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**Translating Transportation Data Between
Dissimilar-Resolution Linear Referencing Systems**

Andrew J. Graettinger, A. Lane Morrison
University of Alabama
Department of Civil, Construction and Environmental Engineering
260 H. M. Comer
Box 870205
Tuscaloosa, AL 35487-0205
andrewg@eng.ua.edu almorrison@crimson.ua.edu

Steven T. Parker
Wisconsin Traffic Operations and Safety Laboratory
University of Wisconsin, Madison
B239 Engineering Hall
1415 Engineering Dr.
Madison, WI 53706
sparker@engr.wisc.edu

Susie Forde
Wisconsin Department of Transportation
4802 Sheboygan Ave.
Madison, WI 53702
Susie.Forde@dot.state.wi.us

Xiao Qin
South Dakota State University
Department of Civil and Environmental Engineering
Crothers Engineering Hall 120
Box 2219
Brookings, SD 57007
Xiao.Qin@sdstate.edu

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ABSTRACT

The Wisconsin Department of Transportation (WisDOT) uses two separate linear referencing systems (LRSs) for complete statewide crash mapping. The State Trunk Network (STN) represents only state routes while the Wisconsin Information System for Local Roads (WISLR) includes all roads, with specific detail given to local routes. A functional link between the two systems has been developed that allows data to be translated from STN, a higher resolution representation, to WISLR, a lower resolution representation. While data is easily translated from high to low resolution, ambiguities arise when data is moved from low resolution to high resolution. Research presented in this paper identifies common problems associated with low to high-resolution data translation and provides some rules and guidelines to accommodate these issues.

INTRODUCTION

The Wisconsin Department of Transportation (WisDOT) developed and maintains two separate and independent transportation linear referencing systems (LRSs) for use with traffic and transportation business data in the State. The State Trunk Network (STN) was developed in the early 1990s for use on Wisconsin's interstates and state roads. Within STN there exists a network of links and nodes that represent travel paths between state route intersections. The links are described with unique identifiers and as-driven distances. The Wisconsin Information System for Local Roads (WISLR) was developed approximately 10 years after STN for use on local roads throughout the State. WISLR originated from cartographic representations that were digitized from existing local, state, and federal sources. The digitized lines were converted into multi-directional links that were split at intersections. End points of links were used to create nodes. Unique identifiers describe WISLR links and although WISLR personnel collect linear distances for links, state route distances are not maintained because of existing length data in STN (1). There are approximately 12,000 and 100,000 miles of state routes and local roads represented in STN and WISLR, respectively. Although WISLR shares 12,000 miles of roadway with STN, each system was developed and has progressed independent of each other in order to meet various business needs within WisDOT. Due to differences in data types and formats, structural interoperability between the two systems is difficult.

A connection between STN and WISLR was created that relates a segment of a link in one system to the corresponding segment of link in the other system. This relationship is stored in the "link-link" table. A statewide link-link table was completed in 2011 and was employed to successfully move 2005-2009 state route crash data from STN to 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 from STN to WISLR of any point that contains STN link and offset information. To this point, 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 STN (high resolution) to WISLR (low resolution) has been thus far refined to a functional operation level.

WisDOT currently uses a statewide system of reference points to "code" crashes occurring on state routes. The Reference Point (RP) System allows designation of the linear location of features along a roadway (2). A RP can occur at a number of different physical landmarks including intersections, above ground bridges, railroad crossings, state boundaries, and other identifiable features. When the RP linear referencing method 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 linear referencing system, each RP number was assigned a 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 state routes a RP number and an offset. By using the RP and offset, WisDOT can then assign each crash a STN link and offset.

Recently, WisDOT 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 roadway network. The system will function by a law enforcement officer clicking a point on an in-car map. WISLR will be used as the roadway network in ILT. The tool will function in such a way that when an officer clicks a position on the 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 a STN link and offsets for crashes occurring along state routes. WisDOT seeks to continue using STN link and offset information because of the numerous analysis tools available within the STN system that are not yet functional within WISLR. Unfortunately, inconsistencies between STN and WISLR systems create problems when data is moved from WISLR to STN. In the near term, WisDOT will flag crashes that move from WISLR to ambiguous locations in STN, and manually use the existing RP coding method to assign a STN link and offset.

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

BACKGROUND

Linear Referencing Systems are made up of multiple levels of related information. STN and WISLR follow the basic components of a LRS. Additionally, WisDOT business data reporting methods follow the requirements for events within a LRS. The structure of these systems and data reporting methods allow for the use of typical LRS rules when translating data from the high resolution STN system to the low resolution WISLR system. The conceptual model in Figure 11 shows a LRS as a compilation of three main parts: a datum, network(s), and linear referencing methods (LRMs).

