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16. Abstract

The Texas Department of Transportation (TxDOT) is responsible for managing 1.1 million acres of land that provide right of way for approximately 80,000 centerline miles of state-maintained roads. Management of the huge right of way asset involves considerable resources and the integration of numerous business processes. There is an urgent need to develop a right of way asset data architecture to facilitate the inventory and management of TxDOT right of way assets. This architecture would facilitate the identification of current right of way boundaries, tracking of right of way boundary changes, automatic mapping of right of way surveying data to other layers of information such as control section job and route number locations, and complete attribution of right of way assets. It would also simplify the production of reports, including those needed to address financial reporting requirements.

As part of the research, the researchers evaluated current right of way data practices at TxDOT and other agencies, and developed and tested a prototype geographic information system (GIS)-based right of way asset data model. The data model included a logical model, a physical model, and data dictionary, following current TxDOT data architecture standards and findings from recent research and implementation projects.

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RIGHT OF WAY REAL PROPERTY ASSET MANAGEMENT – PROTOTYPE DATA ARCHITECTURE

by

Cesar Quiroga, P.E.
Research Engineer
Texas Transportation Institute

Edgar Kraus, P.E.
Assistant Research Engineer
Texas Transportation Institute

Nicholas Koncz
Assistant Research Scientist
Texas Transportation Institute

Stacey Lyle, R.P.L.S.
Associate Professor
Texas A&M–Corpus Christi

and

Yingfeng Li
Assistant Research Scientist
Texas Transportation Institute

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TEXAS TRANSPORTATION INSTITUTE
The Texas A&M University System
College Station, Texas 77843-3135

DISCLAIMER

The contents of this document reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the Federal Highway Administration (FHWA) or the Texas Department of Transportation (TxDOT). This document does not constitute a standard, specification, or regulation, nor is it intended for construction, bidding, or permitting purposes. The engineer in charge of the project was Cesar Quiroga, P.E. (Texas Registration #84274).

The United States Government and the State of Texas do not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the object of this report.

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AADT	Annual Average Daily Traffic
AASHTO	American Association of State Highway and Transportation Officials
ADOT	Arizona Department of Transportation
ALAS	Aeronautical Land Acquisition System
API	Application Programming Interface
BLM	Bureau of Land Management
CAD	Computer Aided Design
CAF	Combined Adjustment Factor
Caltrans	California Department of Transportation
CC	Carbon Copy
CCSJ	Controlling Control Section Job
CD	Compact Disk
CLMS	Caltrans Land Management System
COTS	Commercial-off-the-Shelf
CSDGM	Content Standard for Digital Geospatial Metadata
CSJ	Control Section Job
DCIS	Design and Construction Information System
DFO	Distance from Origin
DOT	Department of Transportation
EDMS	Enterprise Document Management System
EDTIS	Electronic Document Technologies Implementation and Support
ELMS	Excess Land Management System
ER	Entity Relationship
ESRI	Environmental Systems Research Institute
FGDC	Federal Geographic Data Committee
FHWA	Federal Highway Administration
FIG	International Federation of Surveyors (Fédération Internationale des Géomètres)
FK	Foreign Key
FM	Farm to Market
FOA	Fiscal Operation and Administration
GAIP	GIS Architecture and Infrastructure Project
GASB	Governmental Accounting Standards Board
GENII	Genesis Enterprise Information Integrator
GIS	Geographic Information System
GPS	Global Positioning System
GUI	Graphical User Interface
ID	Identifier
IDOT	Illinois Department of Transportation
IRIS	Integrated Realty Information System
IRWIN	Integrated Right of Way Information Network
IRWS	Integrated Right of Way System
LAS	Land Acquisition System
LIS	Land Information System

LPA	Local Public Agency
LPAFA	Local Project Advance Funding Agreement
MAFA	Master Agreement Governing Local Transportation Project Advance Funding Agreements
MDOT	Maryland Department of Transportation
Mn/DOT	Minnesota Department of Transportation
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
MST	Main Street Texas
NCHRP	National Cooperative Highway Research Program
NDOT	Nevada Department of Transportation
NMDOT	New Mexico Department of Transportation
NILS	National Integrated Land System
NOAA	National Oceanic and Atmospheric Administration
NORWAY	Non-operating Highway Right of Way
NSDI	National Spatial Data Infrastructure
ODOT	Oregon Department of Transportation
OGC	Open Geospatial Consortium
PATS	Parcel Acquisition and Tracking System
PDF	Portable Document Format
PDP	Project Development Process
PennDOT	Pennsylvania Department of Transportation
PLSS	Public Land Survey System
PS&E	Plans, Specifications, and Estimates
REALMS	Right of Way Electronic Acquisition Land Management System
REIS	Real Estate Information System
REMIS	Real Estate Management Information System
ROI	Return on Investment
ROW	Right of Way
ROWIS	Right of Way Information System
RPLS	Registered Professional Land Surveyor
RUMS	Right of Way Utility Management System (Caltrans) Right of Way and Utilities Management System (Virginia Department of Transportation)
RWDMS	Right of Way Data Management System
RWMIS	Right of Way Management and Information System
RWPS	Right of Way Property System
SH	State Highway
SQL	Structured Query Language
STIP	Statewide Transportation Improvement Program
StratMap	Texas Strategic Mapping Program
SUE	Subsurface Utility Engineering
TBPLS	Texas Board of Professional Land Surveyors
TIF	Tagged Image File
TNRIS	Texas Natural Resources Information System
TRM	Texas Reference Marker

TRMEOY	Texas Reference Marker End of Year
TSID	TxDOT System Interface Diagram
TSPS	Texas Society of Professional Surveyors
TTI	Texas Transportation Institute
TxDOT	Texas Department of Transportation
UACT	Utility Accommodation and Conflict Tracker
UIR	Utility Installation Review
US	U.S. Highway
USFS	U.S. Department of Agriculture Forest Service
VDOT	Virginia Department of Transportation
WMS	Web Mapping Service
WSDOT	Washington Department of Transportation

CHAPTER 1. INTRODUCTION

The Texas Department of Transportation (TxDOT) manages about 1.1 million acres of land that provide right of way for approximately 80,000 centerline miles of state-maintained roads. Management of the huge right of way (ROW) asset involves considerable resources and integration of numerous business processes, such as determining right of way boundaries; inventorying roadside features; preparing right of way maps; buying, selling, and leasing assets; regulating the accommodation of utilities within the right of way; and preparing reports documenting right of way assets. In general, ready access to right of way asset data, as is the case for other core data at TxDOT, is a key requirement not just for streamlining project delivery but also throughout the life of a transportation facility. Furthermore, asset reporting is a codified requirement in the Texas Government Code (§ 2101.011) (*1*), which supports the use of Governmental Accounting Standards Board (GASB) accounting principles (*2*).

The amount of right of way data that districts produce is growing steadily. However, many factors decrease the long-term usefulness of the data. For example, districts frequently manage right of way maps that go back many years and that, for one reason or another, have not been updated to reflect current conditions on the ground. Many of these maps may not be compliant with current surveying and/or drawing standards, and may be in a variety of storage media (e.g., old paper rolls) that limit the usability of the information. These inefficiencies can result in redundant data collection efforts, unnecessary project delays, and asset management difficulties throughout the life of the right of way assets.

There is a need to develop a prototype right of way asset data architecture to facilitate the inventory and management of TxDOT right of way assets. This architecture would facilitate the identification of current right of way boundaries, tracking of right of way boundary changes, automatic mapping of right of way surveying data to other layers of information such as control section job and route number locations, and complete attribution of right of way assets. It would also simplify the production of reports, including those needed to address financial reporting requirements.

The purpose of the research was to develop a prototype data architecture for the management of right of way assets in a geographic information system (GIS)-based environment. The research resulted in two products:

- 0-5788-P1 (included on the compact disk [CD] with this report) includes the prototype architecture's logical and physical data models, data dictionary, and sample data.

- 0-5788-P2 (included in Chapter 6 of this report) includes recommendations for implementation.

This report (0-5788-1) summarizes the work completed to develop the prototype right of way asset data architecture. The report is organized as follows:

- Chapter 1 (this introductory chapter),
- Chapter 2 (practices at TxDOT),

- Chapter 3 (practices at other agencies),
- Chapter 4 (prototype right of way asset data model),
- Chapter 5 (prototype data model testing process), and
- Chapter 6 (conclusions and recommendations for implementation).

CHAPTER 2. RIGHT OF WAY ASSET DATA MANAGEMENT PRACTICES AT TXDOT

RIGHT OF WAY ASSET PROPERTY RIGHTS AND ENCUMBRANCES

According to the Texas Property Code, "an estate in land that is conveyed or devised is a fee simple unless the estate is limited by express words or unless a lesser estate is conveyed or devised by construction or operation of law" (*3*). The state does not always have fee simple on the right of way it uses for transportation purposes. In fact, TxDOT routinely excludes subsurface mineral rights from the deed. According to TxDOT Form ROW-N-14 ("Deed"), grantors reserve all the oil, gas, and sulphur rights in and under the land conveyed to TxDOT (*4*). However, the grantors waive all access rights to the surface for exploring, developing, mining, or drilling those mineral resources.

TxDOT also uses Form ROW-N-21 ("Release of Mineral Surface Rights") to document that the seller has agreed to waive all surface rights in cases where the mineral estate has been severed from the surface estate and the acquisition is in an area of active mining operations (*5*). If there is a previous lease to a third party covering the oil, gas, and sulphur rights, TxDOT uses Form ROW-N-85 ("Subordination of Mineral Lease") (*6*) to ensure that the lessee subordinates all surface rights to the state while retaining the right to maintain and operate existing gathering lines. For controlled-access facilities, TxDOT uses Form ROW-N-88 ("Subordination of Mineral Lease (Controlled Access Highway Facility)") that limits access to the lessee's facilities from the frontage roads, adjacent public roads and streets, or trails connecting to an intersecting road (*7*).

Confirming the property rights TxDOT has on a piece of property can be challenging. For example, there might not be enough documentation to prove TxDOT's ownership of the right of way, even though a state-maintained road has been in operation for many years. Typical examples of this type of situation are roads that counties transferred to TxDOT decades ago but for which details and documentation associated with the transfer were lost over the years, including whether there was a title transfer to TxDOT.

For consistency throughout the report, this section includes a few basic definitions related to the use of parcels and property rights at TxDOT:

- **Parcel**. A parcel is a contiguous area of land described by a deed (therefore contained in a single description). TxDOT uses a standardized procedure for setting up and numbering right of way parcels (*8*). For example, in the case of urban projects, the main criterion to set up parcels is unity of use, in such a way that if two or more lots have a unity of use, it is possible to combine those lots into one parcel number. For rural projects, the focus is normally the parent tract (a single property not divided by a public way or platted as a subdivision).

- **Boundary line**. A boundary line is an imaginary line that provides demarcation between two adjacent land parcels. At TxDOT, it is customary to call the boundary line that separates the highway right of way from adjacent property the right of way line.

- **Real property interest**. Real property interest is a legal right (i.e., a right created or recognized by law) that someone has on real property. Real property refers to the land (including the surface, air space, and what lies beneath the surface, e.g., minerals) as well as structures such as buildings, utility installations, and other appurtenances. Normally, the distinction is between real property (i.e., land and things attached to it) and personal property (anything else, e.g., money, furniture, and clothing). Real property and real estate are synonyms.

- **Fee simple**. Fee simple is the most complete real property interest, in which the owner has the right to *use*, *possess*, and *transfer* the real property at will. Some basic government functions can limit fee simple rights, such as taxation, eminent domain, police power, and escheat (i.e., when a property is transferred to the state because the owner dies without a will and without heirs).

- **Lease**. A lease is the temporary right to *possess* and *use* property (real or personal), usually in exchange for payment. The two parties in a lease are the *lessor* and the *lessee* (or tenant).

- **Easement**. An easement is the right to *use* the real property of another for a specific purpose, mostly in connection with right of way needs. The two parties in an easement are the *grantor* and the *grantee*.

- **License**. A license is the right to *use* the property of another for a specific purpose. Unlike an easement, a license can be revoked. The two parties in a license are the *licensor* and the *licensee*.

- **Access right**. An access right is the right to enter or exit a right of way from an adjacent property. In general, the right of access to an existing state highway is part of the rights an adjacent property owner has (*9*). However, the state can regulate, limit, or deny this right under the state's police power. If there is a loss of access, the affected property owner may be entitled to compensation. TxDOT has the ability to purchase access rights from adjacent property owners, e.g., on frontage roads of controlled-access facilities within a certain distance around exit ramps (*9*). If an existing road is converted to a controlled-access facility, compensation for damages is possible unless the design includes frontage roads and the adjacent property owner is provided access to those frontage roads. In cooperation with TxDOT, local municipalities or metropolitan planning organizations can also develop access management plans for specific state highway segments for corridor preservation purposes (*10*). Priority in developing corridor access management plans is on facilities that have high traffic volumes or provide important statewide or regional connectivity and mobility.

  In some cases, adjacent property owners may not claim damages for denial of access. For example, under provisions in the Transportation Code (*11*), the state denies adjacent property owners access to any controlled-access highway at new locations, unless there is a specific grant of access (*9*). Adjacent property owners may not claim damages for denial of access because the road, and therefore the access right, did not exist previously.

(Note: The *Right of Way Manual* [*9*] describes the procedure to follow in the case of "uneconomic remainders" after partial property acquisitions.)

- **Denial of access line**. A denial of access line is an imaginary line (that generally coincides with the right of way line) that depicts specific locations where TxDOT does not allow access to the state right of way from an adjacent property. Note: Right of way maps must show denial of access lines. In the past, the location of these lines was frequently wrong or missing on right of way maps. One of the results was that district maintenance sections would issue driveway access permits in areas of denied access. To avoid such mistakes, some districts use original deeds to verify the information on the right of way maps. Furthermore, beginning in 2004, there is a new deed form that references access restrictions to the parcel's property description (*8*).

- **Mineral right**. A mineral right is the legal right to explore, drill, extract, and use the minerals found in a property. In general, a mineral is any inorganic substance or compound, including metals, oil, gas, sulfur, and water. It is customary to handle water rights separately from other mineral rights. Note: Road materials such as stone, earth, gravel, caliche, and iron ore gravel are not considered minerals. When the grantor reserves title to minerals, the reservation does not include road materials (*8*).

- **Water right**. A water right is the legal right to explore, drill, extract, and use the water found in a property. The water rights associated with a right of way parcel are normally transferred to the state at the time TxDOT acquires the parcel. The standard TxDOT deed form does not specifically indicate that water rights remain with the previous parcel owner (as opposed to mineral rights such as oil, gas, and sulphur, which are rights TxDOT typically does not acquire) (*4*). In recent years, water districts, irrigation districts, and counties have approached TxDOT expressing interest in purchasing or leasing water rights from TxDOT to increase their permit acreage. There is also discussion within TxDOT regarding the possibility of selling water rights using the right of way surplus sale tool.

  In the case of right of way easements, TxDOT has a provision in Form ROW-N-15 ("Right of Way Easement") that enables the department to take and use water (as well as other road building materials such as stone, earth, and gravel) needed for the construction and maintenance of highway facilities without additional compensation to the easement grantor (*12*).

- **Mineral surface right**. A mineral surface right is the right to enter and exit the surface for the purpose of exploring, developing, mining, or drilling a mineral right. For owners who retain mineral rights when TxDOT acquires land (and the mineral rights have not been separated from the surface rights), TxDOT normally requires grantors to waive their mineral surface rights, forcing those grantors to explore or recover minerals from a point outside of the property. If the mineral estate has been separated from the surface estate, the surface estate owner cannot waive the right of the mineral estate owner to use the surface to reasonably develop the mineral estate. In this case, the state needs to negotiate with the mineral right owner.

- **Pass**. A pass is a right to cross the right of way. TxDOT handles passes on a case-by-case basis and relies on permits, contractual agreements with the state, or as provided in the right of way conveyance to the state. TxDOT normally handles three categories of passes: passes that are automatically available due to drainage need, passes warranted to meet safety needs, and remaining passes where dual appraising is necessary to determine justification and cost participation. Note: If the grantee sells his/her property rights on one side of the highway, the pass right ceases to exist.

- **Fence**. A fence is a structure that restricts or prevents movement across a boundary. Types of fences relevant to this research include control of access fences and property fences. A control of access fence is an integral component of a highway facility located along or immediately inside control of access lines or as a safety measure to prevent the intrusion of people, animals, or equipment from outside the right of way (*8*). Normally, TxDOT builds and maintains control of access fences. A property fence is a fence that property owners build and maintain. TxDOT handles the replacement of property fences along the right of way during the right of way acquisition process as a "cost to cure" item (*13*).

- **Monument**. A monument is "any object or collection of objects (physical, natural, artificial) that indicates the position on the ground of a survey station" (*14*). According to the *TxDOT Survey Manual* (*15*), it is necessary to set aluminum caps stamped "TxDOT ROW" with 1/2-inch or 5/8-inch diameter rebar at all property corners, angle points, and points of curvature and tangency. Note: Districts also set access caps (labeled "beginning denial-of-access" and "end denial-of-access") to mark denial of access locations in the field.

- **Improvement**. An improvement is any structure or valuable addition to property. When TxDOT acquires right of way for a project, it acquires the responsibility not just for the land but also for the improvements on the land. TxDOT does not necessarily acquire all improvements included in the approved value (*16*). However, if a seller fails to remove an improvement originally retained by the seller and, as a result, the improvement becomes TxDOT property, it is necessary to include that improvement in the inventory of improvements to track until final disposition. In the case of condemned parcels acquired in fee, TxDOT acquires title to all improvements (unless the final judgment includes an expressed finding to the contrary).

- **Encroachment**. An encroachment is "any obstruction intruding upon the property of another" (*13*). Examples of possible encroachments include aerial encroachments (such as overhead electric and telephone lines with cross arms), fences, rock walls, guy wires, driveways, underground utility installations, and sidewalks. Note: Districts sometimes use leases to deal with existing encroachments.

- **Deed**. A deed is a legal document that grants a privilege. In the context of real property transactions, a deed is the instrument that conveys the interest in real property from one person to another. There are several types of deeds, such as warranty deeds, deeds

without warranty, quitclaim deeds, and donation deeds. A warranty deed is a deed that explicitly provides a warranty that the seller has title to the property. Two types of warranty deeds are general warranty deeds and special warranty deeds. TxDOT prefers general warranty deeds but might accept special warranty deeds on a case-by-case basis. A deed without warranty is a deed that makes no warranties of title (i.e., the seller has no liability for title defects). A quitclaim deed is a deed that operates as a release of any interest that a grantor has in the property. Quitclaim deeds do not warrant title or possession.

- **Agreement**. An agreement is a legal contract between two or more parties that outlines rights and responsibilities. There are many types of agreements. Of particular interest to this review are joint use agreements, multiple use agreements, and contractual agreements:

    - A joint use agreement allows TxDOT to use right of way owned by other agencies (e.g., cities, counties, and railroad companies) in situations where purchasing right of way would be extremely difficult to accomplish or where purchasing right of way would involve assuming maintenance of existing utility installations or other improvements. Note: There are also joint use agreements between utility companies, where one of the utilities has a property interest (typically between utility pole owners and utility pole users) (*17*).

    - A multiple use agreement is an agreement that allows the use of TxDOT right of way for purposes other than highway purposes. Examples of multiple use agreements are agreements with political subdivisions, state, or federal agencies for uses such as parking lots, hike and bike trails, or boat ramps that do not interfere or cause detriment to the use of the highway facility.

    - A contractual agreement is an agreement between TxDOT and a local public agency (LPA), which outlines the responsible party in charge of right of way acquisition. With the exception of interstate highways, LPAs are responsible for right of way acquisition (unless the LPA requests TxDOT to assume that function). Note: The TxDOT Contract Services Office has implemented a new procedure for use in conjunction with contractual agreements. The new procedure includes two agreements: a Master Agreement Governing Local Transportation Project Advance Funding Agreements (MAFA) and a Local Project Advance Funding Agreement (LPAFA).

RIGHT OF WAY ASSET-RELATED ACTIVITIES IN THE PROJECT DEVELOPMENT PROCESS AT TXDOT

The project development process (PDP) at TxDOT includes six general groups of activities, which may vary in scope and duration depending on project requirements (*18*) (Figure 1):

- planning and programming,
- preliminary design,

- environmental,
- right of way and utilities,
- project specifications and estimate (PS&E) development, and
- letting.

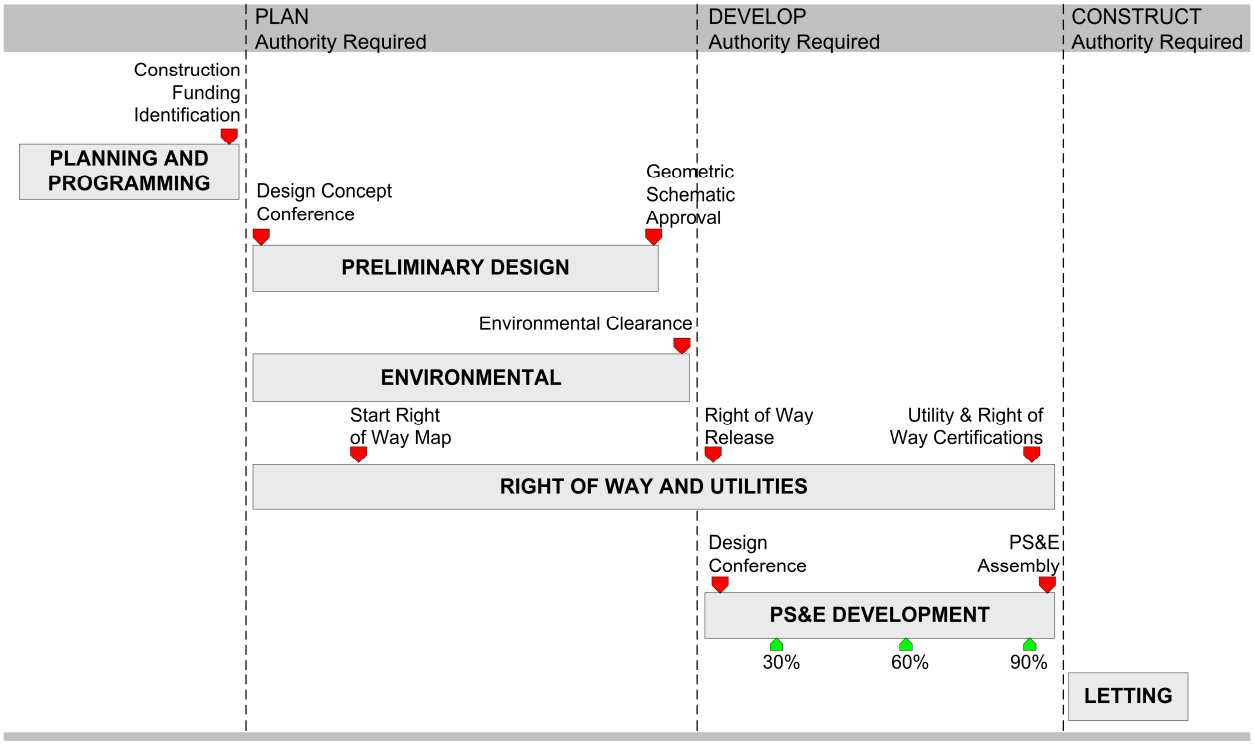


Figure 1. Current Project Development Process at TxDOT (Adapted from [*18*]).

Several PDP activities produce and/or use right of way asset data. A summary of the most relevant activities follows.

Planning and Programming

Although the planning and programming phase in general does not produce detailed right of way asset data, it has a direct effect on the right of way acquisition process. For example:

- Section 4, Study Requirements Determination, includes Task 1400 (Review scope, cost, and staff requirements of project development), which determines whether in-house or consultant staff will handle right of way acquisition activities.

- Task 1500 (Evaluate railroad corridor preservation) involves determining whether a potential railroad corridor (abandoned or under consideration for abandonment) should be acquired for the project.

Preliminary Design

The preliminary design phase of the PDP process contains a number of tasks that lead to the production and development of right of way asset data. For example:

- Section 2, Data Collection/Preliminary Design Preparation, contains Task 2230 (Perform topographic surveys), which involves locating and identifying existing features within the project limits. Frequently, TxDOT supplements or substitutes this activity by using aerial photography along the project corridor. Task 2240 (Perform other surveys) may include a right of way or property survey to provide additional information.

- Section 4, Preliminary Schematic, contains several tasks that result in a document describing the preferred project alternative. Task 2320 (Evaluate route alternatives) develops preliminary schematics for route alternative selection, which includes an approximation of right of way needs for each route. Task 2330 (Initiate railroad coordination) describes activities that result in data used for railroad agreements if TxDOT must use railroad right of way for a project. Task 2340 (Identify requirements for crossing navigable waters) identifies requirements and permits needed for crossing streams and rivers. Task 2350 (Evaluate geometric alternatives) includes a preliminary determination of right of way requirements (including drainage) and access restrictions, as well as the selection of the preferred alternative.

- Section 5, Geometric Schematic, discusses steps to develop the geometric schematic. Task 2500 (Develop preferred geometric alignment) evaluates different alignment options and determines the preferred alignment. Task 2590 (Establish preliminary retaining and/or noise wall locations) and Task 2620 (Perform preliminary hydraulic analysis/design) evaluate the placement of large structures such as retaining or noise walls, storm drain structures, detention ponds, pump stations, and other hydraulic facilities. Task 2620 also includes an assessment of construction costs and estimated cost of right of way acquisition for hydraulic facilities. Task 2630 (Determine right of way and access needs) determines overall right of way and access requirements for the project. The task also involves coordination with TxDOT's Aviation Division in cases where right of way from an airport may be necessary, as well as the determination of encroachments on existing right of way and plans for expedient removal. Task 2650 (Identify potential utility conflicts) could also result in right of way–related data if there is a need for proposed right of way changes because a geometric alignment revision is the most feasible option to address major utility conflicts.

Environmental

Overall, few activities produce right of way asset data or related documentation, but some are worth mentioning here. For example:

- Section 1, Preliminary Environmental Issues, includes Task 3050 (Identify potential Section 4[f] properties), which requires a survey of the project corridor. This survey

focuses on environmental issues but can provide data needed to help produce right of way asset-related documentation.

- Section 3, Environmental Documentation, includes Task 3270 (Prepare Section 4[f] evaluation) and Task 3280 (Perform hazardous materials assessment and investigation), which might result in changes to the proposed right of way in an effort to minimize environmental impacts. The hazardous materials assessment also includes considerations for right of way acquisition and design. Coordination with regulatory agencies and negotiation with potentially responsible parties must be complete before right of way acquisition can proceed.

Right of Way and Utilities

This phase produces most of the right of way asset data and related documentation. For example:

- Section 1, Right of Way and Utility Data Collection, includes Task 4000 (Perform preliminary right of way research), which involves determining TxDOT's existing property rights, restrictions such as easements, and abutting property interests.

- Section 2, Right of Way Map and Property Descriptions, includes Task 4300 (Prepare right of way map/parcel plats/property descriptions), which involves preparing required documentation for property acquisition.

- Section 3, Right of Way Appraisals and Acquisition, contains the greatest number of tasks that contribute to the development of right of way asset data. Task 4410 (Perform advance acquisition for qualified parcels) covers parcel acquisition prior to the standard right of way release, which might apply in certain situations, e.g., land donations, hardship cases, and protective acquisition. Task 4430 (Appraise parcels) and Task 4470 (Implement right of way acquisition process) cover the acquisition of property after the right of way release. Task 4430 involves using the property description and parcel plat to determine the market value of a property. Task 4470 provides additional guidance in the acquisition process, such as the need to negotiate conditions of acquisition, make offers based on appraised value, and use eminent domain when necessary. It also mentions alternative right of way acquisition mechanisms such as easements and agreements. Task 4425 (Prepare and execute joint-use/multiple-use agreements) describes these types of documents. Task 4490 (Dispose of improvements) identifies improvements on the right of way that are either salable or unsalable, as determined through appraisal, and then disposes of the improvements. Task 4500 (Prepare right of way and encroachment certifications) describes the process to certify that all the required right of way acquisition is complete, or will be complete, by a certain date. An encroachment certification certifies the right of way is free of encroachments, or if they exist, they do not pose a safety conflict or interfere with the roadway construction.

PS&E Development

Most right of way requirements should be complete at the beginning of the design phase. However, a few design-related tasks could result in right of way requirement refinements or changes. For example:

- Section 1, Design Conference, includes Task 5010 (Obtain additional or updated data), which includes a requirement to retrieve original conveyance documents for construction within easements to check for restrictions on property use.

- Section 2, Begin Detailed Design, includes Task 5040 (Plan sequence of construction) and Task 5150 (Prepare stream crossing hydraulics), which could result in additional needs for temporary construction easements, drainage easements, right of way, access rights, or railroad agreements.

- Section 4, Roadway Design, includes Task 5250 (Review right of way requirements), which involves a determination of right of way requirements after taking into consideration fee simple acquisition needs, drainage easements, control of access, and temporary construction easements. At this point, TxDOT incorporates temporary construction easements into the right of way map and coordinates additional right of way acquisition.

- Section 7, Drainage Design, includes Task 5560 (Perform hydraulic design for pump station[s]) and Task 5570 (Prepare culvert and storm drain details), which describe further design refinements that might result in additional right of way requirements.

- Section 9, Traffic Control Plan, includes Task 5730 (Design detour roadways), which may include the determination of additional right of way needs for a temporary detour and/or road closure plan.

RIGHT OF WAY MAP DEVELOPMENT

Right of Way Map Content

The *TxDOT Survey Manual* (*15*) and Volume 1 (Procedures Preliminary to Release) of the *Right of Way Manual* (*8*) describe requirements and procedures for the production and submission of right of way maps as well as all surveying necessary for right of way acquisition. Developing right of way maps involves the following general steps:

- complete and submit preliminary maps, property descriptions, surveyor reports, and closure sheets to the district for review;
- review the submission for compliance with TxDOT policy and Texas Board of Professional Land Surveyors (TBPLS) requirements (*19*);
- send a map marked “Preliminary” to the Right of Way Division, along with the necessary supporting documentation, for approval and right of way release;

- at the Right of Way Division, conduct an administrative review, which might include outlining potential map revisions;
- identify the parcels in the Right of Way Information System (ROWIS) that are ready for acquisition and prepare the right of way release documentation;
- acquire right of way parcels and record documents; and
- send a map marked "Final" to the Right of Way Division for permanent file archival.

