



HCS™

Freeways Reliability Module

USER GUIDE

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Introduction

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Getting Started

Getting Started

Software Requirements

1. Windows 7 or higher
2. HCS Freeways
3. Microsoft .NET 4.5 or higher

Note: Although HCS Freeways Reliability may work on Windows Vista and Windows XP, detailed testing was not performed on these platforms.

Freeway Facility Reliability Analysis

Freeway Facility Reliability analyses evaluate the travel time reliability experiences by motorists on an urban or rural freeway facility. Travel time reliability reflects the distribution of trip travel time over an extended period of time. The distribution arises from the occurrence of a number of factors that influence travel time (e.g., weather events, incidents, work zone presence, etc.). The distribution describes *how often* these factors occur and *how bad* operations are as a result. The methodology of the application uses the HCM Chapters 11 and 25 procedures.

General Controls

Menu Items

New – Creates a new Freeways Reliability file (*.xfr) and starts a new analysis project; shortcut is Ctrl+N

Open – Opens an existing Freeways Reliability file (*.xfr); shortcut is Ctrl+O

Example Folder – Opens folder with all HCS examples in File Explorer

Save – Saves an open Freeways Reliability file (*.xfr) using the current file name; shortcut is Ctrl+S

Save As... – Saves an open Freeways Reliability file (*.xfr) using a specified file name; shortcut is F12

Close – Closes an existing Freeways Reliability file (*.xfr); shortcut is Ctrl+W

Units

USC Units – Changes the units of the current file to U.S. Customary

Metric Units – Changes the units of the current file to Metric

Print – Brings up printer selection and prints a Freeways Reliability report to the printer or specified file type; shortcut is Ctrl+P

Print Preview – Displays preview of current report before printing; shortcut is Ctrl+F2

Report

Formatted Report – Displays formatted report including the most important values; shortcut is F4

Text Report – Displays text report with input, intermediary, and final results; shortcut is F6

Default Settings – Opens a dialog box for the user to input defaults for Analyst, Agency, and Jurisdiction, which will be applied to all new files; also allows selection of USC or SI units, which will be applied to all new files; shortcut is Alt+F

Planning – Opens the Reliability Planning Calculator for the user to input all the necessary information to calculate results using the planning procedure

Help

Contents – Provides access to glossary, acknowledgements, copyrights, and information on the HCM procedures; shortcut is Ctrl+F1

Index – Allows user to search keywords within the glossary

Search – Allows user to search for any word within the glossary

User Guide – Opens a comprehensive user guide in PDF format; shortcut is Ctrl+G

HCM6 Reference Guide – Opens the McTrans website in the default web browser to access the Highway Capacity Manual Reference Guide PDF

HCS Updates – Sends the HCS version number anonymously without any personally identifiable information to McTrans to check for a newer version

HCM/HCS Training – Opens the McTrans Training Page in the default web browser to view the latest training opportunities

HCQS Web Page – Opens the TRB Highway Capacity and Quality of Service Committee page in the default web browser

Support

Frequently Asked Questions – Opens the McTrans support page for HCS in the default web browser

HCS on the Web – Opens the McTrans HCS Overview page in the default web browser

McTrans on the Web – Opens the McTrans home page in the default web browser

E-mail McTrans – Composes a new e-mail addressed to McTrans in the default e-mail client with registration number, serial key, module, and version number already populated in the Subject field

About HCS – Opens an about window with software version information, EULA, general acknowledgements, contact information, and other relevant links

Exit – Exits the *HCS* Freeways Reliability module; shortcut is Alt+F4

Freeway Reliability

HCM Chapter 11

The Highway Capacity Software (*HCS*) faithfully implements the methodology prescribed in the Highway Capacity Manual (HCM) for analyzing a freeway's travel time reliability over a multiday or multimonth *reliability reporting period* (RRP). The methodology estimates the impacts of recurring and non-recurring congestions (i.e., demand variations and fluctuations, incidents, weather, work zones, and special events) on the travel time distribution over the course of the RRP. As an extension, the methodology can be used to estimate the impacts of Active Traffic and Demand Management (ATDM) strategies on the travel time distribution.

This chapter's methodology relies on the freeway facilities core methodology presented in Chapter 10, which in turn applies the freeway segment methodologies in Chapters 12, 13, and 14. The freeway facilities core methodology focuses the analysis on a single day or less, while the segment methodologies are limited to the analysis of one 15-min period. In contrast, this chapter's methodology is capable of repeatedly applying the core method across multiple days, weeks, months, up to a one-year RRP. A one-year RRP is the most common application, although shorter periods are possible for specific applications (e.g., reliability of summer tourist traffic, a focus on the construction season). RRP's longer than one year are uncommon, as most typical variations in travel time (day-of-week, month-of-year, weather, and incidents) are encapsulated in a single year.

STRENGTHS OF THE METHODOLOGY

The methodology is capable of estimating the impacts of non-recurring congestion (due to demand variability, weather, incidents, work zones, and special events) on the operational performance of a freeway facility over an extended reliability reporting period—up to one year. Due to the computational efficiency of the HCM freeway facility core methodology, compared to an analysis of a freeway facility in simulation, for example, a whole-year analysis can be performed relatively quickly. Specific strengths of the methodology are:

- An efficient method to estimate travel time reliability, which can be applied quickly several hundred times to derive a travel time distribution over a reliability reporting period up to one year.
- A core methodology that is less computationally intensive than microsimulation.
- A core methodology that can be directly calibrated on the basis of local or regional capacity defaults to replicate recurring bottlenecks.
- The consideration of local and regional weather defaults for the 101 largest U.S. metropolitan areas based on a ten-year average.
- A method to estimate incident and crash rates in the absence of detailed local incident logs.
- The ability to extend the method for evaluating ATDM strategies.

In addition, the strength of the core methodology described in HCM Chapter 10 also apply to the reliability and strategy assessment methods presented here.

LIMITATIONS OF THE METHODOLOGY

Because the reliability method applies the freeway facility core methodology multiple times, it inherits the core methodology's limitations. These limitations were described in HCM Chapter 10. For example, one limitation of the core method is its use of 15-min analysis periods. Therefore, all event durations (e.g., weather, incidents) used by the reliability method must be expressed as integer numbers of 15-min analysis periods. The reliability method has the following additional limitations:

- The method assumes a multiplicative effect when two or more factors (weather and incident) affect speed or capacity. This assumption has not been sufficiently tested empirically, and may overstate the deleterious effects of combined non-recurring congestion effects.
- Weather events that have a small effect (<4%) on segment capacity reduction are not addressed. A given weather event (e.g., rain, snow) is always assumed to occur at its mean duration value. Sun glare is not accounted for.
- The method assumes that incident occurrence and traffic demand are independent of weather conditions, although all are indirectly tied to each other through the specification of demand, incident, and weather probabilities on a calendar basis. However, the analyst is able to adjust incident frequencies by month on the basis of local data.
- The method estimates incident occurrence as a function of segment demand and month of the year. It does not consider potentially elevated incident rates in segments with low demands. Some segments may be overly prone to incidents due to poor visibility, poor geometry, a short weaving segment, or a host of other factors that are not considered by the reliability method.
- The method does not consider full facility closures in the scenarios. In the course of assigning incidents to the segments, at least one lane should therefore remain open. The scenario generation methodology does not assign incidents that result in full-segment closure, but reassigns those probabilities to other (less severe) incidents. This is also true for work zones, where at least one travel lane has to remain open.
- The travel time reliability analysis assumes similar effects of demand variation and weather conditions on general purpose and managed lanes, when a managed lane facility is included in the analysis.
- Work-zone events are only allowed to be modeled in general purpose lanes; no managed-lane work zone effects are considered.
- The traffic-demand adjustment assumes a proportional demand effect across the entire facility, meaning that all inputs and outputs (across time and space in the base scenario) are increased or decreased by the same factors.

CALIBRATION AT THE TRAVEL TIME RELIABILITY LEVEL

After calibrating the core freeway facility methodology and fixing the value of its parameters, a comprehensive travel time reliability calibration is performed. The process includes three major steps: whole-year demand calibration, incident calibration, and weather calibration.

To calibrate the methodology for a particular site, it is recommended that the analyst perform an initial comprehensive reliability run using default values for all input parameters and subsequently compare the predicted travel time index (TTI) cumulative distribution to the observed distribution.

The comprehensive reliability calibration steps include:

- Step 1: Gather input data (demand, weather, incident, distribution, and work zone data)
- Step 2: Determine demand multipliers
- Step 3: Calibrate incident probabilities
- Step 4: Calibrate weather probabilities
- Step 5: Validate parameters

Operational Data

BASE

On the Base page, the user is required to load a base dataset to run a Freeways Reliability analysis. There are two options when using a base dataset: *Load Base Dataset* and *Create Base Dataset*. The program requires the HCS Freeways module for both these options. The *Load Base Dataset* button opens a dialog that allows users to open an existing HCS Freeways (*.xuf) file. The *Create Base Dataset* button launches the Freeways module where a user can create a new HCS Freeways (*.xuf) file. If HCS is already installed on the computer, then the Freeways module should open when this button is clicked. If HCS is not installed, an error will popup and HCS will need to be installed on the computer to continue with the Freeway Reliability analysis.

The Base page shows a summary of the data from the Freeways file. When a Freeways file is loaded, the required information from the dataset is extracted for reliability analysis. Two sections appear when the Freeways file is loaded: *Base Dataset Facility* and *Base Dataset General Information*. The number of segments in the facility, along with the segment type, segment length, and number of lanes on each segment are displayed graphically in the first section. The second section lists out the Analyst Name, Agency, Jurisdiction, Year, Date, File Name, and Project Description taken directly from the Freeways file.

ANALYSIS

On the Analysis page, there are fields for the user to specify project properties. These include: Analyst, Agency, Analysis Year, Jurisdiction, Time Analyzed, Date, and Project Description. The Analysis page is further used to specify the duration of the reliability reporting period. There are three main sections in the analysis page: *Reporting Period*, *Study Period*, and *Number of Replications*.

The reliability reporting period represents the specific days over which the travel time distribution it to be computed, for example, all nonholiday weekdays in a year. The period is specified by start and end dates as well as by the days of week being considered. The start and end dates can be selected by clicking the calendar in the respective textbox and selecting the date on the calendar or by typing the date in the format MM/DD/YYYY. The days of week to be considered in a reliability analysis can be selected by clicking the checkboxes provided for each day of the week.

If these values are not changed by the user, the following defaults will be used:

- Start Date: Today's date
- End Date: Today's date, a year later
- Days of Week: Mon, Tue, Wed, Thu, Fri (all weekdays)

The number of days should be reflected under each month based on the information input for reporting period. The reliability reporting period is used with the study period to describe the temporal representation of the performance measure fully (e.g., average travel time on nonholiday weekdays from 4:00 to 6:00 p.m. for the current year).

The *Study Period* is based on information pulled from the Freeways Base Dataset. Listed in the *Study Period* box is the *Start Time*, *End Time*, and *Duration (min)*.

The user can specify the number of times the methodology is applied changing the *Number of Replications*. For a one-year reliability reporting period, the methodology is typically applied with four replications for each of five weekdays (Monday through Friday) and 12 months in the year, for a total of 240 scenarios. This approach roughly corresponds to 250 work days in a typical calendar year. A reliability analysis that includes weekend effects would result in an increased number of scenarios. For reliability reporting periods that are significantly shorter than one year, the analyst should increase the number of replications to ensure a sufficient sample size for scenario generation. The HCM exhibit found below provides guidance on the recommended number of replications in such cases.

RRP Duration (months)	Number of Days Considered	Recommended Number of Replications	Resulting Number of Scenarios
1	5 (all weekdays)	48	240
2		24	240
4		12	240
6		8	240
9		6	270
12*	5	4*	240*
12	2 (weekend only)	10	240
12	7 (all days)**	3	252

Notes: RRP = reliability reporting period.

*Default value.

**Not desirable; separating weekday and weekend reliability analysis is preferred.

WEATHER

On the Weather page, a drop-down list is located at the top of the screen where a city with available weather data can be chosen. A city can also be typed into the search bar, which will then match and select the city from the drop down list.

Once a city is selected, the first table displayed will show the defaults of Weather Event Probability and Weather Event Duration. The probability of a weather event happening is displayed for each month based on the location and the study period start time and end time. The default probabilities are based on the Metropolitan Weather Database for Freeway Reliability Analysis in Volume 4 of the HCM. The duration associated with each weather event is the length of time of the weather event in minutes. The default duration for each weather event is the same for each location. If any of the probability defaults or duration is changed, the weather location originally selected will change to 'Custom'. To restore the default values, the user can set the location again.

Based on weather conditions and free-flow speeds, the second table displayed shows the Demand Adjustment Factors, Capacity Adjustment Factors, or Speed Adjustment Factors by switching between the DAF, CAF, and SAF tabs. Demand Adjustment Factor default values are 1.000 for all. Capacity Adjustment Factor and Speed Adjustment Factor default values can be found in the tables below.

Default CAFs by Weather Condition:

Weather Type	Weather Event Definition	Capacity Adjustment Factors				
		55 mi/h	60 mi/h	65 mi/h	70 mi/h	75 mi/h
Medium rain	> 0.10-0.25 in/h	0.94	0.93	0.92	0.91	0.90
Heavy rain	> 0.25 in/h	0.89	0.88	0.86	0.84	0.82
Light snow	>0.00 – 0.05 in/h	0.97	0.96	0.96	0.95	0.95
Light-medium snow	>0.05 – 0.10 in/h	0.95	0.94	0.92	0.90	0.88
Medium-heavy snow	>0.10 – 0.50 in/h	0.93	0.91	0.90	0.88	0.87
Heavy snow	>0.50 in/h	0.80	0.78	0.76	0.74	0.72
Severe cold	< -4°F	0.93	0.92	0.92	0.91	0.90
Low visibility	0.50 – 0.99 mi	0.90	0.90	0.90	0.90	0.90
Very low visibility	0.25 – 0.49 mi	0.88	0.88	0.88	0.88	0.88
Minimal visibility	< 0.25 mi	0.90	0.90	0.90	0.90	0.90
Non-severe weather	All conditions not listed above	1.00	1.00	1.00	1.00	1.00

Source: Zegeer et al. (1).

Note: Speeds given in column heads are free-flow speeds.

Default SAFs by Weather Condition:

Weather Type	Weather Event Definition	Speed Adjustment Factors				
		55 mi/h	60 mi/h	65 mi/h	70 mi/h	75 mi/h
Medium rain	> 0.10-0.25 in/h	0.96	0.95	0.94	0.93	0.93
Heavy rain	> 0.25 in/h	0.94	0.93	0.93	0.92	0.91
Light snow	>0.00 – 0.05 in/h	0.94	0.92	0.89	0.87	0.84
Light-medium snow	>0.05 – 0.10 in/h	0.92	0.90	0.88	0.86	0.83
Medium-heavy snow	>0.10 – 0.50 in/h	0.90	0.88	0.86	0.84	0.82
Heavy snow	>0.50 in/h	0.88	0.86	0.85	0.83	0.81
Severe cold	< -4°F	0.95	0.95	0.94	0.93	0.92
Low visibility	0.50 – 0.99 mi	0.96	0.95	0.94	0.94	0.93
Very low visibility	0.25 – 0.49 mi	0.95	0.94	0.93	0.92	0.91
Minimal visibility	< 0.25 mi	0.95	0.94	0.93	0.92	0.91
Non-severe weather	All conditions not listed above	1.00	1.00	1.00	1.00	1.00

Source: Zegeer et al. (1).

Note: Speeds given in column heads are free-flow speeds.

DEMAND

The Demand page is used to display user inputs related to demand to specify demand ratios.

One of the required inputs is the *Freeway Area Type*. There are two freeway area types considered: *Urban Freeway* and *Rural Freeway*. The default in the program is *Urban Freeway*. Once selected, the defaults for *Default Freeway Demand Ratios* and *Demand Ratios Relative To Base Dataset* are displayed. Similar to the table on the Weather page, the fields in the *Default Freeway Demand Ratios* table can be edited if necessary. The ratios were derived from a national freeway dataset developed by SHRP 2 Project L03. All ratios reflect demand relative to a Monday in January. Where possible, analysts should obtain local or regional estimates of demand variability to account for facility-specific and seasonal trends on the subject facility.

Default Urban Freeway Demand Ratios (ADT/Mondays in January):

Month	Day of Week						
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
January	1.00	1.00	1.02	1.05	1.17	1.01	0.89
February	1.03	1.03	1.05	1.08	1.21	1.04	0.92
March	1.12	1.12	1.14	1.18	1.31	1.13	0.99
April	1.19	1.19	1.21	1.25	1.39	1.20	1.05
May	1.18	1.18	1.21	1.24	1.39	1.20	1.05
June	1.24	1.24	1.27	1.31	1.46	1.26	1.10
July	1.38	1.38	1.41	1.45	1.62	1.39	1.22
August	1.26	1.26	1.28	1.32	1.47	1.27	1.12
September	1.29	1.29	1.32	1.36	1.52	1.31	1.15
October	1.21	1.21	1.24	1.27	1.42	1.22	1.07
November	1.21	1.21	1.24	1.27	1.42	1.22	1.07
December	1.19	1.19	1.21	1.25	1.40	1.20	1.06

Source: Derived from data presented by Cambridge Systematics et al. (2).

Note: Ratios represent demand relative to a Monday in January.

Default Rural Freeway Demand Ratios (ADT/Mondays in January):

Directional Lanes	No Incident	Shoulder Closed	1 Lane Closed	2 Lanes Closed	3 Lanes Closed	4 Lanes Closed
2	1.00	0.81	0.70	N/A	N/A	N/A
3	1.00	0.83	0.74	0.51	N/A	N/A
4	1.00	0.85	0.77	0.50	0.50	N/A
5	1.00	0.87	0.81	0.67	0.50	0.50
6	1.00	0.89	0.85	<u>0.75</u>	0.52	0.52
7	1.00	0.91	0.88	0.80	0.63	0.63
8	1.00	0.93	0.89	0.84	0.66	0.66

Source: Zegeer et al. (1).

