Maryland Traffic Monitoring System Handbook

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Traffic Monitoring System Team

Data Services Engineering Division
Office of Planning and Preliminary Engineering
Maryland State Highway Administration

Table of Contents	Page No

1. Introduction

The Maryland Traffic Monitoring System Handbook provides review of activities regarding vehicle data collection by the Traffic Monitoring System (TMS) team of the Data Services Engineering Division (DSED) in the Office of Planning and Preliminary Engineering (OPPE) at the Maryland State Highway Administration (SHA).

2. Background

In 1997 as part of a major re-engineering effort DSED, then known as the Highway Information Services Division (HISD), was given responsibility for administering SHA's TMS that included development of a database to store data related to traffic counts. The maintenance of the permanent continuous count sites remained the responsibility of the Office of Traffic and Safety until 2006 at which time it was also transferred to DSED. Another major part of the re-engineering was the restructuring of all short term traffic counts, which are now performed by consultants under contract to SHA.

3. Traffic Monitoring System -Program Overview

3.1.1. Traffic monitoring is performed to collect data that describes the use and performance of the roadway system (TMG, 2013). [1]

3.1.2. The TMS program is responsible for the collection, processing, analysis and reporting of traffic volume, vehicle classification, and delay, vehicle occupancy, turning movement at intersections and other data as required in the State of Maryland.

3.1.3. The TMS program includes an Oracle database to store data related to traffic counts, an application with web interface to request special project related counts by traffic personnel as required, delivery of short term traffic counts by contractors and a reporting system providing access to all reviewed and validated traffic count data on the Maryland State Highway intranet site[2].

[1] Traffic Monitoring Guide 2013 Federal Highway Administration (TMG, 2013)
[2] http://www.roads.maryland.gov

3.1.4. Maryland's TMS Program includes 87 Continuous Count Sites using Automatic Traffic Recorders (ATRs) of which 21 that also currently perform vehicle classification counts based on Federal Highway Administration (FHWA) 13-bin 'Scheme F' vehicle classification.

3.1.5. There are over 8,850 short term (48-hour) Program count locations distributed throughout the state, that are counted on a three year or six year cycle.

3.1.6. In addition approximately 1,200 Special counts that include volume, vehicle classification, turning movement, and delay and vehicle occupancy are performed yearly and on an as-needed basis as requested by State Highway Traffic Engineers.

4. Terminology & Definitions

This section provides definitions of terms and the explanation of the meanings as used in the implementation of Maryland's TMS Program which quantifies traffic characteristics such as number, type, occupancy, turning movement, speed and direction of vehicles, pedestrians and bicycles.

4.1. Counting Methods

4.1.1. Manual: Visual observation using tally sheets or electronic counting boards to record results. This is usually considered the "ground truth" or the gold standard for accuracy but also very labor intensive and costly.

4.1.2. Automatic: Collection of traffic data using automatic electronic equipment either portable or permanently installed, designed to continuously record traffic flow in distinct time periods (e.g. durations of 5 min, 15 min, hourly, daily, weekly, and monthly from year to year).

4.2. Counting Equipment

4.2.1. Automatic Traffic Recorder (ATR): This is a permanently installed traffic device that continuously collects data 24 hours a day, 7 days a week for all days of the year.

4.2.2. Portable Traffic Recorder (PTR): This is an automatic traffic vehicle counter that is temporarily installed and collects data for short duration counts of up to a week.

4.2.3. Weigh-In-Motion (WIM): A WIM detector measures the dynamic tire forces applied to the roadway by a moving vehicle and converts those forces to weights.

4.3. Count Programs

4.3.1. The Continuous Count program consists of collecting, storing, reviewing, and reporting data from the permanent ATR network.

4.3.2. The Program Count program relies on short duration count sites, that collect 24-hour, 48-hour or 1-week of data to provide the spatial geographic coverage needed to generate traffic information on the state roadway system typically on a rotating schedule over a 3 or 6 year time period.

4.4. Count Location

4.4.1. Traffic counts are recorded at a specific point on the roadway referred to as a “count station” or “site’ but extrapolated to represent the entire segment or section of roadway by a linear referencing system (LRS) integration process.

4.4.2. Continuous Count Sites (also known as Permanent ATRs): These are locations reporting data 24 hours a day, 7 days a week for 365 days of the year.

4.4.3. Program Count Sites: These are locations where data is collected in a 24-hour, 48-hour, or one week duration. These sites are counted on either a 3 year or 6 year rolling cycle.

4.4.4. Special Count Sites: These are locations where short duration counts relating to turning movement, delay and occupancy data are collected.

4.5. Count Data Products

4.5.1. Annual Average Daily Traffic is the number that represents a typical traffic volume number any time or day of the year at a site.

4.5.2. A factor is a number that represents a ratio of one number to another number, used to normalize the data collected for variability during short duration counts.

4.5.3. Axle, Seasonal, Monthly, and Day-of-week (DOW) factors are computed from continuous count station data for use in adjusting short count data to estimates of AADT.

4.5.4. K, D, and Peak hour factors are computed from data collected at continuous count stations and are used in engineering analyses.

4.6. Count Data Review

4.6.1. Traffic count data that pass the Quality Analysis/Quality Control (QA/QC) process and are determined to be within normal parameters are marked as Valid (V). These data are published for utilization and are used in calculating other TMS products, such as Seasonal Factors.

4.6.2. Count Data that pass the QA/QC process but are determined to be outside normal parameters are marked as Valid with Reason (R). These data are used for AADT calculations.

4.6.3. Count data failing the QA/QC process initiates a manual review by the TMS team to evaluate the validity of the data to determine whether it matches the characteristics of the site. Any data determined to match site characteristics are also marked as Valid (V) or Valid with Reason (R) at the discretion of the reviewer. Data determined to be outside of the site characteristics are marked as Invalid (I) and are rejected.

5. TMS web-based application

5.1. TMS Application is web-based Geographical Information System (GIS) module available to authorized users on the SHA network, which allows users to do the following:

5.1.1. Request traffic counts

5.1.2. Schedule traffic counts

5.1.3. Check on the status of traffic counts

5.1.4. Track contracts and invoicing for contractors performing counts

5.1.5. Report the count data in various standard reports

5.1.6. Display count locations using the GIS-based map.

6. TMS Reports online

All validated traffic count data is published online[3]. Users can search data by date, day of week, count type (vehicle classification, turning movement, vehicle occupancy, and volume), functional classification, and location (county and route). The majority of these reports require statistical analysis using the previous year's traffic data. Maryland SHA produces the following publications on an annual basis, these reports are also available in printed format.

The Traffic Trends Report4 is a summary of traffic volume data from the permanent ATR stations for individual stations and ATR Groups, including hourly, daily, monthly, and seasonal variations in traffic volumes and factors for converting short-term counts to AADTs.

