Translating Transportation Data Between Linear Referencing Systems of Dissimilar Resolution

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The Wisconsin Department of Transportation uses two linear referencing systems (LRSs) for complete mapping of crashes statewide: the State Trunk Network (STN), which represents only state routes, and the Wisconsin Information System for Local Roads (WISLR), which includes all roads but gives specific detail for local routes. A functional link between the two systems was developed; this link allows data to be translated from the STN, a higher-resolution representation, to the WISLR, a lower-resolution representation. Although data are easily translated from high to low resolution, ambiguities arise when data are moved from low resolution to high resolution. The research presented in this paper identifies common problems associated with translation of data from low to high resolution and provides some rules and guidelines to accommodate these issues.

The Wisconsin Department of Transportation (DOT) developed and maintains two independent transportation linear referencing systems (LRSs) for use with traffic and transportation business data in the state: the State Trunk Network (STN) and the Wisconsin Information System for Local Roads (WISLR). The STN was developed in the early 1990s for use on Wisconsin's Interstate highways and state roads. Within the STN there exists a network of links and nodes that represent travel paths between state route intersections. The links are described with unique identifiers (IDs) and as-driven distances. The WISLR was developed approximately 10 years after the STN for use on local roads throughout the state. The WISLR originated from cartographic representations that were digitized from existing local, state, and federal sources. The digitized lines were converted into multidirectional links that were split at intersections. End points of links were used to create nodes. WISLR links are described by unique IDs, and although WISLR personnel collect linear distances for links, state route distances are not maintained because of existing length data in the STN (*1*).

Approximately 12,000 and 100,000 mi of state routes and local roads are represented in the STN and WISLR, respectively. Although the WISLR shares 12,000 mi of roadway with the STN, each system was developed and has progressed independently of the other to meet various business needs within the Wisconsin DOT. Because of differences in data types and formats, structural interoperability between the two systems is difficult.

A connection that relates a segment of a link in one system to the corresponding link segment in the other system was created for the STN and WISLR. This relationship is stored in the link–link table. A statewide link–link table was completed in 2011 and was employed to successfully move state route crash data for 2005 to 2009 from the STN to the WISLR. Specifically, the link–link table has allowed crash data points described with STN links and offsets to be translated into crash data points described with WISLR links and offsets. Moreover, the link–link table allows for movement of any point that contains STN link and offset information from the STN to the WISLR. Until now, sharing and translating crash data has been the main focus of this effort. In addition, because of differences in data resolution between the two systems, only movement from the STN (high resolution) to the WISLR (low resolution) has been refined to a functional operational level.

The Wisconsin DOT currently uses a statewide system of reference points to code crashes that occur on state routes. The reference point (RP) system allows designation of the linear location of features along a roadway (*2*). An RP can occur at a variety of different physical landmarks, including intersections, aboveground bridges, railroad crossings, state boundaries, and other identifiable features. When the RP linear referencing method (LRM) was originally developed in the 1970s, each RP was given a number and an offset, or plus distance, on the route on which the RP appeared. After the development of the STN link–offset LRS, each RP number was assigned an STN link and offset. Current state route crash-locating procedures involve manually analyzing written crash record information created by law enforcement agents and assigning each crash that occurs on a state route an RP number and an offset. With the RP and offset, the Wisconsin DOT can then assign each crash an STN link and offset.

Recently, the Wisconsin DOT embarked on a project to develop and implement an incident location tool (ILT) to assist law enforcement with crash locations. This interactive tool will use a cartographic representation of the WISLR roadway network. The tool will function in such a way that when a law enforcement officer clicks a position on an in-car map, the associated WISLR link and offset information will be captured and stored in the crash record. The link–link table will then be used to determine an STN link and offsets for crashes that occur along state routes.

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The Wisconsin DOT seeks to continue to use STN link and offset information because of the numerous analysis tools available within the STN system that are not yet functional within the WISLR. Unfortunately, inconsistencies between the STN and WISLR systems create problems when data are moved from the WISLR to the STN. In the near term, the Wisconsin DOT will flag crashes moved from the WISLR to ambiguous locations in the STN and manually use the existing RP coding method to assign an STN link and offset.

Because crash location data need to be in three formats—STN link and offset, WISLR link and offset, and RP number and offset—within the STN system, accurate movement of data between the WISLR and STN systems is necessary. The goal of this research was to use a systematic approach to translate data between associated LRSs to reduce the manual workload associated with statewide crash mapping.

BACKGROUND

An LRS is made up of multiple levels of related information. The STN and WISLR follow the basic components of an LRS. Additionally, the Wisconsin DOT's business data reporting methods follow the requirements for events within an LRS. The structure of these systems and data reporting methods allows for the use of typical LRS rules in translating data from the high-resolution STN system to the low-resolution WISLR system. The conceptual model in Figure 1 shows an LRS as a compilation of three main parts: a datum, network(s), and LRMs.

The datum, shown in the center of Figure 1, is an absolute set of an anchor point and anchor sections. The anchor point and segments relate to real locations and act as a platform for movement between the other parts of the conceptual model. Anchor points require some detailed explanation of the location in the field; this explanation can be quantitative or qualitative, or both. Anchor sections are solely a connection between two anchor points. The length of the anchor section can be calculated in the field to provide an accurate relationship between the anchor points (*4*).

