Oregon Department of Transportation

Using HERS-ST for CMS Analysis

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EXECUTIVE STATEMENT

The primary function of the Congestion Management System (CMS) for the Oregon Department of Transportation (ODOT) is to identify and monitor congestion along the roadway network that composes the Oregon State Highway System. ODOT uses the state version of the Highway Economic Requirements System (HERS-ST) to evaluate preliminary CMS analysis, such as calculating the roadway capacity and identifying congestion for segments on the mainline of the state highway system; congestion being defined by the Highway Mobility Standards identified in the 1999 Oregon Highway Plan (OHP)[1]. Additional analysis is conducted through a secondary post-processing method to evaluate general performance measurements for all roadway segments under consideration, including the volume-to-capacity ratio (v/c) and average daily traffic-to-capacity ratio (adt/c).

INTRODUCTION

The Oregon Department of Transportation uses a number of management systems to evaluate and preserve the integrity of Oregon State Highway System. The Oregon Transportation Management System (OTMS) Unit is entrusted with the responsibility of coordinating the interaction of data between the different management systems, for the purpose of facilitating the evaluation of system level condition and performance. Oregon's Congestion Management System is one of the primary management systems used by decision-makers to develop, evaluate and implement improvement strategies for the state highway system. The CMS analysis is provided in a semi-interactive format on the internet, in an overlaying process with graphical information from other management systems and data sources. All analysis associated with CMS is developed in-house, and is available for review on ODOT's internet website[2].

The primary function of Oregon's CMS is to identify and monitor congestion across the Oregon State Highway System network. The CMS process calculates the roadway capacity and outputs performance measures in a useful manner for decision-makers who evaluate highway system improvements.

The fundamental software model used for Oregon's CMS analysis is the state's version of HERS-ST, which is developed and maintained by the Federal Highway Administration (FHWA) and is freely available from their internet website[3]. The HERS-ST software incorporates the standard Highway Performance Monitoring System (HPMS)[4] dataset

[1] http://www.oregon.gov/ODOT/TD/TP/docs/orhwyplan/hwyplan/goal1.pdf, Pages 38-42
[2] https://keiko.odot.state.or.us/whalecomf967440f33ed138991f0be107f56/whalecom0/main/index.htm
[3] http://www.fhwa.dot.gov/infrastructure/asstmgmt/hersindex.htm.
[4] http://www.fhwa.dot.gov/ohim/hpmsmanl/hpms.htm.

format, as presented in Appendix A, to evaluate present and future roadway needs or deficiencies on the highway system.

The HERS-ST model uses a number of sophisticated internal sub-models to forecast and calculate short and long-range highway deficiencies. The prediction models include **Speed Model** (Section 5.4[5]), **Pavement Deterioration Model** (Section 5.1[5]), **Travel Forecast Model** (Section 5.6[5]), **Fleet Composition Model** (Section 2.11[5]), **Widening Feasibility Model** (Section 4.3[5]) and a **Capacity Model** (Section 4.4[5]). Oregon's CMS analysis specifically incorporated the **Capacity Model** calculations to estimate sectional capacity for each HPMS record and to identify congestion for the highway segments. The capacity analysis is based on procedures derived from the 2000 edition of the Highway Capacity Manual (HCM). The general capacity analysis is based on the "Procedures for Estimating Highway Capacity" found in Appendix N of the HPMS Field Manual[6], updated to incorporate algorithms from the HCM 2000.

> *Note that though HERS-ST has the ability to evaluate future year congestion by calculating the number of lanes needed in a future design year to adequately accommodate the projected traffic volumes in said year, ODOT's CMS analysis is **only** concerned with base year congestion for reasons beyond the scope of this report.*

The focus of this paper is to identify how the CMS analysis is developed using HERS-ST, rather than how the analysis is being used by decision-makers. The latter subject will be covered in a separate report. It should be understood that CMS analysis is a dynamic process, and as such is a "work in progress" and subject to change. There are a number of performance measure improvements that are continually being enhanced with HERS-ST, which will be included in a subsequent report.

