A Logical Model for the State of Iowa Department of Transportation's Linear Referencing System

Technical Document

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Prepared by

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I. OVERVIEW

The purpose of this document is to provide the detailed model requirements of the Logical Design Phase for the Iowa DOT Linear Referencing System (LRS). This technical document focuses exclusively on the LRS data and process models. A summary document also exists, written for non-technical business staff. It contains an overview of the LRS requirements by LRS subsystem (subsystems are explained in the next section of this document). LRS organizational and technology requirements are also found in the summary document.

Section II of this document provides background on the logical design model scope and design methodology. The next three sections document the resulting data model. Section III provides background on the data model syntax used in this document. Section IV provides the entity relationship diagrams (ERDs) of the LRS, by LRS subsystem. Section V provides the entity and attribute definitions.

Following the data model sections are two sections, VI and VII, documenting the process model. The first section contains the LRS process model, followed by a section that defines the model functions and processes.

The last two sections, VII and IX, of this document are interaction models. The first section contains the data and process interaction model (CRUD matrix). The last section provides a LRS subsystem and process interaction model.

It is important to note that this technical document is a "living" or dynamic document, with potential changes and comments added throughout the remaining project phases. Therefore, it is critical for the reader to possess the most current document version.

II. LOGICAL DESIGN APPROACH

During the Needs Assessment phase, requirements were gathered from existing documentation, requirements-gathering workshops and interviews. The Logical Design Team continued the requirements gathering in workshops that focused on each LRS subsystem. These workshops included staff that maintained LRS-like data as well as those who used the data. There were several iterations of workshop sessions.

The Logical Design Team then used an information engineering approach for requirements analysis and design. This approach allowed the Team to perform data life-cycle analysis that resulted in data, process, and data-process interaction models. The Team was required to use an industry template, NCHRP 20-27(2) as the basis for the logical data and process models.

For the operational architecture requirements, the Logical Design Team used the NCHRP 20-27(2) conceptual model as a base for the logical model. Figure 1 illustrates this conceptual model. The Logical Design Team detailed the requirements by subsystem, as outlined in the Conceptual Design. Figure 2 illustrates the different subsystems. Each subsystem, beginning with the Linear Datum, was designed based on the requirements analysis outlined above. Each data model per subsystem was designed followed by the process models. This report documents the end results of the operational modeling as well as documenting any issues or ambiguities that remain.

GDW requirements were compiled initially from the Needs Assessment, and then validated and detailed in the workshop sessions. Figure 3 provides an overview of the GDW workflow. The final set of interviews focused primarily on how users saw themselves interacting with the LRS components in the GeoData Warehouse (GDW) environment. The GDW requirements present in this document are data model requirements supporting the need to transform between LRS subsystems, and the need to post (stage) LRS data into the GDW for use (the “publish” elementary process found throughout the process model).

The requirements gathering and analysis resulted in changes in some of the subsystems interfaces with each other. Figure 4 illustrates these changes. The Milepoint Subsystem is now part of the Route Management Subsystem. The Segmental, Stationing, and the Coordinate Route Subsystems directly link to the Datum Management Subsystem.

Figure 1: Iowa Conceptual Design - A Modified 20-27(2) Model

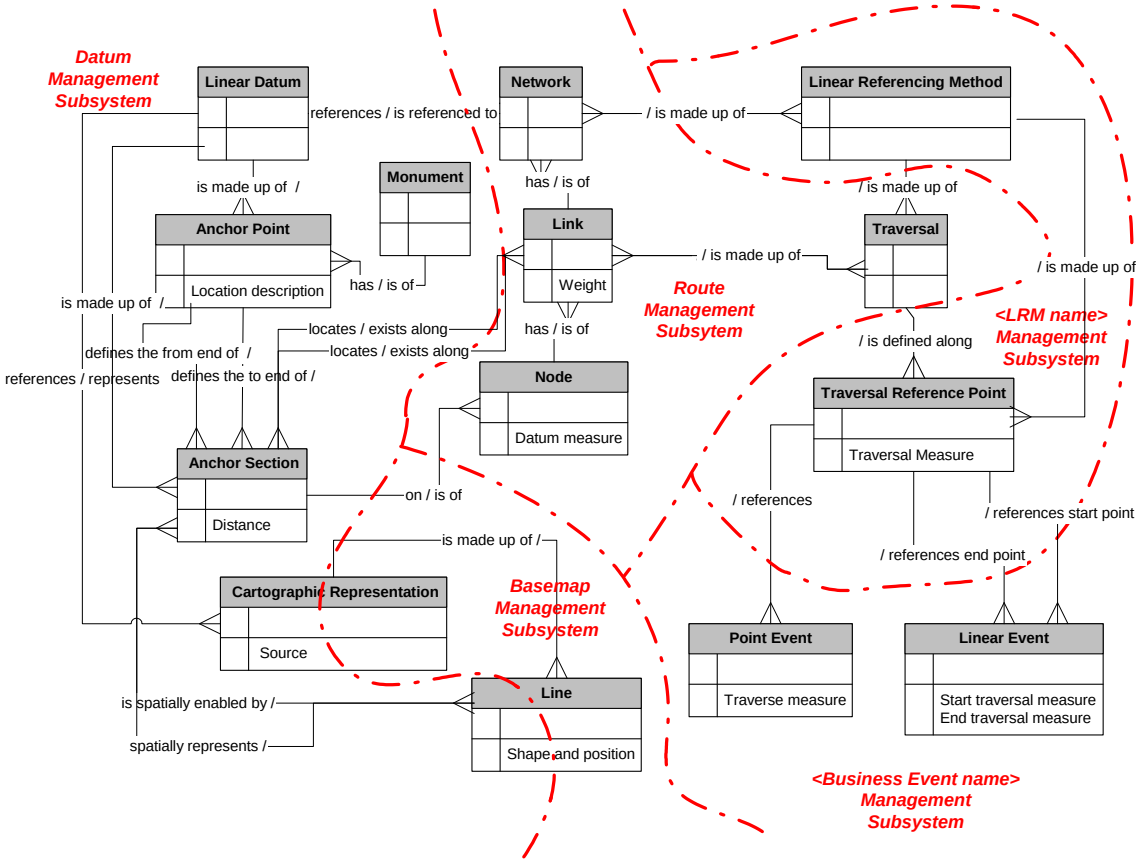

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Figure 2: LRS Operational Architecture

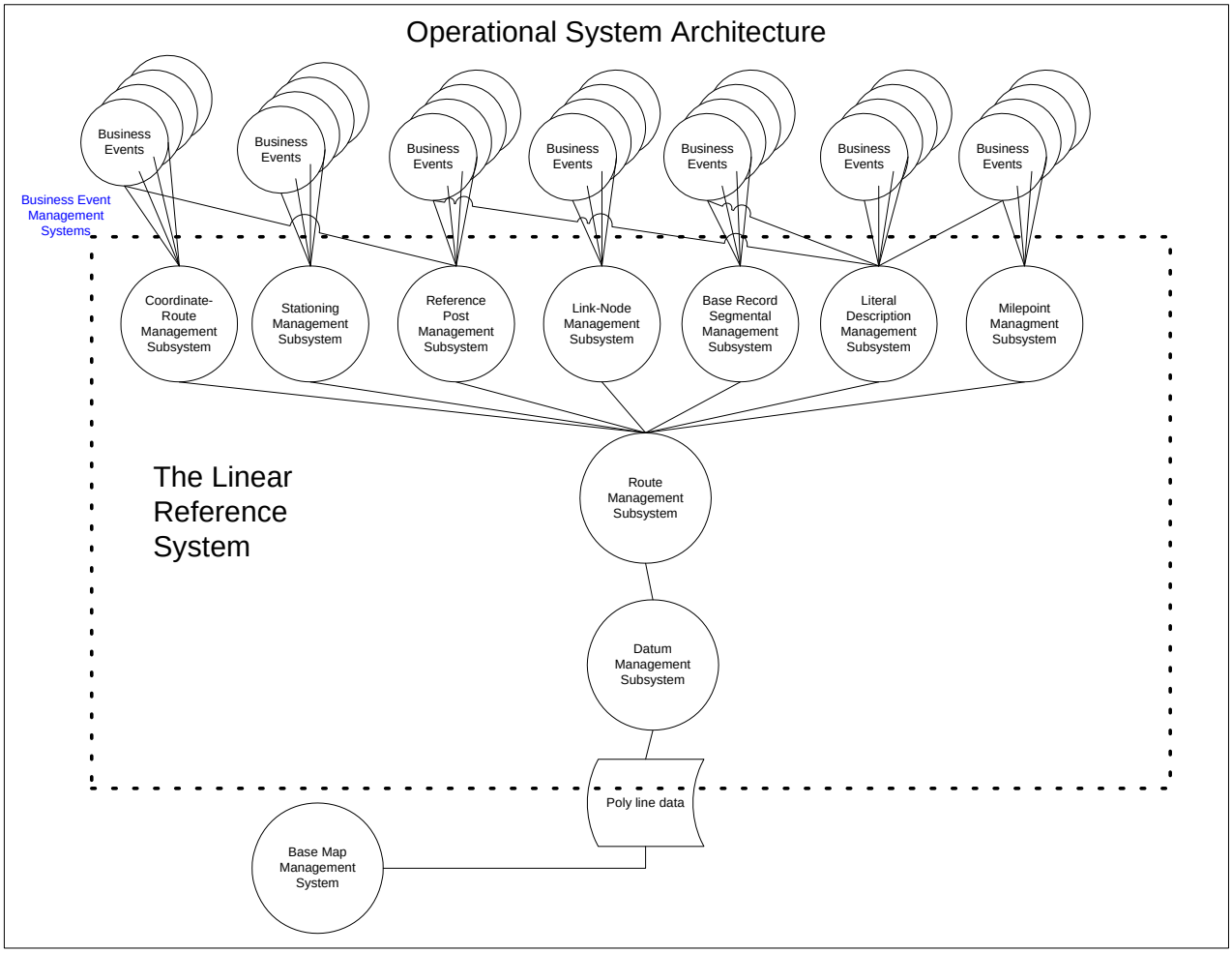


Figure 3: Iowa DOT GeoData Warehouse Architecture

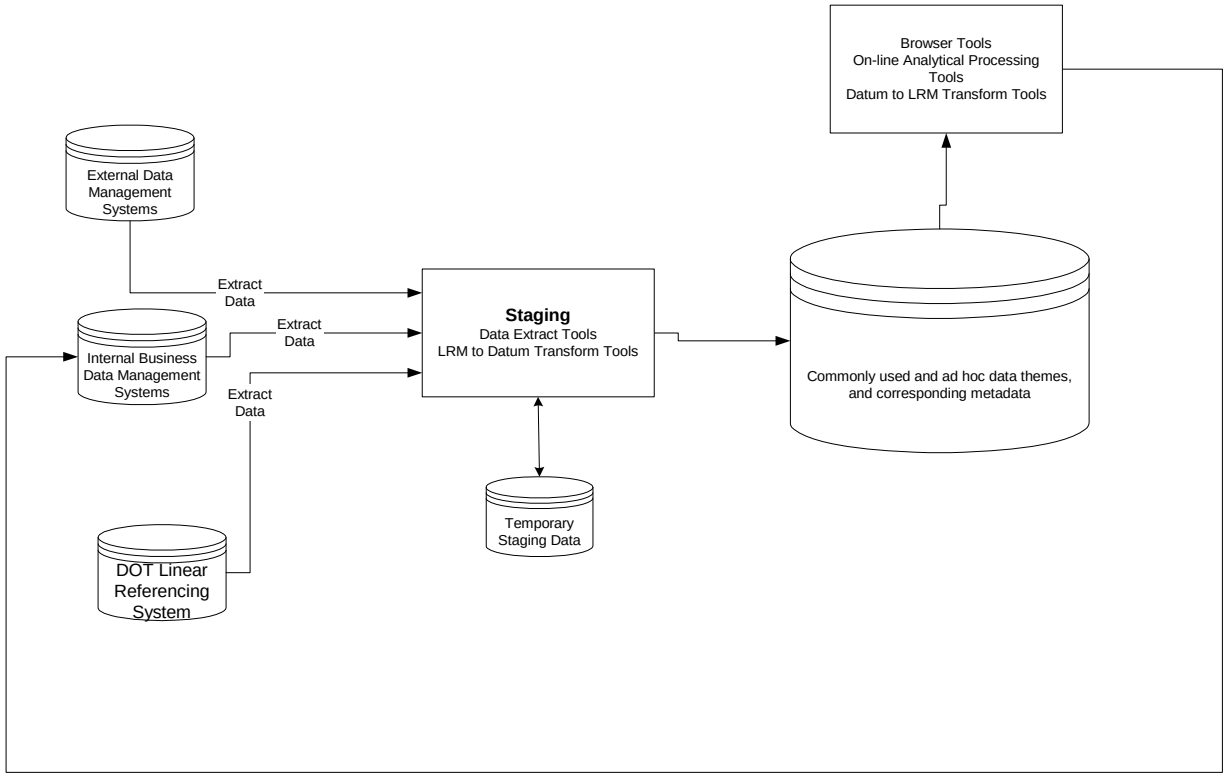
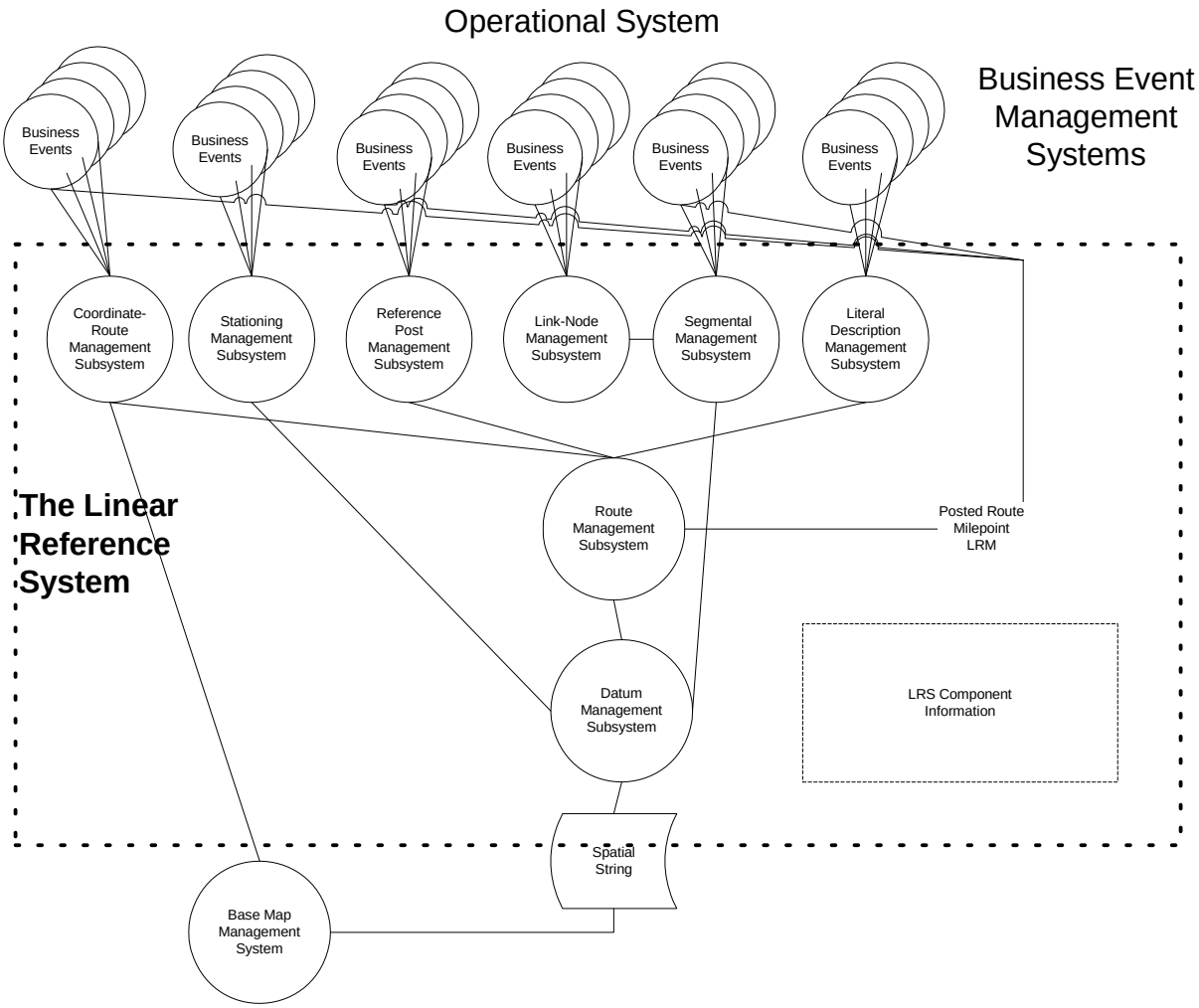


Figure 4: Logical Design Operational Model



III. Data Model Diagram Concepts and Definitions

The LRS data requirements are captured as entity relationship diagrams (ERD). The syntax used to capture these requirements is described. The ERD illustrates three components of a relational data model: Entity Types, Relationships, and Cardinality. All three contribute to documenting data requirements.

a. Entity Types

A data entity represents any object about which the organization chooses to collect data. Attributes are additional information about the entity. Entities and their attributes are defined in a data dictionary. Data entities are shown in boxes on the entity relationship diagram where the entity's name is shown in a shaded portion of the box and their attributes are listed below the entity name.

b. Relationships

Relationships describe how the data entities are related to each other. The relationships in this logical data model are one-to-one, one-to-many, and many-to-many. In the case of the many-to-many associations they have been modified slightly to indicate that the relationship is two-to-many. This is used in the spatial entities to show beginning and ending points.