A network, as seen in Figure 1, is described as a means for communication and movement between point locations (*5*). There are different types of networks that can be presented simultaneously through a common datum that is associated with an LRS, as shown by Network N in Figure 1. A common network type is a link–node system, in which links are directional and act as flow conduits, and nodes are locations where links meet. Conversely, nodes can be described as locations where flow can change, and the links simply connect certain nodes, as described in the *Wisconsin Location Control Management Manual* (*2*).

An LRM is a way of describing the location of transportation data on a given network. Although there are several common LRMs, the Wisconsin DOT employs the link–offset method in the STN and WISLR systems. This method uses the directional link on which the transportation data are located as well as the distance down link that must be traveled from the beginning of the link to the event.

Events are the visual product of processing business information through an LRS and are at the center of spatial analysis. In a link–offset LRM, event points are represented by a link ID and an offset (*3*) from a known traversal reference point (TRP), which is typically the beginning of the link. Bridge locations and segments of pavement are physical data events, and crash points and project reference lines are intangible data events. Events are generated solely through an LRS and will not always correspond to the actual location in the field, because an LRS is only an abstract representation of actual conditions.

Multiple maps and cartographic representations can be related to an LRS on the basis of the virtual anchors of the linear datum, meaning that cartography is not necessary to the function of an LRS. However, cartography provides a visual perspective for better

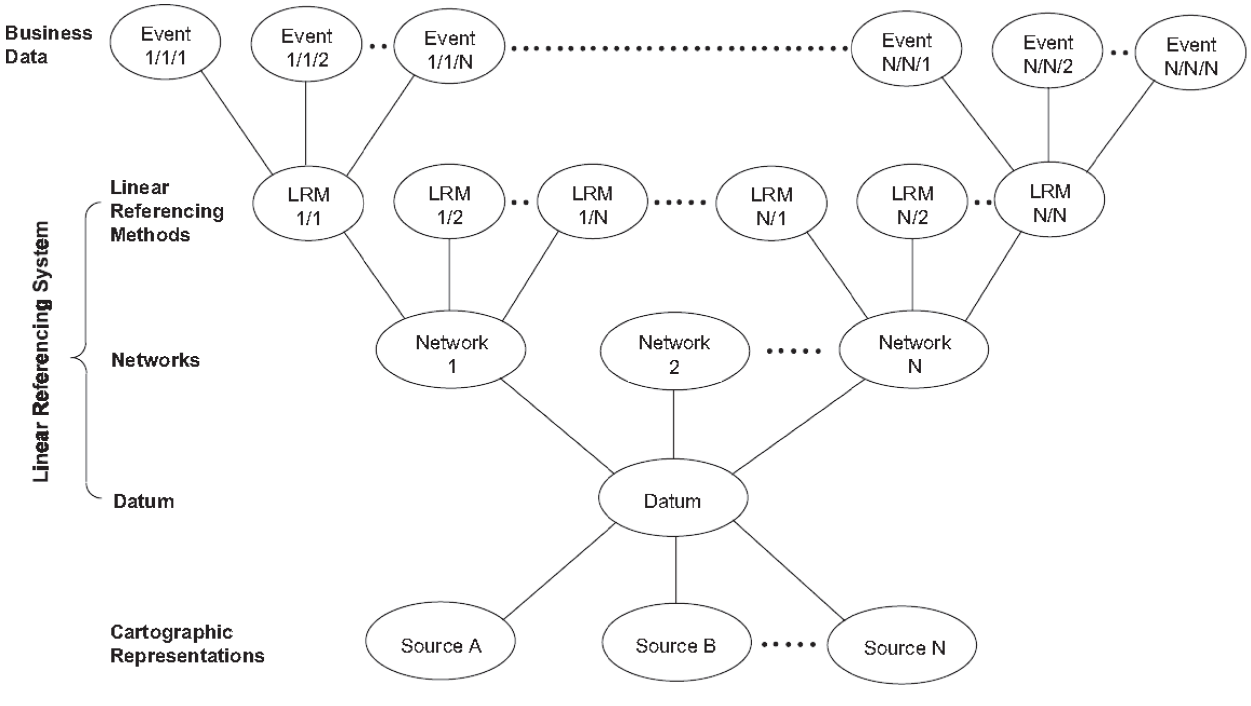


FIGURE 1 Generalized LRS model known as NCHRP Project 20-27(2) model (*3*).

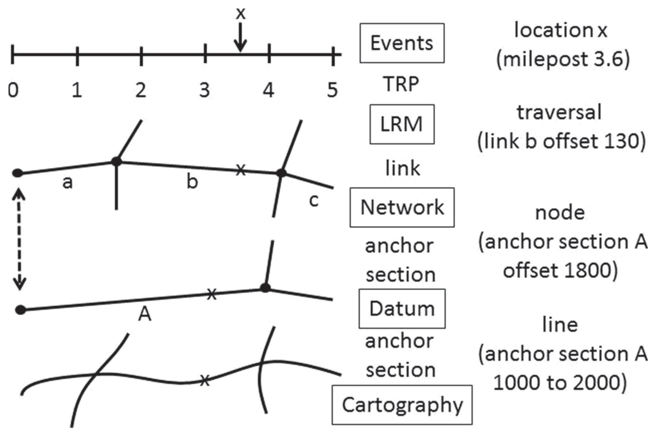


FIGURE 2 Visualization of NCHRP Project 20-27(2) conceptual model (*7*).

understanding of the relationships of the network(s) and the event data (*6*). An LRM processes events by referencing the network; the network is located on the earth's surface by the datum, and the cartography is overlaid onto the datum for visualization. A graphic illustration showing the levels of the conceptual LRS data model is shown in Figure 2.