HISTORICAL ANALYSIS

The HERS-ST is a long-range deficiency analysis model used by states to evaluate existing and future needs on the highway system. As an analytical model, HERS-ST evaluates a dataset of highway records, as defined in a general HPMS format, to evaluate the current condition and performance of the highway system, as well as identifying future highway deficiencies and a subsequent series of improvement candidates that will rectify the needs. In short, the analytical process uses engineering concepts to identify long-term deficiencies on the highway system, based on the defined standard measures for each scenario and then selects the most economically prudent improvement according to economic criteria and funding levels.

[5] U.S. Department of Transportation, Federal Highway Administration, *Highway Economic Requirements System – State Version Technical Report*, Washington, D.C., August 2005.
[6] http://www.fhwa.dot.gov/ohim/hpmsmanl/appn.htm.

ODOT began using HERS-ST in 2001 to evaluate roadway congestion for CMS. At that point in time, it was determined that the Capacity Model within HERS-ST (version 1.0) was a useful tool for evaluating capacity on each HPMS record within the database, using revised or modified HCM formulas developed for the 1987 HCM manual. Additional research revealed that only a few data input items from the standard HPMS dataset were actually used for calculation within the Capacity Model, so the coded formulas were rewritten in an Excel spreadsheet using VBA[7]. In essence, ODOT treated the CMS input dataset as a subset of the HPMS dataset. A list of data elements used in the CMS input dataset is shown in Figure 1.

Figure 1
Data Elements used in CMS (version1.0)

Section Length(xxxx.xx)	Type of Terrain
Rural/Urban Designation	Percent of Length with Sight Distance of at least 1500
Urbanized Area Code	Posted Speed Limit
Functional Classification	Weighted Design Speed
Generated Functional System Code	Percent Single Unit Commercial Vehicles
Type of Facility	Percent Combination Commercial Vehicles
AADT for Year Designated	K-Factor
Number of Through Lanes	Directional Factor
Access Control	Type of Development
Median Type	Right Turning Lanes
Median Width	Left Turning Lanes
Lane Width	Typical Peak Percent Green Time
Right Shoulder Width	Number of At-Grade Intersections w/ Stop Signs
Left Shoulder Width	Number of At-Grade Intersections w/ Signals
Peak Parking	Number of At-Grade Intersections w/ No Control

For each record segment inputted, the spreadsheet calculates and outputs the capacity, the volume-to-capacity ratio, and the average daily traffic-to-capacity ratio.

CMS DATASETS

The HERS-ST model evaluates the base and future condition of the highway system, as defined in the HPMS dataset. The model was originally developed to evaluate the data that state highway departments annually submit to FHWA, as specified in the HPMS Field Manual[8]. The standard dataset contains information that describes each highway section to be analyzed. All states can make use of the HERS-ST model by using the submittal datasets, which they are required to submit annually to FHWA.

[7] A copy of the HERS-HCM Excel Spreadsheet is available @ http://www.oregon.gov/ODOT/TD/TP/tpauCM.shtml/HERS_HCM.XLS

[8] U.S. Department of Transportation, Federal Highway Administration, *Highway Performance Monitoring System Field Manual*, Washington, D.C., December 2000. - available on-line @ http://www.fhwa.dot.gov/ohim/hpmsmanl/hpms.htm

Currently, the standard HPMS dataset contains 98 data items per input record, of which only 70 data elements are actually used within the HERS-ST model, which means that 28 data items are not used and can be zero-filled. Oregon uses these columns to carry additional data elements for post-processing, such as Region and District flags, Bridge Management System (BMS) and Pavement Management System (PMS) identification numbers or other non-HPMS related information for each section record. Research for CMS application discovered that only 30 data elements (see Appendix B) are actually required for the capacity calculations, meaning a number of additional data elements can be set to a default level in order to reduce the amount of data development effort required to create an HPMS dataset for HERS-ST. Note that the datasets must still be in the HPMS format. However, the default values have no effect on the Capacity Model calculations. The reader must keep in mind that though the HERS-ST model contains six sub-models, only the application of one is being discussed here.