A one-to-one relationship (1:1) means that, at a point in time, a given value of A has one and only one value of B. For example, one person has one social security number. The person and their social security number are a one-to-one relationship. Most one-to-one relationships are described as a unique attribute of an entity, but in this Logical Model they are to show connectivity to other systems.

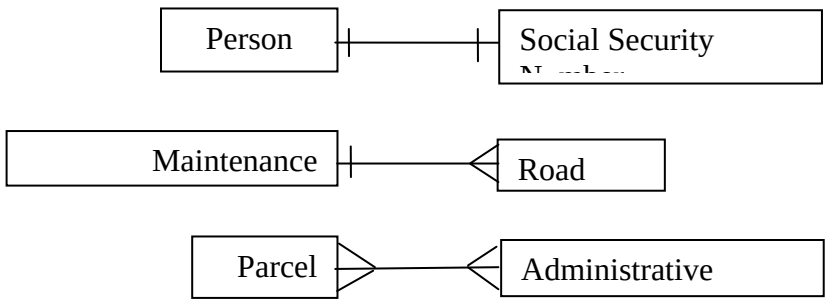
A one-to-many relationship (1:m) means that, at a point in time, item A could have an arbitrary number of items C associated with it. For example, a maintenance jurisdiction has many roads within it and each road (as defined for the example) has one maintenance jurisdiction. In this case the maintenance jurisdiction has a one-to-many relationship with the roads contained within it.

Many-to-many relationships (m:m) occur when, at a point in time, a given value is associated with many other values and the converse is also true. For example, one parcel can be located in many administrative districts such as fire, police, school, and emergency response. Conversely, one administrative district is composed of many parcels. Many to many relationships are logical,

but are not modeled unless there is an intersection table to correlate the various relationships between the entity types.

Figure 5 illustrates the three relationships described above. The "crows foot" symbol indicates many and the single line indicates one.

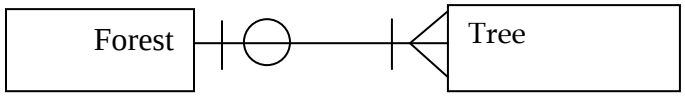
Figure 5: Entity Relationships



c. Cardinality

Cardinality in the context of this document means whether the relationship between the two entities is mandatory or optional. For example, a forest must have more than one tree, but a tree may be in a forest. Cardinality is the must and may. *The cardinality aspects of the data model are shown as a circle for optional and a line for mandatory.* The relationship between a forest and a tree with the cardinality is shown in Figure 6, below.

Figure 6: Entity Types, Relationships, and Cardinality

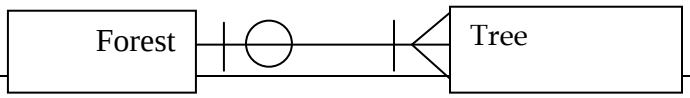


In Figure A3 a line has been added to the many symbol and a circle has been added to the single symbol. The associations and their cardinality are read in a clockwise manner, which means the associations in Figure A3 are read as shown in Figure 7.

Figure 7: Reading Entity Types, Relationships, and Cardinality

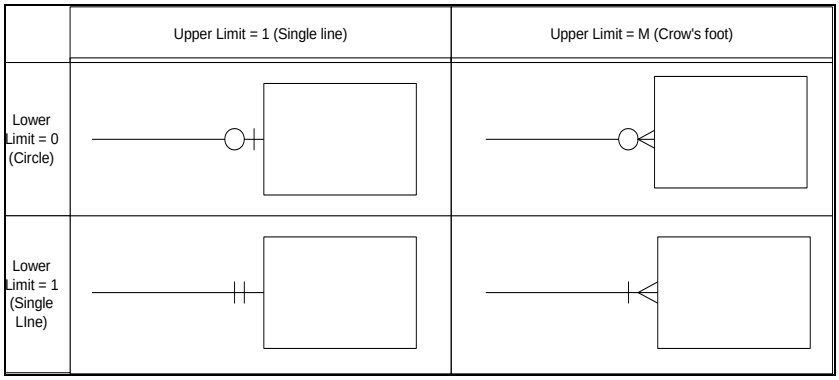
One tree may be within a forest.

One forest must contain many trees



In our Logical Design ERDs, the James Martin Cardinality and Optionality symbology is used. It is very similar to those described above except that two lines, not one, illustrate one and only one relationship. The diagram below (Figure 8) illustrates the James Martin method.

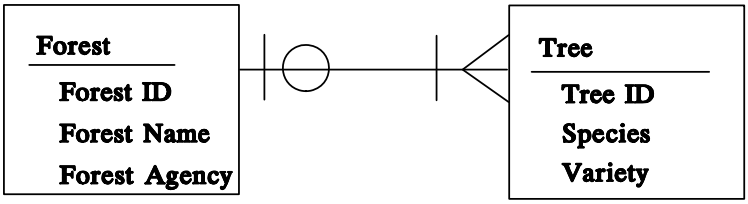
Figure 8: James Martin Data Model Syntax



d. Attributes

Attributes are the properties and characteristics of entities. These are listed in the box with the entity name. In many entities the first attribute has a name that ends with an ID, such as Forest ID. This is an attribute that serves as an identifier for each unique record or entry in the entity and is called a *primary key*. An example of a completed model with the attributes is shown in Figure 9.

Figure 9: Completed Data Model for Tree and Forest



Another kind of key attribute is a *foreign key*. A foreign key is a primary key from another entity that points to a record in the related entity. For example, Forest Name could be a foreign key that links the Forest entity to a master database of forest names.

Finally, certain attributes are highlighted (***bolded and italicized***) to indicate they are derived attributes. Database programs and triggers automatically massage or combine values from other database attributes to populate the derived attribute. Fully normalized logical designs do not include derived items. However, the data models in this document do include derived attributes to emphasize why certain entity relationships are needed and to illustrate that Iowa DOT staff do not need to manually update these attributes.

IV. LOGICAL DATA MODEL DIAGRAMS

The Logical Data Model of the LRS should be thought of as one data model. However, for the reporting purposes, the LRS data requirements are decomposed into ERDs by the LRS subsystems. The diagrams repeat certain entities to provide the subsystem context to the overall data model. The subsystems are presented in the following order: Datum, Route, Reference Post, Coordinate Route, Segmental Referencing, Stationing, Literal Description, and LRS Component Information. A single ERD data model diagram is available upon request.

Figure 10: Datum Management Subsystem Entities

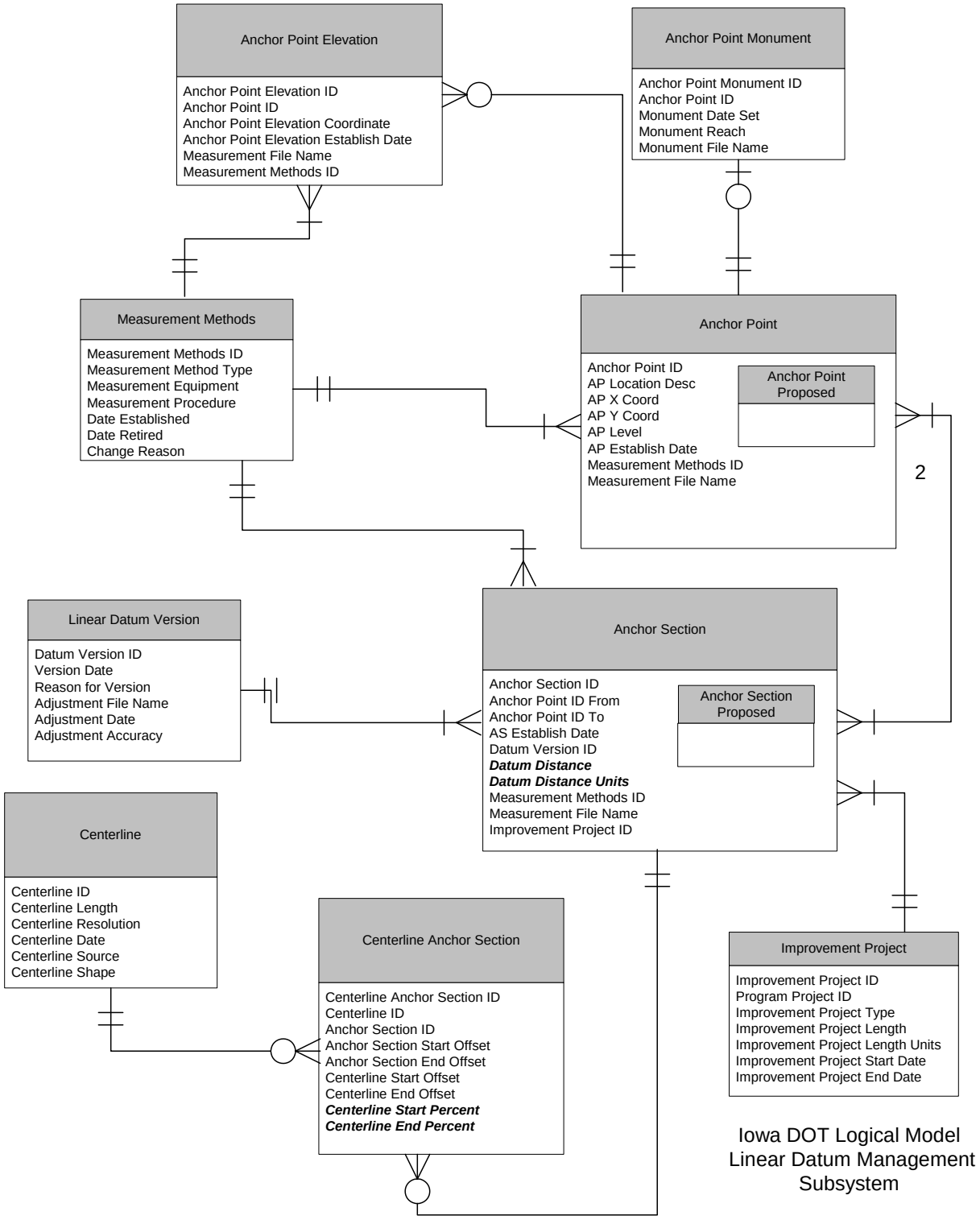


Figure 11: Route Management Subsystem Entities

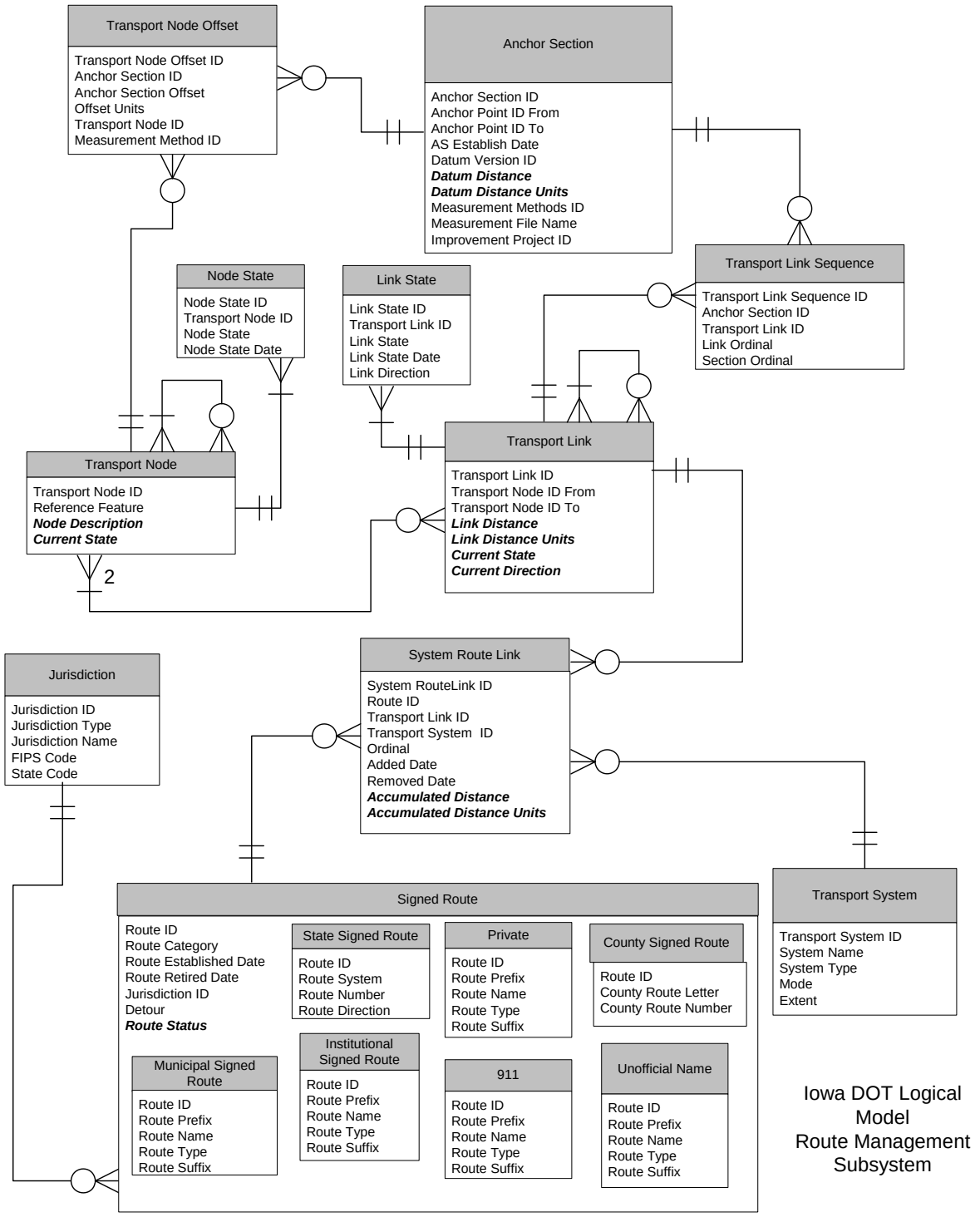


Figure 12: Reference Post Management Subsystem Entities

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Figure 13: Coordinate Route Subsystem Entities

