Roadway Safety Data Program

ARIZONA IMPORTING LOCAL AND TRIBAL DATA FOR SAFETY ANALYSIS

ROADWAY SAFETY DATA AND ANALYSIS

CASE STUDY

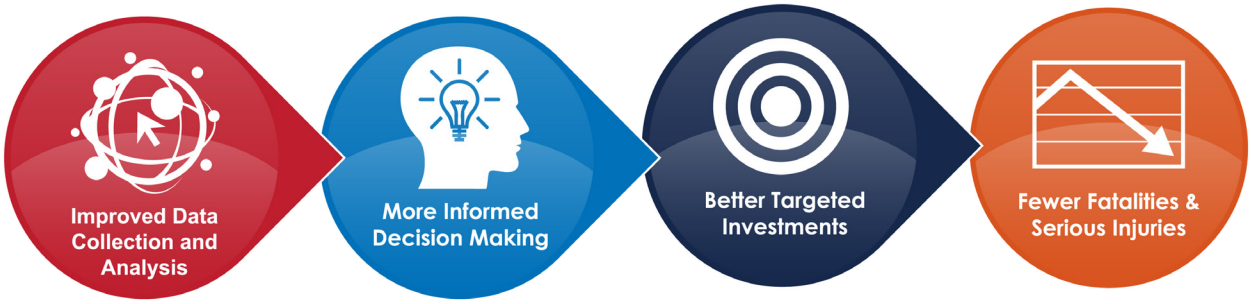
FHWA-SA-16-061

Prepared for

Federal Highway Administration Office of Safety

Roadway Safety Data Program

http://safety.fhwa.dot.gov/rsdp/



October 27, 2016

U.S. Department of Transportation
Federal Highway Administration

Safe Roads for a Safer Future
Investment in roadway safety saves lives
http://safety.fhwa.dot.gov

Notice

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.

The U.S. Government does not endorse products or manufacturers. Trademarks or manufacturers' names appear in this report 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. FHWA periodically reviews quality issues and adjusts its programs and processes to ensure continuous quality improvement.

TECHNICAL DOCUMENTATION PAGE

<table>
<tr><td colspan="2">1. Report No.
FHWA-SA-16-061</td><td>2. Government Accession No.</td><td colspan="2">3. Recipient's Catalog No.</td></tr>
<tr><td colspan="3" rowspan="2">4. Roadway Safety Data and Analysis Case Study: Arizona Importing Local and Tribal Data for Safety Analysis</td><td colspan="2">5. Report Date
October 2016</td></tr>
<tr><td colspan="2">6. Performing Organization Code</td></tr>
<tr><td colspan="3">7.Author(s)
Richard Brown and Robert Scopatz</td><td colspan="2">8. Performing Organization Report No.</td></tr>
<tr><td colspan="3" rowspan="2">9. Performing Organization Name and Address

VHB
8300 Boone Blvd., Suite 700
Vienna, VA 22182-2626</td><td colspan="2">10. Work Unit No.</td></tr>
<tr><td colspan="2">11. Contract or Grant No.
DTFH61-10-D-00022
Task Order T-13-003</td></tr>
<tr><td colspan="3" rowspan="2">12. Sponsoring Agency Name and Address
Federal Highway Administration Office of Safety
1200 New Jersey Ave., SE
Washington, DC 20590</td><td colspan="2">13. Type of Report and Period
Case Study</td></tr>
<tr><td colspan="2">14. Sponsoring Agency Code
FHWA</td></tr>
<tr><td colspan="5">15. Supplementary Notes
The contract manager for this report was Esther Strawder.</td></tr>
<tr><td colspan="5">16. Abstract
The Arizona Department of Transportation (ADOT) and the Federal Highway Administration (FHWA) Office of Safety completed a pilot project that allows the State to acquire roadway data elements from local and Tribal agencies and load the data into the Arizona Transportation Information System (ATIS) database. ADOT created a new process that allowed business users to import the data from local agencies, export combined State and local/tribal data, and load data into AASHTOWare Safety Analyst™ for analysis. ADOT used contractor support to establish data integration procedures for crash, roadway, and traffic volume data for both roadway segments and intersections. The results from the pilot created processes for the data submissions to ADOT, data integration in ATIS, the ETL process for bringing data into AASHTOWare Safety Analyst™, and quality control checks prior to analysis.</td></tr>
<tr><td colspan="2">17. Key Words:
safety data, roadway inventory data, traffic data, data integration</td><td colspan="3">18. Distribution Statement
No restrictions.</td></tr>
<tr><td>19. Security Classif. (of this report)
Unclassified</td><td>20. Security Classif. (of this page) Unclassified</td><td>21. No. of Pages
##</td><td colspan="2">22. Price</td></tr>
</table>