> ***Warning****: The CMS dataset, as described here,* ***<u>is not useful</u>*** *for any other type of analysis other than that discussed here. The trade off with this process is it allows the analyst to quickly build HPMS type datasets for analysis, but the datasets are only useful for said purpose. In addition, the CMS analysis is* ***<u>only</u>*** *applicable with base year congestion analysis and* ***<u>is not conducive</u>*** *for evaluating future congestion*

SENSITIVITY TESTING

The CMS analysis initially developed in an Excel spreadsheet was originally sourced from HERS-ST v1.0. Sensitivity testing was conduced on HERS-ST v3.2 to evaluate analysis results based on default values used within a standard HPMS dataset. The test analysis revealed identical results after running the test dataset, regardless of whether the default values were used or not. For capacity analysis, a comparison of software version outputs demonstrated no variance for CMS practice.

POST-PROCESSING

Performance measures are developed to adequately evaluate the congestion on the highway system. By nature, these works are a dynamic process, subject to change and improve as the data and technology improves. The bottom-line goal is to provide the decision-maker with the best information available to properly fulfill their obligation to their customers (i.e., the general tax paying public).

The CMS output is post-processed to evaluate several elementary performance measures, as defined below.

Compare V/C Standards – Existing vs. Maximum Allowable

Acceptable levels of congestion are defined by the mobility standards found in the 1999 Oregon Highway Plan. To evaluate this, a process was developed to compare the existing v/c outputted from HERS-ST, with the maximum allowable v/c standards defined by Table 6 & 7 (the OHP mobility standards). Each section is classified into one of three categories based on a comparison of the existing roadway v/c with OHP's maximum allowable v/c. Due to the mushiness of the input data, a ±5% error was applied to the allowable v/c. In other words, if the maximum v/c was 0.70, then anything under 0.65 was considered below the maximum, anything above 0.75 exceed the maximum allowable threshold and anything between 0.65 and 0.75 was too close to the maximum level to be able to clearly know (meaning it could be over or could be under). Subsequently, each dataset record was classified in one of the three categories: below capacity, at capacity or over capacity.

Degree of Congestion

The average daily adt/c was calculated to evaluate the degree of daily congestion. Nine categories for Daily Congestion are subjectively defined in Figure 2.

Figure 2
Daily Congestion Range (AADT/C)

Level	Name	Description	AADT/C Range	
			Lower	Upper
1	Uncongested	No decrease in speeds during the peak hour.	0.00	6.75
2	Uncongested to Moderately		6.75	8.25
3	Moderately Congested	Speeds decrease slightly during portions of the peak hour.	8.25	9.25
4	Moderately to Congested		9.25	9.75
5	Congested	Speeds decrease significantly during portions of the peak hour.	9.75	10.75
6	Congested to Very		10.75	12.25
7	Very Congested	Speeds decrease substantially for substantial portions of the peak hour.	12.25	13.75
8	Very to Extremely		13.75	15.25
9	Extremely Congested	Speeds decrease substantially for more than the peak hour.	15.25	24.00

Percent that Experienced Congestion

One of the basic calculations that can be derived from the HPMS dataset is the vehicle miles traveled (VMT). A quick performance measure was developed to evaluate the percentage of VMT on the system that daily experienced congestion. The segment data was aggregated to five mile sections as a smoothing process to remove sharp data edges associated with data input errors (i.e., the effects of point congestion) and a weighted level of congestion was developed. The five-mile sections were selected to closely match the data segments associated with the Crash Unit data.

The selection of the five categories listed below is subjective, but are meant to help identify the percentage of VMT traveling on any given five mile section that experiences congestion during the peak period:

- = 0% of VMT Experiencing Congestion
- > 0% & <= 25% - VMT Experiencing Congestion
- > 25% & <= 50% - VMT Experiencing Congestion
- > 50% & <= 75% - VMT Experiencing Congestion
- > 75% - VMT Experiencing Congestion

OPERATION PERFORMANCE MEASURES

Several years ago, ODOT partnered with Texas Transportation Institute (TTI) to develop and evaluate operational performance measures (OPM)[9], based on HERS-ST's internal calculations for the existing system condition. The primary purpose of the OPM study was to evaluate the application of HERS-ST for analysis when existing ITS data is either missing or in short supply.