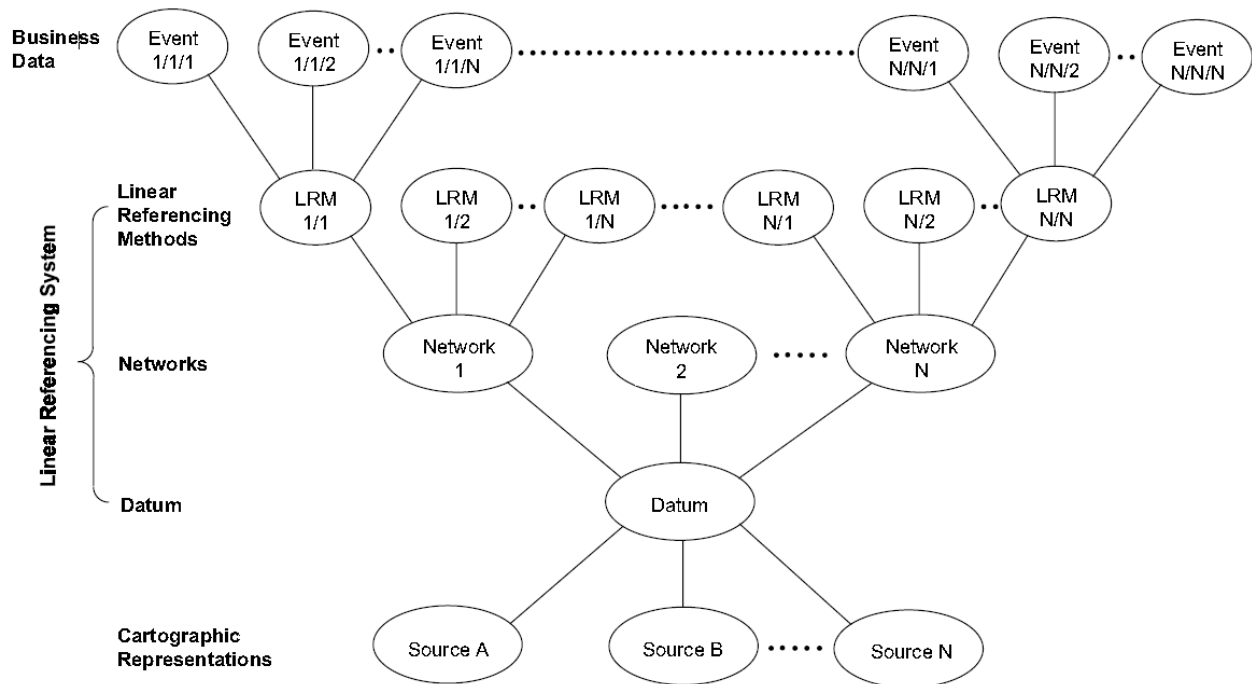


FIGURE 1 Generalized LRS model known as NCHRP 20-27(2) model (3).

The datum, shown in the center of Figure 1, is an absolute set of anchor point and anchor sections. These anchors points and segments relate to real locations and act as a platform for movement among the other parts of the conceptual model. Anchor points require some detailed explanation of the location in the field, which can be quantitative and/or qualitative. 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 Generalized LRS model known as NCHRP 20-27(2) model (3), FIGURE 2 Visualization of 20-27(2) conceptual model (7), is described as a means for communication and movement among point locations (5). There are different types of networks that can be presented simultaneously through a common datum that is associated with a LRS, as shown by Network N in Figure 1. A common network type is a link-node system, where links are directional and act as flow conduits, and nodes are locations where links meet. Vice-versa, nodes can be described as locations where flow can change, and the links simply connect certain nodes, as described in the WisDOT Location Control Management Manual (2).

A linear referencing method (LRM) is a way of describing the location of transportation data on a given network. While there are several common LRMs, the link-offset method is employed by WisDOT in the STN and WISLR systems. This method uses the directional link on which the transportation data is 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 a LRS and are at the center of spatial analysis. In a link-offset LRM, event points will be represented by a link ID and an offset (3). Bridge locations and segments of pavement are physical data events, while crash points and project reference lines are intangible data events. Events are generated solely through a LRS and will not always correspond to the actual location in the field due to fact that a LRS is only an abstract representation of actual conditions.

Multiple maps and cartographic representations can be related to a LRS based on the virtual anchors of the linear datum, meaning that cartography is not necessary to the function of a LRS. However, cartography provides a visual perspective to better understand the relationships of the network(s) and event data (6). A 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.

