 14 trip time	0:25:00		0:25:00	

Corridor: Killington to Woodstock

Intersections 9 to 17

Model Period: Friday, February 18, 2001

5:00 - 6:00 PM

Summary	5-6 PM
Travel Time Run	28.00
Model Estimate	28.30
% Difference	1.1%

Model Estimate:

Segment							
From	Through	Next Turn Movement	Travel Time Row	Intersection Delay (s)	Segment Travel Time (min)†	Seg + Inter Sec TT	Running Total
	9	8		0.0		0.00	0.00
9	10	8	18	0.0	5.9	5.93	5.93
10	11	8	20	0.0	1.4	1.39	7.32
11	15	8	23	0.0	6.9	6.86	14.18
15	16	8	35	0.0	13.5	13.45	27.64
16	17	8	37	0.0	0.7	0.66	28.30

Total Estimated Travel Time 9 -17 28.30

Travel Time Run: Feb 18, 2001

Intersection No.	5:00
time stopped 9	5:14:00
time through	5:14:00
11	5:21:00
	5:21:00
15	5:28:00
	5:28:00
16	5:40:00
	5:40:00
17	5:42:00
	5:42:00
18	5:47:00
	5:47:00

trip time 9-17 0:28:00

Segment Comparison			Start Time 5:00		
From	To		Model Estimate	Field Travel Time	% Diff
From	To		Model	5-6 PM	% Diff
9	11		7.3	7.0	5%
11	15		6.9	7.0	-2%
15	16		13.5	12.0	12%
16	17		0.7	2.0	-67%

Version 5 Notes:

Includes revised free flow speeds based on posted speeds plus 5 mph
Includes corrections to speed formula and "no-pass" factor
Assumes 2% Trucks

Corridor: Ludlow to Chester

Intersections 22 to 29

Model Period: Friday, February 18, 2001
5:00 - 6:00 PM

Model Estimate:

Segment From	Segment To	Next Turn Movement	Travel Time Row	Intersection Delay (s)	Segment Travel Time (min)†	Seg + Inter Sec TT	Running Total
	22	11		10.0		0.17	0.17
22	23	5	50	8.0	6.1	6.28	6.45
23	25	5	53	0.0	5.7	5.69	12.14
25	28	11	60	0.0	6.0	5.96	18.09
28	29	5	68	0.0	1.1	1.07	19.17

Total Estimated Travel Time 22 - 29: 19.17

Segment Comparison			Start Time 5:00		
From	To		Model Estimate	Field Travel Time	% Diff
22	23		6.1	4.2	46%
23	25		5.7	5.2	9%
25	28		6.0	7.1	-16%
28	29		1.1	1.3	-18%

Version 5 Notes:

Includes revised free flow speeds based on posted speeds plus 5 mph
Includes corrections to speed formula and "no-pass" factor
Assumes 2% Trucks

Summary	5:00 Start
Travel Time Run	21.43
Model Estimate	19.17
% Difference	-10.6%

Travel Time Run: Feb 18, 2001

Intersection No.	5:00
time stopped 6	5:00
time through	5:00:12
14	5:00:51
	5:00:51
21	5:02:07
	5:13:57
22	5:14:13
	5:17:51
23	5:22:03
	5:22:03
25	5:27:16
	5:27:16
28	5:34:21
	5:34:21
29	5:35:39
	5:35:39
end	5:45:51
	5:45:51

22 - 29 Trip Time 0:21:26

ATTACHMENT B

Spreadsheet Model Worksheet Documentation

Worksheet Name(s)	Type	Specific Purpose	Links to Other Worksheets	Other Notes
TM-1.2.3, TM-4.5.6, TM-7.8.9, TM-10.11.12, TM-13.14.15, TM-16.17.18, TM-19.20.21, TM-22.23.24, TM-25.26.27,TM-28.29.30.31, TM-32.33.34	Data Entry	Enter intersection turning movement counts for the study intersections.	None	• The worksheet numbers refer to the intersection numbers. See Figure 1 for location of intersections.
D1-6,D7-12, D13-18, D19-24, D25-30, D31-34	Data Entry	Enter delay in terms of seconds for each turning movement at an intersection.	None	• Refer to Figure 4 for intersection turn movement numbering convention used throughout spreadsheet. • Delays are calculated outside of the spreadsheet using standard traffic engineering capacity methods. . Delays are calculated outside of the spreadsheet using standard traffic engineering highway capacity methods. • Highway Capacity Software is used for stop-controlled intersections. During model testing and calibration, delay at signalized intersections was calculated using the Synchro 5, Traffic Signal Coordination Software. Other software packages may also be used to estimate delay at the intersections including the Highway Capacity Software and SIGNAL2000.
DelaySum	Calculations – Do not modify	Organizes the delays entered for all intersections by movement in one table for reference in further calculations.	D1-6,D7-12, D13-18, D19-24, D25-30, D31-34	
RoadVolumes	Calculations – Do not modify	Estimates traffic volumes for each road segment by averaging the related traffic volumes on up-stream and down-stream intersections.	TM-1.2.3, TM-4.5.6, TM-7.8.9, TM-10.11.12, TM-13.14.15, TM-16.17.18, TM-19.20.21, TM-22.23.24, TM-25.26.27,TM-28.29.30.31, TM-32.33.34	

Worksheet Name(s)	Type	Specific Purpose	Links to Other Worksheets	Other Notes
CALC1	Calculations & Data Entry	Calculates road segment capacity, peak hour speed, and travel time. Also contains information on road segment characteristics such as number of lanes, shoulder widths, percent no-passing zones, percent trucks and free flow speeds.	RoadVolumes	• Travel times calculated using NCHRP formulas presented in the Phase 1report and also documented on this worksheet. • Changes in the physical characteristics of road segments (number of lanes, shoulder widths, percent no passing), can be made in this worksheet when the model is used to test mitigation measures.
Segment_TT_Summary	Calculations – Do not modify	Summarized outputs from CALC1 without all of the various factors used in the formulas	CALC1	
Export to PPT	Calculations – Do not modify	Summarizes road segment traffic volume, volume to capacity ratio, peak hour speed and travel time in a format that can be exported to PowerPoint and linked with the Ski Corridors Study area map as shown in Figure 1.	RoadVolumes CALC1	
CALC2	Calculations – Do not modify	Reorganizes road segment volumes and travel time results for reference in total travel time calculations.	RoadVolumes Segment_TT_Summary	
CALC3	Calculations – Do not modify	Provides a row reference in worksheet CALC2 by which to look up the travel time for a specific road segment.	None	
Total_Travel_Time	Data Entry	Produces the final output fro the model. Calculates total travel time (road segment plus intersection delay) within a specified corridor.	CALC3 DelaySum CALC2	A user must specify the beginning intersection, the turn movement number using the convention shown in Figure 1, and the beginning and ending intersection number for each road segment along the corridor being analyzed. The spreadsheet will automatically extract the relative intersection delays and road segment travel times from the appropriate worksheets and will sum the travel time for the entire corridor.