Because the STN and WISLR were developed to meet separate business needs within the Wisconsin DOT, the systems are independent in almost all respects, including the network, the network rules, LRMs, and cartography. The STN and WISLR are similar, in that both systems lack a distinct datum as defined by NCHRP (*4*). Instead, each system has the datum embedded in the respective network.

The Wisconsin DOT seeks to use the link–link table, which is a functional join between the STN and WISLR, to move from an event on a WISLR chain, or cartographic representation, to an event containing an STN link and offset. This translation is direct when the link–link table defines a one-to-one relationship between the two systems. However, ambiguities occur when one-to-many relationships exist.

Schema uniformity is critical for data translation between transportation systems. For data system interoperability to be possible, agreement must be created between the data models. The models must both identify transportation features with corresponding attributes and be represented as line or point events through the use of linear referencing (*8*).

Given that the WISLR and STN systems exist on different scales, or resolution levels, nonarbitrary rules had to be used to describe relationships within the data when linking the data sets (*9*). During link–link coding, rules were formulated in this way, but only with consideration of one direction: STN to WISLR (*6*). An STN-to-WISLR relationship was accomplished by linking the two systems with the link–link table. The names and descriptions of the six main link–link columns and three relevant link–link flag columns are as follows (*6*):

- Main link–link columns:
  - –STNid = unique identifier for the STN link,
  - –STNstart = start measure for the STN section,
  - –STNend = end measure for the STN section,
  - –WISLRid = unique identifier for the WISLR link,
  - –WISLRstart = start measure for the WISLR section, and
  - –WISLRend = end measure for the WISLR section, and
- Link–link flag columns:
  - –T = flag for turn lanes,
  - –M = flag for median crossovers, and
  - –W = flag for waysides.

The STNid and WISLRid columns were populated with the unique ID number of the STN and WISLR link lengths that were found to correspond to each other. The STNstart and STNend columns identify the section of an STN link that corresponds to the section of the WISLR link identified by the WISLRstart and WISLRend columns.

Additionally, rules were established to deal with areas that did not have a one-to-one relationship. Rules associated with the link–link table were implemented with the use of flag columns within the table. Although five main flag columns were used during the coding of the link–link table, the T, M, and W flags identified above were relevant to this research. The turn lane (T) column identified areas in which the STN represented an intersection with physically separated turn lane links and the WISLR did not. The median crossover (M) column similarly identified areas in which the STN represented median crossover with a link and the WISLR did not. The wayside (W) flag identified roadside areas that were represented in the STN with links but were not represented in the WISLR. The flag columns were created to manage discrepancies, such that every point along an STN link was able to translate to some point along a WISLR link.

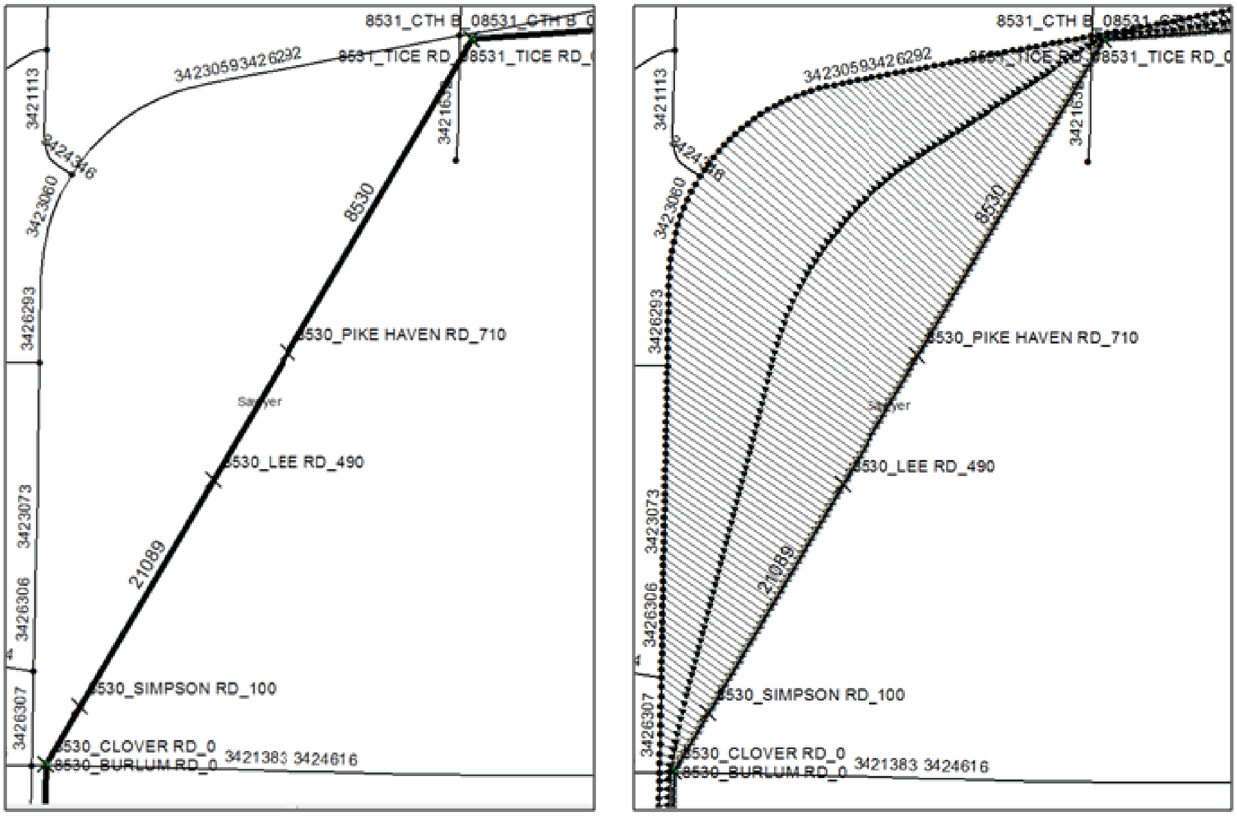
Although rules for moving data sets in the opposite direction, from the WISLR to the STN, had not previously been considered, such rules had to be determined. One way to develop these rules is to move data between the systems and visually inspect the results. Problems arise in this approach because of the difficulty in finding every possible data movement that requires a specific rule (*9*).