At TxDOT, a property description prepared for a right of way project includes a heading with TxDOT identification items, along with a metes and bounds description and parcel plats prepared on letter size (8½ inch × 11 inch) sheets (*15*). Letter size sheets allow the filing of descriptions and plats at the county clerk's office without reducing copies. In addition, letter size is standard at TxDOT. In general, TxDOT uses metes and bounds descriptions to support property description requirements, although for federal land acquisitions, the property description can be either in the form of a metes and bounds description or a public land survey description (*9*). A property description must be signed and sealed by a registered professional land surveyor (RPLS) (*15*). In some instances, a brief property description is sufficient instead of the complete metes and bounds description, e.g., in the case of statements that qualify as sufficient evidence of title for title insurance policies and the attorney's certificate when an LPA is the acquiring agency (*9*).

Property descriptions must include the following elements (*15*):

- metes and bounds description prepared on letter size sheets;
- one or more parcel plats prepared on letter size sheets;
- descriptions and plats tied to the Texas State Plane Coordinate System and reference metadata used in preparing the survey;
- a Texas plane coordinate for at least one point on the plat (optional for a metes and bounds description);
- type of public record referenced (e.g., deed records, official records, real property records, and/or plat records) as well as volume and page data;
- for all partial acquisitions, at least one reference tie to an established corner outside the parcel area;
- centerline station ties (optional);
- area in each county or land grant for parcels located in more than one county or land grant survey; and
- control of access lines.

Although all right of way maps must be prepared under the supervision of an RPLS, under an agreement between TxDOT and TBPLS, the maps do not need to be signed and sealed by an RPLS (*15*). Right of way maps do not function as survey plats but rather as internal engineering plans and asset management documents that provide an index to parcels. In fact, the title sheet of a right of way map must include the following statement: "This map is an internal TxDOT document. Its contents shall not be used for any other purpose" (*8*).

A complete right of way map consists of several sheets, including title sheet, parcel index sheet, control sheet, and plan sheets (*8*, *15*). The title sheet provides general information about the

project, including construction control section job (CSJ) number, right of way CSJ number, and federal project numbers (if applicable); a datum statement including the basis of bearings and coordinates, adjustment factor for converting from grid coordinates to surface coordinates, and theta (true-to-grid rotation) angle (if applicable); and appropriate signatures. The parcel index sheet shows an overall view of project parcels and plan sheets (which could be omitted if individual map sheets show all applicable data). The control sheet shows monument and control data relevant to the project (alternatively, the parcel index sheet could show this information). The plan sheets depict existing right of way, adjacent properties, and proposed parcels. Plan sheets must provide legible and clear information and should use a scale of 1:1200 (1 inch = 100 feet) for rural areas or 1:600 (1 inch = 50 feet) for urban areas, unless the project requires a different scale for legibility. For the base map of a right of way plan sheet, the surveyor may use a planimetric plan sheet developed from aerial photography. Each plan sheet should include the following items:

- existing and proposed right of way (by bearing and distance) through the entire project length (Note: In areas where new right of way is only needed on one side of the roadway, the map should show the right of way on both sides of the roadway);
- relevant portions of the proposed alignment, including main lanes, frontage roads, and connection ramps (shown using either single lines or shading);
- points of curvature, tangency, and intersection;
- survey lines;
- parcel property lines by bearing and distance relative to existing and new right of way as well as bearing and distance to a monument outside the area that TxDOT aims to acquire;
- parcel data, including owner name, number, parent tract, location in relation to project stations, area, limits, offset to new right of way line, and area of property remainder;
- property adjacent to the right of way, including whole property sketches (Note: The *TxDOT Survey Manual* includes a reference to the need to show sufficient topography of the parent tract of land from which the parcel is to be acquired or a distance of 600 feet, whichever is lesser);
- improvements (located within 25 feet of the new right of way line to assist appraisers in determining damages to the remainders of properties), obstructions, and/or encroachments (Note: At least twice, the *TxDOT Survey Manual* also includes a reference to the need to show improvements within 50 feet of the right of way line);
- as appropriate, data such as subdivision name, lot numbers, block numbers, and intersecting streets;
- denial of access lines as described in a recorded deed;
- existing utility lines and utility, drainage, and channel easements, including recorded plat and/or deed references if known; and
- city limits, county lines, existing public roads, streets, and alleys.

TxDOT officials highlighted the need to include information related to improvements, such as fences, driveways, concrete flat work, water wells, and privately owned utilities. Information about land use is useful, as is the location of features that may affect the appraised value of the parcel(s) being acquired, such as economically valuable trees and sand or gravel pits. A depiction of watercourses and ravines is also helpful. Topographic information such as elevations and contour lines is not critical (although, if properly depicted in light gray tones to

avoid clutter, it can provide background and context in situations where there are significant differences in elevation).

MicroStation Files

TxDOT has specific requirements for the use of Bentley® MicroStation™ files to support the preparation of right of way maps (*15*), including requirements for base files, topographic files, title sheet files, map sheet files, cells, levels, labels, line weight and symbology, and whole property sketches. Of particular interest here are the requirements for cells and levels because of the ramifications regarding the conversion of MicroStation-format features to GIS features.

TxDOT maintains a large cell library that includes hundreds of cells that depict a variety of mappable objects on the ground (*20*). As Table 1 shows, many of those cells pertain to right of way–related features, including right of way lines, access denial lines, blocks, easements, fences, property lines, subdivisions, survey lines, and monuments. In general, cells depict point or linear locations, although cells can also be used to generate patterns for area features. In MicroStation, the cell name (e.g., RWAL, RWLE, or RWPYL) is a property of each cell added to the file. This characteristic makes it possible to automate the import of MicroStation-format features into a geodatabase by executing a query in the GIS environment that only selects features that match certain cell names. For example, to generate features for Type 1 monuments from a MicroStation file in the GIS, the analyst would open the MicroStation file in the GIS, run a query to select features for which the cell name is RWTIF or RWTIS, and then import those features into a predefined monument feature class. The "or" condition would also be necessary to address potential cases of redundancy in the cell library. For example, to select points used in connection with existing right of way lines, it would be necessary to run a query to select features for which the cell name is ROWE or RWLE.

This procedure is valid for point features and linear features, but not necessarily for area features (e.g., parcels) unless the area feature itself is a closed boundary cell (which is not practical for irregularly shaped features such as parcels). In this case, it would be necessary to first generate area features in MicroStation (snapping to corners and linear features, which could be cells, and making sure the perimeter closes) and then import the resulting area features into polygon feature classes in the GIS.

TxDOT also uses a variety of levels to display features in MicroStation. With the introduction of MicroStation version 8, it became possible to use levels outside the traditional 63-level structure. By default, MicroStation resolves the level to use as a function of the cell name. In addition, TxDOT has configured its cell library structure so that certain cells are automatically assigned to the same level. For example, cells RWSL and RWSLL, which represent points and lines that are used in connection with right of way survey lines (Table 1), are automatically assigned to the "E_ROW_Survey_ROW Survey Line RWSL" level. This automatic level placement can facilitate the import of MicroStation features into a GIS environment.

Table 1. Sample of Right of Way–Related MicroStation Cells at TxDOT.

Cell Name	Cell Description	Cell Name	Cell Description
ROW	Right of Way Line Proposed	RWLT	ROW Lot Name
ROWE	Right of Way Line Existing	RWLTL	ROW Lot Line
ROWEL	Right of Way Line Existing	RWLTLL	ROW Lot Line
ROWL	Right of Way Line Proposed	RWLTN	ROW Lot Number
RWA	ROW Abstract Name	RWM	Right of Way Marker
RWADL	ROW Access Denial Line	RWMF	ROW Monument Found
RWADLL	ROW Access Denial Line	RWMS	ROW Monument Set
RWAL	ROW Abstract Line	RWO	ROW Ownership Data
RWALL	ROW Abstract Line	RWPA	ROW Property Address
RWAN	ROW Abstract Number	RWPR	ROW Parcel Name
RWBK	ROW Block Name	RWPRL	ROW Parcel Line
RWBKL	ROW Block Line	RWPRLL	ROW Parcel Line
RWBKLL	ROW Block Line	RWPRN	ROW Parcel Number
RWBKN	ROW Block Number	RWPY	ROW Property Name
RWCLE	ROW Centerline Existing	RWPYL	ROW Property Line
RWCLEL	ROW Centerline Existing	RWPYLL	ROW Property Line
RWCLP	ROW Centerline Proposed	RWPYN	ROW Property Number
RWCLPL	ROW Centerline Proposed	RWRR	ROW Railroad ROW
RWCOA	ROW Control of Access	RWRRL	ROW Railroad ROW
RWCOAL	ROW Control of Access	RWS	ROW Survey Name
RWD	ROW Recorded Deed Data	RWSB	ROW Subdivision Name
RWEP	ROW Easement Line Proposed	RWSBL	ROW Subdivision Line
RWEPL	ROW Easement Line Proposed	RWSBLL	ROW Subdivision Line
RWET	ROW Easement Line Temporary	RWSBN	ROW Subdivision Number
RWETL	ROW Easement Line Temporary	RWSL	ROW Survey Line
RWFN	Rock Wall Fence Point	RWSLL	ROW Survey Line
RWFNC	ROW Fence Line at ROW	RWSN	ROW Survey Number
RWFNCL	ROW Fence Line at ROW	RWTIF	ROW Type 1 Monument Found
RWFNL	Rock Wall Fence	RWTIIF	ROW Type 2 Monument Found
RWLE	ROW Line Existing	RWTIIS	ROW Type 2 Monument Set
RWLEL	ROW Line Existing	RWTIS	ROW Type 1 Monument Set
RWLP	ROW Line Proposed	RWVP	ROW Volume Page Original ROW
RWLPL	ROW Line Proposed		

IMPROVEMENTS AND DISPOSITION OF SURPLUS RIGHT OF WAY

When TxDOT acquires right of way for a project, it acquires the responsibility not just for the land but also for the improvements on the land. Depending on the case, disposition of improvements might include renting, selling, clearing the right of way of hazards and unsightly or unsanitary conditions, disposal of non-salable improvements, as well as disposal of rubbish, rubble, and debris. Final disposition of right of way improvements requires the application of certain accounting procedures, including the submission of Form ROW-RM-9 ("Final Disposition of Right of Way Improvements") (*21*).

Right of way asset management also includes managing the disposition of surplus right of way that is no longer necessary for highway purposes. Only the Texas Transportation Commission may declare right of way to be surplus, subject to approval by the Texas Office of the Attorney General, the secretary of state, and the governor. After the recorded instrument conveying or

releasing the surplus land is produced, the district and the Right of Way Division need to update the right of way map to reflect the changes.

DATA MANAGEMENT–RELATED PRACTICES AND PLANS

Document Archival Processes

The Texas State Records Retention Schedule included in the Texas Administrative Code documents minimum document retention schedules and requirements for state agencies (*22*). In addition, each state agency must submit a complete records retention schedule to the state and Local Records Management Division of the Texas State Library and Archives Commission. This records retention schedule documents retention periods, security codes, archival location, and medium (e.g., paper, microfilm, computer printout, electronic, or other) of record classifications for a given division, section, or district (*23*). As an illustration, Table 2 lists document files that the TxDOT Right of Way Division needs to keep permanently (or for the life of the assets). Similarly, Table 3 shows a summary of right of way records that districts need to retain. Typically, districts need to retain construction project records for at least four years after closing a project (normally after the engineer in charge has accepted delivery of the finished construction project).

In the case of electronic records, both the Texas and district retention schedules require the retention of documents for a minimum of four years after project closing (*22*). Retention of electronic documents beyond the minimum number of years tends to vary based on district, office, and project manager practices. With initiatives such as the implementation of IBM® FileNet®, described in subsequent sections, it is likely that electronic document management at TxDOT will become more structured, thereby facilitating project information access, querying, and reporting.

Table 2. Documents That the Right of Way Division Needs to Keep for the Life of the Asset or Permanently (Adapted from [*23*]).

TxDOT Division	Document
Right of Way	Non–right of way acquisitions Selected records in final right of way project files containing right of way conveyances and judgments, final right of way maps, title insurance policies, or other instruments pertaining to the state's title to land or interests

Table 3. Right of Way Documents That TxDOT Districts Need to Retain (Adapted from [*24*]).

District Section/Area	Document
Right of Way Records	Right of way project files for state, federal, and local participating agency right of way acquisition Non–right of way acquisitions District right of way leasing files Utility agreements Outdoor advertising sign permit files

Right of Way–Related Supporting Information Systems

TxDOT uses a variety of information systems to support the project development process. Of particular interest are the Design and Construction Information System (DCIS), ROWIS, the Texas Reference Marker (TRM) System, FileNet, and Plans Online.

Design and Construction Information System

TxDOT uses DCIS to track projects throughout the project development process (*25*). DCIS includes a large number of project, contract, and utility screens that enable authorized users to complete data inputs and updates, and run queries and reports. The screens cover a wide range of topics, including project identification and evaluation data, project planning and finance data, project estimate data, and contract summary data. DCIS runs on an Adabas non-relational database platform. There are several files in Adabas that handle data needed for DCIS, including File 121 (DCIS-PROJECT-INFORMATION), File 122 (DCIS-WORK-PROGRAM), File 123 (DCIS-PROJECT-ESTIMATE), and File 124 (DCIS-CONTRACT-LETTING). Table 4 shows a short sample of fields from those files. DCIS uses the CSJ number to uniquely identify projects. TxDOT is currently working on a conversion of DCIS to a relational database platform.

Table 4. Sample DCIS File Fields.

File 121 (DCIS-PROJECT-INFORMATION)	File 122 (DCIS-WORK-PROGRAM)	File 123 (DCIS-PROJECT-ESTIMATE)	File 124 (DCIS-CONTRACT-LETTING)
COMMON-DATA	WORK-PROGRAM	COMMON-DATA	COMMON-DATA
CONTROL-SECT-JOB	CONTROL-SECT-JOB	CONTROL-SECT-JOB	CONTRACT-CSJ
DISTRICT-NUMBER	DISTRICT-NUMBER	LAST-REVISION	LAST-REVISION
LAST-REVISION	DATE-LAST-REV	USER-LAST-REV	DATE-LAST-REV
DATE-LAST-REV	TIME-LAST-REV	DATE-LAST-REV	TIME-LAST-REV
TIME-LAST-REV	TOTAL-DATA	TIME-LAST-REV	RECORD-TYPE
REQUIRED-ID-DATA	FIS-YEAR	PLANS-ESTIMATE-DATA	BIDITEM-SUMMARY-DATA
COUNTY-NUMBER	YEARS-ACTIVE	LINE-NUMBER	BIDITEM-SEQUENCE-NO
HIGHWAY-NUMBER	TOTAL-OBLIG-AMT	CARD-TYPE	ALTERNATE-GROUP-NO
PROJ-LENGTH	TOTAL-ALLOC-AMT	ALTERNATE-GROUP-NO	BIDITEM-NO
CATEGORY	DISTRICT-ARRAY25	BIDITEM-SPECPROV	BIDITEM-DESC-CODE
ELIG-FED-FUND	DIST-ALLOC-AMT	BIDITEM-NO	SPECIAL-PROV-NO
PROJ-CLASS	DIST-OBLIG-AMT	BIDITEM-DESC-CODE	SPECIAL-ACCT-NO
MANAGER-NUMBER	CZ-FILLER-FIELD	SPECIAL-PROV-NO	QUANTITY
EST-CONST-COST	STATE-TRANS-IMPRV-PGM-GRP	BIDITEM-REF-NO	ESTIMATED-PRICE
DATE-EST-COST	STIP-MPO-CODE	SPCL-000-PROV-TEXT	DUP-PRICE-INDICATOR
AUTO-LINE-NUMBER	STIP-FY	SPECIAL-ACCT-NO	BIDDER-CONTROL-DATA
TYPE-OF-WORK	STIP-PROJECT-ID	ENG-QUANTITY	BIDDER-SEQNO
LIMITS-FROM	STIP-PROJECT-NBR	ENG-ESTIMATE-PRICE	TOTAL-BID
LIMITS-TO	STIP-PHASE-CODE	UNIT-PRICE	VERIFY-CODE
LAYMAN-DESCRIPTION1	STIP-FEDERAL-COST-PCT	BIDITEM-FLAG	BIDDER-RANKNO
LAYMAN-DESCRIPTION2	STIP-STATE-COST-PCT	BIDITEM-DESCRIPTION	INCOMPLETE-FLAG
BEG-MILE-POINT	STIP-LOCAL-CONTRIBUTIONS-AMT	UNIT-WORK	VENDOR-NOS
END-MILE-POINT	STIP-LOCAL-COST-PCT	COMMENT	BI-SEQNO-DISCREP31
OPTIONAL-ID-DATA	STIP-EST-CONSTRUCTION-AMT	CATGWORK-DESC	BIDITEM-ALT-FLAG9
CONTRACT-CSJ	STIP-FUNCTIONAL-CLASS-CODE	CATGWORK-MILES	BIDITEM-ALT-FLAG
PROJ-SUSP	STIP-STATE-CATEGORY-CODE	FUND-SOURCE-GROUP3	BIDITEM-DETAIL-11

Right of Way Information System

The Right of Way Division implemented ROWIS in 1997 to track and report financial data associated with the right of way acquisition process (*26*). The system enables users to capture, track, and report on property acquisition processes such as right of way parcel development during negotiations, settlements, or eminent domain proceedings. Although ROWIS was not designed to accommodate the utility coordination process, the Right of Way Division currently uses ROWIS to track reimbursable utility agreement payments by creating parcel records in ROWIS to represent utility agreements.

ROWIS runs on a Microsoft® Structured Query Language (SQL) Server™ database platform. Table 5 provides a listing of all tables in ROWIS. Figure 2 shows a high-level representation of the ROWIS logical data model that only includes the most relevant entities. The system interface includes screens to display or query data on topics such as projects, parcels, tasks, owners, CSJ numbers, minute orders, and public agencies. A description of the core entities in ROWIS follows:

- **Parcels**. The Parcels entity contains attributes that describe property parcels, such as description, appraised value, acquisition status, and several dates including possession date, parcel release date, and total paid date. The primary key or identifier (ID) in Parcels is Parcel ID (which is also a foreign key in entities Projects, Agencies, Control Section Jobs, and Associates).

- **Projects**. The Projects entity includes attributes that characterize a project including project type code, beginning and ending limits, project CSJ, right of way CSJ, and several date attributes such as estimated letting date or right of way clearance date. The primary key in Projects is Project ID (which is not the same as project CSJ or right of way CSJ). Project ID is a foreign key in entities Parcels, Control Section Jobs, and Agencies. In Projects, the right of way CSJ and right of way account number attributes are inversion entry keys (i.e., they are frequently accessed, non-unique attributes).

- **Control Section Jobs**. The Control Section Jobs entity includes attributes that provide additional information about projects, including project CSJ, CSJ type, project limits, and federal funding eligibility. The primary key in Control Section Jobs is CSJ ID (which is not the same as the project CSJ). CSJ ID provides a linkage between Control Section Jobs and Parcels through the many-to-many entity Control Section Jobs Parcels.

ROWIS uses data produced and managed in DCIS, such as CSJ numbers, federal project number, project limits, and authorized funds. ROWIS is not integrated with DCIS, which means that DCIS data must be manually entered into ROWIS. Data synchronization issues arise when there are data updates in DCIS since a ROWIS project manager must make the same change in ROWIS manually.

Table 5. ROWIS Tables.

AGENCIES	INVOICES	PBCATVLD
APPRAISALS	INVOICES TASKS	PROJECTS
APPRAISED ITEMS	LEGAL NAMES	PRSNL PROP MOVES
ASSOCIATES	LOGIC DRILLDOWN	QUALIFICATIONS
ASSOCIATES DISTRICTS	LOGIC HELP	RENTAL SUPPLEMENTS
ASSOCIATES TASKS	LOGIC LINK	REPORTS SCHEDULED
ASSOCTASK DISPLACEE	LOGIC SEARCH	RESIDENTIAL MOVES
AUDIT LOG	LOGIC WINDOW	ROWIS STATS
CACHE CONTROL	LOGIC WINDOW CONTROL	SECURITY APPS
COMMENTS	MAP SHEET INDEX	SECURITY GROUPINGS
COMPONENTS	MESSAGES	SECURITY INFO
CONTROL SECTION JOBS	MINUTE ORDERS	SECURITY TEMPLATE
CONTROL SECTION JOBS PARCELS	MINUTE ORDERS PARCELS	SECURITY USERS
DISPLACEE	MINUTE ORDERS PROJECTS	SEGMENTS
DISPLACEE DOCUMENTS	NEW ROWIS LOGINS	SEQUENCE NBRS
DOCUMENTS	NON RESIDENTIAL MOVES	STATUS VALUES
ENCUMBRANCES	PARCELS	TASKS
ESTIMATED EXPENSES	PARTICIPATING AGENCIES	TEMP ASSOCIATES TASKS REF
EVENT HISTORY	PARTICIPATING AGENCIES DEPOSIT	TEMP OWNER REFERENCE
EXP CATG CD	PARTICIPATING AGENCIES PARCELS	TEMP PARCEL REFERENCE
EXP TYPE CD	PAYMENT ERRORS	TEMP PROJ PARCEL REFERENCE
FORMS	PAYMENTS	TXDOT DISTRICTS
HOUSING SUPPLEMENTS	PBCATCOL	TYPE CODES
IMPROVEMENTS	PBCATEDT	WORKORDERS
INTEREST OWNERS	PBCATFMT	WORKORDERS TASKS
INTEREST OWNERS ITEMS	PBCATTBL	

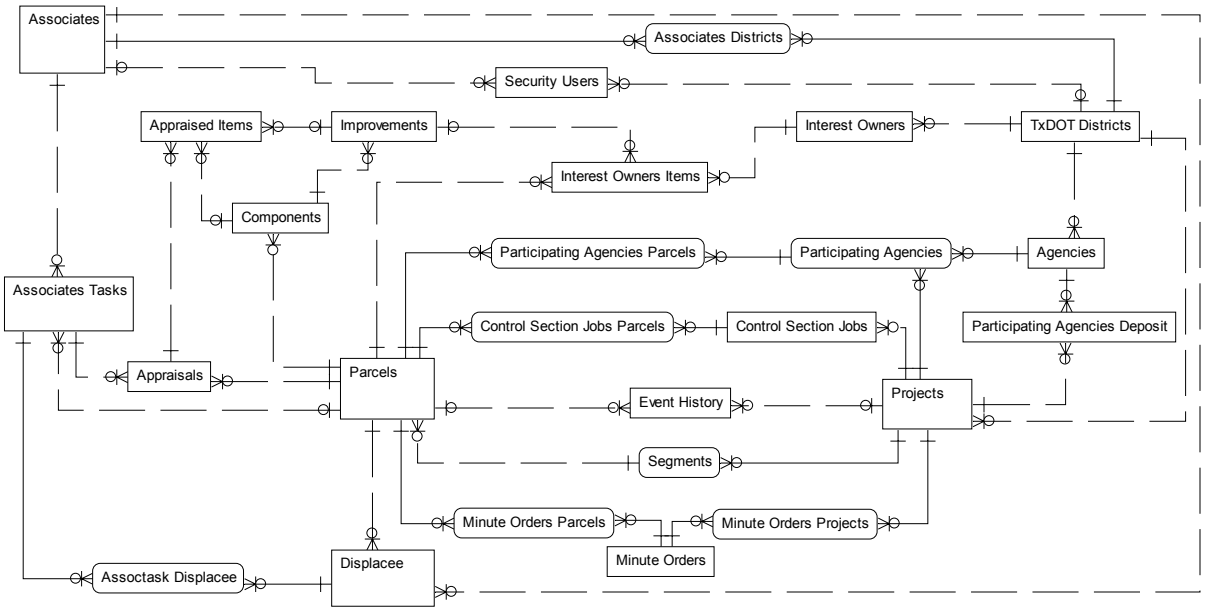


Figure 2. ROWIS High-Level Logical Data Model.

The main function of ROWIS is to support the TxDOT right of way acquisition process. It provides very little support for the management and inventory of right of way assets after the conclusion of the acquisition process. In addition, ROWIS does not have the functionality to display (or to provide a link to) right of way parcels or utility adjustments on a map. In fact, the

Parcels entity in ROWIS does not contain any spatial data except for a general description of the physical location of the parcel. ROWIS is not compatible with the GIS Architecture and Infrastructure Project (GAIP) and cannot make data available to TxDOT users through Main Street Texas (MST). In addition, ROWIS handles property right encumbrances (e.g., easements) as an acquisition interest code in the entity Components, which simply references the parcel ID without any detailed spatial information. As a result, a user cannot visualize the location and spatial extent of the encumbrance without physically finding and reviewing the parcel's conveyance document. This lack of detailed spatial information within ROWIS has several effects on TxDOT's ability to manage the right of way efficiently. For example, currently there is no simple way to accurately determine the total right of way area that TxDOT manages or the total statewide extent or area of certain property rights such as access rights, water rights, and mineral subsurface rights. Likewise, it is currently not possible to produce an accurate map of statewide encumbrances within or outside the state right of way, such as easements, lease agreements, and license agreements.

For the development of the right of way asset data model, the researchers envision a connection of the data architecture with ROWIS to enable data sharing and reduce data redundancy. The link between the two architectures is an entity called ROWIS CONNECTION, which minimizes the need for changes to the ROWIS architecture. The discussion of the Project Subject Area in Chapter 3 provides a more detailed discussion of this construct.

Texas Reference Marker System

TRM is a mainframe-based system that documents physical and performance characteristics of the state-maintained highway network using the statewide reference marker network as a geo-referencing tool (*27*). With TRM, the location of features on the ground is defined in terms of mileage displacement from the nearest marker. TRM is centerline based although it does provide for the identification of features on either side of the centerline. Although TRM relies on displacement from markers as the mechanism to reference features to the highway network, the system also enables the calculation of cumulative distances by using the relative location of the markers along the highway network.

TRM is currently the main repository of state highway network and associated data. Examples of roadway attribute data include annual average daily traffic (AADT), classification, surface type, location of features (e.g., culverts, signs, and streams), and administrative data (e.g., county and district). Several data attributes in TRM are relevant to this research, including right of way width, surface width, roadbed width, and section length.

While TRM provides data for a wide range of reporting options, the structure and characteristics of the data have shortcomings that limit the usability of the system. For example, TRM is centerline based, which means the positional accuracy of any feature or measure (such as right of way width, roadbed width, or beginning and ending project limits) cannot be better than the positional accuracy of the underlying centerline map. The lateral positional accuracy of the official TxDOT centerline map varies by location, from a few feet in most cases to much larger values where 100 feet or more are not unusual. TRM is also cumulative distance dependent, which means the positional accuracy of any feature or measure cannot be better than the

longitudinal positional accuracy of *both* reference markers and the underlying centerline map. Although reference markers are supposed to be permanent features on the ground, the reality is frequently quite different. As a result, it is very difficult to determine the actual location of features using cumulative distances alone.

FileNet

Currently, most TxDOT districts and divisions follow ad-hoc procedures to manage electronic documentation. In 1996, the Houston District started using the enterprise document management system (EDMS) FileNet to track construction project as-built drawings, PS&E documents, and correspondence. TxDOT is currently implementing FileNet statewide. TxDOT's goal is to implement FileNet separately for each business unit within the organization.

In the TxDOT implementation, the system stores document-related data in a centrally located Microsoft SQL Server database. The database also contains pointers to files that are physically stored on a dedicated server at every business unit where TxDOT has implemented FileNet. Users interact with FileNet through an interface similar to the Microsoft Windows Explorer® interface, with additional functionality such as viewing current file users, assigning file attributes or tags, querying, searching, and file versioning. Currently, TxDOT uses two FileNet configurations: a "thick-client" configuration (which involves the use of a special-purpose client application on user computers) and a "thin-client" configuration called TxDocsOnline (which is web based and uses a Microsoft Internet Explorer® browser to interact with the database and the FileNet file server). The TxDOT FileNet implementation does not support viewing GIS or computer aided design (CAD) documents, although this functionality is possible through third-party programs.

In the TxDOT FileNet implementation, a library represents the structure that business units choose to organize documents, mainly along functional areas, using lessons learned from the Houston District's experience with FileNet. The Houston District organized its FileNet implementation around projects. According to TxDOT officials, one of the reasons to develop a "standard" library around functional areas instead of projects was that a structure based on functional areas could reduce document redundancy more effectively. A potential disadvantage of this approach is the risk of losing the "natural" linkage that exists among documents that pertain to the same project. To reduce this risk, the CSJ number is a mandatory attribute for project-related documents in FileNet.

Following the Electronic Document Technologies Implementation and Support (EDTIS) Project Content Services library standards, FileNet uses document classes, record types, and document types to organize documents (*28*, *29*). Document classes represent the highest folder aggregation level (Table 6). Document classes have record types, and record types have document types (Table 7). In addition, documents have a predefined set of attributes, which could vary by document class (Table 8). Each document class, record type, and document type has a numerical code (e.g., 13 for document class "Right of Way," 2 for record type "Easements," and 3 for document type "Drainage Easements"). The combination of the three numerical codes is a unique file code (e.g., 13.2.3) that represents a unique document class/record type/document type combination. The relationship between document classes and their corresponding numerical

codes is one to one. However, the same is not necessarily true for record types or document types, where the same record type or document type in different document classes may have different numerical codes. This situation prevents the use of generic lookup tables to index record types and document types.

Table 6. Document Classes in the TxDOT FileNet Implementation (Adapted from [*28*]).

Document Class Code	Document Class
1	Administrative
2	Construction
3	Contracts Leases and Agreements
4	Environmental Operations
5	Equipment and Facilities
6	Finance
7	Human Resources
8	Information Systems
9	Maintenance Operations

Document Class Code	Document Class
10	Occupational Safety
11	Project Development and Design
12	Purchasing and Warehouse
13	Right of Way
14	Traffic Operations
15	Transportation Planning
16	Travel and Public Information
17	Incoming Mail
18	WebXtra Document

Table 7. Right of Way Record Types and Document Types (Adapted from [*28*]).

