Managing Data by Direction

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Executive Summary

This white paper reviews the challenges and opportunities that state Departments of Transportation (DOTs) have creating a single uniform route network containing consistent representations of both divided and undivided facilities that supports all internal and external customers' needs. The problem statement being that what constitutes a divided or undivided facility is highly dependent on individual customer interpretations and needs, and therefore there is a need for the DOT to address these differences to allow for proper use in each customer's business case. This paper will discuss potential solutions and well as next steps to solve the problem.

Introduction

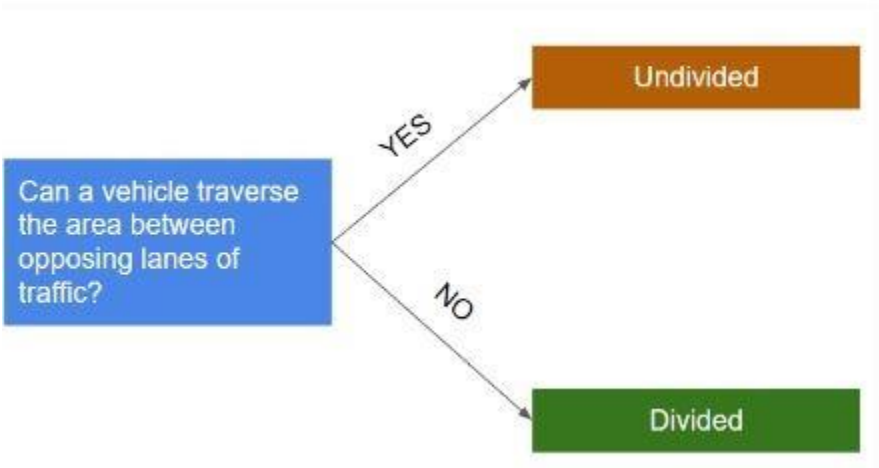
The distinction between divided and undivided facilities has been a long debated topic in the transportation industry. How these facilities are managed in the linear referencing system (LRS) differs from agency to agency. As the LRS continues to be leveraged by other business units within the Arizona Department of Transportation (ADOT), the need to identify business needs and clear rules is desired. Managing roadway data by direction has its benefits and challenges that are worth discussing. The white paper will discuss data challenges, benefits, potential solutions and next steps for implementation.

Defining the Problem

The distinction between divided and undivided facilities is important for many topics including Highway Performance Monitoring System (HPMS), asset management and emergency routing. Defining what a divided facility is depends on several factors. The definition can also change depending on the audience.

A road that may be considered divided in the eyes of the public may not be for emergency personnel. For example, if an emergency vehicle can traverse the area between the opposing lanes, then it would be considered an undivided facility (See Figure 1).

Figure 1.

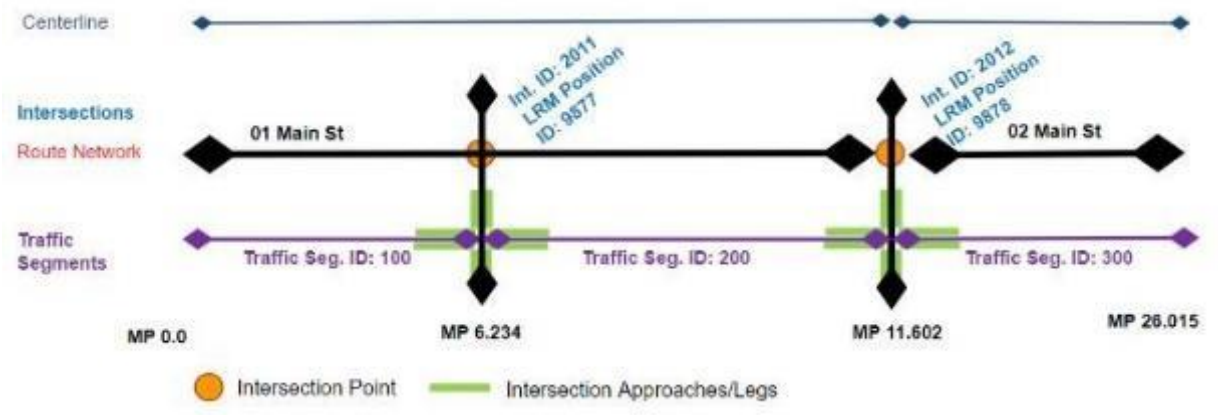


It is important to understand how ADOT's data is managed and why. The Federal Highway Administration (FHWA) defines a Divided Highway as a multi-lane facility

with a curbed or positive barrier median that is 1.2 meters (4 feet) or wider. This definition can be challenging to implement on a LRS due to data availability.