6.1.1. The Traffic Volume Maps [5]display AADTs at the ATR, Program Count, and Toll locations by county.

6.1.2. The Truck Volume Maps[6] display the average percentages of trucks at various locations on Maryland's roadways by county. Also included at these locations is the current AADT.

6.1.3. The GIS Traffic Count Data [7]consists of historical Annual Average Daily Traffic (AADT) and Annual Average Daily Weekday Traffic (AAWDT), percentage single unit and combination trucks in Nad83 feet. HARN in both Shape file and KML file formats.

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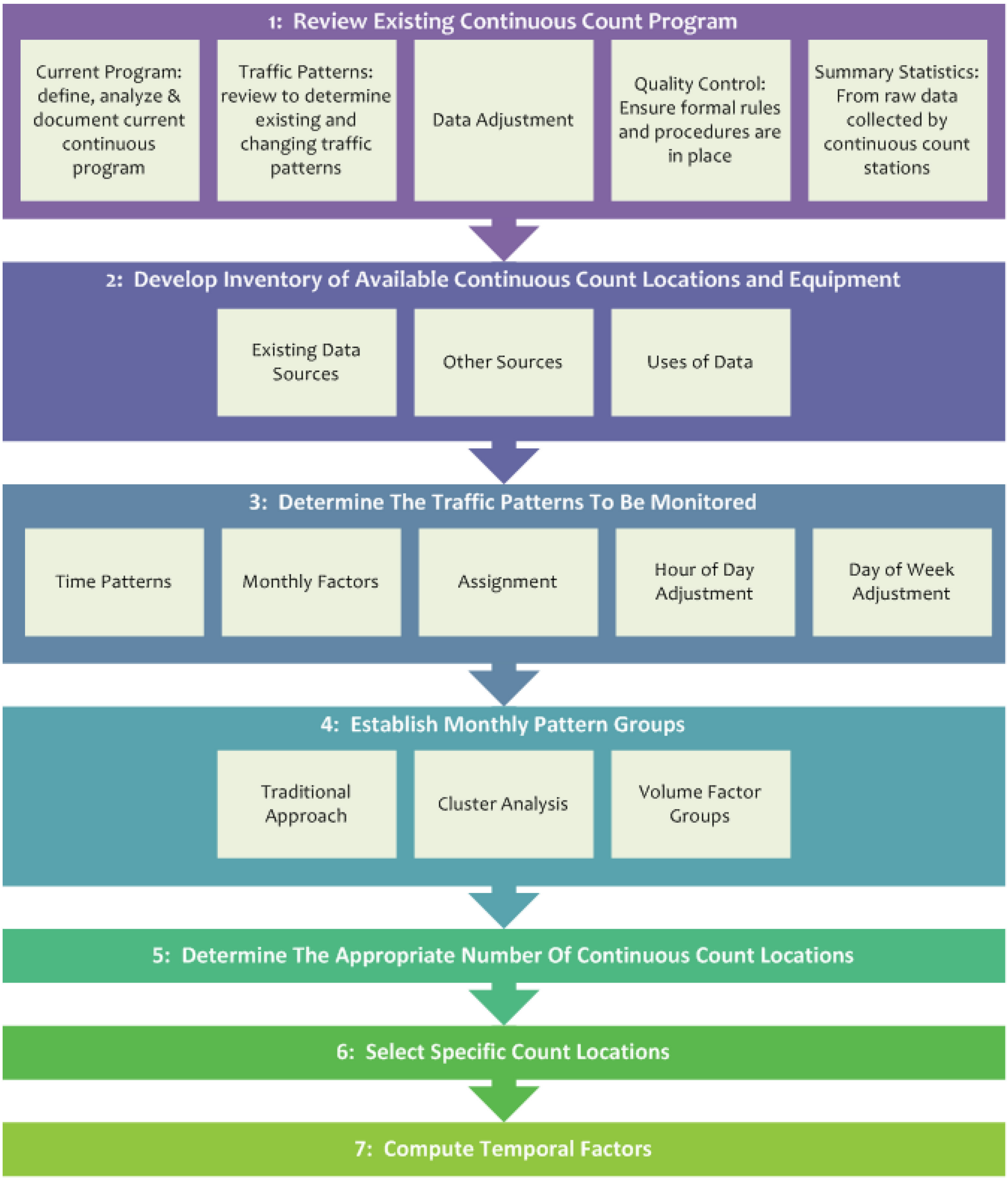
[3] http://shagbhisdadt.mdot.state.md.us/ITMS_Public/default.aspx
[4] http://roads.maryland.gov/Index.aspx?PageId=253&d=35
[5] http://roads.maryland.gov/Index.aspx?PageId=792
[6] http://roads.maryland.gov/Index.aspx?PageId=793
[7] http://roads.maryland.gov/pages/GIS.aspx?PageId=838

Figure 1. TMG Review of Continuous Count Program (from TMG 2013)



7. Continuous Count Program

The Continuous Count Program consists of data reported from ATRs that collect data 24 hours a day, 7 days a week for 365 days of the year. Maryland currently has approx. 87 ATR locations throughout the state. A cabinet adjacent to the roadway contains the recording unit, surge protection, power supply, and communication device which are polled on a daily basis via telemetry. The ATRs utilize several different sensor configurations, which determine the type of data that can be collected at the site.

Table 1. Types of Sensor Configuration (from TMG 2013)

Sensor Configuration Per Lane	Volume	Speed	Length	Classification	Weigh-In-Motion
Loop	X				
Loop-Loop	X	X	X		
Loop-Piezo-Loop	X	X	X	X	
Piezo-Loop-Piezo	X	X	X	X	X
Radar	X	X	X		

Total number of functional change as ATRs go offline for various reasons like maintenance, failure or damage.

Below is a list of the number of ATRs by county and the number of ATRs by functional classification.