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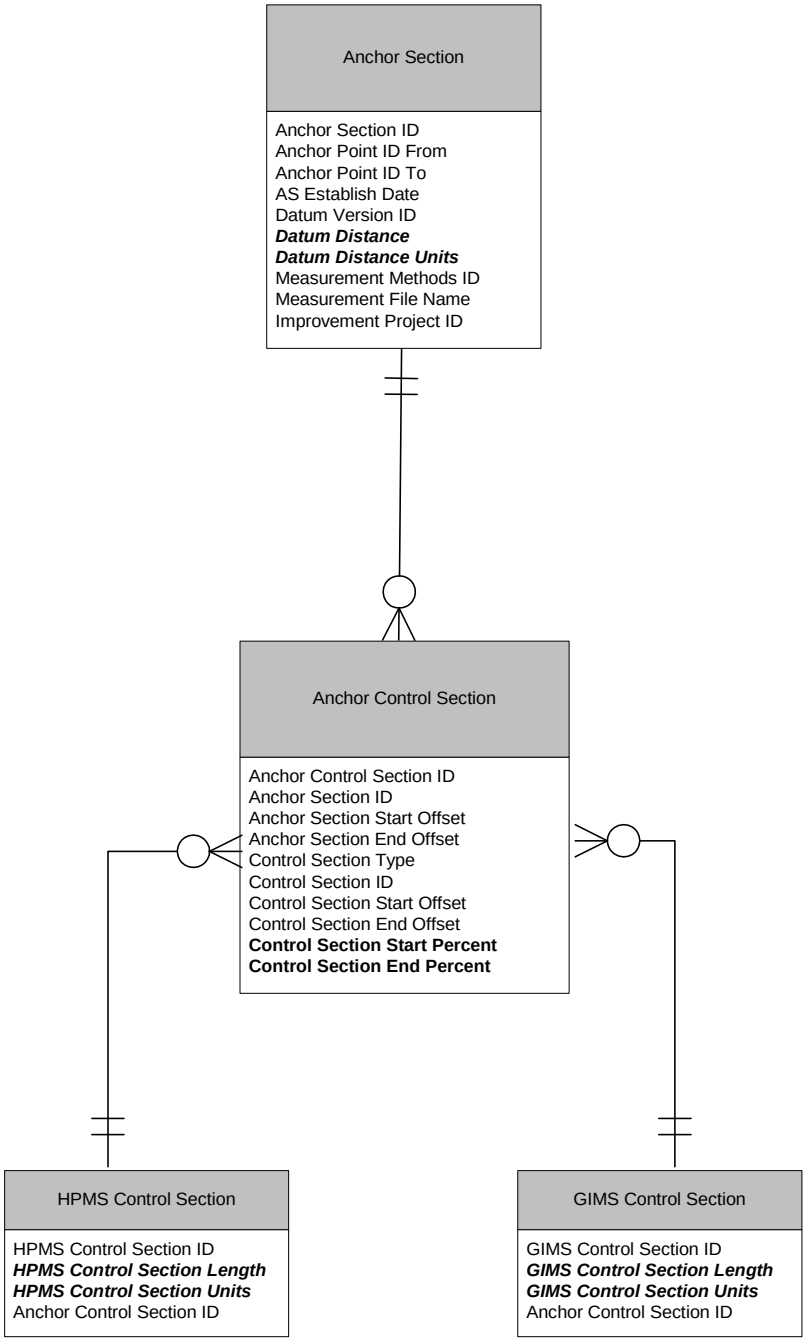
Figure 14: Segmental Management Subsystem Entities



Iowa DOT Logical Model
Segmental Managment
Subsystem

Figure 15: Stationing Management Subsystem Entities

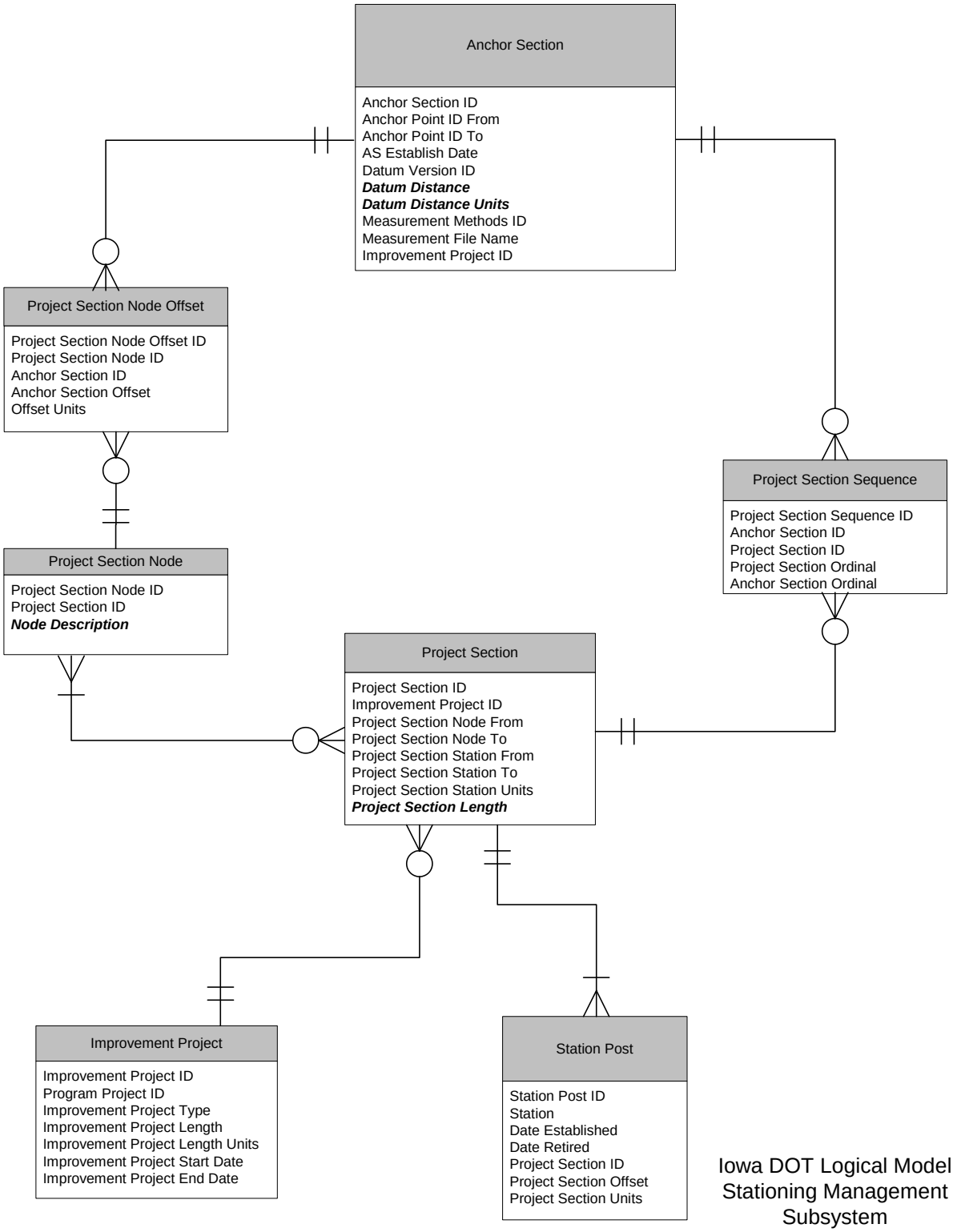


Figure 16: Literal Description Management Subsystem Entities

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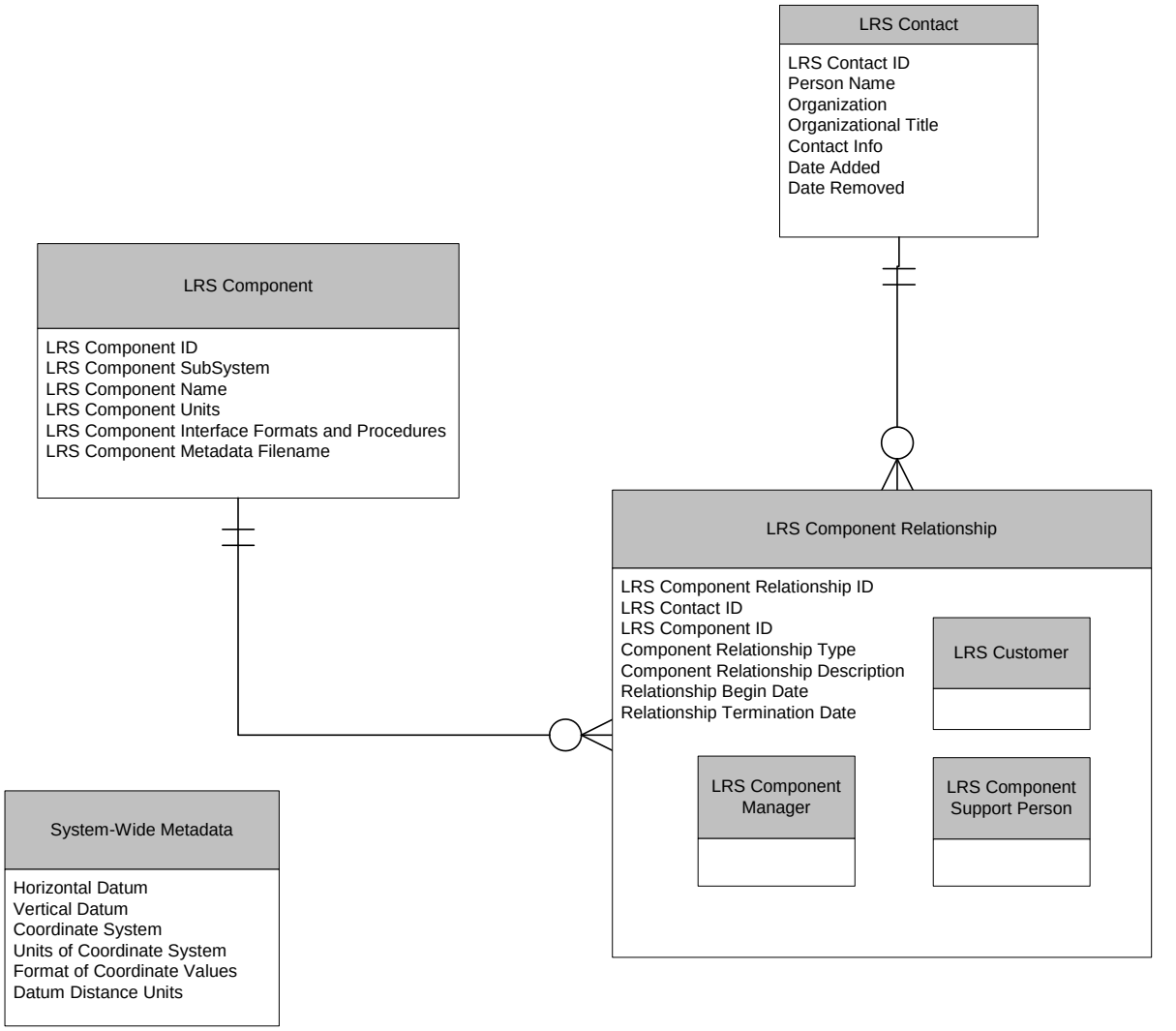
Figure 17: LRS Component Entities



EXTERNAL INFORMATION SOURCE
DOT Policies and Procedures

Iowa DOT Logical Model
LRS Component Information

V. LOGICAL DATA MODEL ENTITIES AND THEIR ATTRIBUTES

The entity and attributes descriptions are provided. Entities are presented in alphabetic order. For each entity, a definition, business rules, and remaining issues are included. For each attribute, a definition is provided. Enumerated lists of values for attributes are provided when necessary. Any issues remaining for attributes are also included.

911

Definition:

A sub entity of the signed route entity that contains the information for the E911 signed route-naming system.

Business Rules:

Attributes:

Route ID
Definition: Foreign key to relate to entity type Signed Route.

Jurisdiction ID
Definition: Foreign key to relate to the jurisdiction that establishes the route (assigned establish and retired dates) .

Route Prefix
Definition: (optional) Enumerated list of acceptable street name prefixes (North, South, East, West, etc)

Route Name
Definition: Enumerated list of acceptable street names (Maple, 1st, Grant, Main, etc)

Route Type
Definition: (optional) Enumerated list of acceptable street types (Avenue, Street, Boulevard, etc)

Route Suffix
Definition: (optional) Enumerated list of acceptable street suffixes (NW, EW, etc)

Anchor Point

Definition:

"...a zero-dimensional location that can be uniquely identified in the real world in such a way that its position can be determined and recovered in the field. Each anchor point has a 'location description' attribute..." [1]

Business rules:

- Occupies zero dimensional space.
- Is a point which may terminate more than one Anchor Section
- Must have a description that allows the location of an anchor point to be identified in the field.
- Anchor Points do not retire and are not deleted based on real world changes. The condition of a Transport System at a point in time or over time is dependent on the "state" or "existence" of the key object for which the time analysis is based. That is, the "birth" or death of an object depends on the application, not when the Point was defined. For example, the following are all valid "births" of a roadway: exists in the improvement program, roadway can be driven upon (during construction), officially open-to-traffic (ribbon-cutting), etc.
- Horizontal coordinates are used to recover and / or re-establish anchor points in the field. Error in this recovery and/ or re-establishment process affect anchor section distances.

Attributes:

Anchor Point ID
Definition: Primary key that is a unique arbitrary for each record in the entity.

Anchor Point Location Desc
Definition: Provides the information necessary for determining and recovering the anchor point's position in the field. The information is either quantitative or descriptive locators or both.

Anchor Point (AP) X COORD
Definition: This is the X Coordinate value or easting for a coordinate set[2]. This may be measured in latitude coordinates, for example.

Anchor Point (AP) Y COORD
Definition: This is the Y coordinate value or northing for a coordinate set[1]. This may be measured in longitude coordinates, for example.

Anchor Point (AP) Level

[1] NCHRP Linear Referencing System Data Model
[2] Cadastral Data Content Standard for the National Spatial Data Infrastructure, Federal Geographic Data Committee, December 1996

Definition: Designation for upper, lower, middle location for anchor points in order to accommodate for overpasses. This is an optional attribute.

Anchor Point (AP) Establish Date
Definition: The date the Anchor Point is established in the field.

Measurement File Name (external files)
Definition: A text file to point to an external file or database that contains the originally collected information.

Measurement Methods ID
Definition: Foreign key relating to the Measurement Methods entity type.

Anchor Point Elevation

Definition:

The absolute elevation (Z values) of the anchor point.

The elevation value is separate because its purpose is more long term and is less defined than an anchor point's X,Y coordinate values. Its value will change frequently in the next few years as improved accuracies are acquired.

Business Rules:

- The business purpose determined for this entity is to know where on which roadway and object or incident occurs when two or more roadways occupy the same planar location but at different elevations (like bridges and ramps).
- No Z can exist without an X, Y coordinate from the anchor point.

Attributes:

Anchor Point Elevation ID
Definition: Primary key that is a unique arbitrary value for each record in the entity.

Anchor Point ID
Definition: Foreign Key that links monument to the anchor point.

Anchor Point Elevation Coordinate
Definition: The actual Z value in geodetic measurements.

Anchor Point Elevation Establish Date
Definition: The date when the elevation was measured (if it was processed, the date it was processed).

Measurement File Name
Definition: A text file to point to an external file or database that contains the originally collected information.

Measurement Methods ID
Definition: Foreign key to relate to the Measurement Methods entity type.

Anchor Point Monument

Definition:

"A zero-dimensional location that can be uniquely identified in the real world in such a way that its position can be determined and recovered in the field". [3]

Business Rules:

- Optional data collection.
- No monument can exist without an Anchor Point.