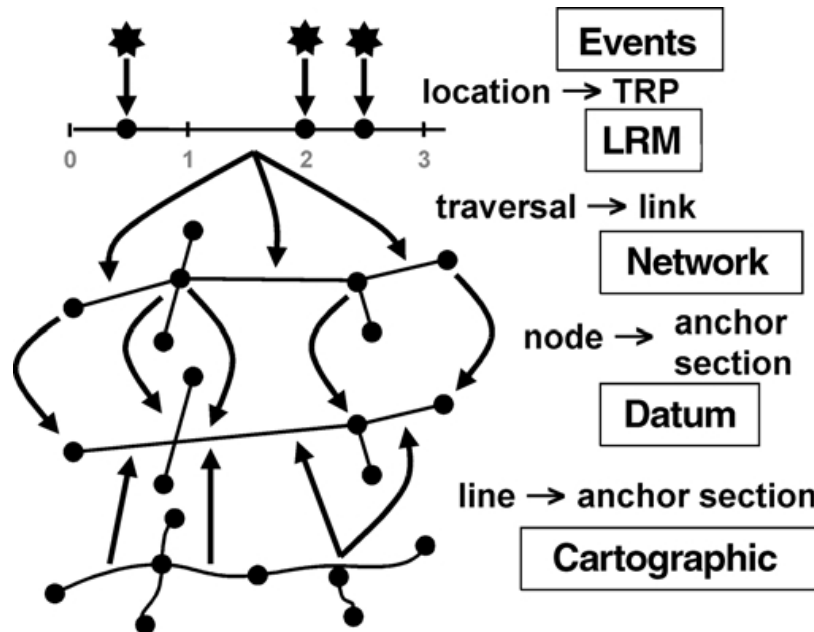


FIGURE 2 Visualization of 20-27(2) conceptual model (7).

Because STN and WISLR were developed to meet separate business needs within WisDOT, the systems are independent in almost all respects including: the network, network rules, LRMs, and cartography. 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.

WisDOT seeks to use the link-link table, which is a functional join between STN and WISLR, to move from an event on a WISLR chain, or cartographic representation, to an event containing a 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 regarding 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 must be represented as line or point events using linear referencing (9).

Given that the WISLR and STN systems exist on different scales, or resolution levels, linking the data sets had to utilize non-arbitrary rules to describe relationships within the data (10). During link-link coding, rules were formulated in this way but only with consideration of one direction: STN to WISLR (6). A STN-to-WISLR relationship was accomplished by linking the two systems with the link-link table. The table’s design and basic description is illustrated in **Error! Reference source not found.** 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 a STN link that corresponds to the section of the WISLR link identified by the WISLRstart and WISLRend columns.

Table 1 Names and Descriptions for the Six Main Link-Link Columns and Three Relevant Link-Link Flag Columns (6)

STNid	STNstart	STNend	WISLRid	WISLRstart	WISLRend	T	M	W
Unique identifier	Start measure	End measure	Unique identifier	Start measure for	End measure for	Flag for	Flag for Median	Flag for waysides

for the STN link	for the STN section	for the STN section	for the WISLR link	the WISLR section	the WISLR section	Turn Lanes	Crossovers	
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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 coding of the link-link table, three are relevant to this research: turn-lane (T), median crossover (M), and wayside (W). The turn-lane column identified areas in which STN represented an intersection with physically separated turn lane links, while WISLR did not. The median crossover column similarly identified areas in which STN represented median crossover with a link, while WISLR did not. The wayside flag identified roadside areas that were represented in STN with links, but were not represented in WISLR. The flag columns were created to manage discrepancies such that every point along a STN link was able to translate to some point along a WISLR link.

Although not previously considered, rules must be determined to similarly move data sets in the opposite direction, from WISLR to STN. 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 (10).

In earlier research regarding moving data from the high resolution system, STN, to the low resolution system, WISLR, it was found that a methodology could be successfully implemented between the two systems while each system continued regular independent functions. This methodology was refined with quality assurance and quality control measures that allowed full crash data sharing from the STN to WISLR systems. This research seeks 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 STN to WISLR was successfully accomplished through earlier phases of related research with the link-link table, the approach to translate data from WISLR to STN was most practically accomplished by using the link-link table. As was the case for STN to WISLR translation, the link-link table's ability 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 can be seen 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 travel in an opposite direction. The link-link table relates a segment of a STN link to the corresponding WISLR links as shown in Figures 3 (c) and (d). The length relationships defined in the link-link table provide a means for moving a point from STN to 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 the equivalent location in 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 WISLR (e.g. $80/100 \times 581 = 464.799$).