Document Class	Record Type	Document Type	File Code
Right of Way	Certifications	Encroachment	13.1.1
Right of Way	Certifications	Relocation	13.1.2
Right of Way	Certifications	Right of Way	13.1.3
Right of Way	Certifications	Utility	13.1.4
Right of Way	Easements	Attorney Certificate City County	13.2.1
Right of Way	Easements	Attorney Certificate State	13.2.2
Right of Way	Easements	Drainage Easement	13.2.3
Right of Way	Easements	Release of Easement	13.2.4
Right of Way	Easements	Request for Easement	13.2.5
Right of Way	Easements	Temporary Easement	13.2.6
Right of Way	Eminent Domain Litigation	Abstract	13.3.1
Right of Way	Eminent Domain Litigation	Affidavit	13.3.2
Right of Way	Eminent Domain Litigation	Appeal	13.3.3
Right of Way	Eminent Domain Litigation	Attorney Certificate	13.3.4
Right of Way	Eminent Domain Litigation	Award	13.3.5
Right of Way	Eminent Domain Litigation	Brief	13.3.6
Right of Way	Eminent Domain Litigation	Certificate	13.3.7
Right of Way	Eminent Domain Litigation	Checklist	13.3.8
Right of Way	Eminent Domain Litigation	Citation	13.3.9
Right of Way	Eminent Domain Litigation	Complaint	13.3.10
Right of Way	Eminent Domain Litigation	Conveyance or Title	13.3.11
Right of Way	Eminent Domain Litigation	Correspondence	13.3.12
Right of Way	Eminent Domain Litigation	Data Sheet Settlement	13.3.13
Right of Way	Eminent Domain Litigation	Decision	13.3.14
Right of Way	Eminent Domain Litigation	Deposition	13.3.15
Right of Way	Eminent Domain Litigation	Discovery	13.3.16
Right of Way	Eminent Domain Litigation	Docket	13.3.17
Right of Way	Eminent Domain Litigation	Exhibit	13.3.18
Right of Way	Eminent Domain Litigation	Hearing	13.3.19
Right of Way	Eminent Domain Litigation	Notice	13.3.20
Right of Way	Eminent Domain Litigation	Offer	13.3.21
Right of Way	Eminent Domain Litigation	Order	13.3.22

Table 7. Right of Way Record Types and Document Types (Adapted from [*28*]) (Continued).

Document Class	Record Type	Document Type	File Code
Right of Way	Eminent Domain Litigation	Petition	13.3.24
Right of Way	Eminent Domain Litigation	Release	13.3.25
Right of Way	Eminent Domain Litigation	Settlement	13.3.26
Right of Way	Eminent Domain Litigation	Statement	13.3.27
Right of Way	Eminent Domain Litigation	Subpoena	13.3.28
Right of Way	Eminent Domain Litigation	Transcript	13.3.29
Right of Way	Encroachments	Conveyance or Title	13.4.1
Right of Way	Encroachments	Correspondence	13.4.2
Right of Way	Encroachments	Removal	13.4.3
Right of Way	Encroachments	Sale	13.4.4
Right of Way	Inverse Condemnation	Abstract	13.5.1
Right of Way	Inverse Condemnation	Affidavit	13.5.2
Right of Way	Inverse Condemnation	Appeal	13.5.3
Right of Way	Inverse Condemnation	Award	13.5.4
Right of Way	Inverse Condemnation	Brief	13.5.5
Right of Way	Inverse Condemnation	Certificate	13.5.6
Right of Way	Inverse Condemnation	Checklist	13.5.7
Right of Way	Inverse Condemnation	Citation	13.5.8
Right of Way	Inverse Condemnation	Complaint	13.5.9
Right of Way	Inverse Condemnation	Correspondence	13.5.10
Right of Way	Inverse Condemnation	Decision	13.5.11
Right of Way	Inverse Condemnation	Deposition	13.5.12
Right of Way	Inverse Condemnation	Discovery	13.5.13
Right of Way	Inverse Condemnation	Docket	13.5.14
Right of Way	Inverse Condemnation	Exhibit	13.5.15
Right of Way	Inverse Condemnation	Hearing	13.5.16
Right of Way	Inverse Condemnation	Notice	13.5.17
Right of Way	Inverse Condemnation	Offer	13.5.18
Right of Way	Inverse Condemnation	Order	13.5.19
Right of Way	Inverse Condemnation	Petition	13.5.20
Right of Way	Inverse Condemnation	Settlement	13.5.21
Right of Way	Inverse Condemnation	Statement	13.5.22
Right of Way	Inverse Condemnation	Subpoena	13.5.23
Right of Way	Inverse Condemnation	Transcript	13.5.24
Right of Way	Junkyard	Compliance Monitoring	13.6.1
Right of Way	Junkyard	Enforcement Action	13.6.2
Right of Way	Junkyard	Inspections	13.6.3
Right of Way	Junkyard	Screening Plan and Specifications	13.6.4
Right of Way	Junkyard	Violation Notice	13.6.5
Right of Way	Municipal Sign Oversight	Annual Review	13.7.1
Right of Way	Municipal Sign Oversight	Certification	13.7.2
Right of Way	Municipal Sign Oversight	Copy of Ordinance and Amendments	13.7.3
Right of Way	Municipal Sign Oversight	Municipal Enforcement Plan	13.7.4
Right of Way	Municipal Sign Oversight	Report	13.7.5
Right of Way	Non ROW Acquisition	Appraisal	13.8.1
Right of Way	Non ROW Acquisition	Billing Statement Form 132	13.8.2
Right of Way	Non ROW Acquisition	Blueprint	13.8.3
Right of Way	Non ROW Acquisition	Conveyance or Title	13.8.4
Right of Way	Non ROW Acquisition	GIWW Dredge Disposal Site	13.8.5
Right of Way	Non ROW Acquisition	Insurance	13.8.6
Right of Way	Non ROW Acquisition	Map	13.8.7
Right of Way	Non ROW Acquisition	Mineral Interests	13.8.8
Right of Way	Non ROW Acquisition	Negotiation	13.8.9
Right of Way	Non ROW Acquisition	Offer	13.8.10

Table 7. Right of Way Record Types and Document Types (Adapted from [*28*]) (Continued).

Document Class	Record Type	Document Type	File Code
Right of Way	Non ROW Acquisition	Property Description and Plat	13.8.11
Right of Way	Non ROW Acquisition	Submission	13.8.12
Right of Way	Non ROW Acquisition	Tax Appraisal or Statement	13.8.13
Right of Way	Property Management and Disposal	Advertisement	13.9.1
Right of Way	Property Management and Disposal	Bid	13.9.2
Right of Way	Property Management and Disposal	Form 1134, Request to Sell Right of Way Improvement Acquired	13.9.3
Right of Way	Property Management and Disposal	Form 1135, Photographs	13.9.4
Right of Way	Property Management and Disposal	Inventory	13.9.5
Right of Way	Property Management and Disposal	Location Map	13.9.6
Right of Way	Property Management and Disposal	Notice	13.9.7
Right of Way	Property Management and Disposal	Property Description or Plat	13.9.8
Right of Way	Property Management and Disposal	Removal or Disposal	13.9.9
Right of Way	Property Management and Disposal	Resolution	13.9.10
Right of Way	Property Management and Disposal	Submission	13.9.11
Right of Way	Reference Files	User Defined	13.10.1
Right of Way	ROW Acquisition Project Files	Affidavit	13.11.1
Right of Way	ROW Acquisition Project Files	Appraisal	13.11.2
Right of Way	ROW Acquisition Project Files	Appraiser Evaluation	13.11.3
Right of Way	ROW Acquisition Project Files	Conveyance or Title	13.11.4
Right of Way	ROW Acquisition Project Files	Existing Constraints and Structures	13.11.5
Right of Way	ROW Acquisition Project Files	Improvement Removal Plan	13.11.6
Right of Way	ROW Acquisition Project Files	Improvement Survey	13.11.7
Right of Way	ROW Acquisition Project Files	Map	13.11.8
Right of Way	ROW Acquisition Project Files	Property Description or Plat	13.11.9
Right of Way	ROW Acquisition Project Files	Receipt	13.11.10
Right of Way	ROW Acquisition Project Files	Relocation	13.11.11
Right of Way	ROW Acquisition Project Files	Request Notice or Access Permission	13.11.12
Right of Way	ROW Acquisition Project Files	Schematic	13.11.13
Right of Way	ROW Map	Map	13.12.1
Right of Way	ROW Releases	Funding	13.13.1
Right of Way	ROW Releases	Map	13.13.2
Right of Way	ROW Releases	Minute Order	13.13.3
Right of Way	ROW Releases	Payment	13.13.4
Right of Way	ROW Releases	Property Description and Plat	13.13.5
Right of Way	ROW Releases	Resolution	13.13.6
Right of Way	ROW Releases	ROW Release	13.13.7
Right of Way	ROW Releases	Schematic	13.13.8
Right of Way	Sign Inventory	Sign Inventory	13.14.1
Right of Way	Sign Permit Activity Reports	Permit Activity Report	13.15.1
Right of Way	Sign Permit Files	Bond	13.16.1
Right of Way	Sign Permit Files	Conveyance	13.16.2
Right of Way	Sign Permit Files	Illegal Sign Notice	13.16.3
Right of Way	Sign Permit Files	Legal Action Request	13.16.4
Right of Way	Sign Permit Files	Permit Application	13.16.5
Right of Way	Sign Permit Files	Permit Report	13.16.6
Right of Way	Sign Permit Files	Permit Transfer	13.16.7
Right of Way	Sign Permit Files	Registration	13.16.8
Right of Way	Sign Permit Files	Removal	13.16.9
Right of Way	Sign Permit Files	Violation Notice	13.16.10
Right of Way	Sign Reimbursements Relocations	Correspondence	13.17.1
Right of Way	Sign Reimbursements Relocations	Waiver of Damages	13.17.2
Right of Way	Utility Accommodation	Adjustment	13.18.1
Right of Way	Utility Accommodation	Affidavit	13.18.2

Table 7. Right of Way Record Types and Document Types (Adapted from [*28*]) (Continued).

Document Class	Record Type	Document Type	File Code
Right of Way	Utility Accommodation	Compensable Interest Certificate	13.18.3
Right of Way	Utility Accommodation	Consultant Contract Review	13.18.4
Right of Way	Utility Accommodation	Correspondence	13.18.5
Right of Way	Utility Accommodation	Cost Estimate	13.18.6
Right of Way	Utility Accommodation	Date of Eligibility Request	13.18.7
Right of Way	Utility Accommodation	Determination of Eligibility	13.18.8
Right of Way	Utility Accommodation	Funding	13.18.9
Right of Way	Utility Accommodation	Layout Schematic or Drawing	13.18.10
Right of Way	Utility Accommodation	Letter of Authority	13.18.11
Right of Way	Utility Accommodation	Meeting Minutes and Notes	13.18.12
Right of Way	Utility Accommodation	Notice or Notification	13.18.13
Right of Way	Utility Accommodation	Plan	13.18.14
Right of Way	Utility Accommodation	Relocation	13.18.15
Right of Way	Utility Accommodation	Specification	13.18.16
Right of Way	Utility Accommodation	Subsurface Utility Engineering (SUE) Deliverable	13.18.17
Right of Way	Utility Accommodation	SUE Media Information Form	13.18.18
Right of Way	Utility Accommodation	Survey	13.18.19
Right of Way	Utility Accommodation	Utility Conflict Check	13.18.20
Right of Way	Utility Accommodation	Utility Coordination	13.18.21
Right of Way	Utility Accommodation	Utility Easement	13.18.22
Right of Way	Utility Accommodation	Utility Exception Request	13.18.23
Right of Way	Utility Accommodation	Utility Standard Sheet	13.18.24
Right of Way	Working Papers	User Defined	13.19.1

Table 8. Right of Way Document Required and Optional Attributes (*28*).

Attribute Name	Display Name	Property Type	Required/Optional
Title	Title	System	Required
Record_Type	Record Type	Document	Required
Document_Type	Document Type	Document	Required
File_Code	File Code	Document	Required
Document_Date	Document Date	Document	Required
Document_Status	Document Status	Document	Required
Version_Status	Version Status	Version	Optional
Destruction_Date	Destruction Date	Document	Optional
Comment	Document Comment and Version Comment	System	Optional
Addressee_To [1]	Addressee or To	Document	Optional
Author_From [1]	Author or From	Document	Optional
Carbon Copy (CC) [1]	Copy To or CC	Document	Optional
Ending_Date	Ending Date or Close Date	Document	Optional
External_Document_Location	External Document Location	Document	Optional
Business_Function [1]	Business Function	Document	Required
Account_Number	Account Number	Document	Required
Parcel_Number	Parcel Number	Document	Required
Cause_Number	Cause Number	Document	Optional
Consultant_Vendor	Consultant or Vendor	Document	Optional
Organization_Entity	Organization or Entity	Document	Optional
Program_Project_Name [1]	Program or Project Name	Document	Optional
Project_Number	Project Number	Document	Optional
ROW_CSJ	ROW CSJ	Document	Required
CSJ	CSJ	Document	Required
Roadway_or_Highway	Roadway or Highway	Document	Optional
County	County	Document	Optional

[1] Multi-value attributes that require a related table.

Plans Online

Plans Online is a web-based application that TxDOT uses to manage the storage, archival, and delivery of project plans and related documentation to internal and external users (*30*). Project documents typically include letting, contract, and final/as-built plans; proposals; project addenda; and bid tabs. Intranet access to Plans Online is comprehensive and includes pre-letting, post-letting, and archived documents and data. TxDOT maintains a permanent archive of as-built plans (in digital format – TxDOT does not archive the original Mylar plans that divisions provide). In addition, TxDOT maintains a 10-year archive of letting database records. By comparison, Internet access to Plans Online is limited to letting documents for construction and maintenance projects over a five-month period: the current month, the next month, and the prior three months. Internet access also includes post-letting bid tabulation and bid total data for a three-month period: the current month and the previous two months. Plan sheets are available in two formats: tagged image file (TIF) and portable document format (PDF).

Plans Online includes a viewer that enables users to browse through database contents in a folder hierarchy. The viewer also enables users to run queries by project attributes, document attribute fields, document content, file name, folder attribute fields, and document annotations. Currently,

TxDOT is evaluating platforms for upgrading Plans Online, including the implementation of a GIS-based interface to facilitate document querying and viewing.

Data Architecture and Data Modeling Practices

The TxDOT *Data Architecture* document lists standards for diagramming, data modeling, special standards for GIS data, and a process for integrating commercial-off-the-shelf (COTS) software with TxDOT data (*31*). According to the manual, the data design process includes the following components:

- **Project glossary**. The project glossary includes definitions of terms to facilitate communication exchange and avoid confusion during implementation of the project. A project glossary is recommended but not mandatory.

- **Conceptual data model**. A conceptual data model identifies entities (e.g., persons, places, things, concepts, and events) about which it is necessary to keep data and identifies high-level associations among those entities. This type of model is recommended but not mandatory. This type of conceptual data model is not the same as a business process model, which TxDOT currently does not require.

- **Logical data model**. A logical data model represents the data/information needs associated with entities and the relationships among those entities. A logical model is a database-independent model. This type of model is mandatory.

- **Physical data model**. A physical data model represents the mapping of a logical data model to a database platform (e.g., Oracle®, Microsoft SQL Server, or Sybase®). It translates entities, attributes, and relationships into tables, fields, and constraints. This type of model is mandatory.

- **Data dictionary**. A data dictionary is a compilation of entity and attribute definitions (for logical data models) or table and field definitions (for physical data models).

- **TxDOT system interface diagram (TSID)**. A TSID is a diagram that documents the relationships between computer applications and data.

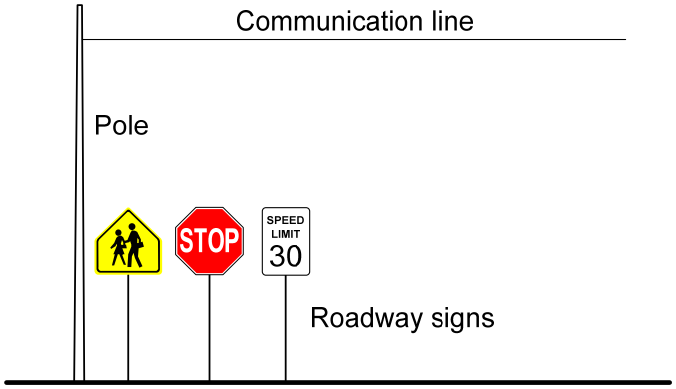
GIS Practices and Plans

TxDOT uses GIS technology primarily to support programming, planning, and maintenance activities – although the use of GIS to support design, construction, and operations is growing. TxDOT is also involved in several multiagency GIS initiatives (*32*, *33*, *34*, *35*). For example, through the Texas Strategic Mapping Program (StratMap), TxDOT has contributed state and county road GIS data to the Texas Base Map Plan transportation dataset. Other contributors to the transportation dataset include municipal, county, and regional agencies. The transportation dataset is available through the Texas Natural Resources Information System (TNRIS) (*34*).

Traditionally, TxDOT's GIS infrastructure has relied on the linear distance-based geo-referencing method. This method uses route features and route event tables to generate points or segments that represent the geographic extent of those features. A route event table typically includes attributes such as Route Name, From Distance from Origin (DFO), To DFO, Length, and other attributes needed to characterize the features of interest. A limitation of this approach is that the collection of different attributes used defines "homogeneous" segments (or points) that share the same attribute values, which means that as the number of attributes used increases, the total number of segments (or points) needed to characterize the entire network also increases. For example, the RHiNo file, which includes 137 attributes that represent a wide range of items (e.g., highway status and type, AADT for the previous 10 years, shoulder width, median width, ROW width, roadbed width, and load limits), requires about 96,000 records to characterize the state highway network. This level of segmentation can make the analysis of information as well as the production of queries and reports quite challenging. Another limitation is that *both* the underlying highway map and the cumulative distances measured along the routes govern the positional accuracy of the resulting features.

Through GAIP, TxDOT developed a framework to reduce the department's dependency on the traditional linear referencing method (*36*, *37*). With this framework, each data element of interest can be managed through a separate table that contains both spatial and non-spatial attribute values that characterize each record spatially and temporally, making the use of event tables as the primary data storage mechanism unnecessary. A feature can be any managed object. As an illustration, Figure 3 shows five roadside features and how GAIP would handle feature changes over time. When there is a feature change (either spatially or non-spatially), the old feature is "retired" by populating a time stamp field indicating the completion of the life cycle for that feature, and a new feature with new attribute values is created as needed. Because each feature can be modeled independently, GAIP makes it possible to use more accurate location technologies such as global positioning system (GPS) technology and fine-resolution aerial photography to develop GIS-based data inventories.

Strictly speaking, the GAIP framework makes it unnecessary to include attributes to describe relative locations along routes because GIS functions can enable the calculation of those attribute values "on the fly." In practice, business processes might require the inclusion of additional linear referencing attributes to optimize the production of queries and reports.



Pole Table

Object ID	Shape	Start Date	End Date	(several attributes)		Comment
100100	Point	04/15/1990	08/27/2003	…	…	Object "retired"
127203	Point	08/28/2003		…	…	Replaced pole

Communication Line Table

Object ID	Shape	Start Date	End Date	(several attributes)		Comment
100312	Polyline	05/01/1990		…	…	Existing line
				…	…	

Roadway Sign Table

Object ID	Shape	Start Date	End Date	Sign Type	(several attributes)		Comment
99156	Point	03/15/1989	01/04/2004	Stop	…	…	Object "retired"
530189	Point	01/05/2004		Stop	…	…	Replaced stop sign
367544	Point	08/12/1996		School crosswalk	…	…	
345678	Point	06/01/1995		Speed limit	…	…	

Figure 3. Conceptual Representation of Roadside Features in GAIP.

GIS-Based Information Systems

A number of GIS-based information systems in production or development at TxDOT are relevant to this research, including MST and Right of Way Map Locator.

Main Street Texas

MST is a web-based information system TxDOT is using to implement GAIP (*38*). MST runs on the Genesis Enterprise Information Integrator (GENII)™ (*39*), which is a web-based portal that enables spatial intersect and relational queries for the production of tabular and mapping reports. TxDOT envisions MST to become a basic platform for developing, managing, and serving GAIP-compliant GIS data to TxDOT users. TxDOT has incorporated a number of GIS-based datasets into MST, including bridges, roadbeds, right of way maps, recycled material facilities, and primary survey control points. MST runs on an Oracle database platform, both for spatial data—using Environmental Systems Research Institute (ESRI)®'s ArcSDE™—and non-spatial data.

Right of Way Map Locator

The Right of Way Map Locator is a web-based application that facilitates the delivery of right of way maps to interested users (*40*). Traditionally, districts provide paper copies of right of way maps in response to internal or external inquiries. However, finding the correct right of way map(s) and making the corresponding paper copies can be time consuming. The right of way map locator application automates this process by providing an interactive map that enables users to navigate and zoom to a specific control section. Clicking a point along a control section displays a list of right of way map files that the user can view, download, or print (Figure 4). Currently, the right of way map locator application includes right of way map image files from three TxDOT districts: San Antonio, Fort Worth, and Pharr. TxDOT is extending the system statewide.

The right of way map locator application is GAIP compliant and is included in the MST portal. In the system, each right of way map is a separate object with spatial and non-spatial attributes. For the spatial component, TxDOT modeled the geographic extent of each right of way map by using a copy of the corresponding control section linear feature. Since from and to data were not readily available (it would be necessary to manually extract this information visually from each map, or the data manager would have to manually plot the extent of the map limits), TxDOT decided to assume the geographic extent of each right of way map *was the same as* that of the corresponding control section. As a result, when users click a control section on the system interface map, the spatial intersect join query retrieves all the right of way map files associated with that control section, even if there is only one right of way map (or none at all) associated with the specific point that the user clicked. In addition, the system does not store information to enable users to overlay right of way map images correctly. After downloading a file, users must manually scale, rotate, and/or translate downloaded files in order to overlay those files in a CAD or GIS environment.

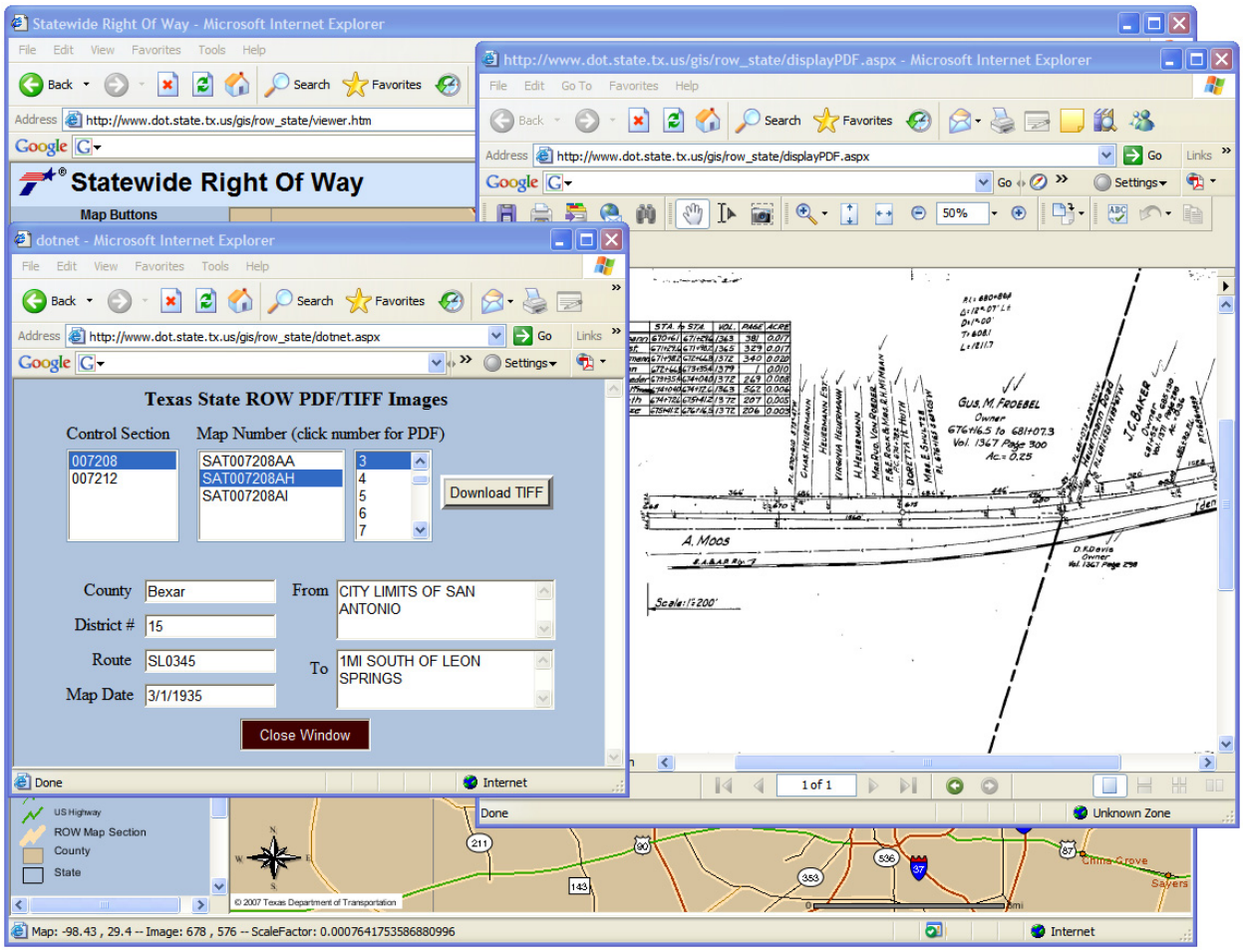


Figure 4. Right of Way Map Locator Interface (*40*).

CHAPTER 3. RIGHT OF WAY ASSET DATA MANAGEMENT PRACTICES AT OTHER AGENCIES

PROPERTY DESCRIPTIONS AND SURVEY METHODS

Property descriptions in Texas can be of several types depending on the type of survey method used:

- **Metes and bounds**. This method describes property lines based on metes (i.e., straight measurements with a direction) and bounds (i.e., a description of the boundary characteristics), typically using natural and/or artificial structures as corner and boundary markers. The method, traditionally used in Europe for land identification and adopted by the original Thirteen Colonies, is now in use by 18 primarily northeastern and southeastern states. The metes and bounds method is also used in Texas. Current metes and bounds in the state are the result of land grants and subsequent subdivisions under Spanish laws (prior to 1821), Mexican laws (1821 to 1836), Republic of Texas laws (1836 to 1845), and State of Texas laws (after 1845) (*41*, *42*). In fact, from its inception, the State of Texas recognized all valid land titles that Spain, Mexico, and the Republic of Texas had issued. A review of the history of land grants and related legislation in the state is beyond the scope of this research. However, several references are available that can provide additional information if needed (*41*, *42*, *43*, *44*).

- **Texas railroad grants**. Through the Texas railroad grants, Texas used a system for land division loosely based on the public land survey system (PLSS). Also called the rectangular survey system, PLSS started with the Land Ordinance of 1785 as a mechanism to raise revenue through the orderly, systematic, "survey before settlement" sale of land (most of it unmapped) west of the original Thirteen Colonies (*45*). The foundation of PLSS was a series of principal meridians (running north-south), baselines (running east-west), and standard parallels (running parallel to baselines at 24- or 30-mile intervals, depending on the location). Land subdivision started by establishing township and range lines (which ran parallel to the corresponding principal meridians and baselines, respectively, at nominally 6-mile intervals), which led to the formation of survey townships that were roughly 96 square miles in size. Further land subdivision involved dividing survey townships into sections (1 mile × 1 mile, or 1 square mile [640 acres]), quarter sections (½ mile × ½ mile, or ¼ square mile [160 acres]), or smaller areas as needed. Another name for quarter sections is "aliquot parts" (*45*).

  In 1854, in an effort to encourage the construction of railroads in the state, Texas started issuing grants typically involving 16 sections (10,240 acres) for each mile of track built (*41, 42*). Most of the grants were in West Texas. As part of the process, railroad company surveyors were instructed to survey designated areas into sections similar to PLSS and into square blocks (no less than 6 miles × 6 miles). The railroad companies then received patents for the odd-number sections, while the state kept the even-number sections.

- **Lot and block (or plat) method**. This method provides property descriptions in terms of unique lot identifiers within a track of land as depicted on an official plat map that is recorded with an official government office. The officially recorded map is the legal description of all the lots in the subdivision. The original tract of land is usually defined by using either the metes and bounds method or aliquot parts of a section. The lot and block method is the usual method for identifying and locating land in urban and suburban areas in the United States.

The following is relevant text from the Texas Society of Professional Surveyors (TSPS) *Manual of Practice for Land Surveying in the State of Texas* in relation to standard land surveys (*46*):

> 12.1 When the surveyed property's dimensions, boundaries and area are in close agreement with the existing recorded deed or platted calls, the aliquot method regarding subdivisions of rectangular surveys or the plat method, involving lot, block and subdivision may be used to describe the property.
>
> 12.2 Where any significant difference appears between the recorded description and the new survey, a metes and bounds description shall be made.
>
> 12.3 Basic information to be conveyed in any description will consist of the general location of the property in relation to the parent tract, established and recorded subdivisions, surveys, leagues or other original land divisions, the abstract number or numbers of such original land divisions, and the name of the county in which the surveyed land is situated. Street addresses for small tracts or lots shall be used when reasonably available.

PARCEL DATA MODELING

National Integrated Land System (NILS)

NILS is a PLSS-based land management system for the collection, management, and sharing of survey data, cadastral data, and land record data, which involves the Bureau of Land Management (BLM), the U.S. Department of Agriculture Forest Service (USFS), and other stakeholders (*47*). NILS includes a PLSS data model and four software modules:

- **Survey Management**. This module supports the capture and processing of field data.

- **Measurement Management**. This module enables the combination of measurement data from a variety of sources into an integrated PLSS network.

- **Parcel Management**. This module provides GIS-based feature classes, tools, and procedures for editing land records in an environment that keeps track of historical events.