Issues:

- What are the standards to which monuments must adhere? (like the need to have geodetic standards).
- For those anchor points collected on ramps, would they be a witness point or an actual anchor point?

Attributes:

Anchor Point Monument ID
Definition: Primary key that is a unique arbitrary for each record in the entity.

Anchor Point ID
Definition: Foreign Key that links monument to the anchor point.

Monument Date Set
Definition: Date (mo/day/yr) monument was set.

Monument Reach
Definition: Text field that describes how to find the anchor point monument in the field, what it looks like. (Should leverage the specifications of the National Geodetic Survey Reach Field?).

Monument File Name
Definition: Link to external file containing specifications of monument collection of data.

[3] Minnesota Department of Transportation, Linear Location Data Model, December, 1998.

Anchor Point Proposed

Definition:

This is a subtype of the Anchor Point. It is created during an improvement project, generally from a station post placement.

An anchor point that defines the terminus of an anchor section for which the datum distance is estimated and not calculated using accepted datum methodologies and technologies. The section typically represents transportation features that are conceptual and coarse in definition, typically defined during strategic planning and program management.

Business Rules:

- A proposed anchor point has a transferable relationship with an anchor point – that is, all relationships that the proposed anchor point has with other entities are transferred to an anchor point when an anchor point is defined.

Attributes:

No new attributes.

Anchor Control Section

Definition:

An entity type used to describe the common relationship of the Control Section to the linear datum (via the Anchor Section).

Business Rules:

Attributes: (for a full description of attributes, see the Centerline Anchor Section entity).

Anchor Control Section ID
Definition: Primary key of a unique and arbitrary value.

Anchor Section ID
Definition: Foreign key to relate to entity type Anchor Section

Anchor Section Start Offset
Definition: A directional reference and measurement value to define where the anchor control section begins in reference to a particular anchor section ID.

Anchor Section End Offset
Definition: A directional reference and measurement value to define where the anchor control section ends in reference to a particular anchor section ID.

Control Section Type:
Definition: Field to indicate which control section is to be referenced (HPMS or Base Record)

Control Section ID
Definition: Foreign key to relate to other entity types such as HPMS Control Section or Base Record Control Section.

Control Section Start Offset
Definition: The start point of the chain on the anchor section, in anchor section units.

Control Section End Offset
Definition: The end point of the chain on the anchor section, in anchor section units.

Control Section Start Percent
Definition: DERIVED; - The normalized (%) form of Control Section Start Offset (unit-independent).

Control Section End Percent
Definition: DERIVED; - The normalized (%) form of Control Section End Offset (unit-independent).

Anchor Section

Definition:

A stable and elementary part of the transportation linear reference space. [4] "...a continuous, directed, non-branching linear feature, connecting two anchor points, whose real-world length can be measured in the field."[5]

Business Rules:

- Each Anchor Section must have at least two Anchor Points (from and to).
- Directionality of the section is implied with the anchor point from and anchor point to fields.
- Sections are intended to be unvarying once established as they are part of the first order linear control.
- Datum Distance values that are improved due to technology enhancements will not retire an anchor section but will be treated as an error correction.
- Anchor Sections do not retire and are not deleted based on real world changes. The condition of a Transport System at a point in time or over time is dependent on the "state" or "existence" of the key object for which the time analysis is based. That is, the "birth" or death of an object depends on the application, not when the section was defined. For example, the following are all valid "births" of a roadway: exists in the improvement program, roadway can be driven upon (during construction), officially open-to-traffic (ribbon-cutting), etc.

Issues:

- How do you describe the path between any two anchor points that describe the ends of an anchor section?

Attributes:

Anchor Section ID
Definition: Primary key that is a unique and arbitrary number for each record in the entity.

Anchor Point ID From
Definition: Identifies the Anchor Point that the Anchor Section is located from (begins).

Anchor Point ID To
Definition: Identifies the Anchor Point that the Anchor Section is located to (to).

Anchor Section (AS) Establish Date
Definition: The date that the Anchor Section is available to others to use. First, this is the same date as the Datum Version. If a section is added after a version is created, it is most likely the date that the anchor section's distance is determined.

[4] Minnesota DOT Linear Location Data Model, December 1998.
[5] NCHRP Linear Referencing System Data Model

Datum Version ID
Definition: Foreign key to relate to Linear Datum Version entity type

Datum Distance
Definition: CALCULATED: the distance for the section determined from a datum adjustment.

Datum Distance Unit
Definition: The measurement unit for the datum distance.

Measurement Methods ID
Definition: A foreign key that associates the method used to collect the datum distances.

Measurement File Name (external files)
Definition: A text string that points to an external file or database that contains the originally collected information. This file includes all the redundancy length information that is used to perform the adjustment and create the datum distance.

Improvement Project ID
Definition: A foreign key that associates the Anchor Section with a construction project date that obliterates the roadway the Anchor Section represents. This date will allow data users the ability to select only "current" Anchor Sections.

Anchor Section Proposed

Definition:

This is a subtype of the Anchor Section.

An anchor section for which the datum distance is estimated and not calculated using accepted datum methodologies and technologies. The section typically represents transportation features that are conceptual and coarse in definition, typically defined during strategic planning, program management and early planning.

Business Rules:

- These sections are not repopulated during datum adjustments.
- A proposed anchor section has a transferable relationship with an anchor section – that is, all relationships that the proposed anchor section has with other entities are transferred to an anchor section when an anchor section is defined. Examples include AADT and bridges.
- For new roads, there would probably be multiple anchor sections in the first phases of constructions that could track the temporal aspects of construction. But, once constructed, there would be only valid anchor section that has been adjusted to the datum.

Issues:

- What about physical characteristics? These most likely should not transfer to the anchor section?

Attributes:

No new attributes.

Centerline

Definition:

A centerline is equivalent to the Spatial Data Transfer Standard object called a string: "A connected non-branching sequence of line segments specified as the ordered sequence of points between those line segments. Note: A string may intersect itself or other strings (A FGDC Spatial Data Transfer Standard 'String', Section 2.3.2.2). " The centerline can represent any transport feature (roadway, rail, waterway, pedestrian way, etc.). The centerline can be created based on any compilation method: cartographic principles (generalization), remotely-sensed principles (satellite imagery, aerial photography, planimetrics, orthometrics), parametric derivation (COGO), etc.

Business Rules:

- Centerlines do not need to be topologically structured, nor do they need to be planar, nor do they need to end only where they intersect three or more other centerlines.

Issue:

What is the intent of the date attribute item?

Attributes:

Centerline ID
Definition: Primary key that is a unique arbitrary for each record in the entity.

Centerline Length
Definition: Distance of the string in spatial units of measure.

Centerline Resolution
Definition: The resolution (imagery) or scale (cartographic data) from which the string was derived.

Centerline Date
Definition: A reference date of cartography centerline to track currency of data.

Centerline Source
Definition: A text string that describes the method used to collect the string, or the existing data set name from which the string was extracted.

Centerline Shape
Definition: The set of coordinate values of the points that compose the string.

Centerline Anchor Section

Definition:

The linear relationship between the linear datum (via Anchor Section) and the spatial representation of a road segment (Centerline). This entity type is basically translating locations between the datum and the cartography.

Business Rules:

- At least one Anchor Section is associated with one or more Centerline Anchor Sections within a given scale.
- The same Anchor Section may be associated with differently scaled Centerline Anchor Sections that represent the same transportation feature.
- Spatial representations are not required to have topologic nodes, and therefore the relationship between spatial representations and the datum must be linear-to-linear. That is the relationship must not rely on centerline nodes as a way of mapping the beginning and end of centerlines to anchor sections (see the Transport Link, Transport Node, and Anchor Section relationships.

Issues:

- Does there need to be an ordinal sequence attribute for the Anchor Section and one for the Centerline?
- This datum relationship is done completely through the anchor section, while the other datum relationships are done via the anchor points and sections – can DOT afford to have both?

Attributes:

Centerline Anchor Section ID
Definition: Primary key that is a unique, arbitrary number for each record in the entity.

Centerline ID
Definition: Foreign key that must be exactly the same format as that attribute in Road Chain.

Anchor Section ID
Definition: Foreign key that must be exactly the same format as that attribute in Anchor Section.

Anchor Section Start Offset
Definition: The start point of the chain on the anchor section, in anchor section units.

Anchor Section End Offset
Definition: The end point of the chain on the anchor section, in anchor section units.

Centerline Start Offset

Definition: The start point of the anchor section on the chain, in chain units.

Centerline End Offset
Definition: The end point of the anchor section on the chain, in chain units.

Centerline Start Percent
Definition: DERIVED - The normalized (%) form of Centerline Start Offset (unit-independent).

Centerline End Percent
Definition: DERIVED - The normalized (%) form of Centerline End Offset (unit independent).

County Signed Route

Definition: Routes that are considered under county jurisdiction.

Business Rules:

- Are defined across the entire state – they do not start over at county boundaries.

Attributes:

Route ID
Definition: Foreign Key relating to entity Signed Route

County Route Letter
Definition: The letter portion of the route name.

County Route Number
Definition: A text field to hold the number portion of the route name.

GIMS Control Section

Definition:

An entity type that describes the Base Record's piece of pavement. The roadway is segmented according to a set of business-driven criteria. See Centerline.

Business Rules:

Attributes:

GIMS Control Section ID
Definition: Primary key of a unique and arbitrary number.

GIMS Control Section Length:
Definition: DERIVED: From the Anchor Section Datum Distance.

GIMS Control Section Units
Definition: DERIVED: The unit of measurement of the Control Section.

Anchor Control Section ID
Definition: A foreign key to reference the anchor control section table.

HPMS Control Section

Definition:

An entity type that describes the HPMS piece of pavement. The roadway is segmented according to a set of business-driven criteria. See Centerline.

Business Rules:

Attributes:

HPMS Control Section ID
Definition: Primary key of a unique and arbitrary number.

HPMS Control Section Length:
Definition: DERIVED: From the Anchor Section Datum Distance.

HPMS Control Section Units
Definition: DERIVED: The unit of measurement of the Control Section.

Anchor Control Section ID
Definition: A foreign key to reference the anchor control section table.

Improvement Project

Definition:

The program level identification and characteristics of each improvement project.

Business Rules:

- Since the stationing reference system is project-based only, this entity type defines the existence, scope, and extent of stationing.

Attributes:

Improvement Project ID
Definition: Primary key that is a unique arbitrary number for each record in the entity.

Program Project ID
Definition: A text field (foreign key) that holds the Iowa DOT's roadway improvement project ID assigned to the project as reference to external files or databases.

Improvement Project Type
Definition: The work that will be performed relative to the improvement: design project, construction project, right-of-way project, etc. The intention of this information is to guide the appropriate use of the attribute information.

Improvement Project Length
Definition: A linear distance for the project (i.e., 2.3 miles of roadway to be resurfaced).

Improvement Project Length Units
Definition: Measurement units for project length (metric, English)

Improvement Project Start Date
Definition: A calendar date for the beginning of the project. For a construction project, this would be the legal date in which construction contractors are authorized to proceed.

Improvement Project End Date
Definition: A calendar date for the end of the project.

Institutional Signed Route

Definition:

A sub-entity of the Signed Route entity. It is a route that is signed and under the jurisdiction by an Iowa State Institution such as the Regents or DNR.

Business Rules:

Attributes:

Route ID
Definition: Foreign key to relate to entity type Signed Route.

Route Prefix
Definition: (optional) Enumerated list of acceptable street name prefixes (North, South, East, West, etc)

Route Name
Definition: Enumerated list of acceptable street names (Maple, 1st, Grant, Main, etc)

Route Type
Definition: (optional) Enumerated list of acceptable street types (Avenue, Street, Boulevard, etc)

Route Suffix
Definition: (optional) Enumerated list of acceptable street suffixes (NW, EW, etc)

Jurisdiction

Definition:

A public or private organization that owns and is responsible for transportation facilities, [6] as opposed to existing within a jurisdiction geographically.

Business Rules:

Issues:

- Jurisdictional breaks and their impacts on the routes. Discontinuous routes break at jurisdictional boundaries but what about continuous routes?

Attributes:

Jurisdiction ID
Definition: Primary key that is a unique arbitrary for each record in the entity.

Jurisdiction Type
Definition: The level of government or administration of the jurisdiction such as federal, state, county, regional, institution, or municipality.

Jurisdiction Name
Definition: The official name of the jurisdiction.

FIPS Code
Definition: Federal Information Processing System code for a jurisdiction (FIPS PUB 55).

State Code
Definition: DERIVED - The codes used by the Iowa DOT to identify a jurisdiction. This value is derived from the FIPS Code.

[6] Minnesota Department of Transportation, Linear Location Data Model, December, 1998.

Linear Datum Version

Definition:

The set of anchor sections to which a mathematical distance adjustment was made. These adjustments are global adjustments, meaning most if not all distances may be modified.

Business Rules:

- Adjustments are required when the co-variance between distances become greater than the accepted tolerance (yet-to-determined).
- Local adjustments will occur when changes to roadway lengths occur or new roads are created. These local adjustments will only impact new sections and not existing sections (no filtering will occur).
- The adjustment date is when the version was accepted by the DOT as a valid version, not the date when the adjustment was created.

Issues:

- Performing an adjustment is analogous to moving from NAD27 to NAD83 for geodetic control. All data controlled in one version must be converted to the new version. Obviously, an adjustment is something that should not be done regularly. The DOT will need to determine how best to initially populate the datum distances. There are basically two strategies: 1) populate datum distances using whatever source is available, and 2) perform a rigorous distance definition up front.

  If DOT used the first strategy, DOT would then use more rigorous measurement techniques over the next few years. Because enough of the datum distances would change, this strategy would require an adjustment within the next few years. This also has readjustment implications for data views that are created in the GeoData Warehouse.

  The second strategy will require significant up-front data collection efforts and costs, which would delay the use of the LRS.

- How to report accuracy. Should the accuracy reporting requirements follow the Federal Geographic Data Committee (FGDC) Geospatial Positioning Accuracy Standards – Chapter 1 Reporting Standards – FGDC Standard 007.

Attributes:

Datum Version ID
Definition: Primary key that is a unique arbitrary for each record in the entity.

Version Date
Definition: The date of the datum version to which the LRS is attached.

Reason for Version

Definition: A text field that provides a synopsis of why it was necessary to create a new version and the benefits the new version will provide.

Adjustment File Name
Definition: Field contains the name and location of the external file(s) that contain the data that stipulated an adjustment was needed such as the Mandli file name, least square adjustment file name, etc.

Adjustment Date
Definition: The date of the adjustment was made.

Adjustment Accuracy
Definition: The accuracy or "confidence level" of the adjustment.

Link State

Definition:

At a given point in time, the change in condition of whether vehicles can travel along a link.

Business Rules:

- A link can have only one state at any one point in time.
- A link can have only one direction at any one point in time.
- A link state has precedence over direction; that is, the direction is meaningless if the Link is closed or retired.

Issue:

- What are the criteria to change the state?

Attributes:

Link State ID
Definition: Primary key of a unique and arbitrary value.

Transport Link ID
Definition: Foreign key to relate back to entity type Transport Node

Link State
Definition: there are three valid states: Open, Closed, Retired. The first Open is the first time the link is established.

Link State Date
Definition: the date and time at which the state became valid.

Link Direction
Definition: The normal operating traffic direction for this link: one-way or bi-directional. If it is one-way, a distinction is required on whether it is the same or opposite direction of the Transport Link From and To direction. Also, the Transport Link Current State can be applied to the entire link, or one direction of travel of a bi-directional link.

LRS Component

Definition:

The object (data, methods, procedures, policies, etc) of a subsystem which by itself is manageable and usable (e.g., the route table, the link/node tables, etc).

Business Rules:

Attributes:

LRS Component ID
Definition: Primary key of a unique and arbitrary value.

LRS Component Subsystem
Definition: The name of the subsystem to which the component belongs (this will be one of a finite set).

LRS Component Name
Definition: The name of the component (e.g., Link/Node).