Form DOT F 1700.7 (8-72) Reproduction of completed pages authorized

TABLE OF CONTENTS

List of Tables

List of Figures

ACRONYMS

ADOT	Arizona Department of Transportation
ATIS	Arizona Transportation Information System
BIA	Bureau of Indian Affairs
CSV	Comma separated value
ETL	Export, transform, and load
LTAP	Local Technical Assistance Program
MAG	Maricopa Association of Governments
MPO	Metropolitan Planning Organization
Navajo DOT	Navajo Division of Transportation
PAG	Pima Association of Governments
RCI	Roadway Characteristics Inventory
SQL	Structured query language
TTAP	Tribal Technical Assistance Program

EXECUTIVE SUMMARY

The Arizona Department of Transportation (ADOT) and the Federal Highway Administration (FHWA) Office of Safety completed a pilot project that allows the State to acquire roadway data elements from local and Tribal agencies and load the data into the Arizona Transportation Information System (ATIS) database. ADOT created a new process that allowed business users to import the data from local agencies, export combined State and local/tribal data, and load data into AASHTOWare Safety Analyst™ for analysis. ADOT used contractor support to establish data integration procedures for crash, roadway, and traffic volume data for both roadway segments and intersections. The results from the pilot created processes for the data submissions to ADOT, data integration in ATIS, the process for bringing data into AASHTOWare Safety Analyst™, and quality control checks prior to analysis.

INTRODUCTION

The Arizona Department of Transportation (ADOT) and the Federal Highway Administration (FHWA) Office of Safety completed a pilot project that allows the State to acquire roadway data elements from local and Tribal agencies and load the data into the Arizona Transportation Information System (ATIS) database. Using a previous plan developed for ADOT (*A Feasibility Study for Arizona's Roadway Safety Management Process Using the Highway Safety Manual and Safety Analyst*), the project team created a new process that allowed business users to import the data from local agencies and export combined State and local/tribal data for analysis.

For this project, the State identified the following four agencies that agreed to supply data for the integration effort:

1. Bureau of Indian Affairs (BIA)
2. Maricopa Association of Governments (MAG)
3. Navajo Division of Transportation
4. Pima Association of Governments (PAG)

It is important to note that of the four agencies identified, MAG and PAG are Metropolitan Planning Organizations (MPOs), meaning they do not own data, but instead receive data from local agencies in their jurisdiction. BIA is a federal agency and is part of the United States Department of the Interior. The Navajo DOT is also a federal agency (all land-based Tribes are sovereign nations), but functions similarly to a State DOT.

Out of the four, PAG was the only agency with data suitable for import and integration. The project was designed to integrate the local agencies' data with existing State data, then export, transform, and load (ETL) the integrated data into AASHTOWare Safety Analyst™. In the end, PAG data were integrated with the State's data. Recommendations for integrating other local and Tribal data were provided to the State for future action.

ADOT used contractor support to establish data integration procedures for crash, roadway, and traffic volume data for both roadway segments and intersections. The results from the pilot created processes for the data submissions to ADOT, data integration in ATIS, the ETL process for bringing data into AASHTOWare Safety Analyst™, and quality control checks prior to analysis.

BACKGROUND

This project arose as a pilot study sponsored by FHWA's Office of Safety as part of the *Integration of State and Local Safety Data* project. ADOT submitted a successful application for

the pilot study and received technical assistance from a consultant team consisting of IT project managers, GIS specialists, and database managers with data integration expertise. ADOT identified partner agencies based on past experiences with them and their own interests in sharing data with the State. The Navajo DOT was involved in a concurrent pilot study integrating data from multiple agencies on Navajo Tribal lands and agreed to share the results with ADOT.

The four contributing agencies represent a range of capabilities and abilities to supply data to ADOT in a specified format. By design, the project makes note of barriers encountered as part of the attempts to integrate, upload, and analyze safety data. The ADOT project lead and consultant team worked with representatives from each of the four agencies to obtain the source data. ADOT sent the partner agencies a spreadsheet requesting information about road segments, traffic volume counts, intersections and ramps, and crash data. ADOT was responsible for data validation and corrections within their own system, and providing additional resources such as an intersection and ramp inventory. The consultant team was responsible for data integration, ETL, and validation within AASHTOWare Safety Analyst™. The contributing agencies were responsible for addressing their own data quality issues where possible. Most of the local and Tribal data quality issues were not resolved as part of the pilot. Where errors persisted and blocked selected data from being used in the pilot, the contractor team documented the deficiencies and suggested methods for addressing the problems in the future.