Notes: N/A = not applicable — the number of lanes closed equals or exceeds the number of directional lanes. The methodology does not permit all directional lanes of a facility to be closed.

The *Demand Ratios Relative To Base Dataset* table displays the demand ratios relative to the base dataset. The values in the *Default Freeway Demand Ratios* table can be edited, if necessary, and the corresponding values in the *Demand Ratios Relative To Base Dataset* table will change based on the edited values.

INCIDENT

The Incident page is used to display user inputs related to incident and crash frequency data, distribution and duration, and adjustment factors based on incident type.

Incidents are generated on the basis of their expected frequency of occurrence per study period (analysis hours in a day) in a given month on the facility. The analyst may opt to use default expected incident frequencies, may supply a facility-specific incident or crash rate, or may supply a 12-month table of facility-specific expected frequencies of any incident type.

The first table displayed on the Incident page is the incident distribution and duration. It provides mean distributions of freeway incidents by severity and default incident duration parameters by incident type.

Parameter	Incident Severity Type				
	Shoulder Closed	1 Lane Closed	2 Lanes Closed	3 Lanes Closed	4+ Lanes Closed
Distribution %	75.4%	19.6%	3.1%	1.9%	0%
Duration (Mean)	34	34.6	53.6	67.9	67.9
Duration (Std Dev)	15.1	13.8	13.9	21.9	21.9
Duration (Min)	8.7	16	30.5	36	36
Duration (Max)	58	58.2	66.9	93.3	93.3

Source: Zegeer et al. (1).

The second table displayed on the incident page can display either values for Demand Adjustment Factor (DAF), Capacity Adjustment Factor (CAF), or Speed Adjustment Factor (SAF) by clicking on the corresponding tabs. The defaults for DAF and SAF are 1.000 for all incident severities. The table below shows the default CAFs associated with each incident severity. The values shown in the table reflect the *remaining relative capacity per open lane*. For example, a two-lane closure incident on a six-lane directional facility (underscored) results in a loss of two full-lane capacities, in addition to maintaining only 75% of the remaining four open lanes' capacities. The result is that only three lanes worth (50%) of the facility's original six lane capacity is maintained. No information is currently available on the effect of incidents on free-flow speed, so this effect is not accounted for at this time.

Directional Lanes	No Incident	Shoulder Closed	1 Lane Closed	2 Lanes Closed	3 Lanes Closed	4 Lanes Closed
2	1.00	0.81	0.70	N/A	N/A	N/A
3	1.00	0.83	0.74	0.51	N/A	N/A
4	1.00	0.85	0.77	0.50	0.52	N/A
5	1.00	0.87	0.81	0.67	0.50	0.50
6	1.00	0.89	0.85	<u>0.75</u>	0.52	0.52
7	1.00	0.91	0.88	0.80	0.63	0.63
8	1.00	0.93	0.89	0.84	0.66	0.66

Source: Zegeer et al. (1).

Notes: N/A: not applicable, the number of lanes closed equals or exceeds the number of directional lanes.

The methodology does not permit all directional lanes of a facility to be closed.

Incident Frequency Data is also provided, with three choices: Local Incident Frequency, Local Crash Frequency, and Calculated Crash Frequency. Choosing Local Incident Frequency will enable a table with fields for Incident Frequency (per 100 million VMT) that by month. Defaults are provided but can be edited if the user is aware of recurring incident occurrences. If, for example, incidents are more likely in winter months (despite potentially lower demands), the user should adjust the incident rate defaults and calibrate for local conditions. Choosing Local Crash Frequency will enable a table with defaults for Crash Frequency (per 100 million VMT) that vary by month. Similar to Local Incident Frequency, the values are editable for the user to calibrate for local conditions. In addition to this table, a field is provided for the user to specify the Incident-to-Crash Ratio (ICR). Choosing Calculated Crash Frequency will cause the Highway Economic Requirements System (HERS) model to be used to calculate crash rate. Fields for ICR, ACR, and Lane Width will also be provided for the user to specify.

WORK ZONE

The Work Zone page is used to add scheduled work zones to the analysis. The user can add work zone events by clicking the 'Add Work Zone Event' button. If there are already work zone events present in a dataset, the user can add more by using either the 'Add Work Zone Event' button or the 'Insert Work Zone Event' button. When the 'Add Work Zone Event' button is used, a new work zone event will be added to the end of the list of work zone events. When the 'Insert Work Zone Event' button is used, a new work zone will be added before the work zone event that is currently selected in the list of work zone events. To delete work zone events, the user can select one or more work zone events and then click the 'Delete Work Zone Event' button.

When a work zone event is added, the following inputs are provided for the user to change: Segment ID, Start Date, End Date, Start Analysis Period, Duration Analysis Period, Lane Closure Type, Barrier Type, Area Type, Lateral Distance, Daylight or Night, Speed Limit, and Percent Drop in Capacity. Segment ID allows the user to specify which segment in the analysis is affected by a work zone. Start Date and End Date provides the date boundaries for when the work zone event takes place. Start Analysis Period provides a drop down menu for the user to select between the analysis periods set from the base dataset. Duration Analysis Period specifies how many analysis periods the work zone event lasts. Based on the geometry of the facility being analyzed, Lane Closure Type can have up to five options: Shoulder Closed, 1 Lane Closed, 2 Lanes Closed, 3 Lanes Closed, and 4 Lanes Closed. Barrier Type has two options: Hard Barrier Separation and Soft Barrier Separation. Area Type also has two options: urban areas and rural areas. Urban areas are typified by high development densities or concentrations of population. Rural areas are areas with widely scattered development and low housing and employment densities. Lateral distance is specified in feet and is the distance from the edge of the travel lane adjacent to the work zone to the barrier, barricades, or cones. Daylight or Night is used to determine whether daytime or nighttime operations are considered. Speed Limit is used to specify the speed limit, in miles per hour, of the work zone. Higher work zone speed limits and higher speed ratios result in higher work zone FFS. Percent Drop in Capacity refers to the percentage drop in pre-breakdown capacity at the work zone due to queuing conditions. Research shows an average queue discharge drop of 7% in non-work zone conditions, and an average value of 13.4% in freeway work zones.

SPECIAL EVENT

The Special Event page is used to add special events, such as football games or concerts, to the analysis. The user can add special events by clicking the 'Add Special Event' button. When the 'Add Special Event' button is used, a new special event will be added to the end of the list of special events. A textbox for 'Scenario ID for Special Event' is provided for the user to enter the appropriate scenario for the special event to be added. To delete special events, the user can select one or more special events and then click the 'Delete Special Event' button.

When a special event is added, a row of the following inputs/information are included: Scenario ID, Analysis Period, Demand Ratio, Weather Event Count, Incident Event Count, Work Zone Event Count, Import from XUF File, and Overwritten by Imported File.

EVENTS

The Events page lays out the events found in each of the scenarios generated from the reliability analysis. There are three tabs to choose what is displayed on the page. These include: Summary, Incident, and Work Zone. The Summary tab displays the Scenario ID, Analysis Period, Demand Ratio, Weather Event Count, Incident Event Count, and Work Zone Event Count. The Incident tab displays the Event ID, Incident Event Type, Scenario ID, Segment ID, Start Analysis Period, and Duration (Analysis Periods). The Work Zone tab displays the Segment ID, Start Date, End Date, Lane Closure Type, and Assigned Scenarios. All three tabs allows the user to specify how many items are shown per page by providing a drop-down menu in the upper left-hand corner. The user can specify 10, 20, 50, or 100 items per page to be shown. Navigation buttons are provided below the tables to allow the user to easily jump between the first, previous, next, or last page of items. All three tabs also provide an 'Export to CSV' button in the upper right-hand corner. This will export the entire table of the corresponding tab to a CSV file.

SUMMARY

The Summary page provides a summary of each of the scenarios generated by the reliability analysis. The Scenario ID, Demand-Combination, Travel Time in minutes, Average Speed in miles per hour, and Average Density in vehicle per mile per lane are provided for each scenario. Similar to the Events page, a drop-down menu is provided in the upper left hand corner to allow the user to specify how many items to be displayed per page. Again, the choices for number of scenarios per page are 10, 20, 50, and 100. Navigation buttons are provided below the table to allow the user to easily jump between the first, previous, next, or last page of scenarios. There are also three export buttons provided above the table. These include: Export Summary Results to CSV, Export to XUF, and Export Facility to CSV. Clicking the 'Export Summary Results to CSV' button will allow the user to save the summary results displayed in the table to be saved in CSV format. 'Export to XUF' will allow the user to save all the scenarios generated in the Freeways XUF format. Clicking this button will open a dialog box allowing the user to browse folders or create a folder which will save a folder with all the scenarios generated. The folder holding all the scenarios will be titled the same as the Freeways Reliability XFR file and all the scenarios will be titled Scenario#, with # being the corresponding scenario number. 'Export Facility to CSV' will export the inputs of each scenario into corresponding CSV files.

Freeways Reliability Report

The Report page displays the results of the analysis in the form of tables and graphs. There are two reports available to the user: the formatted report and the text report. The formatted report is initially displayed, but the user can switch to the text report by clicking the *Switch to Text Report* button located at the bottom of the screen. Similarly, if the user has the text report displayed, the *Switch to Formatted Report* button located at the bottom of the screen can be used to display the formatted report instead.

The report page shows a formatted version of the analysis in a dynamic form, reacting to changes in the Base, Analysis, Weather, Demand, Incident, and Work Zone pages. All or a portion can be copied to the Windows clipboard for insertion into other files by right-clicking into the report and selecting Copy.

The formatted report provides an overview of the results in the table. There are five sections in the table: Project Information, Base Dataset Analysis, Reliability Input Summary, Average Performance Measure Results, and graphs for TTI (TTI Probability Density Distribution and TTI Cumulative Distribution). Project Information provides information on the Analyst, Agency Jurisdiction, Date, Analysis Year, Time Analyzed, and Project Description. Base Dataset Analysis provides general information that can be found in the base dataset. These include: the base dataset file name, the data collection date, the start and end times of the study period, the number of analysis periods, and the number of segments. Reliability Input Summary provides general information on the reliability analysis and the random seed summary. These include: Reporting Start Date, Reporting End Date, Reliability Reporting Period Duration in months, Number of Days Considered, Number of Replications, Number of Scenarios, what is included in the Reliability analysis (Weather Events, Incident Events, Demand Ratios, and Work Zone Events) and the random seed numbers for Weather and Incident. Average Performance Measure Results include: Average Speed in miles per hour, Average Density in passenger cars per mile per lane, Average Travel Time in minutes, 50th Percentile Travel Time Index (TTI₅₀), Mean Travel Time Index (TTI_{mean}), maximum observed facility TTI (TTI_{max}), Misery Index, Reliability Rating as a percentage, semi-standard deviation, and Percent VMT at TTI >2. The four graphs at the bottom of the report show the TTI Probability Distribution Function, TTI Cumulative Distribution Function, Density Distribution, and Speed Distribution.

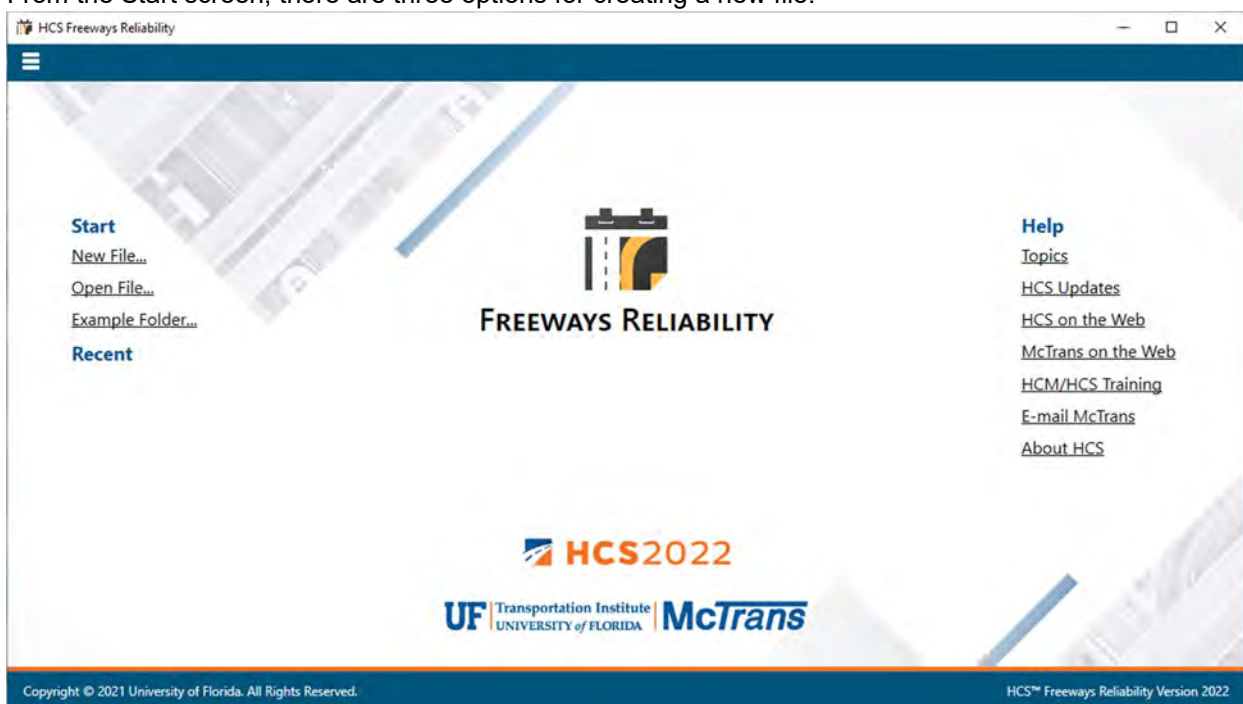
The text report also provides the general project information and base dataset information but provides more Average Performance Results. These include: Average Speed in miles per hour, Average Density in both vehicles per mile per lane and passenger cars per mile per lane, Average Travel Time in minutes, Mean Travel Time Index (TTI_{mean}), 50th Percentile Travel Time Index (TTI₅₀), 80th Percentile Travel Time Index (TTI₈₀), Planning Time Index (PTI) or 95th Percentile Travel Time Index (TTI₉₅), Maximum Observed Facility TTI (TTI_{max}), Misery Index, Semi-Standard Deviation, Reliability Rating as a percentage, and Percent VMT at TTI >2.

Both formatted and text reports are available for viewing and printing.

How To

Create a New File

1. From the Start screen, there are three options for creating a new file:



Note: A new file can be created if an existing file is already open; you do not need to start from the Start screen.

- a. Selecting *File > New* from the main menu; this can be found by selecting the three lines in the top left-hand corner of the screen and then selecting “New”

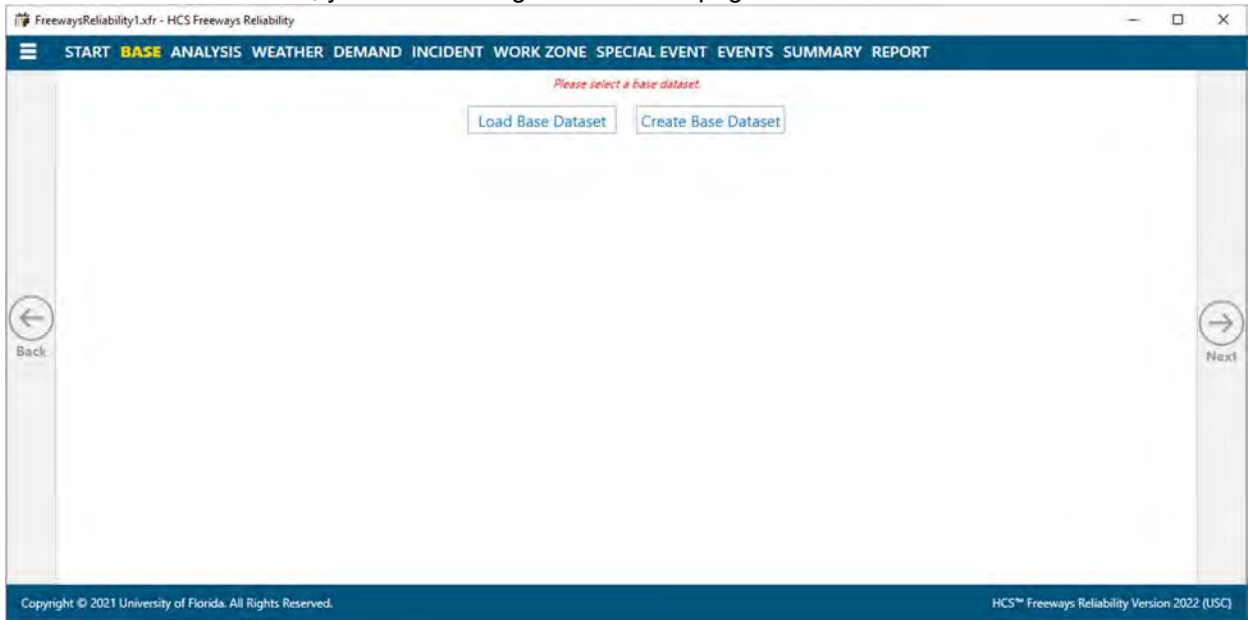


- b. Selecting “New File...” from the Start screen; this can be found below in the red box



- c. Using keyboard shortcut “Ctrl+N”

2. Once a new file is created, you will be brought to the Base page



Open an Existing File

1. From the Start screen, there are six options for opening an existing file:



Note: A file can be opened even if another file is currently open; you do not need to start from the Start screen.