In earlier research regarding moving data from the high-resolution STN to the low-resolution WISLR, it was found that a methodology could be successfully implemented between the two systems while each system continued its regular independent functions. This methodology was refined with quality assurance/quality control (QA/QC) measures that allowed full sharing of crash data from the STN with the WISLR. This research sought to develop data translation techniques from the low-resolution WISLR system to the high-resolution STN system.

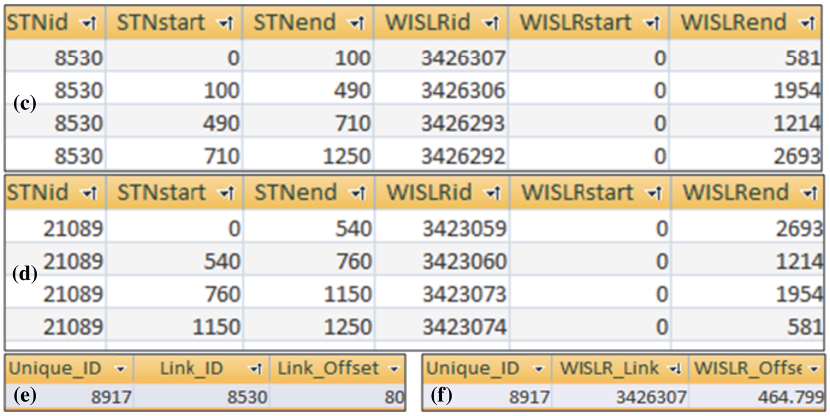
METHODOLOGY AND DATA ANALYSIS

Given that data sharing and translation from the STN to the WISLR were successfully accomplished with the link–link table in earlier phases of related research, the approach to translating data from the WISLR to the STN was most practically accomplished by using the link–link table. As was the case for STN to WISLR translation, the ability of the link–link table to define link-by-link relationships between the two systems was the building block for the WISLR-to-STN translation effort.

A specific example of the basic link–link coding process is shown in Figure 3. In Figure 3*a*, STN Links 8530 and 21089 each relate to four WISLR links. One link is on top of the other and each travels in an opposite direction. The link–link table relates a segment of an STN link to the corresponding WISLR links, as shown in Figure 3, *c* and *d.* The length relationships defined in the link–link table provide a means for moving a point from the STN to the WISLR. For example, if a point exists that is coded to STN Link 8530 with an offset of 80 (Figure 3*e*), the link–link table is able to define that the given point should have an equivalent location in the WISLR system. Figure 3*f* illustrates that



(a) (b)



(c)

STNid	STNstart	STNend	WISLRid	WISLRstart	WISLRend
8530	0	100	3426307	0	581
8530	100	490	3426306	0	1954
8530	490	710	3426293	0	1214
8530	710	1250	3426292	0	2693

(d)

STNid	STNstart	STNend	WISLRid	WISLRstart	WISLRend
21089	0	540	3423059	0	2693
21089	540	760	3423060	0	1214
21089	760	1150	3423073	0	1954
21089	1150	1250	3423074	0	581

(e)

Unique_ID	Link_ID	Link_Offset
8917	8530	80

(f)

Unique_ID	WISLR_Link	WISLR_Offse
8917	3426307	464.799

FIGURE 3 Example of QA/QC procedure for *x-y* lines: (*a*) basic section of roadway with STN (straight thick lines) and WISLR (curved thin lines); (*b*) *x-y* lines connecting data points starting in STN and moving to WISLR; (*c*) link–link records for STN Link 8530; (*d*) link–link records for STN Link 21089; (*e*) example data for STN point with unique ID, STN link number, and offset; and (*f*) example data for WISLR point with unique ID, WISLR link number, and offset.

the equivalent location in the WISLR is on Link 3426307 with an offset equal to the ratio of the full STN length relationship on which the point resides multiplied by the full corresponding length within the WISLR (e.g., $80/100 \times 581 = 464.799$).

