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***Implementing the Colorado Department of
Transportation (CDOT)'s Roadway Geodatabase -
Theory Versus Reality***

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Presentation Overview

- ② **Roadway GeoDatabase (RGDB) Project Goals**
- ② **Overview of Databases**
- ② **Project History**
- ② **Measures in the RGDB**
- ② **Traversals and State Highways**
- ② **Other Issues**

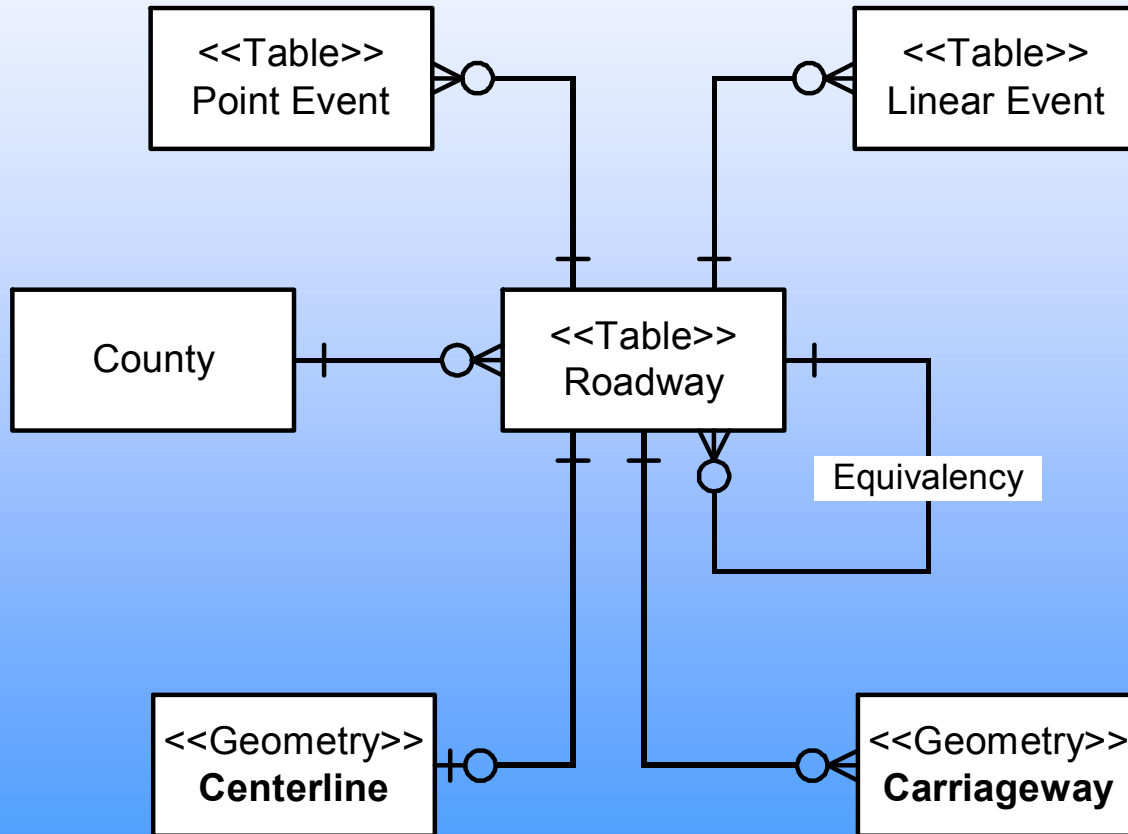
Project Goals

- ② **Adhere to principles and business rules**
- ② **Data model for the editing environment**
- ② **Editing vs. Publication**
- ② **Integrate geographic and tabular data for roadways and jurisdictions into one database**
- ② **Position the geodatabase that we build using ArcSDE/Oracle to become an enterprise database**
- ② **Enable on-going work to continue while migration data model and procedures are developed**

Roadway Geodatabase

- Ⓢ Roadway is a facility in the real world
- Ⓢ Roadways in the geodatabase own their abstractions, attributes, and geometric representations
- Ⓢ Fully normalized
 - No redundancies
 - No derived elements
- Ⓢ Continuous versioning through date stamps
- Ⓢ Be able to reconstruct state of database at any point in time
- Ⓢ Record-level metadata
- Ⓢ Single format (geodatabase)
- Ⓢ Server located in editing staff's office

Basic Roadway Geodatabase Logical Data Model



Publication Databases

- ② **Used by read-only applications**
- ② **Denormalized subsets of editing database**
- ② **Multiple data formats**
- ② **Derived and calculated fields**
- ② **Periodic update with certified data (discrete versioning)**
- ② **Server(s) located in central IT shop**