- a. Selecting *File > Open* from the main menu; this can be found by selecting the three lines in the top left-hand corner of the screen and then selecting “Open”



- b. Selecting “Open File...” from the Start screen; this can be found below in the red box



- c. Using the keyboard shortcut “Ctrl+O”
- d. Selecting a file under the Recent files list from the Start screen; this can be found below in the red box



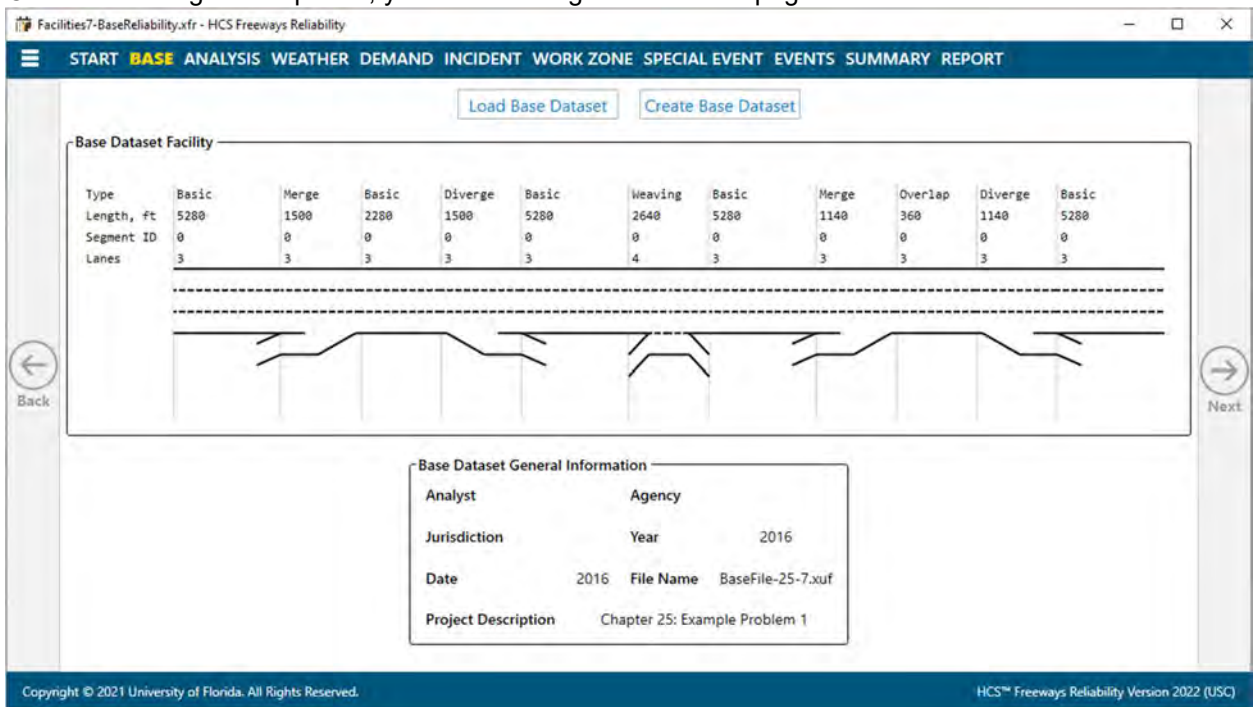
- e. Selecting *File > Example Folder* from the main menu; this can be found by selecting the three lines in the top left-hand corner of the screen and then selecting “Example Folder”. Opening the example folder will open the path of the HCS example files in File Explorer. The desired example file can be double-clicked or right-clicked and selecting ‘Open’, which will open the example file in the Freeways Reliability program.



- f. Selecting “Example Folder...” from the Start screen; this can be found below in the red box. Opening the example folder will open the path of the HCS example files in File Explorer. The desired example file can be double-clicked or right-clicked and selecting ‘Open’, which will open the example file in the Freeways Reliability program.



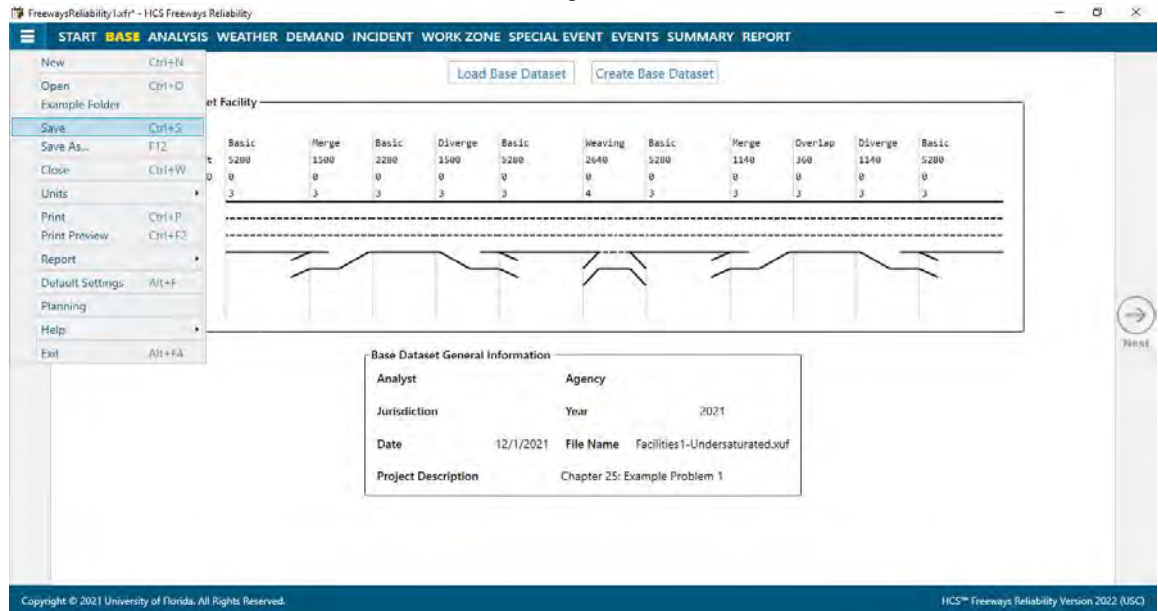
2. Once an existing file is opened, you will be brought to the Base page



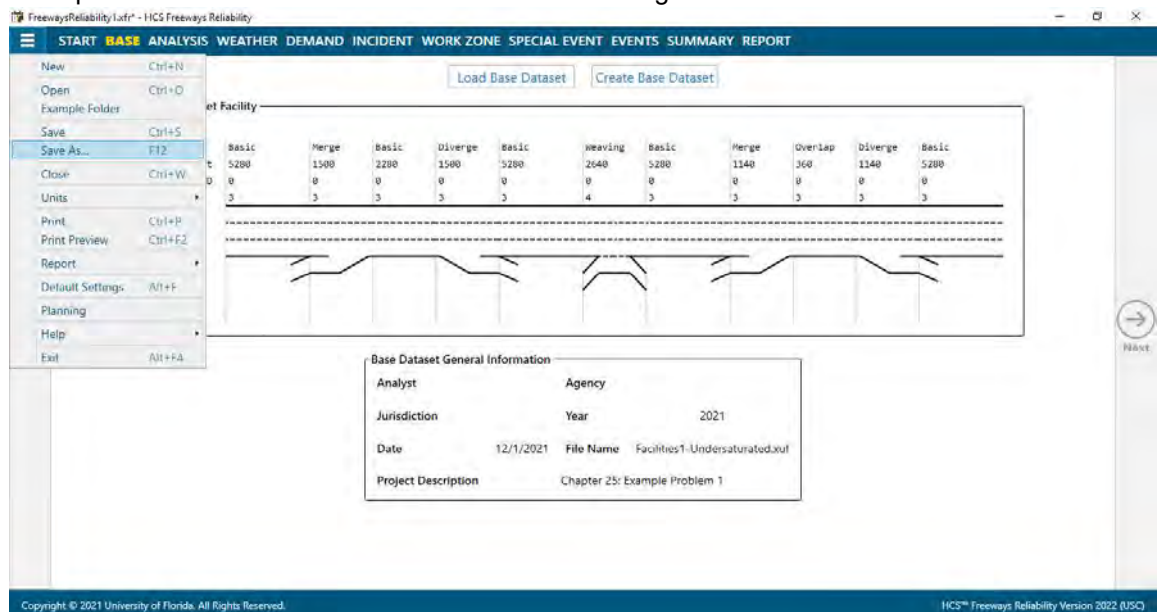
Save a File

1. There are five options for saving an open file:

- a. Selecting **File > Save** from the main menu; this can be found by selecting the three lines in the top left-hand corner of the screen and then selecting “Save”

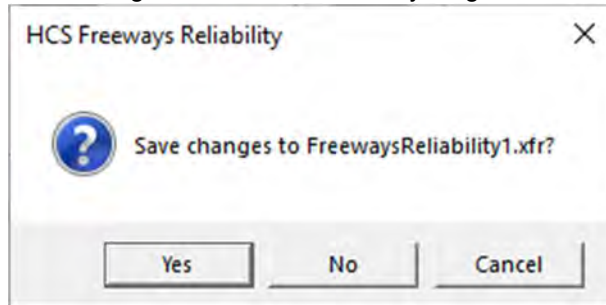


- b. Selecting **File > Save As...** from the main menu; this can be found by selecting the three lines in the top left-hand corner of the screen and then selecting “Save As...”



- c. Using the keyboard shortcut “Ctrl+S” for Save
- d. Using the keyboard shortcut “F12” for Save As

- e. Exiting the program or closing the file without saving changes beforehand; this will prompt you to save changes to the file before anything is closed

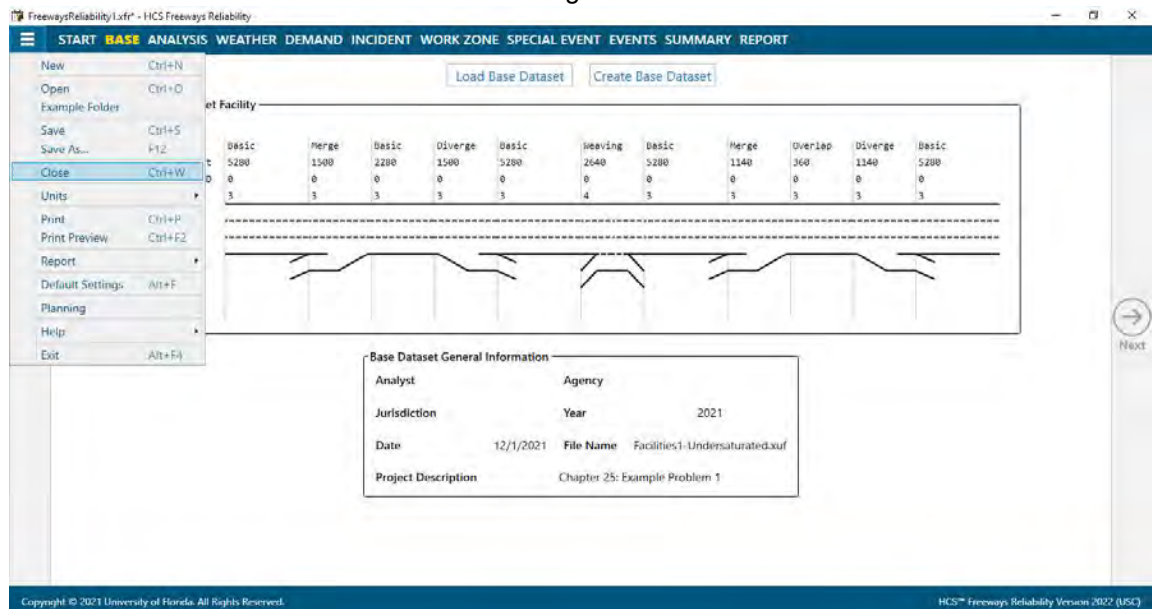


- i. Selecting “Yes” will save the file if it is an existing file. If the file has not been previously saved, the Save As dialog box will pop up allowing you to change the file name and save it.
- ii. Selecting “No” will exit the program or close the file without saving the file
- iii. Selecting “Cancel” will prevent the file from closing

Note: Using Save with an existing file will save a file without prompting you to specify a file name. Using Save with a new file will bring up the Save As dialog box for you to specify file name for saving. Using Save As will always bring up the Save As dialog box for you to specify a file name for saving.

Close a File

1. There are three options for closing an open file:
 - a. Selecting *File > Close* from the main menu; this can be found by selecting the three lines in the top left-hand corner of the screen and then selecting “Close”



- b. Using the keyboard shortcut “Ctrl+W”
- c. Exiting the program itself; please see *How To: Exit the Program*

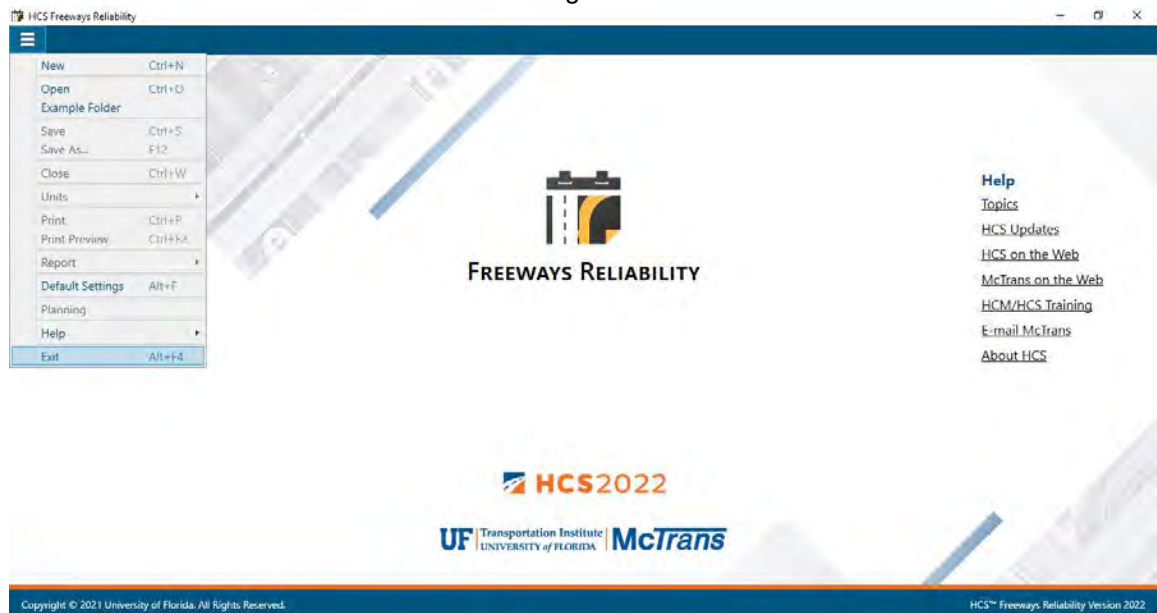
Exit the Program

1. From the Start screen, there are three options for exiting the program:



Note: The program can be exited even if a file is still open; you do not need to start from the Start screen.

- a. Selecting **File > Exit** from the main menu; this can be found by selecting the three lines in the top left-hand corner of the screen and then selecting "Exit"



- b. Using keyboard shortcut "Alt+F4"

- c. Selecting “X” in the top right-hand corner of the screen; this can be found below in the red box



Edit the Default Settings

1. From the Start screen, there are two options for editing the Default Settings:

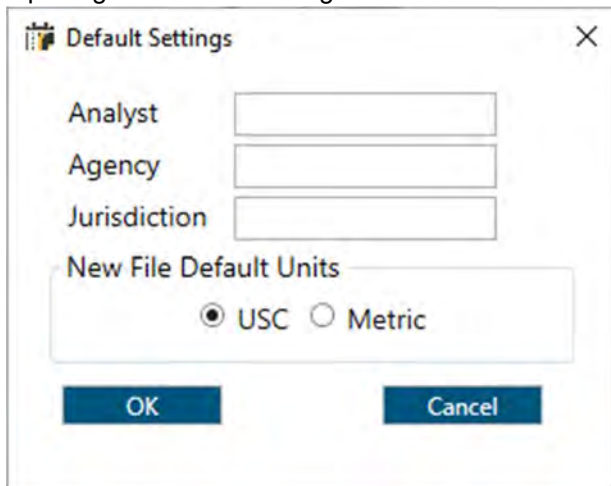


Note: The Default Settings can be changed even if an existing file is already open; you do not need to start from the Start screen.