A point-moving program was developed to calculate the WISLR link and offset given an STN link and offset. This program is used to move crash data and also used in QA/QC procedures to move STN points generated with offsets of every hundredth of a mile along every STN link. Each hundredth-of-a-mile point was moved with the program to the WISLR to determine whether a correct relational coding had been accomplished. From the points generated on each system's line work, it was possible to generate *x-y* lines to visually check the spatial relationship between the STN and WISLR. An example of this spatial check, which appears as parallel lines when the link–link relationship is correct, is shown in Figure 3*b*.

Data Translation

The first step in the WISLR-to-STN data translation effort was to create a general computer program that translated data containing WISLR link numbers and offsets into data containing STN link numbers and offsets. The WISLR-to-STN program, modeled after the original STN-to-WISLR point-moving program, reads point information consisting of a unique point ID, a WISLR link ID, and a WISLR offset. From these data, the program selects a record in the link–link table that contains the same WISLR link number and represents the section of road where the point is located. The program then determines, through mathematical ratios, where on the corresponding STN link the point should be located. A new record is then created with the same unique point ID, an STN link ID, and an STN offset.

Three data sets were used to determine a general data translation method from the WISLR to the STN. First, statewide RPs were moved from the STN to the WISLR and then back to the STN for initial data analysis. Next, hundredth-of-a-mile points along each STN link in Dane County, Wisconsin, were moved to the WISLR then back to the STN. Finally, Dane County crash points were moved.

Although moving points from the WISLR to the STN was successful, resolution issues caused some RP points to land at multiple ambiguous locations when moved back to the STN. To find these points that mapped to multiple locations, the moved points were summarized within ArcMap on the basis of the unique IDs. This process produced a count for each point; a count greater than one indicated that the point from the WISLR moved to multiple locations in the STN. Three common ambiguous point placement problems were identified in this research, namely, problems due to median crossovers, turn lanes, and waysides. These problems are discussed in the following subsections.

Problem 1. Ambiguous Point Translation for Intersection Median Crossovers

The first common issue that caused ambiguous data point placement occurred because of incongruent intersection representations between the STN and WISLR, as shown in the intersection illustrated in Figure 4. This example shows the intersection of two divided highways. The STN represents the intersection with four thick links and four nodes, and the WISLR represents the intersection with a single node. These four STN links represent median crossovers. As illustrated in Figure 4, data points at the ends of the median crossovers, labeled Points 1 through 4, move to a single point in the WISLR, in accordance with the link–link relationship. However, when Points 1 through 4 are moved back from the WISLR to the STN (Figure 4*b*), each point lands at the end of each STN link, because the link–link table relates the single intersection node in WISLR to all the intersection information (links and nodes) in the STN. This point placement pattern does not represent the original location for the moved data points; therefore, location ambiguity is introduced into the process.

Problem 2. Ambiguous Point Translation for Turn Lanes

The second common problem occurred for many state route intersections with roadway entrance or exit ramps and other similarly