The LRS is the backbone for agency asset management. The LRS is the geographic and temporal tie that all the data sits on top of. It is a linear representation of real-world facilities such as highways, railroads or canals. The LRS incorporates measures along a linear element and allows for features (points or linear segments) to be referenced off of them (See Figure 2). This means the measures along the route are a specific geographic place, the road inventory data is only spatially referenced to that measure along the LRS defined route. This means real-world assets can be anchored on the LRS such as signs or guardrails. Managing data via the LRS allows for greater analytical capabilities and improved data management over time and space.

Figure 2.



The challenge is that there is no standard across the country on how to best manage data on a divided or undivided facility within a LRS. A more detailed definition can be found in the breakdown below. A road can be considered divided if:

- An emergency vehicle, ambulance, fire truck, police vehicle cannot traverse the area between the opposing lanes of traffic.
    - This can be because of:
        - Physical barrier that cannot be crossed by any vehicle
        - High medians (e.g., jersey barriers, logs, ditches, steep slopes, water, etc.)

        - Changes of surface materials in the area between lanes are not an issue unless it makes the area impassable (i.e. large rocks).
- If a vehicle can traverse the area between the opposing lanes, then for the definition it is undivided.
    - Normal curb and gutter
    - Normal, passable landscaping
    - “Painted” open divisions

- Only divided from making turns from side traffic (one direction, e.g., turn lanes near traffic lights)

This gap in process provides a number of challenges but also opportunities for improvement.

Challenges and Opportunities

Understanding individual customer business needs will help to shed light on the 'why'. Much of how the LRS is managed comes from federal guidelines from HPMS or All Roads Network of Linear referenced Data (ARNOLD). Historically there was little need to manage data by direction. The LRS has been designed to model the route network as it functions. For example, if a route has a curbed raised median with crossings (See Figure 3) it will be managed as an undivided section of a roadway. It will be represented by a single route or overlapping, concurrent routes. This does not follow FHWA guidelines.

Figure 3.

For the LRS to be broken out into separate routes there needs to be a positive barrier such as a jersey barrier that impedes traffic flow. This is seen on an interstate highway for example (See Figure 4). The level of effort to break up the routes that are currently defined as undivided into divided would be substantial.

Figure 4.

The challenge is that different business units within ADOT require varying data quality. For example, the pavement management team has the need to analyze data by direction, regardless if the route is divided or not. This is due to the need to perform in-field data validation. This directly affects how the LRS is managed. The challenge is further complicated by how different State DOT's manage their LRS. This is all due to a lack of a national standard and begs the question, what is the best way to manage the LRS and its events?

On an undivided facility the LRS is best represented as a single route or concurrent overlapping routes with different route names (RouteIds). This makes it difficult to manage data by direction natively in the LRS. Defining whether a facility is divided or undivided takes some analysis and rules based decision making. Data validation via aerial imagery, photo log and Google Street view and the creation of clear guidelines and requirements will help to clarify and properly define what a divided facility is.

For the undivided sections, roadway characteristics data is placed predominantly on the cardinal carriageway (direction of increasing measures of mileposts), through lanes for example. If an undivided route has 3 through lanes in one direction and 2 through lanes in the other, the lanes data will be placed only on the cardinal direction and summed to 5 lanes total. This poses a challenge for teams that need to manage by direction.

Another consideration is how the route functions when determining whether it should be a divided or undivided facility. If it is physically impossible to cross over into the other carriageway the LRS should manage the linework as two separate carriageways, a divided facility. A grade separated facility would also constitute a separate named route, such as an E-ramp (cross over ramp).

The other aspect to consider is how locally owned routes, routes not under the jurisdiction of ADOT are managed. It is important to be consistent between jurisdictions. The use cases will likely vary from one municipality to another. Understanding the driving forces behind this will assist in shedding light on the topic as well as support the creation of a standard.