7.1. Permanent Continuous Count Sites (ATRs) by Location

Table 2 ATRs by Location

Sr. No	Location ID	ATR No	Location	County	Primary Direction	Total Lanes	NE Lanes	SW Lanes	Web (internet)
1	P0001	(ATR#01)	MD 36 at George's Creek Bridge	Allegany	North	2	1	1	See in Google Maps
2	P0002	(ATR#02)	US 40 East of MD 63	Washington	East	2	1	1	See in Google Maps
3	P0003	(ATR#03)	MD 17 North of US 40AL	Frederick	North	2	1	1	See in Google Maps
4	P0004	(ATR#04)	IS 270 South of MD 121	Montgomery	North	6	3	3	See in Google Maps
5	P0005	(ATR#05)	US 301 South of MD 227	Charles	North	4	2	2	See in Google Maps
6	P0006	(ATR#06)	MD 4 North of Patuxent River Bridge	Prince Georges	North	4	2	2	See in Google Maps
7	P0007	(ATR#07)	MD 140 North of Patapsco River Bridge	Carroll	North	4	2	2	See in Google Maps
8	P0008	(ATR#08)	MD 309 North of MD 404	Queen Anne’s	North	2	1	1	See in Google Maps
9	P0009	(ATR#09)	US 13 at Leonards Mill Pond Bridge	Wicomico	North	5	3	3	See in Google Maps
10	P0010	(ATR#10)	MD 413 South of MD 667	Somerset	North	2	1	1	See in Google Maps
11	P0011	(ATR#11)	US 1BU South of Old Joppa Rd	Harford	North	2	1	1	See in Google Maps
12	P0012	(ATR#12)	US 40 at Bush River Bridge	Harford	East	4	2	2	See in Google Maps
13	P0013	(ATR#13)	MD 45 South of Warren Rd	Baltimore	North	4	2	2	See in Google Maps
14	P0014	(ATR#14)	US 40 West of Cemetery La	Howard	East	4	2	2	See in Google Maps
15	P0015	(ATR#15)	MD 213 South of Georgetown Cemetery Rd	Kent	North	2	1	1	See in Google Maps
16	P0016	(ATR#16)	US 50 East of Big Mill Pond	Dorchester	East	4	2	2	See in Google Maps
17	P0017	(ATR#17)	US 50 West of MD 354	Wicomico	East	4	2	2	See in Google Maps
18	P0018	(ATR#18)	MD 2 North of Marley Station Rd	Anne Arundel	North	7	2	3	See in Google Maps
19	P0019	(ATR#19)	US 340 at Potomac River Bridge	Washington	East	2	1	1	See in Google Maps
20	P0020	(ATR#20)	MD 173 South of Stoney Creek Bridge	Anne Arundel	North	2	1	1	See in Google Maps
21	P0021	(ATR#21)	IS 70 - 2.79 Miles East of MD 17	Frederick	East	5	3	2	See in Google Maps
22	P0022	(ATR#22)	US 50 South of Longwoods Rd	Talbot	East	4	2	2	See in Google Maps
23	P0024	(ATR#24)	US 50/IS 595 West of MD 424	Anne Arundel	East	6	3	3	See in Google Maps
24	P0025	(ATR#25 Includes ATR#81)	MD 295(NB) - South of MD 100	Anne Arundel	North	3	3	3	See in Google Maps
25	P0026	(ATR#26)	US 40AL East of MD 55	Allegany	East	2	1	1	See in Google Maps

Sr. No	Location ID	ATR No	Location	County	Primary Direction	Total Lanes	NE Lanes	SW Lanes	Web (internet)
26	P0027	(ATR#27)	IS 83 South of Belfast Rd	Baltimore	North	4	2	2	See in Google Maps
27	P0028	(ATR#28)	US 301 South of MD 304	Queen Anne's	North	4	2	2	See in Google Maps
28	P0029	(ATR#29)	US 29 North of South Entrance Rd	Howard	North	5	2	3	See in Google Maps
29	P0030	(ATR#30)	US 15 North of Monocacy Blvd	Frederick	North	4	2	2	See in Google Maps
30	P0032	(ATR#32)	IS 695 South of Ingleside Ave	Baltimore	North	9	4	3	See in Google Maps
31	P0033	(ATR#33)	IS 68 East of Old Cumberland Rd	Allegany	East	4	2	2	See in Google Maps
32	P0034	(ATR#34)	IS 695 East of US 1 (Belair Rd)	Baltimore	East	6	3	3	See in Google Maps
33	P0035	(ATR#35)	US 219 at Deep Creek Lake Bridge	Garrett	North	3	1	2	See in Google Maps
34	P0036	(ATR#36)	MD 404 East of MD 303	Queen Anne's	East	2	1	1	See in Google Maps
35	P0037	(ATR#37)	US 13 -.10 Mile North of Bunting Rd	Worcester	North	4	2	2	See in Google Maps
36	P0038	(ATR#38)	MD 100 West of Oakwood Rd	Anne Arundel	East	4	2	2	See in Google Maps
37	P0039	(ATR#39)	IS 95 South of MD 103	Howard	North	8	4	4	See in Google Maps
38	P0040	(ATR#40)	IS 495 at Persimmon Tree Rd	Montgomery	East	8	4	4	See in Google Maps
39	P0041	(ATR#41)	IS 495 West of MD 650	Montgomery	East	8	4	4	See in Google Maps
40	P0042	(ATR#42)	MD 2 South of Jones Station Rd	Anne Arundel	North	7	3	3	See in Google Maps
41	P0043	(ATR#43)	IS 95 South of MD 214	Prince Georges	North	8	4	4	See in Google Maps
42	P0044	(ATR#44 Includes ATR#82 WB)	IS 68(EB) .50 Mile East of MD 546	Garrett	East	3	3	0	See in Google Maps
43	P0045	(ATR#45)	IS 70 East of MD 615	Washington	East	4	2	2	See in Google Maps
44	P0046	(ATR#46)	IS 70 West of MD 32	Howard	East	6	3	3	See in Google Maps
45	P0048	(ATR#48)	US 29 North of Randolph Rd	Montgomery	North	6	3	3	See in Google Maps
46	P0049	(ATR#49)	IS 95 at Temple Hill Rd	Prince Georges	North	8	4	4	See in Google Maps
47	P0051	(ATR#51)	IS 95 North of Howard County Line	Baltimore	North	8	4	4	See in Google Maps
48	P0052	(ATR#52)	IS 83 North of IS 695	Baltimore	North	7	3	3	See in Google Maps
49	P0053	(ATR#53)	IS 70 West of IS 695	Baltimore	East	6	3	3	See in Google Maps
50	P0054	(ATR#54)	IS 695 West of Cromwell Bridge Rd	Baltimore	North	7	3	3	See in Google Maps
51	P0055	(ATR#55)	IS 95 North of Good Luck Rd	Prince Georges	North	8	4	4	See in Google Maps

