



Road Authority Practices in Data Storage Survey

<http://aurora-program.org>

Aurora Project 2015-05

**Final Report
June 2019**

About Aurora

Aurora is an international program of collaborative research, development, and deployment in the field of road and weather information systems (RWIS), serving the interests and needs of public agencies. The Aurora vision is to deploy RWIS to integrate state-of-the-art road and weather forecasting technologies with coordinated, multi-agency weather monitoring infrastructures. It is hoped this will facilitate advanced road condition and weather monitoring and forecasting capabilities for efficient highway maintenance and real-time information to travelers.

ISU Nondiscrimination Statement

Iowa State University does not discriminate on the basis of race, color, age, ethnicity, religion, national origin, pregnancy, sexual orientation, gender identity, genetic information, sex, marital status, disability, or status as a U.S. veteran. Inquiries regarding non-discrimination policies may be directed to Office of Equal Opportunity, 3410 Beardshear Hall, 515 Morrill Road, Ames, Iowa 50011, Tel. 515-294-7612, Hotline: 515-294-1222, email eooffice@iastate.edu.

Notice

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the information presented herein. The opinions, findings and conclusions expressed in this publication are those of the authors and not necessarily those of the sponsors.

This document is disseminated under the sponsorship of the U.S. Department of Transportation in the interest of information exchange. The U.S. Government assumes no liability for the use of the information contained in this document. This report does not constitute a standard, specification, or regulation.

The U.S. Government does not endorse products or manufacturers. If trademarks or manufacturers' names appear in this report, it is only because they are considered essential to the objective of the document.

Quality Assurance Statement

The Federal Highway Administration (FHWA) provides high-quality information to serve Government, industry, and the public in a manner that promotes public understanding. Standards and policies are used to ensure and maximize the quality, objectivity, utility, and integrity of its information. The FHWA periodically reviews quality issues and adjusts its programs and processes to ensure continuous quality improvement.

Iowa DOT Statements

Federal and state laws prohibit employment and/or public accommodation discrimination on the basis of age, color, creed, disability, gender identity, national origin, pregnancy, race, religion, sex, sexual orientation or veteran's status. If you believe you have been discriminated against, please contact the Iowa Civil Rights Commission at 800-457-4416 or the Iowa Department of Transportation affirmative action officer. If you need accommodations because of a disability to access the Iowa Department of Transportation's services, contact the agency's affirmative action officer at 800-262-0003.

The preparation of this report was financed in part through funds provided by the Iowa Department of Transportation through its "Second Revised Agreement for the Management of Research Conducted by Iowa State University for the Iowa Department of Transportation" and its amendments.

The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the Iowa Department of Transportation or the U.S. Department of Transportation Federal Highway Administration.

Technical Report Documentation Page

1. Report No. Aurora Project 2015-05	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle Road Authority Practices in Data Storage Survey		5. Report Date June 2019	
		6. Performing Organization Code	
7. Author(s) Heather McClintock, Max Perchanok, Paula Grcevic, and Syed Salman		8. Performing Organization Report No. Aurora Project 2015-05	
9. Performing Organization Name and Address Ministry of Transportation of Ontario 77 Wellesley Street West Ferguson Block, 3rd Floor Toronto, Ontario M7A 1Z8		10. Work Unit No. (TRAIS)	
		11. Contract or Grant No.	
12. Sponsoring Organization Name and Address <div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> Aurora Program Iowa Department of Transportation 800 Lincoln Way Ames, Iowa 50010 </div> <div style="width: 45%;"> Federal Highway Administration U.S. Department of Transportation 1200 New Jersey Avenue, SE Washington, DC 20590 </div> </div>		13. Type of Report and Period Covered Final Report	
		14. Sponsoring Agency Code TPF-5(290)	
15. Supplementary Notes Visit www.intrans.iastate.edu for color pdfs of this and other research reports.			
16. Abstract <p>The purpose of this research was to survey road authorities on their data collection and retention practices and to share the findings with Aurora member agencies. A survey was undertaken of road authorities across the United States of America, Canada, and some European organizations regarding their data collection practices for road weather information systems (RWIS), automated vehicle location (AVL) / global positioning systems (GPS), camera images, and traffic data. The results of this survey can be used by Aurora members to assess their data collection practices with respect to other road authorities.</p>			
17. Key Words automatic vehicle location (AVL)—data collection—data storage—highway departments—road weather information systems (RWIS)—traffic data—weather		18. Distribution Statement No restrictions.	
19. Security Classification (of this report) Unclassified.	20. Security Classification (of this page) Unclassified.	21. No. of Pages 50	22. Price NA

ROAD AUTHORITY PRACTICES IN DATA STORAGE SURVEY

Final Report
June 2019

Authors

Heather McClintock, Max Perchanok, Paula Grcevic, and Syed Salman
Ministry of Transportation of Ontario

Sponsored by
Federal Highway Administration Aurora Program
Transportation Pooled Fund
(TPF-5(290))

Preparation of this report was financed in part
through funds provided by the Iowa Department of Transportation
through its Research Management Agreement with the
Institute for Transportation
(Aurora Project 2015-05)

A report from
Aurora Program
Iowa State University
2711 South Loop Drive, Suite 4700
Ames, IA 50010-8664
Phone: 515-294-8103 / Fax: 515-294-0467
www.intrans.iastate.edu

TABLE OF CONTENTS

ACKNOWLEDGMENTS	vii
EXECUTIVE SUMMARY	ix
PURPOSE	1
SURVEY METHOD AND CONTENT	2
DATA SUMMARY	3
Road Weather Information System (RWIS)	3
Automatic Vehicle Location (AVL)	9
Camera Images.....	17
Traffic Data	22
CONCLUSIONS.....	30
Frequency of Observations by Data Type	30
How Data Are Stored.....	30
APPENDIX A. SURVEY QUESTIONS.....	33
APPENDIX B. ROAD AUTHORITY SURVEY RESPONSES	35

LIST OF FIGURES

Figure 1. Location of responses	2
Figure 2. Types of RWIS in use.....	3
Figure 3. Number of RWIS units of each type	4
Figure 4. Frequency of observations for RWIS data	5
Figure 5. Collected RWIS data storage.....	6
Figure 6. RWIS data observation period.....	6
Figure 7. RWIS data subject to quality control by type.....	7
Figure 8. RWIS data subject to quality control.....	7
Figure 9. Period of online storage for RWIS data	8
Figure 10. Period of offline storage for RWIS data.....	9
Figure 11. Number of organizations collecting AVL data by type.....	10
Figure 12. Number of AVL units collecting data by type	11
Figure 13. Frequency of observations for AVL data	12
Figure 14. Collected AVL data storage	13
Figure 15. AVL data observation period	14
Figure 16. AVL data subject to quality control by type	15
Figure 17. AVL data subject to quality control	15
Figure 18. Period of online storage for AVL data	16
Figure 19. Period of offline storage for AVL data.....	16
Figure 20. Number of organizations collecting images by camera type.....	17
Figure 21. Number of units collecting images by camera type	18
Figure 22. Frequency of observations for image data.....	19
Figure 23. Collected image data storage.....	20
Figure 24. Image data subject to quality control by type.....	20
Figure 25. Period of online storage for image data.....	21
Figure 26. Period of offline storage for image data.....	21
Figure 27. Number of organizations collecting traffic data by type	22
Figure 28. Number of units collecting traffic data by type.....	23
Figure 29. Frequency of observations for traffic data.....	24
Figure 30. Collected traffic data storage.....	25
Figure 31. Traffic data observation period	26
Figure 32. Traffic data subject to quality control by type.....	27
Figure 33. Traffic data subject to quality control	28
Figure 34. Period of online storage for traffic data.....	28
Figure 35. Period of offline storage for traffic data	29
Figure 36. Data subject to quality control by device type	30
Figure 37. Period of storage by type.....	31

LIST OF TABLES

Table 1. Response count for each RWIS data type.....	3
--	---

ACKNOWLEDGMENTS

This research was conducted under the Federal Highway Administration (FHWA) Transportation Pooled Fund Aurora Program: TPF-5(290). The authors would like to acknowledge the FHWA, the Aurora Program partners, and the Iowa Department of Transportation (DOT), which is the lead state for the program, for their financial support and technical assistance.

EXECUTIVE SUMMARY

The purpose of this research was to survey road authorities on their data collection and retention practices and to share the findings with Aurora member agencies. A survey was undertaken of road authorities across the United States of America, Canada, and some European organizations regarding their data collection practices for road weather information systems (RWIS), automated vehicle location (AVL) / global positioning systems (GPS), camera images, and traffic data. The results of this survey can be used by Aurora members to assess their data collection practices with respect to other road authorities.

PURPOSE

The purpose of this research was to survey road authorities on their data collection and retention practices and to share the findings with Aurora member agencies. A survey was undertaken of road authorities across the United States of America, Canada, and some European organizations regarding their data collection practices for road weather information systems (RWIS), automated vehicle location (AVL) / global positioning systems (GPS), camera images, and traffic data.

The results of this survey can be used by Aurora members to assess their data collection practices with respect to other road authorities.

SURVEY METHOD AND CONTENT

The questions included in the survey were divided into four groups:

- RWIS data from road weather observation stations
- AVL (GPS) equipped vehicles
- Camera images
- Traffic data

Each group had a range of questions ranging from the number of units in use, frequency of information collection, quality checking methods, and duration of data retention. The questions as they appeared in the questionnaire can be found in Appendix A.

The survey was sent out to a list of 84 individuals from different road authorities, including US state governments, Canadian provincial and municipal governments, and a few European organizations. A total of 28 responses were collected. The typical survey response rate was 30%; therefore, the data collected from this survey can be considered adequate to draw valid conclusions. The location breakdown of the responders is shown in **Error! Reference source not found..**

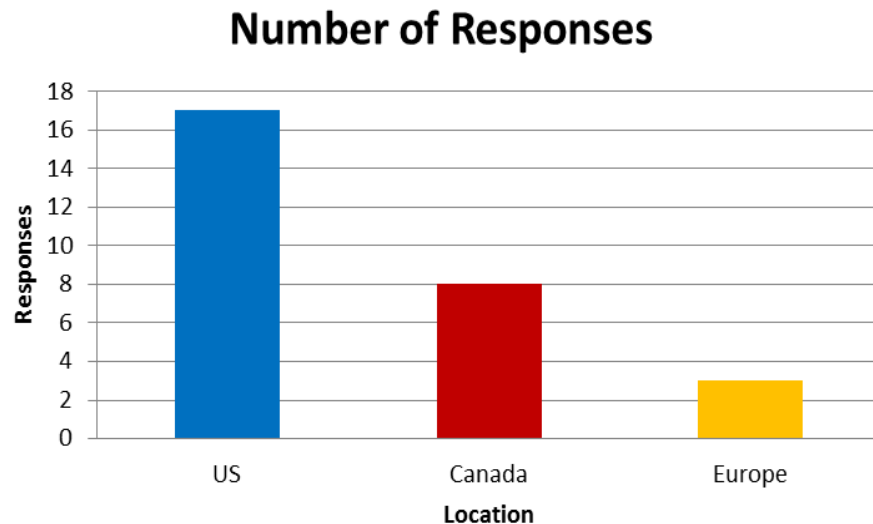


Figure 1. Location of responses

A numerical summary of all results is provided in Appendix B.

DATA SUMMARY

Road Weather Information System (RWIS)

Types of RWIS in Use

Collection and retention of data from RWIS stations were covered by the first part of the survey (Question 2). Table 1 shows the total number of responses received for each RWIS type.

Table 1. Response count for each RWIS data type

RWIS Station	Mobile Spectral Camera	IR/Temp Sensors	Portable RWIS	RWIS Forecast	Virtual RWIS
25	23	23	23	24	22

Looking at the results displayed in the bar graph in Figure 2, it is evident that the most common method of collecting RWIS data across North America and Europe is fixed roadside RWIS stations, with 24 out of 25 organizations using it.

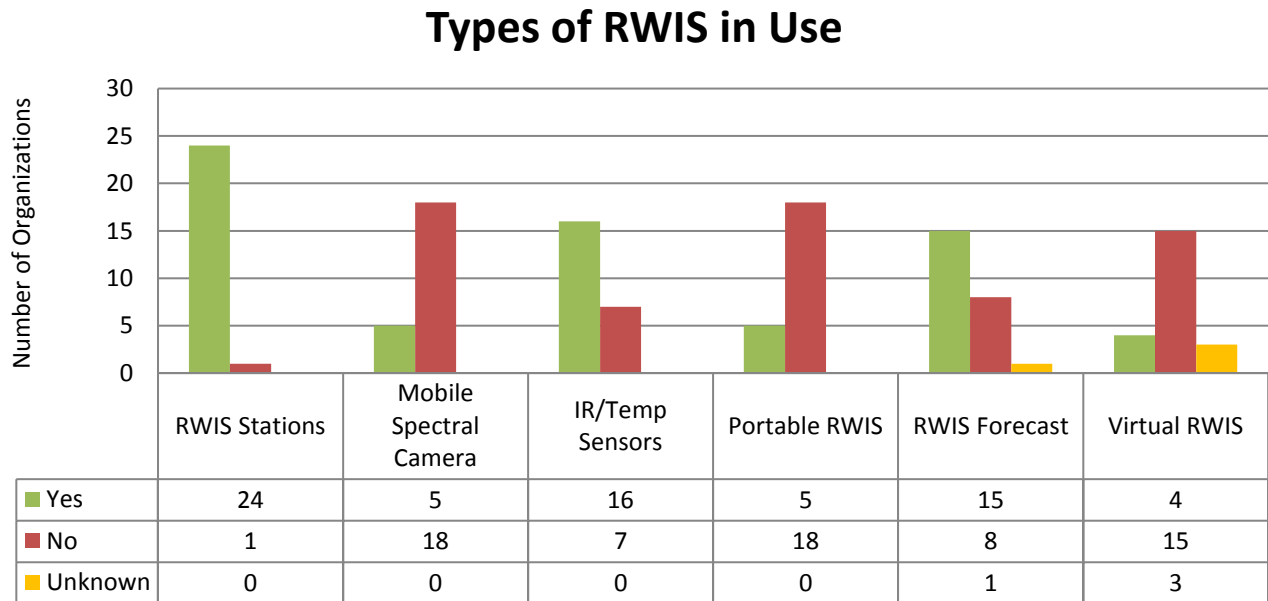


Figure 2. Types of RWIS in use

This is followed by data collection methods using infrared (IR) or other similar temperature sensors and RWIS forecast systems, with 70% and 63% of organizations, respectively. Other data collection methods, such as mobile spectral cameras (mobile RWIS), portable RWIS stations, and virtual RWIS predictions, are the least used methods, representing 22%, 22%, and 18%, respectively.

Number of RWIS Units

The numbers of RWIS units have been grouped into three ranges of units: 1 to 50, 51 to 100, and 100 to 1000. As shown in Figure 3, it is evident that the most numerous type of RWIS is IR or other similar temperature sensors, with at least 12 organizations having 101 to 1000 units.

