Research Paper

Statewide Advanced Traveler Information System (ATIS) Project

Industry Research on Data Fusion for the Statewide ATIS

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List of Acronyms

ADOT .... Arizona Department of Transportation
ATIS .... Advanced Traveler Information System
CAD .... Computer-aided Dispatch
CARS .... Condition Acquisition and Reporting System
DFS .... Data Fusion System
FDOT .... Florida Department of Transportation
FHP .... Florida Highway Patrol
FHWA .... Federal Highway Administration
FIHS .... Florida Intrastate Highway System
FTE .... Florida's Turnpike Enterprise
GUI .... Graphical User Interface
HCRS .... Highway Conditions Reporting System
ID .... Identification
ITS .... Intelligent Transportation System
JPO .... Joint Program Office
SIS .... Strategic Intermodal System
TIC .... (GEWI) Traffic Info Centre
USDOT .... United States Department of Transportation
XML .... Extensible Markup Language

1. Introduction

This paper summarizes the data fusion options available to the Florida Department of Transportation (FDOT) for its expected 2008 deployment of a statewide advanced traveler information system (ATIS). The paper also assesses the available technology and solutions, and provides estimated high-level costs for the various options.

2. Florida's Needs

A data fusion system (DFS) must be able to perform the following functions: [1]

- Gather data from a variety of sources, such as:
    - Automated traffic detection systems
    - Construction management systems
    - Law enforcement dispatch systems, including the Florida Highway Patrol (FHP) and local agencies
    - Weather reporting systems
    - Other statewide systems
    - Other District systems
- Match the data with the appropriate source.
- Ensure that all data is represented in the same temporal and geographic frames of reference.
- Address and repair anomalies or inconsistencies between data sources.
- Put the data from the various sources into one standard output stream.
- Estimate the current state of the system (i.e., traffic flow) from the available data.
- Provide a way to assess the quality of the fused data and fusion processes.

[1] United States Department of Transportation (USDOT) Federal Highway Administration (FHWA) Intelligent Transportation Systems (ITS) Joint Program Office (JPO), *Data Fusion for Delivering Advanced Traveler Information Services* (May 2003), Report No. FHWA-OP-03-119. Available online at http://www.itsdocs.fhwa.dot.gov//JPODOCS/REPTS_TE//13837.html).

The FDOT may not necessarily need all of these functions, or they may be willing to trade off excellence in some for adequacy in others. The key will be to find the appropriate trade-offs between cost, functionality, and schedule.

The FDOT will need to make several key choices to deploy a statewide DFS, including those listed below.

- *Should the system be deployed primarily at the District level (i.e., distributed) or at a statewide level (i.e., centralized)?* It has already been determined that the system should be primarily decentralized and that the Districts should be responsible for their own data entry, though it is probable that the system administration or support function will need to be centralized.
- *How much of the system should be automated, and how much should rely on operators to enter or modify data?*
- *Should the system be dedicated to ATIS, or should it also be used for traffic management or other purposes?* The working assumption is that this system will focus on ATIS, but it could conceivably be used for other purposes, such as providing data to traffic management and operations applications.
- *Should the system build on existing resources or should it be an entirely new system?*
- *If it is a new system, should it be based on commercially available systems or should it be developed as a custom application for the FDOT?*[2]

[2] This report will focus more on functional questions as opposed to procurement questions. The Federal Highway Administration's (FHWA) manual entitled *The Road to Successful Software Acquisition* (1998) addresses, among other things, how to determine whether to buy or develop software. The manual's executive summary is available online at http://www.itsdocs.fhwa.dot.gov/jpodocs/repts_te/36s01!.pdf. Volumes I and II of the manual are available online at http://www.itsdocs.fhwa.dot.gov/jpodocs/repts_te/36q01!.pdf and http://www.itsdocs.fhwa.dot.gov/jpodocs/repts_te/36r01!.pdf, respectively.

3. Existing Functionality

Prior to assessing future options, it is important to understand the current situation. This section describes the current data fusion assets in FDOT Districts 4, 5, 6, and 7. The scope for this effort is limited to those Districts with current ATIS projects in place. The current functionality is as follows:

- In Districts 4 and 6, Westwood One/Smart Routes Systems operates the 511 telephone service and Web page.[3] Westwood One uses its own proprietary system. The system relies on operators to input data, which is then placed on the Web map and disseminated over the 511 system.
- For District 5 and the statewide system, operators input data into a conditions reporting system developed by Castle Rock.[4]
- In District 7, Traffic.com operates the 511 telephone service and Web page using its own proprietary DFS. Operators enter incident and event data, and the system incorporates flow data automatically.