LRS Component Unit
Definition: The measurement unit associated with this component (English, metric).

LRS Component Interface Formats and Procedures
Definition: the information necessary for other to successfully interface with the subsystem: data formats, policies on use, etc.

LRS Component Metadata Filename
Definition: the name of the file that contains a myriad of component-specific metadata.

LRS Component Relationship

Definition:

The relationship between a LRS Contact and a given Component.

Business Rules:

Attributes:

LRS Component Relationship ID
Definition: Primary key of a unique and arbitrary value.

LRS Contact ID
Definition: Foreign Key relating to entity LRS Contact that must be in the same format.

LRS Component ID
Definition: Foreign Key relating to entity LRS Component that must be in the same format.

Component Relationship Type
Definition: There are three types of relationships:

- LRS Customer: one who applies the component in some business function or activity.
- LRS Subsystem Manager: one who is responsible for satisfying the customer and business performance expectations of the component.
- LRS Subsystem Support Person: one who performs some role in the maintenance and management of the component.

Component Relationship Description
Definition: a text string that describes any specific information about the relationship that must be managed over time. For LRS customer, what they use the component for, how often, etc.

Relationship Begin Date
Definition: When the relationship began.

Relationship Termination Date
Definition: When the relationship no longer existed.

LRS Contact

Definition:

An Iowa DOT staff person who is somehow involved with the LRS.

Business Rules:

Attributes:

LRS Contact ID
Definition: Primary key that is a unique arbitrary for each record in the entity.

Person Name
Definition: Full name.

Organization
Definition: What organization the person represents (organization, division, section, unit).

Organizational Title
Definition: The person's formal title in the organization.

Contact Info
Definition: The person's address, phone, email, etc.

Date Added
Definition: The date that data is being added.

Date Removed
Definition: The date that data is being removed from active viewing.

Measurement Methods

Definition:

The method and related technologies used to acquire LRS data. This information provides the range in which data qualities are possible.

Business Rules:

Issues:

Attributes:

Measurement Methods ID
Definition: Primary key that is a unique arbitrary number for each record in the entity.

Measurement Method Type
Definition: the LRS object to which this method of data collection is applied. For example, the 'Datum Anchor Section' would be one type to which several methods may exist.

Measurement Equipment
Definition: The original measurement tools used to gather the data source (handheld GPS, digitizer)

Measurement Procedure
Definition: A text file to hold a brief description of how the measurement was collected and processed.

Date Established
Definition: The date when this method was accepted as a valid DOT approach to measurement.

Date Retired
Definition: The date when this method was no longer accepted as a valid DOT approach to measurement.

Change Reason
Definition: A text string that is updated, describing why a method was established and retired.

Municipal Signed Route

Definition:

A sub entity of the Signed Route entity that contains the routes signed by municpal governments.

Business Rules:

Issues:

- Need the detailed anatomy of the route name and related business rules.

Attributes:

Route ID
Definition: Foreign key to relate to entity type Signed Route.

Route Prefix
Definition: (optional) Enumerated list of acceptable street name prefixes (North, South, East, West, etc)

Route Name
Definition: Enumerated list of acceptable street names (Maple, 1st, Grant, Main, etc)

Route Type
Definition: (optional) Enumerated list of acceptable street types (Avenue, Street, Boulevard, etc)

Route Suffix
Definition: (optional) Enumerated list of acceptable street suffixes (NW, EW, etc)

Node State

Definition:

At a given point in time, the change in condition of whether vehicles can travel through a node.

Business Rules:

- A node can have only one state at any one point in time.

Issue:

- What are the criteria to change the state?

Attributes:

Node State ID
Definition: Primary key of a unique and arbitrary value.

Transport Node ID
Definition: Foreign key to relate back to entity type Transport Node

Node State
Definition: there are three valid states: Open, Closed, Retired; the first Open is the first time the node is established.

Node State Date
Definition: the date and time at which the state became valid.

Private (Route)

Definition:

The name of a road that is not publicly owned.

Business Rules:

Issues:

- Need the detailed anatomy of the route name and related business rules.

Attributes:

Route ID
Definition: Foreign key to relate back to entity type Signed Route

Private Route Name
Definition: a text string

Route Prefix
Definition: (optional) Enumerated list of acceptable street name prefixes (North, South, East, West, etc)

Route Name
Definition: Enumerated list of acceptable street names (Maple, 1st, Grant, Main, etc)

Route Type
Definition: (optional) Enumerated list of acceptable street types (Avenue, Street, Boulevard, etc)

Route Suffix
Definition: (optional) Enumerated list of acceptable street suffixes (NW, EW, etc)

Project Section

Definition:

A section of roadway that is part of an improvement project.

Business Rules:

- Sections break where cross stationing occurs (to reduce accumulative error), where station equations occur (to handle station value differences), or at the ends of the improvement project (to define the ends of the project).
- There must be at least one Project Section for any given Improvement Project.

Attributes:

Project Section ID
Definition: Primary key that is a unique arbitrary number for each record in the entity.

Improvement Project ID
Definition: Foreign key to relate to entity type Improvement Project.

Project Section Node From and To
Definition:. Foreign key to relate to entity type Project Section Node.

Project Section Station From and To
Definition: The stationing value at the beginning and end of the section. The station value may be negative if it extends before the beginning or end of the project.

Project Section Station Units
Definition: Measurement units for the Station From and To attributes.

Project Section Station Length
Definition: DERIVED – It is calculated from the From and To values.

Project Section Node

Definition:

The shared location between Project Section ends. The nodes define whether there is a gap in the project between sections or whether cross streets are parts of the project.

Business Rules:

- There must be two points per Project Section.

Attributes:

Project Section Node ID
Definition: Primary key that is a unique arbitrary for each record in the entity.

Project Section ID
Definition: Foreign key to relate back to entity type Project Section.

Node Description
Definition: A description of where this terminus is, typically in terms of signed routes, positions to cities and easily identifiable roadway features (e.g., bridges). This value should be DERIVED by using the Literal Description LRM.

Project Section Node Offset

Definition:

The measured location of where the node falls within the datum.

Business Rules:

Attributes:

Project Section Node Offset ID
Definition: Primary key of a unique and arbitrary number.

Project Section Node ID
Definition: Foreign key to relate back to entity type Project Section Node.

Anchor Section ID
Definition: Foreign key to relate back to entity type Anchor Section.

Anchor Section Offset
Definition: DERIVED. This is the datum measure attribute that is used to locate the node on the anchor section. It is an offset measure from the "from" anchor point of the anchor section and is expressed as a distance measure in the same units as the "distance" attribute of the associated anchor section.

Offset Units
Definition: DERIVED. The measurement units of the anchor section offset.

Project Section Sequence

Definition:

How the project section is defined along the anchor sections, and vice versa. It is an intersection table.

Business Rules:

Attributes:

Project Section Sequence ID
Definition: Primary key of a unique and arbitrary number.

Anchor Section ID
Definition: Foreign key to relate back to entity type Anchor Section.

Project Section ID
Definition: Foreign key to relate back to entity type Project Section.

Project Section Ordinal
Definition: Provides the order of Anchor Section or their parts that comprise a Project Section.

Anchor Section Ordinal
Definition: Provides the order of Project Sections or their parts that comprise an Anchor Section.

Reference Feature (External Information Source)

Definition:

A physical object in the field along a transportation facility. Its purpose is to provide a known and consistent point from which to locate objects and events that occur along the facility.

Business Rules:

- The location of a reference feature must be repeatedly identifiable in the field.
- The position of a reference feature is always a measured distance from the beginning of an anchor section. This distance must be collected using approved methods that result in accuracies required of all LRS reference objects.

Attributes:

Reference Feature ID
Definition: Primary key that is a unique and arbitrary number.

Reference Feature Category
Definition: There are only two categories: Bridge-related or railroad crossing-related reference features.

Reference Feature Source ID
Definition: The actual primary key of the feature object from its source data base (e.g., the unique and arbitrary number for a bridge).

Reference Feature Name
Definition: DERIVED: A text string that names the feature, pulled from the source data base.

Reference Feature Type
Definition: Depends on the category. For Bridge, types can include middle abutment, span beginning, span ending, etc.

Transport Link ID
Definition: CALCULATED: Based on the relationship between anchor section and the transport link.

Transport Link Offset
Definition: CALCULATED: Based on the offset distance from the beginning of the anchor section.

Date Created
Definition: The date the feature was added as a reference feature.

Date Removed
Definition: The date the feature can no longer be used as a reference feature.

Measurement Method ID
Definition: A foreign key that associates the method used to collect the Anchor Section Offset. The associated method provides the quality of the offset and whether it node's position meets reference object accuracy standards.

Reference Post

Definition:

Posts placed at approximately 1-mile increments along a signed route. Formerly known as a milepost.

Business Rules:

- There may be many reference posts to any one route.
- A change in post value causes a new data base instance (i.e., a new record a table) to be created.

Attributes:

Reference Post ID
Definition: Primary key that is a unique arbitrary number.

Post Value
Definition: The alphanumeric value that is posted (e.g., 'A35').

Date Established
Definition: The date that the reference post is established in the field with the marker value. Dates that reflect when the post was destroyed (purposely or by accident) are managed as part of the business system that maintains the markers.

Date Retired
Definition: The date that the reference post no longer portrays the marker value. Dates that reflect when the post was destroyed (purposely or by accident) are managed as part of the business system that maintains the markers.

System Route Link ID
Definition: Foreign key that must be exactly the same attribute as in the System Route Link.

Route ID
Definition: DERIVED - Foreign key that must be exactly the same attribute as in the System Route Link.

Link ID
Definition: DERIVED - Foreign key that must be exactly the same attribute as in the System Route Link.

Link Offset
Definition: CALCULATED - A distance measurement along the link where the reference post is positioned. Because of the accuracy requirements of LRS reference objects, the Reference Post distances (d1) must be measured in the field as an offset from the beginning of an anchor section. Transport Nodes will also be reference objects and will have the same requirement (d2). Therefore, the Link Offset of the Reference Post

meets the same accuracy requirements (d1-d2 = offset value). The Anchor Section distance for the Reference Post is not stored as data (since it is just data used in the process). The Link Offset value is because this format meets the LRM data requirements.

Link Offset Units
Definition: DERIVED - The measurement units of the link offset.

Signed Route

Definition:

The administrative and legislative assignment to a collection of links within a transport system. These are typically the posted routes in the field.(include detours), but also include aliases. There are four key signed route systems in the state – primary (state), secondary, municipal, and institutional and parks.

Business Rules:

- A signed route may have one or more links.
- A signed route may be within one or more transport systems.
- A signed route may be made up of one or more sub-entities – state (primary), county (secondary), local (municipal) or institutional (parks, universities, etc.).
- Actual traversals through a network – like snowplow routes and transit routes are entities that are not part of the LRS. They are part of some business system. However, these routes should use the same data formats and tools.

Issues:

- If a route is renamed the existing route (System Route Link entries) is retired (to satisfy the temporal requirements); it is not enough to just change the name.

Attributes:

Route ID
Definition: Primary key that is a unique arbitrary for each record in the entity.

Route Category
Definition: The type of signed route based on the syntax of the route name. Route categories include State, County, E911, Local, Park, Institutional, Detour, Alternate, and Private.

Route Established Date
Definition: The date/time when the route was officially made a route by the governing body of the system (legislature, city council, DOT, etc).

Route Retired Date
Definition: The date/time when the route was officially retired by the governing body of the system (legislature, city council, DOT, etc).

Jurisdiction ID
Definition: Foreign key to relate to the jurisdiction that establishes the route (assigned establish and retired dates).

Detour
Definition: Boolean indicator of whether the route is a detour or not.

Route Status

Definition: DERIVED: Temporal attribute to indicate if route is P (pre-current – not yet open), C (current) or H (historical) based on the absolute dates. Implies change.

State Signed Route

Definition:

A type of Signed Route that is typically managed by the State of Iowa and influenced by the state legislature and the federal government.

Business Rules:

Issues:

- Need the detailed anatomy of the route name and related business rules.

Attributes:

Route ID
Definition: Foreign Key relating to entity Signed Route

Route System
Definition: A text field to identify the type of route system (i.e., Interstate, U.S. Highway, State Highway)

Route Number
Definition: The "official" number of the State of Iowa Signed Route (i.e., 23)

Route Direction
Definition: The direction of the set of lanes on a State of Iowa Signed Route. This occurs on divided highways.

Station Post

Definition:

The Station Posts or Pavement Stamps placed at approximately 500’ increments along an improvement project.

Business Rules:

- There may be many station posts to any improvement project.
- A change in Station causes a new data base row to be created.

Attributes:

Station Post ID
Definition: Primary key that is a unique and arbitrary number.

Station
Definition: The value that is posted as the station in the field.

Date Established
Definition: The date that the reference post is established in the field with the marker value. Dates that reflect when the post was destroyed (purposely or by accident) are managed as part of the business system that maintains the markers.

Date Retired
Definition: The date that the reference post no longer portrays the marker value. Dates that reflect when the post was destroyed (purposely or by accident) are managed as part of the business system that maintains the markers.

Project Section ID
Definition: Foreign key that must be exactly the same attribute as in the Project Section.

Project Section Offset
Definition: A distance measurement along the Project Section where the Station Post is positioned.

Project Section Units
Definition: DERIVED - The measurement units of the Project Section.

System Route Link

Definition:

A specific link in a route, where the route is defined based on a sequence of system route links. This route is defined within one transport system. This entity also contains the LRS signed route milepoint system (a type of transport system) composed of derived distances based on link distances. It eliminates redundancy for added and removed dates. It will also generate the snapshots of road systems for the Geo Data Warehouse.

Business Rules:

- There may be many links per transport system but there must be one transport system for any link.
- There may be many routes per link or per transport system but there must be one route per link or per transport system.

Issues:

Attributes:

System Route Link ID
Definition: Primary key that is a unique arbitrary for each record in the entity.

Route ID
Definition: Foreign key relating to the Official name of the route.

Transport Link ID
Definition: Foreign key relating to entity Transport Link

Transport System ID
Definition: Foreign key relating to entity Transport System

Ordinal
Definition: The ordinal value (e.g., 1,2,3, etc) that defines the sequence of a link in the signed route. This sequence is based on the Federal definition of sequencing south to north and west to east. This is the only place that defines route topology.

Added Date
Definition: Date/time when a route was created along a link or set of links (e.g., a detour, a jurisdictional transfer, etc).

Removed Date
Definition: Date/time when a route no long traverses a link or set of links (e.g., the end of a detour, a jurisdictional transfer, etc).

Accumulated Distance

Definition: A derived measurement of length that relates to the milepoint system that is calculated based on order provided by the Ordinal attribute of this table.

Accumulated Distance Units
Definition: The derived measurement units of the derived distance (miles, feet, kilometers, etc.).

System-wide Metadata

Definition:

The referencing parameters for the entire system. Used to provide vital information to external users of data as well as data providers.

Business Rules:

Attributes:

Horizontal Datum
Definition: Type of referencing mapping surface that provides positional information with reference to a mathematical model of the earth's surface. For instance, the North American Datum of 1983 with a 1991 adjustment (NAD83(91)) with reference to the Clarke spheroid of 1866.

Vertical Datum
Definition: A reference surface that defines the elevation of mapped features on the earth such as the National Geodetic Vertical Datum of 1929 (NGVD29). this datum is based on measurements of mean sea level of 21 tidal stations in the U.S.

Coordinate System
Definition: The type of geographic referencing system being used for the system, such as Cartesian, PLSS, etc.

Units of Coordinate System
Definition: What the coordinate system is measured in such as meters, kilometers, etc.

Format of Coordinate Values
Definition: A text file describing the digital format for coordinate values.

Datum Distance Units
Definition: Measurement units (metric, English, etc.) of any distance on the datum.