Project History

- ④ **Geodatabase Logical Data Model – Editing Environment – July ‘03**
- ④ **Application Requirements & Geodatabase Physical Data Model – Nov. ‘03**
- ④ **Pilot Data Migration – Completed and Validated – May ‘04**
- ④ **Data Migration Project – June ‘05 (Consultant Finished)**
- ④ **Key Staffing Changes – Summer ‘05**
- ④ **Migration Implementation Starts – Summer ‘05**
- ④ **Roadway Editor Project Starts – Jan. ‘06**
- ④ **Migration Recovery – July ‘06 to Oct. ‘06**
- ④ **Migration Implementation Restarts – Oct. ‘06**
- ④ **Roadway Editor Project Restarts – Apr. ‘07**

Varieties of Measures

- ② **Reference Points**
- ② **Measured Roadway Segment Lengths**
- ② **Anchor Points, Anchor Segments**
- ② **Arc Measures (“M” values)**
- ② **Calibration Points (and Segments)**
- ② **Mile Groups**
- ② **Arc Feature Length**

Categories of Measures

Ⓢ **Measures *Along* a Roadway**

- Reference Points
- Arc Measures (“M” values)
- Calibration Points

Ⓢ **Measures *Of* a Roadway**

- Measured Roadway Segment Lengths
- Arc Feature Lengths

Ⓢ **Measure Control**

- Anchor Points, Anchor Segments
- Mile Groups
- Calibration Segment

Anchor Point



Requirements of and Problems with Measures

② Measures *Along* a Roadway

- Reference Points Remain Fixed Once Established
- Arithmetic Differences (ToRefPt – FromRefPt) CANNOT Be Used as a Roadway Length Measure
- These first two requirements are CDOT Business Rules
- Calibration Points Become Anchor Points When Applied To Roadway Centerlines

② Measures *Of* a Roadway

- Measured Roadway Segment Lengths Must Be Preserved Across All Kinds of Roadway Segmentation
- Arc Feature Lengths Are Useful Only For Dynamic Segmentation

② Measure Control

- Anchor Points Are Not Very Densely Found – Can Increase Length Errors
- Mile Groups – More Dense and Tied to Mile Post Locations
- Calibration Segments – Most Dense, but Termini May Be Hard to Find in the Field or on Aerial Photograph

HPMS Impacts

Ⓢ HPMS Sample Segment Termini

- About Two-Thirds of Samples Along State Highways Can Be Found in the Field
- For Samples Along Other Public Roadways (Off-System), Many Termini Are Located At Municipal Boundaries
- Many Municipal Boundaries Have Varying Accuracies

Ⓢ HPMS Sample Segment Lengths

- Measured Roadway Segment Lengths Must Be Preserved For HPMS Sample Segments
- Within a Sample Segment, Some Segment Lengths Can Vary