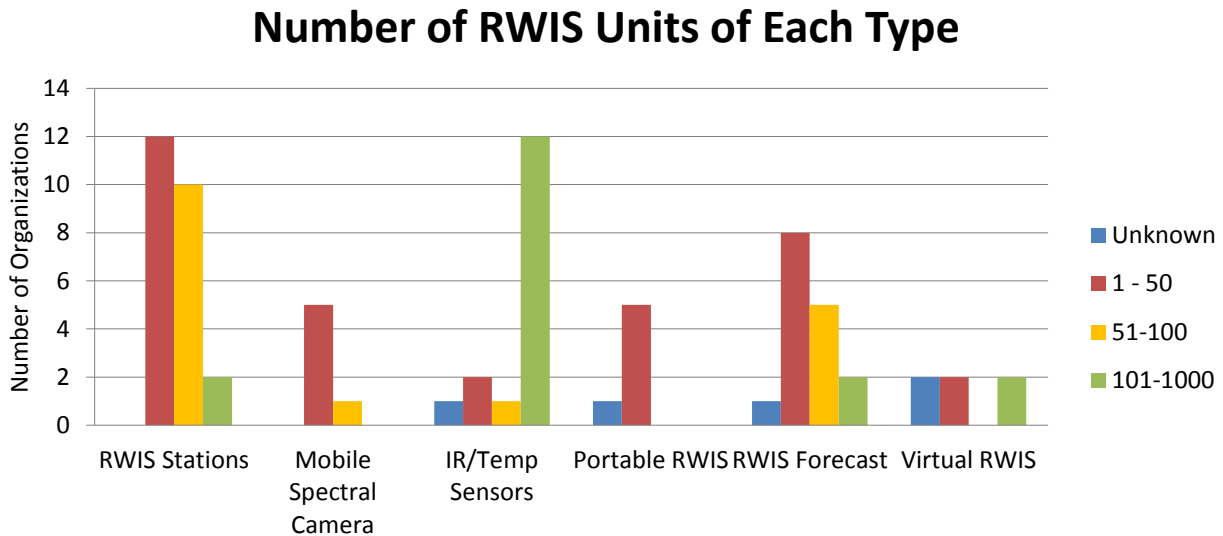


Figure 3. Number of RWIS units of each type

However, the most commonly used RWIS type is fixed roadside RWIS stations, with 12 organizations using 1 to 50 units, 10 organizations using 51 to 100 units, and 2 organizations using as many as 101 to 1000 units.

Frequency of Observations

From the responses collected, it is evident that roadside fixed RWIS stations are the most frequently used source of data, used by 23 different organizations; followed by IR or other similar temperature sensors, used by 16 organizations; and RWIS forecasts, used by 15 organizations. Furthermore, 6 organizations make use of mobile spectral cameras, portable RWIS stations, and virtual RWIS to gather road weather information. (Note that some organizations may use more than one data type; as a result, an overlap may occur.)

According to the data displayed in Figure 4, most roadside fixed RWIS stations take observations multiple times an hour, more specifically one to six observations per hour.

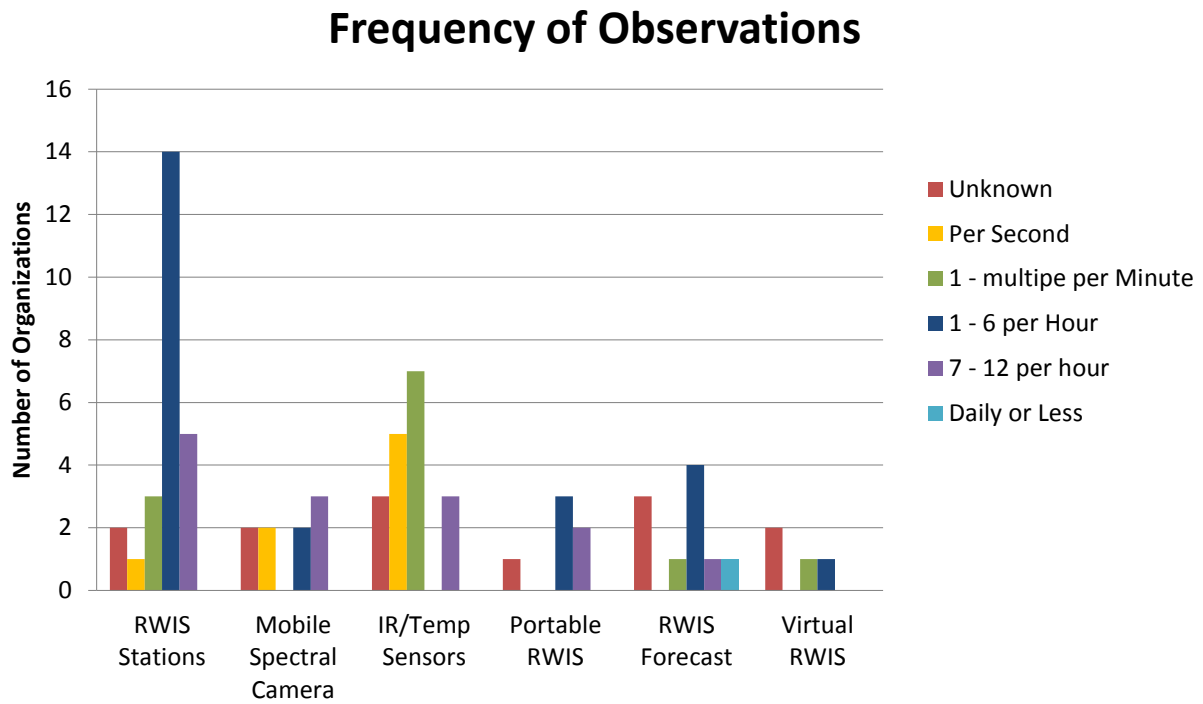


Figure 4. Frequency of observations for RWIS data

Data Storage

As seen in Figure 5, most organizations store their collected RWIS data, with 96% of organizations storing data collected from fixed RWIS stations. Similarly, most organizations tend to not store the data received from IR or other similar temperature sensors.

Collected RWIS Data Storage

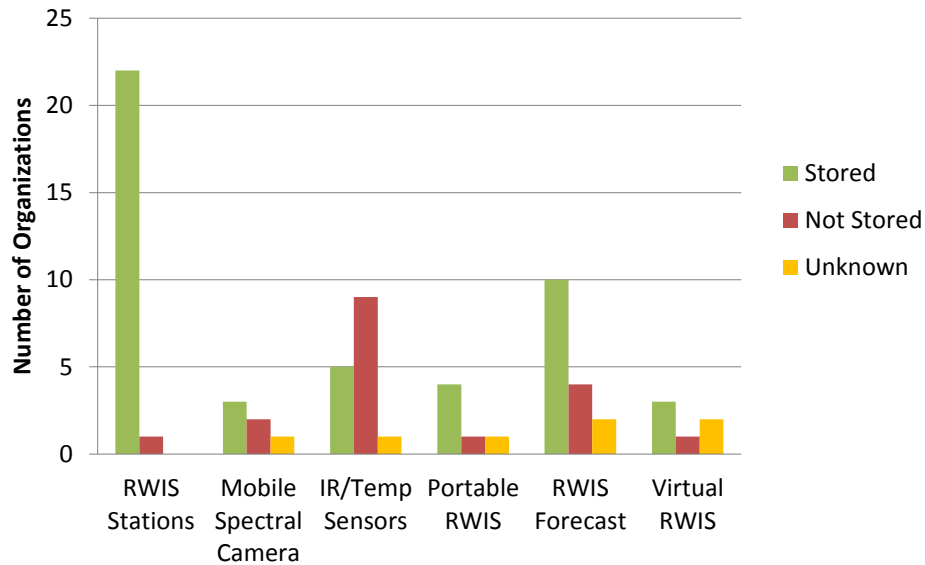


Figure 5. Collected RWIS data storage

Figure 6 shows that all organizations, with the exception of three, store their data as the data are received without averaging the data over a longer period of time.

RWIS Data Aggregated Before Storage

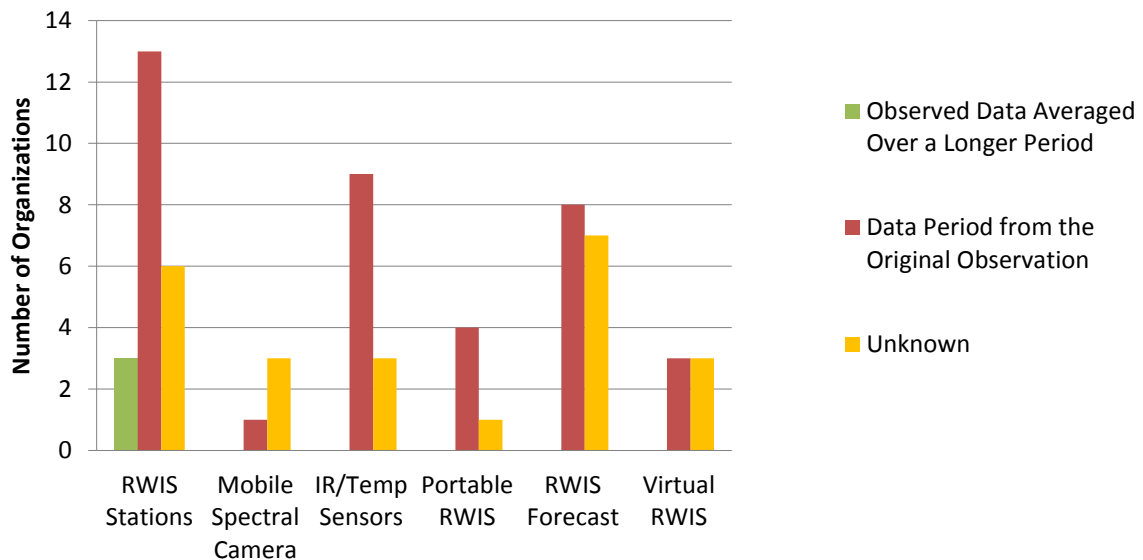


Figure 6. RWIS data observation period

Figure 7 shows that most organizations do not perform any sort of quality control procedures before storing their data, and Figure 8 sums up the data collected from all the RWIS sources into a pie chart to show the percentage of data subjected to quality checks before storage.

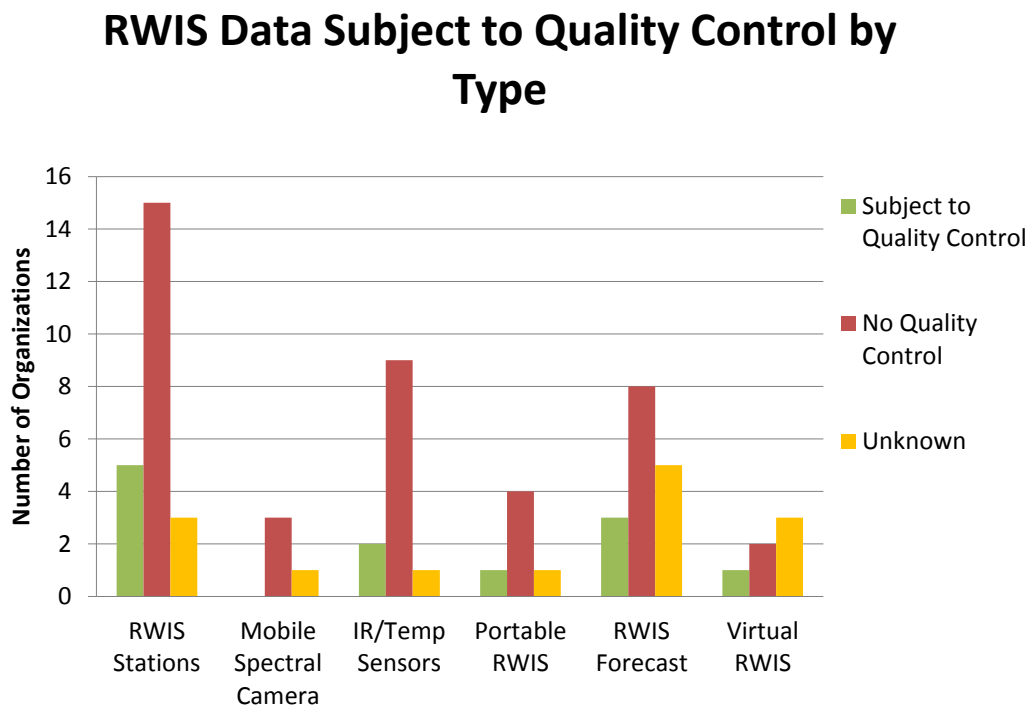


Figure 7. RWIS data subject to quality control by type

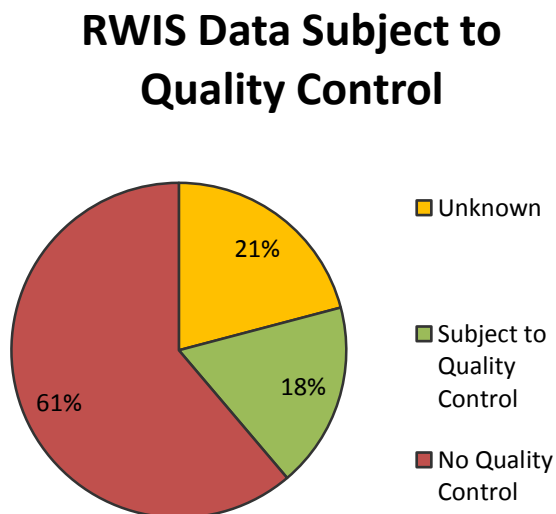


Figure 8. RWIS data subject to quality control

Figure 9 shows that most organizations store the collected data indefinitely, and Figure 10 shows the number of organizations that store data offline.