Transport Link

Definition:

"A topological connection between two ordered nodes. "[6] The definition is from NCHRP 20-27(2).[7]

Business Rules:

- A link goes from a node to a node. There must be at least two nodes per link.
- Different links may share nodes.
- Impedance other than travel distance (such as time or cost) is part of a business system and is not part of the LRS.
- Traffic restriction information (one ways, weight, height, etc) is part of a business system and is not part of the LRS. By default, traffic can flow both directions along a link, and any vehicle can traverse a link.
- A link can be a generalized link, which represents a set of links; that is, a link can be a generalized representation of other links. This rule addresses the need for higher level representations of networks for interstate CVO, crash analysis, multi-modal corridor analysis, etc. For example, one generalized link may represent all ground transportation between Ames and Dubuque.
- A generalized link has no direct relation to the datum; a generalized link only has a relation to the datum via a standard link.

Attributes:

Transport Link ID
Definition: Primary key that is a unique arbitrary for each record in the entity.

Transport Node ID From
Definition: The node where the link begins. The ID is gathered from the Transport Node entity.

Transport Node ID To
Definition: The node where the link ends. The ID is gathered from the Transport Node entity.

Link Distance
Definition: DERIVED: The datum distance derived from Anchor Section for the length of the link.

Link Distance Units
Definition: DERIVED: The measurement units for link distance.

Current State

[7] NCHRP 20-27(2) Linear Referencing System Data Model

Definition: DERIVED: This is a toggle attribute to indicate if a link is open to traffic or not based on the value from the link state entity.

Current Direction
Definition: DERIVED: This indicates the current direction of traffic flow based on the direction value from the link state entity.

Transport Link Sequence

Definition:

The relationship between anchor sections and transport links to determine which anchor sections are associated with which links and vice versa. It is an intersection table.

Business Rules:

- There must be at least one anchor section per link.
- Dead ends (odd valence) must have an anchor point.

Attributes:

Transport Link Sequence ID
Definition: Primary key that is a unique arbitrary for each record in the entity.

Anchor Section ID
Definition: Foreign key that must be exactly the same as the primary key attribute for Anchor Section.

Transport Link ID
Definition: Foreign key that must be exactly the same as the primary key attribute for Transport Link.

Link Ordinal
Definition: Provides the order of Anchor Sections or their parts that comprise a Link.

Section Ordinal
Definition: Provides the order of Links or their parts that comprise a Section.

Transport Node

Definition:

"A zero-dimensional object that is a topological junction of two or more links, or end point of a link. They are located geometrically by reference to the datum."[8] This entity includes the information that comprises the Literal Description LRM for intersection features.

Business Rules:

- There may be one to many nodes to one (mandatory) Anchor Section.
- There must be at least two nodes per Transport Link.
- Impedance (such as time delay or costs) is part of a business system and is not part of the LRS.
- Traffic restriction information (turning restrictions) is part of a business system and is not part of the LRS. By default, a vehicle can turn at any node.
- A node can be a generalized node, which represents a set of nodes; that is, a node can be a generalized representation of other nodes. This rule addresses the need for higher-level representations of networks for interstate CVO, crash analysis, multi-modal corridor analysis, etc. For example, one generalized node may represent an entire complex interchange.
- A generalized node has no direct relation to datum; a generalized node only has a relation to the datum via a standard node.

Attributes:

Transport Node ID
Definition: Primary key that is a unique arbitrary for each record in the entity.

Reference Feature
Definition: This is a Boolean attribute ('Yes' or 'No') to indicate whether the node is designated as a reference feature as part of the Literal Description linear reference method.

Node Description
Definition: DERIVED: A text field that lists all routes by name where the node has a relationship with at least one link from the route. This description is used by the Literal Description LRM processes.

Current State
Definition: DERIVED: This is a toggle attribute to indicate if a link is open to traffic or not based on the most current state of the node.

[8] NCHRP Linear Referencing System Data Model

Transport Node Offset

Definition:

An intersection table relates the many-to-many relationships between the anchor section and the transport node.

Business Rules:

Issues:

Attributes:

Transport Node Offset ID
Definition: Primary key to be a unique and arbitrary number.

Anchor Section ID
Definition: Foreign key to relate to entity type Anchor Section.

Anchor Section Offset
Definition: This is the datum measure attribute that is used to locate the node on the anchor section. It is an offset measure from the "from" anchor point of the anchor section and is expressed as a distance measure in the same units as the "distance" attribute of the associated anchor section.

Offset Units
Definition: The units of measurement for the offset distance.

Transport Node ID
Definition: Foreign key to relate to entity type Transport Node.

Measurement Method ID
Definition: A foreign key that associates the method used to collect the Anchor Section Offset. The associated method provides the quality of the offset and whether it node's position meets reference object accuracy standards.

Transport System

Definition:

A set of system route links serving a common purpose or representing transport facilities that are commonly managed. Some key examples are the primary, secondary, municipal, and parks/institutions systems. Other examples are transit systems, snowplow systems, and so on. Transport Systems are typically networks, but do not have to be networks. That is, a system can be non-contiguous sections of transport facilities, like road sections.

Business Rules:

- The need for a transport system is defined by the need to support DOT policy, statutes, etc to satisfy a key performance expectation from the Federal or State government (e.g., NHS).
- A transport system defines the need for and extent for the linear datum.
- Any transport system may have one or more links.
- Any transport system may have one or more routes.
- Transport Systems are defined by geography (county area extent), by functionality (snow plowing), or by jurisdiction (roadways managed by the county).
- Many transport systems will be derived algorithmically (in the form of a query) from other transportation systems.
- A Transport system may have one or more transport modes (road, rail, etc).
- The LRS will not support Transit operations (scheduling, dispatch), but does support Iowa DOT programming requirements related to transit planning and transit asset management.

Attributes:

Transport System ID
Definition: Primary key that is a unique and arbitrary number for each Transport System

System Name
Definition: A text field for naming the system. (e.g., City of Ames Public Road System)

System Type
Definition: Combinations of routes that serve a purpose and run over a combination of route categories (e.g., municipal network).

Mode
Definition: Enumerated entity type to describe the means of transportation – highway, transit, railroad, pedestrian/biking, intermodal, etc. There is a finite set.

Extent
Definition: The geographic region that the particular transport system covers such as statewide, city of Ames, etc.

Unofficial Name

Definition:

This is a type of Signed Route. These are names of traversals through the transport system that are most likely non-official but are used regularly. Examples include "The beltway", the "Loop", "Old 53", the "back 40 road", etc. End user is crash reporting so they will likely be maintaining this information.

Business Rules:

- Alternate names do not have to traverse the same links of a particular signed route. Alternate names can actually traverse links that are concurrent with several different signed routes (Peggi Knight, 8/13/99).

Attributes:

Route ID
Definition: Foreign key to relate to entity type Signed Route.

Route Prefix
Definition: (optional) Enumerated list of acceptable street name prefixes (North, South, East, West, etc)

Route Name
Definition: Enumerated list of acceptable street names (Maple, 1st, Grant, Main, etc)

Route Type
Definition: (optional) Enumerated list of acceptable street types (Avenue, Street, Boulevard, etc)

Route Suffix
Definition: (optional) Enumerated list of acceptable street suffixes (NW, EW, etc)

VI. Logical Process Model – Functional Decomposition

The process model captures a broad range of process requirements for several different functions, down to the elementary process level. The first function captured is Location Reference Administration. The Location Reference Administration function has requirements for customer-driven LRS policy development, system development, system implementation, and support.

The Location Reference Maintenance function includes requirements for initializing the LRS, establishing the datum, and establishing data for several of the LRS subsystems. The Location Reference Operations function also contains process requirements for establishing some of the LRS subsystems. The primary intent behind this function is to apply the LRS for capturing the location of business data. The last function provided is Location Reference System Monitoring. This function describes the process requirements for capturing and evaluating LRS performance, for both field and office activities.

1. Location Referencing
    1.1. Location Reference Administration
        1.1.1. Develop Location Reference Policy
            1.1.1.1. Determine Location Reference Needs
                1.1.1.1.1. Conduct Location Reference Customer Survey
                1.1.1.1.2. Evaluate Location Reference Needs
                1.1.1.1.3. Publish Location Reference Needs
            1.1.1.2. Determine Location Reference Objective
                1.1.1.2.1. Determine Location Reference System Goal
                1.1.1.2.2. Determine Location Reference System Benchmark
                1.1.1.2.3. Publish Location Reference Policy
            1.1.1.3. Develop Location Reference Standard
                1.1.1.3.1. Determine Location Reference Standard
                1.1.1.3.2. Publish Location Reference Standard
        1.1.2. Develop Location Reference System
            1.1.2.1. Develop Location Reference System Architecture
                1.1.2.1.1. Develop Conceptual Architecture
                1.1.2.1.2. Develop Logical Architecture
                1.1.2.1.3. Develop Physical Architecture
            1.1.2.2. Develop Location Reference System
                1.1.2.2.1. Analyze LRS
                1.1.2.2.2. Design LRS
                1.1.2.2.3. Construct LRS
                1.1.2.2.4. Test LRS
            1.1.2.3. Develop Interface to Legacy System

1.1.2.3.1. Develop Interface to Base Records System
1.1.2.3.2. Develop Interface to PMIS
1.1.2.3.3. Develop Interface to IPMP
1.1.2.3.4. Develop Interface to HPMS
1.1.2.3.5. Develop Interface to Video Log
1.1.2.3.6. Develop Interface to ALAS
1.1.2.3.7. Develop Interface to Safety Features Inventory
1.1.2.3.8. Develop Interface to Field Inventory
1.1.2.3.9. Develop Interface to Access Control Points
1.1.2.4. Deploy Location Reference System
1.1.3. Develop Location Reference Staff
1.1.3.1. Assign Location Reference Staff
1.1.3.2. Conduct Location Reference System Training
1.2. Location Reference Maintenance
1.2.1. Initialize LRS
1.2.1.1. Establish LRS Controls
1.2.1.2. Establish LRS Parameters
1.2.1.3. Determine Transport System
1.2.2. Establish Linear Datum
1.2.2.1. Design Linear Datum
1.2.2.1.1. Determine First Order Datum Design
1.2.2.1.2. Determine Second Order Datum Design
1.2.2.1.3. Determine Third Order Datum Design
1.2.2.2. Conduct Linear Datum Survey
1.2.2.2.1. Plan Linear Datum Survey
1.2.2.2.2. Prepare Measurement Device
1.2.2.2.3. Survey Linear Datum
1.2.2.2.3.1. Place Anchor Point
1.2.2.2.3.2. Monument Anchor Point
1.2.2.2.3.3. Measure Anchor Point Span
1.2.2.2.3.4. Determine Anchor Section Distance
1.2.2.2.4. Adjust Linear Datum
1.2.2.2.5. Position Linear Datum
1.2.2.2.5.1. Position Anchor Point
1.2.2.2.5.2. Position Anchor Section
1.2.2.3. Publish Linear Datum
1.2.3. Establish Route System
1.2.3.1. Determine Transport System Network
1.2.3.1.1. Add Transport Node
1.2.3.1.2. Add Transport Link
1.2.3.1.3. Change Link State
1.2.3.1.4. Change Node State
1.2.3.1.5. Remove Transport Link
1.2.3.1.6. Remove Transport Node
1.2.3.2. Establish System Route
1.2.3.2.1. Assign Route Name

1.2.3.2.2. Assemble System Route
1.2.3.2.2.1. Add System Route Link
1.2.3.2.2.2. Remove System Route Link
1.2.3.2.3. Remove Signed Route
1.2.3.2.4. Determine Route Link Distance
1.2.3.2.5. Publish Transport System Route
1.2.4. Establish Linear Reference Method
1.2.4.1. Establish Reference Post
1.2.4.1.1. Place Reference Post
1.2.4.1.2. Position Reference Post
1.2.4.1.3. Publish Reference Post
1.2.4.2. Establish Station Post
1.2.4.2.1. Place Station Post
1.2.4.2.2. Determine Project Section Location
1.2.4.2.3. Position Project Section
1.2.4.2.4. Position Station Post
1.2.4.2.5. Publish Project Section
1.2.4.2.6. Publish Station Post
1.2.4.3. Establish Literal Description
1.2.4.3.1. Establish Reference Feature
1.2.4.3.2. Publish Reference Feature
1.3. Location Reference Operations
1.3.1. Locate Transportation Assets
1.3.1.1. Locate Pavement Section
1.3.1.1.1. Determine Pavement Section Location
1.3.1.1.2. Position Pavement Section
1.3.1.1.3. Publish Pavement Section Location
1.3.1.2. Locate HPMS
1.3.1.2.1. Determine HPMS Section Location
1.3.1.2.2. Position HPMS Section
1.3.1.2.3. Publish HPMS Section Location
1.3.1.3. Locate Transportation Feature (i.e. Bridges)
1.3.1.3.1. Determine Transportation Feature Location
1.3.1.3.2. Position Transportation Feature
1.3.1.3.3. Publish Transportation Feature Location
1.3.1.4. Locate Utility Feature
1.3.1.4.1. Determine Utility Feature Location
1.3.1.4.2. Position Utility Feature
1.3.1.4.3. Publish Utility Feature Location
1.3.1.5. Locate Access Control Point
1.3.1.5.1. Determine Access Control Point Location
1.3.1.5.2. Position Access Control Point
1.3.1.5.3. Publish Access Control Location
1.3.1.6. Locate Traffic Control Device
1.3.1.6.1. Determine Traffic Control Device Location
1.3.1.6.2. Position Traffic Control Device

VII. Logical Process Model - Decomposition Definitions

The process model descriptions are provided below. For a functional hierarchy of the processes, see the previous section of this report.

Location Referencing
Type: Function

Description: Ongoing activities that create, administer, and operate the Department's location referencing system, methods, procedures and technologies.

Location Reference Administration
Type: Function

Description: Ongoing activities that establish, carry out, and oversee location reference system policy, procedures and automated support.

Develop Location Reference Policy
Type: Process

Description: Clarify, enhance or expand formal courses of action regarding location referencing.

Determine Location Reference Needs
Type: Process

Description: Investigate Iowa DOT business requirements for location referencing.

Conduct Location Reference Customer Survey
Type: Process

Description: Conduct a formal investigation of location referencing business requirements.

Evaluate Location Reference Needs
Type: Process

Description: Examine, assess and synthesize location reference business requirements. (Availability, accuracy, format, etc.)

Publish Location Reference Needs
Type: Process

Description: Adopt, print and disseminate location reference needs to LRS system users and other interested parties.

Determine Location Reference Objective
Type: Process

Description: Decide on a statement of direction and extent for the availability, quality or performance of location reference.

Determine Location Reference System Goal
Type: Process

Description: Decide on a specific, measurable outcome for a location reference objective

Determine Location Reference System Benchmark
Type: Process

Description: Measure the availability, quality or performance of a Location Reference characteristic.

Publish Location Reference Policy
Type: Process

Description: Adopt, print and disseminate a Location Reference policy to system users and other interested parties

Develop Location Reference Standard
Type: Process

Description: Create and distribute a uniform rule or procedure concerning the use of the Location Reference System

Determine Location Reference Standard
Type: Process

Description: Create a rule or procedure concerning the use of the Location Reference System

Publish Location Reference Standard
Type: Process

Description: Adopt, print and disseminate a rule or procedure concerning the use of the Location Reference System to system users and other interested parties.

Develop Location Reference System
Type: Process

Description: Establish a set of office, field and automated procedures for determining the locations of transportation related features and events.

Develop Location Reference System Architecture
Type: Process

Description: Establish a framework of institutional, procedural, data and technical components for the LRS.

Develop Conceptual Architecture
Type: Process

Description: Establish a business domain framework of institutional, procedural, data and technical components for the LRS.

Develop Logical Architecture
Type: Process

Description: Establish an information model of the institutional, procedural, data and technical components for the LRS.

Develop Physical Architecture
Type: Process

Description: Establish the information systems model and design for the institutional, procedural, data and technical components of the LRS.