Sr. No	Location ID	ATR No	Location	County	Primary Direction	Total Lanes	NE Lanes	SW Lanes	Web (internet)
52	P0056	(ATR#56)	MD 210 South of Old Fort Rd	Prince Georges	North	6	3	3	See in Google Maps
53	P0057	(ATR#57)	US 40 East of MD 700	Baltimore	East	4	2	2	See in Google Maps
54	P0058	(ATR#58)	MD 213 North of MD 310	Cecil	North	2	1	1	See in Google Maps
55	P0059	(ATR#59)	US 13 North of Peggyneck Rd	Somerset	North	4	2	2	See in Google Maps
56	P0060	(ATR#60)	IS 270 South of Middlebrook Rd	Montgomery	North	8	4	4	See in Google Maps
57	P0061	(ATR#61)	US 50 West of MD 202	Prince Georges	East	4	2	2	See in Google Maps
58	P0062	(ATR#62)	US 50 West of MD 818	Worcester	East	4	2	2	See in Google Maps
59	P0063	(ATR#63)	MD 90 West of MD 346	Worcester	East	2	1	1	See in Google Maps
60	P0064	(ATR#64)	MD 24 North of Tollgate Rd	Harford	North	4	2	2	See in Google Maps
61	P0065	(ATR#65)	MD 2 North of Dowell Rd	Calvert	North	4	2	2	See in Google Maps
62	P0066	(ATR#66)	IS 195 North of MD 295	Anne Arundel	North	4	2	2	See in Google Maps
63	P0067	(ATR#67)	IS 70 at Monocacy River Bridge	Frederick	East	6	3	3	See in Google Maps
64	P0068	(ATR#68)	US 15 North of Basford Rd	Frederick	North	2	1	1	See in Google Maps
65	P0069	(ATR#69)	MD 32 West of IS 95	Howard	North	6	3	3	See in Google Maps
66	P0070	(ATR#70)	IS 68 West of MD 144	Allegany	East	4	2	2	See in Google Maps
67	P0071	(ATR#71)	IS 95 North of IS 195	Baltimore	North	8	4	4	See in Google Maps
68	P0072	(ATR#72 Includes ATR#73)	IS 795(NB) at Mt. Wilson La	Baltimore	North	3	3	3	See in Google Maps
69	P0073	(ATR#73 Combined with ATR#72)	IS 795(SB) at Mt. Wilson La	Baltimore	South	3	3	2	See in Google Maps
70	P0074	(ATR#74)	MD 695 at Trappe Rd	Baltimore	North	4	2	2	See in Google Maps
71	P0075	(ATR#75)	IS 695 West of MD 170	Anne Arundel	North	8	3	3	See in Google Maps
72	P0076	(ATR#76)	IS 83 at Old Pimlico Rd	Baltimore	North	6	3	3	See in Google Maps
73	P0077	(ATR#77)	IS 695 at Hollins Ferry Rd	Baltimore	North	7	3	3	See in Google Maps
74	P0078	(ATR#78)	IS 695 South of IS 795	Baltimore	North	8	3	4	See in Google Maps
75	P0079	(ATR#79)	IS 95 South of Joh Ave	Baltimore	North	10	4	4	See in Google Maps
76	P0080	(ATR#80)	MD 5 - .10 Mile South of Renner Rd	Charles	North	4	2	2	See in Google Maps
77	P0081	(ATR#81 Combined	MD 295(SB) - South of MD 100	Anne Arundel	South	3	3	3	See in Google Maps

Sr. No	Location ID	ATR No	Location	County	Primary Direction	Total Lanes	NE Lanes	SW Lanes	Web (internet)
		with ATR#25)							
78	P0082	(ATR#82 Combined with ATR#44 EB)	IS 68(WB) .50 Mile East of MD 546	Garrett	West	2	0	2	See in Google Maps
79	P0083	(ATR#83)	MD 610 - .30 Mile North of MD 346	Worcester	East	2	1	1	See in Google Maps
80	P0084	(ATR#84)	MD 313 - .22 Mile South of Queen Anne's County Line	Caroline	North	2	1	1	See in Google Maps
81	P0085	(ATR#85)	MD 439 - .44 Mile East of IS 83	Baltimore	East	2	1	1	See in Google Maps
82	P0086	(ATR#86)	MD 257 - .40 Mile South of Morgantown Rd	Charles	North	2	1	1	See in Google Maps
83	P0087	(ATR#87)	MD 5 - .20 Mile North of Fresh Pond Neck Rd	St Mary's	North	2	1	1	See in Google Maps
84	P0088	(ATR#88)	MD 277 - .10 Mile East of Oakridge Ct	Cecil	East	2	1	1	See in Google Maps
85	P0089	(ATR#89)	MD 953 - .10 Mile North of Atwell Ave	Prince Georges	North	4	2	2	See in Google Maps
86	P0090	(ATR#90)	MD 129 - .18 Mile South of MD 130	Baltimore	North	2	1	1	See in Google Maps
87	P0091	(ATR#91)	MD 638 - .13 Mile North of Porter Cemetery Rd	Allegany	North	2	1	1	See in Google Maps

7.2. Geographical distribution of ATR sites by County

Table 3 ATR sites by County

Name of County	Numbers of ATR's
Allegany	5
Anne Arundel	9
Baltimore	19
Calvert	1
Caroline	1
Carroll	1
Cecil	2
Charles	3
Dorchester	1
Frederick	5
Garrett	3

Name of County	Numbers of ATR's
Harford	3
Howard	5
Kent	1
Montgomery	5
Prince George's	7
Queen Anne's	3
Somerset	2
St Mary's	1
Talbot	1
Washington	3
Wicomico	2
Worcester	4

7.3. Distribution of ATR sites by Road type (functional class)

Table 4 ATR sites by road type (functional class)

Functional Class	Numbers of ATRs
Rural Interstate	8
Rural Major Collector	7
Rural Minor Arterial	5
Rural Other Principal Arterial	16
Urban Collector	3
Urban Interstate	25
Urban Minor Arterial	1
Urban OPA Freeway/Expressways	13
Urban Other Principal Arterial	9

8. Validations of ATR data

The ATRs are remotely polled on a daily basis via telemetry. A member of the TMS team reviews the results of the validations on a daily (I). A series of data validations are performed against the data files as part of the review process. The data is then loaded into an Oracle database. Only data that passes validation is used in the calculation of group, growth, axle correction factors and AADTs.

As the ATR data is being loaded into the database, the following validation checks are performed against each ATR's data:

8.1.1. An individual lane should not collect the same number of vehicles for 4 or more consecutive hours.

8.1.2. The directional split of the total volume is out of range based on user supplied parameters (Default is 60% - 40%).

8.1.3. Directional volumes should be within 2 standard deviations of 3 years of seasonal historical data.

8.1.4. The ATR must collect 24 hours of data.

8.1.5. Any lane collecting zero volume for an hour or more on the Interstate and freeway system.

8.1.6. The 1:00 AM hour should have less vehicles than 1:00 PM hour.

8.1.7. Individual lane volume over theoretical capacity based on the functional classification and design speed.

8.1.8. Distribution of traffic in the same lane should remain similar from day to day

8.1.9. Daily Vehicle Class Percent Distribution should remain similar from day to day

8.1.10. Motorcycles should account for less than 2% of the total volume for the day by lane

8.1.11. Unclassified vehicles Class 14 and 15 should be less than 0.5% of the total volume for the day by lane

8.1.12. Volumes of adjacent lanes should not be identical(Cross talk)

8.1.13. Percent distribution of various types of classification should be similar from day to day to historical data.

If the data collects 24 hours of data as per rule 4, but fails any of the other validation checks, it is loaded into the database and marked as 'invalid'.