- **GeoCommunicator**. This module is a web portal for sharing information with stakeholders. GeoCommunicator includes a web-based mapping interface and a map service that enables remote users to overlay BLM-hosted layers on client GIS applications, including PLSS township, range, section, and aliquot data; oil and gas leases; mining claims; and non-mineral leases and permits.

Figure 5 shows a view of the NILS Survey Management and Measurement Management data model (*48*).

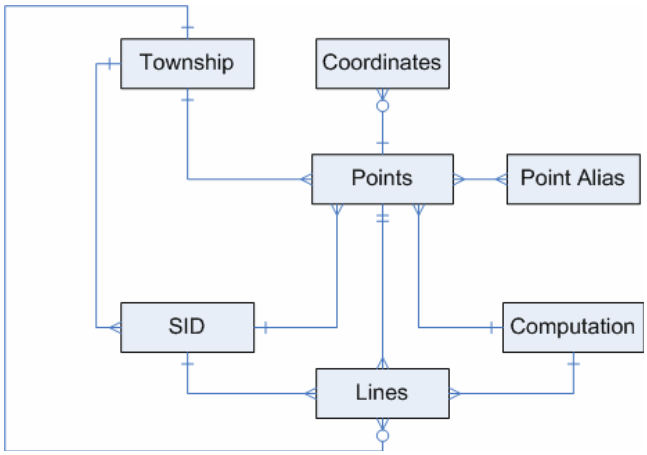


Figure 5. NILS Survey Management and Measurement Management Data Model (*48*).

Federal Geographic Data Committee (FGDC) Cadastral Data Content Standard

The FGDC Cadastral Data Content Standard provides semantic definitions of objects related to land surveying, land records, and landownership information (*49*). Basic definitions in the standard include the following:

- **Cadastral data**. Cadastral data are "the geographic extent of the past, current, and future rights and interests in real property including the spatial information necessary to describe that geographic extent."

- **Parcel**. A parcel is "a single cadastral unit, which is the spatial extent of the past, present, and future rights and interests in real property."

- **Rights and interests**. Rights and interests are "the benefits or enjoyment in real property that can be conveyed, transferred, or otherwise allocated to another for economic remuneration."

- **Restrictions**. Restrictions capture "information related to administrative, judicial, or other limitations or permissions for the use and enjoyment of land by the land right holder. These are not transferred rights, although succeeding owners may agree to the same restriction on a parcel."

The standard includes logical-level entity-relationship (ER) diagrams that describe entity names and relationships among entities, including an overview diagram (Figure 6) as well as more detailed diagrams for specific subject areas: parcels (Figure 7), legal area descriptions (Figure 8), boundaries and corners (Figure 9), and agents and geopolitical places (Figure 10). The model is generic in that it is not tied to any specific GIS architecture or database platform.

In Figure 8 and Figure 9, the model supports various types of property descriptions, *provided* there is a mechanism for converting descriptive information into measurements that can be represented in terms of boundaries, corners, and coordinate data (particularly critical in the case of metes and bounds descriptions).

As Figure 7 shows, the model provides some basic attribution for parcel data, including parcel ID, actual and legal area, parcel transactions, restrictions, and rights and interests. The relationship between parcels and restrictions is one to many (suggesting that a parcel can be subject to many different restrictions). By comparison, the relationship between parcels and rights and interests is many to many, requiring the use of a third entity to represent that relationship. The model includes the following rights and interests subtypes: separated rights (e.g., mineral rights), encumbrances (e.g., easements, grazing rights, fishing rights, development rights, floodplains, liens, leases, or mortgages), and tribal interests. Although the documentation suggests the model can handle fee simple rights, fee simple is not one of the rights and interests subtypes.

The model includes suggested domains for a number of data elements, including monument types, corner types, parcel types, parcel area types, direction types, information source types, survey system types, transaction agent role types, and ownership types.

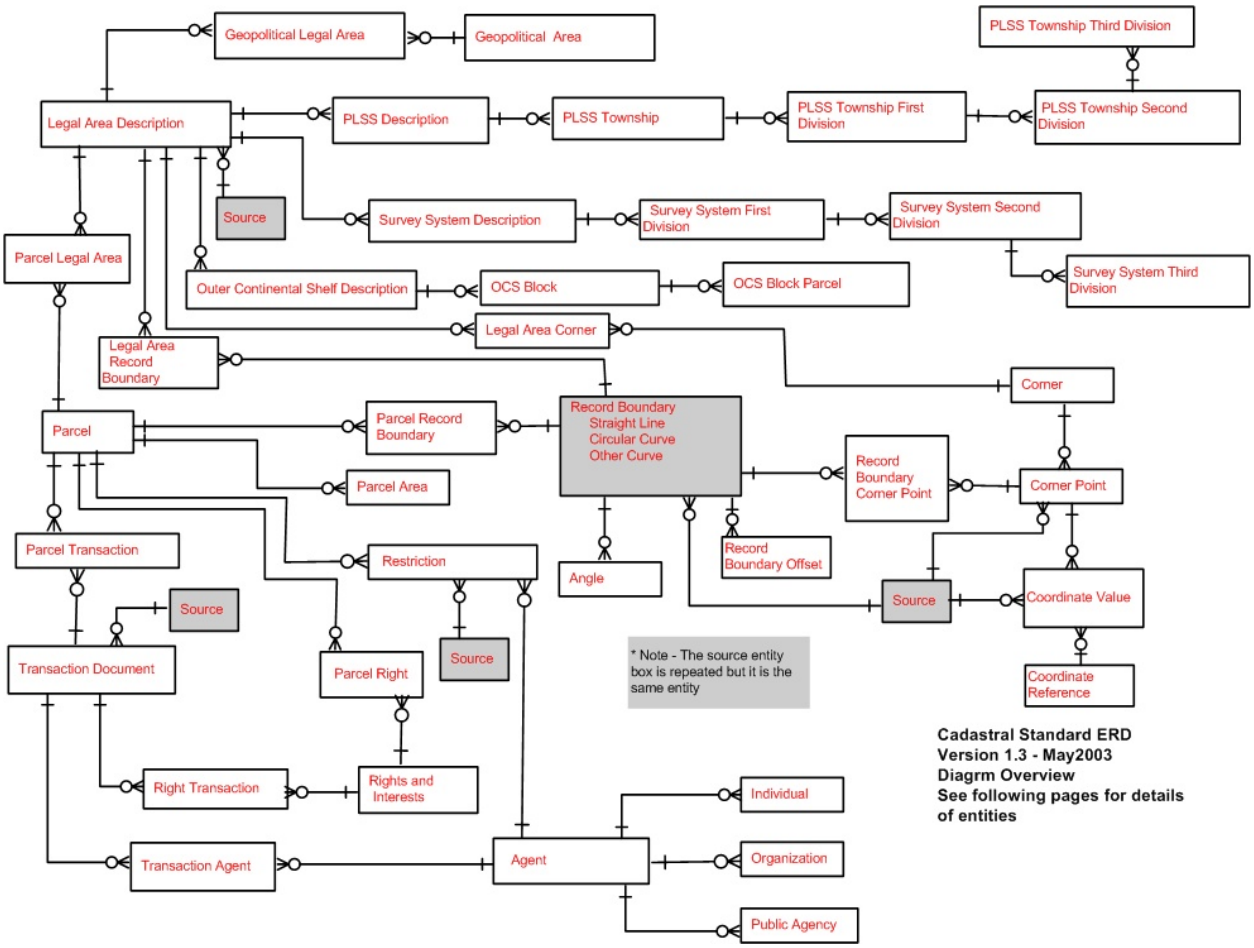


Figure 6. FGDC Cadastral Data Content Standard ER Diagram – Overview (*49*).

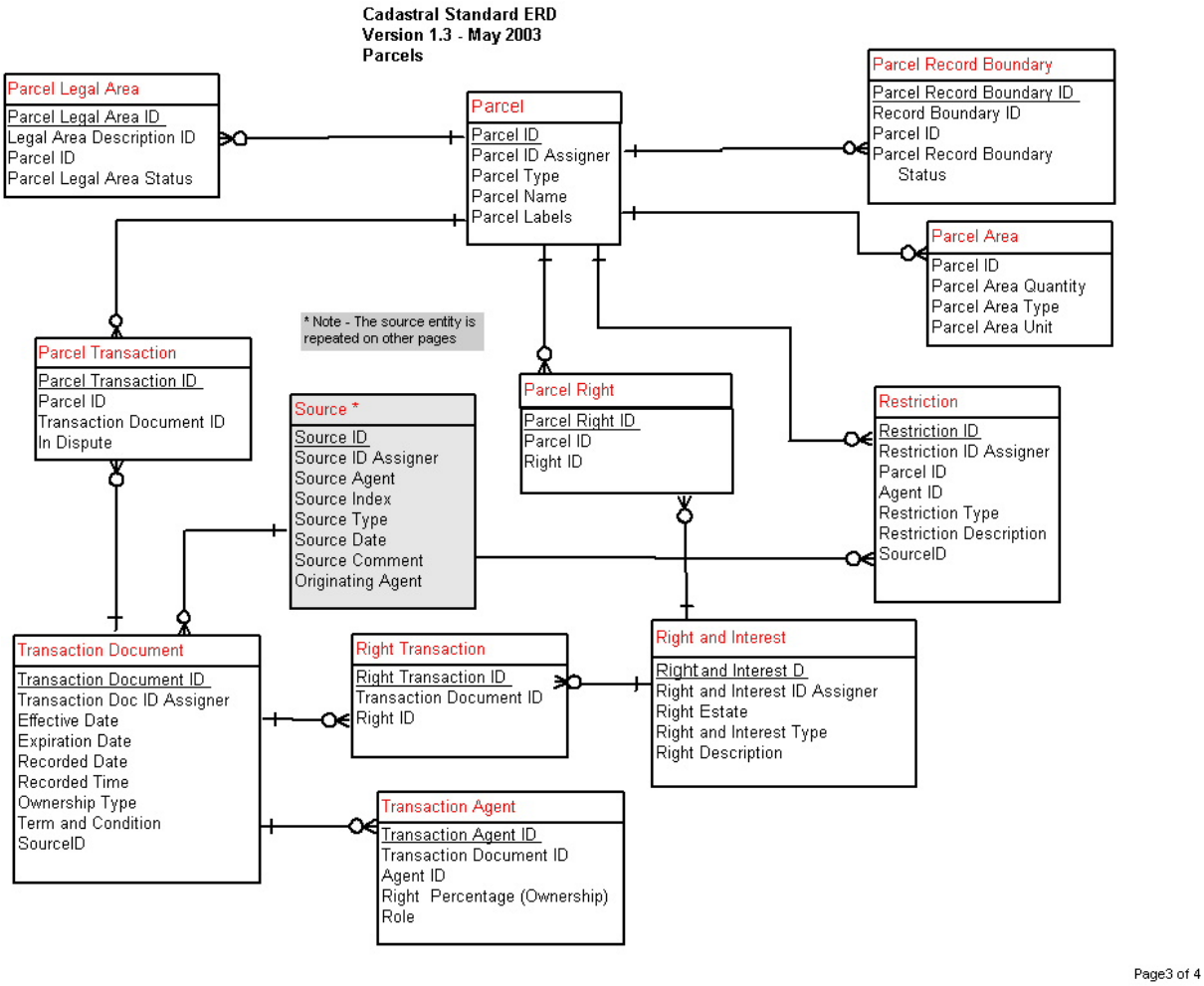


Figure 7. FGDC Cadastral Data Content Standard ER Diagram –Parcel Subject Area (*49*).

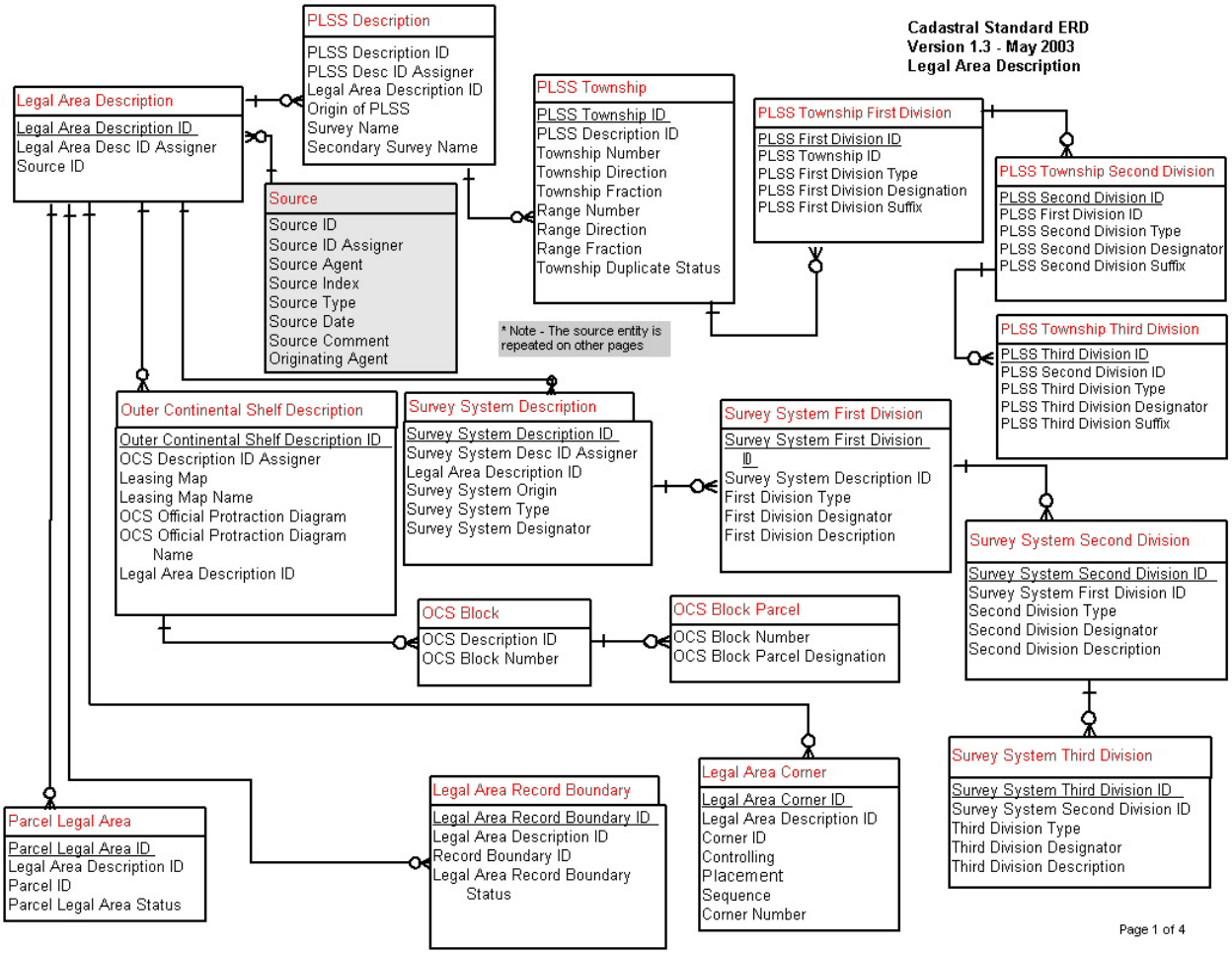


Figure 8. FGDC Cadastral Data Content Standard ER Diagram –Legal Area Description Subject Area (*49*).

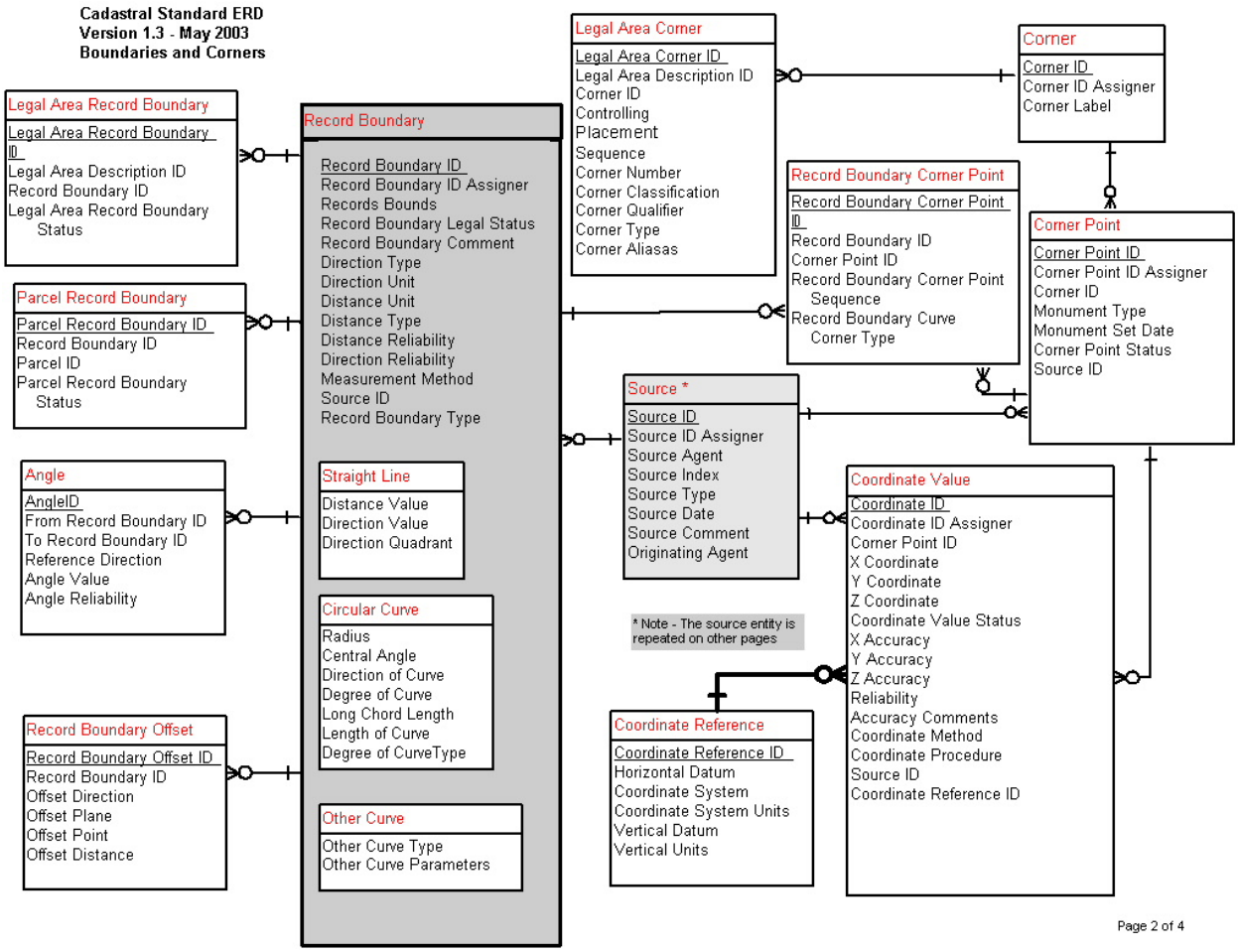


Figure 9. FGDC Cadastral Data Content Standard ER Diagram – Boundaries and Corners Subject Area (*49*).

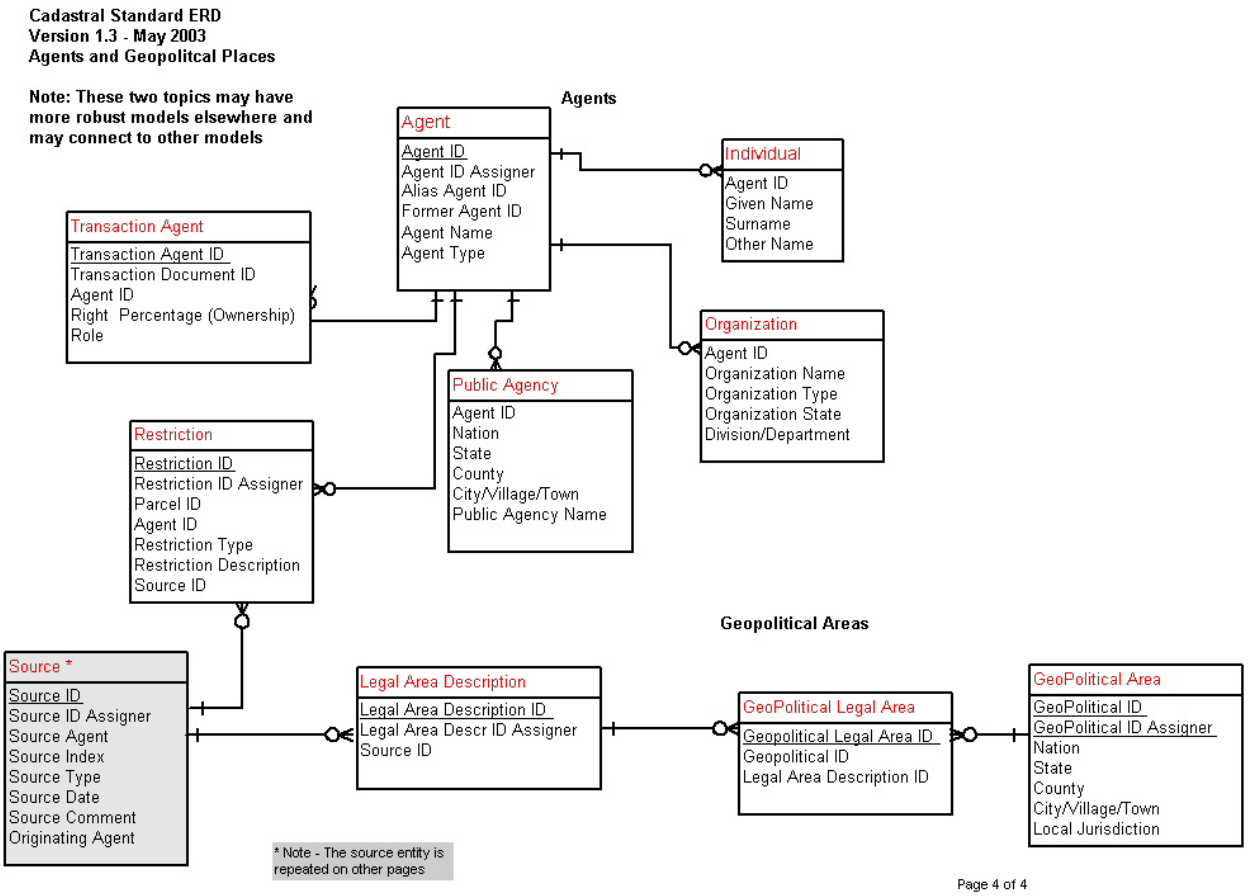


Figure 10. FGDC Cadastral Data Content Standard ER Diagram – Agents and Geopolitical Places Subject Area (*49*).

Cadastral National Spatial Data Infrastructure (NSDI)

The Cadastral NSDI is "a minimum set of attributes about land parcels that is used for publication and distribution of cadastral information by cadastral data producers for use by applications and business processes" (*50*). The Cadastral NSDI is a subset of the Cadastral Data Content Standard. The Cadastral NSDI has two components: cadastral reference and parcels. The cadastral reference provides elements that are necessary for query, mapping, and navigation purposes, including information about the survey system used (Figure 11). Parcels contain information about property and its characteristics. Parcels may be polygons or points with enough attribute information to link the spatial component to attribute data produced externally (Figure 12). On federally managed public lands, parcels include information about grazing leases, mineral surveys, and use authorizations. On private lands, parcels are typically tax parcels, which may include additional information about restrictions such as easements.

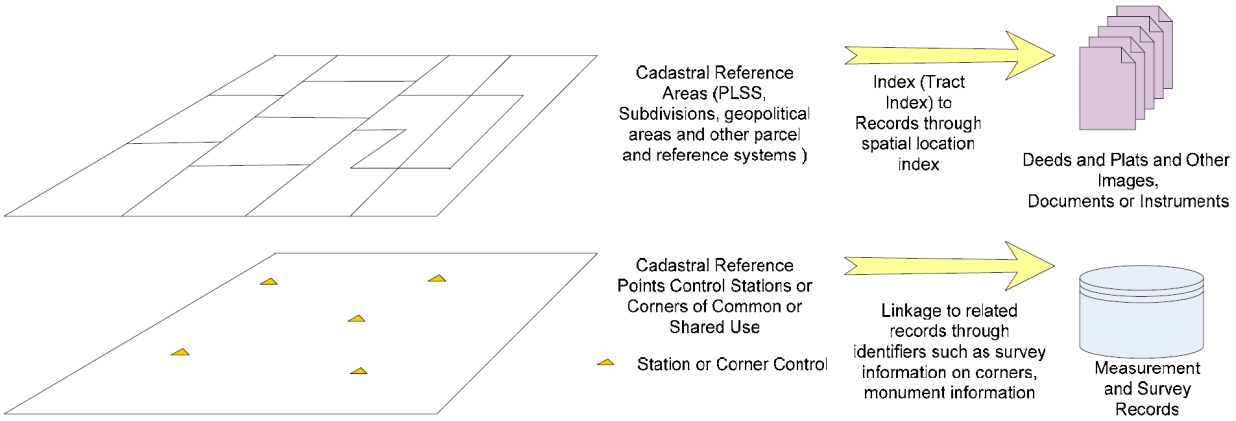


Figure 11. Cadastral NSDI – Cadastral Reference (*50*).

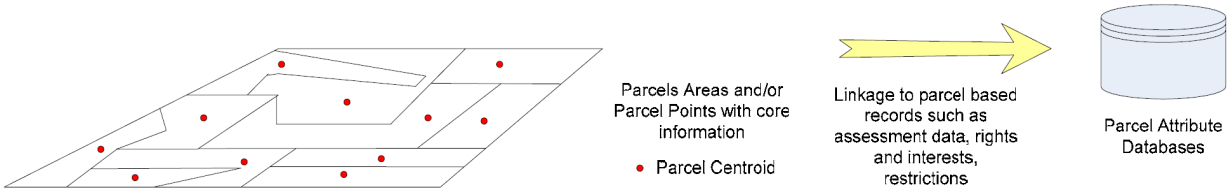


Figure 12. Cadastral NSDI – Parcels (*50*).

ArcGIS™ Parcel Data Model

The ArcGIS parcel data model is one of several data models that ESRI has developed with academic and industry collaboration (*51*). The parcel data model, shown in Figure 13, is in many ways similar to the FGDC Cadastral Data Content Standard. For example, both models account for parcels, rights and interests, restrictions, corners, and boundaries. However, the treatment of these entities in the ArcGIS parcel data model is different. For example, the ArcGIS parcel data model assumes parcels, encumbrances, and separated rights are independent geographic feature classes, which might have different corners and boundaries. At the same time, the model is somewhat limited in scope in that it does not specifically handle property descriptions (although it does handle corner, boundary, and PLSS data) or parcel transaction data.

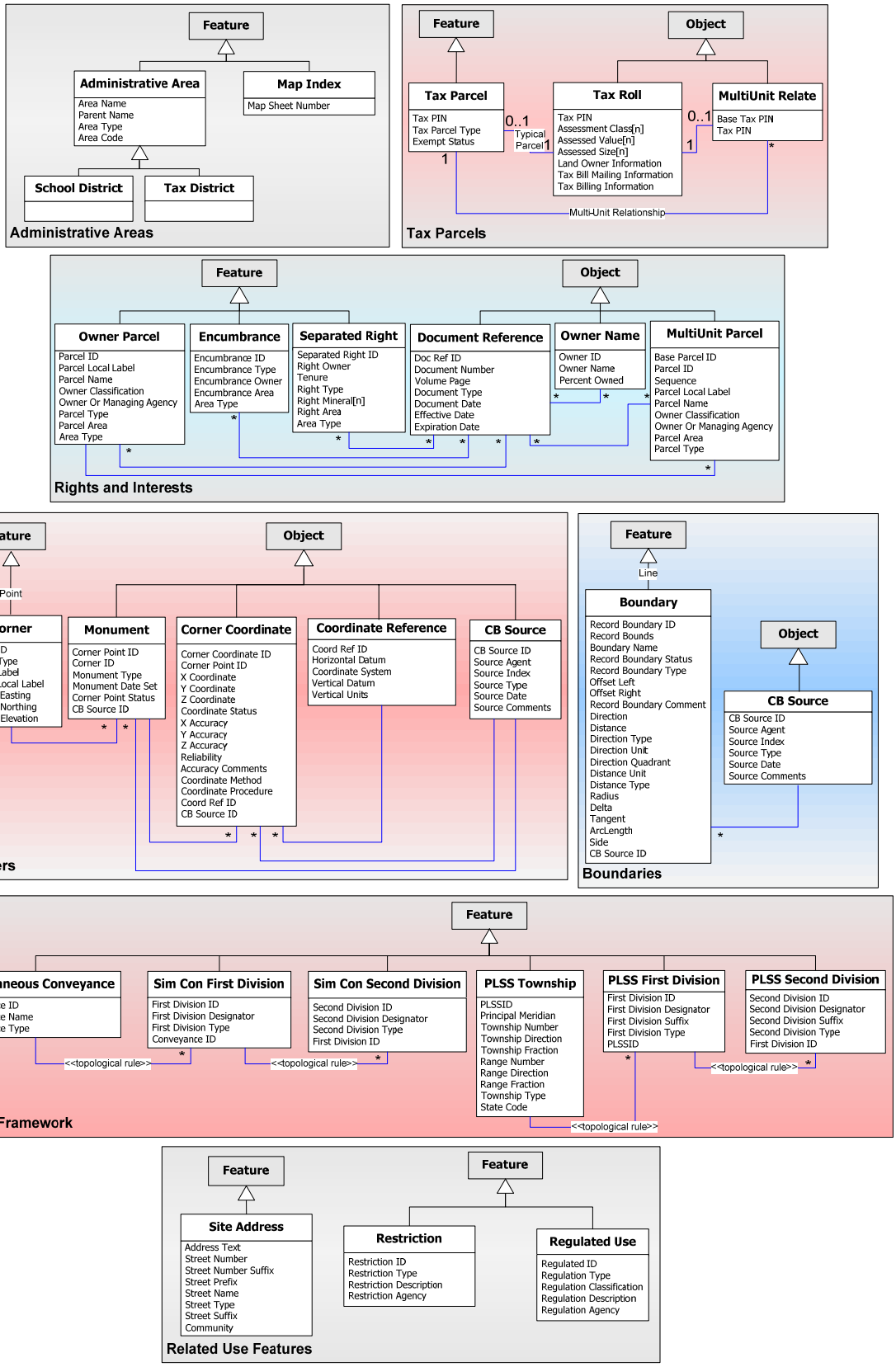


Figure 13. ArcGIS Parcel Data Model (Adapted from [*51*]).