OBJECTIVE

The ADOT pilot project was designed to achieve the following:

- Create a method to integrate data from local agencies into the statewide crash, roadway, and traffic volume databases.
- Create a method for data to be extracted from multiple sources, transformed, and loaded into AASHTOWare Safety Analyst™.
- Create an ETL process that requires very little interaction by the user. The State desired a solution that was as automated as possible, and with as few steps as possible so that it would be both reliable and repeatable without extensive training or staff time.
- Develop a customized ETL process and software tools that would work with ADOT's existing databases.
- Establish methods for data validation that would satisfy the data quality requirements of AASHTOWare Safety Analyst™ and make the best use of the integrated data for network screening.

AUDIENCE

This case study applies to the following audiences:

- State Departments of Transportation: Roadway Data System Managers, Safety Engineers, GIS specialists, and IT project managers.
- Local Agencies: Regional Planning Commissions, Metropolitan Planning Organizations, cities, and counties, plus Local Technical Assistance Programs (LTAPs).
- Tribal Agencies: including Tribal governments, public agencies responsible for transportation safety data in Tribal areas, and Tribal Technical Assistance Programs (TTAPs).
- Consultants and private businesses involved with safety data analysis and GIS.

DEVELOPMENT OF THE ETL PROCESS

An ETL process takes data from one or more sources and transforms it into a required format for other uses (e.g., performing analyses). AASHTOWare Safety Analyst™ includes a very strict set of data validations for data import. The ADOT pilot effort sought to create a process that an end user could complete with very few steps and with minimal interaction. The consultant team accomplished this by using structured query language (SQL) views. SQL views can act as a virtual table that can be manipulated instead of making changes to the real database tables. Through scripting, these functions can be performed automatically for the user. The user only needs to know the desired data source for the analysis (e.g., a specific date range or portion of the State) in order to create the necessary data extract and obtain a desired analytic output. Figure 1 displays the ETL process for Arizona's ATIS data with integrated local data using AASHTOWare Safety Analyst™ as the analytic tool.