The TMS team meets on a monthly basis to review a daily summary of all the previous month's ATR. The summary includes total volume, directional distribution, peak hour, peak hour volume, historical monthly ADT, whether the count is valid (V) or invalid (I). After review of the data an additional status of validated with a reason (R) is added if necessary. This status is used when there is no error in the ATR, but the traffic pattern/volume is not consistent with the norm due to external factors such as weather related events, construction, holidays or other reasons. While reviewing the data, the team is looking for data anomalies, such as the total volume is consistently over the maximum or under the minimum volume based on historical volumes for the day of week, or the directional split consistently exceeds the 60/40 split on weekends, etc. In certain situations, a site visit to the ATR or a phone discussion with the District Traffic Engineer may explain the changes to the data. The data for these days is published but not used for the generation of factors.

48 hour verification counts are also performed at each ATR, usually twice a year. The data is compared to the ATR data from the same date: by lane, direction and total volume by hour. If the data from the 48 hour verification count and the data from the ATR diverge a TMS field technician(s) will be sent to the site to investigate the problem and if required, will make the necessary repairs or adjustments.

Maryland uses only data that has been marked as valid for Group Factors, Growth Factors, Axle Correction Factors and Traffic Trends reporting. A combination of the data marked as valid and valid with a reason is used for the creation of AADTs as that represents the actual traffic at that location. All publications are based on actual data collected, as Maryland does not impute data.

9. Program Counts (Short-term counts for geographical coverage)

Maryland's Program Counts consist of approximately 8,750 locations which are counted on a three or six year cycle based on HPMS requirements. Program Counts are 48 hour volume or vehicle classification counts, which are taken during the week on either Tuesday and Wednesday or Wednesday and Thursday to reflect typical weekday travel patterns. Approximately 50% of the Program Counts taken each year are vehicle classification counts, based on the FHWA 13 bin vehicle classification schema. All Program Counts are factored with seasonal factors and axle correction factors when necessary in order to adjust to reflect annual traffic conditions.

Below is a list of the number of Program Count Locations by county and by functional classification:

9.1. Program Count Locations by County

Table 5 Program Count Locations

County	Number of Program Count Locations
Allegany	279
Anne Arundel	920
Baltimore	1281
Calvert	98
Caroline	109
Carroll	232
Cecil	155
Charles	121
Dorchester	103
Frederick	444
Garrett	129
Harford	335
Howard	458
Kent	76
Montgomery	1032
Prince George’s	1072
Queen Anne’s	146
St Mary’s	94
Somerset	67
Talbot	79
Washington	406
Wicomico	207
Worcester	146

County	Number of Program Count Locations
Baltimore City	761

9.2. Program Count

9.3. Roads by Functional Classification

Table 6 Roads by Functional Classification

Rural	Number of Program Count Stations	Urban	Number of Program Count Stations
Interstate	296	Interstate	1435
Other Principal Arterial	292	OPA Freeway/Expressways	1050
Minor Arterial	307	Other Principal Arterial	1044
Major Collector	530	Minor Arterial	1214
Minor Collector	410	Collector	1820
Local	133	Local	219

10. Program Count Data Validations

The following validations are performed against Program Counts before they are used to calculate AADTs.

10.1. By consultant conducting count

10.1.1. Before submitting the count to SHA, each Program Count must signed off by a Professional Traffic Engineer, working for the consultant firm performing the count, verifying that the count has been reviewed and validated.

10.1.2. The consultant who performed the count provides SHA with a data file containing the raw data, and a factored AADT, based on the previous year's day of week, seasonal and axle correction factors. The count is compared with the previous year's factored AADT at the location. If the new factored AADT is not within ± 5% of the previous year's factored AADT, the consultant is required to prove a valid reason explaining the difference in the AADT (such as a new mall opened causing an increase in AADT, or a new bypass road opened resulting in a decrease in the AADT).

10.2. By SHA on receiving the Data

10.2.1. Lane Distribution - Number of records for each direction should be the same, unless the number of lanes is uneven.

10.2.2. Validation by Travel Forecasting and Analysis Section - The raw data, along with a cover sheet highlighting the raw AADT, factored AADT using last the previous year's factors, the factors used, directional percentage and additional data for the count is sent to the Travel Forecasting and Analysis Section for validation by Traffic Engineers who are familiar with the location of the count.

10.2.3. Images - Check if all the images of the location and other digital documents accompanied with the count match the count data.

10.3. By SHA on loading the data in database

10.3.1. Number of Lanes and Directions - Check if the counts have the same number of lanes as the station table and if the directions of all the counts match the inventory direction.

10.3.2. Volume Distribution - Check if the volume distribution is uneven between the two directions, if it is not within a 60/40 split; look at the number of lanes in each direction and the historic volume distribution at the station.

10.3.3. Class Validation - Check Class percentages by lane, for each all the stations, look for uniformity of different classes of vehicles throughout the lanes and directions.

10.3.4. End of Year Edits - As a final edit, after all the Program Counts for the year have been completed, loaded into the database, and factored into AADTs using the current years factors, a report displaying county, route, mile point, the new factored AADT, the previous year's AADT and the percent difference between the previous and current year AADT is reviewed by the TMS Team & Travel Forecasting and Analysis Section. At this point, if a count seems out of range without a valid reason, the count will be marked invalid, a growth factor will be applied to the previous year's AADT, and the location will be re-counted the next year.

11. ATR Groups for Adjustment Factors

Maryland uses five groups. Each ATR is assigned to one of the following groups based on the functional classification of the road where the ATR is located, with the exception of the Seasonal Group.

11.1. Number of ATRs by Group Classification

Table 7 ATRs by Group Classification

ATR Group	Numbers of ATRs
Rural Interstate	8
Rural Other	17
Urban Interstate	25
Urban Other	26
Seasonal	11
Total:	87

12. Adjustment Factors

One of the primary uses of ATR data is to calculate factors which are used to adjust short term counts to reflect annual conditions. These factors include adjustment factors for each day of week by month, axle correction factors and growth factors.

12.1. Calculating Day of Week, Month of Year Factor

Maryland uses factors based on day of week for each month for each ATR group. Adjustment factors are calculated for each day of the week for each month, resulting in 84 factors for each ATR Group (7 weekdays X 12 Months = 84). Only ATRs that have at least one valid day of data for each day of the week for every month are used in the calculation (i.e. each ATR must have at least 1 valid Monday, Tuesday, Wednesday, Thursday, Friday, Saturday and Sunday for each month).

Follow the steps below to calculate the factors:

12.1.1. For each ATR used to calculate Group Factors, calculate a median hourly volume for each day of the week each month of the year.

Example: ATR # P0001 had four valid Wednesdays in March 2015, as shown in the example below. Calculate the (hypothetical) median hourly volume for Wednesdays in March 2015 and insert it into a database table.