A "point moving" program was developed to calculate WISLR link and offset given a 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 WISLR to determine if a correct relational coding had been accomplished. From the points generated on each system's line work, it was possible to generate "XY Lines" to visually check the spatial relationship between 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).

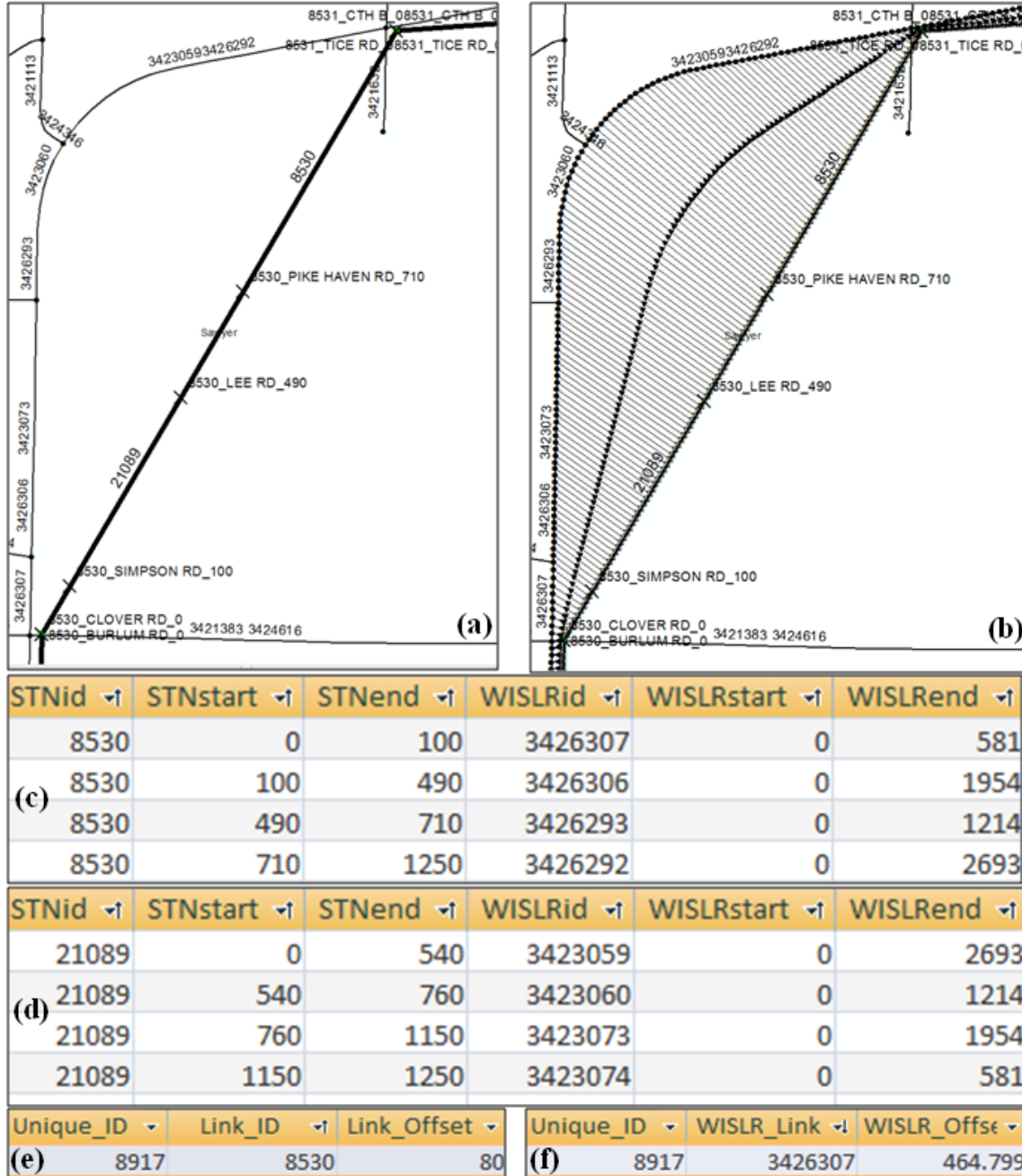


FIGURE 3 Example of "XY Lines" QA/QC procedure: (a) basic section of roadway with STN (straight thick lines), WISLR (curved thin lines); (b) "XY Lines" connecting data points starting in STN and moving to WISLR; (c) link-link records for STN link 8530; (d) link-link records for STN link 21089; (e) example data for a "STN Point" with unique

identifier, STN link number, and offset; (f) example data for a “WISLR Point” with unique identifier, WISLR link number, and offset.**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 identifier, a WISLR link ID, and a WISLR offset. From this 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 identifier, a STN link ID, and a STN offset.