Up to this point, all previous analysis discussion is associated with the CMS sub-group dataset, comprised of the 30 HPMS data elements shown in Appendix B. With OPM, the performance measure analysis is centered on travel speed and its associated delay, which involves analysis using the Speed Model. Data requirements for Speed Model analyses as yet are not completely evaluated and will be discussed in a revised version of this report. It is anticipated that the number of required HPMS data items will double.

Note that additional HPMS data elements are required for evaluating speed and delay.

There are two types of output provided by HERS-ST, **Section Condition** analysis and **System Condition** analysis. It is important to distinguish between the two because there are significantly different delay analysis elements available to the analyst based on which type of output is selected.

The **Section Condition** output provides detailed analysis of the highway system at the dataset record level (i.e., for each section of input data) for each funding period (generally 5 years). The output provides a section-by-section description of numerous data elements

[9] A copy of the TTI report can be found at http://mobility.tamu.edu/resources/odot_op_perf_measures_final.pdf.

such as type of deficiencies evaluated, and type and cost of improvements simulated. The total daily traffic is broken into three demand periods for all capacity, speed and delay analysis: peak period in the peak direction, peak period in the counter-peak (opposite) direction and off-peak. However, the peak/off-peak analysis is only available for multi-lane roadways (2 lanes or more per direction). Subsequently, only the average speed, capacity and delay are available for standard two-lane, two-way highways.

The **System Conditions** output aggregates the detailed record level data (section data) identified in the **Section Condition** data to a level, aggregated by functional classification and funding period. The **System Condition** analysis provides an aggregated analysis for the entire system (be it a corridor system or a representation of some type of district or region boundary area) for the entire analysis period (generally 20 years). The output table describes the system information or statistics such as the total vehicle miles of travel, total cost of improvements, simulated pavement conditions, and the total amount of delay on the system.

For CMS, the most important set of data elements produced from the **System Conditions** are associated with delay. There are three kinds of delay estimated in HERS-ST: zero, incident, and congestion. <u>Zero-volume delay</u> is the delay associated with traffic control devices (stop signs and traffic signals). Zero-volume is the expected delay that a single vehicle would encounter even if it were the only vehicle on the road. Zero-volume delay only exists for sections controlled with stop signs or traffic signals, and as such is not calculated for uncontrolled sections. <u>Incident delay</u> is the delay associated with crashes. HERS-ST estimates delay due to crashes through a secondary (or inferred) process, where first HERS-ST model estimates the delay cost of crashes, and then back-calculates the delay estimates due to crash incidents from the cost calculations. <u>Congestion (or recurring) delay</u> is the average delay due to non-incident congestion.