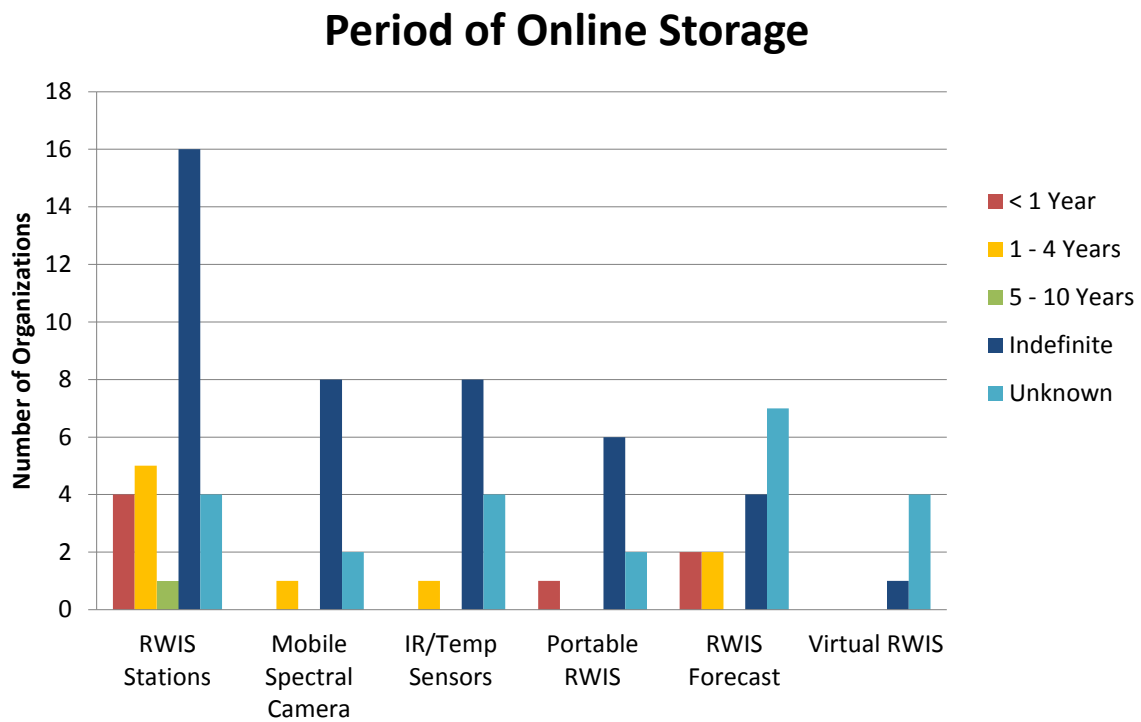


Figure 9. Period of online storage for RWIS data

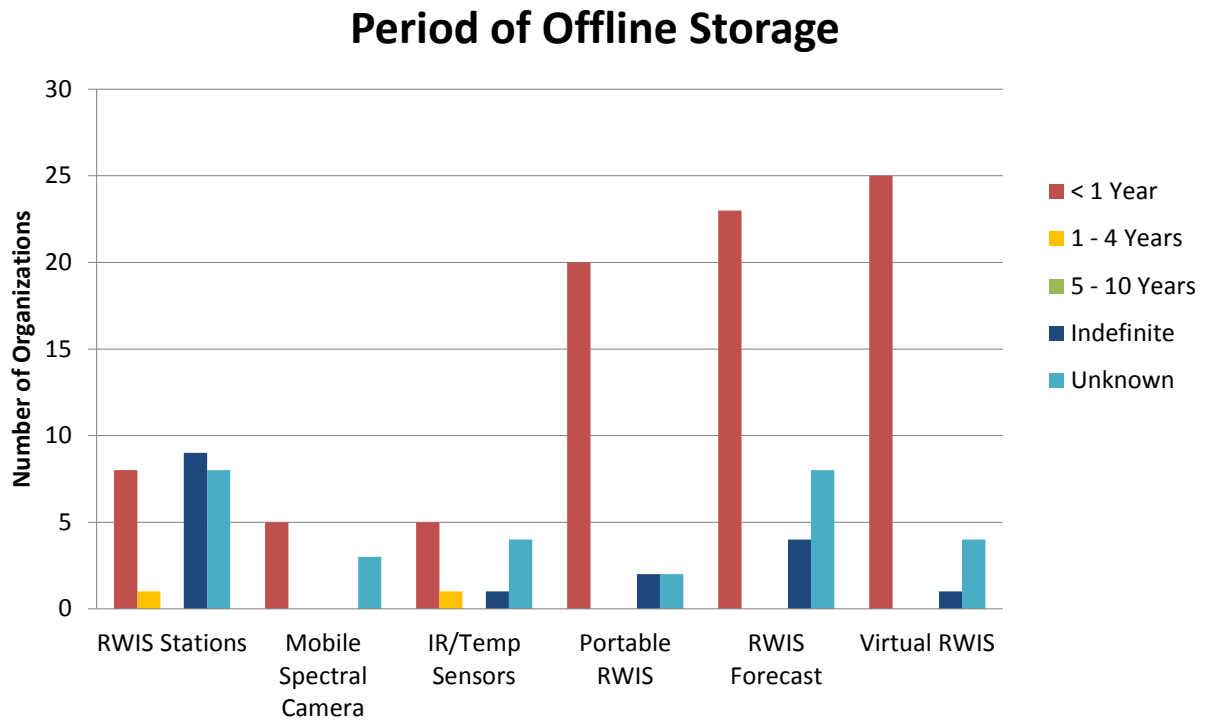


Figure 10. Period of offline storage for RWIS data

Automatic Vehicle Location (AVL)

Data Collected

This section refers to Question 3 on the questionnaire, which covers data collected from vehicles equipped with AVL (GPS) and the type of data recorded, such as plow/spreader speed, spread quantities, position of the plow (up/down), tow-plow deployment, pavement markings, and weed spraying.

A total of 23 responses were collected for this section. The first part of the question asks the survey subjects to specify whether or not their organization uses AVL data. Results from this section are displayed in Figure 11.

Number of Organizations Collecting AVL Data by Type

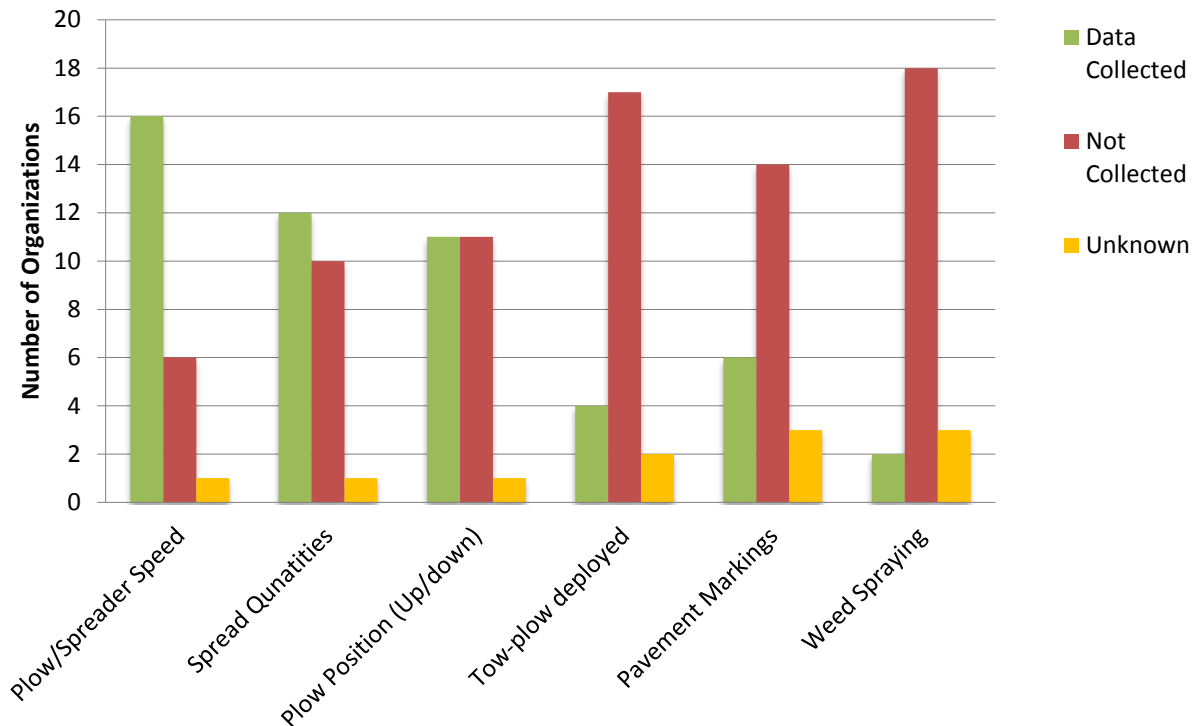


Figure 11. Number of organizations collecting AVL data by type

Figure 11 shows that most organizations collect plow and spreader speed, as well as spread quantities. However, only a few collect data regarding tow-plow deployment, pavement markings, and weed spreading.

Number of AVL Units

Figure 11 displays the number of AVL units used by each organization in four range groups: 1 to 50 units, 51 to 100 units, 101 to 500 units, and 501 to 1000 units.

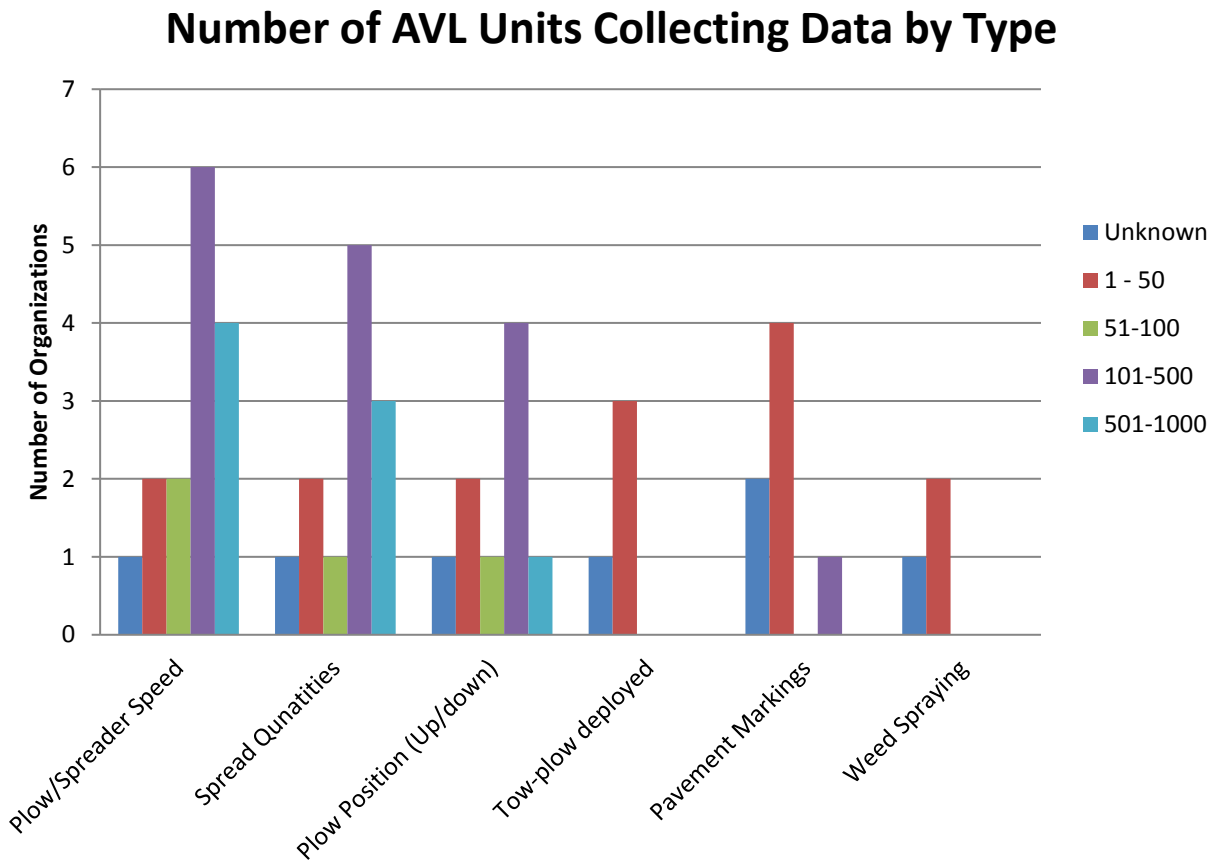


Figure 12. Number of AVL units collecting data by type

The responses collected show that most organizations have 100 to 500 units recording plow/spreader speed, spreader quantities, and plow positions.

Frequency of Observations

Figure 12 shows the frequency of observations for each type of AVL data collected.

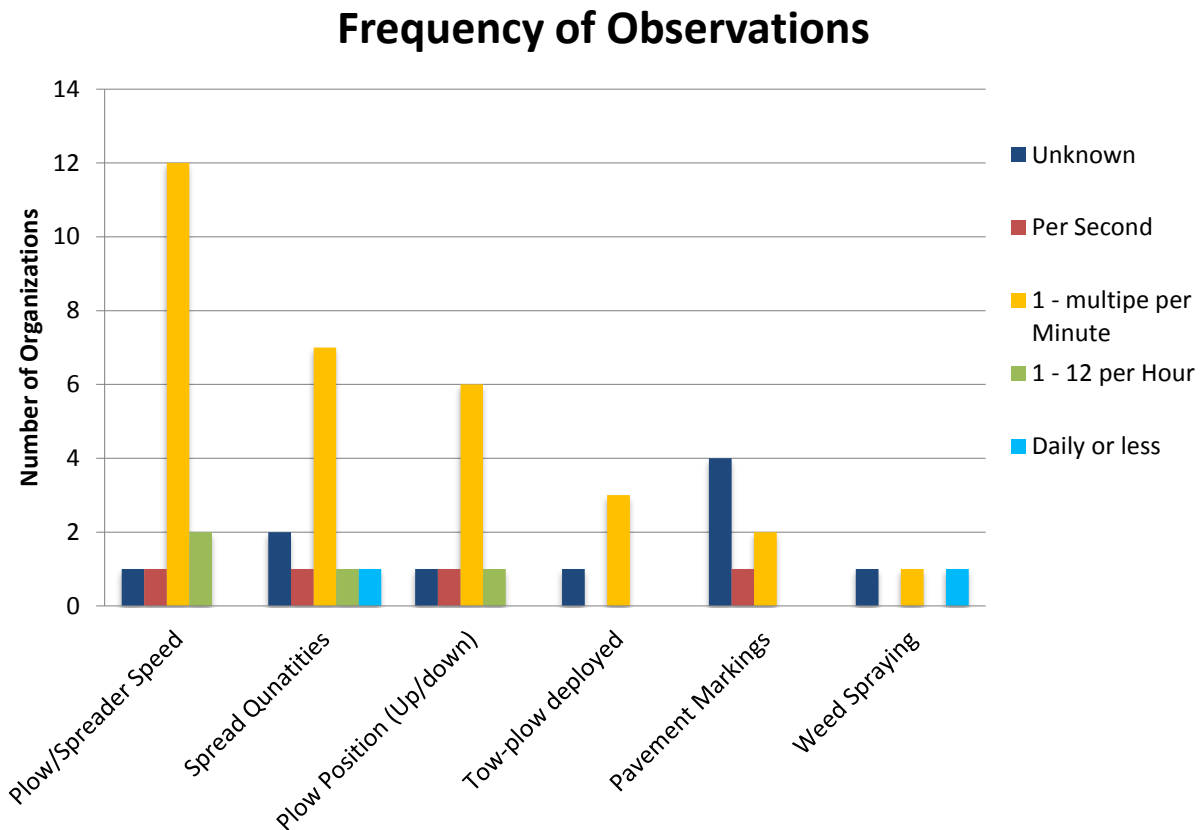


Figure 13. Frequency of observations for AVL data

Most of the collected data are recorded one to multiple times per minute. Note that some of the data are collected per second and are represented separately and are not included in the “1 - multiple per minute” group.

Data Storage

As seen in Figure 14, most of the data are stored by most organizations, with the exception of a few organizations that do not store some data.

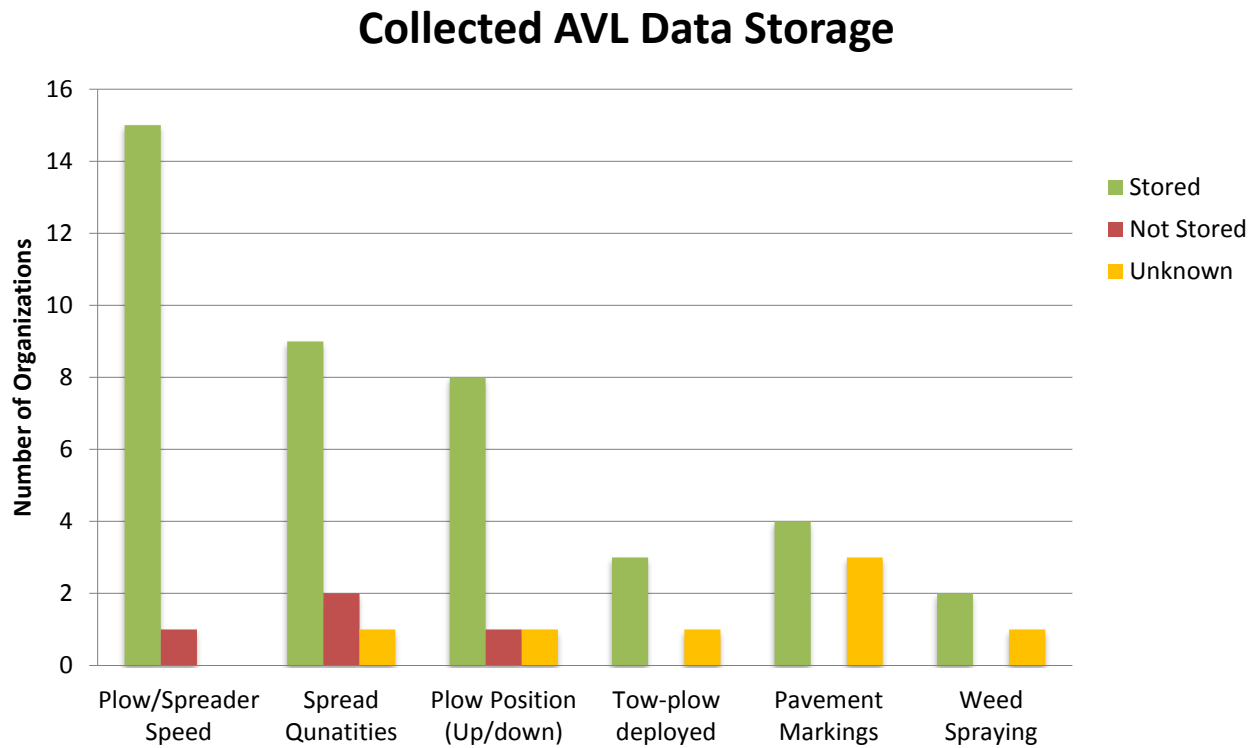


Figure 14. Collected AVL data storage

Figure 15 shows that most organizations are not sure if the AVL data are averaged over longer periods.