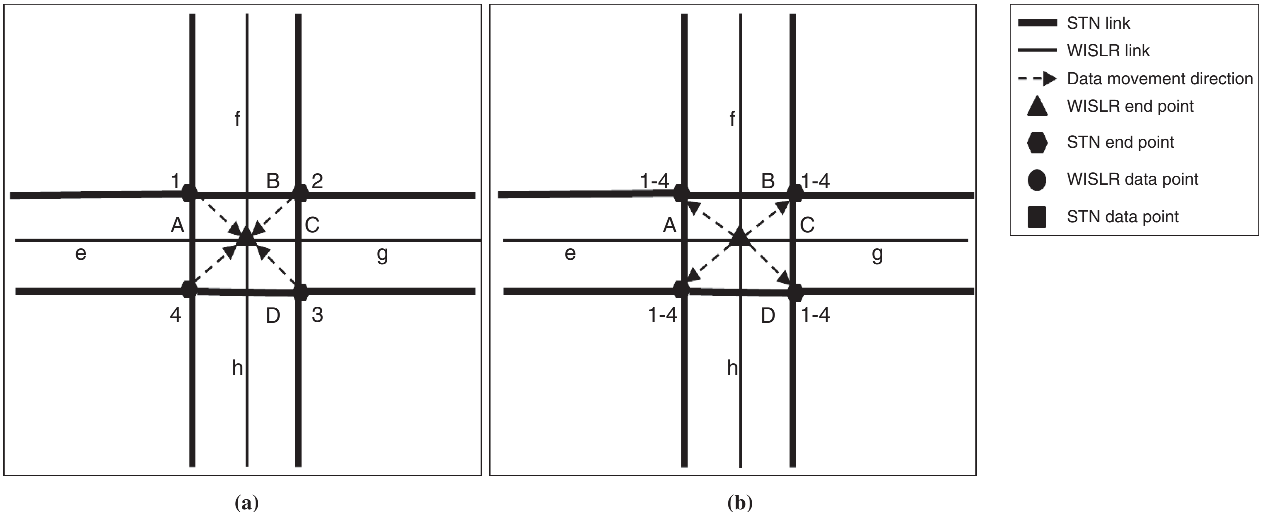
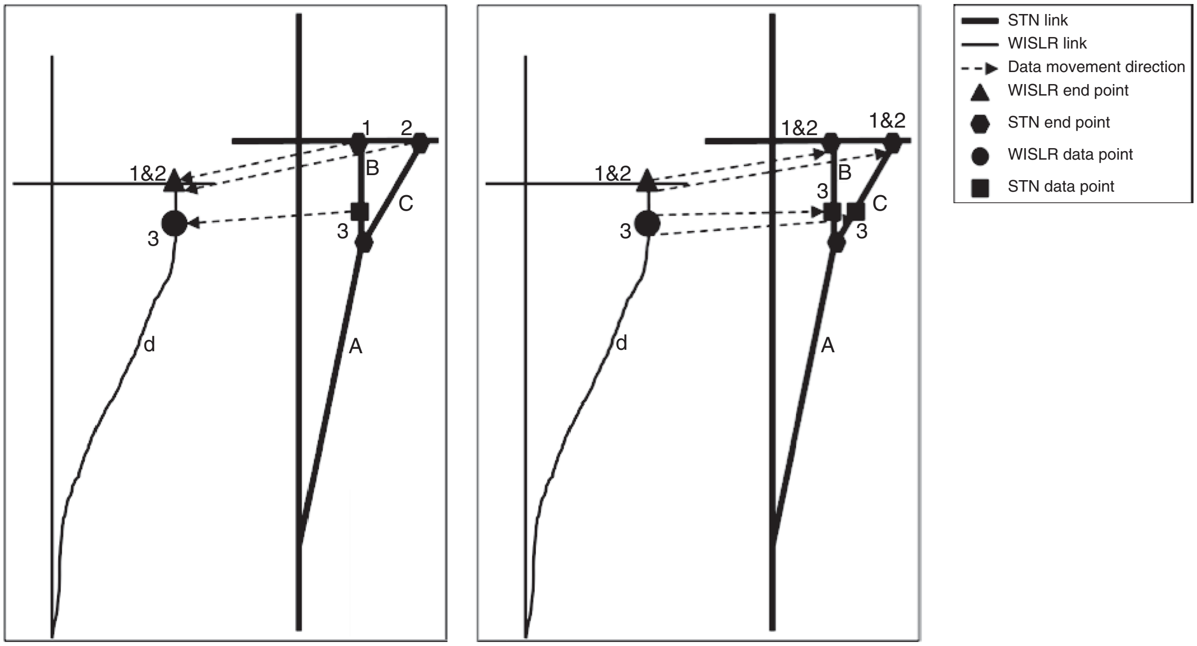


FIGURE 4 General example of ambiguous point placement caused by incongruent intersection median crossover representations: (*a*) accurate movement of data from a high-resolution intersection represented by four links and four nodes (STN) to a low-resolution intersection represented by a single node (WISLR) and (*b*) movement of data from a low- to a high-resolution system produces location ambiguity because one node in the low-resolution system represents four links and four nodes in the high-resolution system.



(a) (b)

FIGURE 5 General example of ambiguous point placement caused by incongruent turn lane representations: (*a*) accurate movement of data from a high-resolution intersection with two turn lane links and three nodes (STN) to a low-resolution intersection represented with a single link and node (WISLR) and (*b*) movement of data from low to high resolution produces location ambiguity because one link and node in the low-resolution system represent two links and three nodes in the high-resolution system.

designed intersections. This problem primarily involved resolution differences between the STN and WISLR at intersections with turn lanes. An example of this problem is shown in the intersection illustrated in Figure 5, in which the STN accounts for turn lanes with physically separated links represented by straight thick black lines and the WISLR represents the intersection with a single curved thin link and single triangular node. Link C in the STN represents a right-turn lane and Link B represents a straight or left-turn lane. Figure 5*a* shows that Data Points 1 and 2 move correctly from the high-resolution STN to the low-resolution intersection point represented in the WISLR. However, when Points 1 and 2 are moved back from the low-resolution WISLR system to the high-resolution STN system (Figure 5*b*), both points move to two locations, because the system cannot distinguish between locations in the STN. Additionally, Point 3 represents an event in the STN that occurred on Link B. In Figure 5*a*, Point 3 moves to the WISLR correctly, but in Figure 5*b*, Point 3 moves back to two ambiguous locations in the STN. Given that the event did not occur in the right turn lane, Point 3 placed on Link C in Figure 5*b* is a completely erroneous point.