Develop Location Reference System
Type: Process

Description: Analyze, design, construct and test an automated Location Reference System

Analyze LRS
Type: Process

Description: Establish the technical specifications for the automated portion of the LRS.

Design LRS
Type: Process

Description: Select the elements, steps and procedures for building the LRS

Construct LRS
Type: Process

Description: Build the individual components and assemble the LRS

Test LRS
Type: Process

Description: Examine and validate the performance of the LRS.

Develop Interface to Legacy System
Type: Process

Description: Design, build and implement interoperable interfaces to Iowa DOT client systems

Develop Interface to Base Records System
Type: Process

Description: Design, build and implement interoperable interfaces to the base records system.

Develop Interface to PMIS
Type: Process

Description: Design, build and implement interoperable interfaces to the Pavement Management Information System.

Develop Interface to IPMP
Type: Process

Description: Design, build and implement interoperable interfaces to Iowa Pavement Management Program.

Develop Interface to HPMS
Type: Process

Description: Design, build and implement interoperable interfaces to the HPMS.

Develop Interface to Video Log
Type: Process

Description: Design, build and implement interoperable interfaces to the Video Log System.

Develop Interface to Accident Location and Analysis System (ALAS)
Type: Process

Description: Design, build, and implement interoperable interface between the ALAS System and the Route management subsystem.

Develop Interface to Safety Features Inventory
Type: Process

Description: Design, build, and implement interoperable interfaces to the Safety Features Inventory.

Develop Interface to Field Inventory
Type: Process

Description: Design, build, and implement interoperable interfaces to the Field Inventory system

Develop Interface to Access Control Points
Type: Process

Description: Design, build, and implement interoperable interfaces to the Access Control Points System.

Deploy Location Reference System
Type: Process

Description: Place the LRS into production.

Develop Location Reference Staff
Type: Process

Description: Recruit and train the staff necessary to operate the LRS.

Assign Location Reference Staff
Type: Process

Description: Identify or recruit Iowa DOT staff who will operate the LRS.

Conduct Location Reference System Training
Type: Process

Description: Develop training materials and provide instruction about LRS procedures and tools to Iowa DOT and other interested staff responsible for managing, operating, maintaining or using the LRS

Location Reference Maintenance
Type: Function

Description: Ongoing activities necessary to maintain the LRS databases and the interfaces to Iowa DOT operational systems.

Initialize LRS
Type: Process

Description: Establish the starting values for the LRS.

Establish LRS Controls
Type: Elementary Process
Not Repetitive
Online Implementation suggested

Description: Set and document LRS responsibilities, authority, and access permissions.

Establish LRS Parameters
Type: Elementary Process
Not Repetitive
Online Implementation suggested

Description: Set global parameters, units of measure and other system wide meta-data for the LRS.

Determine Transport System
Type: Elementary Process
Not Repetitive
Online Implementation suggested

Description: Determine the functionality, mode, extent and classification of a transportation system for the Department. There are many transport systems of interest including the state trunk system, individual county trunk and local systems, special systems such as scenic roads, transit and inter-modal systems. Each identified system is associated with one or more network models and is supported by a portion of the linear datum.

Establish Linear Datum
Type: Process

Description: Create, maintain and expand the linear datum and its components.

Design Linear Datum
Type: Process

Description: Determine the specifications for locating and describing anchor points and sections and measuring anchor section distances

Determine First Order Datum Design
Type: Elementary Process
Non-Repetitive
On-line Implementation Suggested

Description: Select the optimal configuration for the datum. That is, select the numbers and locations of datum and reference objects and the measurements (and measuring device) that will

be made using these. : Specify the linear accuracy and allowable degree of error propagation of the datum.
Reference: "A Methodology for Design of a Linear Referencing System for Surface Transportation," Vonderohe and Hepworth, 1997.

Determine Second Order Datum Design
Type: Elementary Process
Non-Repetitive
On-line Implementation Suggested

Description: Determine the optimum accuracy of the anchor span measurements.
Reference: "A Methodology for Design of a Linear Referencing System for Surface Transportation," Vonderohe and Hepworth, 1997.

Determine Third Order Datum Design
Type: Elementary Process
Non-Repetitive
On-line Implementation Suggested

Description: Determine the optimal measurements necessary to improve or expand an existing Datum.
Reference: "A Methodology for Design of a Linear Referencing System for Surface Transportation," Vonderohe and Hepworth, 1997.

Conduct Linear Datum Survey
Type: Process

Description: Carry out the fieldwork necessary to build the linear datum.

Plan Linear Datum Survey
Type: Process

Description: Determine the extent and order of the linear datum components to be established.

Prepare Measurement Device
Type: Process

Description: Adjust and calibrate distance measuring device.

Survey Linear Datum
Type: Process

Description: Establish field locations and distances for datum objects.

Place Anchor Point
Type: Elementary Process
Repetitive

On-line implementation suggested

Description: Using the datum design, locate and document Anchor Point in the field.

Monument Anchor Point
Type: Elementary Process
Repetitive

Description: Establish a permanent, recoverable monument at an anchor point location.

Measure Anchor Point Span
Type: Elementary Process
Repetitive
On-line implementation suggested

Description: Ascertain the linear, surface distance between two datum reference objects.

Determine Anchor Section Distance
Type: Elementary Process
Repetitive
On-line Implementation suggested

Description: Allocate anchor span distances to anchor sections.

Adjust Linear Datum
Type: Elementary Process

Description: Determine the most likely length of the anchor sections by distributing the measurement errors.

Position Linear Datum
Type: Process

Description: Attach Anchor Sections and Anchor Points to their appropriate cartographic representations.

Position Anchor Point
Type: Elementary Process
Repetitive
On-line Implementation suggested

Description: Position Anchor Points on top their appropriate cartographic representations as a frame of reference for Anchor Section placement.

Position Anchor Section
Type: Elementary Process

Repetitive
On-line Implementation suggested

Description: Attach Anchor Sections to their appropriate cartographic representations.

Publish Linear Datum
Type: Elementary Process
Repetitive
On-line Implementation suggested

Description: Approve and disseminate the datum database. This includes staging the database to the geo data warehouse.

Establish Route System
Type: Process

Description: Establish a network model (i.e., an ordered, topologically connected set of links and nodes) representing a transport system, including traversals through the network.

Determine Transport System Network
Type: Process

Description: Assemble the set of transport links and nodes that represent or model the transport system.

Add Transport Node
Type: Elementary Process
Repetitive
On-line Implementation Suggested

Description: Add a transport node to a transport system.

Add Transport Link
Type: Elementary Process
Repetitive
On-line Implementation Suggested

Description: Create a transport link between two transport nodes and add to a transport system.

Change Link State
Type: Elementary Process
Repetitive
On-line Implementation Suggested

Description: Change link state from open to closed or closed to open. That is, travel is allowed or not allowed through the link (open/closed). Also, change the direction of travel (one-way or bi-directional).

Change Node State
Type: Elementary Process
Repetitive
On-line Implementation Suggested

Description: Change node state from open to closed or closed to open. That is, travel is allowed or not allowed through the node.

Remove Transport Link
Type: Elementary Process
Repetitive
On-line Implementation Suggested

Description: Remove a transport link and link sequence from the data base (set the Link State to Retired).

Remove Transport Node
Type: Elementary Process
Repetitive
On-line Implementation Suggested

Description: Remove a transport node and node offset from the data base (set the Link State to Retired).

Establish System Route
Type: Process

Description: Create the route and its traversal through a transport system.

Assign Route Name
Type: Elementary Process
Non-Repetitive
On-line Implementation Suggested

Description: Add a signed route to the system.

Assemble System Route
Type: Process

Description: Create an ordered arrangement of transportation links for a transport system by route.

Add System Route Link
Type: Elementary Process
Repetitive
On-line Implementation Suggested

Description: Add a transport system route link to a route chain

Remove System Route Link
Type: Elementary Process
Repetitive
On-line Implementation Suggested

Description: Remove a transport system route link from a route chain

Remove Signed Route
Type: Elementary Process
Non-Repetitive
On-line Implementation Suggested

Description: Remove a signed route and all of its associated links.

Determine Route Link Distance
Type: Elementary Process
Repetitive
On-line Implementation Suggested

Description: Calculate the accumulative distance for each system route link from the beginning of a route to the end of the route.

Publish Transport System Route
Type: Elementary Process
Non-repetitive

Description: Approve and disseminate the transport routes database. This includes staging the database to the geo data warehouse.

Establish Linear Reference Method
Type: Process

Description: Set up the reference objects used for location reference methods.

Establish Reference Post
Type: Process

Description: Place, position, and publish fixed reference posts.

Place Reference Post

Type: Elementary Process
Repetitive
On-line Implementation Suggested

Description: Locate and monument (put the post there) a reference post along a transportation route (This is a field activity) Measurement is from datum reference object

Position Reference Post
Type: Elementary Process
Repetitive
On-line Implementation Suggested

Description: Attach a reference post to its appropriate LRS position (i.e., link offset).

Publish Reference Post
Type: Elementary Process

Description: Document and disseminate the location of a reference post. This process includes staging to the geo data warehouse.

Establish Station Post
Type: Process

Description: Place, position, and publish fixed station posts or pavement stamps.

Place Station Post
Type: Elementary Process
Repetitive
On-line Implementation Suggested

Description: Locate and monument (actually put the post or stamp) a station post or pavement stamp along a highway improvement project section. Measurement is according to project stationing.

Determine Project Section Location
Type: Elementary Process
Repetitive
On-line Implementation Suggested
Description: Describe the location of a project section to an anchor section.

Position Project Section
Type: Elementary Process
Repetitive
On-line Implementation Suggested

Description: Attach a project section to its appropriate LRS position.

Position Station Post
Type: Elementary Process
Repetitive
On-line Implementation Suggested

Description: Attach a station post to its appropriate project section position.

Publish Project Section
Type: Elementary Process

Description: Document and disseminate the location of a project section. This process includes staging to the geo data warehouse.

Publish Station Post
Type: Elementary Process

Description: Document and disseminate the location of a station post. This process includes staging to the geo data warehouse.

Establish Literal Description
Type: Process

Description: Identify and document intersection and non-intersection transportation features used as reference objects in the field.

Establish Reference Feature
Type: Elementary Process
Repetitive
On-line Implementation Suggested

Description: Identify a reference features object (i.e. bridges)

Publish Reference Feature
Type: Elementary Process
Repetitive
On-line Implementation Suggested

Description: Document and disseminate the location of a reference feature object. This process includes staging to the geo data warehouse.

Location Reference Operations
Type: Function

Description: Location Reference Operations are ongoing services available to Iowa DOT transportation information systems. They represent an interoperable relationship between legacy systems maintaining field location measurements or descriptions and the LRS.

Locate Transportation Assets
Type: Process

Description: Find the field position and LRS position of fixed transportation features.

Locate Pavement Section
Type: Process

Description: Find the field position and LRS position of a pavement section.

Determine Pavement Section Location
Type: Elementary Process
Repetitive
On-line Implementation Suggested

Description: Describe the field location of a pavement section using a reference method.

Position Pavement Section
Type: Elementary Process
Repetitive
On-line Implementation Suggested

Description: Determine the LRS position of a pavement section.

Publish Pavement Section Location
Type: Elementary Process
Repetitive
On-line Implementation Suggested

Description: Document and disseminate the location of a pavement section. This process includes staging to the geo data warehouse.

Locate HPMS
Type: Process

Description: Find the field position and LRS position of HPMS sections.

Determine HPMS Section Location
Type: Elementary Process
Repetitive
On-line Implementation Suggested

Description: Determine the field location of an HPMS section.

Position HPMS Section
Type: Elementary Process
Repetitive
On-line Implementation Suggested

Description: Determine the LRS position of an HPMS section.

Publish HPMS Section Location
Type: Elementary Process
Repetitive
On-line Implementation Suggested

Description: Document and disseminate the location of an HPMS section. This process includes staging to the geo data warehouse.

Locate Transportation Feature
Type: Process

Description: Find the field position and LRS position of fixed transportation objects and features (i.e. bridges).

Determine Transportation Feature Location
Type: Elementary Process
Repetitive
On-line Implementation Suggested

Description: Find the field position of a named transportation feature.

Position Transportation Feature
Type: Elementary Process
Repetitive
On-line Implementation Suggested

Description: Describe the LRS position of a named transportation feature.

Publish Transportation Feature Location
Type: Elementary Process
Repetitive
On-line Implementation Suggested

Description: Document and disseminate the location of a named transportation feature. This process includes staging to the geo data warehouse.

Locate Utility Feature

Type: Process

Description: Find the field position and LRS position of a utility feature within or crossing a transportation ROW.

Determine Utility Feature Location
Type: Elementary Process
Repetitive
On-line Implementation Suggested

Description: Find the field position of a utility feature within or crossing a transportation ROW.

Position Utility Feature
Type: Elementary Process
Repetitive
On-line Implementation Suggested

Description: Find the LRS position of a utility feature within or crossing a transportation ROW

Publish Utility Feature Location
Type: Elementary Process

Description: Document and disseminate the location of a utility feature within or crossing the ROW. This process includes staging to the geo data warehouse.

Locate Access Control Point
Type: Process

Description: Find the field position and LRS position of an access control point.

Determine Access Control Point Location
Type: Elementary Process
Repetitive
On-line Implementation Suggested

Description: Find the field position of an access control point using a location reference method.

Position Access Control Point
Type: Elementary Process
Repetitive
On-line Implementation Suggested

Description: Determine the LRS position of an access control point

Publish Access Control Location
Type: Elementary Process

Description: Document and disseminate the location of an access control point. This process includes staging to the geo data warehouse.

Locate Traffic Control Device
Type: Process

Description: Find the field position and LRS position of a traffic control device, such as a signal, sign or pavement marking.

Determine Traffic Control Device Location
Type: Elementary Process
Repetitive
On-line Implementation Suggested

Description: Find the field location of a traffic control device such as a signal, sign or pavement marking.

Position Traffic Control Device
Type: Elementary Process
Repetitive
On-line Implementation Suggested

Description: Determine the LRS position of a traffic control device.

Publish Traffic Control Device Location
Type: Elementary Process

Description: Document and disseminate the location of a traffic control device (e.g., sign, signal, meter, marking). This process includes staging to the geo data warehouse.

Locate GIMS Segment
Type: Process

Description: Find the field position and LRS position of fixed GIMS segments.

Determine GIMS Segment Extents
Type: Elementary Process
Repetitive
On-line Implementation Suggested

Description: Calculate the variable length extents of a GIMS segment.

Position GIMS Segment
Type: Elementary Process
Repetitive

On-line Implementation Suggested

Description: Determine the LRS position of a base record segment.

Publish GIMS Segment Extent
Type: Elementary Process

Description: Document and disseminate the location of a GIMS segment. This process includes staging to the geo data warehouse.

Locate Transportation Events
Type: Process

Description: Find the field position and LRS position of dynamic transportation objects or events

Locate Crash
Type: Process

Description: Find the field position and LRS position of a crash.

Determine Crash Location
Type: Elementary Process
Repetitive
On-line Implementation Suggested

Description: Describe the field location of a motor vehicle crash using a location reference method.

Position Crash
Type: Elementary Process
Repetitive
On-line Implementation Suggested

Description: Determine the LRS position of a motor vehicle crash.

Publish Crash Location
Type: Elementary Process

Description: Document and disseminate the location of a motor vehicle crash. This process includes staging to the geo data warehouse.

Locate Vehicle
Type: Process

Description: Find the field position and LRS position of dynamic transportation objects or events.

Determine Vehicle Location
Type: Elementary Process
Repetitive
On-line Implementation Suggested

Description: Measure the location of a vehicle using an AVL technology (e.g., GPS, inertial guidance).

Position Vehicle
Type: Elementary Process
Repetitive
On-line Implementation Suggested

Description: Determine the real-time position of a vehicle relative to the LRS and its cartographic representation.