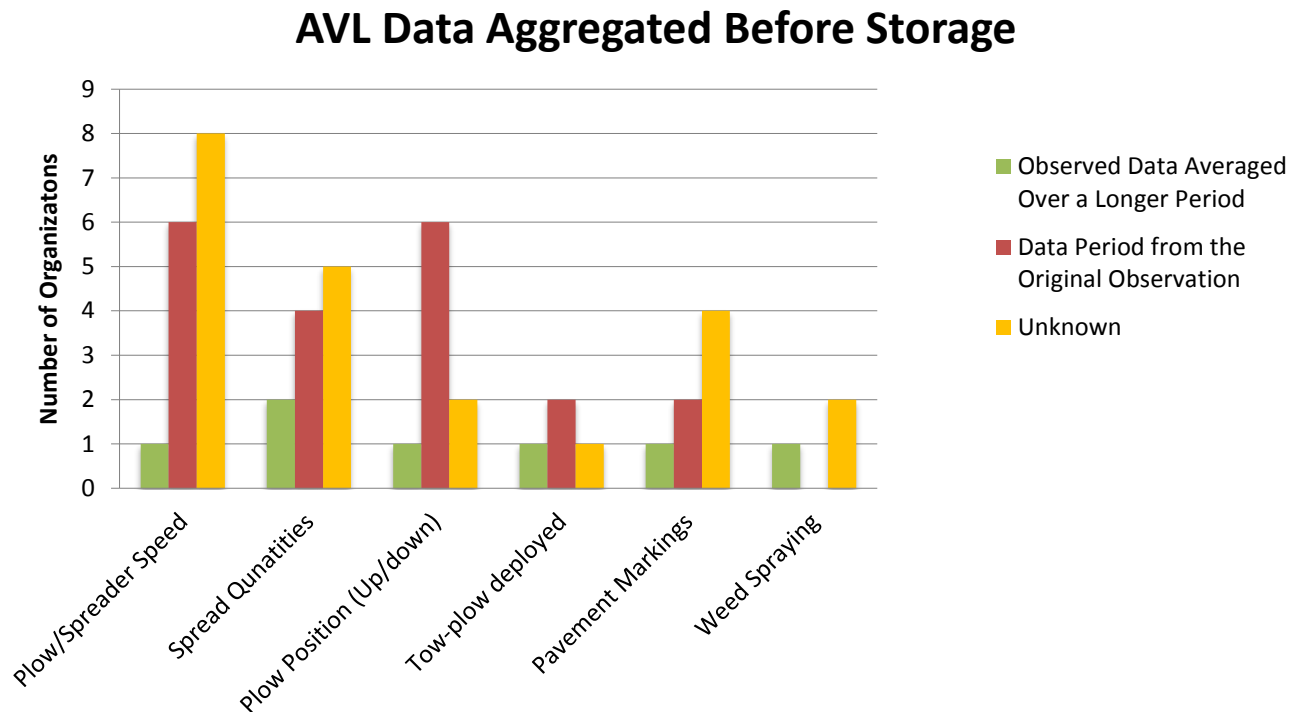


Figure 15. AVL data observation period

However, within the known data storage policies, most of the data collected through AVL are stored as they are without being averaged over a longer period, such as hourly, daily, or seasonally, except for a few cases where data are averaged seasonally or over a defined section of a road.

Figure 16 shows the number of organizations that perform quality checks on the collected data before the data are stored. Most collected data are saved as they are without going through a quality control procedure.

AVL Data Subject to Quality Control by Type

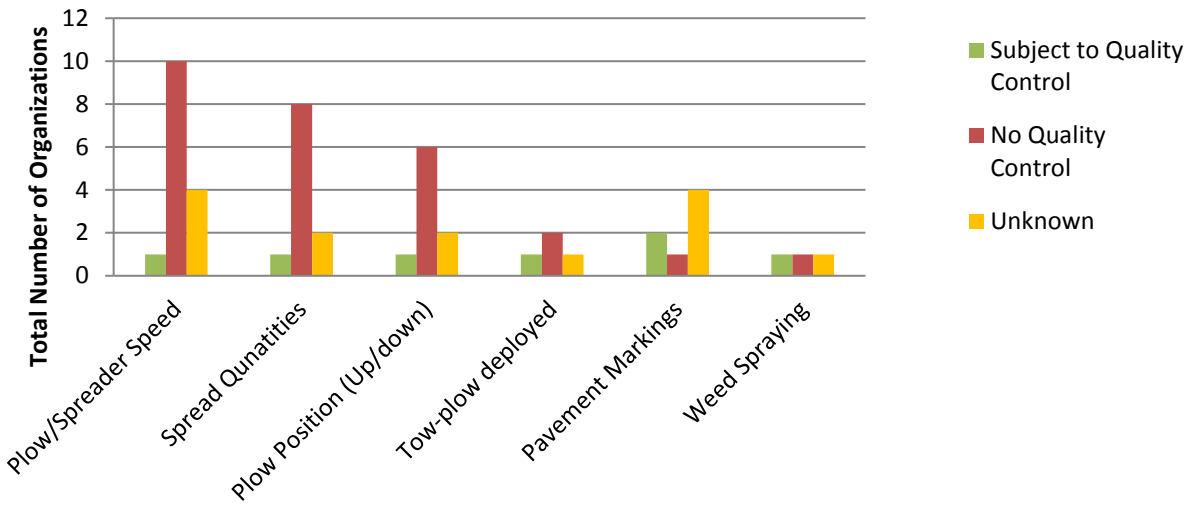


Figure 16. AVL data subject to quality control by type

Figure 17 shows that only 14% of the total data are subject to a quality check before being stored, whereas 57% of the data are stored as they are received without going through a quality control procedure.

AVL Data Subject to Quality Control

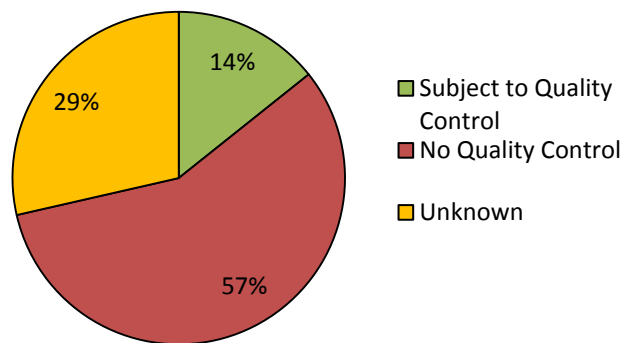


Figure 17. AVL data subject to quality control

Figure 18 and Figure 19 show that the period of storage either online or offline is largely unknown.

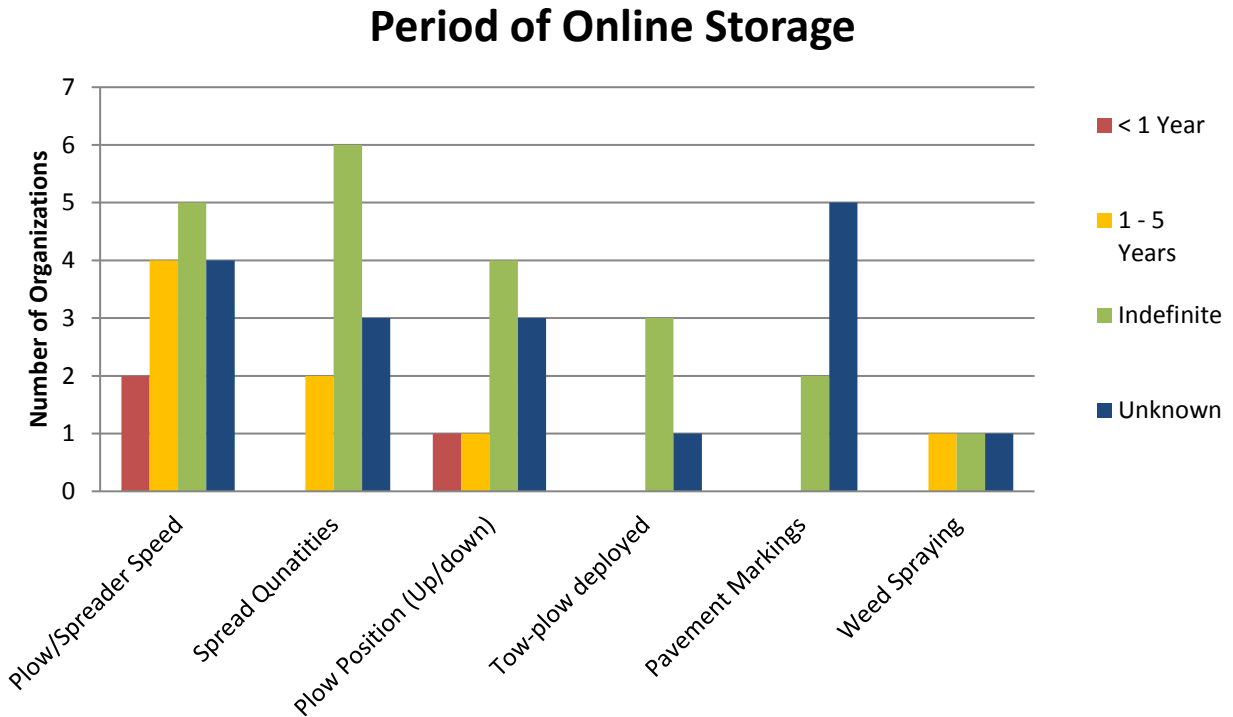


Figure 18. Period of online storage for AVL data

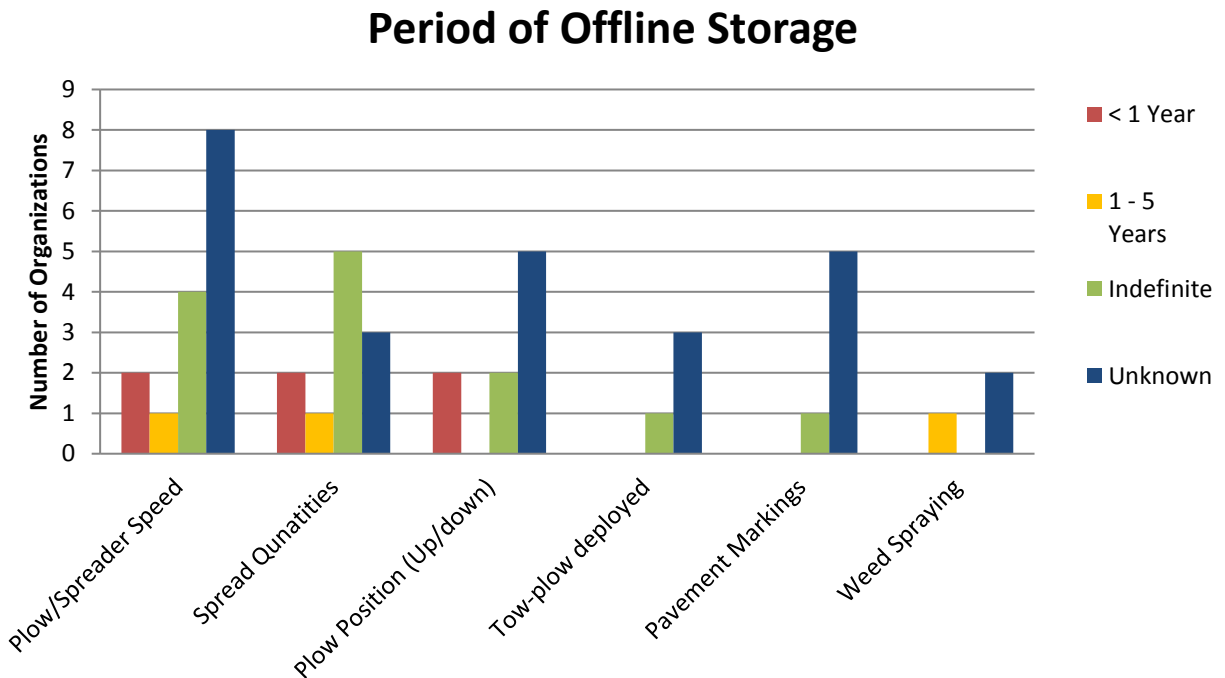


Figure 19. Period of offline storage for AVL data

Camera Images

Data Collected

Figure 20 shows the breakdown between the two sources of camera images used for collecting data used by different organizations, namely dash camera images and roadside traffic camera images.

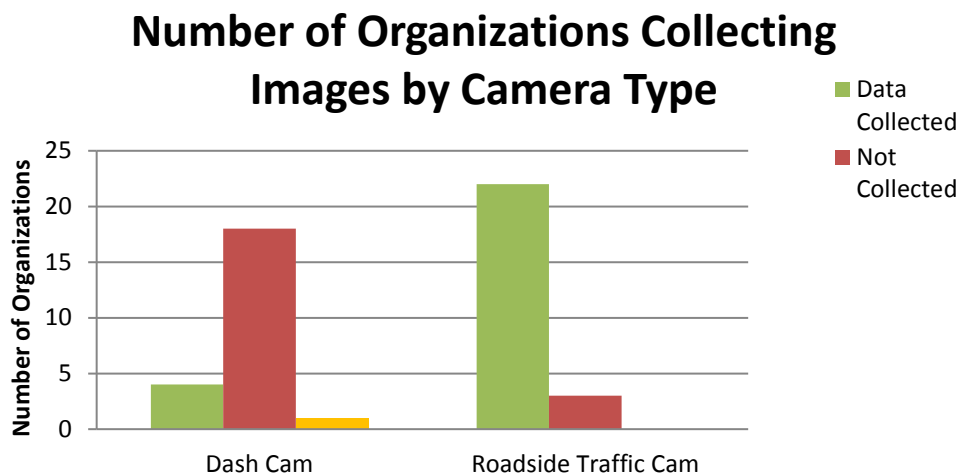


Figure 20. Number of organizations collecting images by camera type

Figure 20 shows that only 4 out of the 23 responding organizations, or 17%, use images from dash cameras. However, 22 out of the 25 responding organizations, or 88%, use roadside traffic cameras to collect data.

Number of Units

The bar chart in Figure 21 shows that 10 out of the 23 responding organizations using roadside traffic cameras, or 43%, have at least 1 to 50 cameras, followed by 7 organizations, or 30%, with 101 to 500 cameras.

Number of Units Collecting Images by Camera Type

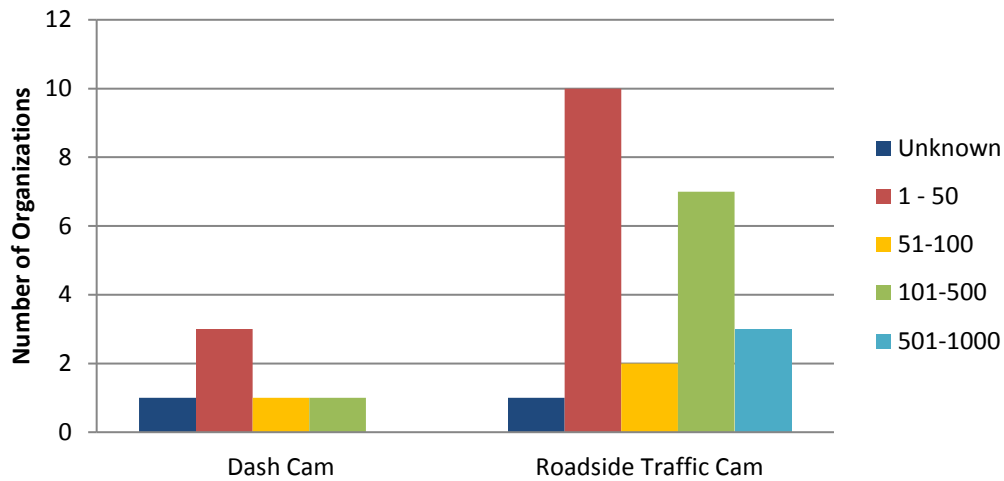


Figure 21. Number of units collecting images by camera type

Only 3 organizations, or 13%, have 500 to 1000 cameras. There are significantly fewer dash cameras than roadside cameras. A total of 3 organizations, also 13%, have 1 to 50 units of dash cameras.