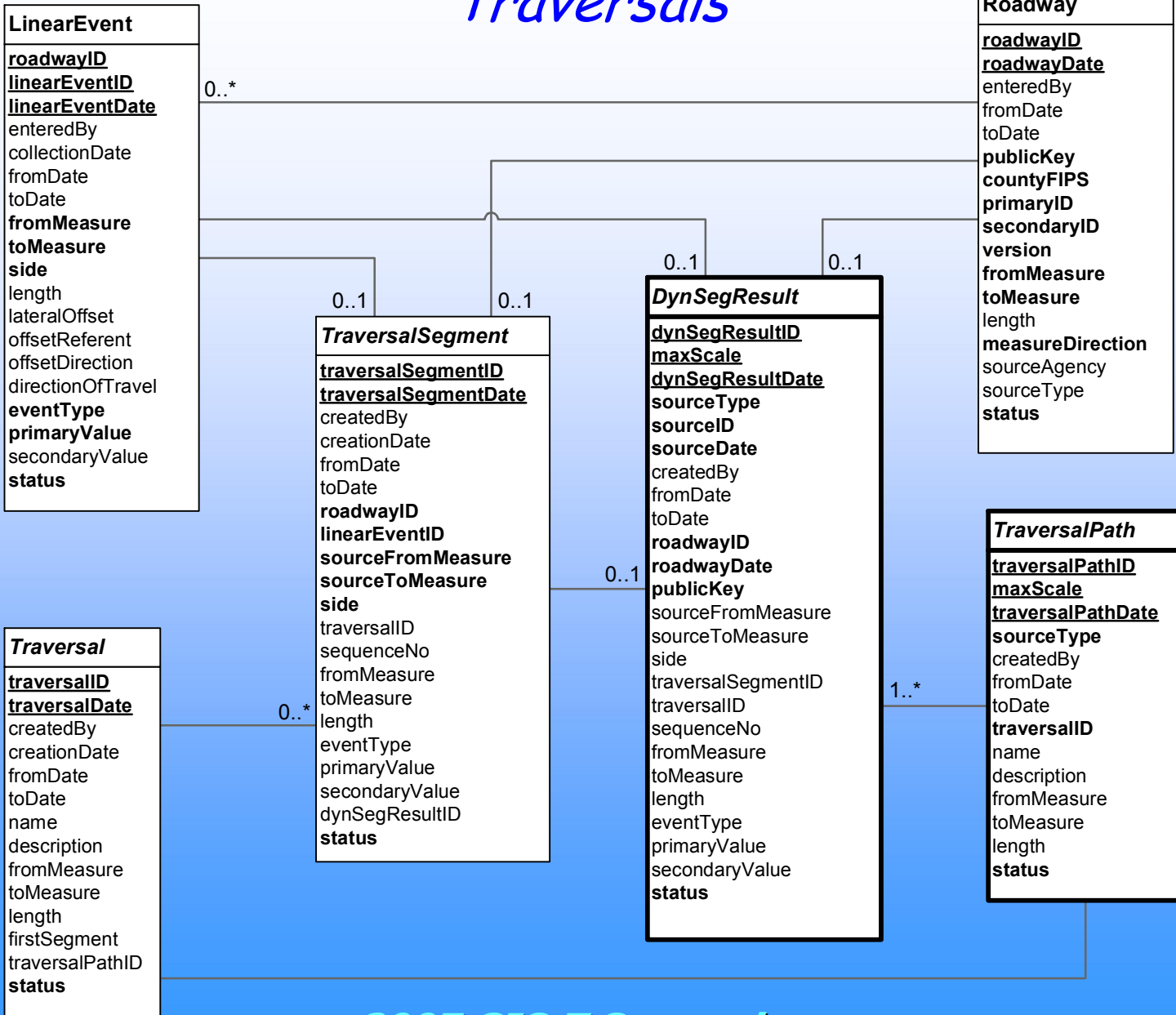
Ⓢ Measure Control Solutions

- Determine Accuracy Requirements For Reported Lengths
- Place Markers Along the Highways Where HPMS Sample Segments Previously Did Not Have a Controlled Terminus Location
- Revise HPMS Sample Segments to Place All Termini At Controlled Location