- a. Selecting *File > Default Settings* from the main menu; this can be found by selecting the three lines in the top left-hand corner of the screen and then selecting “Default Settings”



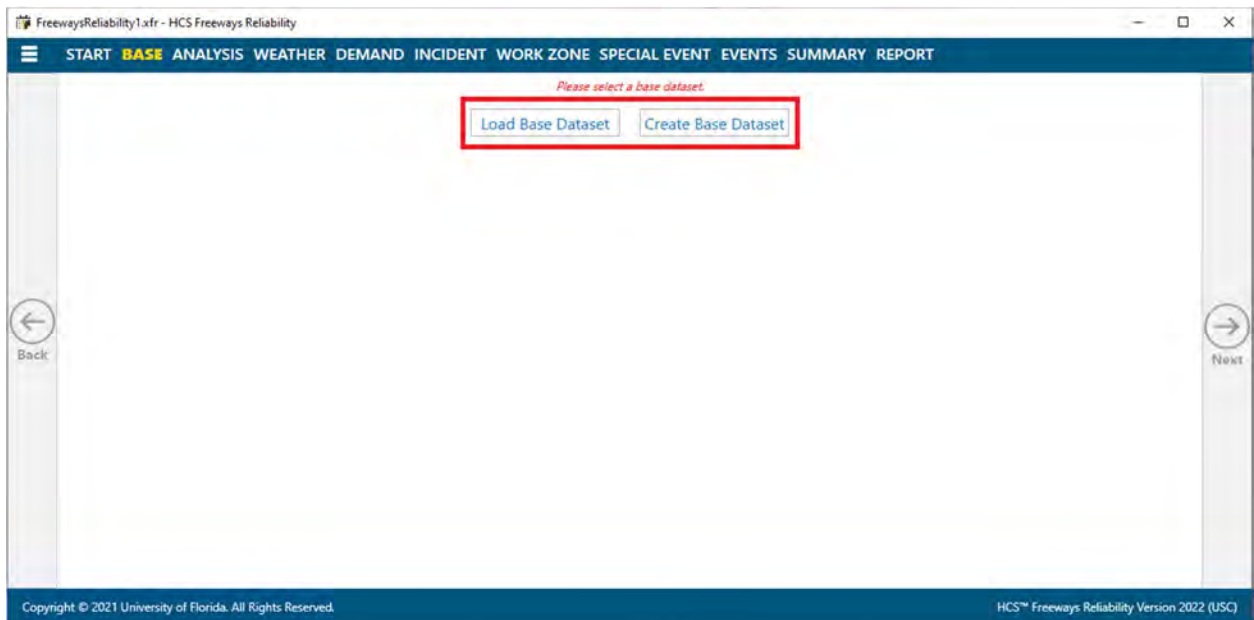
- b. Using the keyboard shortcut “Alt+F”
2. Opening the Default Settings will cause a Default Settings window to pop up:



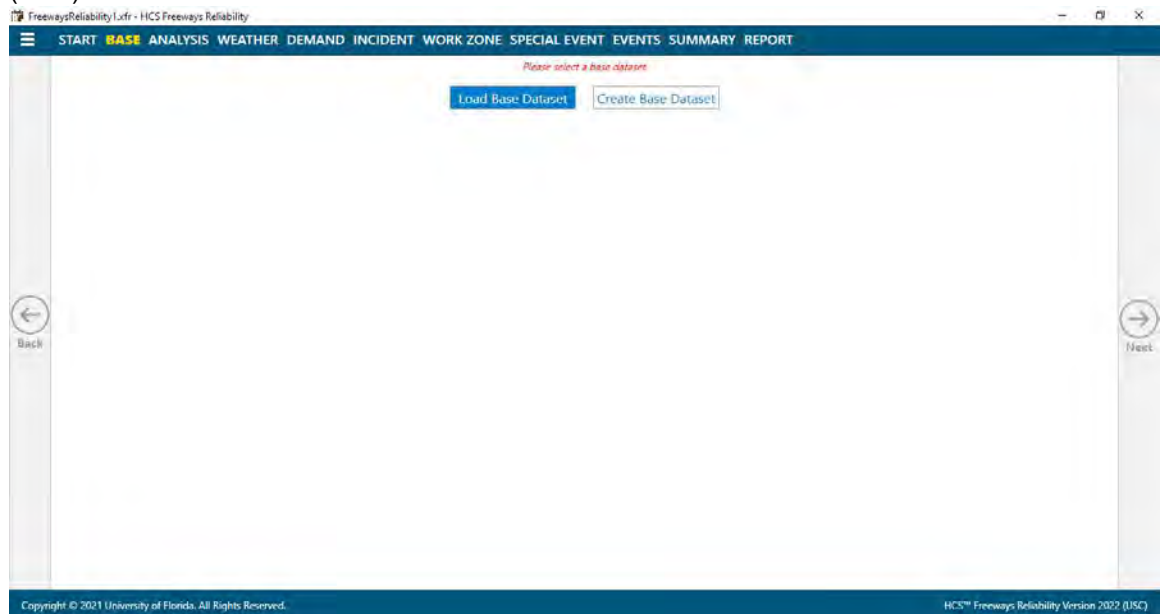
3. You can specify Analyst, Agency, and Jurisdiction by clicking in the corresponding text boxes and typing the desired text.
4. Under 'Units', you are given the option of running the analyses in either *U.S. Customary (USC)* or *SI (Metric)* units.
5. Clicking “OK” will save the changes made and close the Default Settings window; clicking “Cancel” will close the Default Settings window without saving any changes.
6. When a new file is created, the Analyst, Agency, and Jurisdiction fields will automatically be populated with the text specified in the Default Settings.
7. When starting a new file, the inputs and results will display according to the units specified in the Default Settings.

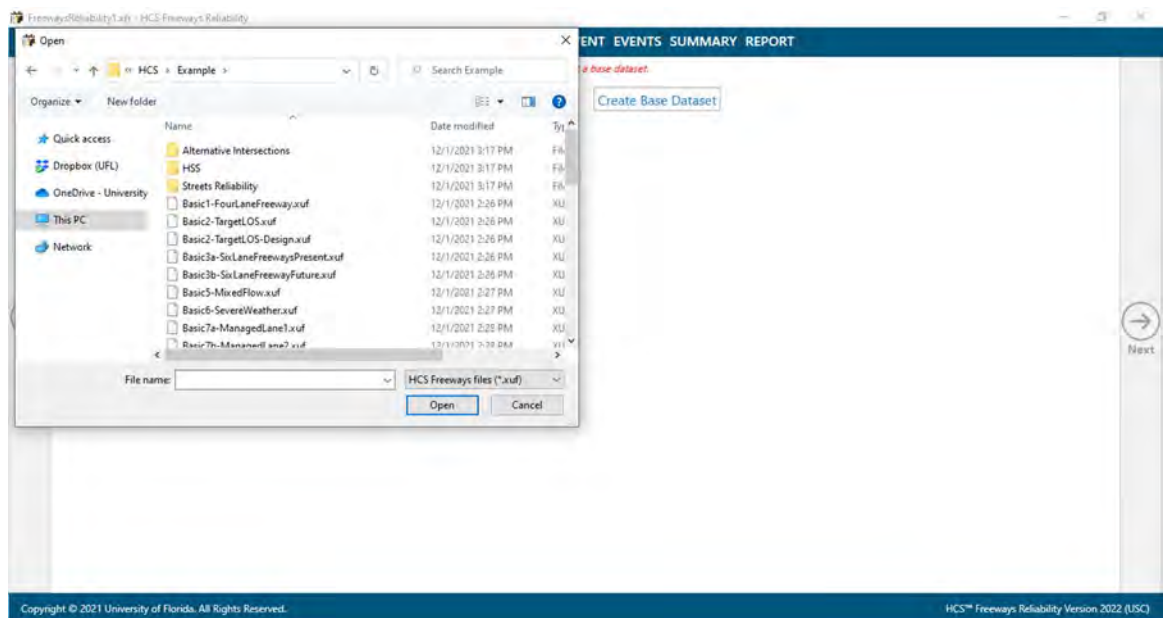
Load a Base Dataset

1. On the Base page, there are two options to load a base dataset: 'Load Base Dataset' and 'Create Base Dataset'

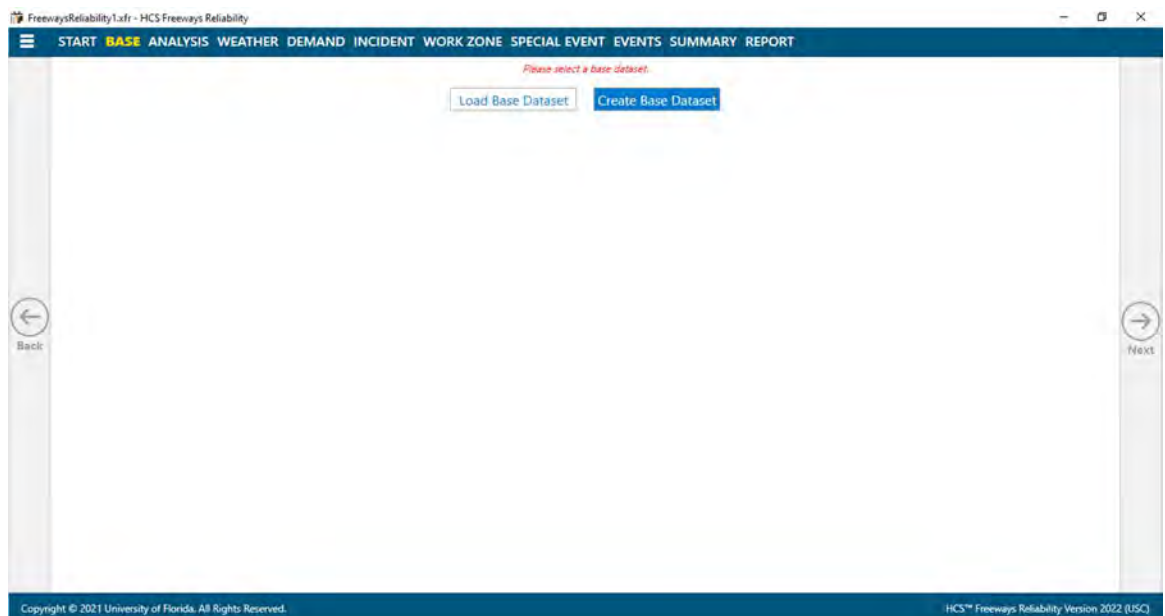


- a. 'Load Base Dataset' will bring up an Open dialog box to allow selection of an existing Freeways (*.xuf) file





- b. 'Create Base Dataset' opens the *HCS Freeways* program allowing you to create a Freeway (*.xuf) file which can then be saved and loaded into *HCS Freeways Reliability* using the 'Load Base Dataset' button





Load Regional Weather

1. On the Weather page, a weather location can be selected if you choose not to use the HCM defaults.

Please select a Weather Location

Current Location: HCM Default

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Duration
Medium rain	0.80	0.80	1.01	1.01	1.01	0.71	0.71	0.71	0.86	0.86	0.86	0.80	40.2
Heavy rain	0.47	0.47	0.81	0.81	0.81	1.33	1.33	1.33	0.68	0.68	0.68	0.47	33.7
Light snow	0.91	0.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.91	93.1
Light-medium snow	0.29	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29	33.4
Medium-heavy snow	0.04	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	21.7
Heavy snow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.3
Severe cold	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Low visibility	0.97	0.97	0.12	0.12	0.12	0.16	0.16	0.16	0.34	0.34	0.34	0.97	76.2
Very low visibility	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Minimal visibility	0.44	0.44	0.10	0.10	0.10	0.00	0.00	0.00	0.03	0.03	0.03	0.44	145.0
Non-severe weather	96.09	96.09	97.95	97.95	97.95	97.80	97.80	97.80	98.08	98.08	98.08	96.09	999.0

	55 mi/h	60 mi/h	65 mi/h	70 mi/h	75 mi/h
Medium rain	1.000	1.000	1.000	1.000	1.000
Heavy rain	1.000	1.000	1.000	1.000	1.000
Light snow	1.000	1.000	1.000	1.000	1.000
Light-medium snow	1.000	1.000	1.000	1.000	1.000
Medium-heavy snow	1.000	1.000	1.000	1.000	1.000
Heavy snow	1.000	1.000	1.000	1.000	1.000
Severe cold	1.000	1.000	1.000	1.000	1.000

- A drop down list of U.S. cities is provided. You can open the list by selecting the down arrow and scrolling through to search for a particular city or you can type a city in the box which will find the location in the list.

FreewaysReliability1.xlfr - HCS Freeways Reliability

START BASE ANALYSIS **WEATHER** DEMAND INCIDENT WORK ZONE SPECIAL EVENT EVENTS SUMMARY REPORT

Please select a Weather Location

RCM Default

HCM Default

Akron, OH

Albany, NY

Albuquerque, NM

Allentown, PA

Atlanta, GA

Augusta, GA

Austin, TX

Bakersfield, CA

Baltimore, MD

Baton Rouge, LA

Birmingham, AL

Boise City, ID

	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Duration
Medium rain	1.01	1.01	0.71	0.71	0.71	0.86	0.86	0.86	0.80	40.2
Heavy rain	0.81	0.81	1.33	1.33	1.33	0.68	0.68	0.68	0.47	33.7
Light snow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.91	93.1
Light-medium snow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29	33.4
Medium-heavy snow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	21.7
Heavy snow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.3
Severe cold	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Very low visibility	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Minimal visibility	0.44	0.44	0.10	0.10	0.10	0.03	0.03	0.03	0.44	145.0
Non-severe weather	96.09	96.09	97.95	97.95	97.80	97.80	98.08	98.08	96.09	999.0

DAF	CAF	SAF
	55 mi/h	60 mi/h
Medium rain	1.000	1.000
Heavy rain	1.000	1.000
Light snow	1.000	1.000
Light-medium snow	1.000	1.000
Medium-heavy snow	1.000	1.000
Heavy snow	1.000	1.000
Severe cold	1.000	1.000

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- Once a city is selected, it will automatically populate the table with the corresponding values.

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START BASE ANALYSIS **WEATHER** DEMAND INCIDENT WORK ZONE SPECIAL EVENT EVENTS SUMMARY REPORT

Orlando, FL

Current Location: Orlando, FL

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Duration
Medium rain	0.35	0.40	0.70	0.05	0.30	0.35	0.05	0.25	0.20	0.70	0.30	0.25	40.2
Heavy rain	1.20	0.40	0.75	0.30	0.50	0.10	0.25	0.20	0.40	0.50	0.15	0.70	33.7
Light snow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	93.1
Light-medium snow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.4
Medium-heavy snow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	21.7
Heavy snow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.3
Severe cold	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Low visibility	2.75	1.25	0.50	0.50	0.20	0.60	0.35	0.10	0.50	0.55	1.25	2.30	76.2
Very low visibility	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Minimal visibility	4.40	5.35	1.50	0.95	0.20	0.00	0.50	0.05	0.35	0.65	1.45	2.30	145.0
Non-severe weather	91.30	92.50	96.55	98.20	98.80	98.95	98.90	99.35	98.55	97.60	96.90	94.45	999.0

DAF	CAF	SAF
	55 mi/h	60 mi/h
Medium rain	1.000	1.000
Heavy rain	1.000	1.000
Light snow	1.000	1.000
Light-medium snow	1.000	1.000
Medium-heavy snow	1.000	1.000
Heavy snow	1.000	1.000
Severe cold	1.000	1.000

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- The table is editable so individual cells can be changed if necessary. If a value is changed, the Current Location will change to Custom.

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START BASE ANALYSIS **WEATHER** DEMAND INCIDENT WORK ZONE SPECIAL EVENT EVENTS SUMMARY REPORT

Custom

Current Location: Custom

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Duration
Medium rain	0.40	0.40	0.10	0.05	0.30	0.35	0.05	0.25	0.20	0.70	0.30	0.25	40.2
Heavy rain	1.20	0.40	0.75	0.30	0.50	0.10	0.25	0.20	0.40	0.50	0.15	0.70	33.7
Light snow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	93.1
Light-medium snow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.4
Medium-heavy snow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	21.7
Heavy snow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.3
Severe cold	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Low visibility	2.75	1.25	0.50	0.50	0.20	0.60	0.35	0.10	0.50	0.55	1.25	2.30	76.2
Very low visibility	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Minimal visibility	4.40	5.35	1.50	0.95	0.20	0.00	0.50	0.05	0.35	0.65	1.45	2.30	145.0
Non-severe weather	91.30	92.60	96.55	98.20	98.80	98.95	98.85	99.40	98.55	97.60	96.85	94.45	999.0

	DAF	CAF	SAF
	55 mi/h	60 mi/h	65 mi/h
	70 mi/h	75 mi/h	
Medium rain	1.000	1.000	1.000
Heavy rain	1.000	1.000	1.000
Light snow	1.000	1.000	1.000
Light-medium snow	1.000	1.000	1.000
Medium-heavy snow	1.000	1.000	1.000
Heavy snow	1.000	1.000	1.000
Severe cold	1.000	1.000	1.000

Copyright © 2021 University of Florida. All Rights Reserved. Event Probabilities -- Range: 0.00 to 100.00, -- Default: 0.00 HCS™ Freeways Reliability Version 2022 (USC)

View Results of the Analysis

- After editing all the necessary inputs and generating scenarios, results of the analysis can be found in the form of tables on the Events and Summary pages, and in the form of reports on the Report page.