Frequency of Observations

Figure 22 shows the frequency of observations for the dash cameras and roadside cameras.

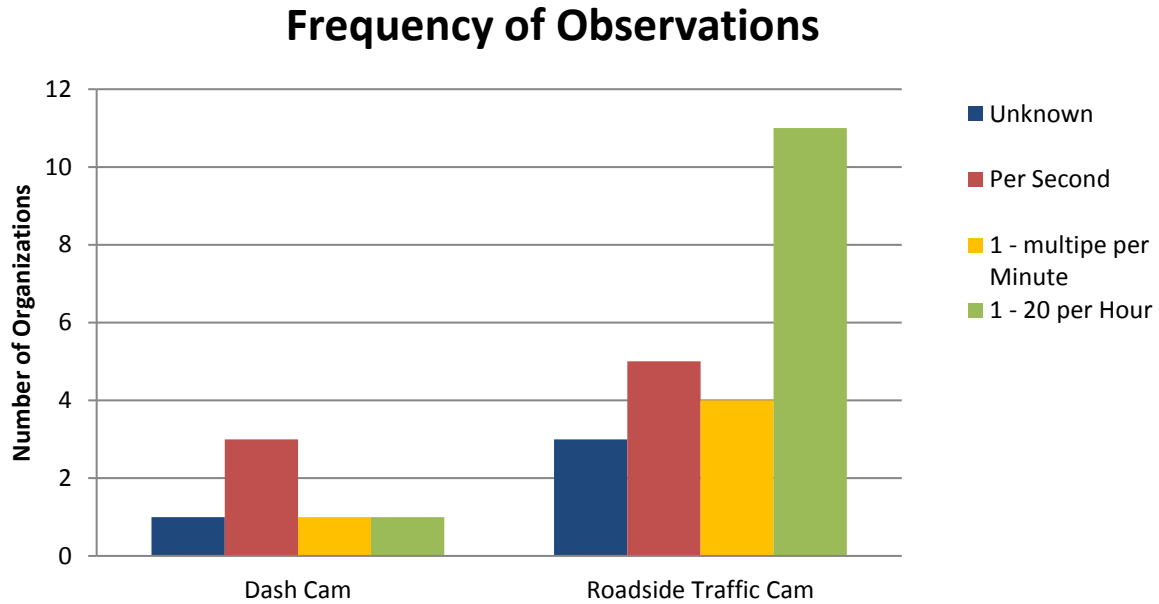


Figure 22. Frequency of observations for image data

Most dash camera observations are taken per second. Most observations made through roadside traffic cameras are less frequent than those made through dash cameras, with the majority falling in the range of 1 to 20 observations per hour.

Data Storage

As illustrated by the bar chart in Figure 23, only one-third of organizations using dash cameras store their images. However 11 out of the 23 organizations using roadside cameras, or 48%, do store the images, while 10 organizations do not and 2 are unknown.

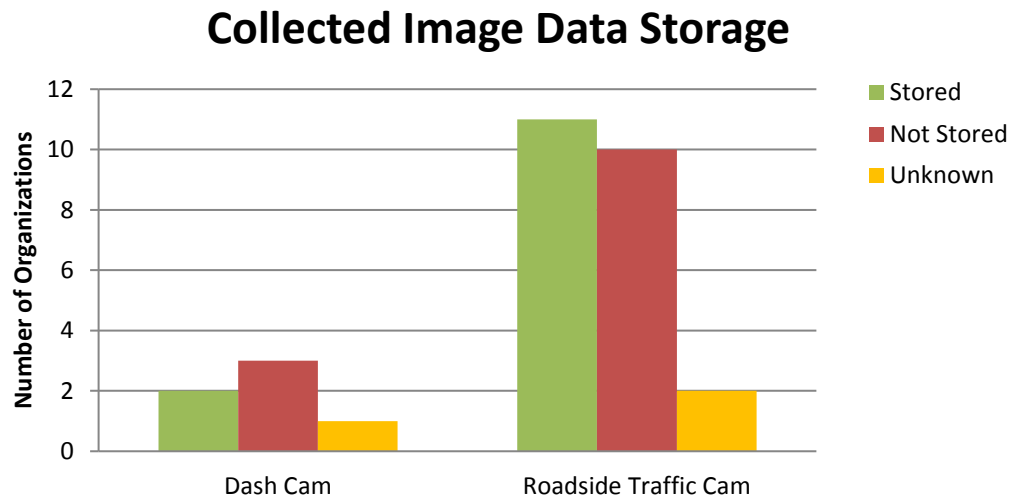


Figure 23. Collected image data storage

Figure 24 shows that quality checks are not performed on camera images, whether the images are from dash cameras or roadside traffic cameras. Quality control for camera images is not applicable to most of the responding organizations.

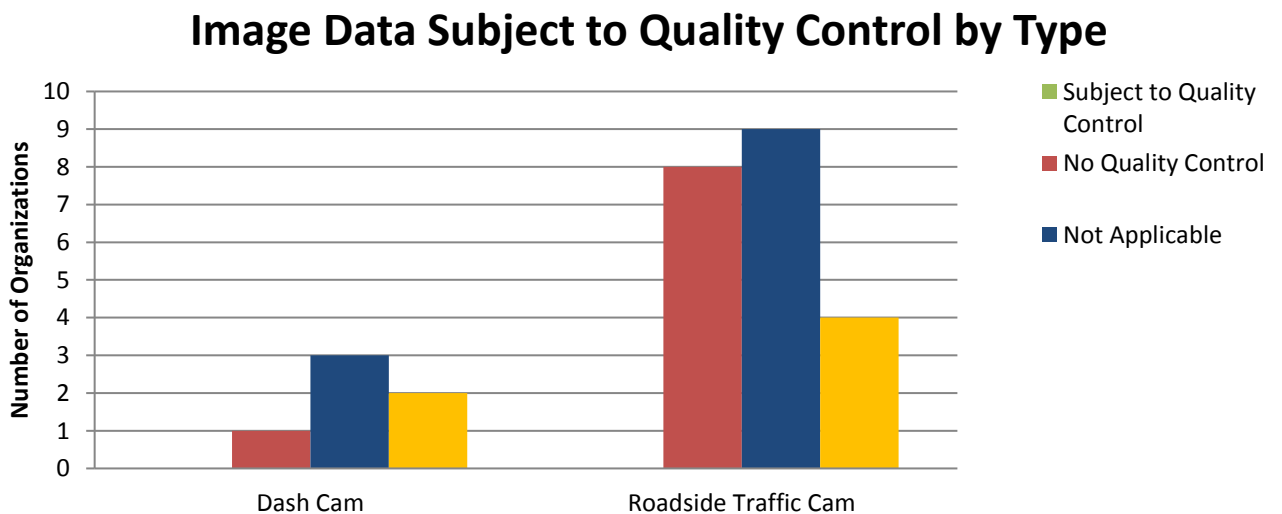


Figure 24. Image data subject to quality control by type

Figure 25 and Figure 26 show a mixture of online and offline data storage/retention periods for camera images.

Period of Online Storage

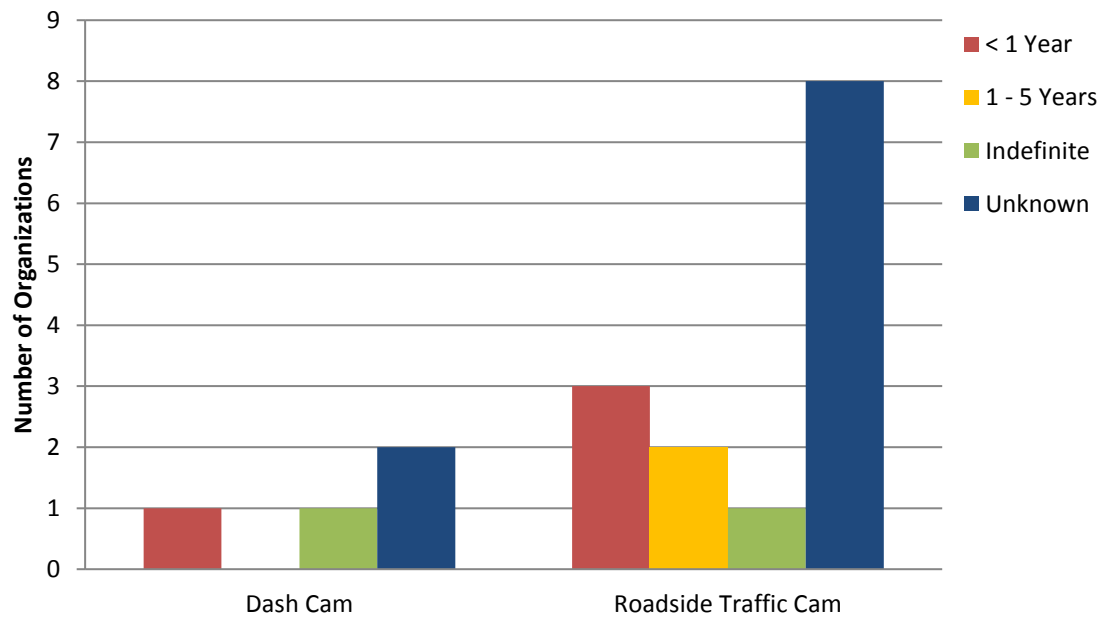


Figure 25. Period of online storage for image data

Period of Offline Storage

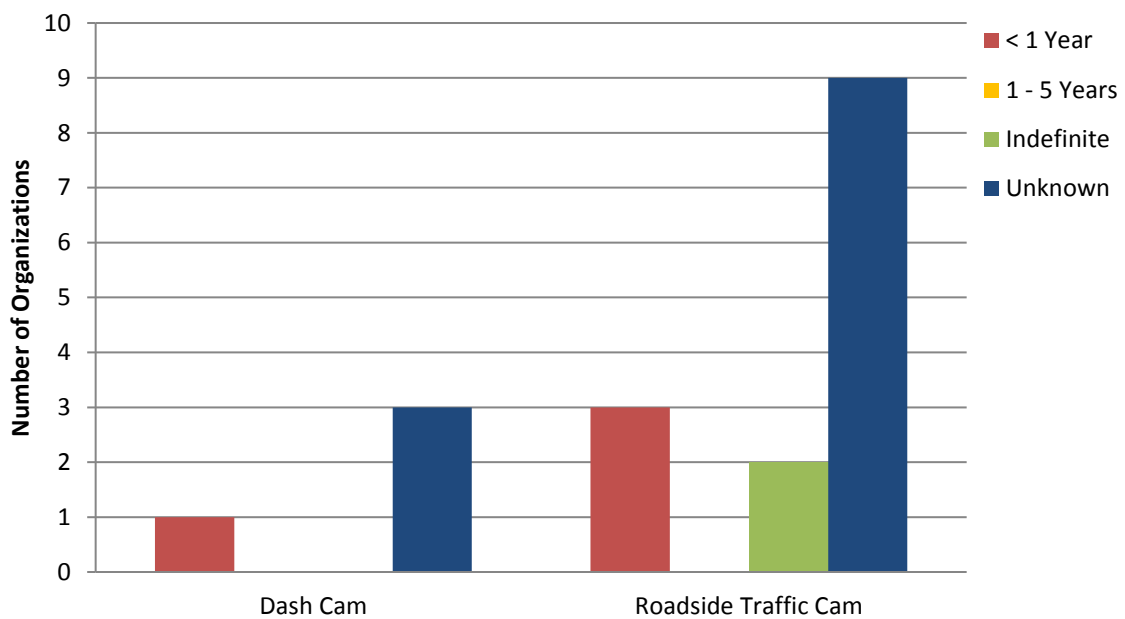


Figure 26. Period of offline storage for image data

Traffic Data

This section covers traffic data, including traffic volume, speed, spacing between vehicles, type of vehicle, and travel time.

Data Collected

A total of 23 responses were collected for this section. The first questions ask whether or not the organization records data related to traffic. Results from this section are shown in Figure 27.

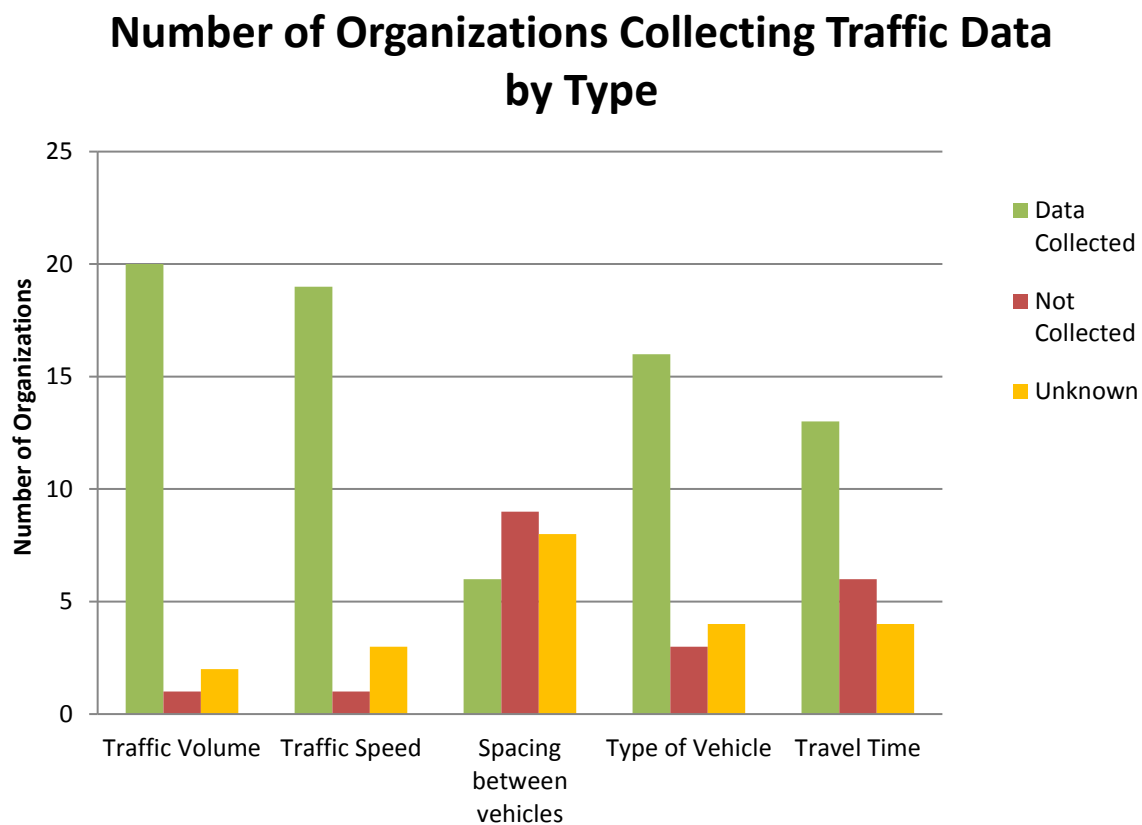


Figure 27. Number of organizations collecting traffic data by type

Figure 27 shows that most road authorities record traffic volume, speed, vehicle type, and travel time. However, only 6 out of the 23 responding organizations, or 26%, record spacing between vehicles.