Potential Solutions

There are several options to manage data by direction, the two major options are:

1. Directionality per event
2. Directionality per route network

The modeling of assets on a roadway with directional attribution is the hallmark of good data management. This is especially important on undivided routes as a single carriageway creates challenges for mileage summarization and reporting for business units that need to report data by direction. This is especially important for teams that perform field work.

Directionality per event (option 1 in Figure 5) allows for the LRS to stay largely static and leverages direction attribution for specific events (See Table 1). To perform this analysis there will need to be updates to the database schema and coordination with data owners. The use of esri's route dominance functionality will ensure that events are located on the most dominant route. This ensures that mileage querying and summarization are performed on the proper route.

Figure 5.

Table 1.

RouteId	FromMeasure	ToMeasure	Pavement Condition	Direction
S 010	50	60	Good	EB
S 010	50	60	Poor	WB

The other potential solution is to update the LRS (option 2 in Figure 6) to have concurrent overlapping routes or completely separate routes into a dual carriageway model (See Table 2). This will greatly align the LRS with ARNOLD business requirements. It will create substantial work on the LRS data owners to update the network as well as maintenance moving forward.

Figure 6.

Table 2.

RouteId	FromMeasure	ToMeasure	Pavement Condition
S 010	50	60	Good
S 010 0	50	60	Poor

Whichever method is decided upon, the empowerment of data owners to manage their data via the GIS is paramount for long term success. The creation of standard work is vital to long term sustainability and consistency. The development of clearly defined business needs and rules will support data driven decision making. Using humble inquiry to understand specific needs and develop targeted solutions will help drive the next steps.

Next Steps

Benefits will take the form of standard work related to route and event management. Improved analytics by route and by lane will support asset management for maintenance crews and planning activities. Success will be measured by time saved for analytics, cost savings by reducing the need to perform field verification, improved customer service to business units that leverage the LRS and much more.

As the use of the LRS expands into other teams within ADOT to support specific workflows the LRS will need to evolve. A worthwhile activity would be to coordinate with teams that leverage the LRS including the Multimodal Planning Division (MPD), Transportation Systems Management Operations (TSMO) and Information Technology Group (ITG):

- MPD Geospatial Analysis Team - data owners of the LRS
- MPD Data Analytics Team - data steward for federal reporting
- MPD Traffic Monitoring Team - data owners and user for federal reporting
- MPD Pavement Management Team - data owners and user for integration with the pavement management system
- ITG GIS - data custodians of the LRS database
- TSMO Traffic Safety Team - data owners and support safety analysis using GIS data

Identifying these customers will allow for a better understanding of what the data is being used for. The next step will be to coordinate with the identified teams to understand their business needs. Documentation will be produced in the form of core process mapping, workflow documentation and metadata to support long term sustainability.

The need for an agency-wide standard that is implemented in all workflows and enforced across the department will allow for improved analytics. One method would be to develop business use case stories with affected teams. This would help to distinguish between wants and needs to assist in setting priorities. There needs to be a common standard between communities of practice (i.e. NG911).

For a national perspective, the Applications of Enterprise GIS for Transportation (AEGIST) guidebook is looking to further define these carriageway nuances as well as create a national standard. If this method is desired it would be recommended to wait for AEGIST to complete its work before implementing. That way best practices can be incorporated.

Conclusions

Whichever solution is proposed, the need for a standard to improve data consistency is vital. It is clear that as the LRS continues to be leveraged by other customers it must also evolve. Coordination with business units will help to define business needs. A focus on business development through outreach will ensure all impacted have a voice in the process. Lastly, aligning business needs with staffing will help to set the priority and customer expectations. Creating milestones will ensure quick wins and help to measure success.

Resources

- AEGIST Pooled Fund Study is being administered by the Federal Highways Administration (FHWA) and is looking to create a national standard on how states manage their LRS. This is one aspect of the study that is being reviewed. https://www.gis.fhwa.dot.gov/AEGIST.aspx
- Download ADOT GIS data from the statewide data clearing house, AZGeo.
- To learn more about the GIS community in Arizona, please get involved with the Arizona Geographic Information Council (AGIC).

The Author

Mr. Whiteford has over 15 years of professional Transportation GIS experience. He has been with the Arizona Department of Transportation for 10 of those years in a progressive leadership role. Mr. Whiteford is a visionary leader that is a passionate geospatial advocate.

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