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START BASE ANALYSIS WEATHER DEMAND INCIDENT WORK ZONE SPECIAL EVENT **EVENTS** SUMMARY REPORT

Summary Incident Work Zone

Scenarios per page: 20 Export to CSV

Scenario ID	Analysis Period	Demand Ratio	Weather Event Count	Incident Event Count	Work Zone Event Count
1	Jan-Mon	0.826	0	1	0
2	Jan-Mon	0.826	0	0	0
3	Jan-Mon	0.826	0	2	0
4	Jan-Mon	0.826	0	0	0
5	Jan-Tue	0.826	1	2	0
6	Jan-Tue	0.826	0	0	0
7	Jan-Tue	0.826	0	1	0
8	Jan-Tue	0.826	0	1	0
9	Jan-Wed	0.843	0	1	0
10	Jan-Wed	0.843	0	1	0
11	Jan-Wed	0.843	0	0	0
12	Jan-Wed	0.843	0	0	0
13	Jan-Thu	0.868	0	1	0
14	Jan-Thu	0.868	0	1	0
15	Jan-Thu	0.868	0	0	0
16	Jan-Thu	0.868	1	1	0
17	Jan-Fri	0.970	0	0	0
18	Jan-Fri	0.970	0	0	0

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START BASE ANALYSIS WEATHER DEMAND INCIDENT WORK ZONE SPECIAL EVENT EVENTS **SUMMARY** REPORT

Scenarios Details

Scenarios per page : 20

Export Summary Results to CSV Export to XUF Export TTI in TPs to CSV

Scenario ID	Demand Combination	Travel Time (min)	Average Speed (mi/h)	Average Density (pc/mi/ln)
1	Jan-Mon	6.20	58.1	18.7
2	Jan-Mon	6.20	58.1	18.7
3	Jan-Mon	6.20	58.1	18.7
4	Jan-Mon	6.20	58.1	18.7
5	Jan-Tue	6.30	57.1	19.1
6	Jan-Tue	6.20	58.1	18.7
7	Jan-Tue	6.20	58.1	18.7
8	Jan-Tue	6.20	57.7	18.9
9	Jan-Wed	6.20	58.1	19.1
10	Jan-Wed	6.20	58.1	19.1
11	Jan-Wed	6.20	58.1	19.1
12	Jan-Wed	6.20	58.1	19.1
13	Jan-Thu	6.20	58.0	19.7
14	Jan-Thu	6.20	58.0	19.7
15	Jan-Thu	6.20	58.0	19.7
16	Jan-Thu	8.50	42.5	27.2
17	Jan-Fri	6.30	57.5	22.2
18	Jan-Fri	6.20	57.7	22.2
19	Jan-Fri	6.20	57.7	22.2
20	Jan-Fri	6.20	57.7	22.2

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Facilities7-BaseReliability.xfr - HCS Freeways Reliability

START BASE ANALYSIS WEATHER DEMAND INCIDENT WORK ZONE SPECIAL EVENT EVENTS SUMMARY **REPORT**

HCS Freeway Reliability Report

Project Information

Analyst		Date	12/1/2021
Agency		Analysis Year	2021
Jurisdiction		Time Analyzed	
Project Description	Chapter 25: Example Problem 7	Units	U.S. Customary

Base Dataset Analysis

Base Dataset File Name	BaseFile-25-7.xuf	Data Collection Date	11/1/2016
Start Time	07:00	End Time	10:00
Number of Analysis Periods	12	Number of Segments	11

Reliability Input Summary

Reporting Start Date	2/14/2017	Reporting Start Date	2/14/2018
RRP Duration, months	12	Number of Days Considered	262
Number of Replications	4	Number of Scenarios	240
Include Weather Event	Yes	Include Incident Event	Yes
Weather Seed Number	1	Incident Seed Number	1
Include Demand Ratio	Yes	Include Work Zone	Yes

Average Performance Measure Results

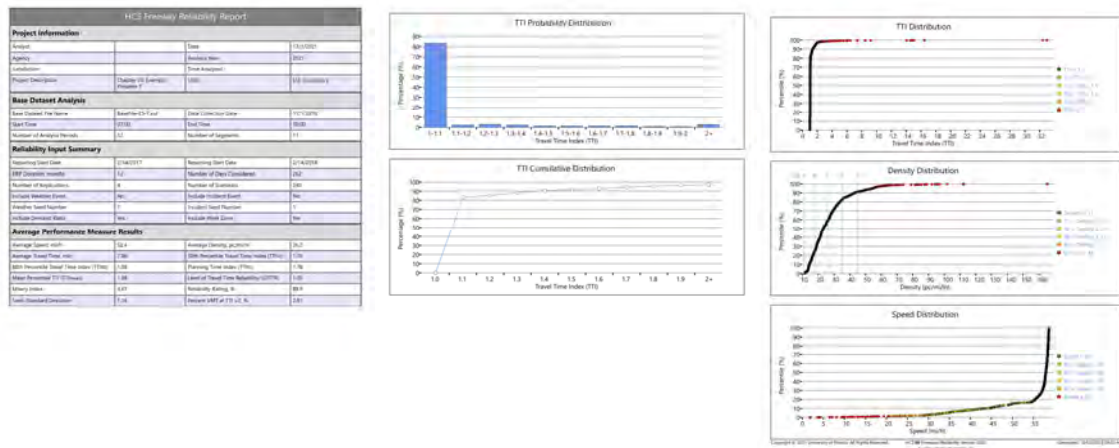
Average Speed, mi/h	52.4	Average Density, pc/mi/ln	26.2
Average Travel Time, min	7.06	50th Percentile Travel Time Index (TTI ₅₀)	1.03
90th Percentile Travel Time Index (TTI ₉₀)	1.08	Planning Time Index (TTI _{pl})	1.78

Switch to Text Report

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2. There are two options for reports: Formatted and Text

a. Formatted reports show the most important results in presentable format.



b. Text reports show the results in plain text.

```

File Name: Facilities7-BaseReliability.xfr
Analyst:
Agency:
Jurisdiction:
Date: 12/1/2021
Analysis Year: 2021
Time Analyzed:
Project Description: Chapter 25: Example Problem 7
Units: U.S. Customary

Base Free-Flow Speed, mi/h 60.0
Base Free-Flow Travel Time, h 6.00
Number of Segments 11
Number of Analysis Periods 12
Start Time 07:00
End Time 10:00
Reliability Reporting Period (RRP), months 12
Number of Scenarios 240

Average Performance Results
Average Speed, mi/h 52.4
Average Density, veh/mi/in 26.2
Average Density, pc/mi/in 26.8
Average Travel Time, min 7.06
Mean Percentile Travel Time Index (TTImean) 1.21
50th Percentile Travel Time Index (TTI50) 1.03
80th Percentile Travel Time Index (TTI80) 1.08
Level of Travel Time Reliability (LOTR) 1.05
Planning Time Index (TTI95) 1.78
Maximum Observed Facility TTI (TTImax) 32.97
Misery Index 3.61
Semi-standard Deviation 1.16
Standard Deviation 1.14
Reliability Rating, % 88.9
Percent VMT at TTI>2, % 2.81

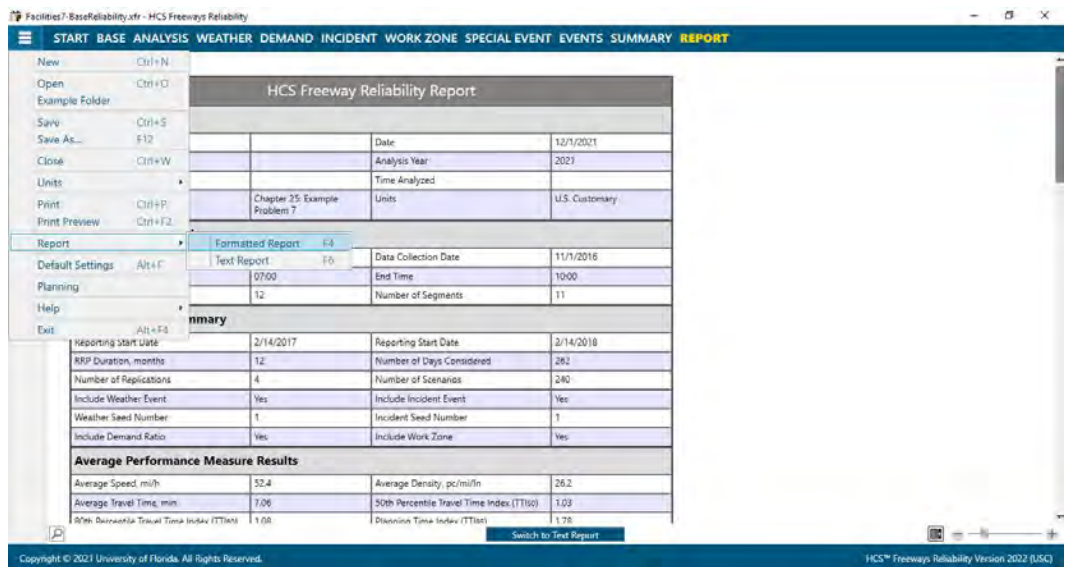
This Freeways Travel Time Reliability text report was created in HCS™ Freeways Reliability Version 2022 on 12/2/2021 08:06:38

```

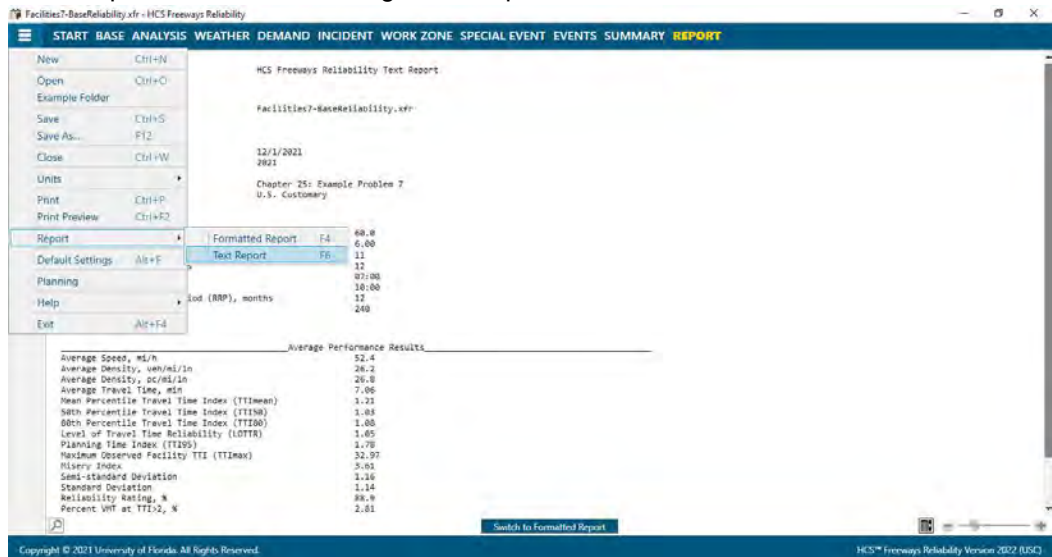
3. The type of report displayed can be changed by using the main menu items, keyboard shortcuts, or toggle buttons found under the report

a. Main Menu Items

- To switch to the Formatted Report, select *File > Report > Formatted Report* from the main menu; this can be found by selecting the three lines in the top left-hand corner of the screen, hovering over “Report”, and then selecting “Formatted Report”.



- ii. To switch to the Text Report, select *File > Report > Text Report* from the main menu; this can be found by selecting the three lines in the top left-hand corner of the screen, hovering over “Report”, and then selecting “Text Report”.



- b. Keyboard Shortcuts
 - i. Formatted Report: keyboard shortcut is “F4”
 - ii. Text Report: keyboard shortcut is “F6”
- c. Report Toggle Buttons
 - i. A toggle button is available at the bottom of the screen underneath the report.

- ii. If the formatted report is currently being displayed, the toggle button will say “Switch to Text Report” which will allow you to display the text report if clicked.

HCS Freeway Reliability Report

Project Information

Analyst		Date	12/1/2021
Agency		Analysis Year	2021
Jurisdiction		Time Analyzed	
Project Description	Chapter 25: Example Problem 7	Units	U.S. Customary

Base Dataset Analysis

Base Dataset File Name	Basefile-25-7.xuf	Data Collection Date	11/1/2016
Start Time	07:00	End Time	10:00
Number of Analysis Periods	12	Number of Segments	11

Reliability Input Summary

Reporting Start Date	2/14/2017	Reporting End Date	2/14/2018
RRP Duration, months	12	Number of Days Considered	262
Number of Replications	4	Number of Scenarios	240
Include Weather Event	Yes	Include Incident Event	Yes
Weather Seed Number	1	Incident Seed Number	1
Include Demand Ratio	Yes	Include Work Zone	Yes

Average Performance Measure Results

Average Speed, mi/h	52.4	Average Density, pc/mi/in	26.2
Average Travel Time, min	7.08	50th Percentile Travel Time Index (TTI ₅₀)	1.03
80th Percentile Travel Time Index (TTI ₈₀)	1.08	Elevation Time Index (TTI _{max})	1.78

Switch to Text Report

- iii. If the text report is currently being displayed, the toggle button will say “Switch to Formatted Report” which will allow you to display the formatted report if clicked.

HCS Freeway Reliability Text Report

File Name: Facilities7-BaseReliability.txt

Analyst:
Agency:
Jurisdiction:
Date: 12/1/2021
Analysis Year: 2021
Time analyzed:
Project Description: Chapter 25: Example Problem 7
Units: U.S. Customary

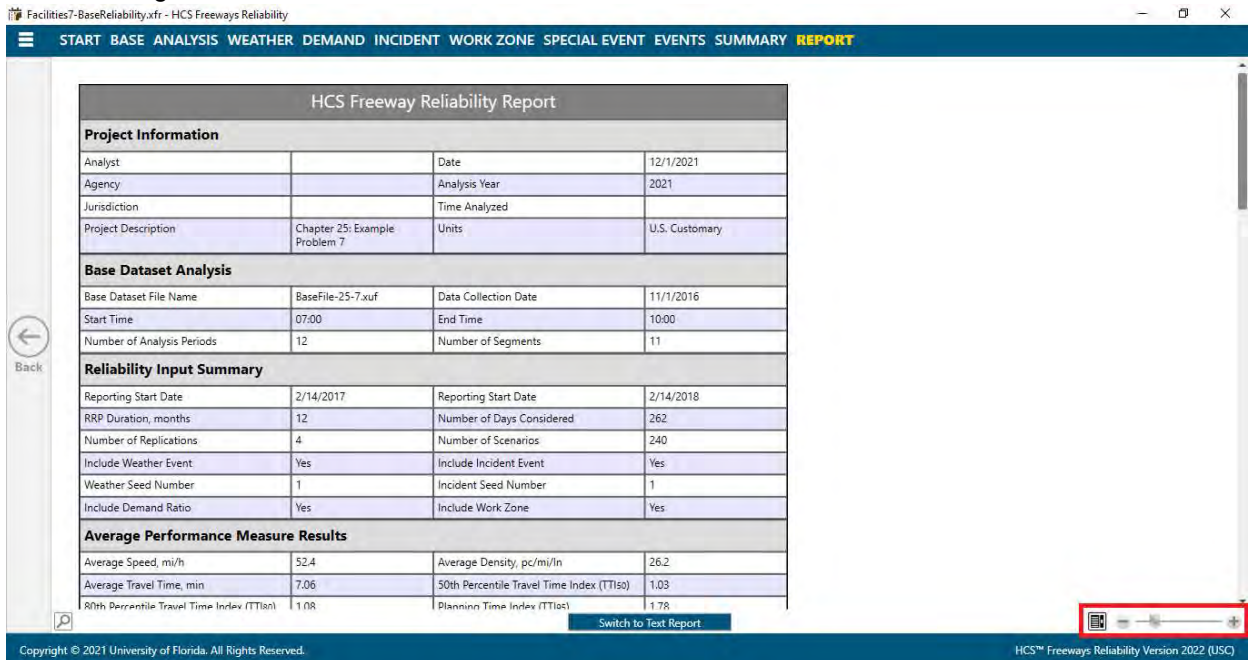
Base Free-Flow Speed, mi/h 60.0
Base Free-Flow Travel Time, h 6.00
Number of Segments 11
Number of Analysis Periods 12
Start Time 07:00
End Time 10:00
Reliability Reporting Period (RRP), months 12
Number of Scenarios 240

Average Performance Results

Average Speed, mi/h	52.4
Average Density, veh/mi/in	26.2
Average Density, pc/mi/in	26.2
Average Travel Time, min	7.08
Mean Percentile Travel Time Index (TTI _{mean})	1.21
50th Percentile Travel Time Index (TTI ₅₀)	1.03
80th Percentile Travel Time Index (TTI ₈₀)	1.08
Level of Travel Time Reliability (LOTR)	1.05
Planning Time Index (TTI ₁₀₀)	1.78
Maximum Observed Facility TTI (TTI _{max})	22.97
Reliability Index	3.61
Sample Standard Deviation	1.16
Standard Deviation	1.14
Reliability Rating, %	88.9
Percent VMT at TTI ≤ 2, %	2.81

Switch to Formatted Report

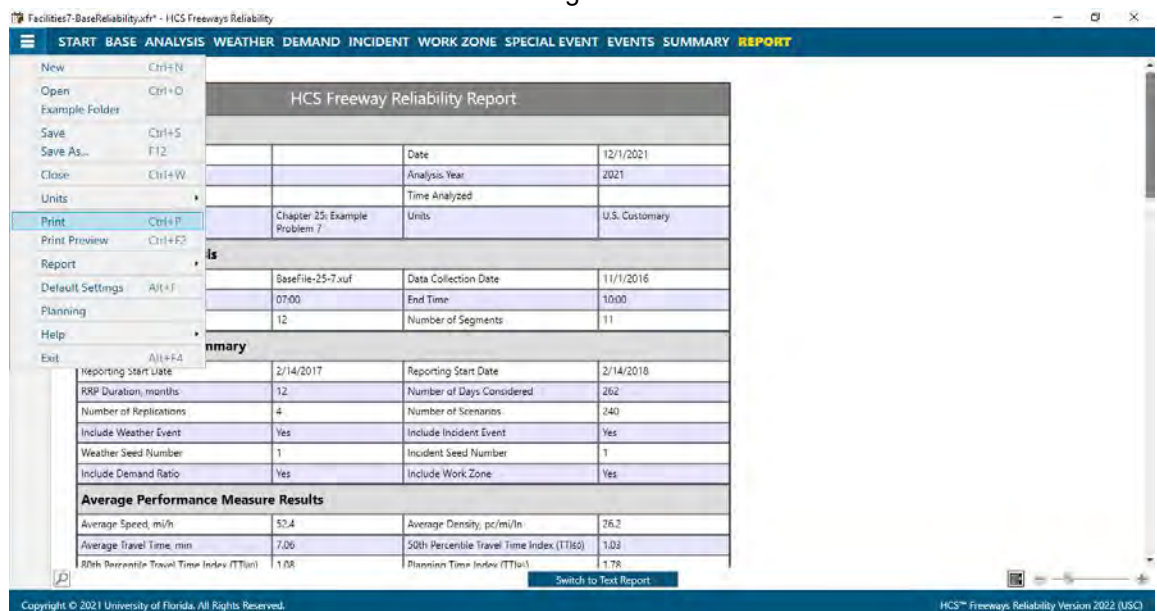
4. The magnification of the report currently being displayed can be changed using the zoom slider found at the bottom right-hand corner of the screen.