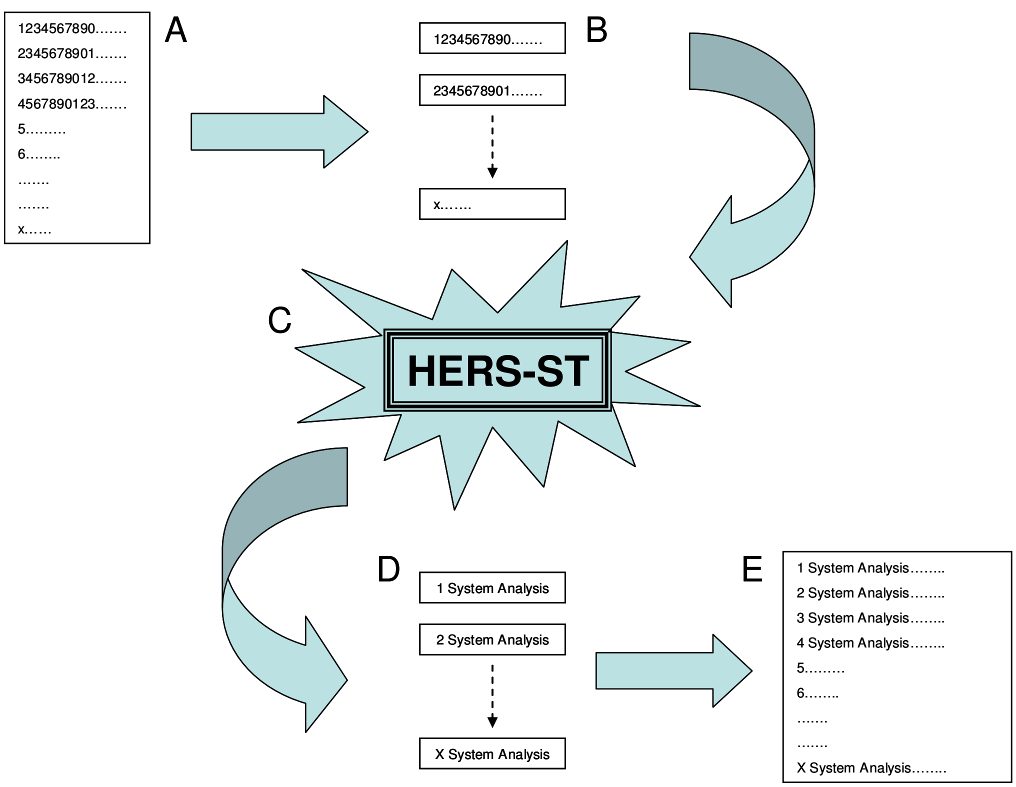
There are two delay procedures used within HERS-ST. The first process is used for all freeways, sections with traffic signals (no stop signs), and other multi-lane sections where there are two or more lanes per direction of traffic flow. These delay procedures generated delay estimates for incident delay (and the "NonIncident Travel Rate", which is the inverse of speed) during the three demand periods; peak, counter-peak and off-peak at the sectional level (i.e., **Section Condition** output). The second process is used to generate separate estimates of zero-volume delay, incident delay and recurring congestion delay at the system level for all other roadway configurations, which are predominately two-lane, two-way highways (i.e., **System Condition** output).

> *Note that the zero, incident, and congestion delay elements can only be gathered at from the System Condition output.*

A number of data elements required for the performance measure calculations are automatically outputted in the sectional condition data files. However, several key delay data elements are only available at the aggregated system condition level. In order to capture the key delay information at the individual disaggregated record level, each record must be analyzed as a pseudo dataset using HERS-ST. In order to accomplish this, the initial HPMS formatted dataset must be parsed out to a number of single record HPMS datasets, each containing a single row of data.

ODOT developed a parsing process, using R-script, to; 1) disaggregate the original HPMS dataset into individual datasets, 2) run a batch program for HERS-ST analysis and 3) (re)aggregate the individual System Condition output back into a dataset that can be linked back to the original HPMS dataset. This parsing or disaggregated process can be seen in **Figure 3**, and will be quickly described below.

Figure 3
HPMS Dataset Parsing Analysis Process



The process begins with a standard HPMS dataset, identified as **A, (see Figure 3)**. As an example, if there were 500 records in the original HPMS dataset, this process would parse out the data into 500 separate HPMS datasets, each dataset containing one single record (i.e., row of data), shown as **B**. Each individual HPMS dataset is then run through HERS-ST (see **C**) to develop the delay elements identified in the **System Condition** output (see **D)**. In this example, the HERS-ST batch process evaluates 500 datasets and creates 500 separate outputs. Finally, the R-script joins (or aggregates) the individual

HPMS datasets back to a single dataset level to match the original HPMS dataset. In this example, the 500 individual files are aggregated back into a single file containing 500 records (see **E**). At this point the redeveloped dataset contains the delay elements for each record, which are only available at the higher system level. In other words, each individual record is treated as if they were an entire system unto themselves.

Additional analysis of the model and software code is required to properly determine the correct number of HPMS dataset elements required to make adequate use of the Speed Model within HERS-ST. A revised report to address this deficiency will soon follow.

CONCLUSION

The CMS analysis, as presented here, is an excellent tool for providing a quick, overall picture of congestion issues on the Oregon State Highway System. This technique is most useful for evaluating system level analysis at the "20,000 foot" level. A more site-specific analysis is required to develop the appropriate congestion analysis at a detailed project level.