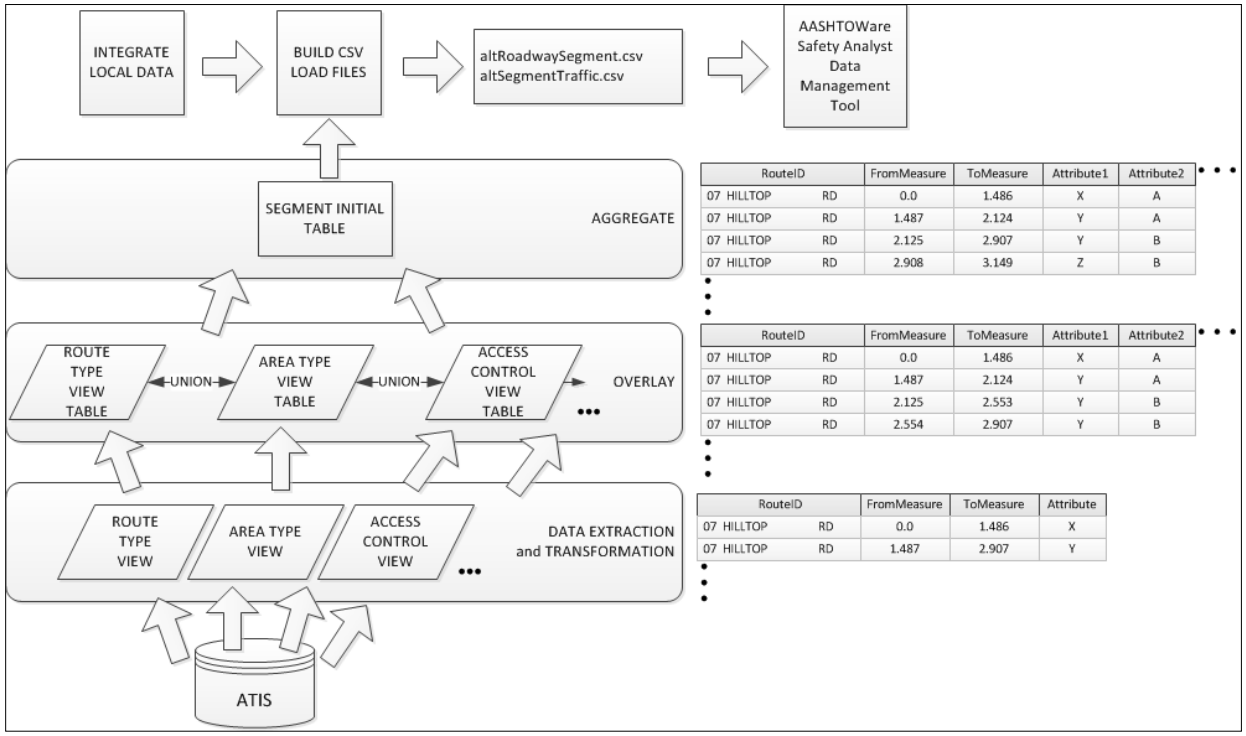


Figure 1. Chart. Extract, Transform, Load (ETL) process for Arizona Safety Data.

The ETL process is demonstrated as follows:

- The Data Extraction and Transformation component collects the data elements from the ATIS database. The view converts the value to one that AASHTOWare SafetyAnalyst™ recognizes. In Figure 1, the view uses the location field values (i.e. RouteID, FromMeasure, and ToMeasure) for every row identified in the ATIS table.
- The Overlay component merges the segments for each attribute for the events and creates a union of the inputs.
- The Aggregate component standardizes the road inventory data and ensures proper segmentation of the roadway.
- The data originally from ATIS and the local data is compiled into comma separated value (CSV) files based on feature type.
- The data is formatted and loaded for import into AASHTOWare Safety Analyst™

LOCAL AGENCY DATA COLLECTION AND EVALUATION

The data integration step in Figure 1 brought local agency and Tribal data into a CSV file suitable for uploading into AASHTOWare Safety Analyst™. The CSV file included State data

from ATIS and data from the local and Tribal agencies. Data included segment identifiers and inventory attributes, traffic volume, and crash data..

Table 1 presents a portion of the Local Agency summary of responses for the data integration pilot. This summary document provides a snapshot of the data the four agencies provided and what is useful for import. The four agencies differed widely in their capabilities and in the success with which the project team could integrate their data with the State's data. While MAG, Navajo DOT, and BIA provided roadway information, PAG had a more comprehensive file that better met the needs for integration and analysis. Most importantly for ease of integration, PAG uses Route/Milepost for its location referencing system as compared to Route/Roadway Section. PAG's location coding is similar to the way that ATIS references locations, which greatly simplified the task of integrating this local dataset with the State data. Also the PAG dataset included a number of required fields such as road name, classification, category, and travel direction that were missing in the others. However, the PAG data set lacked traffic volume data, which are useful for analysis. Since their data was more complete and better aligned with the State location coding system, PAG was the only local agency used for the ETL process in the attempt to load integrated data into AASHTOWare Safety Analyst™.

Table 1. Local agency summary of segment data submissions.

Item	General Description	SaA Required?	SaA Data Import Ref.	SaA Data Type	# of Agencies providing the data element
Segment Identifier	Unique identifier for a section of roadway	Yes	2.1.1	varchar(128)	3
Route Number	Signed route number	Yes	2.1.4	varchar(128)	4
Major Road Name	Route or street name, where different from Route Number	No	2.1.12	varchar(128)	4
Location System	Location reference method	Yes	2.1.2	varchar(128)	n/a
Begin Segment Location	Location reference	Yes	2.1.7	varchar(128)	4
End Segment Location	Location of the end of the segment	Yes	2.1.8	varchar(128)	4
Route Type	Category of the route segment	Yes	2.1.3	varchar(128)	0
Area Type	Characterize the area as rural or urban	Yes	2.1.17	varchar(128)	0
Segment Length	Length of the roadway segment in miles	Yes	2.1.13	numeric	3
Direction of Travel	Direction of travel on unidirectional segments	Yes	2.1.45	varchar(128)	2
Functional Class	Functional class of the segment	No	2.1.19	varchar(128)	2
Median Type	Type of median	Yes	2.1.30	varchar(128)	0
Access Control	Degree of access control	Yes	2.1.40	varchar(128)	2
One/Two-Way	Whether the segment operates as a one- or two-way roadway	Yes	2.1.44	varchar(128)	0
Ownership	Type of governmental ownership	No	2.1.16	varchar(128)	3
Number of Through Lanes	Separately for each direction of travel, the number of through lanes, excluding turn lanes and auxiliary lanes	Yes	2.1.20	integer	1
Interchange Influence	Whether segment is within interchange influence area	Yes	2.1.49	varchar(128)	0