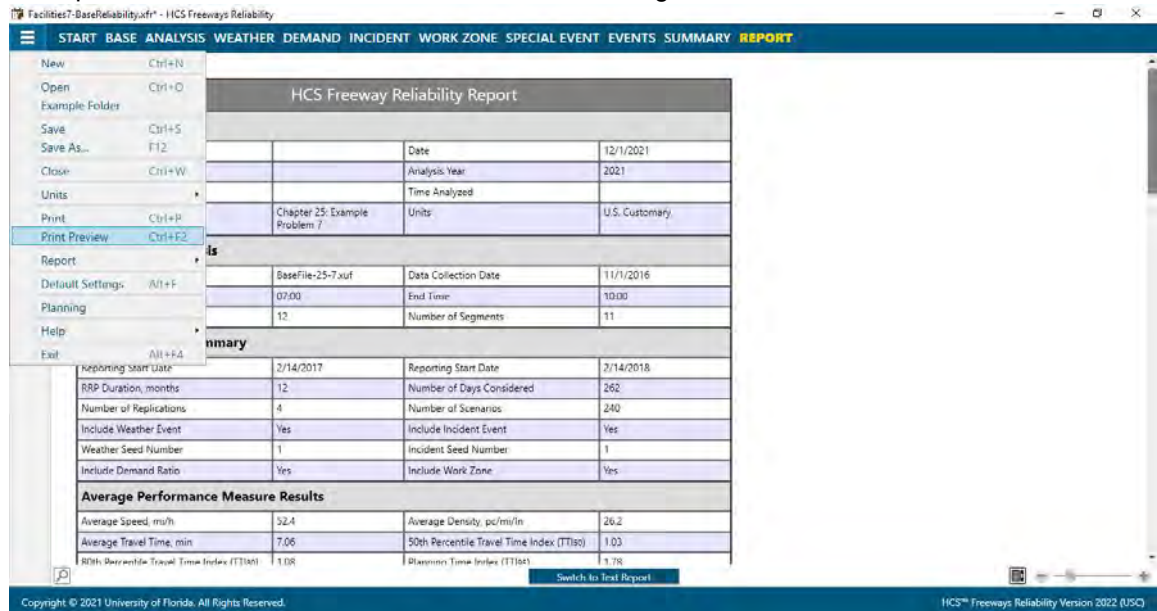
- a. To zoom in, drag the slider to the right; to zoom out, drag the slider to the left
- b. Clicking the plus (+) button will zoom in; clicking the minus (-) button will zoom out
- c. Holding down "ctrl" on the keyboard and scrolling up on the mouse wheel will zoom in; holding down "ctrl" on the keyboard and scrolling down on the mouse wheel will zoom out

Print a Report

1. There are four options for printing a report:
 - a. Selecting **File > Print** from the main menu; this can be found by selecting the three lines in the top left-hand corner of the screen and then selecting "Print"



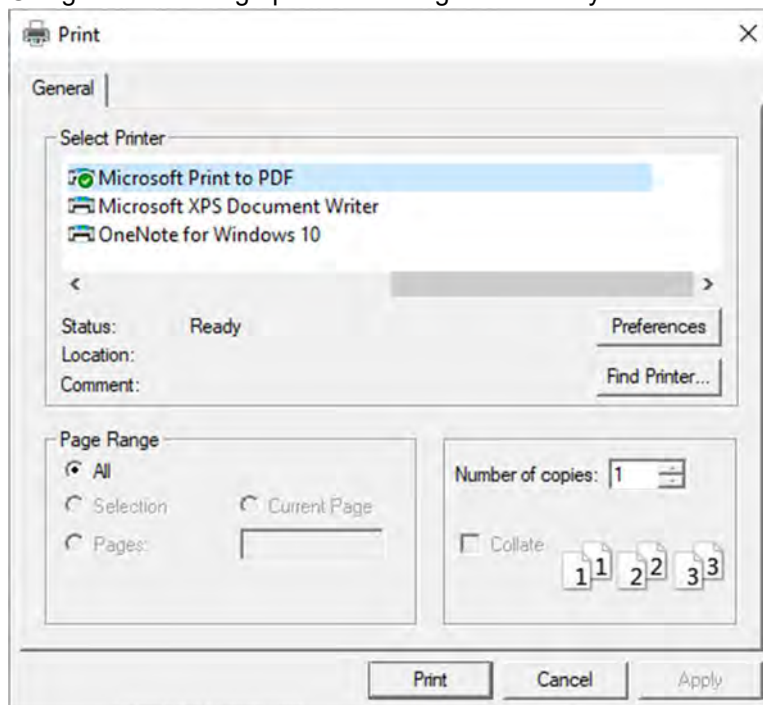
- b. Selecting **File > Print Preview** from the main menu; this can be found by selecting the three lines in the top left-hand corner of the screen and then selecting “Print Preview”



- c. Using keyboard shortcut “Ctrl+P” for Print
- d. Using keyboard shortcut “Ctrl+F2” for Print Preview

2. Print

- a. Using Print will bring up a Print dialog box where you can select which printer to print to



3. Print Preview

- a. Using Print Preview will bring up a window where you can view how the report will look on paper before sending it to the printer

The screenshot shows a 'Print Preview' window for an 'HCS Freeway Reliability Report'. The report is organized into several sections: Project Information, Base Dataset Analysis, Reliability Input Summary, and Average Performance Measure Results. Each section contains a table of data.

HCS Freeway Reliability Report			
Project Information			
Analyst		Date	12/1/2021
Agency		Analysis Year	2021
Jurisdiction		Time Analyzed	
Project Description	Chapter 25: Example Problem 2	Units	U.S. Customary
Base Dataset Analysis			
Base Dataset File Name	BaseFile-25-7.xul	Date Collection Date	11/1/2016
Start Time	07:00	End Time	10:00
Number of Analysis Periods	12	Number of Segments	11
Reliability Input Summary			
Reporting Start Date	2/14/2017	Reporting Start Date	2/14/2018
RRP Duration, months	12	Number of Days Considered	1
Number of Replications	4	Number of Scenarios	0
Include Weather Event	Yes	Include Incident Event	Yes
Weather Seed Number	1	Incident Seed Number	1
Include Demand Ratio	Yes	Include Work Zone	Yes
Average Performance Measure Results			
Average Speed, mi/h	0.0	Average Density, pc/mi/in	0.0
Average Travel Time, min	0.00	50th Percentile Travel Time Index (TTI ₅₀)	1.00
80th Percentile Travel Time Index (TTI ₈₀)	1.00	Planning Time Index (TTI _{pl})	1.00
Mean Percentile TTI (TTI _{mean})	1.00	Level of Travel Time Reliability (LOTR)	1.00

- b. The print icon in the toolbar found in the top left-hand corner can then be selected



- c. A print dialog box will pop up where you can select which printer to print to

The screenshot shows a standard Windows 'Print' dialog box. The 'General' tab is active. Under 'Select Printer', three options are listed: 'Microsoft Print to PDF' (selected), 'Microsoft XPS Document Writer', and 'OneNote for Windows 10'. Below this, the status is 'Ready'. There are buttons for 'Preferences' and 'Find Printer...'. The 'Page Range' section has radio buttons for 'All' (selected), 'Selection', and 'Current Page', with a 'Pages' input field. The 'Number of copies' is set to 1, and there is a 'Collate' checkbox. At the bottom are 'Print', 'Cancel', and 'Apply' buttons.

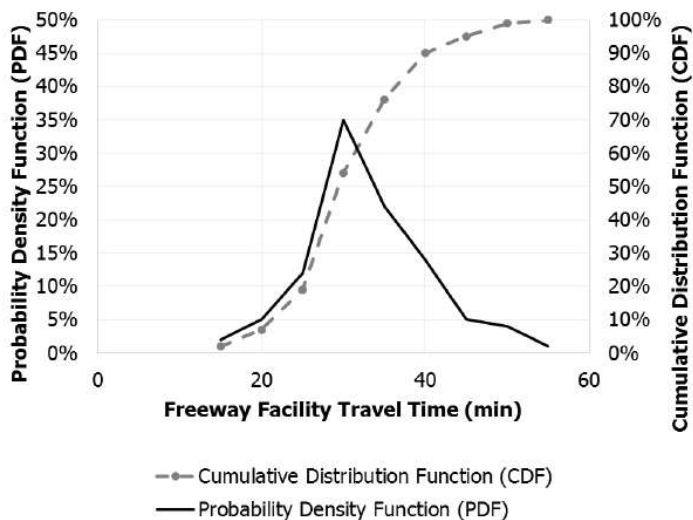
Glossary of Terms

50th Percentile Travel Time Index (TTI₅₀)

TTI₅₀ describes the median of the TTI distribution. This can be a useful measure and is less influenced by outliers than the mean.

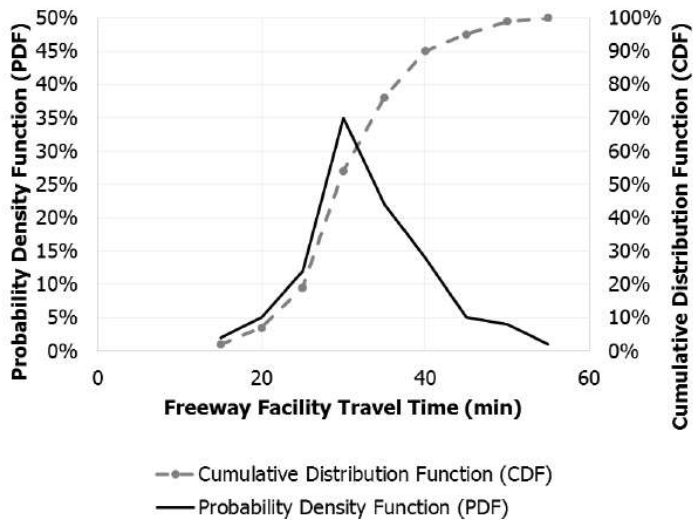
80th Percentile Travel Time Index (TTI₈₀)

This measure has been found to be more sensitive to operational changes than the TTI₉₅, which makes it useful for strategy comparison and prioritization purposes. In the exhibit found below, the 80th percentile travel time is approximately 36 minutes, thus the 80th percentile TTI is $36/15 = 2.4$.



95th Percentile Travel Time Index (TTI₉₅)

The 95th Percentile TTI is also referred to as the planning time index (PTI) and is a useful measure for estimating the added time travelers must budget to ensure an on-time arrival with “failure” limited to one trip per month. In the exhibit found below, the 95th percentile travel time is 45 min, compared to a free-flow travel time of 15 min; thus, $TTI_{95} = 3.0$. The planning time is the difference between the 95th percentile and free-flow travel times, or 30 min.



ACR

The facility AADT divided by its two-way hourly capacity; this value is used in the computation of *CR*, which is the crash rate per 100 million VMT (or 161 million VkmT in metric).

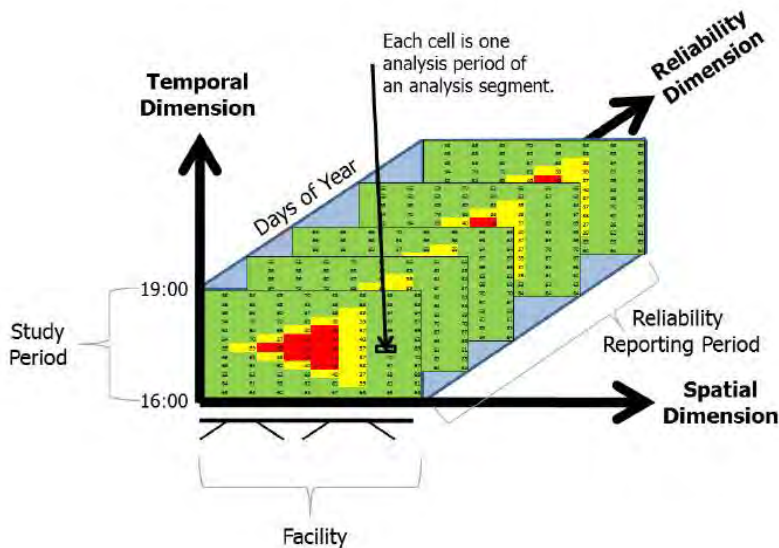
See also *Highway Economic Requirements System (HERS)*.

Agency

This field is provided to document the agency or company associated with this analysis or project.

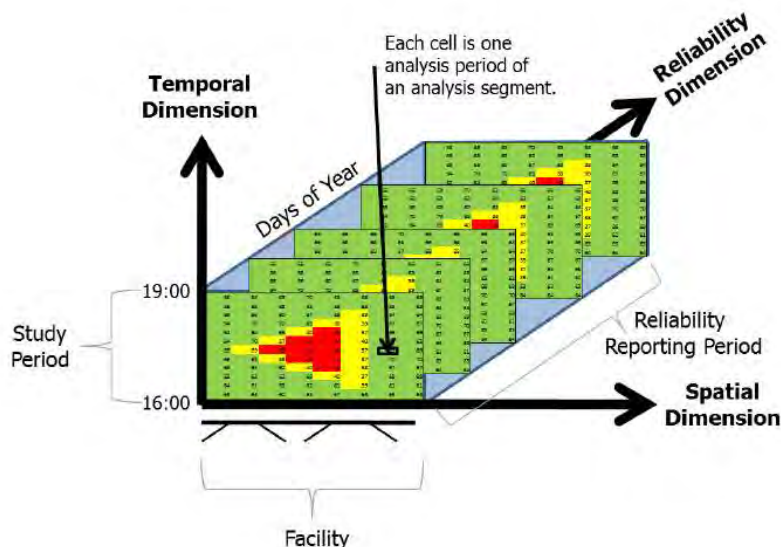
Analysis Period

The time interval evaluated by a single application of an HCM methodology (15 min for the freeway facility core methodology). In the exhibit found below, there are 12 such analysis period for the facility, represented by the rows in the rectangles. Each cell in a rectangle represents a single analysis period for a single analysis segment.



Analysis Segment

An HCM freeway segment (e.g., basic, merge, diverge, weaving) as described in Chapters 12 through 14. Each column in the exhibit found below represents an analysis segment.



Analysis Year

This field is provided to document the year for which the analysis is being performed.

Analyst

This field is provided to document the name of the analyst.

Area Type

There are two area types: urban areas and rural areas. Urban areas are typified by high development densities or concentrations of population. Rural areas are areas with widely scattered development and low housing and employment densities.

Barrier Type

There are two barrier types: concrete and hard barrier separation; and cone, plastic drum, or other soft barrier separation.

Base Dataset

The base dataset provides all the required input data for the freeway facilities core methodology described in HCM Chapter 10. Some data are specific to the freeway facility being studied. These include, at a minimum, all segment geometries (both general purpose and managed lanes, if applicable), free-flow speed, lane patterns, and segment type, along with base demands that are typically, but not necessarily, reflective of average (AADT) conditions. In addition, the base dataset contains the required input data to execute HCM Chapter 11's reliability methodology. These data include a demand multiplier matrix, weather, work zones, and incident events as described later in this section. The majority of the reliability-specific input data can be defaulted when they are not available locally, but the analyst is encouraged to supply facility-specific data whenever feasible.

The user has the option to load a base dataset or create a base dataset. Clicking on 'Load Base Dataset' will open a dialog box to allow the user to select a Freeways Facility (*.xuf) file for the user to open and load into the Freeways

Reliability program. Once loaded, a facility graphic of the base dataset will be displayed on the page, along with general information. Clicking on 'Create Base Dataset' will open the HCS Freeways program to allow the user to create a new base dataset for use in the Freeways Reliability program.

Base Dataset Date

This specifies the date of the base dataset. A base scenario is always required and is used to describe base conditions (particularly demand and factors influencing capacity and free-flow speed). The base scenario is intended to represent average demand conditions (e.g., annual average daily traffic, AADT), or the demand measured on a specific day. HCM Chapter 11's methods factor these demands on the basis of user-supplied or defaulted demand patterns to generate demands representative of all other analysis periods during the reliability reporting period.

Base Scenario (Seed File)

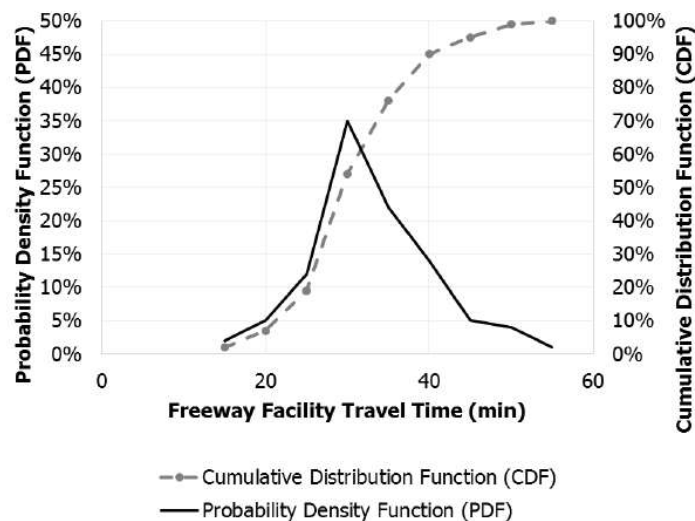
A set of parameters representing the facility's calibrated operating conditions during one study period. All other scenarios are developed by adjusting the base scenario's inputs to reflect the effects of varying demand, weather, incidents, work zones, or a combination of these that occur in other study periods. When the methodology is executed using a computational engine, the base scenario's parameters become inputs to the seed file used by the engine.

Capacity Adjustment Factor (CAF)

Factor used to allow the user to adjust the capacity for reduced-capacity situations or to match field measurements. The capacity in any cell of the time-space domain can be reduced to represent incident situations such as construction and maintenance activities, adverse weather, traffic accidents, and vehicle breakdowns. Similarly, capacity can be increased to match field measurements.

Cumulative Density Function (CDF)

The CDF gives the number of percent of all observations *at or below* a specified travel time bin. The exhibit found below illustrates two types of distributions, with the PDF shown by the solid line and the CDF by the dashed line. The facility travel times shown on the x-axis represent the midpoints of the various travel bins. See also *Probability Density Function (PDF)*.



Date

This field is provided to document the date when the analysis is performed.