Cadastre 2014

Cadastre 2014 was the result of efforts between 1994 and 1998 by the International Federation of Surveyors (or Fédération Internationale des Géomètres) (FIG) to develop a vision for future cadastral development efforts (*52*, *53*). Central to that vision was the recognition of the key role that automation and the explicit spatial modeling of land objects (such as land parcels, property rights, restrictions, administrative units, and land use zones) will play in the future. The Cadastre 2014 vision included six major components:

- accounting for the complete legal situation of land, including rights and restrictions;
- elimination of the separation between "maps" and "registers";
- focus on cadastral modeling instead of cadastral mapping;
- elimination of paper-based cadastral systems;
- increasing role of the private sector; and
- emphasis on cost recovery.

Cadastral Initiatives in Other States

For illustration purposes, this section summarizes cadastral initiatives found while conducting an online review of practices at other states. The summary includes Arkansas, California, New Mexico, Ohio, and Oregon. Arkansas developed a cadastral mapping standard with the goal of making digital cadastral data more accurate and uniform (*54*). The standard included requirements for creating cadastral vector layers, including heads-up digitizing and metes and bounds descriptions, as well as requirements for basic cadastral data attribution (essentially one table including commonly used parcel attributes, e.g., parcel ID, legal description, owner name, road name and type, address, property type code, assessed value, legal area, and calculated area). The standard also specifies that cadastral data must meet FGDC metadata standards (*55*).

In 2003, the State of California completed a study to identify the requirements, benefits, and strategies for implementing a standardized statewide source of digital land record data to support the needs of all state agencies (*56*). Participants in the study included 20 state agencies (including the California Department of Transportation [Caltrans]®) and 2 federal agencies. In relation to current practices, the study revealed redundant land record management efforts resulting in inconsistent, inaccurate, and/or incomplete data; multiple, different land information management approaches; multiple hardcopy and digital data collection and archival formats and standards; and a lack of statewide vision and strategy for land record information management. To address these issues, study participants identified a number of critical data quality requirements, including spatial data positional accuracy and consistency, data consistency among various databases, and conformance with established data standards.

The New Mexico Taxation and Revenue Department's Property Tax Division has a standard for the submission of property records by each county in the state (*57*). The standard includes five entities documenting parcel data, building segment data, book page data, land segment data, and sale data. The parcel entity contains information such as owner's name, property and owner mailing address, legal description, PLSS data, area, land and building values, total taxable value,

veteran exemption data, and disability exemption data. A GIS application represents parcels by polygons, which include a centroid attribute that links to the parcel attribute data.

In 2005, BLM completed a study to evaluate the applicability of the FGDC Cadastral Data Content Standard to support a variety of survey systems in Ohio (*58*). BLM chose Ohio because Ohio was the first place in the United States where PLSS was developed and tested and because the metes and bounds method is also used and transitions with PLSS. The original development of PLSS in Ohio involved the implementation of a series of PLSS origin areas and survey names that followed a township nesting structure with a variety of spatial configurations, references, and numbering structures. Examples of special situations included cases where PLSS townships were divided into non-regular tracts and lots, cases where there were long fractional areas that were not lotted, and cases where the township structure included gaps for which there was not a PLSS township designation. These special situations resulted in recommendations for updates to the FGDC Cadastral Data Content Standard, primarily in relation to the modeling of PLSS areas and survey names. The study did not detect problems in the FGDC standard regarding the logical modeling of division of parcels that followed non-PLSS survey systems. However, there were problems with the actual spatial representation of lots, more specifically in relation to the positional accuracy of corners and boundaries and differences between county and state dataset versions.

In 2005, Oregon published a cadastral data exchange standard (*59*) with the goals of supporting the Oregon property tax system, a multi-purpose land information system, and appropriate state and national standards. The Oregon standard uses two main entities: one entity that describes tax lot polygons following PLSS naming conventions and a second entity that contains data about land transactions, such as owner name(s), address, transaction date, instrument number and type, and property class description. The relationship between the tax lot polygon entity and the land transaction entity is one to many.

RIGHT OF WAY ASSET MANAGEMENT PRACTICES AT OTHER STATE DEPARTMENTS OF TRANSPORTATION

There is a wide range of right of way asset management practices at departments of transportation (DOTs) around the country (*60*, *61*, *62*). As an illustration, this section includes a summary of practices at the following DOTs: Arizona, California, Illinois, Maryland, Minnesota, Nevada, New Mexico, Oregon, Pennsylvania, Virginia, and Washington. For completeness, this section also includes a discussion of National Cooperative Highway Research Program (NCHRP) Projects 8-55 and 8-55A.

Arizona Department of Transportation

Arizona Department of Transportation (ADOT) officials have access to right of way data stored in spreadsheets and desktop databases, including parcel information, deeds, adjacent land ownership, and access rights. Contractors, consultants, appraisers, landowners, and the public can access right of way records through open record laws by contacting ADOT. An index of right of way maps is available on the ADOT web page (*63*). To record information about land

acquisitions and appraisals, ADOT uses a legacy system called the Parcel Acquisition and Tracking System (PATS) (*64*). PATS allows users to store parcel data and create reports that ADOT uses during several stages of the project development process, including base mapping review, final plans review, acceptance review, and change orders (*65*). PATS includes the following records (*66*):

- **Acquisition record.** This record stores data such as parcel number, grantor, description (section, township and range, or lot and block), type of instrument, date of instrument, recording data, project number, map number (row maps), size of parcel (area), and cost of parcel (acquisition cost).

- **Property control data.** This record includes data such as realty improvements, initial parcel package received date, project possession date, close of escrow date, actual possession date, site clearance deposit amount, date parcel sent to condemnation, date of site clearance deposit, disposition of improvement, bid amount on improvement, date site cleared, and demolition number.

- **Facility site information.** This record includes data such as land cost, fiscal year of land values, improvement number, type of improvement, type of construction, fiscal year improvement constructed, size of improvement, economic life improvement, effective age improvement, value of improvement, condition of improvement, fiscal year improvement value, and construction cost.

ADOT supplements PATS with Microsoft Access® databases that track acquisition, condemnation, and excess land data. These databases store data on acquisition, geographic location, operating right of way status, facility sites, excess lands, material sites, and improvements on ADOT property. In practice, ADOT enters some of the data, including acquisition and ownership data, both in PATS and the Access databases. Although redundant, this practice enables the use of PATS as a check for data entry errors in Access. PATS has been in operation for approximately 15 years. According to ADOT officials, it is cumbersome to access data in PATS and to cross-reference data with other data sources. A limitation of the system is that if the parcel ID (which is a unique record identifier) changes during the project development process, the connection to other data items in the system is lost. Another limitation is the lack of connectivity to the agency's financial system (called ADVANTAGE).

California Department of Transportation

Caltrans maintains right of way asset data using paper records, spreadsheets, various engineering software systems, desktop databases, and custom-built applications. Caltrans stores electronic records of parcel and right of way data in an Intranet system. The department has begun implementing a new system called the Right of Way Management and Information System (RWMIS) to replace a legacy mainframe application called the Integrated Right of Way System (IRWS) that handles property purchases (*67*). RWMIS is a web-based system that uses Sun Microsystems® Java™ and Oracle and allows users to create data reports based on existing data from IRWS. RWMIS supports activities throughout the project development process, including property acquisition, appraisals, and condemnation, but it is not intended for the management of

acquired property. To support other right of way processes, Caltrans uses a number of legacy mainframe systems, including the Excess Land Management System (ELMS), the Right of Way Utility Management System (RUMS), and the Right of Way Property System (RWPS). Caltrans uses ELMS to manage disposition of excess land that is no longer useful to Caltrans, uses RUMS to manage utility installations, and uses RWPS to support property management activities, including the management of services contracts, rental property, and property not immediately needed for projects. Caltrans obtains adjacent land ownership data using applications such as Google Earth™ and Digital Map Products LandVision™.

Caltrans plans to include GIS functionality and integrate other legacy mainframe systems in future versions of RWMIS. In the long term, Caltrans is considering a new integrated enterprise system called the Caltrans Land Management System (CLMS) to replace all or most existing legacy systems. Caltrans considers RWMIS to be an intermediate solution until CLMS becomes a reality (*68*).

Districts manage right of way boundary information in different ways, including using a database of calculated values, an Access database of survey monuments, and a database of right of way boundary line data in Autodesk® CAiCE™ format. The accuracy of the available data in CAiCE varies. Most data from recent projects are surveyed. To include data from older projects, which typically exist on paper records, Caltrans computed coordinates from bearings and distances given on the maps or, in some cases, resurveyed the locations. As a rough estimate, Caltrans estimates that the data in CAiCE format currently capture about 25 percent of the total state right of way, with the amount of data varying from district to district. Caltrans also uses a survey control interactive map in an ESRI ArcIMS™ environment. Because practices for managing right of way information vary from district to district, Caltrans is evaluating the development of a statewide database for survey-related control, which would be accessible through a web-based application in its initial release and through a web-based GIS application in the future. Types of control would include right of way monuments, PLSS monuments, and surveyed property monuments.

Illinois Department of Transportation

The Illinois Department of Transportation (IDOT) uses a legacy system called the Land Acquisition System (LAS) to track and manage right of way acquisition activities during the project development process, including disposition of all improvements (*69*). LAS also includes an inventory of parcels and improvements that are leased or rented to other parties (*70*). In the LAS database, the parcel number is a unique identifier, which has created problems in the past when the need arises to change a parcel number. IDOT also uses an Access-based system called Non-operating Highway Right of Way (NORWAY) to manage records of parcels that IDOT flags as not used for highway purposes (*71*). Parcels that are available for disposal are listed in LAS. NORWAY includes the following parcel type codes: route relocation, uneconomic remnant/remainder, abandoned rest area, abandoned project, landlocked parcel, unfunded future construction, and mitigation acquisitions as required by law or other policies.

For a recent airport construction project involving the acquisition of approximately 2000 parcels, IDOT developed an Internet-based and geospatially enabled information management system

called the Aeronautical Land Acquisition System (ALAS) (*62*). ALAS includes an interactive map viewer that shows layers such as acquired parcels, sections, township lines, existing roads, project area, and imagery. In ALAS, consultants enter acquisition and property management data, and IDOT views the information and generates summary reports for project oversight. ALAS manages data such as parcel, title, appraisal, negotiation, survey, site audit, residential relocation, residential property management, commercial relocation, commercial property relocation, agricultural relocation, agricultural property management, demolition, condemnation excess lands, and financial. The system enables the linkage of scanned documents to parcels and allows quick searches using a map viewer. ALAS allows the creation of customized, parcel-specific or function-specific reports for an entire project, including cost data and notification of parcel acquisition. One drawback of ALAS is that it does not link directly to IDOT's Fiscal Operation and Administration (FOA) system. As a result, property payments and billings have to be entered separately, which creates some data redundancy. IDOT is currently using ALAS for other aeronautic projects and has piloted the use of the system for highway projects.

Maryland Department of Transportation

The Maryland Department of Transportation (MDOT) uses a system called MdProperty View to simplify the way in which the state gathers, presents, and uses property information. MDOT uses this system to obtain parcel data for the acquisition of right of way for transportation projects. MdProperty View works with ESRI ArcGIS software and includes a number of tools that can be accessed through a toolbar on the ArcGIS interface (*72*). The toolbar provides access to MdProperty View functions such as search property, link to the State Department of Assessments and Taxation website for property data, and smart growth priority funding areas. The geocoding tool allows users to match client address datasets to the MdProperty View dataset to map and overlay the data. Data to support MdProperty View are available on CDs containing satellite imagery, road features, and water and political boundaries along with property maps and parcel data files. MdProperty View is available by subscription through the Maryland Department of Planning for an annual license fee.

Minnesota Department of Transportation

In 2005, the Minnesota Department of Transportation (Mn/DOT) implemented a system called the Right of Way Electronic Acquisition Land Management System (REALMS). REALMS is a customized version of the Virginia Department of Transportation's (VDOT's) Right of Way and Utilities Management System (RUMS) (*61*, *62*). More information about RUMS is provided in the VDOT section.

Mn/DOT also developed an interactive web-based mapping application in ArcIMS called Right of Way Mapping and Monitoring, which enables users to view and query a number of right of way–related layers, as well as view and download TIF versions of scanned right of way maps (*73*). The web-based mapping application shows the location of the right of way maps by displaying rectangles that show the location (or "footprint") of the corresponding right of way maps. The map also shows additional layers such as aerial images for reference purposes.

Mn/DOT handled the geo-referencing process on a county-by-county basis. The original maps were multi-sheet rolls ranging from less than 3 feet to 86 feet in length. In 1997, Mn/DOT scanned these rolls. Beginning in 2002, Mn/DOT converted the multi-sheet TIF files to single-sheet TIF files and geo-referenced each image, one at a time. To geo-reference the files, Mn/DOT used the Minnesota Department of Natural Resource's control point-generated PLSS layer, Mn/DOT's statewide base map, and other reference datasets as necessary to support the positioning of the images. Overall positional accuracy was about 40 feet, which is the horizontal accuracy of Mn/DOT's statewide base map, since Mn/DOT used this base map when there were discrepancies with the PLSS data.

Nevada Department of Transportation

The Nevada Department of Transportation (NDOT) maintains information on right of way assets such as cadastral surveys, deeds, and adjacent land ownership using paper records and spreadsheets. NDOT is developing an Integrated Right of Way Information Network (IRWIN) to manage right of way data including property inventory, utilities, and outdoor advertising (*74*). The IRWIN project started in 2002 and is scheduled for completion in March 2009. In its final state, IRWIN will consist of eight modules: GIS, Videolog, Electronic Document Management, Acquisition, Property Management, Permits, Billboard, and Junkyard. Currently, the Electronic Document Management module is operational, and NDOT has scanned a large number of right of way documents including paper copies and microfiche of right of way maps and other legal documents. NDOT will continue to archive all documents on microfiche and use the electronic document management system as a system to simplify document retrieval.

To provide a spatial reference for parcels, NDOT is creating a PLSS layer as part of the IRWIN project. Other relevant datasets under development are county boundaries, bridges, facilities, material sites, and imagery. IRWIN will also provide a mechanism to geo-reference documents. For documents developed prior to 1976 (the NDOT road network and milepost system became operational in 1976), NDOT will provide a latitude and longitude location. For documents developed after 1976, NDOT will use the starting mile point of the right of way document. In the future, NDOT anticipates adopting the use of latitude and longitude including a temporal component to replace the milepost referencing system (*75*).

New Mexico Department of Transportation

The New Mexico Department of Transportation (NMDOT) implemented the Non-Right of Way Parcel and Improvement Inventory System as a template-based automated process that uses ESRI's ArcGIS and Adobe® Acrobat® to generate one-page summaries of parcels that are available for sale to the public (*60*, *61*). Each summary includes relevant data such as district number, county, and project number, as well as a map that shows the parcel of interest overlaying aerial photography and other layers. The system has simplified the process of storing, retrieving, and producing parcel maps, which were previously recorded on spreadsheets and Access databases. NMDOT uses templates that automatically generate parcel summaries that NMDOT then posts on the NMDOT website (*76*). An additional benefit of the system is that

data about NMDOT-owned parcels are located in a centralized repository that provides both geospatial location and associated information.

Oregon Department of Transportation

The Oregon Department of Transportation (ODOT) started the development of a new Right of Way Data Management System (RWDMS) in May 2005 following a request by the Oregon Legislature to capture and evaluate historical right of way data to assess how much property ODOT owns and how much of that property would be excess property. RWDMS uses several FileNet tools along with basic GIS functionality (*77*). ODOT completed the first phase of the implementation project in June 2007, which focused on scanning old right of way records, installing the basic FileNet search capability, and entering the scanned documents into the system. The project is currently in its second phase, which focuses on the implementation of electronic form functionality and geo-referencing of right of way maps. Right of way maps that ODOT has geo-referenced appear as points on a map viewer that is available to ODOT employees. ODOT plans to make the map viewer and right of way data available to the public by the fall of 2008. ODOT is also considering the use of FileNet as an agency-wide archival and document management system.

ODOT developed a library for right of way documents based on document classes and document types, which apply to both single documents and document packages. Document packages are useful for document sets that consist of several documents with an inherent connection, such as the documents related to the appraisal of a parcel. To track updates of documents and document packages, ODOT uses FileNet's automatic versioning feature.

Pennsylvania Department of Transportation

In 2003, the Pennsylvania Department of Transportation (PennDOT)™ started the process to replace its old legacy mainframe Real Estate Management Information System (REMIS) with an off-the-shelf application from Bentley called Right of Way Office (*61*). Right of Way Office is a web-based application for land acquisition that uses a relational database such as Oracle or Microsoft SQL Server. The system can capture data for appraisal, property management, acquisition, relocation, excess land management, and record archival. The interface also enables the generation of reports using a variety of report templates. Several hundred employees and consultants have access to the system based on authorized functions that follow a tree folder structure. Folders in the system represent activities such as appraisal or negotiation, which provide access to electronic forms that allow data entry. The system is linked to the statewide accounting system, which enables faster approval of payments. PennDOT plans to expand the system to include additional entry forms and link the application to the department's multimodal planning management and electronic document management systems (*61*).

Virginia Department of Transportation

In 1999, VDOT implemented the web-based system RUMS to manage right of way and utility adjustment activities at the department (*61*, *78*). RUMS replaced a legacy system that had a number of limitations, including lack of consistent tracking of critical dates; difficulty in finding, searching, and updating data; and lack of standardization in forms and document tracking during the right of way acquisition process. The new system supports the following right of way functions:

- right of way acquisition appraisal, acquisition, title reviews, deeds, eminent domain proceedings, relocations, and disposition of improvements;
- utility design and adjustments, and
- property management, including leasing and disposition of surplus and residue properties.

RUMS runs on an Oracle platform. The interface includes a large number of screens with automated forms that contain data populated from the database. For increased efficiency, the forms presented to the user are screen dependent. Users can customize forms using Microsoft Word. RUMS uses Business Objects™ Crystal Reports™ to generate reports.

VDOT is identifying new uses for RUMS in addition to right of acquisition and utility adjustments. Their Environmental Division now uses RUMS to track asbestos abatement and wetland mitigation sites (*61*).

Washington Department of Transportation

The Washington Department of Transportation (WSDOT) uses primarily paper records to manage right of way parcel information. WSDOT has a desktop database for managing access rights and has spreadsheets for managing telecommunication infrastructure assets. WSDOT also uses Oracle Stellent™, a commercial off-the-shelf enterprise content management system, to manage deeds.

In the past, WSDOT used a desktop application called the Real Estate Information System (REIS) to manage right of way activities. A commercial off-the-shelf software called the Integrated Realty Information System (IRIS) is currently replacing REIS. IRIS is an implementation of Smart Data Strategies DREAMaps™ software, which provides workflow management and GIS tools in a web-based platform to support right of way activities such as appraisal, acquisition, condemnation, and relocation (*79*). IRIS was designed primarily for use within the WSDOT Intranet, but it can also provide access to users outside the WSDOT network. After a user logs into the system, IRIS provides options to search the database for acquisition data (e.g., project number, parcel number, and property owner) or for property management data (e.g., inventory number, lease number, and property address). Another link provides access to the reports section, which enables users to generate a variety of reports.

NCHRP Projects 8-55 and 8-55A

The National Cooperative Highway Research Program undertook NCHRP Project 8-55 to identify data elements to include in a geo-enabled data model for a right of way information system and to provide examples of return on investment resulting from adding the geo-spatial capability (*61*). The study included a summary of six real-world examples where geo-spatial technologies support the right of way management process, a high-level characterization of the right of way business process (including appraisal, right of way acquisition, relocation, and property management), and a compilation of data elements for each area identified in the high-level business process model.

The data elements in NCHRP Project 8-55 included some information about entities, primary keys, and attributes. In general, the modeling approach was to use a spatial entity to manage parcels (in the form of spatial cadastral data obtained from the tax assessor's office or equivalent) and a spatial entity to manage highway project alignments (obtained from project alignment and project end data). Additional non-spatial entities that point to the parcel and project entities in a one-to-many fashion handle different aspects of the right of way management process. For example, the initial parcel review activity includes project ID and parcel ID as the primary key as well as estimated value, complexity, and appraisal requirement as attributes. Likewise, the lease agreement activity includes project ID and parcel ID as the primary key as well as tenant ID, date of lease, term of lease, personal liability insurance, and lease agreement as attributes.

A follow-up project, NCHRP Project 8-55A (currently active), is expected to provide more detail to the business process model, develop an enterprise-level logical model, and use the model to analyze at least three case studies to determine gaps in the state of the practice as well as long-term ramifications, costs, and benefits of adopting a system based on the logical model (*80*).

CHAPTER 4. PROTOTYPE RIGHT OF WAY ASSET DATA MODEL

GENERAL REQUIREMENTS AND SCOPE

For the development of the prototype data model, the researchers took into consideration a number of requirements that guided the development and testing phases. A summary of general requirements and guiding principles used during the research phase follows:

- **Focus on asset data architecture, not on graphical user interfaces (GUIs)**. At TxDOT's request, the research focused on asset data architecture modeling and identification of implementation issues, not on GUI development or business processes needed to support the implementation of the right of way asset data model. For data model testing purposes, the researchers developed simple offline (standalone) and online prototype GUIs. As described in Chapter 5, the offline prototype GUIs used standard ArcGIS and Access interfaces, while the online prototype GUI used ArcIMS-based web pages. The level of functionality of the prototype GUIs, while adequate for assessing the feasibility of the data model and conducting database tests, would not necessarily be an accurate reflection of the level of functionality expected of a production-level system. However, whenever possible, the researchers included data elements in the database design to make sure the database would support appropriate GUI developments. Along with the requirement to focus on asset data architecture elements was the requirement to focus on long-term asset data management issues (more specifically, related to the spatial component of the assets) after the completion of the right of way acquisition phase. The reason is that TxDOT has a functional right of way information system (i.e., ROWIS) that handles the acquisition phase, and that TxDOT is implementing the results of several research projects that focus on specific right of way process components.

- **Data integration**. To optimize existing computing resources, the researchers identified integration points with TxDOT's existing systems, such as DCIS, FileNet, and MST. Chapter 2 provides a summary of these systems, which are also described in published TxDOT documents (*31*). The identification of integration points with existing TxDOT systems was at a high conceptual/logical level because, with the exception of MST, DCIS, and ROWIS, detailed database design documents of other systems were not available to the researchers. In the specific case of FileNet, a database representation of the FileNet library structure was not available to the researchers. In general, the researchers created "placeholders" in the prototype database structure for tables and fields that are related to project data (which are DCIS or ROWIS related) or engineering documents (which are FileNet related). During implementation, it should be possible to replace the placeholders with pointers to relevant existing systems, provided the necessary application programming interface (API) components are in place.

- **Compatibility with existing TxDOT information systems**. The data model developed in this research is compatible with existing TxDOT data architecture requirements (*31*). To the extent possible, the prototype is also compatible with other existing data standards, e.g., TxDOT's CAD standards (*20*) and right of way map production standards (*8*, *15*).

In addition, the data model uses concepts gathered, as well as lessons learned, from the literature review in Chapter 3.

CONCEPTUAL DATA MODEL

Property Rights

If the state owned all right of way parcels in fee simple, parcel outlines would provide all the information needed to represent TxDOT real property interests spatially (Figure 14a). In practice, it is necessary to deal with property rights that are not only separated from the parcel (Figure 14b) but that might also have a different spatial outline from that of the original parcel.

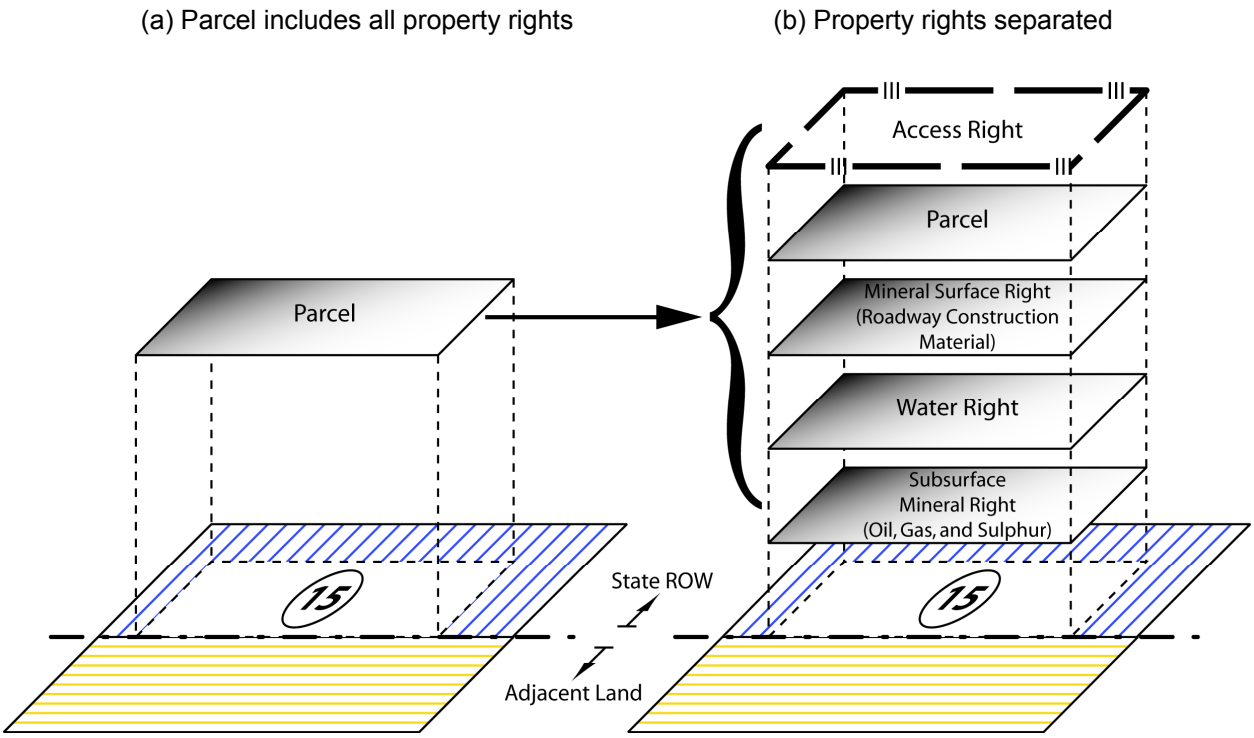


Figure 14. All Property Rights Combined versus Property Rights Separated.

Most property rights can be represented by polygons (i.e., closed features with a perimeter and an area). Some rights, e.g., access rights, typically take place along boundaries, and therefore it is best to model those rights using linear features. Two general alternatives to deal with the wide range of property right combinations (i.e., combined or separated from the parcel) are as follows:

- **Alternative 1**. An entity represents a parcel that includes all the rights that remain with the parcel (which could vary from parcel to parcel), while additional entities represent each right that is separated from the parcel (which could also vary from parcel to parcel). This approach is conceptually simple because it matches typical business practices at TxDOT. However, the result could be additional complexity when trying to develop generalized database representations of property rights because of the lack of consistency

throughout the entire set of property rights associated with parcels on the state right of way.

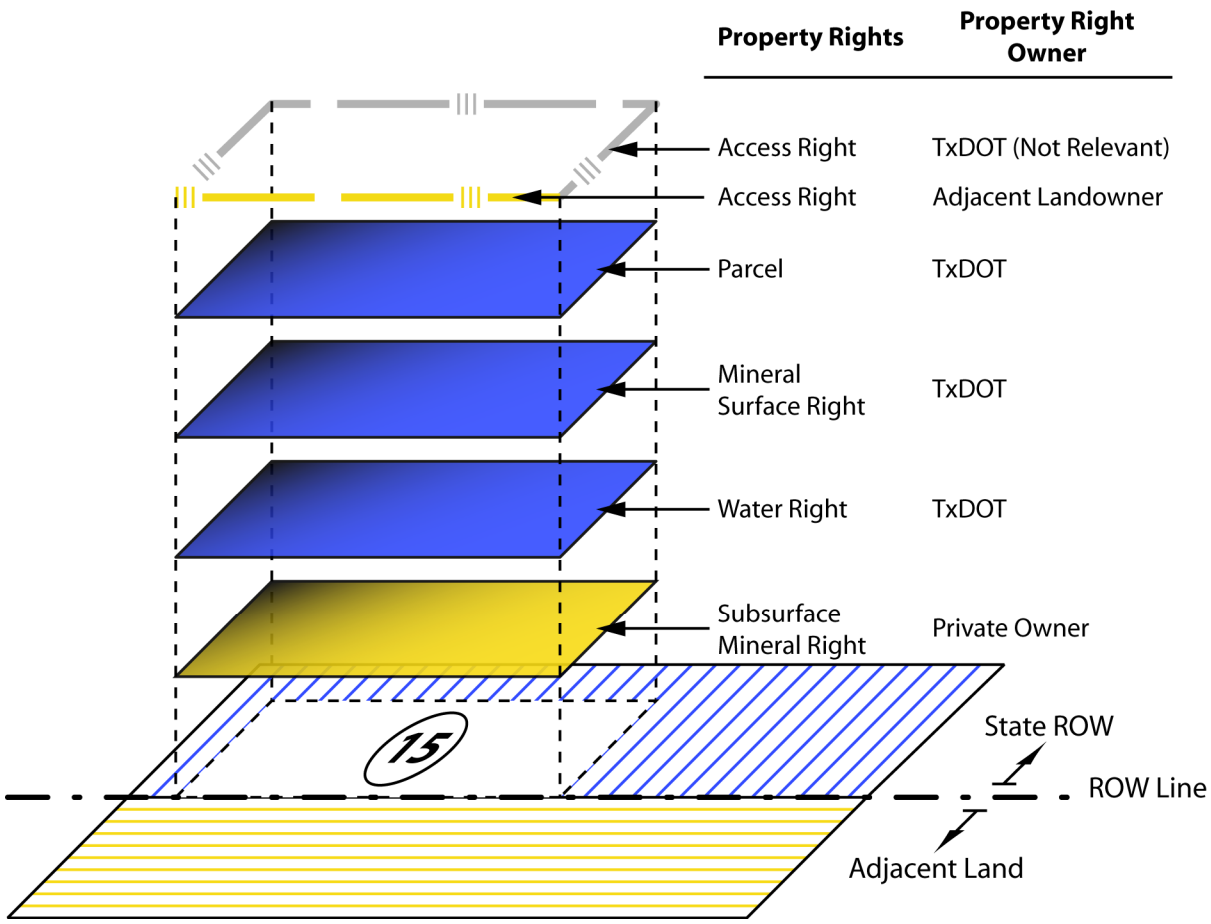
- **Alternative 2**. An entity represents a parcel that includes a default set of property rights (which is the same for all parcels), except certain property rights that are always modeled independently regardless of whether those rights remain with or have been separated from the parcel (e.g., access rights, mineral surface rights, water rights, and subsurface mineral rights). This approach is apparently more "cumbersome" to conceptualize, particularly in situations where TxDOT acquires a property in fee simple and the question might arise why it would be necessary to model the associated property rights independently. However, in practice, this approach can facilitate the systematic implementation of database representations of property rights. Discussions with the project advisors indicated TxDOT might prefer this option, and therefore this is the approach followed in this report.