Locate Improvement Project
Type: Process

Description: Find the field position and LRS position of a transportation improvement project.

Determine Improvement Project Location
Type: Elementary Process
Non-Repetitive
On-line Implementation Suggested

Description: Establish the project termini and stationing values for a highway improvement project.

Position Improvement Project
Type: Elementary Process
Non-Repetitive
On-line Implementation Suggested

Description: Find the LRS position of a highway improvement project.

Publish Improvement Project Location
Type: Elementary Process
Non-repetitive

Description: Document and disseminate the location of a highway improvement project. This process includes staging to the geo data warehouse.

Locate Video Log Trip
Type: Process

Description: Find the field position and LRS position of a video log record.

Determine Video Log Trip Location
Type: Elementary Process
Repetitive
On-line Implementation Suggested

Description: Record and synchronize the vehicle location to a video frame (or sequence) location.

Position Video Log Trip Location
Type: Elementary Process
Repetitive
On-line Implementation Suggested

Description: Find the LRS position of a video frame (or sequence).

Publish Video Log Trip Location
Type: Elementary Process
Repetitive
On-line Implementation Suggested

Description: Document and disseminate the location of video log imagery. This process includes staging to the geo data warehouse.

Location Reference System Monitoring
Type: Function

Description: Continuously audit and evaluate the performance of the LRS.

Audit Linear Reference Quality
Type: Process

Description: Monitor or test the quality (e.g., accuracy, timeliness, performance) of the LRS.

Design Quality Audit
Type: Process

Description: Establish uniform quality measures for the LRS.

Conduct Quality Audit
Type: Process

Description: Verify and validate the LRS attribute and relationship data.

Conduct Field Audit
Type: Process

Description: Verify and validate the linear offset distances used in the LRS.

Conduct Data Base Audit
Type: Process

Description: Verify and validate the coherency, completeness and accuracy of the LRS data.

Publish Quality Audit
Type: Process

Description: Document, approve, and publish the LRS quality report. Prepare the meta-data quality statement according to NSDI practice.

Evaluate Linear Reference System Performance
Type: Process

Description: Using the quality audit, system objectives and benchmarks, evaluate the overall performance of the LRS.

VIII. DATA AND PROCESS MODEL INTERACTION (CRUD)

The following CRUD matrixes are shown grouped by which processes are assigned to which LRS subsystem, and which entity types have an interaction with the processes. The first table groups datum entities versus datum subsystem processes. The second table, groups route entities versus route subsystem processes. The following two tables group the LRM entities versus LRM subsystem processes. The entire CRUD matrix is available as an EXCEL spreadsheet upon request.

In summary, the following LRMs will be deployed for the listed business areas, based on interviews with Iowa DOT.

Business Area	LRM used
Transportation feature	Literal Description, Stationing
Utility	Stationing, Reference Post
Access Control	Stationing, Reference Post
Traffic Control	Coordinate Route, Stationing, GIMS Segmental
Crash	Coordinate Route
Video Log	Coordinate Route

Table VIII-1: Entity Type versus LRS & Datum Processes

Elementary Process														
Entity Type	Establish LRS Controls	Establish LRS Parameters	Determine Transport System	Determine First Order Datum Design	Determine Second Order Datum Design	Determine Third Order Datum Design	Place Anchor Point	Monument Anchor Point	Measure Anchor Point Span	Determine Anchor Section Distance	Adjust Linear Datum	Position Anchor Point	Position Anchor Section	Publish Linear Datum
Anchor Control Section														
Anchor Point				**C**	**R**	**C**	**U**	**R**	**R**		**R**	**R**	**R**	**R**
Anchor Point Elevation							**C**							**R**
Anchor Point Monument								**C**						**R**
Anchor Section				**C**	**R**	**C**				**U**	**U**		**U**	**R**
Centerline													**U**	**R**

Elementary Process														
Entity Type	Establish LRS Controls	Establish LRS Parameters	Determine Transport System	Determine First Order Datum Design	Determine Second Order Datum Design	Determine Third Order Datum Design	Place Anchor Point	Monument Anchor Point	Measure Anchor Point Span	Determine Anchor Section Distance	Adjust Linear Datum	Position Anchor Point	Position Anchor Section	Publish Linear Datum
Centerline Anchor Section													**C**	**R**
GIMS Control Section														
HPMS Control Section														
Improvement Project				**C**										
Jurisdiction			**C**											
Linear Datum Version				**C**										**R**
Link State														
LRS Component	**C**													**R**
LRS Component Relationship	**C**													**R**
LRS Contact	**C**													**R**
Measurement Methods	**C**			**U**		**R**				**U**		**R**	**R**	
Node State														
Non-Intersection Feature														
Project Section														
Project Section Node														
Project Section Node Offset														
Project Section Sequence														
Reference Post														
Signed Route														
Station Post														
System Route Link														
System Wide Metadata		**C**												**R**
Transport Link														
Transport Link Sequence														
Transport Node														
Transport Node Offset														
Transport System			**C**											

Table VIII-2: Entity Type versus Route Processes

Elementary Process											
Entity Type	Add Transport Link	Change Link State	Change Node State	Remove Transport Link	Remove Transport Node	Assign Route Name	Add System Route Link	Remove System Route Link	Remove Signed Route	Determine Route Link Distance	Publish Transport System Route
Anchor Control Section											
Anchor Point											
Anchor Point Elevation											
Anchor Point Monument											
Anchor Section											**R**
Centerline											**R**
Centerline Anchor Section											**R**
GIMS Control Section											
HPMS Control Section											
Improvement Project											
Jurisdiction											
Linear Datum Version											
Link State		**C**		**D**							**R**
LRS Component											**R**
LRS Component Relationship											**R**
LRS Contact											**R**
Measurement Methods											
Node State			**C**		**D**						**R**
Non-Intersection Feature											
Project Section											
Project Section Node											
Project Section Node Offset											
Project Section Sequence											
Reference Post											
Signed Route						**C**	**R**		**D**	**R**	**R**
Station Post											
System Route Link				**R**			**C**	**D**	**D**	**U**	**R**
System Wide Metadata											

Entity Type	Add Transport Link	Change Link State	Change Node State	Remove Transport Link	Remove Transport Node	Assign Route Name	Add System Route Link	Remove System Route Link	Remove Signed Route	Determine Route Link Distance	Publish Transport System Route
	Elementary Process										
Transport Link	**C**	**U**		**D**	**R**		**R**			**R**	**R**
Transport Link Sequence	**C**			**D**							**R**
Transport Node	**R**		**U**		**D**						**R**
Transport Node Offset					**D**						**R**
Transport System						**R**	**R**		**R**	**R**	**R**

Table VIII-3: Entity Type and LRM Processes

Entity Type	Place Reference Post	Position Reference Post	Publish Reference Post	Place Station Post	Determine Project Section Location	Position Project Section	Position Station Post	Publish Project Section	Publish Station Post	Establish Reference Feature	Publish Reference Feature	Determine Pavement Section Location	Position Pavement Section	Publish Pavement Section Location	Determine HPMS Section Location	Position HPMS Section	Publish HPMS Section Location	Determine Transportation Feature Location	Position Transportation Feature	Publish Transportation Feature Location	Determine Utility Feature Location	Position Utility Feature	Publish Utility Feature Location
	Elementary Process																						
Anchor Control Section																**C**	**R**						
Anchor Point																							
Anchor Point Elevation																							
Anchor Point Monument																							
Anchor Section			**R**					**R**	**R**		**R**			**R**		**R**	**R**			**R**			**R**
Centerline			**R**					**R**	**R**		**R**			**R**			**R**			**R**			**R**
Centerline Anchor Section			**R**					**R**	**R**		**R**			**R**			**R**			**R**			**R**
GIMS Control Section																							
HPMS Control Section																**C**	**R**						

Elementary Process																								
Entity Type	Place Reference Post	Position Reference Post	Publish Reference Post	Place Station Post	Determine Project Section Location	Position Project Section	Position Station Post	Publish Project Section	Publish Station Post	Establish Reference Feature	Publish Reference Feature	Determine Pavement Section Location	Position Pavement Section	Publish Pavement Section Location	Determine HPMS Section Location	Position HPMS Section	Publish HPMS Section Location	Determine Transportation Feature Location	Position Transportation Feature	Publish Transportation Feature Location	Determine Utility Feature Location	Position Utility Feature	Publish Utility Feature Location
Improvement Project					**C**																		
Jurisdiction	**R**		**R**							**R**	**R**												
Linear Datum Version																							
Link State																							
LRS Component			**R**					**R**	**R**		**R**												
LRS Component Relationship			**R**					**R**	**R**		**R**												
LRS Contact			**R**					**R**	**R**		**R**												
Measurement Methods										**R**													
Node State																							
Non-Intersection Feature										**C**	**R**								**R**				
Project Section						**C**	**R**	**R**	**R**														**R**
Project Section Node						**C**		**R**															**R**
Project Section Node Offset						**C**		**R**															**R**
Project Section Sequence						**C**		**R**	**R**														**R**
Reference Post	**C**	**R**	**R**										**R**	**R**								**R**	**R**
Signed Route	**R**		**R**							**R**	**R**												
Station Post							**C**		**R**										**R**			**R**	**R**
System Route Link	**U**	**R**	**R**							**R**													**R**
System Wide Metadata																							
Transport Link																							**R**
Transport Link Sequence																							**R**
Transport Node										**U**	**R**								**R**				**R**
Transport Node Offset																							**R**
Transport System			**R**							**R**	**R**												

Table VIII-4: Entity Type versus LRM

Elementary Process																				
Entity Type	Determine Access Control Point Location	Position Access Control Point	Publish Access Control Point Location	Determine Traffic Control Device Location	Position Traffic Control Device	Publish Traffic Control Device Location	Determine GIMS Segment Extents	Position GIMS Segment	Publish GIMS Segment	Determine Crash Location	Position Crash	Publish Crash Location	Determine Vehicle Location	Position Vehicle	Determine Improvement Project Location	Position Improvement Project	Publish Improvement Project Location	Determine Video Log Trip	Position Video Log Trip	Publish Video Log Trip Location
Anchor Control Section					**R**	**R**		**C**	**R**											
Anchor Point																				
Anchor Point Elevation																				
Anchor Point Monument																				
Anchor Section			**R**			**R**			**R**			**R**		**R**	**C**	**R**	**R**			**R**
Centerline			**R**		**R**	**R**			**R**		**R**	**R**		**R**	**C**	**R**	**R**		**R**	**R**
Centerline Anchor Section			**R**		**R**	**R**			**R**		**R**	**R**		**R**	**C**	**R**	**R**		**R**	**R**
GIMS Control Section					**R**	**R**		**C**	**R**											
HPMS Control Section																				
Improvement Project															**R**		**R**			
Jurisdiction																				
Linear Datum Version																				
Link State																				
LRS Component									**R**								**R**			
LRS Component Relationship									**R**								**R**			
LRS Contact									**R**								**R**			
Measurement Methods																				
Node State																				
Non-Intersection Feature																				
Project Section			**R**			**R**									**C**	**R**	**R**			
Project Section Node			**R**			**R**										**C**	**R**			
Project Section Node Offset			**R**			**R**										**C**	**R**			
Project Section Sequence			**R**			**R**										**C**	**R**			
Reference Post		**R**	**R**																	
Signed Route					**R**	**R**					**R**	**R**		**R**					**R**	**R**
Station Post		**R**	**R**		**R**	**R**														
System Route Link			**R**		**R**	**R**					**R**	**R**		**R**					**R**	**R**
System Wide Metadata																				
Transport Link			**R**		**R**	**R**					**R**	**R**		**R**					**R**	**R**
Transport Link Sequence			**R**		**R**	**R**					**R**	**R**							**R**	**R**

Elementary Process																					
Entity Type	Determine Access Control Point Location	Position Access Control Point	Publish Access Control Point Location	Determine Traffic Control Device Location	Position Traffic Control Device	Publish Traffic Control Device Location	Determine GIMS Segment Extents	Position GIMS Segment	Publish GIMS Segment	Determine Crash Location	Position Crash	Publish Crash Location	Determine Vehicle Location	Position Vehicle	Determine Improvement Project Location	Position Improvement Project	Publish Improvement Project Location	Determine Video Log Trip	Position Video Log Trip	Publish Video Log Trip Location
Transport Node			**R**		**R**	**R**					**R**	**R**							**R**	**R**
Transport Node Offset			**R**		**R**	**R**					**R**	**R**							**R**	**R**
Transport System																				

IX. PROCESS AND SUBSYSTEM INTERACTION

This matrix assigns the responsibility of performing a process to a specific subsystem.

Table IX-1: Elementary Process per Subsystem

	SUBSYSTEM																		
Elementary Process	LRS Main	Coordinate	Linear Datum	Reference Marker	Route	Segmental	Stationing	Literal Description	Link/Node	Base Records	PMIS	HPMS Reporting	Pavement Mgmt Program	Video Log	Snow Plow Tracking	Maintenance Inventory	ALAS	Utilities	RDS
Establish LRS Controls	X																		
Establish LRS Parameters	X																		
Determine Transport System					X														
Determine First Order Datum Design			X																
Determine Second Order Datum Design			X																
Determine Third Order Datum Design			X																
Place Anchor Point			X																
Monument Anchor Point			X																
Measure Anchor Point Span			X																
Determine Anchor Section Distance			X																
Adjust Linear Datum			X																
Position Anchor Point			X																
Position Anchor Section			X																
Publish Linear Datum			X																
Add Transport Node					X														
Add Transport Link					X														
Change Link State					X														
Change Node State					X														
Remove Transport Link					X														
Remove Transport Node					X														
Assign Route Name					X														
Add System Route Link					X														
Remove System Route Link					X														

	SUBSYSTEM																		
Elementary Process	LRS Main	Coordinate	Linear Datum	Reference Marker	Route	Segmental	Stationing	Literal Description	Link/Node	Base Records	PMIS	HPMS Reporting	Pavement Mgmt Program	Video Log	Snow Plow Tracking	Maintenance Inventory	ALAS	Utilities	RDS
Remove Signed Route					X														
Determine Route Link Distance					X														
Publish Transport System Route					X														
Place Reference Post				X															
Position Reference Post				X															
Publish Reference Post				X															
Place Station Post																			X
Determine Project Section							X												
Position Project Section							X												
Position Station Post							X												
Publish Project Section							X												
Publish Station Post							X												
Establish Reference Feature								X											
Publish Reference Feature								X											
Determine Pavement Section Location											X								
Position Pavement Section				X															
Publish Pavement Section Location				X															
Determine HPMS Section Location												X							
Position HPMS Section						X													
Publish HPMS Section Location						X													
Determine Transportation Feature Location																?			
Position Transportation Feature								X											
Publish Transportation Feature Location								X											
Determine Utility Feature Location																?		?	?
Position Utility Feature							X												
Publish Utility Feature							X												

	SUBSYSTEM																		
Elementary Process	LRS Main	Coordinate	Linear Datum	Reference Marker	Route	Segmental	Stationing	Literal Description	Link/Node	Base Records	PMIS	HPMS Reporting	Pavement Mgmt Program	Video Log	Snow Plow Tracking	Maintenance Inventory	ALAS	Utilities	RDS
Location																			
Determine Access Control Point Location																X			
Position Access Control Point							X												
Publish Access Control Point Location							X												
Determine Traffic Control Device Location																X			
Position Traffic Control Device							?												
Publish Traffic Control Device Location							?												
Determine Base Record Extents										X									
Position Base Record						X													
Publish Base Record Location						X													
Determine Crash Location																	X		
Position Crash		?						?											
Publish Crash Location		?						?											
Determine Vehicle Location															X				
Position Vehicle		X																	
Determine Improvement Project Location																			X
Position Improvement Project							X												
Publish Improvement Project Location							X												
Determine Video Log Trip														X					
Position Video Log Trip					X														
Publish Video Log Trip Location					X														