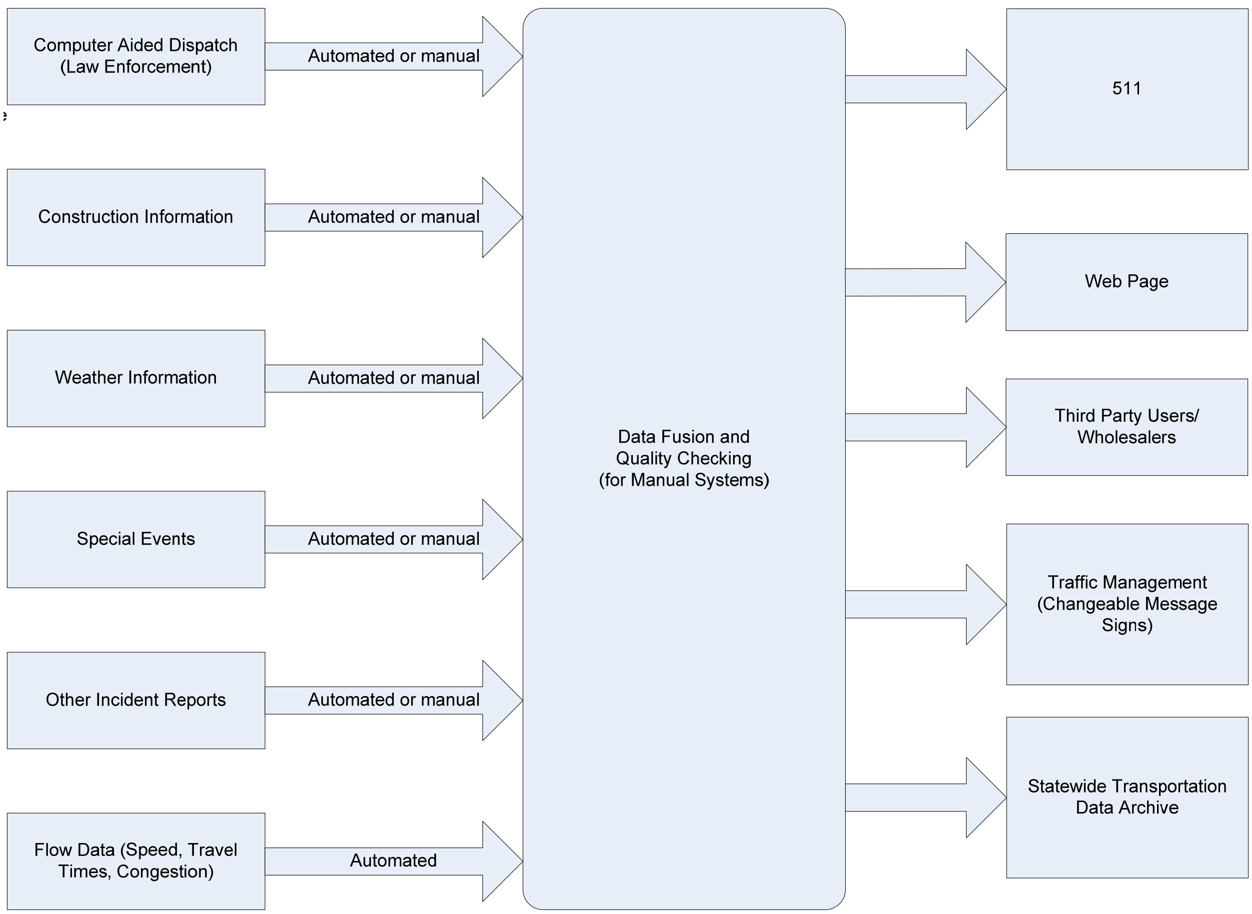
[3] More information regarding Westwood One/SmartRoute Systems is available online at http://www.smartroute.com/.

[4] More information regarding Castle Rock Intelligent Transportation Systems is available online at http://www.crc-corp.com/index.htm.

4. Interface Needs and System Functionality

This section addresses how a DFS must interface with other systems — both upstream and downstream — and the functions that the system must perform. The number and type of interfaces are major cost drivers that affect the deployment of a DFS. Figure 4.1 shows the high-level interfaces needed.

Figure 4.1 – Needed High-level Interfaces



As the figure indicates, most of the interfaces can either be automated or manual. For automated interfaces, software is required to translate between one system and the other, and a communications system is needed to actually transfer the data. For manual interfaces, on the other hand, operators enter data using a graphical user interface (GUI). For those interfaces, no software is needed (other than the GUI); operators often obtain information directly from the data source, such as viewing the National Weather Service Web page, accessing a computer-aided dispatch (CAD) feed, or some other similar method. Each method has its advantages and disadvantages, which are presented in Table 4.1 below.