ODOT has used the HERS-ST model to assist in evaluating v/c and adt/c thresholds, as a source for identifying and assessing congestion on the state highway system. Subsequently, this process provides decision-makers yet another practical data source that is useful for appraising the condition and performance of the Oregon State Highway System.

Development and application of CMS performance measures is an on-going process, as new measures are evaluated and adopted over time. Oregon DOT has confidence in applying the Capacity Model within HERS-ST to CMS analysis and is stretching to investigate incorporating the Speed Model in subsequent analysis. This effort is dynamic in nature and will continue to evolve with better data and improved modeling.

HPMS Formatted Data Items Used (✓) by HERS-ST (*Items not used are shaded blue and italic*)

Used	#	Variable Name	Description
✓	1	Yr	Year
✓	2	State	State Code
✓	3	Metric	Reporting Units (English or metric)
✓	4	Cnty	County Code
✓	5	SecID	Section Identification
✓	6	Sample	Is Standard Sample
	7	*Donut*	*Is Donut Sample*
--	8	SCF [1]	State Control Field
	9	*Grouped*	*Is Section Grouped*
--	10	LRSID [1]	LRS Identification
--	11	BegMP [1]	LRS Beginning Point
--	12	EndMP [1]	LRS Ending Point
✓	13	RurUrb	Rural/Urban Designation
	14	*UrbSampTech*	*Urbanized Area Sampling Technique*
	15	*UrbAreaCode*	*Urbanized Area Code*
	16	*NonAttainCode*	*NAAQS Nonattainment Area Code*
✓	17	FC	Functional System Code
✓	18	GFC	Generated Functional System Code
	19	*NHS*	*National Highway System*
	20	*Unblt*	*Planned Unbuilt Facility*
	21	*InstRtNum*	*Official Interstate Route Number*
	22	*RouteSign*	*Route Signing*
	23	*RouteSignQual*	*Route Signing Qualifier*
	24	*SingRtNum*	*Signed Route Number*
	25	*GovOwn*	*Governmental Ownership*
	26	*SpecSys*	*Special Systems*
✓	27	FT	Type Of Facility (One Way Or Two Way)
	28	*TrkRoute*	*Designated Truck Route*
	29	*Toll*	*Toll*
✓	30	SLEN	Section Length
	31	*DonutGrpID*	*Donut Area Sample AADT Volume Group Identifier*
	32	*StdGrpID*	*Standard Sample AADT Volume Group Identifier*
✓	33	AADT	Annual Average Daily Traffic
✓	34	TLanes	Number Of Through Lanes
✓	35	IRI [2]	International Roughness Index
✓	36	PSR [2]	Present Serviceability Rating (Pavement Condition)
✓	37	HOV	High Occupancy Vehicle Operations
	38	*HWSurvSysA*	*Electronic Surveillance*
	39	*HWSurvSysB*	*Metered Ramps*
	40	*HWSurvSysC*	*Variable Messages Signs*
	41	*HWSurvSysD*	*Highway Advisory Radio*
	42	*HWSurvSysE*	*Surveillance Cameras*
	43	*HWSurvSysF*	*Incident Detection*
	44	*HWSurvSysG*	*Free Cell Phone*
	45	*HWSurvSysH*	*On-Call Service Patrol*
	46	*HWSurvSysI*	*In-Vehicle Signing*
✓	47	SampID	HPMS Sample Identifier
	48	*DonutExpFact*	*Donut Area Expansion Factor*
✓	49	ExpFac	Standard HPMS Sample Expansion Factor
✓	50	Surf	Surface/Pavement Type
✓	51	SNorD	Structural Number or Slab Thickness
✓	52	Climate	General Climate Zone