Daylight or Night

This is used to determine whether daytime or nighttime operations are considered.

Demand Adjustment Factor (DAF)

Factor used to allow the user to adjust the demand for the purpose of calibration, or to reflect the impacts of weather, incidents, and work zones.

Demand Ratios

The exhibits found below present default demand ratios by day of week and month of year for urban and rural freeway facilities. The ratios were derived from a national freeway dataset developed by SHRP 2 Project L03. All ratios reflect demand relative to a Monday in January. Where possible, analysts should obtain local or regional estimates of demand variability to account for facility-specific and seasonal trends on the subject facility.

Default Urban Freeway Demand Ratios (ADT/Mondays in January):

Month	Day of Week						
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
January	1.00	1.00	1.02	1.05	1.17	1.01	0.89
February	1.03	1.03	1.05	1.08	1.21	1.04	0.92
March	1.12	1.12	1.14	1.18	1.31	1.13	0.99
April	1.19	1.19	1.21	1.25	1.39	1.20	1.05
May	1.18	1.18	1.21	1.24	1.39	1.20	1.05
June	1.24	1.24	1.27	1.31	1.46	1.26	1.10
July	1.38	1.38	1.41	1.45	1.62	1.39	1.22
August	1.26	1.26	1.28	1.32	1.47	1.27	1.12
September	1.29	1.29	1.32	1.36	1.52	1.31	1.15
October	1.21	1.21	1.24	1.27	1.42	1.22	1.07
November	1.21	1.21	1.24	1.27	1.42	1.22	1.07
December	1.19	1.19	1.21	1.25	1.40	1.20	1.06

Source: Derived from data presented by Cambridge Systematics et al. (2).

Note: Ratios represent demand relative to a Monday in January.

Default Rural Freeway Demand Ratios (ADT/Mondays in January):

Month	Day of Week						
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
January	1.00	0.96	0.98	1.03	1.22	1.11	1.06
February	1.11	1.06	1.09	1.14	1.35	1.23	1.18
March	1.24	1.19	1.21	1.28	1.51	1.37	1.32
April	1.33	1.27	1.30	1.37	1.62	1.47	1.41
May	1.46	1.39	1.42	1.50	1.78	1.61	1.55
June	1.48	1.42	1.45	1.53	1.81	1.63	1.57
July	1.66	1.59	1.63	1.72	2.03	1.84	1.77
August	1.52	1.46	1.49	1.57	1.86	1.68	1.62
September	1.46	1.39	1.42	1.50	1.78	1.61	1.55
October	1.33	1.28	1.31	1.38	1.63	1.47	1.42
November	1.30	1.25	1.28	1.35	1.59	1.44	1.39
December	1.17	1.12	1.14	1.20	1.43	1.29	1.24

Source: Derived from data presented by Cambridge Systematics et al. (2).

Note: Ratios represent demand relative to a Monday in January.

These default demand ratios are displayed in the first table of the Demand page depending on the Freeway Area Type selected. The second table of the Demand page displays the demand ratios relative to the base dataset. The values in the first table can be edited by the user, if necessary, and the corresponding values in the second table will change based on the edited values.

Export Buttons

Export buttons are provided on the Events page and Summary page.

On the Events page, Export to CSV is provided under each tab for the user to export the table results into a CSV file. For example, if the user wants to export the Incident data, a dialog box will appear after clicking 'Export to CSV' under the Incident tab. The user can specify a name for the CSV file or keep the default name. After saving the file, all incident events from all pages will be saved in CSV format.

On the Summary page, three export buttons are provided. These include: Export Summary Results to CSV, Export to XUF, and Export Facility to CSV. 'Export Summary Results to CSV' is similar to the export buttons on the Events page. Clicking this button will allow the user to save the summary results displayed in the table to be saved in CSV format. 'Export to XUF' will allow the user to save all the scenarios generated in the Freeways XUF format. Clicking this button will open a dialog box allowing the user to browse folders or create a folder which will save a folder with all the scenarios generated. The folder holding all the scenarios will be titled the same as the Freeways Reliability XFR file and all the scenarios will be titled Scenario#, with # being the corresponding scenario number. 'Export Facility to CSV' will export the inputs of each scenario into corresponding CSV files.

Facility Evaluation

In the facility evaluation step, each scenario is analyzed using the freeway facilities core methodology. The performance measures of interest to the evaluation—in particular, facility travel time—are calculated for each analysis period in each scenario and stored. At the end of this process, a travel time distribution is formed from the travel time results stored for each scenario.

Failure or On-Time Measures

The percentage of analysis time periods with space mean speeds above (on time) or below (failure) one or more target values (e.g., 35, 45, and 50 mi/h). These measures address how often trips succeed or fail in achieving a desired travel time or speed.

Free-Flow Speed

1. The average speed of vehicles on a given segment, measured under low-volume conditions, when drivers are free to drive at their desired speed and are not constrained by the presence of other vehicles or downstream traffic control devices.
2. The theoretical speed when both density and flow rate are zero.

Units: USC

The adjusted free-flow speed is determined by the HCM equation found below.

$$FFS = BFFS - f_{LW} - f_{RLC} - 3.22 \times TRD^{0.84}$$

where

- FFS = free-flow speed of the basic freeway segment (mi/h),
- $BFFS$ = base FFS for the basic freeway segment (mi/h),
- f_{LW} = adjustment for lane width (mi/h),
- f_{RLC} = adjustment for right-side lateral clearance (mi/h), and
- TRD = total ramp density (ramps/mi).

If a field measured free-flow speed is entered, no subsequent adjustments are made and the adjusted free-flow speed will simply be the field-measured free-flow speed. Freeway Merge, Diverge, and Weaving segments require direct speed measurements, estimated from design speed or speed limit.

Units: Metric

Free-Flow Speed is measured in km/h. Calculations are done in USC but converted to metric.

Highway Economic Requirements System (HERS)

When the crash rate is not available locally, the Highway Economic Requirements System (HERS) model can be used to estimate it. The crash or incident rate is estimated per 100 million VMT (or per 161 million VkmT in metric). The HERS models uses the following equation to estimate crash rate:

$$CR = (154.0 - 1.203 \times ACR + 0.258 \times ACR^2 - 0.00000524 \times ACR^5) \times e^{0.0082 \times (12 - LW)}$$

where CR is the crash rate per 100 million VMT (or per 161 million VkmT in metric), ACR is the facility AADT divided by its two-way hourly capacity, and LW is the lane width in feet (or meters in metric).

Import from XUF File

Clicking this will allow the user to choose a file to override the default event creation.

Incident Distribution and Duration

The duration of each incident severity type is assumed to follow a lognormal distribution. The default parameters for the incident duration distribution was developed through research. The defaults for freeway incident severity distribution and duration parameters, in minutes, are provided below:

Parameter	Incident Severity Type				
	Shoulder Closed	1 Lane Closed	2 Lanes Closed	3 Lanes Closed	4+ Lanes Closed
Distribution %	75.4%	19.6%	3.1%	1.9%	0%
Duration (Mean)	34	34.6	53.6	67.9	67.9
Duration (Std Dev)	15.1	13.8	13.9	21.9	21.9
Duration (Min)	8.7	16	30.5	36	36
Duration (Max)	58	58.2	66.9	93.3	93.3

Source: Zegeer et al. (1).

Incident Frequency Data

Radio button choices are provided for specifying the type of Incident Frequency Data. These choices include: Local Incident Frequency, Local Crash Frequency, and Calculated Crash Frequency.

Selecting Local Incident Frequency will provide a table with defaults for Incident Frequency (per 100 million VMT in USC or per 161 million VkmT in metric) that vary by month. The values are editable for the user to calibrate for local conditions.

Selecting Local Crash Frequency will provide a table with defaults for Crash Frequency (per 100 million VMT in USC or per 161 million VkmT in metric) that vary by month. The values are editable for the user to calibrate for local conditions. In addition to this table, a field is provided for the user to specify the Incident-to-Crash Ratio (ICR).

Selecting Calculated Crash Frequency will cause the Highway Economic Requirements System (HERS) model to be used to calculate crash rate. Fields for ICR, ACR, and Lane Width will also be provided for the user to specify.

Incident-to-Crash Ratio (ICR)

ICR is the local incident-to-crash ratio. In the absence of other data, a national default value for ICR is 4.9.

Items per page

A drop down menu is provided for the user to specify the scenarios or events to be displayed per page.

Jurisdiction

This field is provided to document any jurisdiction convention or project related information.

Lane Closure Type

Lane Closure Type expresses how many lanes are closed in the work zone.

The lane closure configuration in a work zone is expressed as the ratio of the number of original lanes to the number of lanes present in the work zone. For instance, a 3-to-1 lane closure configuration means that three lanes are normally available, but that two lanes were closed during construction and only one lane was open. Research shows that this ratio is effective in showing influences of different lane configurations on speed or capacity.

Lane Width

The lateral distance, in feet (or meters in metric), between stripes for a given lane

Lateral Distance

The distance, in feet (or meters in metric), from the edge of travel lane adjacent to the work zone to the barrier, barricades, or cones.

Level of Travel Time Reliability (LOTTR)

Level of travel time reliability, or LOTTR, is the measure of the 80th percentile travel time index (TTI₈₀) divided by the 50th percentile travel time index (TTI₅₀):

$$\text{LOTTR} = \text{TTI}_{80} / \text{TTI}_{50}$$

Local Crash Frequency

Fields are provided for Crash Frequency (per 100 million VMT in USC or per 161 million VkmT in metric) if the analyst is aware of recurring crash occurrences that vary by month. If, for example, crashes are more likely in winter months (despite potentially lower demands), the analyst should adjust the crash rate defaults and calibrate for local conditions.

Local Incident Frequency

Fields are provided for Incident Frequency (per 100 million VMT in USC or per 161 million VkmT in metric) if the analyst is aware of recurring incident occurrences that vary by month. If, for example, incidents are more likely in winter months (despite potentially lower demands), the analyst should adjust the incident rate defaults and calibrate for local conditions.

Location

Rainfall, snow, temperature, and visibility weather data were collected for several different cities. Defaults are provided by month for each of the cities listed in the drop down menu on the Weather page. If a city is not listed and the analyst has local data available, the fields in the table can be edited and the Current Location will become 'Custom'.

Mean Travel Time Index (TTI_{mean})

TTI_{mean} describes the mean of the TTI distribution. This can be a useful measure and more influenced by outliers than the median.

Misery Index

A measure comparing the average of the worst 5% of travel times to the free-flow travel time.

Navigation Buttons

On the Events page and Summary page, there are four buttons that can be found at the bottom of the table being displayed. These buttons include: << First, < Previous, Next >, and Last >>. When there are several scenarios or events in an analysis that are displayed in multiple pages, the user can use the buttons to navigate between pages. The '<< First' button will display the first page, the '< Previous' button will display one page back, the 'Next >' will display one page forward, and the 'Last >>' button will display the last page. If all scenarios or events can be displayed on one page, then all four buttons will be disabled.

Number of Lanes

This specifies the number of lanes on the freeway in the analysis direction. If there is a weaving segment, the number of auxiliary lanes is also included. When there is a managed lane, the number of lanes is the number of general purpose lanes.

Number of Replications

This number ensures a sufficient sample size for scenario generation.

For a one-year RRP, the methodology is typically applied with four replication for each of five weekdays (Monday through Friday) and 12 months in the year, for a total of 240 scenarios. This approach roughly corresponds to 250 work days in a typical calendar year. A reliability analysis that includes weekend effects would result in an increased number of scenarios.

For RRP that are significantly shorter than one year, the analyst should increase the number of replications to ensure a sufficient sample size for scenario generation. The exhibit below provides guidance on the recommended number of replications in such cases.

RRP Duration (months)	Number of Days Considered	Recommended Number of Replications	Resulting Number of Scenarios
1	5 (all weekdays)	48	240
2	5	24	240
4	5	12	240
6	5	8	240
9	5	6	270
12*	5	4*	240*
12	2 (weekend only)	10	240
12	7 (all days)**	3	252

Notes: RRP = reliability reporting period.

*Default value.

**Not desirable; separating weekday and weekend reliability analysis is preferred.

Peak Hour Speed

The speed expected on the freeway during the peak hour, in miles per hour (or kilometers per hour in metric).

Percent Drop in Capacity

Percent Drop in Capacity refers to the percentage drop in pre-breakdown capacity at the work zone due to queuing conditions. Research shows an average queue discharge drop of 7% in non-work zone conditions, and an average value of 13.4% in freeway work zones.

Percentile Travel Time Index (TTI_{pp})

Represents the pp percentile TTI in the travel time distribution. For example, TTI_{85} means that this observation is exceeded only 15% of the time in the travel time distribution. Common TTI percentiles are TTI_{50} (the median TTI) and TTI_{95} (the 95th percentile TTI). When pp is omitted, the value often represents the *mean* TTI for the distribution, which in HCM chapter 11 is referred to as TTI_{mean} .

Performance Summary

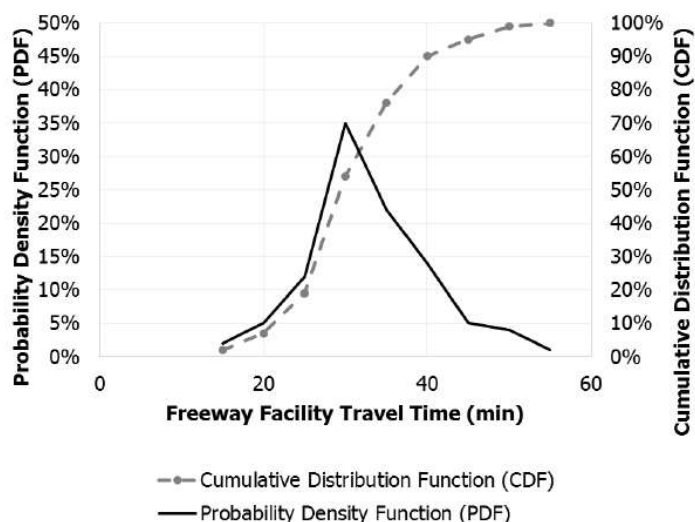
In the final step, travel time reliability is described for the entire RRP. The travel time distribution is used to quantify a range of variability and reliability metrics.

Planning Time Index (PTI)

See 95th Percentile Travel Time Index (TTI_{95}).

Probability Density Function (PDF)

The PDF gives the number or percent of all observations within a specified travel time (or TTI) bin. The exhibit found below illustrates two types of distributions, with the PDF shown by the solid line and the CDF by the dashed line. The facility travel times shown on the x-axis represent the midpoints of the various travel bins. See also *Cumulative Density Function (CDF)*.



Project Description

This field is provided for the user to document the analysis with any information for identification purposes.

Random Number Seed

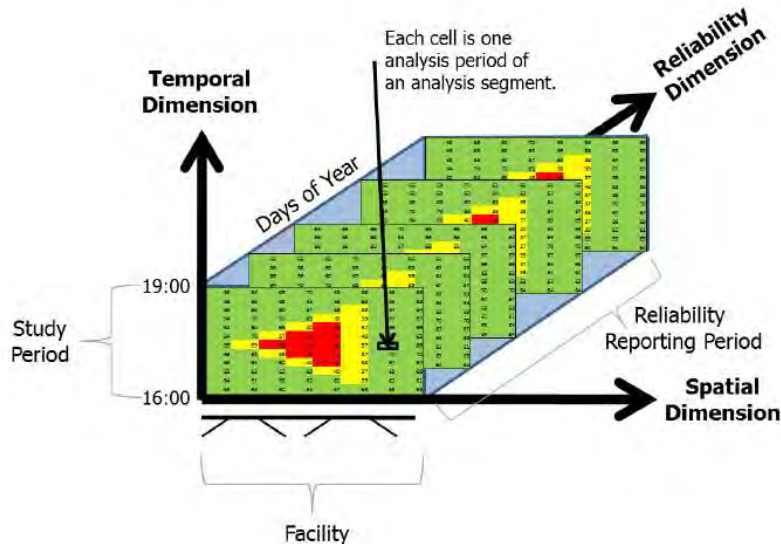
A random number seed is used with the Monte Carlo methods in the reliability methodology. A seed is used so that the sequence of random events can be reproduced. Unique seed numbers are separately established for weather events and incidents. For a given set of two seed numbers, a unique combination of demand levels, weather events, incidents, and work zones is estimated for each analysis period in the reliability reporting period.

Reliability Rating

The percentage of vehicle miles traveled (or vehicle kilometers traveled in metric) on the freeway facility that experiences a TTI less than 1.33. This threshold approximates the points beyond which travel times become much more variable (unreliable).

Reliability Reporting Period (RRP)

The specific set of days over which travel time reliability is computed; for example, all non-holiday weekdays in a year. The RRP represents the third dimension that extends the freeway facility core methodology and is illustrated in the exhibit found below by the series of rectangles (scenarios).



The Start Date indicates the beginning date of the RRP, the End Date indicates the final date of the RRP, and the days checked off indicate which days of the week are considered within the timeframe of the RRP.

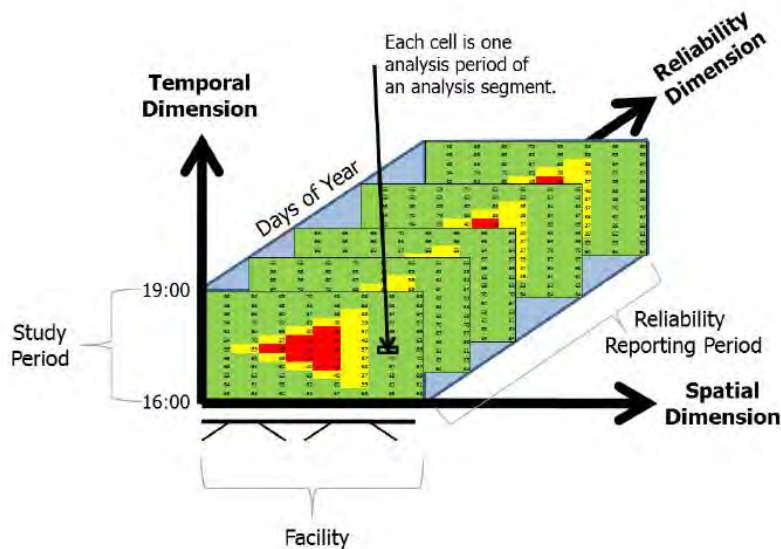
The RRP can be as long as one calendar year, although shorter periods are also possible. A one-year RRP is most typical, as it encompasses all day-to-day, and month-to-month variability in demand, as well as all weather and incident effects. However, shorter RRP's can be used to focus on reliability during specific analysis periods. The minimum recommended RRP is one month to capture sufficient variability in demand and other factors.