Table 4.1 – Interface Advantages and Disadvantages

TYPE OF INTERFACE	ADVANTAGES	DISADVANTAGES
Automated Interface	• Less costly operations • Smaller chance of introducing errors into the system	• Can be difficult to develop • Require revisions if the source data stream changes the output format • Some agencies are reluctant to authorize automated interfaces from their systems.
Manual Interface	• Operators are available to quality-check the data • Provides the flexibility to deal with anomalies	• High ongoing labor costs • Operators need to be trained (and re-trained) to reduce data entry and interpretation mistakes

In reality, most DFSs are a combination of automated and manual interfaces, depending on individual agency needs, budget, and legacy systems. Regardless of the interface type, the DFS must be able to accomplish the key functions described in *Section 2* of this paper. This requires translating these high-level functions into a series of functional requirements that can be used to develop a procurement for a DFS. These functional requirements include:

1. System Reliability
   - 1.1 The DFS must operate at full capacity 99.9 percent of the time.
2. System Security
   - 2.1 The DFS must require unique user identifications (IDs) and "strong" passwords (i.e., eight characters or more, including at least one letter, one number, and one special character) for system access.
   - 2.2 The DFS must support at least three different levels of access. The access levels will be tied to user IDs.

2.3 The DFS must be configured so that operators in one District cannot enter information for another District.

2.4 The DFS must be configured so that a supervisor or administrator can override the functionality called for in Requirement 2.3 in the event of hurricanes or other emergencies.

3. Number and Location of Users

3.1 The DFS must be able to support 30 simultaneous users and have the capacity to be expanded to support 50 simultaneous users.

3.2 The DFS must be able to support at least three simultaneous users in each FDOT District, including Florida's Turnpike Enterprise (FTE).

3.3 The DFS must be able to support at least two simultaneous users at the central system location.

4. System Capacity

4.1 The DFS must be able to actively support 10,000 active events.

4.2 The DFS must be able to support reports every minute from at least 2,500 automated roadside or virtual sensors.

5. Data Inputs

5.1 The DFS must be able to support automated and manual data entry for all event types.

5.2 The DFS must have a standardized interface to facilitate the addition of new data streams.

5.3 The DFS must be able to support event reports for all roadways on the Florida Intrastate Highway System (FIHS) and the emerging Strategic Intermodal System (SIS).[5]

5.4 For incidents and events, the DFS must include a minimum of the following fields:

5.4.1 Latitude
5.4.2 Longitude
5.4.3 District
5.4.4 County
5.4.5 Roadway affected
5.4.6 Lanes affected
5.4.7 Segment affected

[5] More information regarding the FIHS and Florida's emerging SIS is available online at http://www.dot.state.fl.us/planning/SIS/.

5.4.8 Mile marker
5.4.9 Nearest interchange or cross street
5.4.10 Direction of travel affected
5.4.11 Length of backup
5.4.12 Other effects of the incident
5.4.13 Estimated duration
5.4.14 Type of incident
5.4.15 date
5.4.16 Incident start time
5.4.17 Incident update time(s)
5.4.18 Incident clearance time
5.4.19 Suggested traveler behavior
5.4.20 Operator identification
5.4.21 Data source

5.5 For automated speed reports, the DFS must include a minimum of the following fields:

5.5.1 All of the fields in Requirement 5.3
5.5.2 Time data collected at the roadside (latency)
5.5.3 Travel speed

5.6 The DFS must be able to identify conflicting event reports for the same facility and be able to inform operators of the conflict. Note that the operators in adjoining Districts will need to coordinate with each other on this issue.

6. Data Accuracy

6.1 The DFS must allow information to be referenced with at least as much geographic accuracy as the systems providing data inputs.

6.2 The DFS must maintain the temporal accuracy of data from the systems providing data inputs.

7. Data Timeliness

7.1 The DFS must process data and prepare it for dissemination at a configurable time period with a 60-second default.

8. Reporting, Archiving, and Quality Assessment

8.1 The DFS must archive all data.

8.2 The DFS must be able to generate reports using any of the fields described in Requirements 5.3 and 5.4 as filters.

5. Data Output

All DFSs must have a mechanism for providing data to users.[6] Regardless of whether the user is internal to the FDOT, a contractor hired by the FDOT, or a third party taking the data for its own purposes, the same principles will apply. The output must be in a standardized format, both in terms of how it is delivered and how the elements are defined. The extensible markup language (XML) is becoming the format of choice for traffic information; the output itself should follow intelligent transportation system (ITS) data standards.