Figure 15 illustrates a hypothetical situation where TxDOT has purchased all the property rights associated with a new parcel, except for the subsurface mineral rights (oil, gas, and sulphur) and the access right from/to the adjacent land. TxDOT owns the property surrounding the parcel in question along the three remaining edges (depicted in grey in Figure 15), making the need to model the access rights through those edges irrelevant and, therefore, unnecessary.

Figure 16 shows the case where TxDOT acquires access rights along a specific segment of roadway. For completeness, it may be necessary to also model the situation before the access right acquisition (Figure 15) to properly account for all access right changes throughout the lifetime of the parcel. As described later in this chapter, keeping track of access right changes is possible through the inclusion of from and to dates in the feature table.

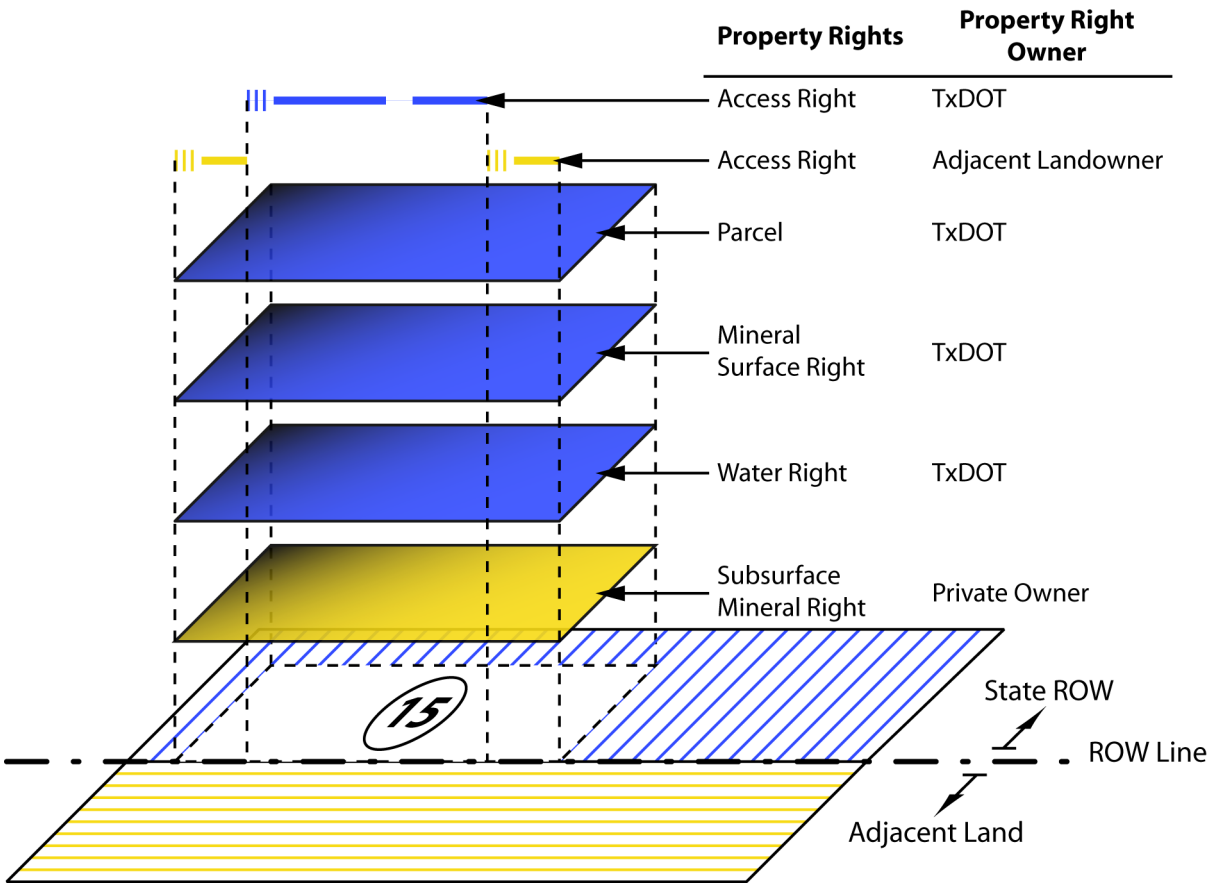
A potential disadvantage of tracking the entire history of access right changes, particularly in the case of general-purpose roadways where TxDOT only acquires small access right segments, is that TxDOT would end up with a very large number of linear features in the database representing access rights owned by adjacent landowners. Considering that the default situation for general-purpose roadways (which is the case for most state highways) is that adjacent landowners have the right to access the state right of way, having a large number of records depicting that situation does not appear to be particularly advantageous.

An alternative would be only to track cases where TxDOT explicitly purchases access rights. For example, in Figure 16, this solution would be possible by only generating a feature for the specific segment of access right that TxDOT has purchased. For completeness, it might also be advantageous to track situations where the access right remains with the adjacent landowner but TxDOT has invoked police powers to limit or deny that right.



Note: Blue represents TxDOT ownership; yellow represents ownership by others.

Figure 15. Property Rights with Access Rights Remaining with Adjacent Property Owner.



Note: Blue represents TxDOT ownership; yellow represents ownership by others.

Figure 16. Property Rights with Some Access Rights Acquired by TxDOT.

Encumbrances

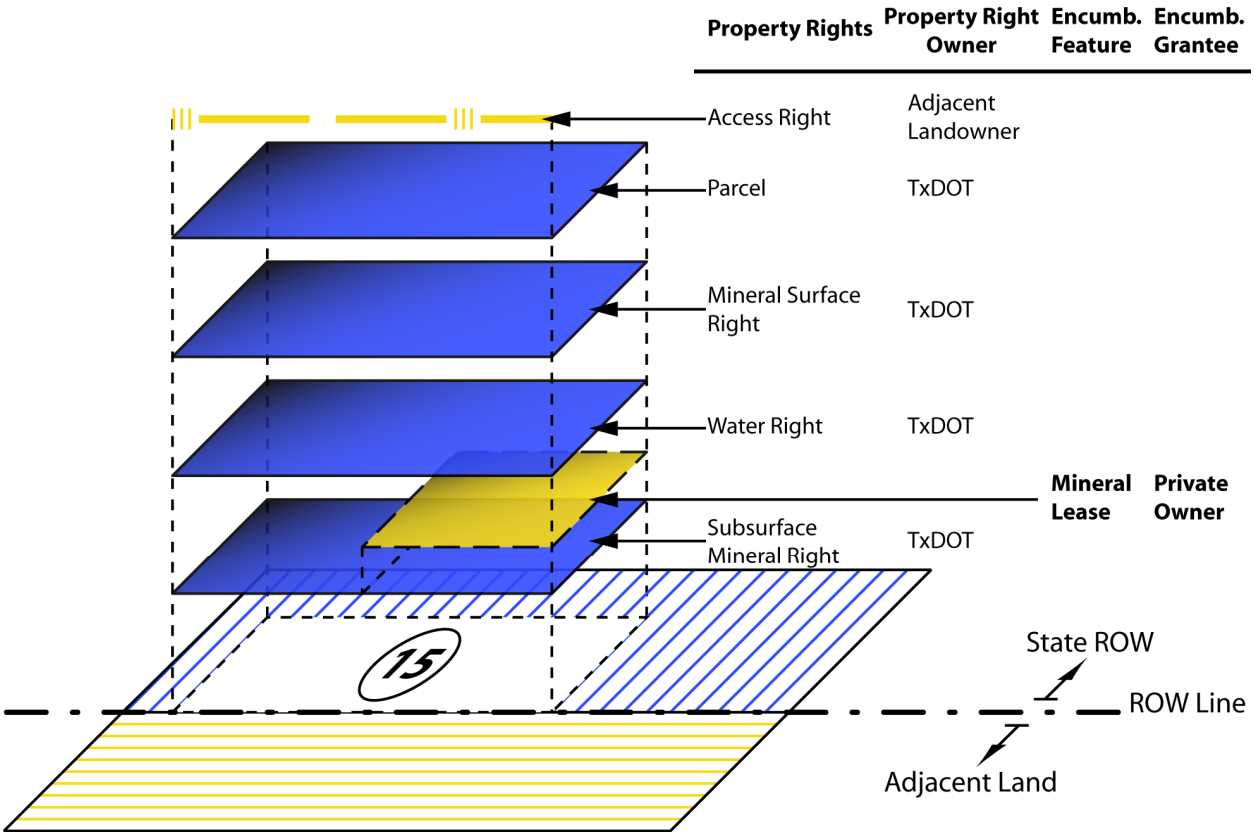
Examples of encumbrances include leases, easements, and mortgages. The researchers considered two general approaches for modeling encumbrances and their relationship with the corresponding property right(s) affected:

- **One-to-many relationship between property rights and encumbrances**. This option would enable linking encumbrances to property rights without having to create separate spatial encumbrance features. For example, a lease agreement linked to a subsurface mineral right feature would not require a separate spatial subsurface mineral lease feature because the subsurface mineral right feature would be sufficient to characterize the spatial boundary of the lease agreement. While conceptually simple, this modeling approach has two significant disadvantages. First, a property right would have to exist in the database *before* a record for an encumbrance on that right could be generated. In practice, TxDOT does not always have adequate property right documentation. However, there may be situations where TxDOT would want to generate records for encumbrances independently of any property right documentation that might exist, e.g., in the case of a multiple-use agreement with a city to develop parking spaces under a highway overpass.

In this case, it would be advantageous to have the flexibility to develop encumbrance features independently of property rights. Second, the assumption of a one-to-many relationship between a property right and an encumbrance means that the spatial boundary of the encumbrance matches that of the corresponding property right, which is not always the case. For example, TxDOT may only lease a portion of a parcel to an external entity. In this case, it would be necessary to split the parcel feature to ensure a correct representation of the encumbrance boundary.

- **Many-to-many relationship between property rights and encumbrances**. This option would enable developing encumbrances independently of property rights, while enabling a linkage between property right and encumbrance through separate database procedures, e.g., regular many-to-many relationships or spatial overlays. The many-to-many relationship design allows for a more flexible management of encumbrances because it allows generating encumbrance features in the database without having to create the corresponding property right feature first. It also makes it possible to model the spatial boundaries of encumbrances separately.

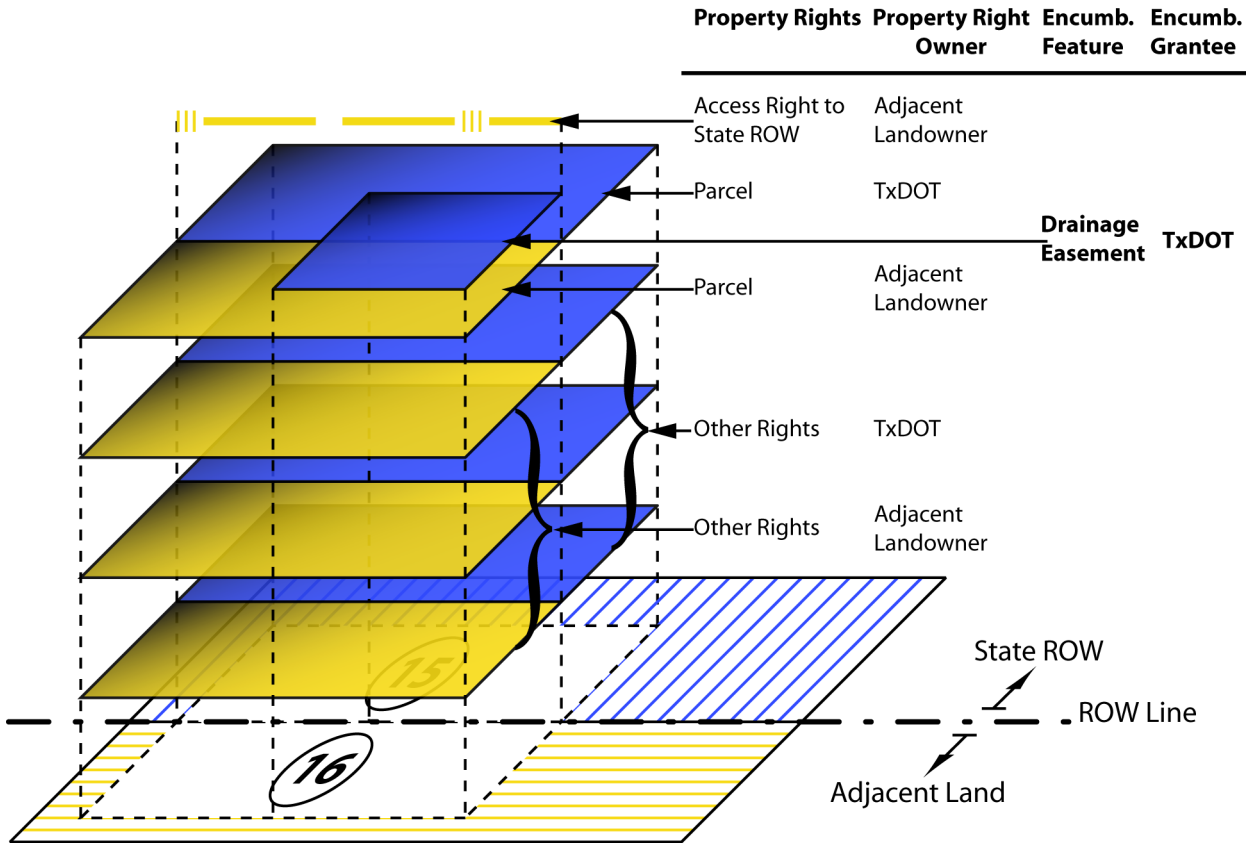
This report models encumbrances as separate entities that can be linked to property rights using a many-to-many relationship construct. As an illustration, Figure 17 shows the case of a parcel that TxDOT owns on a non–access-controlled highway, including all property rights but not the access right to prevent ingress and egress from the adjacent parcel to the state right of way. If TxDOT decides to lease half of the parcel's subsurface mineral rights to an external entity, the model can track the lease of that portion of subsurface mineral rights by using a separate encumbrance feature that can be associated with the subsurface mineral right feature through a regular many-to-many relationship. The encumbrance feature could also be associated with the parcel through a spatial query in a GIS that would show all property right features and the encumbrance feature.



Note: Blue represents TxDOT ownership; yellow represents ownership by others.

Figure 17. Private Lease Encumbrance on Subsurface Mineral Rights.

Figure 18 shows the case of a drainage easement that TxDOT needs for a project. A variation of this theme would be a lease agreement with an external entity to enable TxDOT to build or expand a roadway because the external entity cannot sell the property to TxDOT (e.g., airports and land-grant universities). In this case, TxDOT would create an encumbrance feature on the land owned by the external entity. In Figure 18, although it would be necessary to generate an encumbrance feature to model the encumbrance relationship between TxDOT and the adjacent landowner, modeling the adjacent parcel and other associated property rights would not be required.



Note: Blue represents TxDOT ownership; yellow represents ownership by others.

Figure 18. Easement Encumbrance on Privately Owned Property Right Feature.

General Approach for Managing Property Rights and Encumbrances in the Database

The data architecture described in this report is generic in that it enables TxDOT to model property rights and encumbrances, regardless of who owns those rights (TxDOT or an external entity). For property adjacent to the state right of way, it seems unlikely that, in the long term, TxDOT would want to keep track of the associated property rights unless TxDOT has an interest, e.g., in the form of a drainage easement. Since ownership of adjacent land may change frequently, it may be more cost-efficient to determine land ownership at the time a need would arise to purchase adjacent property. At the same time, it is clear that TxDOT is interested in managing the associated property rights of parcels on the state right of way, including encumbrances. TxDOT's ownership of this property could be "explicit," i.e., ownership is unambiguous and supported by deed documentation, or "assumed," i.e., ownership is assumed and supported by possession and use for a long time, although formal documents of ownership may not be available. TxDOT would need to make a decision about what property to include in the database. Regardless of that decision, there are three approaches for managing property rights on the state right of way in a database, as follows:

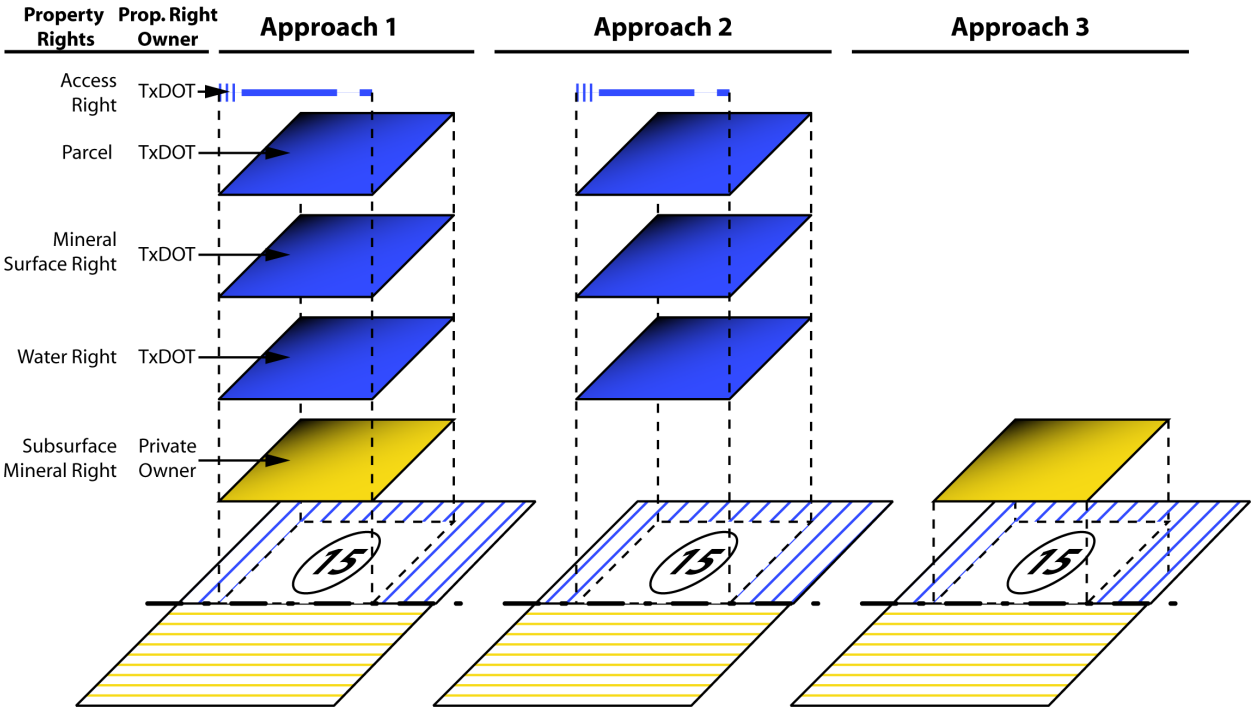
- Track all property rights for all parcels, regardless of ownership (Approach 1 in Figure 19). With this approach, TxDOT would track all property rights associated with each

parcel and assign ownership in the database. Although comprehensive, this approach may be time consuming because it requires the creation of property features for all property rights along with the research of ownership for property rights that TxDOT does not own. In addition, TxDOT would need to consider updating the non-TxDOT property rights periodically.

- Only track property rights that TxDOT owns (Approach 2 in Figure 19). With this approach, TxDOT would only track property rights owned by the state, but not property rights that were excluded from a parcel acquisition (e.g., subsurface mineral rights). An advantage of this approach is that it would not be necessary to create non-TxDOT property features and track changes in ownership of those property rights. A disadvantage is that in cases where documentation for a property right does not exist, a user of the system might assume that the property right belongs to an external entity. In practice, the implication is that TxDOT would generate records for property rights only when TxDOT acquires them. For property rights that TxDOT sells, it would be necessary to populate appropriate fields to document the corresponding transactions. The result would be a database of mostly TxDOT property features and some non-TxDOT property features.

- Only track property rights that TxDOT does *not* own (Approach 3 in Figure 19). With this approach, TxDOT would only track property rights that external entities own, e.g., all property rights that were separated from the parcel and that TxDOT did not acquire at the time of acquisition of the parcel. The reasoning for this approach is the assumption that TxDOT owns the majority of the right of way in fee simple, making it only necessary to track property rights that TxDOT does not already own and thus avoid the creation of several property right features for each parcel. An advantage of this approach is a very compact property right database. A significant disadvantage is the implication of TxDOT property ownership by omission, i.e., absence of a property right feature in the database would imply TxDOT ownership (perhaps incorrectly), and the practical difficulty of what to do in cases where TxDOT sells a property right. In addition, this approach would require tracking the boundary of the state right of way separately from the parcel features to allow for the identification of property that TxDOT holds in fee simple.

Considering the advantages and disadvantages of the three approaches described above, the researchers recommended to the panel the implementation of a testing version of the database using Approach 1. The research panel concurred with the recommendation.



Note: Blue represents TxDOT ownership; yellow represents ownership by others.

Figure 19. Conceptual Approaches for Property Rights Management.

DATA MODEL DEVELOPMENT

At the highest level, managing right of way assets systematically involves managing four types of data: data about features on the ground (normally on the state right of way); data about right of way asset documents; data about projects; and data about users who may need to interact with features, documents, or projects. In reality, features, documents, projects, and users are not standalone entities. For example, a project can have many documents and/or be associated with many features or users; a document can be associated with many projects, features, and/or users; a feature can be associated with many documents, projects, and/or users; and a user may be associated with many documents, features, and/or projects. As Figure 20 shows, the relationships among features, projects, documents, and users are clearly many to many.

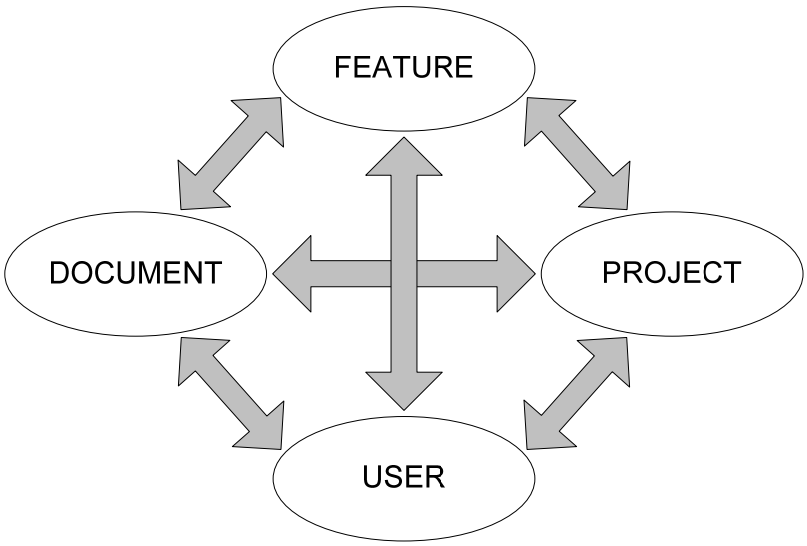


Figure 20. Right of Way Asset Data Model – Conceptual Design.

The approach to modeling features, documents, projects, users, and their corresponding interrelationships depends on a number of factors, including business processes, implementation strategies, and available supporting technologies. Traditionally, agencies have implemented information systems to support and vertically integrate business processes within major areas (features, documents, or projects), while only providing limited support for data exchange and relationship handling among those major areas. Improvements in technology have resulted in systems that routinely handle two of the areas in Figure 20 and their relationships, mainly projects and documents. With improvements in GIS technology over the last few years, it is becoming increasingly feasible to incorporate features, and the relationships between features and documents and between features and projects.

The researchers' approach to developing the prototype right of way asset data model was to consider not just the four main areas in Figure 20, but also the corresponding many-to-many relationships. Figure 21 shows a corresponding high-level logical data model, which also includes a few critical entities. Figure 22 shows an expanded view of the logical model in Figure 21. For clarity, the model includes four subject areas, one for each core entity in the model. The researchers developed the prototype right of way asset data model using CA® ERwin® Data Modeler (*31*).

In most cases, the entities shown (or groups of entities) have real-world information system counterparts at TxDOT. For example, the system counterpart for project-related entities is DCIS, the system counterpart for document-related entities is FileNet, and the system counterpart for feature-related entities is GAIP. This characterization enables a direct mapping between the model and those systems, and facilitates the interpretation of the high-level diagram in Figure 20 as a set of system placeholders for which the prototype right of way asset data model provides the connecting framework.

A more formal definition of the four main entities in Figure 21 follows:

- **FEATURE**. A FEATURE is an object (real or virtual) that has boundaries in space and time. In the model, a feature can be represented by points, lines, or polygons. Points represent features such as poles, signs, signals, and pedestals. Lines represent features such as centerlines, project limits, guardrails, barriers, and utility lines. Polygons represent features such as parcels, paved areas, bridges, and building footprints.

- **DOCUMENT**. A DOCUMENT is a tangible product in printed or electronic format. A document can have several versions based on date and/or author.

- **DCIS PROJECT**. A PROJECT is a roadway project for which there are data in DCIS and other systems.

- **SYSTEM USER**. A SYSTEM USER is a company, agency, or individual who is a stakeholder in the right of way asset management process. A SYSTEM USER has a pre-specified level of access to FEATURES, DOCUMENTS, and/or PROJECTS through online and/or standalone system interfaces.

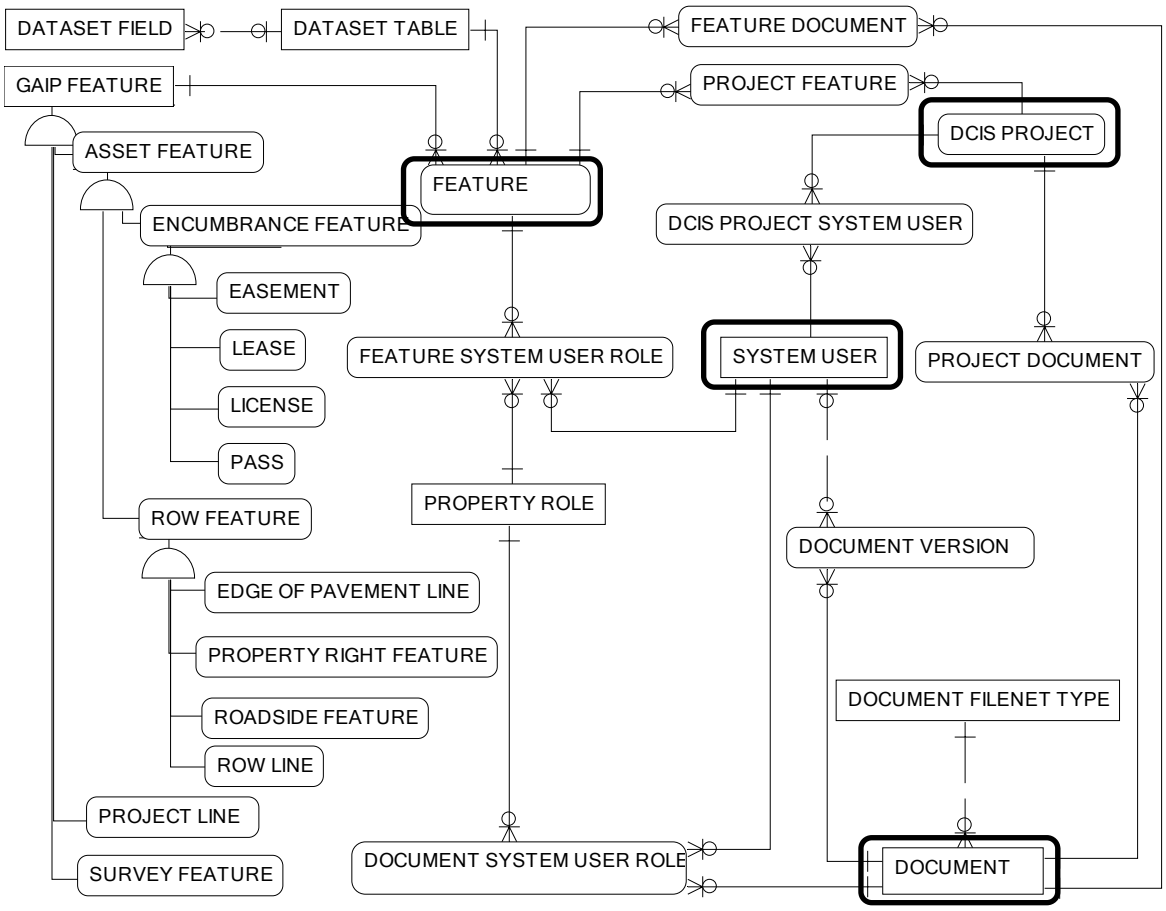


Figure 21. Right of Way Asset Data Model – High-Level Logical Data Model.