Reset to Default Ratios

The 'Reset to Default Ratios' button is provided to undo changes to cells within the Default Freeways Demand Ratios table made by the user. If this button is clicked, all cells within the table will revert back to the default values.

Scenario

A single instance of a study period for the facility, having a unique combination of traffic demands, capacities, geometries, and free-flow speeds represented in its analysis periods. Each rectangle in the exhibit found below represents a unique scenario, or in other words one day of the year.



Scenario Generation

The process of enumerating the various combinations of factors including demand, weather, incidents, and scheduled work zones, and calculating their probability of occurrence is termed *freeway scenario generation*.

The scenario generator develops a set of scenarios reflecting conditions that the freeway facility may experience during the reliability reporting period. Each scenario represents a single study period (typically several hours long) that is fully characterized in terms of demand and capacity variations in time and space. The data supplied to the scenario generator are expressed as multiplicative factors (CAFs, SAFs, and demand adjustment factors [DAFs]) or additive factors (number of lanes) that are applied to the base free-flow speed, demand, capacity, and number of lanes.

The scenario generation process includes the following steps:

- Adjusting the base demand to reflect day-of-week and month-of-year variation associated with a given scenario;
- Generating inclement weather events on the basis of their local probability of occurrence in a given time of year and adjusting capacities and free-flow speeds to reflect the effects of the weather events;
- Generating various types of incidents on the basis of their probability of occurrence and adjusting capacities to reflect their effects; and
- Incorporating analyst-supplied information about when and where work zones and special events occur, along with any corresponding changes to the base demand or geometry.

The results from these steps are used to develop one scenario for each study period in the reliability reporting period.

The Scenario Generation Settings allow the user to indicate whether or not to include Demand, Weather, Incident, and/or Work Zone in scenario generation.

Scenario ID

Scenarios generated from the reliability analysis are numbered in a natural order (1, 2, 3, etc.). The scenario IDs are numbered starting with the earliest demand combination (i.e., Jan-Mon comes before Jan-Tue).

Scenario ID for Special Event

This is provided for the user to enter the appropriate scenario for the special event to be added.

Scenario Name

This is provided for the user to enter a name that describes the corresponding special event.

Segment ID

The segments of a facility are numbered in a natural order (1, 2, 3, etc.). The segment ID number refers to the number of the segment found in the Base Dataset Facility graphic.

Semi-Standard Deviation

A one-sided standard deviation, with the reference point being free-flow travel time (or $TTI=1$) instead of the mean. It reflects the mean variability from free-flow conditions.

Special Event Buttons

On the Special Event page, the user can add and delete special events to be included in the reliability analysis. The “Add Special Event” button allows the user to add a special event for the preselected scenario. The “Delete Special Event” button allows the user to delete one or multiple special events at a time. The user must select the special event(s) to be deleted before clicking the button.

Special Events

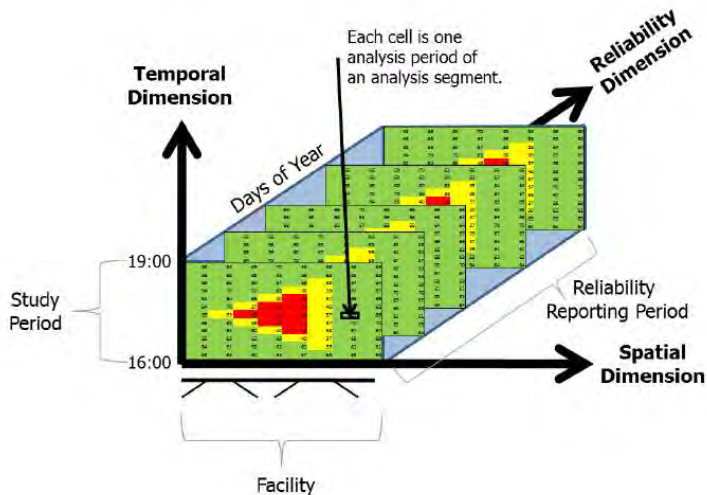
Special events are short-term events, such as major sporting events, concerts, and festivals that produce intense traffic demands on a facility for limited periods. Special traffic control procedures may need to be implemented to accommodate the traffic demands. The analyst should identify whether any events that occur in or near the study area warrant special treatment. If so, a schedule for the event (dates, starting times, typical duration) should be obtained. Some types of events also have varying intensities that will require separate treatment (e.g., a sold-out baseball game compared with a lower-attendance midweek game). Recurring events may have developed special traffic control procedures; if so, these plans should be consulted to identify any changes required from base conditions. Each combination of special event venue and event intensity to be included in the analysis will need to be specified.

Speed Adjustment Factor (SAF)

Factor used to allow the user to adjust speed based on a combination of different sources, including weather and work zone effects. The SAF may also be used to calibrate the estimated FFS for local conditions or other effects that contribute to a reduction in FFS. For example, poor pavement conditions or sun glare may result in drivers reducing their speeds even under low-volume conditions.

Study Period

The time interval within a day for which facility performance is evaluated. It consists of one or more consecutive analysis periods, represented by the rows in the rectangles in the exhibit found below. In this example, the study period is 3 h long, running from 4 p.m. to 7 p.m. (i.e., 16:00 to 19:00 hours).



Time Analyzed

This field is provided to document the time frame of the analysis as morning peak, afternoon peak, existing conditions, future projections, etc.

Traffic Demand

The methodology accounts for demand variability by adjusting the traffic demands for the analysis periods included in the various scenarios. This is done through the use of a *demand multiplier*, which is the ratio of the daily (weekday-month combination) facility demand to the average daily traffic (or to any combination of day of week and month of year). A second adjustment is needed to factor the demand measured on the specific day-month combination *in the base scenario* to any other day-month combination in the year. Traffic demand variation for different hours of the day is already accounted for in the base scenario obtained from the HCM Chapter 10 core facility analysis.

For example, if the *base scenario* demand data were gathered on a Monday in January that has a demand multiplier of 0.85, and a demand scenario is being tested on a Friday in June that has a demand multiplier of 1.10, then the base scenario demands should be factored by a ratio of $1.10/0.85 = 1.29$ to create the demand profile for that Friday-in-June scenario. When considering all days of the week, there could be up to 84 demand combinations; for weekday-only analyses, there could be up to 60 demand combinations.

Traffic Incidents

Incidents are generated on the basis of their expected frequency of occurrence per study period (analysis hours in a day), in a given month on the facility. The analyst may opt to use default expected incident frequencies, may supply a facility-specific incident or crash rate, or may supply a 12-month table of facility specific expected frequencies of any incident type. The incident frequency represents the average number of all incidents experienced on the facility during the study period, and is allowed to vary in each month.

The method makes the following assumptions about a given incident:

- The incident start time is assigned stochastically to any analysis period, which is done automatically by the computational engine;
- The incident duration is assigned stochastically, on the basis of the severity-defined incident duration distribution;
- The incident location is assigned stochastically, weighted by the individual segment vehicle miles traveled (VMT) or vehicle kilometers traveled (VkmT); and
- The incident severity is assigned stochastically, on the basis of the distribution of incident severity.

Default adjustment factors for incidents are provided in Section 5 of HCM Chapter 11.

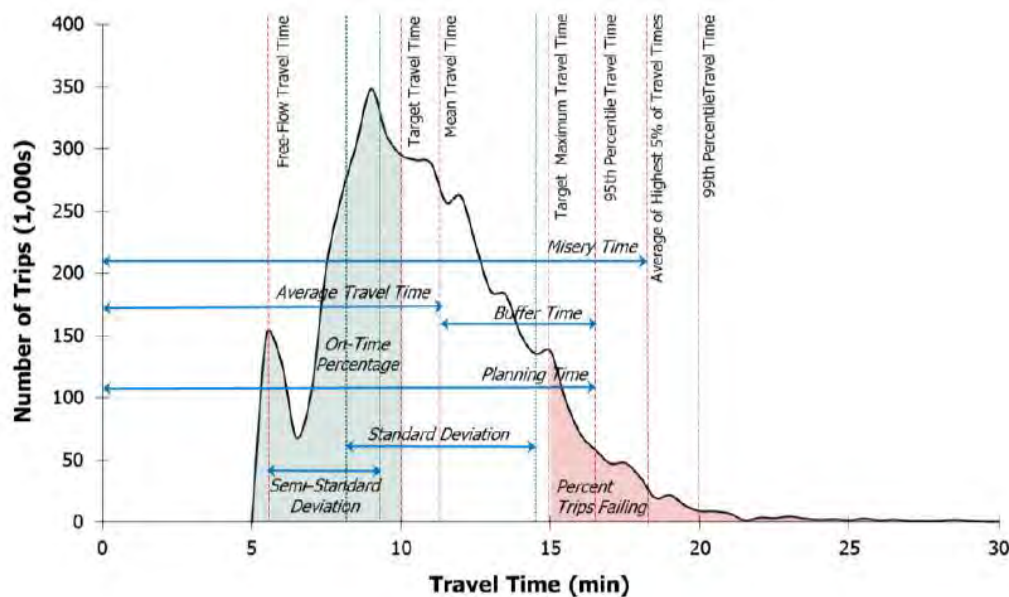
Travel Time

The time required for a vehicle to travel the full length of the freeway facility from mainline entry point to mainline exit point without leaving the facility or stopping for reasons unrelated to traffic conditions

Travel Time Distribution

The distribution of average facility travel times by analysis period across the reliability reporting period. Each 15-min analysis period within each scenario contributes one data point to the travel time distribution. It is *not* the distribution of individual vehicle travel times (or TTIs).

The travel time distribution and some of its key performance measures are illustrated in the exhibit found below.



Travel Time Index (TTI)

The ratio of the actual travel time to the free-flow travel time. By definition, TTI is always ≥ 1.0 . The TTI has an identical distribution to travel time, except that its values are indexed to the free-flow travel time.

Volume-to-Capacity (v/c) Ratio

The ratio of flow rate to capacity for a system element

Weather Event Duration

The duration associated with each weather event is the length of time of the weather event in minutes. The default duration for each weather event is the same for each location. If a duration is changed, the weather location originally selected will change to 'Custom'. To revert back to the default values, the user can set the location again.

Weather Event Probability

The probability of a weather event happening is displayed for each month based on the location and the study period start time and end time. The default probabilities are based on the Metropolitan Weather Database for Freeway Reliability Analysis in Volume 4 of the HCM. If any of the probability defaults are changed, the weather location originally selected will change to 'Custom'. To revert back to the default values, the user can set the location again.

Weather Events

Weather events are generated on the basis of their probability of occurrence during a given month. The scenario generation process accounts for ten categories of severe weather events that have been shown to reduce capacity by at least 4%, along with a *non-severe weather* category that encompasses all other weather conditions and that generates no capacity, demand, or speed adjustments. Default capacity and speed adjustment factors for weather events are provided in Section 5 of HCM Chapter 11.

To capture the actual occurrences of various weather events, the analyst may use default weather data from any of 101 U.S. metropolitan areas, based on 2001-2010 weather records. These values are documented in HCM Chapter 25, Freeway Facilities: Supplemental.

Alternatively, the analyst may supply a 12-month by 11-weather-event matrix (132 total values) of local probabilities of each weather event, along with the average duration for each event (10 values). As mentioned earlier, different weather events are assigned stochastically to the various scenarios in a manner that will match their monthly occurrence based on the site's meteorological data.

Weather Type

There are different types of weather conditions. The HCM categorizes weather into 11 different types. These include: Medium rain, Heavy rain, Light snow, Light-medium snow, Medium-heavy snow, Severe cold, Low visibility, Very low visibility, Minimal visibility, and Non-severe weather.

The tables below provide default CAFs and SAFs by weather type and facility free-flow speed. Note that the changes in CAFs and SAFs for decreasing visibility shown in the exhibit may be counterintuitive, since they are based on a single site.

The SAF is applied to the base free-flow speed, and CAF is applied to the base capacity, both of which are calculated in the respective methodological chapters for the various freeway segment types. Both may also have been adjusted in the process of calibrating the core facility in Chapter 10 of the HCM. The adjustment factors below should be applied in addition to any prior CAF and SAF calibration.

Default CAFs by Weather Type:

Weather Type	Weather Event Definition	Capacity Adjustment Factors				
		55 mi/h	60 mi/h	65 mi/h	70 mi/h	75 mi/h
Medium rain	> 0.10-0.25 in/h	0.94	0.93	0.92	0.91	0.90
Heavy rain	> 0.25 in/h	0.89	0.88	0.86	0.84	0.82
Light snow	>0.00 – 0.05 in/h	0.97	0.96	0.96	0.95	0.95
Light-medium snow	>0.05 – 0.10 in/h	0.95	0.94	0.92	0.90	0.88
Medium-heavy snow	>0.10 – 0.50 in/h	0.93	0.91	0.90	0.88	0.87
Heavy snow	>0.50 in/h	0.80	0.78	0.76	0.74	0.72
Severe cold	<-4°F	0.93	0.92	0.92	0.91	0.90
Low visibility	0.50 – 0.99 mi	0.90	0.90	0.90	0.90	0.90
Very low visibility	0.25 – 0.49 mi	0.88	0.88	0.88	0.88	0.88
Minimal visibility	< 0.25 mi	0.90	0.90	0.90	0.90	0.90
Non-severe weather	All conditions not listed above	1.00	1.00	1.00	1.00	1.00

Source: Zegeer et al. (1).

Note: Speeds given in column heads are free-flow speeds.

Default SAFs by Weather Type:

Weather Type	Weather Event Definition	Speed Adjustment Factors				
		55 mi/h	60 mi/h	65 mi/h	70 mi/h	75 mi/h
Medium rain	> 0.10-0.25 in/h	0.96	0.95	0.94	0.93	0.93
Heavy rain	> 0.25 in/h	0.94	0.93	0.93	0.92	0.91
Light snow	>0.00 – 0.05 in/h	0.94	0.92	0.89	0.87	0.84
Light-medium snow	>0.05 – 0.10 in/h	0.92	0.90	0.88	0.86	0.83
Medium-heavy snow	>0.10 – 0.50 in/h	0.90	0.88	0.86	0.84	0.82
Heavy snow	>0.50 in/h	0.88	0.86	0.85	0.83	0.81
Severe cold	<-4°F	0.95	0.95	0.94	0.93	0.92
Low visibility	0.50 – 0.99 mi	0.96	0.95	0.94	0.94	0.93
Very low visibility	0.25 – 0.49 mi	0.95	0.94	0.93	0.92	0.91
Minimal visibility	< 0.25 mi	0.95	0.94	0.93	0.92	0.91
Non-severe weather	All conditions not listed above	1.00	1.00	1.00	1.00	1.00

Source: Zegeer et al. (1).

Note: Speeds given in column heads are free-flow speeds.

Work Zone

A work zone is a segment of highway in which maintenance or construction operations reduce the number of lanes available to traffic or affect the operational characteristics of traffic flowing through the segment.

This portion of the analysis pertains exclusively to scheduled, significant work zone events. Minor patching and repair activities are not treated as work zones, but these important activities can be treated as incident events in the procedure and may be added to the incident tally. As such, a work zone constitutes any activity that results in scheduled closures of the shoulder or one or more travel lanes. Typically, a work zone lasts multiple days or weeks. In some cases, it involves multiple stages, each with different shoulder- and lane-closure parameters.

The details of scheduled work-zone activities must be entered by the analyst and cannot be defaulted. A work-zone log should be entered in which the following information is input for each work-zone activity that is planned during the RRP:

- Calendar days of the start and end dates of the work-zone activity;
- Facility segment(s) and analysis periods impacted by the work-zone activity;
- Portions of the facility cross-section impacted by closures (i.e., shoulder, one-lane, or multiple-lane closures);
- Type of barrier used to separate traffic from the work activity (i.e., concrete or other hard barrier, or cones, drums, or other soft barrier);
- Regulatory speed limit in effect during the work zone activity; and
- Lateral separation between traffic and the work zone.

The methodology can accommodate multiple work-zone activities, each with its own sets of inputs. CAFs and SAFs for work zones have been developed by national research and are described in Section 4 of HCM Chapter 10, Freeway Facilities Core Methodology.

Work Zone Buttons

On the Work Zone page, the user can add, insert, or delete work zone events to be included in the reliability analysis. The 'Work Zone Event +' button allows the user to add work zone events. An unlimited number of work zone events can be added. The 'Insert Work Zone Event' button allows the user to insert a work zone event in between existing work zone events. The user must select a work zone event to insert a new work zone event before it. The 'Work

Zone Event -' button allows the user to delete one or multiple work zone events at a time. The user must select the work zone event(s) to be deleted before clicking the button.

Work Zone Duration Analysis Period

This number specifies how many analysis periods the work zone event lasts.

Work Zone End Date

This is the date the work zone event finishes.

Work Zone Speed Limit

The work zone speed limit is the speed limit, in miles per hour (or kilometers per hour in metric), of the work zone. Higher work zone speed limits and higher speed ratios result in higher work zone FFS.

Work Zone Start Date

This is the date the work zone event begins.

Work Zone Start Period

This is the beginning analysis period for the work zone event.

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