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

Although moving points from WISLR to STN was successful, due to resolution issues some RP points landed at multiple ambiguous locations when moved back to STN. To find these points that mapped to multiple locations, the moved points were summarized within ArcMap based on the unique identifiers. This process produced a count for each point; a count greater than one indicated that the point from WISLR moved to multiple locations in STN. There were three common ambiguous point placement problems identified in this research. The problems were due to (1) median crossovers, (2) turn-lanes, and (3) waysides. These problems are discussed in the following subsections.

Problem 1: Intersection/Median Crossover Ambiguous Point Translation

The first common issue causing ambiguous data point placement occurs because of incongruent intersection representations between STN and WISLR. This can be seen with an example intersection illustrated in Figure 4 **Error! Reference source not found.**. This example shows the intersection of two divided highways. As can be seen in Figure 4, STN represents the intersection with four thick links and four nodes, while 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 WISLR, in accordance with the link-link relationship. However, when moving points 1 through 4 back from WISLR to STN, shown in Figure 4 (b), each point lands at the end of each STN link because the link-link table only stores the relationship that the single node in WISLR represents all the intersection information in STN. This point placement pattern does not represent the original location for the moved data points; therefore, location ambiguity was introduced into the process.

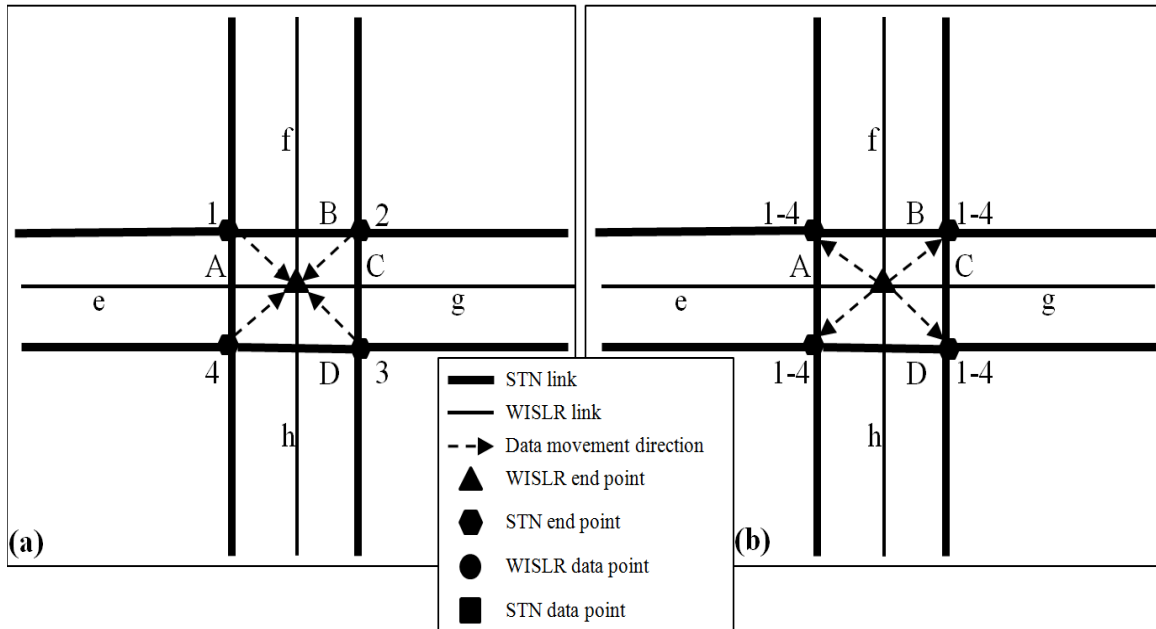


FIGURE 4 General example of ambiguous point placement due to incongruent intersection/median crossover representations: (a) accurately moving data from a high resolution intersection represented by four links and four nodes (STN) to a low resolution intersection represented by a single node (WISLR);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

Problem 2: Turn Lane Ambiguous Point Translation

The second common problem occurs at many state route intersections that include roadway entrance or exit ramps and other similarly designed intersections. This problem primarily involves resolution differences between STN and WISLR at intersections with turn lanes. This issue can be seen in the example in Figure 5 **Error! Reference source not found.** Illustrated in Figure 5 is an intersection where STN accounts for turn lanes with physically separated links, straight thick black lines, while WISLR represents the intersection with a single curved thin link and single triangular node. Link C in STN represents a right turn lane while link B represents a straight or left turn lane. In Figure 5 (a), data points 1 and 2 move correctly from high resolution STN to the low resolution intersection point represented in WISLR. However, when points 1 and 2 are moved back from the low resolution WISLR system to the high resolution STN system in Figure 5 (b), points 1 and 2 both move to two locations because the system cannot distinguish between locations in STN. Additionally, point C represents an event on STN occurring on link B. In Figure 5 (a) point 3 moved to WISLR correctly, but in Figure 5 (b) point 3 moves back to two ambiguous locations in 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.