Used	#	Variable Name	Description
✓	53	ImpYr	Year Of Surface Improvement
✓	54	LaneW	Lane Width
✓	55	Access	Type of Access Control
✓	56	MedT	Median Type
✓	57	MedW	Median Width
✓	58	ShldT	Shoulder Type
✓	59	RShldW	Right Shoulder Width
✓	60	LShldW	Left Shoulder Width
✓	61	PkPark	Peak Parking
✓	62	WdFeas	Widening Feasibility
✓	63	LCurveA	Length of Class A Curves
✓	64	LcurveB	Length of Class B Curves
✓	65	LcurveC	Length of Class C Curves
✓	66	LcurveD	Length of Class D Curves
✓	67	LcurveE	Length of Class E Curves
✓	68	LCurveF	Length of Class F Curves
✓	69	HorAln	Horizontal Alignment Adequacy
✓	70	Terrn	Type Of Terrain
✓	71	VerAln	Vertical Alignment Adequacy
✓	72	LGradeA	Length of Class A Grades
✓	73	LGradeB	Length of Class B Grades
✓	74	LGradeC	Length of Class C Grades
✓	75	LGradeD	Length of Class D Grades
✓	76	LGradeE	Length of Class E Grades
✓	77	LGradeF	Length of Class F Grades
✓	78	PSD	Percent Passing-Sight Distance
✓	79	WDS [3]	Weighted Design Speed
✓	80	SpdLim	Posted Speed Limit
✓	81	PcPkSu	Peak Percent of Single-Unit Trucks
✓	82	PcAvSu	Average Daily Percent of Single-Unit Trucks
✓	83	PcPkCm	Peak Percent of Combination Trucks
✓	84	PcAvCm	Average Daily Percent of Combination Trucks
✓	85	KFac	K-Factor
✓	86	DFac	Directional Factor
✓	87	PLanes	Number Of Peak Lanes
✓	88	LTurn	Left Turning Lanes
✓	89	RTurn	Right Turning Lanes
	90	*SigType*	*Prevailing Type of Signalization*
✓	91	PctGrn	Percent Green Time
✓	92	NSig	Number of At-Grade intersections - signals
✓	93	NStop	Number of At-Grade intersections - stop signs
✓	94	NOInts	Number of At-Grade intersections - other
✓	95	PkCap [3]	Peak capacity
	96	*VSF*	*Volume/Service Flow Ratio*
✓	97	FAADT	Future AADT
✓	98	FAADTYr	Year of Future AADT

1. Variable copied to output files but not otherwise used by HERS-ST (values passed through).
2. HERS-ST requires either IRI or PSR. If both are provided, the PSR/IRI indicator identifies the value to be used.
3. Optional inputs - will be calculated by HERS-ST if not coded.

CMS Data Items Shaped Yellow by HERS-ST (*Items not used are shaded blue and italic*)

Used	#	Variable Name	Description
✓	1	Yr	Year
✓	2	State	State Code
✓	3	Metric	Reporting Units (English or metric)
✓	4	Cnty	County Code
✓	5	SecID	Section Identification
✓	6	Sample	Is Standard Sample
	7	*Donut*	*Is Donut Sample*
--	8	SCF [1]	State Control Field
	9	*Grouped*	*Is Section Grouped*
--	10	LRSID [1]	LRS Identification
--	11	BegMP [1]	LRS Beginning Point
--	12	EndMP [1]	LRS Ending Point
✓	13	RurUrb	Rural/Urban Designation
	14	*UrbSampTech*	*Urbanized Area Sampling Technique*
	15	*UrbAreaCode*	*Urbanized Area Code*
	16	*NonAttainCode*	*NAAQS Nonattainment Area Code*
✓	17	FC	Functional System Code
✓	18	GFC	Generated Functional System Code
	19	*NHS*	*National Highway System*
	20	*Unblt*	*Planned Unbuilt Facility*
	21	*InstRtNum*	*Official Interstate Route Number*
	22	*RouteSign*	*Route Signing*
	23	*RouteSignQual*	*Route Signing Qualifier*
	24	*SingRtNum*	*Signed Route Number*
	25	*GovOwn*	*Governmental Ownership*
	26	*SpecSys*	*Special Systems*
✓	27	FT	Type Of Facility (One Way Or Two Way)
	28	*TrkRoute*	*Designated Truck Route*
	29	*Toll*	*Toll*
✓	30	SLEN	Section Length
	31	*DonutGrpID*	*Donut Area Sample AADT Volume Group Identifier*
	32	*StdGrpID*	*Standard Sample AADT Volume Group Identifier*
✓	33	AADT	Annual Average Daily Traffic
✓	34	TLanes	Number Of Through Lanes
✓	35	IRI [2]	International Roughness Index
✓	36	PSR [2]	Present Serviceability Rating (Pavement Condition)
✓	37	HOV	High Occupancy Vehicle Operations
	38	*HWSurvSysA*	*Electronic Surveillance*
	39	*HWSurvSysB*	*Metered Ramps*
	40	*HWSurvSysC*	*Variable Messages Signs*
	41	*HWSurvSysD*	*Highway Advisory Radio*
	42	*HWSurvSysE*	*Surveillance Cameras*
	43	*HWSurvSysF*	*Incident Detection*
	44	*HWSurvSysG*	*Free Cell Phone*
	45	*HWSurvSysH*	*On-Call Service Patrol*
	46	*HWSurvSysI*	*In-Vehicle Signing*
✓	47	SampID	HPMS Sample Identifier
	48	*DonutExpFact*	*Donut Area Expansion Factor*
✓	49	ExpFac	Standard HPMS Sample Expansion Factor
✓	50	Surf	Surface/Pavement Type
✓	51	SNorD	Structural Number or Slab Thickness
✓	52	Climate	General Climate Zone