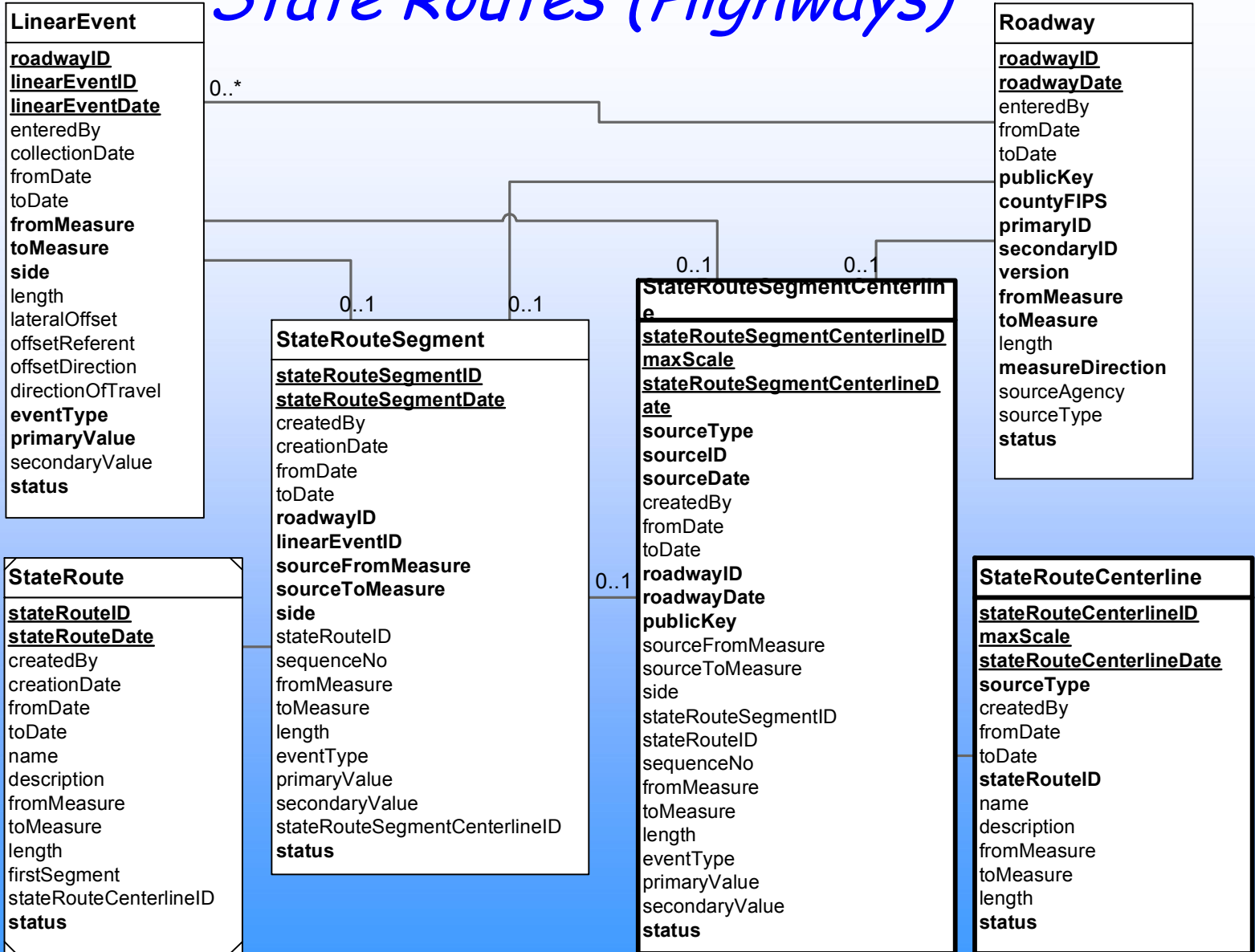
Highway Routes & Roadways

- ④ **Highway Route –** Numbered and signed traversal along a continuous linear sequence of roadways. Has a linear reference system containing reference values assigned along the route. Reference values increase in one travel direction.
- ④ **Roadway –** Physical feature supporting automotive conveyance. Uses a unique public key as its identifier. Highway routes utilize sequences of roadways to define their path through the state.

Traversals



State Routes (Highways)



Implementing Event Extensions

- ① **Event (Linear or Point) Contains a Primary and Secondary Attribute for Each Event Record**
- ① **Event Extension Is a Separate Object Class That Enables Several Attributes to Apply to a Single Event**
- ① **Challenge: Which Event Types Should Be Represented by Event Extensions?**
 - **Speed Limit** **No**
 - **HPMS** **Yes**
 - **Pavement Condition** **Yes**
 - **Traffic Segment** **TBD**

GIS or RDBMS Technology

- ② **Within the Roadway GeoDatabase, Both Are Essential**
- ② **Implementing Business Rules Within the RGDB**
 - **Topology Rules**
 - **Relational Integrity & Cardinality Rules**
 - **Coded Value Domains and Value Ranges**
 - **Rules That Apply to More Than One Event Value**

Documentation is Essential

Ⓢ Needed because:

- **Developers Need to Know What the Project Expects**
- **Managers Need to Have Ways to Measure Success, and to Detect When the Project is Off Track**
- **Staff Can Change During the Life of the Project**
- **Organization's Knowledge Must Be Captured and Preserved**

Ⓢ Resisted because:

- **Developers Like to Design, Write, and Run Software, and Don't Like to Document**
- **Time or Money Runs Out**

Ⓢ **A Solution: Document First! Use Spiral Approach.**

Ⓢ **Warning: Too Much Documentation Can Be Just As Bad As Having No Documentation**

Changes in Staff and Technology

⑩ **Technology Changes**

- **Additional Features to GeoDatabases Can Eliminate Some Implementation**
- **ESRI Does Not Provide Strict Upward Compatibility**
- **Key RDBMS Features Are Not Visible / Accessible Thru GeoDatabase Interfaces**
- **Can Use RDBMS Features Separate From GeoDatabases, But Be Careful**

⑩ **Staff Changes**

- **Key Staff Have Departed**
- **Contracts and Task Orders End**
- **Key Consultant Staff Departed**
- **Staff Grow Into New Roles and Responsibilities**

Summary

- ② **For CDOT, Preserving and Recording Correct Measured Roadway Segment Lengths Was an Unmet Need from the Original Migration Process**
- ② **Conceptually Difficult Data Structures and Migration Process Require More of Staff**
- ② **Theory Embodied Within an Excellent GeoDatabase Design Can Hide Implementation Details That Cost Time and Money**
- ② **Don't Let the Issues Get You Down**
- ② **It's (*STILL*) Happening at CDOT!**