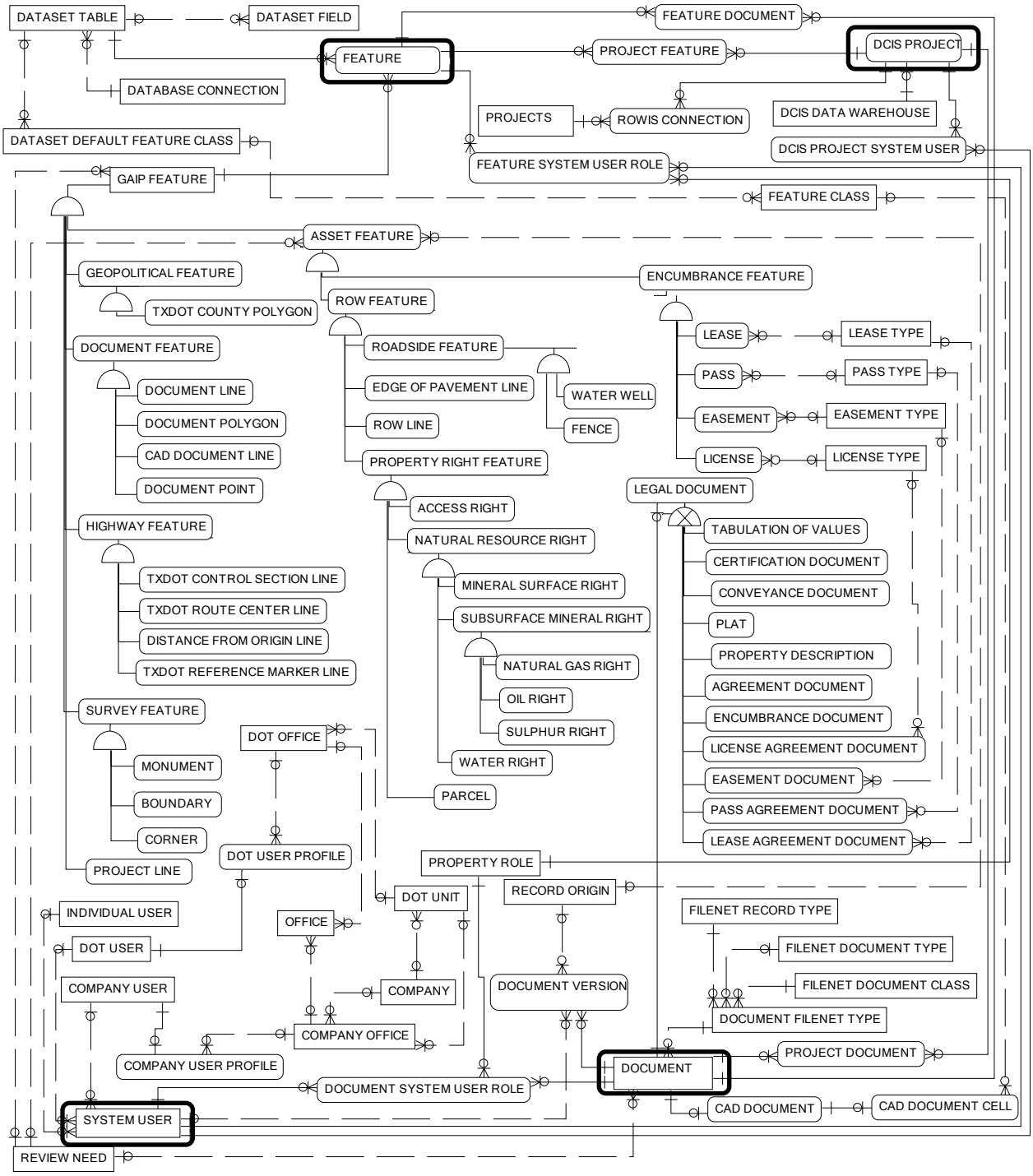


Figure 22. Right of Way Asset Data Model – Entity Overview.

Feature Subject Area

The Feature Subject Area consists of FEATURE, related lookup tables, and linkages to other subject areas (Figure 23 and Table 9). All the features modeled in this research were GAIP FEATURES (i.e., GAIP-compliant features). At the lowest level, the primary key for features is a TXDOT UNIQUE ID attribute. TXDOT UNIQUE ID is unique within each feature class but not necessarily across features classes, i.e., different feature entities could share the same TXDOT UNIQUE ID values. For example, potential TXDOT UNIQUE ID values within the ROW LINE feature are 1, 2, 3, and 4. These values are also potential TXDOT UNIQUE ID values within the PARCEL feature.

All subtype entities between the FEATURE entity level and the actual feature entity level (e.g., GAIP FEATURE, DOCUMENT FEATURE, GEOPOLITICAL FEATURE, HIGHWAY FEATURE, and ASSET FEATURE) are "conceptual" subtype/supertype entities that need to be "collapsed" prior to the generation of the physical data model. After collapsing those intermediate entities, the result is that the TXDOT UNIQUE ID attribute becomes one of the primary key components in the FEATURE entity. The other primary key component is the TABLE UNIQUE ID attribute, which is a foreign key to DATASET TABLE. DATASET TABLE includes a listing of all the entity logical names and table physical names in the database. DATASET FIELD includes a listing of all the entity attribute names and table field names in the database. Both DATASET TABLE and DATASET FIELD are MST entities.

The combination of TABLE UNIQUE ID and TXDOT UNIQUE ID makes FEATURE a comprehensive index of features in the database, facilitating query transactions that involve other subject areas. In a typical situation, the analyst would first select the specific feature of interest (e.g., PARCEL in Figure 23) manually, using a GIS interface, or using a predefined query form. A direct query would enable the retrieval of any specific records of interest in PARCEL. Through DATASET TABLE, the system provides the corresponding TABLE UNIQUE ID value, which the analyst would use to retrieve the corresponding records in FEATURE. With the selected records in FEATURE, the analyst could retrieve records in PROJECT FEATURE, FEATURE DOCUMENT, and/or FEATURE SYSTEM USER ROLE, which in turn would enable the retrieval of data from relevant tables in the Project, Document, and User Subject Areas. The structure of the database is flexible, facilitating other types of database transactions, e.g., in situations where the analyst already knows a specific project, document, or user of interest and it is necessary to retrieve the corresponding feature records. In this case, FEATURE provides the necessary bridge between the Project, Document, and/or User Subject Areas and the corresponding feature of interest.

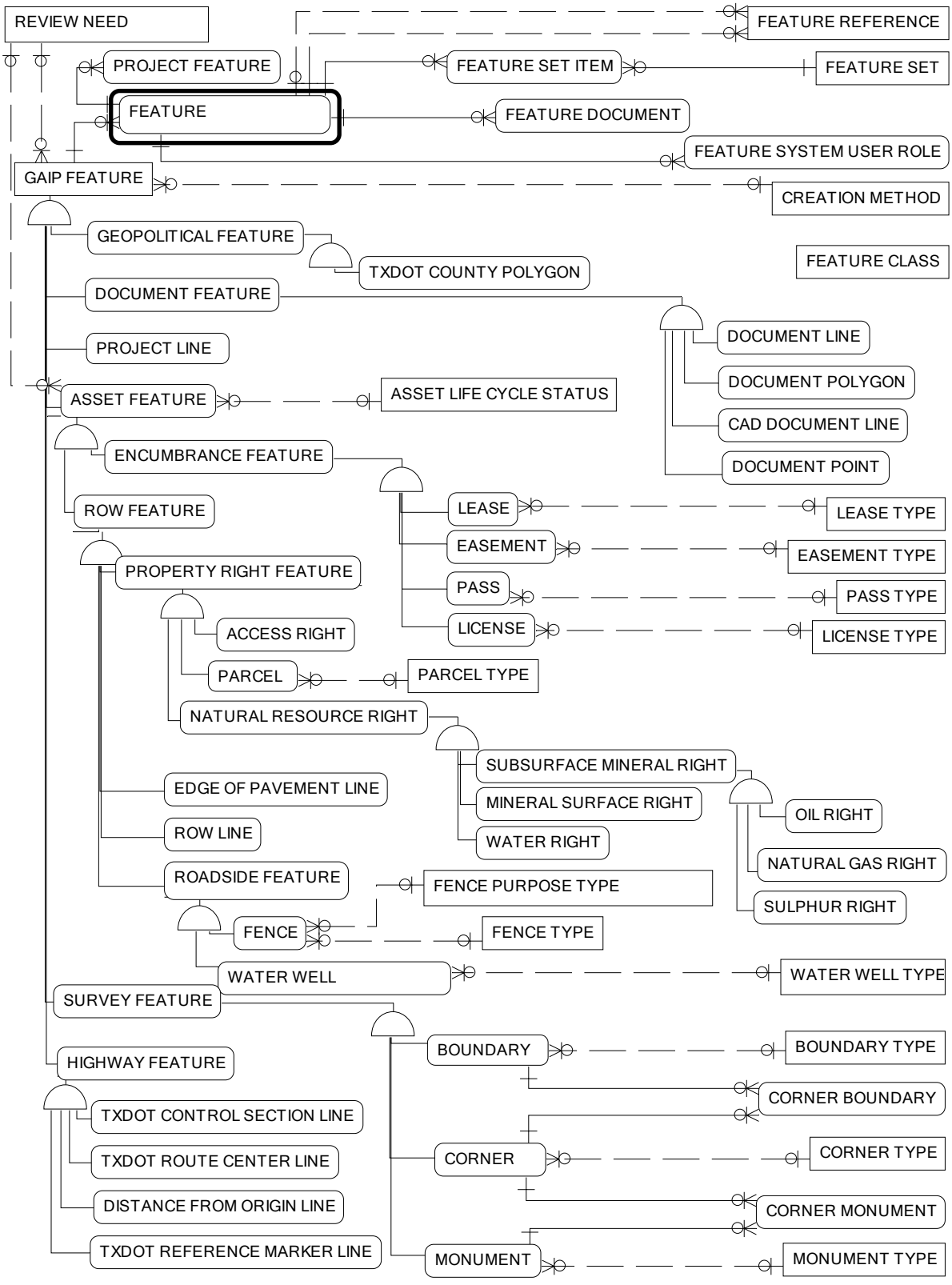


Figure 23. Right of Way Asset Data Model – Feature Subject Area.

Table 9. Feature Subject Area Entities.

Name	Definition
ACCESS RIGHT	An ACCESS RIGHT is the right to enter and exit a right of way from an adjacent property. In general, the right of access to an existing state highway is part of the rights an adjacent property owner has. However, the state can regulate, limit, or deny this right under the state's police power. If there is a loss of access, the affected property owner may be entitled to compensation. TxDOT has the ability to purchase access rights from adjacent property owners, e.g., on frontage roads of controlled-access facilities within a certain distance around exit ramps or as a preventive measure to regulate future access to the state right of way in areas that are undergoing fast urban development. If an existing road is converted to a controlled-access facility, compensation for damages is possible unless the design includes frontage roads and the adjacent property owner is provided access to those frontage roads.
ASSET FEATURE	An ASSET FEATURE is a real-world object that agencies include in their inventories for asset management purposes. Examples include bridges, recreation facilities, utilities, water systems, waste management, public facilities, rest areas, canals, and signs.
ASSET LIFE CYCLE STATUS	An ASSET LIFE CYCLE STATUS is a descriptor of the operational condition of an asset throughout its lifetime. Examples include "proposed," "under construction," and "operational."
BOUNDARY	A BOUNDARY is a line that defines the limits or perimeter of an area.
BOUNDARY TYPE	A BOUNDARY TYPE is a word or phrase that characterizes a BOUNDARY.
CAD DOCUMENT LINE	A CAD DOCUMENT LINE is a representation of a geo-referenced CAD document as a set of multi-lines. In the database, a CAD DOCUMENT LINE represents an entire CAD document.
CORNER	A CORNER is a point where two converging lines intersect or meet.
CORNER BOUNDARY	A CORNER BOUNDARY is a mapping that represents the many-to-many relationship between a CORNER and a BOUNDARY. CORNER BOUNDARY enables the identification of CORNERS associated with a BOUNDARY and the BOUNDARIES associated with a CORNER.
CORNER MONUMENT	A CORNER MONUMENT is a mapping that represents the many-to-many relationship between a CORNER and a MONUMENT. CORNER MONUMENT enables the identification of CORNERS associated with a MONUMENT and the MONUMENTS associated with a CORNER.
CORNER TYPE	A CORNER TYPE is a word or phrase that characterizes a CORNER.
CREATION METHOD	A CREATION METHOD is the process that was used to create a feature database record. Source: Table 27, *TxDOT Graphic Data Standard* (*36*).
DISTANCE FROM ORIGIN LINE	A DISTANCE FROM ORIGIN LINE is a spatial representation of a state route that follows the roadway centerline and is principally used for cartographic purposes. In the database, polylineM features represent DFO line segments. Source: *TxDOT Graphic Data Standard* (*36*).
DOCUMENT FEATURE	A DOCUMENT FEATURE is a simplified spatial representation of a DOCUMENT. In the data model, DOCUMENT FEATURE exists as a logical supertype entity that includes the following subtypes: DOCUMENT LINE, DOCUMENT POINT, and DOCUMENT POLYGON. Note: A DOCUMENT FEATURE is different from a FEATURE DOCUMENT. A FEATURE DOCUMENT identifies the DOCUMENTS associated with a FEATURE.
DOCUMENT LINE	A DOCUMENT LINE is a simplified spatial representation of a DOCUMENT as a linear feature. The purpose of a DOCUMENT LINE is to serve as a spatial pointer to a DOCUMENT such as a cross section or a profile.
DOCUMENT POINT	A DOCUMENT POINT is a simplified spatial representation of a DOCUMENT as a point feature. The purpose of a DOCUMENT POINT is to serve as a spatial pointer to a DOCUMENT such as a photograph, a boring log, or a survey control point description.

Table 9. Feature Subject Area Entities (Continued).

Name	Definition
DOCUMENT POLYGON	A DOCUMENT POLYGON is a simplified spatial representation of a DOCUMENT as a polygon feature. In general, the DOCUMENT POLYGON describes the outline of the spatial content described in the document. The purpose of a DOCUMENT POLYGON is to serve as a spatial pointer to a DOCUMENT such as a construction plan, a scanned right of way map, or a preliminary schematic.
EASEMENT	An EASEMENT is the right to use the real property of another for a specific purpose, mostly in connection with right of way needs. The two parties in an easement are the grantor and the grantee. In the data model, polygons provide a spatial representation for easements.
EASEMENT TYPE	An EASEMENT TYPE is a category of an EASEMENT. Examples of EASEMENT TYPE are utility easement and drainage easement.
EDGE OF PAVEMENT LINE	An EDGE OF PAVEMENT LINE is a line that represents the visible edge of the pavement structure.
ENCUMBRANCE FEATURE	An ENCUMBRANCE FEATURE is an ASSET FEATURE that represents features associated with encumbrances of a property parcel.
FEATURE	A FEATURE is an object (real or virtual) that has boundaries in space and time. In the model, a FEATURE can be represented by points, lines, or polygons. Points represent features such as poles, signs, signals, and pedestals. Lines represent features such as centerlines, project limits, guardrails, barriers, and utility lines. Polygons represent features such as parcels, paved areas, bridges, and building footprints.
FEATURE CLASS	A FEATURE CLASS is a group of features that share common properties and definitions. In the database, FEATURE CLASS provides TxDOT feature codes, which include surveying and MicroStation cells (e.g., BL, EP, MON, and MP), as well as new feature class codes developed to standardize existing feature codes and to support GIS applications.
FEATURE DOCUMENT	A FEATURE DOCUMENT is a mapping that represents the many-to-many relationship between a FEATURE and a DOCUMENT. FEATURE DOCUMENT enables the identification of DOCUMENTS associated with a FEATURE and the identification of FEATURES associated with a DOCUMENT. Note: A FEATURE DOCUMENT is different from a DOCUMENT FEATURE. A DOCUMENT FEATURE (inside the Feature subject area) provides the actual spatial representation of a DOCUMENT.
FEATURE REFERENCE	A FEATURE REFERENCE is a linear reference of one FEATURE to a second/attached FEATURE that provides information about the location of the second FEATURE. For example, a control section feature could be referenced to a ROADSIDE FEATURE to indicate the location of the ROADSIDE FEATURE in a GIS.
FEATURE SET	A FEATURE SET is a collection of features. Examples include signposts with multiple signs or poles with multiple utility features.
FEATURE SET ITEM	A FEATURE SET ITEM is a feature that is part of a FEATURE SET. Examples include each of the utilities on a utility pole and each of the signs on a signpost.
FEATURE SYSTEM USER ROLE	A FEATURE SYSTEM USER ROLE is a mapping that represents the many-to-many relationships between a FEATURE, a SYSTEM USER, and a PROPERTY ROLE. FEATURE SYSTEM USER ROLE enables the identification of system users associated with a FEATURE and the PROPERTY ROLE of each SYSTEM USER.
FENCE	A FENCE is a freestanding structure designed to restrict or prevent movement across a boundary.
FENCE PURPOSE TYPE	A FENCE PURPOSE TYPE is a word or phrase that characterizes fences with similar purposes. Examples include control of access fence and property fence.
FENCE TYPE	A FENCE TYPE is a word or phrase that characterizes fences with similar attributes and characteristics. Examples include chain link, stone, and wood.
GAIP FEATURE	A GAIP FEATURE is an object (real or virtual) that has boundaries in space and time and is modeled in accordance with the TxDOT GAIP standard. In the model, a GAIP FEATURE can be represented by points, lines, or polygons.

Table 9. Feature Subject Area Entities (Continued).

Name	Definition
GEOPOLITICAL FEATURE	A GEOPOLITICAL FEATURE is a spatial boundary defined by a jurisdictional agency. Examples include counties, districts, and cities. In the data model, a GEOPOLITICAL FEATURE exists as a logical supertype entity that includes the TXDOT COUNTY POLYGON subtype.
HIGHWAY FEATURE	A HIGHWAY FEATURE is a spatial representation of a roadbed or roadway centerline. In the data model, HIGHWAY FEATURE exists as a logical supertype entity that includes the following subtypes: TXDOT ROUTE CENTER LINE, TXDOT CONTROL SECTION LINE, TEXAS LINEAR MEASUREMENT LINE, TXDOT REFERENCE MARKER LINE, DISTANCE FROM ORIGIN LINE, TXDOT ROADBED LINE, and TXDOT GROUND SET LINE.
LEASE	A LEASE is the temporary right to possess and use property (real or personal), usually in exchange for payment. The two parties in a lease are the lessor and the lessee (or tenant). In the data model, polygons provide a spatial representation for leases.
LEASE TYPE	A LEASE TYPE is a category of a LEASE. Examples of LEASE TYPE are water lease, grazing lease, mineral lease, and temporary lease.
LICENSE	A LICENSE is the right to use the property of another for a specific purpose. Unlike an easement, a license can be revoked. The two parties in a license are the licensor and the licensee. In the data model, polygons provide a spatial representation for licenses.
LICENSE TYPE	A LICENSE TYPE is a category of a LICENSE. An example of a LICENSE TYPE is a railroad license agreement.
MINERAL SURFACE RIGHT	A MINERAL SURFACE RIGHT is the right to enter and exit the surface for the purpose of exploring, developing, mining, or drilling a mineral right. For owners who retain mineral rights when TxDOT acquires land, TxDOT normally requires grantors to waive their mineral surface rights, allowing those grantors to explore or recover minerals from a point outside of the property. In the data model, polygons provide a spatial representation for mineral surface rights.
MONUMENT	A MONUMENT is "any object or collection of objects (physical, natural, artificial) that indicates the position on the ground of a survey station." Source: *TxDOT Glossary* (*14*).
MONUMENT TYPE	A MONUMENT TYPE is a category of a MONUMENT that describes the material, composition, or other characteristics of the MONUMENT. Examples of MONUMENT TYPE include aluminum cap, aluminum marker, concrete post, marked stone, nail, and PK nail. Source: Adapted from *Cadastral Data Content Standard for the National Spatial Data Infrastructure* (*49*).
NATURAL GAS RIGHT	A NATURAL GAS RIGHT is the right to explore or recover natural gas from a property. TxDOT normally limits access to natural gas rights from outside the right of way and in such a way that no operations are conducted so near the surface as to interfere with the intended use of the right of way or create a hazard to the public.
NATURAL RESOURCE RIGHT	A NATURAL RESOURCE RIGHT is the right to explore or recover a natural resource from a property. In the data model, NATURAL RESOURCE RIGHT exists as a logical supertype entity that includes the following subtypes: MINERAL SURFACE RIGHT, SUBSURFACE MINERAL RIGHT, and WATER RIGHT.
OIL RIGHT	An OIL RIGHT is the right to explore or recover oil from a property. TxDOT normally limits access to oil rights from outside the right of way and in such a way that no operations are conducted so near the surface as to interfere with the intended use of the right of way or create a hazard to the public.

Table 9. Feature Subject Area Entities (Continued).

Name	Definition
PARCEL	A PARCEL is a contiguous area of land described by a deed (therefore contained within a single description). TxDOT uses a standardized procedure for setting up and numbering right of way parcels (*8*). For example, in the case of urban projects, the main criterion to set up parcels is unity of use, in such a way that if two or more lots have a unity of use, it is possible to combine those lots into one parcel number. In the case of rural projects, the focus is the parent tract (a single property not divided by a public way or platted as a subdivision). In the model, a PARCEL provides a spatial representation of all the rights associated with a property, except those that are tracked separately (access rights, mineral surface rights, water rights, and subsurface mineral rights).
PARCEL TYPE	A PARCEL TYPE is a word or phrase that characterizes parcels with similar attributes and characteristics. Examples include wetlands, mitigation, and joint use.
PASS	A PASS is the right to cross the right of way. TxDOT handles passes on a case-by-case basis and relies on permits, contractual agreements with the state, or the terms as provided in the right of way conveyance to the state. TxDOT normally handles three categories of passes: passes that are automatically available due to drainage need, passes warranted to meet safety needs, and remaining passes where dual appraising is necessary to determine justification and cost participation. In the data model, polygons provide a spatial representation for passes.
PASS TYPE	A PASS TYPE is a category of a PASS. Examples of a PASS TYPE are livestock pass and pedestrian pass.
PROJECT FEATURE	A PROJECT FEATURE is a mapping that represents the many-to-many relationship between a PROJECT and a FEATURE. PROJECT FEATURE enables the identification of FEATURES associated with a PROJECT and the identification of PROJECTS associated with a FEATURE.
PROJECT LINE	A PROJECT LINE is a transportation project represented as a roadway centerline segment bounded by project limits.
PROPERTY RIGHT FEATURE	A PROPERTY RIGHT FEATURE is a spatial representation of a specific property right.
REVIEW NEED	A REVIEW NEED is a description of the need for a TxDOT database administrator to review a DOCUMENT or ASSET FEATURE record because of a potential error or omission.
ROADSIDE FEATURE	A ROADSIDE FEATURE is a feature located within the right of way between a ROW LINE and an EDGE OF PAVEMENT LINE.
ROW FEATURE	A ROW FEATURE is a spatial representation of a right of way feature. In the data model, ROW FEATURE exists as a logical supertype entity that includes the following subtypes: ROW LINE and EDGE OF PAVEMENT.
ROW LINE	A ROW LINE is the boundary line that separates the highway right of way from adjacent property.
SUBSURFACE MINERAL RIGHT	A SUBSURFACE MINERAL RIGHT is the right to explore or recover minerals from a property. In the data model, SUBSURFACE MINERAL RIGHT exists as a logical supertype entity that includes the following subtypes: NATURAL GAS RIGHT, OIL RIGHT, and SULPHUR RIGHT.
SULPHUR RIGHT	A SULPHUR RIGHT is the right to explore or recover sulphur from a property. TxDOT normally limits access to sulphur rights from outside the right of way and in such a way that no operations are conducted so near the surface as to interfere with the intended use of the right of way or create a hazard to the public.
SURVEY FEATURE	A SURVEY FEATURE is a spatial representation of a survey object. In the data model, SURVEY FEATURE exists as a logical supertype entity that includes the following subtypes: CORNER, BOUNDARY, and MONUMENT.

Table 9. Feature Subject Area Entities (Continued).

Name	Definition
TXDOT CONTROL SECTION LINE	A TXDOT CONTROL SECTION LINE is a linear graphic object that represents the location of a TxDOT control section. A TxDOT control section is a four-digit number representing the "control" (a definite section of highway with well-defined geographic termini, usually 25 to 30 miles) and a two-digit number representing the "section" (parts of the "control" that are shorter in length). Source: TxDOT Production GIS Data (*35*).
TXDOT COUNTY POLYGON	A TXDOT COUNTY POLYGON is a spatial representation of the "largest politically bounded geographic area defined to serve a local government within the state of Texas." Examples of counties include Bexar, Travis, Harris, and Dallas. Source: TxDOT Production GIS Data (*35*).
TXDOT REFERENCE MARKER LINE	A TXDOT REFERENCE MARKER LINE is a spatial representation of the section of roadbed centerline between adjacent highway reference markers. A TXDOT REFERENCE MARKER LINE follows roadbed centerlines under TxDOT jurisdiction and is intended to model roadbed features for engineering asset location purposes. A TXDOT REFERENCE MARKER LINE is not provisioned to manage ramps, connectors, and turnarounds. A TXDOT REFERENCE MARKER LINE is currently managed through a set of markers with an intended marker distance of 2 miles that may be moved occasionally. Source: *TxDOT Graphic Data Standard* (*36*).
TXDOT ROUTE CENTER LINE	A TXDOT ROUTE CENTER LINE is a spatial representation that follows roadway centerlines of TxDOT routes. Source: TxDOT Production GIS Data (*35*).
WATER RIGHT	A WATER RIGHT is the legal right to explore, drill, extract, and use the water found in a property. The water rights associated with a right of way parcel are normally transferred to the state at the time TxDOT acquires the parcel. In the data model, polygons provide a spatial representation for water rights.
WATER WELL	A WATER WELL is a structure (usually bored or drilled) to extract groundwater from an aquifer.
WATER WELL TYPE	A WATER WELL TYPE is a word or phrase that characterizes water wells with similar attributes and characteristics. Examples include irrigation well, stock well, and domestic well.

Document Subject Area

The Document Subject Area consists of DOCUMENT, related lookup tables, and linkages to other subject areas (Figure 24, Table 10). In the model, DOCUMENT and several other entities within the Document Subject Area are "place holders" for equivalent entities in the FileNet database structure. The researchers did not have access to the FileNet data model, and it was not possible to determine how closely the entities in the Document Subject Area match the corresponding entities in FileNet. Therefore, during implementation, it may be necessary to modify some of the entities in this subject area, particularly at the physical level. For consistency with the rest of the model components, the entities in the Document Subject Area comply with TxDOT data architecture standards, both in terms of content and entity and attribute naming conventions (*31*).

The primary key of the DOCUMENT entity is DOCUMENT UNIQUE ID. A DOCUMENT can have multiple versions through the DOCUMENT VERSION entity. Because a document can have multiple versions, each with a unique physical file name, DOCUMENT VERSION includes

DOCUMENT VERSION LOGICAL NAME and DOCUMENT VERSION PHYSICAL NAME attributes.

DOCUMENT FILENET TYPE represents the TxDOT EDTIS library structure. The primary key for DOCUMENT FILENET TYPE is the DOCUMENT FILENET TYPE CODE attribute, which contains the FileNet File Code (Table 7). This attribute is a foreign key in DOCUMENT. DOCUMENT FILENET TYPE includes a DOCUMENT TYPE ADDED FLAG attribute to highlight document types the researchers added, which were not in the list of document types received from TxDOT.

In the model, a DOCUMENT SET models documents that are combinations or aggregations of other documents, e.g., proposals and PS&E plan sets. In DOCUMENT SET, DOCUMENT SET NUMBER provides an optional index for document sets (e.g., change order 1, 2, and 3). DOCUMENT SET ITEM represents the many-to-many relationship between DOCUMENT SET and DOCUMENT (i.e., a DOCUMENT can be associated with more than one DOCUMENT SET, and a DOCUMENT SET can be associated with more than one DOCUMENT). DOCUMENT SET TYPE is a lookup table that categorizes document sets.

A DOCUMENT can be associated with multiple features through the FEATURE DOCUMENT entity. A DOCUMENT does not have to be associated with a FEATURE, and a FEATURE does not have to be associated with a DOCUMENT. While FEATURE DOCUMENT represents the many-to-many relationship between DOCUMENT and FEATURE, DOCUMENT FEATURE (inside the FEATURE subject area) provides the actual spatial representation of a DOCUMENT.

In some cases, the spatial location of a document is not available, but a linear reference is. DOCUMENT LOCATION stores the linear reference of a DOCUMENT as a set of distances, offsets, and linear referencing methods. LOCATION UNIT indicates the units (e.g., feet, meters, or kilometers) associated with the location measurement attributes. LOCATION REFERENCE METHOD indicates the linear reference method used in DOCUMENT LOCATION.