Dissemination to third parties is generally accomplished by making the data available via a secure Internet feed or some other similar method. The third parties are responsible for all costs associated with retrieval of the feed.

[6] Note that, in this instance, "users" generally refer to other systems, such as the 511 system, and are not a reference to an individual traveler.

6. Options for Procurement

Existing ATIS projects have a wide range of DFSs. Many use commercial (or near-commercial) products, such as Castle Rock's Condition Acquisition and Reporting System (CARS) or the Highway Conditions Reporting System (HCRS). Others use systems developed specifically for their regions by software development firms. These options all have different trade-offs when comparing cost, functionality, and deployment times. The following table describes the primary options available to the FDOT, includes high-level cost estimates, and describes any other salient features.

Table 6.1 – Procurement Options

System	Cost to Implement	Cost for Additional Interfaces	Annual Operating Costs	Comments
CARS	$250K	Not applicable	Minimal	CARS is the result of a pooled fund study. It is used primarily for operator data entry, so is best suited to manual environments.
HCRS	$600K	$40K-$80K	Minimal	HCRS was developed for the Arizona Department of Transportation (ADOT) and has since been implemented in Nebraska as well.
GEWI TIC[7]	$150K-$250K	Minimal	Minimal	GEWI's Traffic Info Centre (TIC) is a commercial product widely used in Europe. It is able to accommodate manual and automated entry.
SunGuide^{SM} [8]	$500K	$100K	Minimal	SunGuide is already available to FDOT Districts, who, at their discretion, can use it as part of their DFS. Note, however, that SunGuide is not a data fusion system and, as such, would need to be modified to provide data fusion functions, such as providing segment-based data; outputting data in the appropriate standards; and accepting data from other data streams.
"Home Grown"	$1M-$2.5M	$100K-$150K	$50K-$100K	This option provides the most functionality and the highest level of customization. The development timeframe is long and costly.

[7] More information regarding GEWI products is available online at http://www.gewi.com/.

[8] SunGuide is a service mark of the Florida Department of Transportation. More information regarding the SunGuide software system is available online at http://sunguide.datasys.swri.edu/.

In addition to the estimates provided in Table 6.1, the following are major drivers that will affect the cost of a DFS. In general, these drivers would apply to any of the options described above.

- Number of interfaces needed
- Format of interfaces (following standards or not)
- Stability of interfaces
- Number and location of users

Note that any addition in functionality will greatly increase the cost and development time of the above options.

7. Projected Costs and Assumptions

Table 7.1 shows the estimated start-up costs for the DFS. Note that the following assumptions were used to develop these estimates.

- Hardware costs for Years 1 and 5 were estimated at $114,000.
- It was assumed that seven servers will be required for the central system.
- Each District — a total of eight, including FTE — were assumed to need three workstations.
- Software costs were estimated at $608,000.
- Communication costs were estimated at $8,000.

Table 7.1 – Estimated Start-up Cost for the Data Fusion System

WORK ELEMENT	YEAR 1
Data Fusion System Build	$730,000

Table 7.2 shows the estimated five-year O&M costs for the DFS. Note that the following assumptions were used to develop these estimates.

- Annual software/system maintenance costs were estimated at $50,000.
- Annual software enhancements were estimated at $50,000.
- Annual communication costs were estimated at $120,000.
- Costs provided include one full-time equivalent employee.
- Costs provided do not include District operations costs.

Table 7.2 – Estimated Five-year Annual Operations and Maintenance Costs for the Data Fusion System

WORK ELEMENT	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6
Data Fusion System	$320,000	$320,000	$320,000	$434,000	$320,000

Table 7.3 provides the total estimated start-up costs and O&M costs for the DFS.

Table 7.3 – Total Estimated Costs for the Data Fusion System

WORK ELEMENT	TOTAL ESTIMATED COSTS
Data Fusion Start-up Costs	$730,000
Total O&M Costs	$1,714,000
Total	**$2,444,000**

8. Recommendations

It is recommended that the FDOT use the functional requirements defined above (and fleshed out over the next several months) as a basis for the procurement of the DFS. Rather than recommend that the FDOT procure a specific system, or even decide at this point whether to procure an off-the-shelf or custom-built system, it is believed that a procurement that is based on the system functional requirements that must be met will result in the best system for the available funds. This approach will also institute, at the outset, a systems engineering approach that can then be used throughout the project.