Figure 2 Calculation of Median Hourly Volume

LOCATION_ID	DATE	WEEKDAY	TIME	VOLUME
P0001	03/04/2015	Wednesday	01	31
P0001	03/11/2015	Wednesday	01	35
P0001	03/18/2015	Wednesday	01	19
P0001	03/25/2015	Wednesday	01	19
	Median Hourly Volume			25

12.1.2. Repeat this process for each ATR. After you finish, the database now contains the median hourly data for each ATR for each day of the week for each month.

12.1.3. Calculate an AADT for each of the five ATR Groups by taking the sum of median hourly volume for each day and dividing it by 84 days = Group AADT.

12.1.4. Divide the Group AADT by the total daily volume for day of week for each month for each ATR group. The result is the Day of Week, Month of Year Factor for each ATR Group.

Example: Calculating the March Wednesday Factor for the group Rural Others, when:
2015 Group AADT, Rural Others = 157,432
and
Total Volume, Rural Others, Wednesdays in March = 155,891

$$\frac{157{,}431 \text{ (2015 Group AADT, Rural Others)}}{155{,}891 \text{ (Total Volume, Rural Others, Wednesdays in March)}}$$

The factor = 1.01.

12.1.5. Apply this factor (1.01) to a 24-hour count taken on a Wednesday in March to calculate a factored AADT.

12.2. Calculating Axle-Correction Factors

Axle correction factors are used to adjust short term counts taken with single axle sensors into vehicle counts. Axle corrections factors for a year are calculated based on all vehicle classification counts taken during that year.

Follow the steps below to calculate axle-correction factors:

12.2.1. Select all vehicle classification counts taken during the previous year grouped by functional classification.

12.2.2. Add the Total Vehicles for each functional classification.

12.2.3. Add the Total Axles for each functional classification by multiplying each vehicle by the number of axles according to the FHWA Vehicle Classification Schema.

12.2.4. Axle Correction Factor = (Total Vehicles/ Total Axles) x 2

12.2.5. Store the result in a database table grouped by year and functional classification.

12.3. Calculating Growth Factors

Growth factors are calculated from permanent count data by year for each ATR group. These factors are applied to Program Counts which were not counted during the current year in order to provide a current AADT estimate. Program Counts (48 hour counts) are counted on a three or six year cycle based on HPMS requirements.

Growth factors are created by calculating the yearly median percent difference in AADT for each ATR in the ATR groups. Only ATRs that have at least one valid day of data for each day of the week for every month for both the previous and current year are used to calculate growth factors.

13. Calculating AADT from Program Count Stations (48-Hour Counts)

13.1.1. Add the total daily volume for each day counted. (Program Counts are 48-hour counts.)

Example: A (hypothetical) 48-hour Program Count was taken on a Wednesday and Thursday in May 2015 at Station # B030098, located on MD 147 in Baltimore County. This location has a functional classification of Urban Minor Arterial and is part of the Urban Other ATR Group.

Wednesday = 14,673
Thursday = 14,891

13.1.2. Apply the short-term count adjustment factor based on the ATR Group and month and day of week the count was taken.

Example:

Wed Volume		Wed Factor	
14,673	x	0.9	= 13,206

Thu Volume		Thu Factor	
14,891	x	0.88	= 13,104

13.1.3. Add the factored results and divide the sum by the number of days counted.

Example:

13,206
+ 13,104

26,310 / 2 = 13,155

13.1.4. Apply the Axle Correction factor based on the functional classification. (If the count is a vehicle classification count, skip this step.)

Example: In this case, the count was a volume count, so apply the Axle Correction factor (ACF).

Factored Volume	x	ACF	= (Factored AADT)
13,155	x	0.98	= 12,892

13.1.5. Since 2006, the TMS team has added a special numeric code to the AADT and AAWDT numbers in order to identify the years in which the counts were actually taken; the last digit represents the number of years prior to the actual count, in which:

0 = Count taken in current year (2015)
1 = Count taken in 2014
2 = Count taken in 2013
3 = Count taken in 2012, etc.

13.2. Program Count Locations Not Counted During the Current Year

Maryland counts approximately one-third of the Program Count locations each year. For the locations that were not counted during the current year, the team applies a growth factor based on the ATR Group to which the Program Count is assigned. Growth factors are calculated for each of the five ATR Groups: Urban Interstate, Urban Other, Rural Interstate, Rural Other, and Seasonal.

14.AASHTO Method: Annual Average Daily Traffic (AADT)

Annual Average Daily Traffic is number that represents a typical traffic volume at a site any day of the year.

There are two basic procedures for calculating AADT:

14.1.1. A simple average of all days. Add the daily total traffic volume for all valid days for the year and divide it by the number of valid days for the year. As a general rule, only ATRs that have a minimum of two weeks' worth of valid data for each season are used to publish AADT count. Maryland SHA has been using the simple average method. This is simple to calculate and easy to program. The disadvantage is that missing data can cause bias and inaccuracy of the data. Also, some of the data is discarded due to being incomplete and hence un-representative of full data.

14.1.2. AASHTO Method - An Average of Averages developed by the American Association of State Highway Transportation Officials.

15.AADT Calculation

As per TMG guidelines, a review of the AADT calculation was done. The TMG2013 advises 'The AASHTO method for computing AADT is recommended" because "it allows factors to be computed accurately even when a considerable number of data is missing from a year at a site, and because it works accurately under a variety of data conditions (both with and without missing data)."

$$AADT = \frac{1}{7}\sum_{i=1}^{7}\left[\frac{1}{12}\sum_{j=1}^{12}\left(\frac{1}{n}\sum_{k=1}^{n} VOL_{ijk}\right)\right]$$

Where:

VOL = daily traffic for day k, of DOW i, and month j

i = day of the week

j = month of the year

k = 1 when the day is the first occurrence of that day of the week in a month, 4 when it is the fourth day of the week

n = the number of days of that day of the week during that month (usually between one and five, depending on the number of missing data)

15.1. Comparison: Simple Average vs. AASHTO Method

A review of the total traffic volume data from last 10 years 2004-2013 was done to assess calculating AADT using both simple average method and AASHTO method.

The data shows that Mean Average Percentage Error (MAPE) between Simple Average Method and AASHTO Method for total traffic volume at ATR stations. Figure 3 below shows the percentages for 2010 through 2013, as these data are illustrative of all the data.

Figure 3 Difference between AASHTO and Simple Average AADT

Year	Mean Average Percentage Error (MAPE)
2010	-0.20%
2011	-0.04%
2012	0.06%
2013	-0.22%

To improve accuracy Maryland implemented a system to calculate and report AADT from ATRs using AASHTO Methodology in 2014.