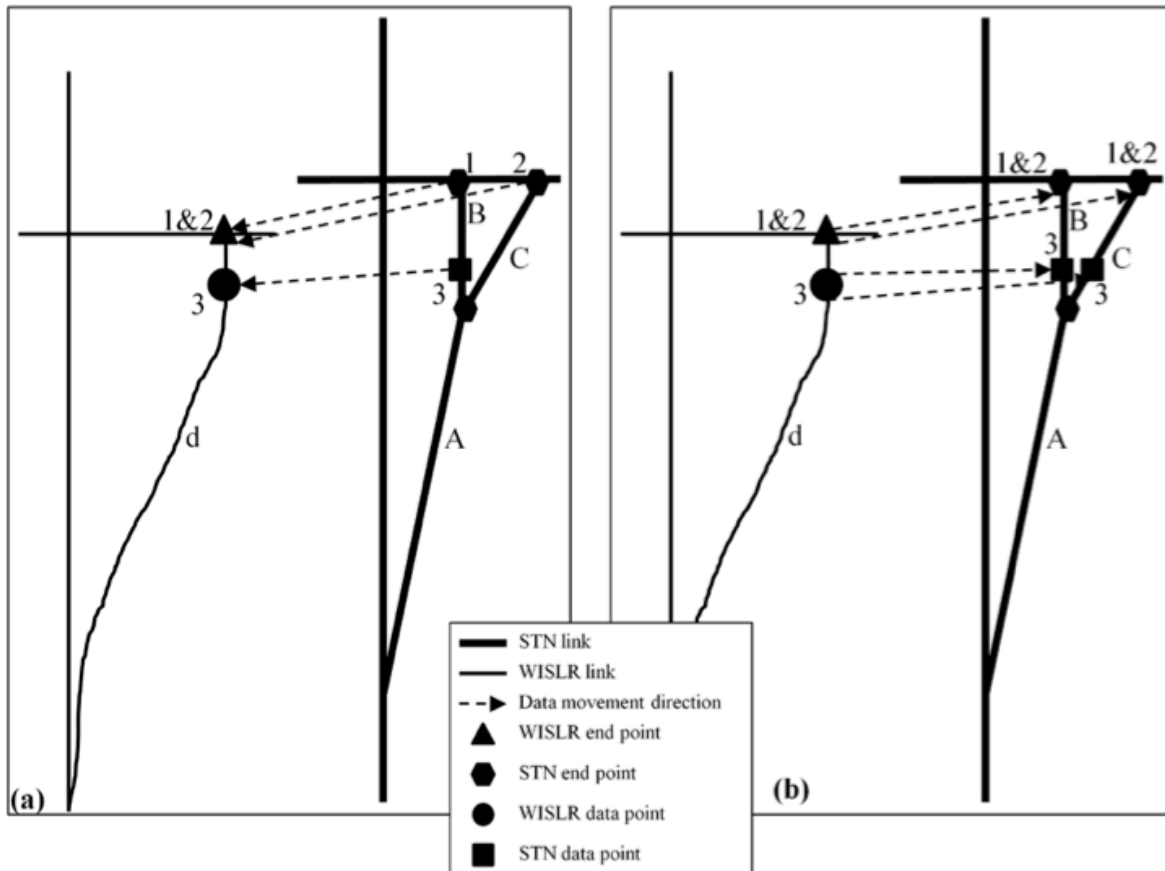


FIGURE 5 General example of ambiguous point placement due to incongruent turn lane representations: (a) accurately moving data from a high resolution intersection with two turn lane links and three nodes (STN) to a low resolution intersection represented with a single link and node (WISLR); (b) moving 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.

Problem 3: Wayside Ambiguous Point Translation

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 where STN represents waysides with thick links and nodes, and WISLR does not represent waysides. In Figure 6 General example of ambiguous point placement due to a wayside: (a) (a) data points 1 through 8 in STN are translated to a single point on 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 mainline link is chosen to represent the location of the wayside. When this single point on WISLR is translated back to STN in 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 mainline. Although it is not desirable that one location in WISLR moves to multiple locations in STN, due to resolution differences, location accuracy is compromised when moving from low to high resolution.