Used	#	Variable Name	Description
✓	53	ImpYr	Year Of Surface Improvement
✓	54	LaneW	Lane Width
✓	55	Access	Type of Access Control
✓	56	MedT	Median Type
✓	57	MedW	Median Width
✓	58	ShldT	Shoulder Type
✓	59	RShldW	Right Shoulder Width
✓	60	LShldW	Left Shoulder Width
✓	61	PkPark	Peak Parking
✓	62	WdFeas	Widening Feasibility
✓	63	LCurveA	Length of Class A Curves
✓	64	LcurveB	Length of Class B Curves
✓	65	LcurveC	Length of Class C Curves
✓	66	LcurveD	Length of Class D Curves
✓	67	LcurveE	Length of Class E Curves
✓	68	LCurveF	Length of Class F Curves
✓	69	HorAln	Horizontal Alignment Adequacy
✓	70	Terrn	Type Of Terrain
✓	71	VerAln	Vertical Alignment Adequacy
✓	72	LGradeA	Length of Class A Grades
✓	73	LGradeB	Length of Class B Grades
✓	74	LGradeC	Length of Class C Grades
✓	75	LGradeD	Length of Class D Grades
✓	76	LGradeE	Length of Class E Grades
✓	77	LGradeF	Length of Class F Grades
✓	78	PSD	Percent Passing-Sight Distance
✓	79	WDS [3]	Weighted Design Speed
✓	80	SpdLim	Posted Speed Limit
✓	81	PcPkSu	Peak Percent of Single-Unit Trucks
✓	82	PcAvSu	Average Daily Percent of Single-Unit Trucks
✓	83	PcPkCm	Peak Percent of Combination Trucks
✓	84	PcAvCm	Average Daily Percent of Combination Trucks
✓	85	KFac	K-Factor
✓	86	DFac	Directional Factor
✓	87	PLanes	Number Of Peak Lanes
✓	88	LTurn	Left Turning Lanes
✓	89	RTurn	Right Turning Lanes
	90	*SigType*	*Prevailing Type of Signalization*
✓	91	PctGrn	Percent Green Time
✓	92	NSig	Number of At-Grade intersections - signals
✓	93	NStop	Number of At-Grade intersections - stop signs
✓	94	NOInts	Number of At-Grade intersections - other
✓	95	PkCap [3]	Peak capacity
	96	*VSF*	*Volume/Service Flow Ratio*
✓	97	FAADT	Future AADT
✓	98	FAADTYr	Year of Future AADT

1. Variable copied to output files but not otherwise used by HERS-ST (values passed through).
2. HERS-ST requires either IRI or PSR. If both are provided, the PSR/IRI indicator identifies the value to be used.
3. Optional inputs - will be calculated by HERS-ST if not coded.