Number of Units

Figure 28 shows the number of units collecting each type of traffic data.

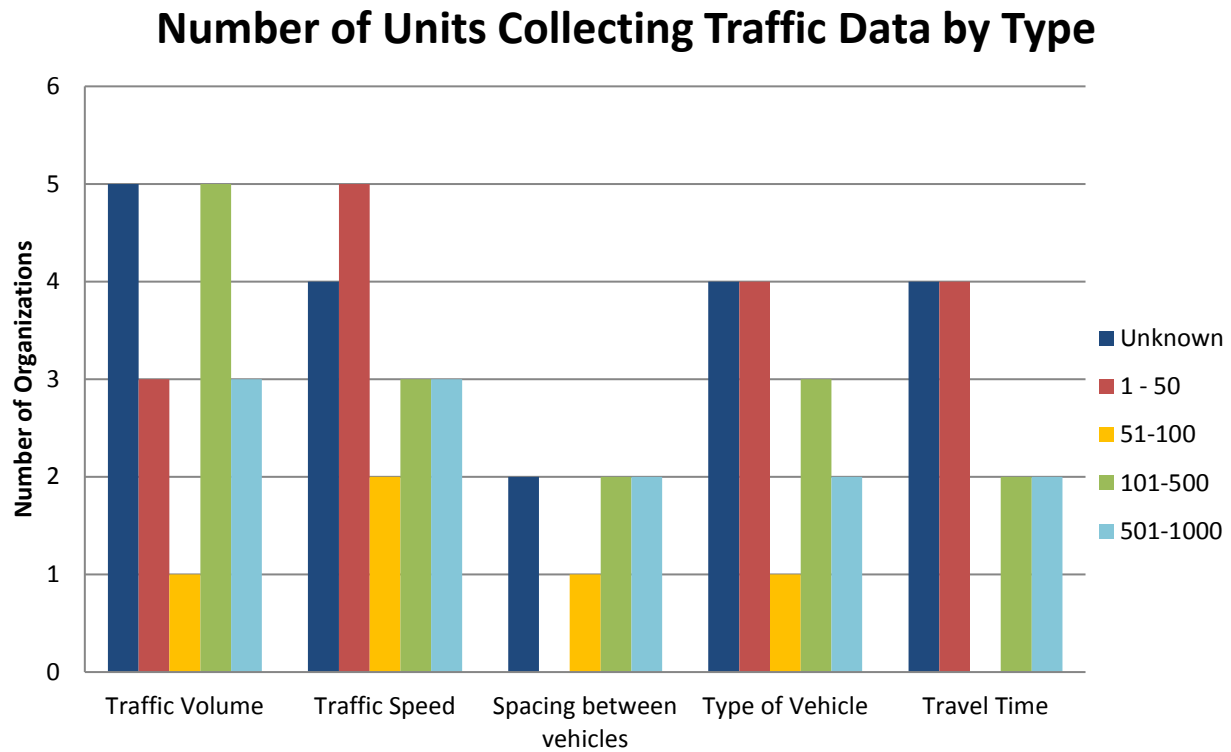


Figure 28. Number of units collecting traffic data by type

As seen in Figure 28, a large number of units collect traffic volume and speed, a moderate number of units record type of vehicle and travel time, and comparatively fewer units record spacing between vehicles.

Frequency of Observations

Figure 29 shows the frequency of observations of each type of traffic data being recorded.

Frequency of Observations

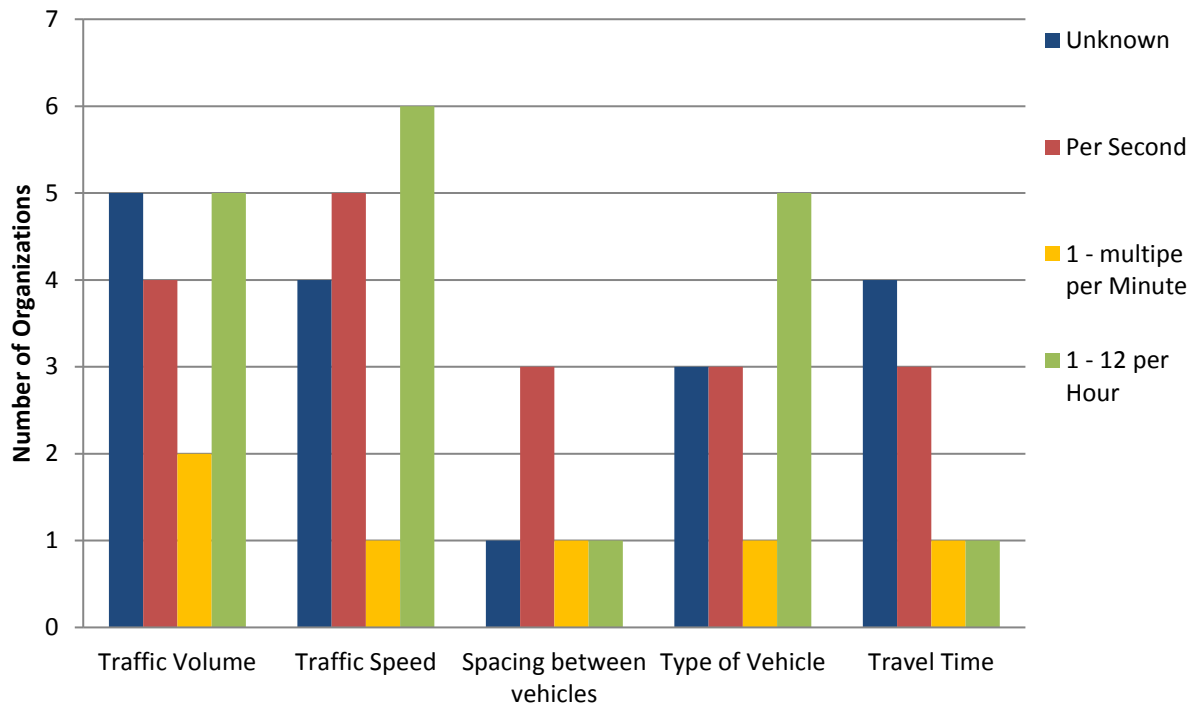


Figure 29. Frequency of observations for traffic data

Frequencies for traffic volume and speed are spread out fairly evenly across all frequency ranges. Spacing between vehicles is mostly recorded per second. Type of vehicle is usually recorded multiple times per hour. Lastly, travel time is mostly recorded per second.

Data Storage

The collected responses show that most of the traffic data collected are stored by the organizations. This can be seen in the bar chart in Figure 30.

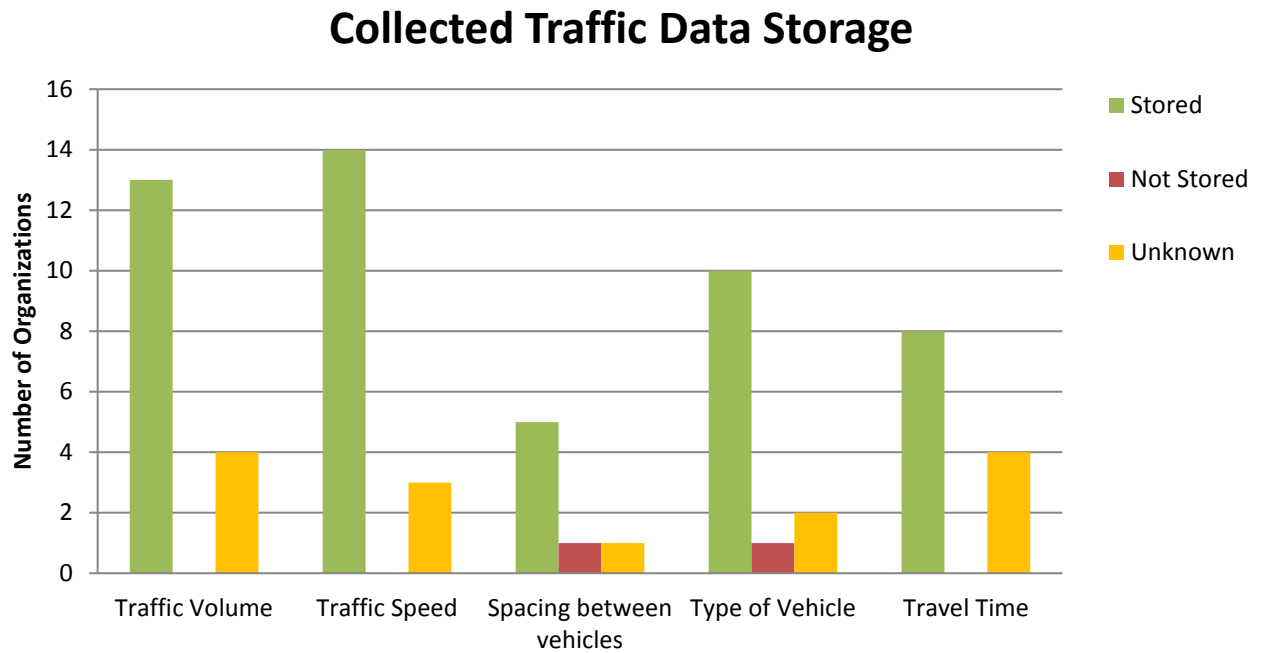


Figure 30. Collected traffic data storage

Figure 31 shows the number of organizations averaging the recorded data over a longer period of time. As seen in the bar chart, most organizations do average their data. However, there were a high number of “unknowns” among the responses.

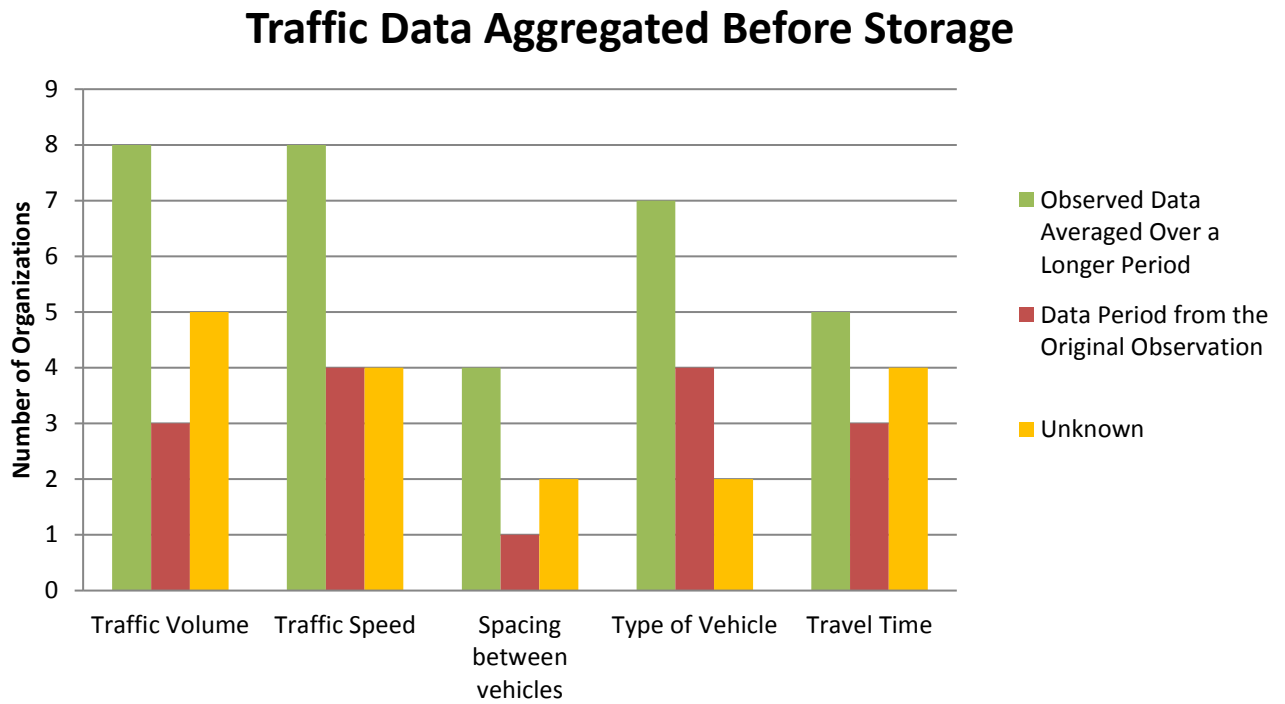


Figure 31. Traffic data observation period

Figure 32 shows that most organizations recording traffic data perform quality checks on the recorded data before they are stored.

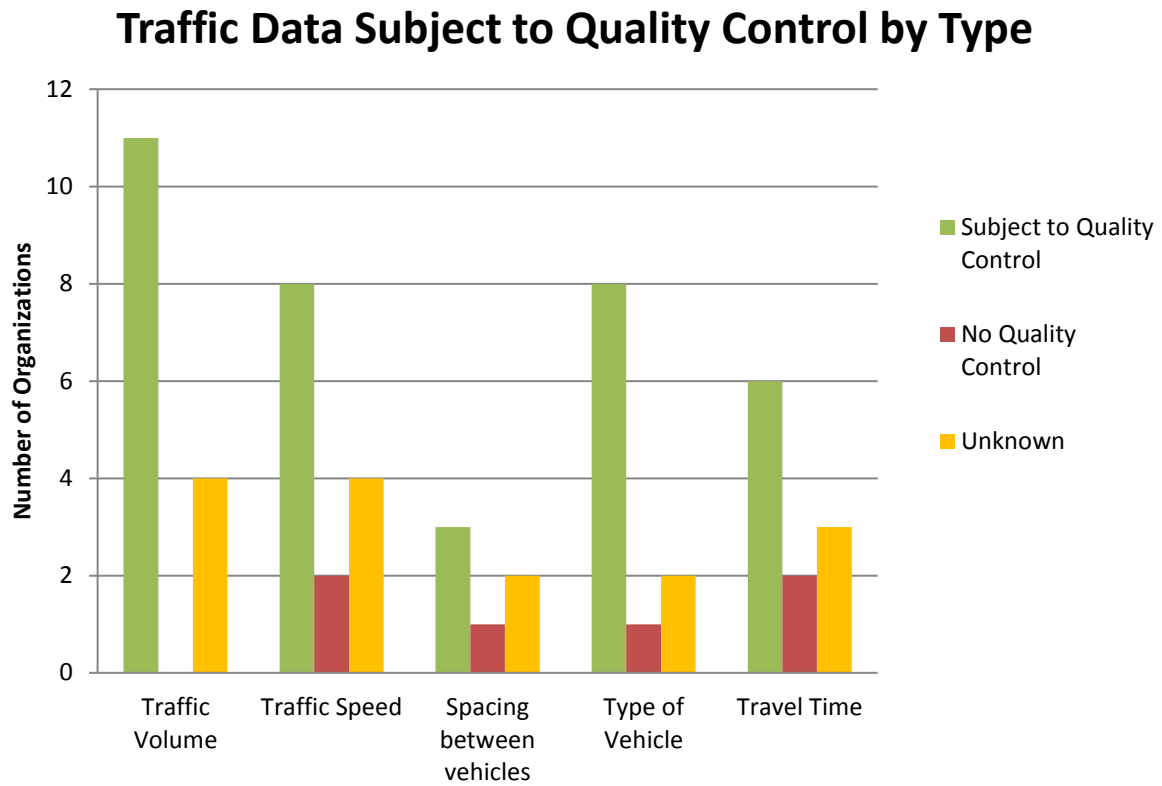


Figure 32. Traffic data subject to quality control by type

Figure 33 shows the total percentage of data that go through quality control before being stored. In total, 63% of the data are subject to quality checks, as opposed to 11% that are not.