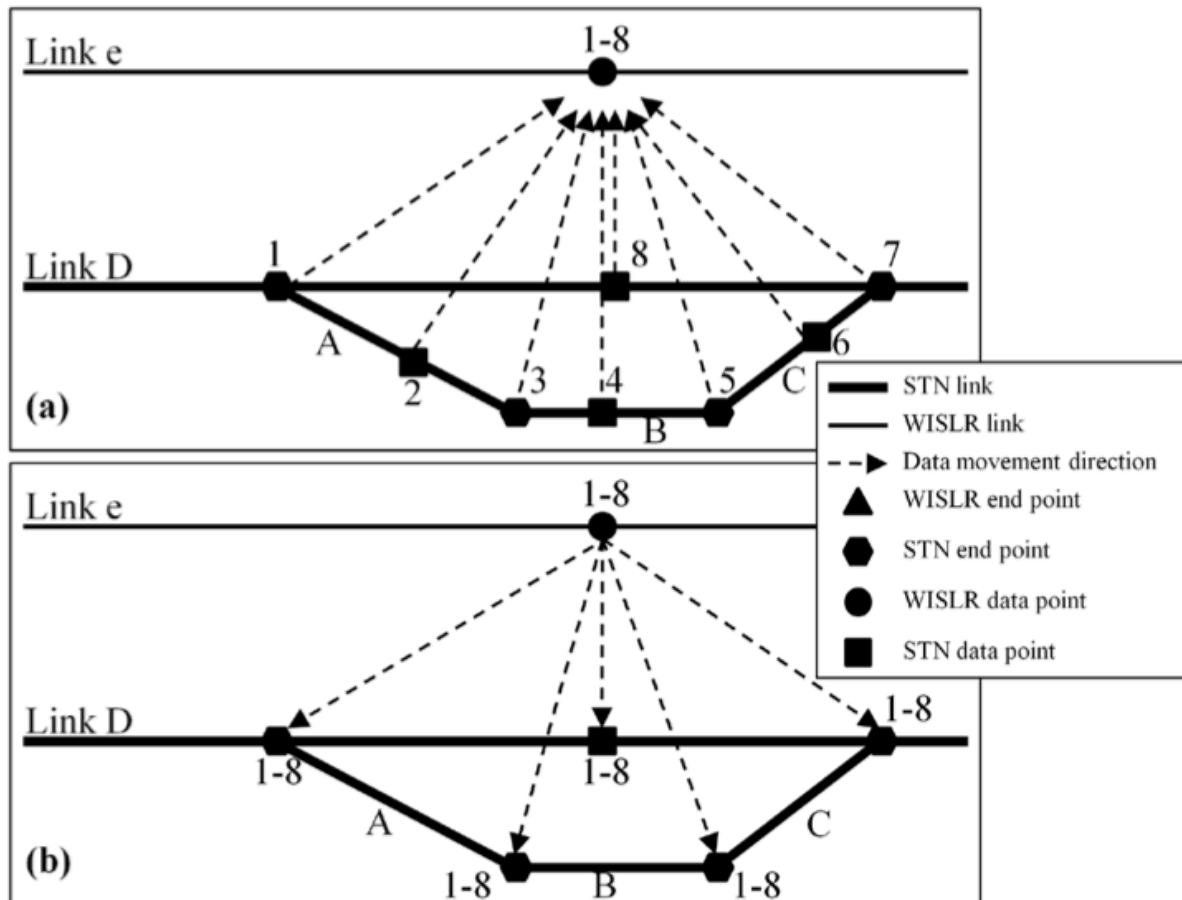


FIGURE 6 General example of ambiguous point placement due to a wayside: (a) moving data from a high resolution wayside represented by multiple links and nodes (STN) to a low resolution representation without the wayside (WISLR); (b) moving data from low to high resolution produces location ambiguity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

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

Proposed Data Translation Rules

An absolute technique to eliminate ambiguities between the WISLR and STN systems, or between any two linear referencing systems 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 linear referencing systems, it is necessary to address common resolution differences. To accomplish this, rules were established that are associated with not only linking linear referencing systems with different resolution levels, but also associated with how data is coded in the lower resolution system before the data is 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 **Error! Reference source not found.**, if a crash record denoted whether the crash occurred on the straight or right turn lane, then an automatic routine could be coded to accurately place the crash in both high and low resolution systems. If this information is recorded on the front end of the data collection process, there is less ambiguity associated with a location. While this rule would be useful for data translation, far-reaching changes would have to be made to crash reporting methods and forms requiring extensive time and effort.