*SaA is AASHTOWare Safety Analyst™

BENEFITS TO USING AN ETL PROCESS FOR DATA IMPORT

The requirement for data formatting within AASHTOWare Safety Analyst™ yields itself to using an ETL process. Here are the benefits uncovered in creating the integrated data set:

- Provides the roadway data system with a structured approach for taking data sets from multiple sources and populating a single system, in this case AASHTOWare Safety Analyst™.
    - 2009 to 2014 source files including State and PAG data yielded the following total numbers of records imported:
        - 26,038 Roadway segments totaling 17,452 mi.
        - 156,228 Traffic volume records.
        - 213,802 Accident records.
    - 51,361 road segments from the PAG data were imported into the system with only 2 warnings.
- Creates a standardized platform that will allow future integration of other data sets as they become available.
- Requires very little user effort for loading very large data sets and integrating them into the statewide system.
- Simplifies the data integration processes so users can easily understand the steps and data movements.
- Identifies errors on import which centralizes the error checking / warning into a single location and step in the process.

TECHNICAL BARRIERS

The largest technical barrier was preparing the integrated State and local data to the point that AASHTOWare Safety Analyst™ would accept it without errors. The software validates each file in its entirety and rejects the entire dataset if there are unresolved errors. As a result, all data cleansing must happen within the State's database. Data analysis can only be conducted when the dataset passes all validation checks. Some unanticipated errors were found in each of the source files. For ADOT's data, roadway segmentation was initially derived from the Roadway Characteristics Inventory (RCI). Data integration, however, caused segment problems, necessitating a switch to ATIS as the source file. ADOT had to correct the source to eliminate overlaps in start and end points of adjacent segments and after that data cleansing, the majority of segments passed the validation checks. The consultant team was unable to use intersection and ramp data because key data elements were missing or in the wrong format. The consultant team provided ADOT with a plan for how to improve those data sources.

After data cleansing of the segment information, AASHTOWare Safety Analyst™ reported few errors, but thousands of warnings. The State's project team categorized these errors into categories that simplified the process of updating and rechecking through the SQL Views and scripts that bound the ETL process. These revisions helped to inform the State's data management for segment definitions and roadway attributes so that the file can be maintained more effectively in the future.

RESULTS

The ETL process was able to import the roadway segment, traffic, and accident data into AASHTOWare SafetyAnalyst™. The combined database contained 26,038 segments of roadway data totaling 17,472 miles. Crash data was combined with only those road segments with associated traffic data. The result was 213,802 crash records available for analysis. For the local data integration, SafetyAnalyst accepted 51,136 segments' data from PAG. This is, however, in addition to PAG segments previously integrated into ATIS. PAG data can serve as a model for future attempts to integrate data from other local or Tribal agencies.

NEXT STEPS

The ETL process developed in this pilot project creates a standardized platform for future data sets. The successful integration of one local data source indicates that integration is possible for others as well, using the same ETL process. The State also learned that the ETL process will work for intersections but that the following data elements will be required:

- The point location of at-grade intersections geocoded in the same linear referencing system as the roadway segment data;
- Identification of two distinct routes that make up the intersection, with designation of which route is the major route and which is the minor route;
- Traffic volume (annual average daily traffic) for each of the two routes at the intersection;
- Intersection type using AASHTOWare Safety Analyst™ enumerated values, indicating whether the intersection is configured as a "T", "Y", 4-leg, 5 or more legs, or roundabout;
- A unique identifier for the intersection.

To import ramp data, an additional field needs to be added to ATIS for the ramp configuration. Table 2 displays the ramp configuration codes and values needed in ATIS.

Table 2. Ramp Configuration Table

Code	Ramp Configuration
1	Diamond
2	Parclo loop
3	Free-flow loop
4	Free-flow outer connection
5	Direct or semi-direct connection
6	C-D road or other connection
0	Other
99	Unknown

Acquiring the necessary data for other local and Tribal agency segments will require additional cooperative agreements between ADOT and the participating agencies. Obtaining the necessary intersection and ramp data statewide is a large undertaking that ADOT will need to plan for the future.

REFERENCES

The following resources were used in development of this case study:

Cambridge Systematics. *A Feasibility Study for Arizona's Roadway Safety Management Process Using the Highway Safety Manual and SafetyAnalyst.* 2012.

AGENCY CONTACT INFORMATION

Pradeep Tiwari
Transportation Safety Engineer
Traffic Safety Section, ITD
1615 W. Jackson St, Mail Drop 065R
Phoenix, AZ 85007
Phone: 602.712.4472, Fax: 602.712.3243