Traffic Data Subject to Quality Control

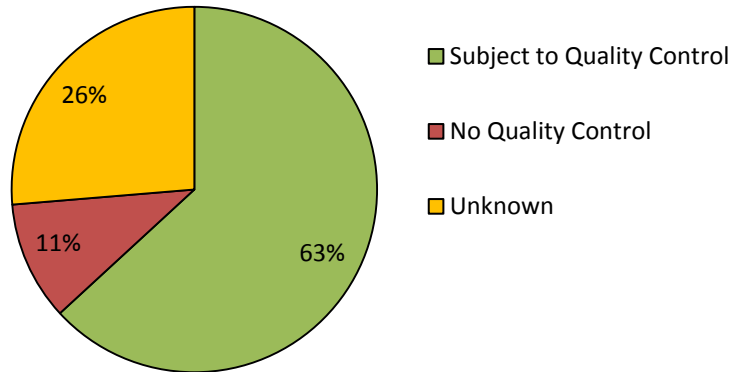


Figure 33. Traffic data subject to quality control

Figure 34 and Figure 35 show the online and offline data storage practices, respectively. Most of the data that are known to be stored are stored indefinitely.

Period of Online Storage

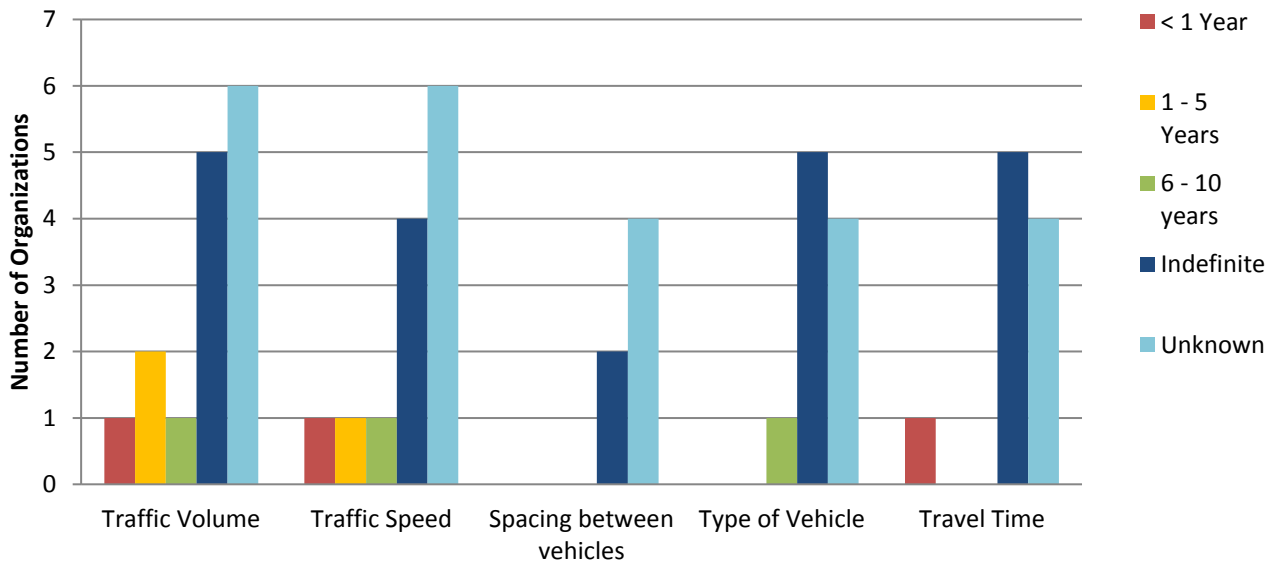


Figure 34. Period of online storage for traffic data

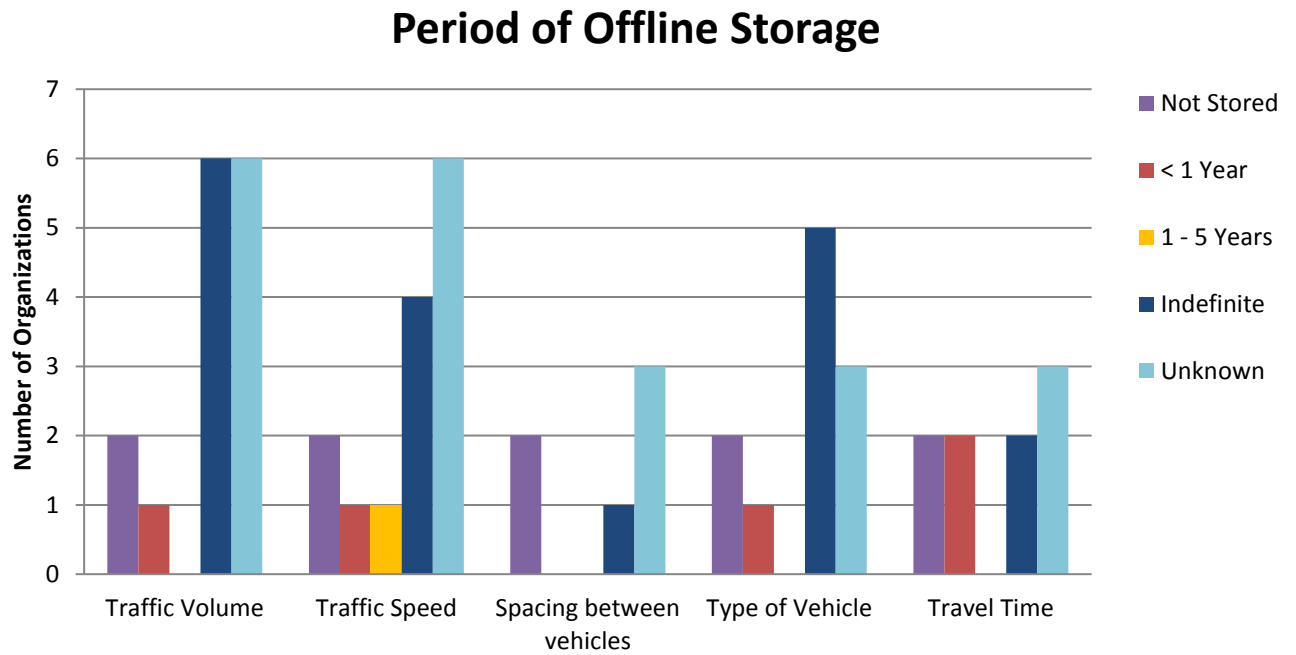


Figure 35. Period of offline storage for traffic data

CONCLUSIONS

Frequency of Observations by Data Type

The frequency of observations varies by device and data type. The majority of data collected from roadside RWIS stations is observed 1 to 6 times per hour, as seen in Figure 4. AVL data, regardless of type, are most frequently observed 1 to multiple times per minute, as seen in Figure 13. Roadside camera images are most frequently observed 1 to 20 times per hour, and dash cams are most frequently observed per second, as seen in Figure 22. Finally, traffic data observation frequencies vary significantly among data types, as seen in Figure 29.

How Data Are Stored

Only 24% of data types are subject to quality control checks, as shown in Figure 36.

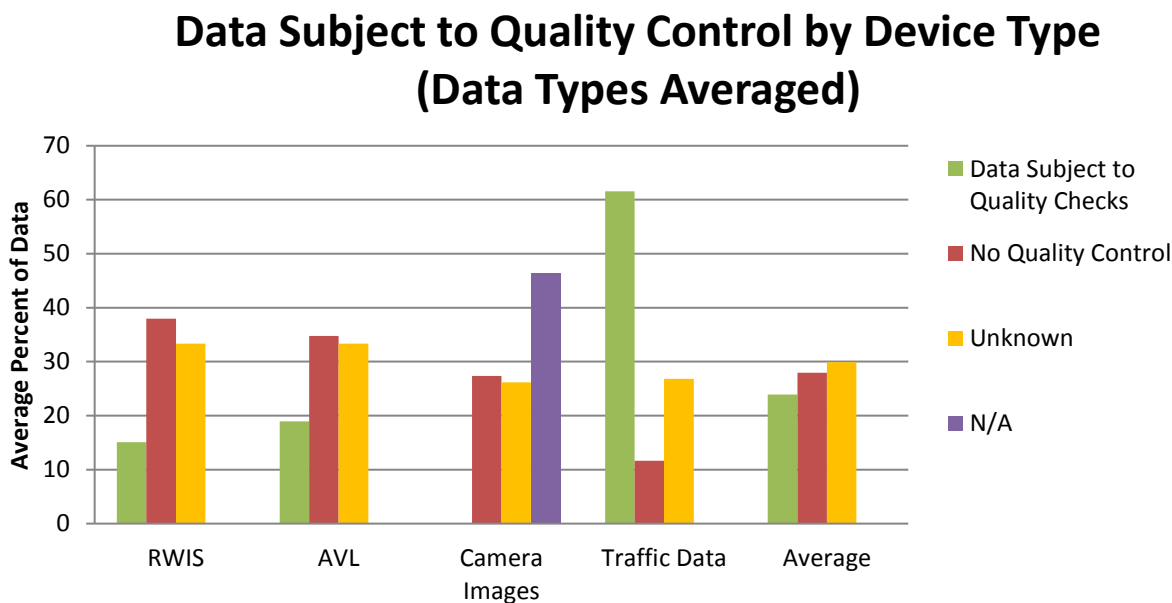


Figure 36. Data subject to quality control by device type

RWIS data are typically subject to more quality control than other data types. It is important to note that a significant number of organizations are not aware of quality control practices.

The majority of data for which the data retention period is known are stored indefinitely, either online or offline, with the exception of camera images, which are most commonly stored for less than one year, as shown in Figure 37.

Period of Storage by Type

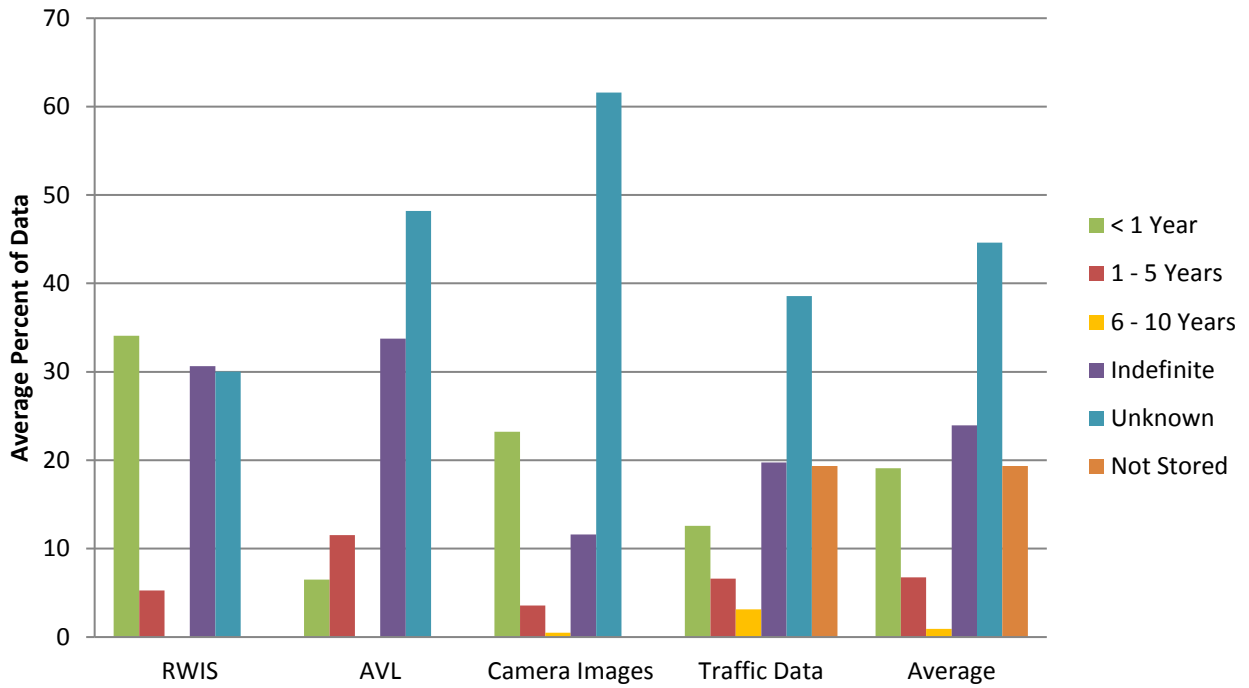


Figure 37. Period of storage by type

Similar to quality control, it is important to note the number of “unknown” responses, which could indicate a lack of policies regarding the period of data retention.


APPENDIX A. SURVEY QUESTIONS

1. Please fill out the following respondent information

Name	<input type="text"/>
Title	<input type="text"/>
Email	<input type="text"/>
Agency name	<input type="text"/>

2. Please answer the following questions about the **road-weather observation stations** of each type used by your organization (please select the most accurate answer from the choices below)

	RWIS in use	Number of RWIS units	Frequency of observations	Is the data collected stored?	Is the data aggregated/averaged over a longer period than the original observation?	Is the data subject to quality checks before it is stored?	For how long is the data retained in on-line storage?	For how long is the data retained in off-line storage?
Road side RWIS station observations	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Mobile spectral camera (Mobile RWIS)	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
IR and similar temperature sensors mounted on a vehicle	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Portable RWIS station observations	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
RWIS Forecast	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Virtual RWIS (predictions for road segments where no data are collected)	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Other (please specify)	<input type="text"/>							


3. Please answer the following question regarding **vehicles equipped with AVL** used by your organization (please select the most accurate answer from the choices below) 

	Data collected	Number of units collecting data	Frequency of observations	Is the data collected stored?	Is the data aggregated/averaged over a longer period than the original observation?	Is the data subject to quality checks before it is stored?	For how long is the data retained in on-line storage?	For how long is the date retained in off-line storage?
Plow/Spreader heading speed	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Spread quantities	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Plow position (up, down)	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Tow-plow deployed	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Pavement marking	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Weed spraying	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

Other (please specify)

4. Camera Images

	Data Collected	Number of units collecting data	Frequency of observations	Are the images captured stored?	Are the images subject to quality check before they are stored?	For how long are the images stored in on-line storage?	For how long are the images stored in off-line storage?
Dash-cam	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Roadside traffic cam	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

5. Please answer the following questions about the **traffic data** collected by your agency (please select the most accurate answer from the choices below) 

	Data collected	Number of units collecting data	Frequency of observations	Is the data collected stored?	Is the data aggregated/averaged over a longer period than the original observation?	Is the data subject to quality checks before it is sorted?	For how long is the data retained in on-line storage?	For how long is the date retained in off-line storage?
Traffic Volume	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Traffic speed	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Spacing between vehicles	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Type of vehicle	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Travel time	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

Others (please specify)

APPENDIX B. ROAD AUTHORITY SURVEY RESPONSES

Please fill out the following respondent information		
Answer Options	Response Percent	Response Count
Name	100.0%	28
Title	100.0%	28
Email	100.0%	28
Agency name	100.0%	28
<i>answered question</i>		28
<i>skipped question</i>		2

Please answer the following questions about the road-weather observation stations of each type used by your organization
(please select the most accurate answer from the choices below)

RWIS in use

Answer Options	Unknown	Yes	No	Response Count
Road side RWIS station observations	0	24	1	25
Mobile spectral camera (Mobile RWIS)	0	5	18	23
IR and similar temperature sensors mounted on a vehicle	0	16	7	23
Portable RWIS station observations	0	5	18	23
RWIS Forecast	1	15	8	24
Virtual RWIS (predictions for road segments where no	3	4	15	22

Number of RWIS units

Answer Options	Unknown	1-24	25-49	50-74	75-99	100-199	200-299	300-399	400-499	500-599	600-699	700-799	800-899	900-1000	Response Count
Road side RWIS station observations	0	9	3	6	4	1	0	1	0	0	0	0	0	0	24
Mobile spectral camera (Mobile RWIS)	0	5	0	0	1	0	0	0	0	0	0	0	0	0	6
IR and similar temperature sensors mounted on a vehicle	1	2	0	1	0	1	1	1	0	4	3	1	0	1	16
Portable RWIS station observations	1	5	0	0	0	0	0	0	0	0	0	0	0	0	6
RWIS Forecast	1	7	1	2	3	0	0	1	1	0	0	0	0	0	16
Virtual RWIS (predictions for road segments where no	2	1	1	0	0	0	1	1	0	0	0	0	0	0	6

Frequency of Observations

Answer Options	Unknown	Every Second	Every Minute	Multiple per minute	Hourly	Daily	< Daily	3 per hour	4 per hour	6 per hour	10 per hour	11 per hour	12 per hour	Response Count
Road side RWIS station observations	2	1	0	3	2	0	0	1	3	9	1	0	1	23
Mobile spectral camera (Mobile RWIS)	2	2	0	0	0	0	0	0	1	1	0	0	0	6
IR and similar temperature sensors mounted on a vehicle	3	5	1	6	0	0	0	0	0	0	1	0	0	16
Portable RWIS station observations	1	0	0	0	1	0	0	0	0	3	0	1	0	6
RWIS Forecast	3	0	0	1	6	0	1	0	2	1	1	0	0	15
Virtual RWIS (predictions for road segments where no	2	0	1	0	3	0	0	0	0	0	0	0	0	6

Is the data collected stored?