Problem 3. Ambiguous Point Translation for Waysides

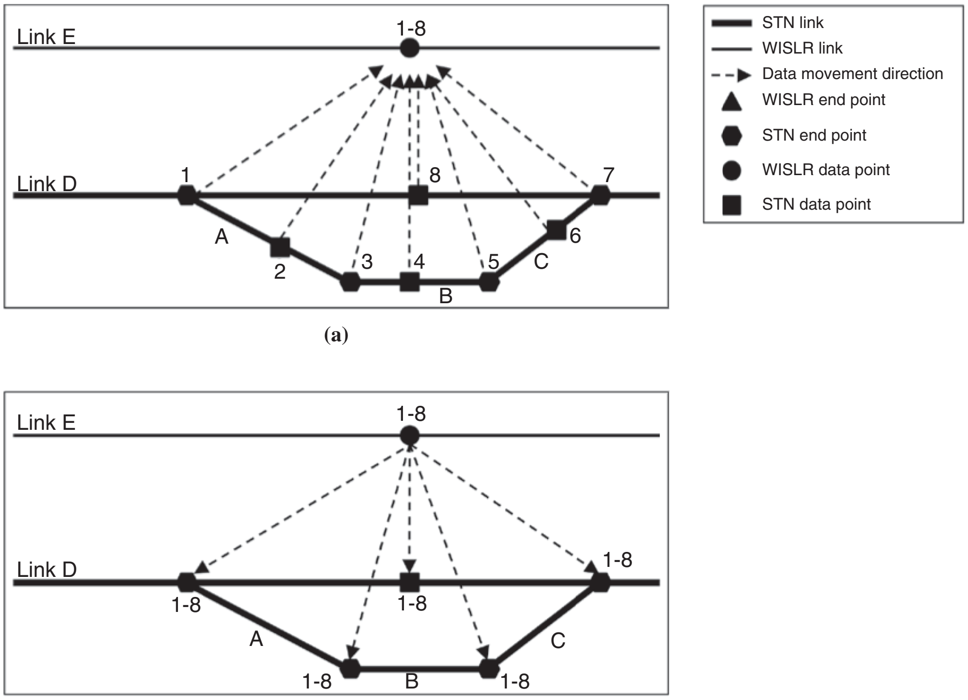
The final common problem that produced ambiguous locations is associated with waysides along state routes. An example of this problem is shown in Figure 6, in which the STN represents waysides with thick links and nodes and the WISLR does not represent waysides. In Figure 6*a*, Data Points 1 through 8 in the STN are translated to a single point in the WISLR, in accordance with relationships defined in the link–link table. This is because the wayside does not exist in the lower-resolution WISLR system, and a single point along the WISLR main-line link is chosen to represent the location of the wayside. When this single point in the WISLR is translated back to the STN (Figure 6*b*), all eight of the data points move back to the endpoints of the STN links representing the wayside as well as the point on the STN main line. Although it is not desirable that one location in WISLR moves to multiple locations in STN, because of resolution differences, location accuracy is compromised when points are moved from low to high resolution.

Objective

To deal with ambiguous data placement, the Wisconsin DOT implemented a process that simply flags crashes that move to ambiguous locations. These crashes are then manually coded to the STN with manual crash-mapping methods. The objective of this research was to identify ways to avoid manual coding in order to save time and resources.

Proposed Data Translation Rules

An absolute technique for eliminating ambiguities between the WISLR and STN systems, or between any two LRSs with different resolution levels, is simply to improve the resolution level of the lower-resolution system. This improvement will allow for complete one-to-one relationships between the two systems. However, in light of the extensive time and effort associated with improving large



(a)

(b)

FIGURE 6 General example of ambiguous point placement caused by a wayside: (*a*) movement of data from a high-resolution wayside represented by multiple links and nodes (STN) to a low-resolution representation without the wayside (WISLR) and (*b*) movement of data from low to high resolution produces location ambiguity because one location along a link in the low-resolution system represents the entire wayside in the high-resolution system.

LRSs, it is necessary to address common differences in resolution. To accomplish this task, rules were established that were associated not only with linking LRSs of different resolution levels, but also with how data are coded in the lower-resolution system before they are translated to the higher-resolution system.

Data Processing Rules

The first potential rule relates to collecting and maintaining additional data about a location. In the case of crash data, reporting intersection details in the crash record will allow for automatic location of the crash in both high- and low-resolution versions of the intersection. For example, in the turn lane intersection shown in Figure 5, if a crash record denoted whether the crash occurred on the straight or in the right-turn lane, then an automatic routine could be coded to accurately place the crash in both the high- and low-resolution systems. If this information is recorded on the front end of the data collection process, less ambiguity is associated with a location. Although this rule would be useful for data translation, far-reaching changes that would require extensive time and effort would have to be made to crash-reporting methods and forms.

To account for institutional constraints on implementing procedural changes in data reporting, additional rules were formulated that related solely to data translation. Fortunately, the original link–link table was equipped with flag columns to identify common resolution discrepancies between the STN and WISLR, and these columns allowed for easier rule implementation at these locations.

Median Crossover Rules

The second set of potential rules is associated with ambiguous data translation of median crossovers caused by resolution differences. As shown in Figure 4*b,* this problem causes points from the WISLR (lower resolution) to move to multiple locations in the STN (higher resolution). To reduce ambiguous placement of event data at median crossovers, two rules can be implemented:

- Place each data point associated with an STN link flagged for median crossover at the center of the median crossing instead of at the ends of the link. This rule would reduce the number of possible locations from the two endpoints of a link to the single midpoint of the median crossover link.
- Ignore records in the link–link table associated with median crossovers when moving data from the WISLR to the STN. A report would then be generated with all of the data associated with median crossover records for future manual placement.

Turn Lane Rules

Four rules could similarly be applied to turn lanes:

- Simply map all crashes that would have mapped to two turn-lane links to a single link. The single link to which a point would be mapped would be arbitrarily determined from the data-associated STN turn lane that was first processed by the computer program.

- Implement single-link data placement, but use the longest turn-lane link for data placement.
- Cause the point-moving program to ignore all data associated with turn lanes and generate a report showing these data points.
- Include an additional table in the LRS to indicate a preferred single location in the high-resolution system for any data coming from a specific point in the low-resolution system.