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

Median Crossover Rules

The second set of potential rules is associated with ambiguous data translation due to resolution differences at median crossovers. As shown in Figure 4 (b), this problem causes points from WISLR (lower resolution) to move to multiple locations in STN (higher resolution). To reduce ambiguous event data placement at median crossovers, two rules can be implemented. The first median crossover rule would place each data point associated with a median-crossover-flagged-STN link at the center of the median crossing instead of the ends of the link. This rule would reduce the number of possible locations from the two endpoints of a link to the single mid-point of the median crossover link. The second median crossover rule would ignore records in the link-link table associated with median crossovers when moving data from WISLR to STN. A report would then be generated with all of the data associated with a median crossover records for future manual placement.

Turn Lane Rules

Four rules could be similarly applied to turn lanes. One rule for turn lanes could be implemented by simply mapping all crashes that would have mapped to two turn lane links to a single link. The single link to which a point would be placed would be arbitrarily determined from which data-associated STN turn lane was first processed by the computer program. The second rule could similarly implement single-link data placement. However in this rule, the longest turn lane link would be used for data placement. A third rule would cause the point moving program to ignore all turn-lane associated data and generate a report showing these data points. Finally, an additional table could be included 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. One option would place data points at all possible locations, basically not changing current data translation methods. The second option would 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. The third option would create a report with all of the data points that would have moved to a wayside-denoted STN link while not actually translating the data. Finally, an additional table could be created 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

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

To test the general effectiveness of implementing 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 moved from an originally coded STN link and offset to a corresponding WISLR link and offset. When these crashes were moved back to STN, all of the original crash locations in STN received the appropriate crashes, but additional ambiguous locations were also produced. The total number of crash locations in STN after moving the data back from WISLR was 17,919. The one-to-many relationship in the link-link table caused 647 (4%) crashes 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 a STN link and offset; only 301 (2%) crashes mapped to multiple STN links. Additionally, all 17,170 original crashes mapped, thus no crash data was lost by excluding median crossover links.

The second data set used for analysis was hundredth-of-a-mile points in Dane County. Points are placed on STN links every hundredth of a mile, the points are moved to WISLR and visually inspected, and then moved back to STN and the initial location and final location are compared. There are 86,178 hundredth-of-a-mile points in Dane County along STN links. All of the points moved from STN to WISLR. When moving the points back to STN, 88,318 points moved, representing 1433 points (1.7%) that moved to multiple links. Of these 1433 points, 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, 87,958 points moved back to STN, representing 1149 points (1.3%) that moved to multiple links. Additionally, all 86,178 hundredth-of-a-mile points mapped to a location on STN; no data was lost with the implementation of this rule.

An extensive analysis was done on the third and final data set: WisDOT's RP database. This was chosen for extensive analysis because of its existence as a statewide database that is 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 WISLR. This value consists of all but one current RPs and 3500 historic RPs. The

historic RPs were not expected to all move to WISLR because some are located on historic STN links that are not included in the link-link table. When the initial data translation was performed, 44,123 point moved back to STN. All of the RP points on WISLR moved successfully back to STN, however 4355 (12%) moved to multiple links. Of these points, 1623 (32%) are associated with link-link records that are flagged as median crossovers, 1150 (26%) are associated with turn lanes, and 209 (5%) are associated with waysides. Additionally, of the 4355 points that mapped multiple times, 2560 (59%) moved to single unique locations multiple times. These 2560 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 problem categories that were previously identified. After the median crossover rule was implemented, 2102 (6%) RPs moved to multiple links. Again, no RP data was 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% without losing any data. While only the median crossover rule was implemented in this analysis, it can be reasonably 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 linear referencing systems having different levels of resolution requires systematic rules, additional data capture detail, and/or manual intervention to accurately move data from low resolution to high resolution. In the case of WisDOT's statewide crash mapping business needs, creating accurate detailed crash location records from lower resolution in-field maps required identifying all crash records at locations with ambiguous location data in the high resolution system. These records are manually reviewed to determine the appropriate high-resolution location of the crash. Evaluating past crash records indicate that between 2005 and 2009 approximately 4% of the crash records would need manual intervention to eliminate duplicate locations. It is anticipated that Wisconsin will see a large time savings in state route crash locating given that in the past 100% of the crashes on state routes were manually located, and now only ambiguous locations (~4%) will need to be manually located.

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