16. Calculating Total Volume AADT (AASHTO Method)

16.1.1. Select the location of ATRs collecting data for a particular year

16.1.2. Select the total daily traffic for each day from each location where the data analyst considered data valid or valid with reason.[8]

16.1.3. Calculate Month and Day of the Week Average (MADWT) volume for each month for each location for e.g. if January contains four Mondays they are averaged as Average Monday in January. This should result in 84 values (12 Month x 7 Day of Week)

16.1.4. Calculate the AADW Annual Average Day of the Week by averaging for each Day of the Week e.g. average of all the average Tuesdays from all months in the year resulting in 7 AADW values.

16.1.5. Calculate the MADT (Monthly Average Daily Traffic) by averaging for all Average Days of the Week in each month result in 12 MADT values.

16.1.6. Calculate the Total Volume AADT by averaging of these 7 AADW values.

17. Calculating Total Volume AADT Factors (AASHTO Method)

Factors are values calculated as a ratio of total values and used to normalize the variability of the data. We basically calculate only three factors for each location using only valid data.

17.1.1. AADT/MADT – Monthly Factors

Ratio of AADT to Monthly Average Daily Traffic (12M=12)

17.1.2. AADT/AADW – Weekly Factors

Ratio of AADT to Annual Average daily Traffic (7DOW=1)

17.1.3. AADT/ MADWT –Month and Day of the Week factor

Ratio of AADT to Month and Day of the Week Averages for each site (12Mx7DOW=84)

[8] Validity of data labeled as Valid (V) or Valid with Reason (R),Invalid(I) in TMS database

18. Continuous Vehicle Classification Count Program (AASHTO Method)

18.1.1. The continuous vehicle classification data collection program is related to, but distinct from, the established continuous count program. SHA collects classification data which also includes total volume information in place of simple volume counts whenever possible.

18.1.2. The vehicle class groups comprise the 13 -bin FHWA Scheme F.

18.1.3. The pattern of temporal variability in truck volumes differs significantly from passenger vehicles. Trucks experience more variability between weekdays and weekends than passenger vehicles, and expansion factors derived from aggregate count data may fail to adequately explain temporal variations in truck traffic.

18.1.4. Traffic data from continuous count stations were used to estimate AADT for two different truck groups (single-unit and multi-unit). The single-unit truck category included FHWA vehicle classes 4 to 7, and the multi-unit truck category included FHWA vehicle classes 8 to 13.

19. Vehicle Class AADT using AASHTO method

19.1.1. Select the location of ATRs collecting data for a particular year collecting vehicle class data in 15 bins.

19.1.2. Select the total daily traffic for each day from each location where the data analyst considered data valid (‘V’) or Valid for reason (‘R’) for Motorcycle, Cars, Light Trucks, Buses, Single Units Trucks and Combination Unit Trucks.

19.1.3. Calculate Month and Day of the Week Average (MADWT) volume for each month for each location for e.g. if January contains four Mondays they are averaged as Average Monday in January. This should result in 84 values (12 Month x 7 Day of Week) each for Motorcycle, Cars, Light Trucks, Buses, Single Units Trucks and Combination Unit Trucks.

19.1.4. Calculate the AADW Annual Average Day of the Week by averaging for each Day of the Week e.g. average of all the average Tuesdays from all months in the year resulting in 7 AADW values each for Motorcycle, Cars, Light Trucks, Buses, Single Units Trucks and Combination Unit Trucks.

19.1.5. Calculate the MADT (Monthly Average Daily Traffic) by averaging for all Average Days of the Week in each month result in 12 MADT values for Motorcycle, Cars, Light Trucks, Buses, Single Units Trucks and Combination Unit Trucks.

19.1.6. Estimate the AADT by averaging of these 12 MADT values if the ATRs was working nearly all the months else.

19.1.7. Calculate the Total Volume AADT by averaging of these 7 AADW values for Motorcycle, Cars, Light Trucks, Buses, Single Units Trucks and Combination Unit Trucks.

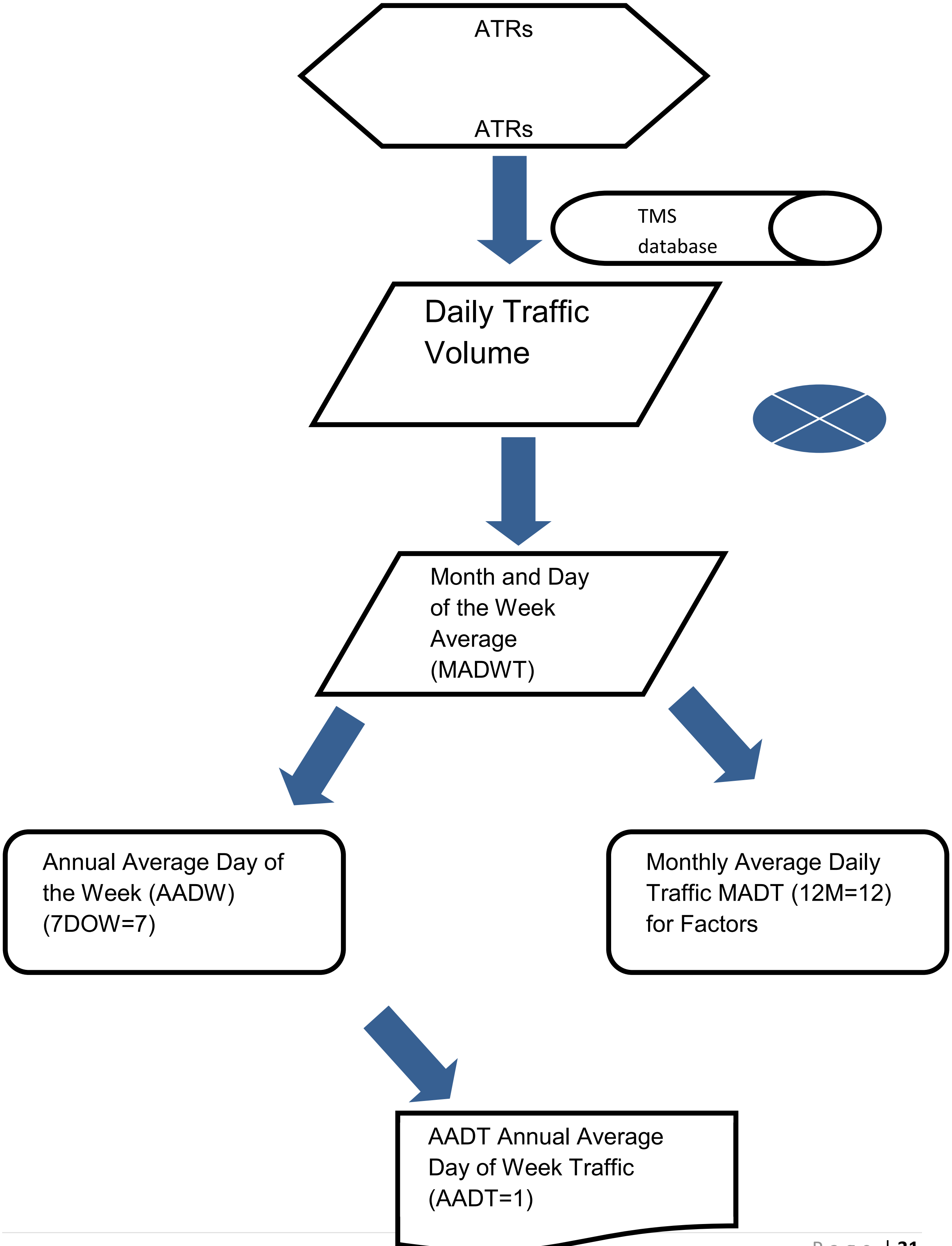
19.2. Volume Correction

19.2.1. Volume Correction is done as per the method enumerated in TMG2013. The total volume of the vehicles must equal the total number of vehicles as sum of all vehicle class.