Wayside Rules

Wayside rules would allow for data placement associated with links not represented in the low-resolution system:

- Place data points at all possible locations. This option would basically not change the current data translation methods.
- Place each data point at only one location. This location would be arbitrarily determined by which STN link was processed first by the computer program.
- Create a report with all of the data points that would have moved to a wayside-denoted STN link without actually translating the data.
- Create an additional table that would specify a preferred single location in the higher-resolution STN system for any data point that originates from a specific location in the lower-resolution system.

Rule Implementation

A point-moving program was written to implement the previous rules when data are translated from the WISLR to the STN. Radio buttons that indicate how waysides, median crossovers, and turn lanes should be implemented in the data translation were added to the user interface. Each previously discussed rule is implemented in the data translation simply by selecting one of these rule-related radio buttons.

To test the general effectiveness of implementing the data translation rules, one of the median crossover rules was implemented after initial, rule-free data translation was performed. In this test, the second median crossover rule was implemented. This rule ignores all link–link records flagged as median crossovers.

RESULTS

Data analysis was performed on the Dane County data sets. There were 17,170 crash points in Dane County between 2005 and 2009 that were moved from an originally coded STN link and offset to a corresponding WISLR link and offset. When these crashes were moved back to the STN, all of them were appropriately placed at the original crash locations in the STN, but additional ambiguous locations were also produced. The total number of crash locations in the STN after the data were moved back from the WISLR was 17,919. The one-to-many relationship in the link–link table caused 647 crashes (4%) to map to multiple STN links. Of these 647 crashes, 28 (4%) were associated with turn lane–flagged link–link records, 313 (48%) with median crossovers, and 2 (0.3%) with waysides. If median crossovers are ignored, 17,512 crash points translated to an STN link and offset; only 301 (2%) crashes mapped to multiple STN links. Additionally, all 17,170 original crashes mapped; thus, no crash data were lost by excluding median crossover links.

The Dane County hundredth-of-a-mile data set was also used for analysis. Data points were placed on STN links every hundredth of a mile, the points were moved to the WISLR and visually inspected and then moved back to the STN, and the initial and final locations were compared. There were 86,178 hundredth-of-a-mile points in Dane County along STN links. All of the points were moved from the STN to the WISLR. After the points were moved back to the STN, there were 88,318 points, including 1,433 points (1.7%) that had moved to multiple links. Of these, 85 (6%) were associated with turn lane–flagged link–link records, 260 (18%) with median crossovers, and 63 (4%) with waysides. When median crossovers were ignored, the number of points that had moved back to the STN was 87,958, including 1,149 points (1.3%) that had moved to multiple links. Additionally, all 86,178 hundredth-of-a-mile points mapped to a location on the STN; no data were lost with the implementation of this rule.

An extensive analysis of the third and final data set, the Wisconsin DOT’s RP database, was performed. This database was chosen for extensive analysis because it is a statewide database of a size that provides a substantial sample of conditions around the state. The most recent statewide RP database consists of 64,131 points with STN links and offsets. Of these points, 37,562 moved to the WISLR. This value consists of all but one current RP and 3,500 historical RPs. Not all of the historical RPs were expected to move to the WISLR, because some were located on historical STN links that were not included in the link–link table. When the initial data translation of the 37,562 points on the WISLR was performed, 44,123 points moved back to the STN. All of the RP points on the WISLR moved successfully back to the STN; however 4,355 (12%) moved to multiple links. Of these points, 1,623 (37%) were associated with link–link records that were flagged as median crossovers, 1,150 (26%) were associated with turn lanes, and 209 (5%) were associated with waysides.

Additionally, of the 4,355 points that mapped multiple times, 2,560 (59%) moved to single unique locations multiple times. These 2,560 points lie on top of each other and contain the same coordinates but exist on different links at the beginning of one link and the end of another link. Visual inspection of the multiple-mapped points showed that these locations were representative of the previously identified problem categories. After the median crossover rule was implemented, 2,102 (6%) of the 37,562 RPs that moved to the WISLR moved to multiple links. Again, no RP data were lost with the implementation of this rule.

Through analysis of each of these data sets, it was found that, in general, allowing a user to choose how to handle ambiguous data placement locations can reduce the number of multiples by up to 50% with no loss of any data. Although only the median crossover rule was implemented in this analysis, it can reasonably be expected that the other rules presented in this research would have similar results in reducing multiples of translated data.

CONCLUSION

Data translation between two or more LRSs with different levels of resolution requires systematic rules, additional detail in data capture, or manual intervention to accurately move data from a low- to a high-resolution system. In the case of the Wisconsin DOT’s statewide crash-mapping business needs, creating accurate detailed crash location records from lower-resolution in-field maps required the identification of all crash records at locations with ambiguous location data in the high-resolution system. These records were manually reviewed to determine the appropriate high-resolution location of the crash. Evaluation of crash records for 2005 to 2009 indicated that approximately 4% of the records would require manual intervention to eliminate duplicate locations. It is anticipated that Wisconsin will see a large time savings in the location of crashes on state routes, given that in the past, 100% of crashes on state routes were manually located, and now only ambiguous locations (approximately 4%) will need to be manually located.

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