Answer Options	Unknown	Yes	No	Response Count
Road side RWIS station observations	0	22	1	23
Mobile spectral camera (Mobile RWIS)	1	3	2	6
IR and similar temperature sensors mounted on a vehicle	1	5	9	15
Portable RWIS station observations	1	4	1	6
RWIS Forecast	2	10	4	16
Virtual RWIS (predictions for road segments where no	2	3	1	6

Is the data aggregated/averaged over a longer period than the original observation?

Answer Options	Unknown	No	Every second	Ever Minute	Hourly	Daily	Weekly	Monthly	Seasonally	Yearly	Response Count
Road side RWIS station observations	6	13	0	1	1	1	0	0	0	0	22
Mobile spectral camera (Mobile RWIS)	3	1	0	0	0	0	0	0	0	0	4
IR and similar temperature sensors mounted on a vehicle	3	9	0	0	0	0	0	0	0	0	12
Portable RWIS station observations	1	4	0	0	0	0	0	0	0	0	5
RWIS Forecast	7	8	0	0	0	0	0	0	0	0	15
Virtual RWIS (predictions for road segments where no	3	3	0	0	0	0	0	0	0	0	6

Is the data subject to quality checks before it is stored?

Answer Options	Unknown	Yes	No	Response Count
Road side RWIS station observations	3	5	15	23
Mobile spectral camera (Mobile RWIS)	1	0	3	4
IR and similar temperature sensors mounted on a vehicle	1	2	9	12
Portable RWIS station observations	1	1	4	6
RWIS Forecast	5	3	8	16
Virtual RWIS (predictions for road segments where no	3	1	2	6

For how long is the data retained in on-line storage?

Answer Options	Unknown	1 day	1 week	1 month	4 months	6 months	1 year	2 years	3 years	4 years	5 years	10 years	Indefinite	Response Count
Road side RWIS station observations	4	2	0	1	0	1	0	5	0	0	1	0	8	22
Mobile spectral camera (Mobile RWIS)	2	0	0	0	0	0	0	1	0	0	0	0	0	3
IR and similar temperature sensors mounted on a vehicle	4	0	0	0	0	0	0	1	0	0	0	0	2	7
Portable RWIS station observations	2	0	0	0	0	0	0	0	0	0	0	0	0	5
RWIS Forecast	7	1	1	0	0	0	0	2	0	0	0	0	3	14
Virtual RWIS (predictions for road segments where no	4	0	0	0	0	0	0	0	0	0	0	0	1	5

For how long is the data retained in off-line storage?

Answer Options	Unknown	0 days	1 day	1 week	1 month	4 months	6 months	1 year	2 year	3 year	4 year	5 year	10 year	Indefinite	Response Count
Road side RWIS station observations	8	3	0	0	0	0	0	0	1	0	0	0	0	9	21
Mobile spectral camera (Mobile RWIS)	3	0	0	0	0	0	0	0	0	0	0	0	0	0	3
IR and similar temperature sensors mounted on a vehicle	4	2	0	0	0	0	0	0	1	0	0	0	0	1	8
Portable RWIS station observations	2	0	0	0	0	0	0	0	0	0	0	0	0	2	4
RWIS Forecast	8	3	0	0	0	0	0	0	0	0	0	0	0	4	15
Virtual RWIS (predictions for road segments where no	4	0	0	0	0	0	0	0	0	0	0	0	0	1	5

Please answer the following question regarding vehicles equipped with AVL used by your organization (please select the most accurate answer from the choices below)

Data collected	Unknown	Yes	No	Response Count
Plow/Spreaders heading speed	1	16	6	23
Spread quantities	1	12	10	23
Plow position (up, down)	1	11	11	23
Tow-plow deployed	2	4	17	23
Pavement marking	3	6	14	23
Weed spraying	3	2	18	23

Number of units collecting data	Unknown	1-24	25-49	50-99	100-199	200-299	300-399	400-499	500-599	600-699	700-799	800-899	900-1000	Response
Plow/Spreaders heading speed	1	0	2	2	3	1	2	0	1	0	0	1	2	15
Spread quantities	1	0	2	1	2	1	1	1	0	0	0	1	2	12
Plow position (up, down)	1	0	2	1	1	2	0	1	0	0	0	0	1	9
Tow-plow deployed	1	3	0	0	0	0	0	0	0	0	0	0	0	4
Pavement marking	2	4	0	0	1	0	0	0	0	0	0	0	0	7
Weed spraying	1	1	1	0	0	0	0	0	0	0	0	0	0	3

Frequency of Observations	Unknown	Every Second	Every Minute	Multiple per minute	Hourly	Daily	< Daily	10 per hour	12 per hour	Response Count
Plow/Spreaders heading speed	1	1	5	7	0	0	0	1	1	16
Spread quantities	2	1	2	5	0	1	0	0	1	12
Plow position (up, down)	1	1	4	2	0	0	0	0	1	9
Tow-plow deployed	1	0	1	2	0	0	0	0	0	4
Pavement marking	4	1	1	1	0	0	0	0	0	7
Weed spraying	1	0	0	1	0	1	0	0	0	3

Is the data collected stored?

Answer Options	Unknown	Yes	No	Response Count
Plow/Spreaders heading speed	0	15	1	16
Spread quantities	1	9	2	12
Plow position (up, down)	1	8	1	10
Tow-plow deployed	1	3	0	4
Pavement marking	3	4	0	7
Weed spraying	1	2	0	3

Is the data aggregated/averaged over a longer period than the original observation?

Answer Options	Unknown	No	Hourly	Daily	Weekly	Monthly	Seasonally	Yearly	Defined route segment	Defined time period	Response Count
Plow/Spreaders heading speed	8	6	0	0	0	0	0	0	1	0	15
Spread quantities	5	4	0	0	0	0	1	0	1	0	11
Plow position (up, down)	2	6	0	0	0	0	1	0	0	0	9
Tow-plow deployed	1	2	0	0	0	0	1	0	0	0	4
Pavement marking	4	2	0	0	0	0	1	0	0	0	7
Weed spraying	2	0	0	0	0	0	1	0	0	0	3

Is the data subject to quality checks before it is stored?

Answer Options	Unknown	Yes	No	Response Count
Plow/Spreaders heading speed	4	1	10	15
Spread quantities	2	1	8	11
Plow position (up, down)	2	1	6	9
Tow-plow deployed	1	1	2	4
Pavement marking	4	2	1	7
Weed spraying	1	1	1	3

For how long is the data retained in on-line storage?

Answer Options	Unknown	1 day	1 week	1 month	4 months	6 months	1 year	2 years	3 years	4 years	5 years	10 years	Indefinite	Response Count
Plow/Spreaders heading speed	4	0	1	0	0	1	1	3	0	0	0	0	5	15
Spread quantities	3	0	0	0	0	0	1	1	0	0	0	0	6	11
Plow position (up, down)	3	0	0	0	0	1	0	1	0	0	0	0	4	9
Tow-plow deployed	1	0	0	0	0	0	0	0	0	0	0	0	3	4
Pavement marking	5	0	0	0	0	0	0	0	0	0	0	0	2	7
Weed spraying	1	0	0	0	0	0	1	0	0	0	0	0	1	3

For how long is the data retained in off-line storage?

Answer Options	Unknown	0 Days	1 day	1 week	1 month	4 months	6 months	1 year	2 years	3 years	4 years	5 years	10 years	Indefinite	Response Count
Plow/Spreaders heading speed	8	1	0	0	0	0	1	0	1	0	0	0	0	4	15
Spread quantities	3	2	0	0	0	0	0	0	1	0	0	0	0	5	11
Plow position (up, down)	5	1	0	0	0	0	1	0	0	0	0	0	0	2	9
Tow-plow deployed	3	0	0	0	0	0	0	0	0	0	0	0	0	1	4
Pavement marking	5	0	0	0	0	0	0	0	0	0	0	0	0	1	6
Weed spraying	2	0	0	0	0	0	0	0	1	0	0	0	0	0	3

Camera Images				
Data Collected				
Answer Options	Unknown	Yes	No	Response Count
Dash-cam	1	4	18	23
Roadside traffic cam	0	22	3	25

Number of units collecting data

Answer Options	Unknown	1	5-9	10-14	15-19	20-24	25-49	50-99	100-199	200-299	300-399	400-499	800-899	900-1000	Response Count
Dash-cam	1	0	0	0	0	0	3	1	0	0	0	1	0	0	6
Roadside traffic cam	1	1	1	1	1	1	4	3	1	3	2	1	1	2	23

Frequency of observations

Answer Options	Unknown	Every Second	Every Minute	Multiple per minute	Hourly	Daily	< Daily	3 per hour	4 per hour	6 per hour	10 per hour	12 per hour	20 per hour	Response Count
Dash-cam	1	3	1	0	0	0	0	0	0	1	0	0	0	6
Roadside traffic cam	3	5	2	2	1	0	0	1	2	2	1	3	1	23

Are the images captured stored?

Answer Options	Unknown	Yes	No	Response Count
Dash-cam	1	2	3	6
Roadside traffic cam	2	11	10	23

Are the images subject to quality check before they are stored?

Answer Options	Unknown	Yes	No	Not applicable	Response Count
Dash-cam	2	0	1	3	6
Roadside traffic cam	4	0	8	9	21

For how long are the images stored in on-line storage?

Answer Options	Unknown	1 day	1 week	1 month	4 months	6 months	1 year	2 years	3 years	4 years	5 years	10 years	Indefinite	Response Count
Dash-cam	2	0	1	0	0	0	0	0	0	0	0	0	1	4
Roadside traffic cam	8	3	0	0	0	0	0	1	1	0	0	0	1	14

For how long are the images stored in off-line storage?

Answer Options	Unknown	0 days	1 day	1 week	1 month	4 months	6 months	1 year	2 years	3 years	4 years	5 years	10 years	Indefinite	Response Count
Dash-cam	3	1	0	0	0	0	0	0	0	0	0	0	0	0	4
Roadside traffic cam	9	2	1	0	0	0	0	0	0	0	0	0	0	2	14

Please answer the following questions about the traffic data collected by your agency (please select the most accurate answer from the choices below)

Data collected	Unknown	Yes	No	Response Count
Traffic Volume	2	20	1	23
Traffic speed	3	19	1	23
Spacing between vehicles	8	6	9	23
Type of vehicle	4	16	3	23
Travel time	4	13	6	23

Number of units collecting data

Answer Options	Unknown	1	5	8	10	15-19	20-24	25-49	50-99	100-199	200-299	300-399	400-499	500-599	600-699	700-799	800-899	900-1000	Response Count
Traffic Volume	5	0	0	1	0	0	0	1	2	4	0	1	0	1	0	0	1	1	17
Traffic speed	4	0	1	0	1	1	0	2	2	3	0	0	0	1	0	0	1	1	17
Spacing between vehicles	2	0	0	0	0	0	0	0	1	2	0	0	0	1	0	0	0	1	7
Type of vehicle	4	0	0	1	0	1	2	1	1	2	0	1	0	1	0	0	0	1	14
Travel time	4	2	0	1	0	0	1	0	0	2	0	0	0	0	0	0	1	1	12

Frequency of observations

Answer Options	Unknown	Every Second	Every Minute	Multiple per minute	Hourly	Daily	< Daily	4 per hour	12 per hour	Response Count
Traffic Volume	5	4	1	1	2	0	0	2	1	16
Traffic speed	4	5	0	1	3	0	0	2	1	16
Spacing between vehicles	1	3	0	1	1	0	0	0	0	6
Type of vehicle	3	3	0	1	3	0	0	1	1	12
Travel time	4	3	1	0	0	0	0	0	1	9

Is the data collected stored?

Answer Options	Unknown	Yes	No	Response Count
Traffic Volume	4	13	0	17
Traffic speed	3	14	0	17
Spacing between vehicles	1	5	1	7
Type of vehicle	2	10	1	13
Travel time	4	8	0	12

Is the data aggregated/averaged over a longer period than the original observation?

Answer Options	Unknown	No	Hourly	Daily	Weekly	Monthly	Seasonally	Yearly	Defined route segment	Defined time period	Response Count
Traffic Volume	5	3	2	1	0	0	2	2	1	0	16
Traffic speed	4	4	2	2	0	0	1	1	0	2	16
Spacing between vehicles	2	1	0	0	0	0	1	1	1	1	7
Type of vehicle	2	4	3	0	0	0	2	1	1	0	13
Travel time	4	3	1	1	0	0	2	0	0	1	12

Is the data subject to quality checks before it is sorted?

Answer Options	Unknown	Yes	No	Response Count
Traffic Volume	4	11	0	15
Traffic speed	4	8	2	14
Spacing between vehicles	2	3	1	6
Type of vehicle	2	8	1	11
Travel time	3	6	2	11

For how long is the data retained in on-line storage?

Answer Options	Unknown	1 day	1 week	1 month	4 months	6 months	1 year	2 years	3 years	4 years	5 years	10 years	Indefinite	Response Count
Traffic Volume	6	1	0	0	0	0	0	1	0	1	0	1	5	15
Traffic speed	6	1	0	0	0	0	0	1	0	0	0	1	4	13
Spacing between vehicles	4	0	0	0	0	0	0	0	0	0	0	0	2	6
Type of vehicle	4	0	0	0	0	0	0	0	0	0	0	1	5	10
Travel time	4	0	1	0	0	0	0	0	0	0	0	0	5	10

For how long is the data retained in off-line storage?

Answer Options	Unknown	0 Days	1 day	1 week	1 month	4 months	6 months	1 year	2 years	3 years	4 years	5 years	10 years	Indefinite	Response Count
Traffic Volume	6	2	0	0	1	0	0	0	0	0	0	0	0	6	15
Traffic speed	6	2	0	0	1	0	0	0	0	0	1	0	0	4	14
Spacing between vehicles	3	2	0	0	0	0	0	0	0	0	0	0	0	1	6
Type of vehicle	3	2	0	0	1	0	0	0	0	0	0	0	0	5	11
Travel time	3	2	0	1	1	0	0	0	0	0	0	0	0	2	9

**THE INSTITUTE FOR TRANSPORTATION IS THE FOCAL POINT FOR TRANSPORTATION
AT IOWA STATE UNIVERSITY.**

InTrans centers and programs perform transportation research and provide technology transfer services for government agencies and private companies;

InTrans manages its own education program for transportation students and provides K-12 resources; and

InTrans conducts local, regional, and national transportation services and continuing education programs.



**IOWA STATE
UNIVERSITY**

Visit www.InTrans.iastate.edu for color pdfs of this and other research reports.