19.2.2. Any difference in total volume is proportionally distributed to each vehicle class.

19.2.3. Any difference is in total volume due to rounding is attributed to passenger cars.

Figure 4 Workflow for calculating AADT (AASHTO method)



20.Vehicle Class AADT Expansion Factors using AASHTO method

20.1.1. Expansion factors for each location for Motorcycle, Cars, Light Trucks, Buses, Single Units Trucks and Combination Unit Trucks separately using only valid data.

20.1.2. AADT/MADT – Monthly Factors.

Ratio of AADT to Monthly Average Daily Traffic (12M=12) for Motorcycle, Cars, Light Trucks, Buses, Single Units Trucks and Combination Unit Trucks separately.

20.1.3. AADT/AADW – Weekly Factors.

Ratio of AADT to Annual Average daily Traffic (7DOW=1) for Motorcycle, Cars, Light Trucks, Buses, Single Units Trucks and Combination Unit Trucks separately.

20.1.4. AADT/ MADWT – Month and Day of the Week factor.

Ratio of AADT to Month and Day of the Week Averages for each site (12Mx7DOW=84) for Motorcycle, Cars, Light Trucks, Buses, Single Units Trucks and Combination Unit Trucks separately.

20.1.5. At the minimum, determine factor groups for 4 groups. Here the factoring of vehicle classification counts (i.e., heavy vehicle volume counts) is performed independently from the process used to compute AADT from short duration volume counts.

- Rural Interstate
- Urban Interstate
- Rural other
- Urban other

21.HPMS Vehicle Class Percentage

21.1.1. This analysis is done to aid HPMS submission of FHWA using Scheme F Classification for Vehicle Class.

21.1.2. We calculated vehicle class percentage using procedure detailed in Section 3.4 of FHWA Traffic Monitoring Guide 2013 for calculating vehicle class percentage.

21.2. Vehicle class groups

21.2.1. Vehicle class traffic volume data collected by continuous count sites statewide was separated into 6 vehicle class groups.

Table 8 HPMS Groups from TMG 2013

	HPMS Summary Table Vehicle Class Group	FHWA 13 Vehicle category Classification Number
Group 1	Motorcycles (MC)	1
Group 2	Passenger Vehicles equal to or under 102"(PV)	2
Group 3	Light Trucks over 102"(LT)	3
Group 4	Buses(BS)	4
Group 5	Single Unit Vehicles (SU)	5,6,7
Group 6	Combination Unit (CU)	8,9,10,11,12,13

21.2.2. AADT as per the AASHTO method

AADT as per the AASHTO method was calculated for each vehicle class groups. Monthly (12) and day of the week (7) expansion factors were calculated from each continuous count location .These factor were averaged into six ATR (6) volume and geographical location groups based on Functional Groups.

21.2.3. ATR Groups for HPMS vehicle class percentage:

1. Rural interstate
2. Rural arterial
3. Rural collector
4. urban interstate
5. urban arterial

6. urban collector

21.2.4. Volume data from short program count (SPC)

Volume data from short program count (SPC) done statewide for the year was multiplied by the total volume monthly factor and individual vehicle class day of the week expansion factor. A proportional adjustment was done such that direct total volume and sum of vehicle class after application of expansion factor is the same as per the procedure explained in TMG. Vehicle class percentage at each such site was obtained for each day for count and averaged. In addition, the average vehicle class percentage at each continuous count site was calculated.

21.3. HPMS Groups

This data set provided us statewide vehicle class percentage at each count location in a particular year. This was averaged per HPMS groups to get state wide truck percentage data.

- 1A-Rural-Interstate
- 2B-Rural-Arterial
- 3C-Rural-Other
- 4D-Urban-Interstate
- 5E-Urban-Arterial
- 6F-Urban-Other

22. Locations suitable for the use of Non-Intrusive Technology

The Maryland State Highway Administration is committed to safety for it personnel who work on collecting data in the field including employees and contractors. The 48-hours duration short term Program Counts collect Volume, Speed, and Vehicle Class statewide on a three (3) or six (6) year cycle from numerous locations. The data collection is conducted with pneumatic tubes placed across a road covering all lanes by traffic count personnel. There may be disruption to the traffic while the placement and removal is conducted, along with the concern for personal safety.

22.1. Multi-criterion decision analysis

A multi-criterion decision analysis was undertaken to identify locations suitable for the use of non-intrusive technology when conducting traffic counts. The parameters considered were maximum speed limit, the Annual Average Daily Traffic (AADT) and its distribution across all lanes. A total of 5813 mainline locations (excluding ramps) were identified, selected and used for this analysis and 785 sites were categorized suitable for Non-Intrusive Technology (NIT) in view of high speed and or high traffic volume location.

For each parameter of interest, we grouped each location using a scoring level of 1 to 4, on a sliding scale based on perceived increased in risk. We then combined these scores to obtain a weighted score using the formula to provide equal weights to speed and volume AADT data. The combined final scores were normalized to scale of 100 that were assigned a Final Priority Score utilizing 95th percentile and 90th percentile cut off value as thresholds.

22.2. Implementation aid for new short term program count site

When new term short program count sites are identified for use, we can use the model data analyzed from this analysis to flag them as a site for non-intrusive counts. For instance, calculating from the above corresponding tables

[Lane score+ speed score + AADT score + AADT per lane] /16*100

Hypothetical site-A is in a six-lane with 55 mph speed limit with AADT of 74,000. Final priority score= (4+4+3+3)/16*100 =87.5 .This would fall in high priority (> 95th percentile) and hence can be classified as site for Non-Intrusive count

Hypothetical site is in a two-lane with 40 mph speed limit with AADT of 24000. Final Priority Score = (2+3+1+3)/16*100 =56.25 .This would fall in medium priority (> 90th percentile)

Hypothetical site-C is s two-lane with 30 mph with AADT of 14000. Final priority score = (2+1+1+1)/16*100 =31.25. Hence this would fall in low priority (<90th percentile)