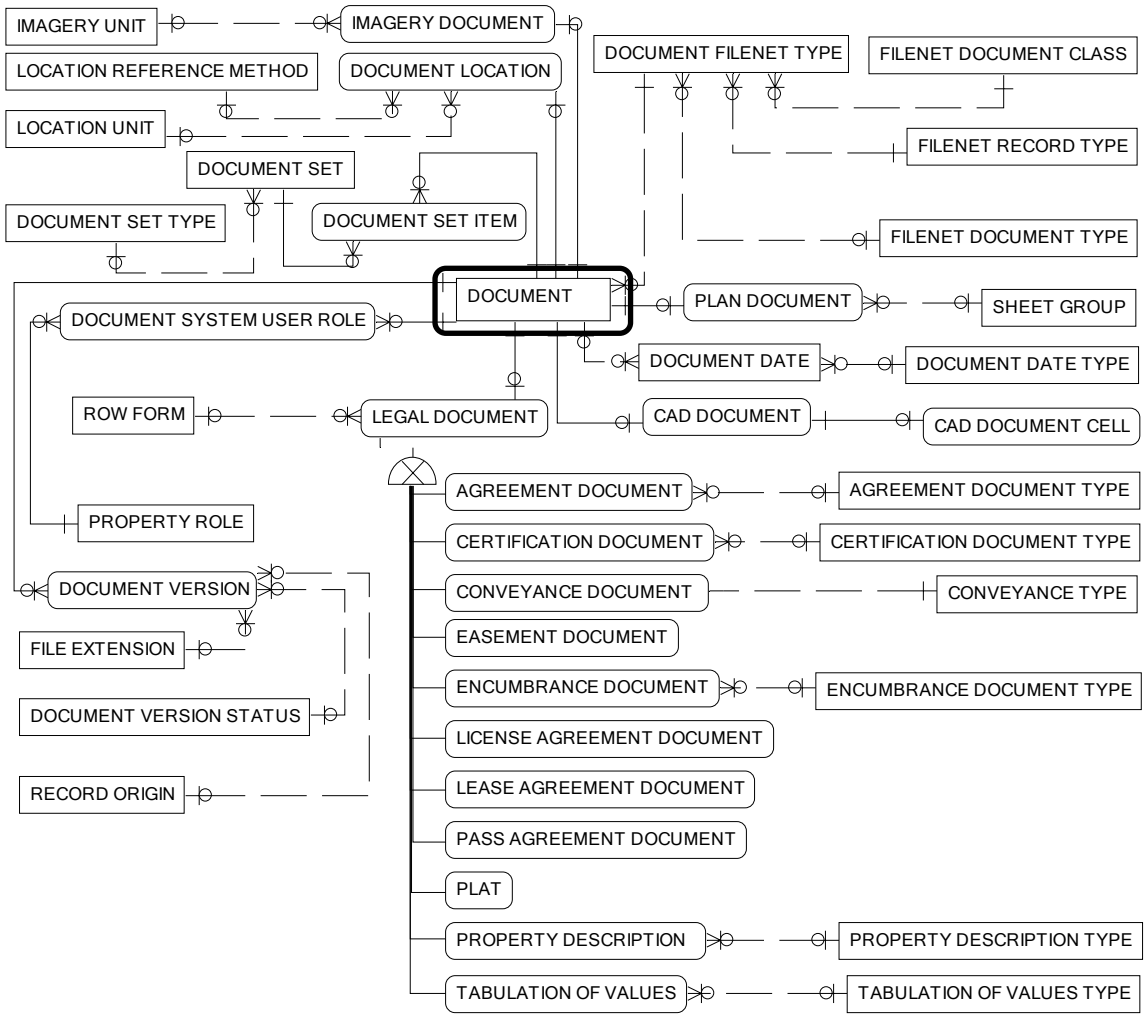


Figure 24. Right of Way Asset Data Model – Document Subject Area.

Table 10. Document Subject Area Entities.

Name	Definition
AGREEMENT DOCUMENT	An AGREEMENT DOCUMENT is a document that identifies the relationships, rights, and responsibilities between two or more parties.
AGREEMENT DOCUMENT TYPE	An AGREEMENT DOCUMENT TYPE is a word or phrase that characterizes an AGREEMENT DOCUMENT. Examples of agreement documents in use at TxDOT include federal project authorization and agreement, LPA agreement, and municipal maintenance agreement.
CAD DOCUMENT	A CAD DOCUMENT is a document in electronic format that represents entities graphically using points, lines, or polygons generated in a CAD environment (e.g., MicroStation).
CAD DOCUMENT CELL	A CAD DOCUMENT CELL is the name of a CAD cell used in a CAD document. A CAD document could have zero, one, or many CAD DOCUMENT CELLs.
CERTIFICATION DOCUMENT	A CERTIFICATION DOCUMENT is a LEGAL DOCUMENT that provides certification that a given task is complete for a TxDOT highway improvement project.

Table 10. Document Subject Area Entities (Continued).

Name	Definition
CERTIFICATION DOCUMENT TYPE	A CERTIFICATION DOCUMENT TYPE is a word or phrase that characterizes a CERTIFICATION DOCUMENT. Examples of certification documents in use at TxDOT include appraisal report, LPA resolution, and negotiator report.
CONVEYANCE DOCUMENT	A CONVEYANCE DOCUMENT is a document that describes the rights and responsibilities of all the parties in a transaction that involves the transfer of property rights. Examples of a CONVEYANCE DOCUMENT include standard deed, quitclaim deed, donation deed, agreed judgment, and judgment of court in absence of objection.
CONVEYANCE TYPE	A CONVEYANCE TYPE is a word or phrase that characterizes a CONVEYANCE DOCUMENT. Examples of a CONVEYANCE TYPE are standard deed, quitclaim deed, donation deed, agreed judgment, and judgment of court in absence of objection.
DOCUMENT	A DOCUMENT is a tangible product in printed or electronic format. A document can have several versions based on date and/or author.
DOCUMENT DATE	A DOCUMENT DATE is a specific point in time that relates to a DOCUMENT and is stored in the database for legal or audit purposes.
DOCUMENT DATE TYPE	A DOCUMENT DATE TYPE is a word or phrase that characterizes a DOCUMENT DATE.
DOCUMENT FILENET TYPE	A DOCUMENT FILENET TYPE is a unique combination of a FileNet document class, record type, and document type that follows TxDOT's EDTIS Content Services library standards. In the standards, a file code represents this unique combination. For example, file code 13.2.3 represents a drainage easement document (document class = "Right of Way," record type = "Easement," and document type = "Drainage Easement").
DOCUMENT LOCATION	A DOCUMENT LOCATION is a linear reference of a document along a state route centerline, expressed in terms of beginning, ending, and offset measurements. For example, a right of way map for a section on IH 10 located in the vicinity of SH 46 may be represented by a from distance of 540.487 miles, a to distance of 541.537 miles, and an offset of 150 feet.
DOCUMENT SET	A DOCUMENT SET is a collection of documents. Examples include PS&E plan sets, proposals, and reports (provided several documents, e.g., chapters in separate files, make up the report; if a report is in a single file, the report is considered a document, not a document set).
DOCUMENT SET ITEM	A DOCUMENT SET ITEM is a document that is part of a DOCUMENT SET. Examples include each of the chapters that make up a report (if each chapter is a separate document) and each of the plan documents that make up a PS&E plan set.
DOCUMENT SET TYPE	A DOCUMENT SET TYPE is a word or phrase that characterizes document sets with similar attributes and characteristics. Examples include utility agreements, utility agreement assemblies, change orders, PS&E assemblies, and plan sets.
DOCUMENT SYSTEM USER ROLE	A DOCUMENT SYSTEM USER ROLE is a mapping that represents the many-to-many relationships between a DOCUMENT, a SYSTEM USER, and a PROPERTY ROLE. DOCUMENT SYSTEM USER ROLE enables the identification of system users associated with a DOCUMENT and the PROPERTY ROLE of each SYSTEM USER. DOCUMENT SYSTEM USER ROLE can identify the parties of a legal document and their perspective roles.
DOCUMENT VERSION	A DOCUMENT VERSION is an instance of a DOCUMENT. For example, for a chapter document, DOCUMENT VERSION represents each of the instances of that document, e.g., version 1, 2, or 3.
DOCUMENT VERSION STATUS	A DOCUMENT VERSION STATUS is a description of the production status of a DOCUMENT VERSION.
EASEMENT DOCUMENT	An EASEMENT DOCUMENT is a document that describes the right to use the real property of another for a specific purpose, mostly in connection with right of way needs. The two parties in an easement are the grantor and the grantee.

Table 10. Document Subject Area Entities (Continued).

Name	Definition
ENCUMBRANCE DOCUMENT	An ENCUMBRANCE DOCUMENT is a document that defines the right or interest in a property that is held by someone who is not the legal owner of the property.
ENCUMBRANCE DOCUMENT TYPE	An ENCUMBRANCE DOCUMENT TYPE is a word or phrase that characterizes an ENCUMBRANCE DOCUMENT. Examples of agreement documents in use at TxDOT include control of access agreement document and height restriction document.
FILE EXTENSION	A FILE EXTENSION is the portion of a file name that indicates the file format or the application used to create the file.
FILENET DOCUMENT CLASS	A FILENET DOCUMENT CLASS is a category of documents within the EDTIS Content Services library standards that corresponds to the highest level of aggregation of TxDOT business functions. Examples include administrative, construction, project design, right of way, traffic operations, and transportation planning.
FILENET DOCUMENT TYPE	A FILENET DOCUMENT TYPE is a type of document within a FILENET RECORD TYPE included in the EDTIS Content Services library standards. The combination between FILENET RECORD TYPE and FILENET DOCUMENT TYPE is unique within each FILENET DOCUMENT CLASS. For example, the FILENET DOCUMENT TYPE "Plan" is a type of document within the FILENET RECORD TYPE "Plans Specifications and Estimates." The combination between "Plans Specifications and Estimates" and "Plan" is unique within the FILENET DOCUMENT CLASS "Project Design."
FILENET RECORD TYPE	A FILENET RECORD TYPE is a document subclass within a FILENET DOCUMENT CLASS included in the EDTIS Content Services library standards. For example, the FILENET RECORD TYPE "Plans Specifications and Estimates" is a document subclass within the FILENET DOCUMENT CLASS "Project Design."
IMAGERY DOCUMENT	An IMAGERY DOCUMENT is a document that represents entities graphically using pixel structures.
IMAGERY UNIT	An IMAGERY UNIT is a measurement unit for imagery documents that provides an indication of the image resolution level (or pixel size). Examples include feet, inches, meters, miles, and kilometers.
LEASE AGREEMENT DOCUMENT	A LEASE AGREEMENT DOCUMENT is a document that describes the temporary right to possess and use property (real or personal), usually in exchange for payment. The two parties in a lease are the lessor and the lessee (or tenant).
LEGAL DOCUMENT	A LEGAL DOCUMENT is a document that describes contractual rights and responsibilities.
LICENSE AGREEMENT DOCUMENT	A LICENSE AGREEMENT DOCUMENT is a document that describes the right to use the property of another for a specific purpose. Unlike an easement, a license can be revoked. The two parties in a license are the licensor and the licensee.
LOCATION REFERENCE METHOD	A LOCATION REFERENCE METHOD is a descriptor of the linear reference method associated with a DOCUMENT LOCATION entity. Examples include stationing, control section, and DFO.
LOCATION UNIT	A LOCATION UNIT is a measurement unit for a DOCUMENT LOCATION. Examples include feet, inches, meters, miles, kilometers, and yards.
PASS AGREEMENT DOCUMENT	A PASS AGREEMENT DOCUMENT is a document that describes the right to cross the right of way. TxDOT handles passes on a case-by-case basis and relies on permits, contractual agreements with the state, or as provided in the right of way conveyance to the state. TxDOT normally handles three categories of passes: passes that are automatically available due to drainage need, passes warranted to meet safety needs, and remaining passes where dual appraising is necessary to determine justification and cost participation.
PLAN DOCUMENT	A PLAN DOCUMENT is a document that contains one or more plan sheets. Plan documents normally include graphical elements that facilitate plan sheet printing for document submission purposes, such as title boxes, notes, and annotations.
PLAT	A PLAT is a map of a PARCEL.

Table 10. Document Subject Area Entities (Continued).

Name	Definition
PROPERTY DESCRIPTION	A PROPERTY DESCRIPTION is a document that reflects a boundary survey conducted for the conveyance of a property interest. At TxDOT, a PROPERTY DESCRIPTION prepared for a right of way project includes a heading with TxDOT identification items, along with a metes and bounds description and parcel plats prepared on letter size (8½ inch × 11 inch) sheets. A PROPERTY DESCRIPTION must be tied to the Texas State Plane Coordinate System, reference metadata used in preparing the survey, and be signed and sealed by an RPLS. Source: *TxDOT Survey Manual* (*15*).
PROPERTY DESCRIPTION TYPE	A PROPERTY DESCRIPTION TYPE is a word or phrase that characterizes a PROPERTY DESCRIPTION. An example of a PROPERTY DESCRIPTION TYPE is metes and bounds.
PROPERTY ROLE	A PROPERTY ROLE is a role or function that an individual or an agency has with respect to a document that involves the transfer of property rights. Examples of a PROPERTY ROLE are grantor, grantee, lessor, lessee, appraiser, negotiator, and owner.
RECORD ORIGIN	A RECORD ORIGIN is an indicator of the source of a specific record in the database. Examples of a RECORD ORIGIN are entered manually, imported from other system, and derived from existing data.
ROW FORM	A ROW FORM is a document in a standard format that TxDOT uses for right of way purposes.
SHEET GROUP	A SHEET GROUP is a document category that facilitates plan document grouping. Examples of a SHEET GROUP are typical sections, estimate and quantity sheets, plan and profile, and traffic control plans.
TABULATION OF VALUES	A TABULATION OF VALUES is a document that contains a listing of items with assessed values, such as total approved values, improvements, damages and enhancements, and sign values, that pertain to a PARCEL. TxDOT uses Form ROW-A-10 for the TABULATION OF VALUES.
TABULATION OF VALUES TYPE	A TABULATION OF VALUES TYPE is a word or phrase that characterizes a TABULATION OF VALUES.

Project Subject Area

The Project Subject Area consists of DCIS PROJECT, DCIS DATA WAREHOUSE, related lookup tables, and linkages to other entity subject areas (Figure 25, Table 11). DCIS DATA WAREHOUSE is a subset of DCIS File 121. To ensure compatibility with DCIS, DCIS DATA WAREHOUSE maintains the same structure as DCIS File 121. As a result, it does not follow TxDOT data architecture standards (*31*). Developing a standard-compliant version of DCIS PROJECT would have been possible but redundant since TxDOT has already started the process to develop a standard-compliant version of DCIS.

DCIS File 121 contains a large number of attributes. For this research, the DCIS DATA WAREHOUSE contained only a few attributes that were relevant to help characterize sample project data (other attributes, while important in DCIS, were not critical for this research). In general, attributes considered relevant were those that helped characterize projects according to key project identifiers, project description, project roadway information, and geo-referencing. Because it maintained the same structure as that of the DCIS File 121, it was convenient to extract project information from DCIS to the DCIS DATA WAREHOUSE table. However,

rather than being directly used for project-related queries, the DCIS DATA WAREHOUSE entity serves as a data repository in the PROJECT subject area.

The primary key of the DCIS PROJECT entity is CONTROL SECTION JOB NUMBER. Before TxDOT authorizes a construction project or a right of way project, that project may have a planning CSJ number, which functions as a temporary CSJ number. After authorization, TxDOT assigns a permanent CSJ number to the project. In addition, a project may have several "parent" (or "grandparent") projects. To model these relationships, the DCIS DATA WAREHOUSE included five attribute fields (ANCESTOR CSJ1 through ANCESTOR CSJ5) to identify the associated CSJ parent numbers.

The model also included a PROJECTS entity as well as an entity called ROWIS CONNECTION to provide a mapping of the many-to-many relationship between the DCIS PROJECT entity and the PROJECTS entity. For simplicity, the PROJECTS entity in Figure 25 only shows a few attributes that are relevant to the model.

PROJECT FEATURE identifies features associated with a given project (e.g., bridges, railroads, or centerlines). PROJECT FEATURE also handles many-to-many relationships between DCIS PROJECT and FEATURE. PROJECT DOCUMENT identifies documents associated with a given project (e.g., as-built plans, schematics, or environmental clearances). PROJECT DOCUMENT also handles many-to-many relationships between DCIS PROJECT and DOCUMENT.

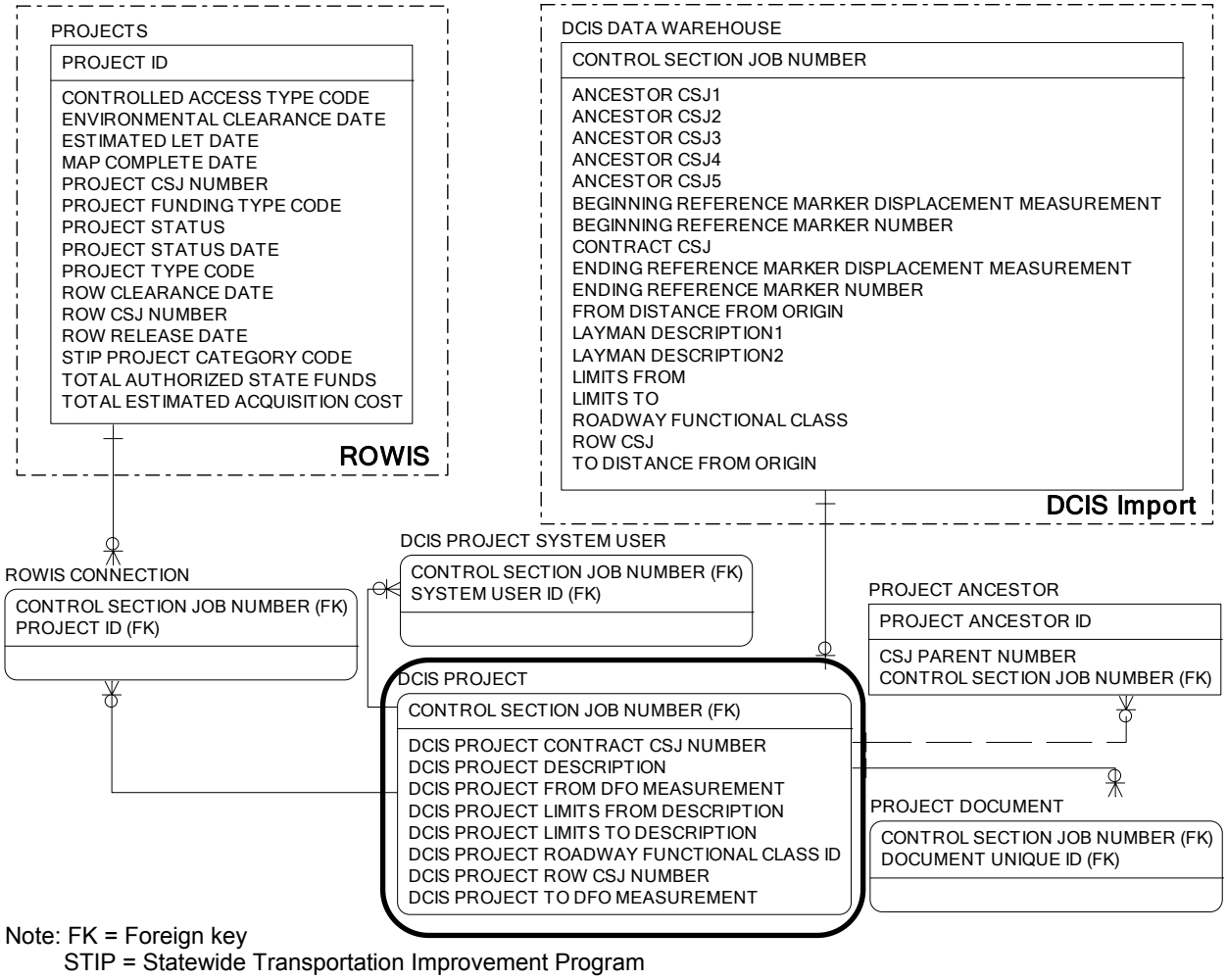


Figure 25. Right of Way Asset Data Model – Project Subject Area.

Table 11. Project Subject Area Entities.

Name	Definition
DCIS DATA WAREHOUSE	A DCIS DATA WAREHOUSE is a TxDOT roadway improvement project whose data are entered into the TxDOT DCIS database and imported into this table.
DCIS PROJECT	A DCIS PROJECT is a TxDOT roadway improvement project whose data are entered into the DCIS DATA WAREHOUSE table, are normalized, and then are imported into this table.
DCIS PROJECT SYSTEM USER	A DCIS PROJECT SYSTEM USER is a mapping that represents the many-to-many relationships between a DCIS PROJECT and a SYSTEM USER. DCIS PROJECT SYSTEM USER enables the identification of DCIS PROJECTS associated with a SYSTEM USER and the SYSTEM USERS associated with a DCIS PROJECT.
PROJECT ANCESTOR	A PROJECT ANCESTOR is a mapping between a CONTROL SECTION JOB NUMBER and one or more CSJ PARENT NUMBERS if the parent CSJ number exists.
PROJECT DOCUMENT	A PROJECT DOCUMENT is a mapping that represents the many-to-many relationship between a PROJECT and a DOCUMENT. PROJECT DOCUMENT enables the identification of DOCUMENTS associated with a PROJECT and the identification of PROJECTS associated with a DOCUMENT.

Table 11. Project Subject Area Entities (Continued).

PROJECTS	PROJECTS is a ROWIS table. No definition was found in the ROWIS data model that TxDOT provided. Apparently, PROJECTS is a listing of project data that pertain to a TxDOT right of way project, such as right of way release date, environmental clearance date, and total authorized state funds.
ROWIS CONNECTION	A ROWIS CONNECTION is a mapping that represents the many-to-many relationship between DCIS PROJECT and PROJECTS.

User Subject Area

The User Subject Area consists of SYSTEM USER, DOT USER, COMPANY USER, INDIVIDUAL USER, related lookup tables, and linkages to other entity subject areas (Figure 26, Table 12). In the model, a SYSTEM USER can be a company, an agency, or an individual. The primary key for the SYSTEM USER entity is SYSTEM USER ID. This unique key identifies all users that are included in the model regardless of type. The SYSTEM USER entity also enables linkages to the DOCUMENT, FEATURE, and DCIS PROJECT subject areas.

Detailed user profile data are stored in one of three profile entities: INDIVIDUAL USER PROFILE, DOT USER PROFILE, and COMPANY USER PROFILE. For TxDOT users and company users, the model also includes entities to handle office and unit data.

A SYSTEM USER can have many-to-many relationships with the FEATURE, DOCUMENT, and DCIS PROJECT entities. In addition, a SYSTEM USER can play different roles in relation to a FEATURE or a DOCUMENT. Although these associations can be established for many cases, a FEATURE is not necessarily related to a USER or a PROPERTY ROLE. Similarly, a DOCUMENT is not necessarily related to a USER or a PROPERTY ROLE as well. The model uses an entity named SYSTEM USER ROLE to model the roles a SYSTEM USER can play. By definition, a PROPERTY ROLE is a legal function or responsibility of a contract party for the purpose of documenting changes in property right ownership. Examples of a PROPERTY ROLE are grantor, grantee, lessor, and lessee.

The SYSTEM USER is associated with a FEATURE and a PROPERTY ROLE through the FEATURE SYSTEM USER ROLE entity (Figure 23). A FEATURE SYSTEM USER ROLE provides a mapping of the many-to-many relationships between a FEATURE, a SYSTEM USER, and a PROPERTY ROLE. The model also includes an entity named DOCUMENT SYSTEM USER ROLE (Figure 24) to map the many-to-many relationships between a DOCUMENT, a SYSTEM USER, and a PROPERTY ROLE. The DOCUMENT SYSTEM USER ROLE enables the identification of system users associated with a DOCUMENT and the PROPERTY ROLE of each SYSTEM USER.

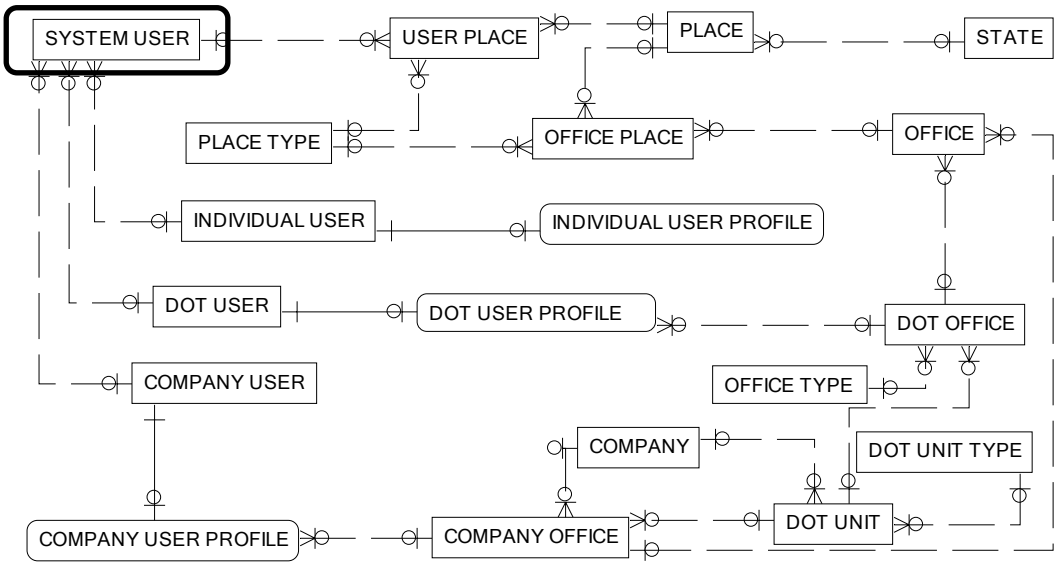


Figure 26. Right of Way Asset Data Model – User Subject Area.

Table 12. User Subject Area Entities.

Name	Definition
COMPANY	A COMPANY is any public or private organization or agency. The origin of this entity is the Utility Installation Review (UIR) system, where COMPANY initially represented agencies external to TxDOT (*81*). As a result of a directive from the TxDOT administration for districts to use UIR to manage TxDOT-owned underground infrastructure, it was necessary to add a record in the company table to identify TxDOT as a company. In the right of way asset data model, a COMPANY is a stakeholder in the right of way management process. Stakeholders include agencies such as TxDOT, the State of Texas, cities, consultant companies, utility companies, title companies, and railroads.
COMPANY OFFICE	A COMPANY OFFICE is an administrative or functional element within the organizational structure of a COMPANY. A COMPANY OFFICE usually has one or more COMPANY USERS.
COMPANY USER	A COMPANY USER is a COMPANY employee that is affiliated with a COMPANY OFFICE.
COMPANY USER PROFILE	A COMPANY USER PROFILE is a listing of basic information about a COMPANY USER.
DOT OFFICE	A DOT OFFICE is an administrative or functional element within a DOT UNIT. A DOT OFFICE usually has one or more DOT USERS.
DOT UNIT	A DOT UNIT is a major unit within the organizational chart of a DOT. Examples of a DOT UNIT at TxDOT include each district (e.g., Fort Worth, Houston, and San Antonio) and each division (e.g., the Right of Way Division and the Technology Services Division). In general, a DOT UNIT can contain one or more DOT OFFICES, starting with an office that designates the DOT UNIT itself (to enable the association of the general manager of the DOT UNIT within a DOT OFFICE). For example, in the database, the district engineer for the San Antonio District DOT UNIT is affiliated with the San Antonio District DOT OFFICE. Additional offices within the district include sections (e.g., Right of Way, Maintenance, and Operations) and area offices (e.g., Hondo and Kerrville).

Table 12. User Subject Area Entities (Continued).

Name	Definition
DOT UNIT TYPE	A DOT UNIT TYPE is a category of a DOT UNIT. Examples of a DOT UNIT TYPE are district and division.
DOT USER	A DOT USER is a DOT employee that is affiliated with a DOT OFFICE.
DOT USER PROFILE	A DOT USER PROFILE is a listing of basic information about a DOT USER.
INDIVIDUAL USER	An INDIVIDUAL USER is an individual who is a stakeholder in the right of way asset management process.
INDIVIDUAL USER PROFILE	An INDIVIDUAL USER PROFILE is a listing of basic information about an INDIVIDUAL USER.
OFFICE	An OFFICE is an administrative unit within an organization or agency. In the model, OFFICE is a centralized location that lists both DOT and COMPANY offices to facilitate the query-building process.
OFFICE PLACE	An OFFICE PLACE is the PLACE of an OFFICE.
OFFICE TYPE	An OFFICE TYPE is a category of an office. Examples of an OFFICE TYPE are area office and district office.
PLACE	A PLACE is a postal address consisting of a street address, city, state, and ZIP code.
PLACE TYPE	A PLACE TYPE is a category of a PLACE. Examples of a PLACE TYPE include mailing address and physical address.
STATE	A STATE is a political division within the United States.
SYSTEM USER	A SYSTEM USER is a company, agency, or individual who is a stakeholder in the right of way asset management process. A SYSTEM USER has a pre-specified level of access to FEATURES, DOCUMENTS, and/or PROJECTS through online and/or standalone system interfaces.
USER PLACE	A USER PLACE is the PLACE of a SYSTEM USER.

ADDITIONAL DATA MODEL DEVELOPMENTS

As mentioned previously, the researchers did not have access to the FileNet data model. As a result, it was not possible to determine how closely the entities in the Document Subject Area match the corresponding entities in FileNet. However, based on further discussions with TxDOT officials, it was possible to gather some additional information about the TxDOT FileNet implementation, which led to the development of two variations of the Document Subject Area in addition to the data model the researchers used for testing (see Chapter 5). The following sections describe the two variations, called Alternative A and Alternative B.

Document Subject Area (Alternative A)

Alternative A includes all entities of the basic tested model and two additional entities, as shown in Figure 27 and Table 13: DOCUMENT SUBTYPE and DOCUMENT FILENET TYPE DOCUMENT SUBTYPE. The main purpose of entity DOCUMENT SUBTYPE is to address a limitation in the current EDTIS Content Services library standards regarding the availability of options to describe similar types of documents. For example, Table 14 shows four options in the current library that would enable a user to classify a deed. However, the current structure does not enable the classification of deeds by type (e.g., standard deed, donation deed, or quitclaim deed). One option to address this issue would be to expand the document type list to include all possible document subtypes. One of the disadvantages of this approach would be to have to add potentially many records to the library structure: at least one record for each document

subtype/record type/document class combination. Another option, which Alternative A follows, would be to use the current library structure as is and add a document subtype attribute in the DOCUMENT entity (there is a direct link between DOCUMENT SUBTYPE and DOCUMENT in Figure 27).

The purpose of DOCUMENT FILENET TYPE DOCUMENT SUBTYPE is to provide a mechanism to display document subtypes that are available to users once a user selects a document type. In the current TxDOT FileNet implementation, users select a record type of interest, and the interface displays available document types based on the entries in the DOCUMENT FILENET TYPE entity. DOCUMENT FILENET TYPE DOCUMENT SUBTYPE would enable the system to display available document subtypes through a many-to-many relationship between DOCUMENT SUBTYPE and DOCUMENT FILENET TYPE.

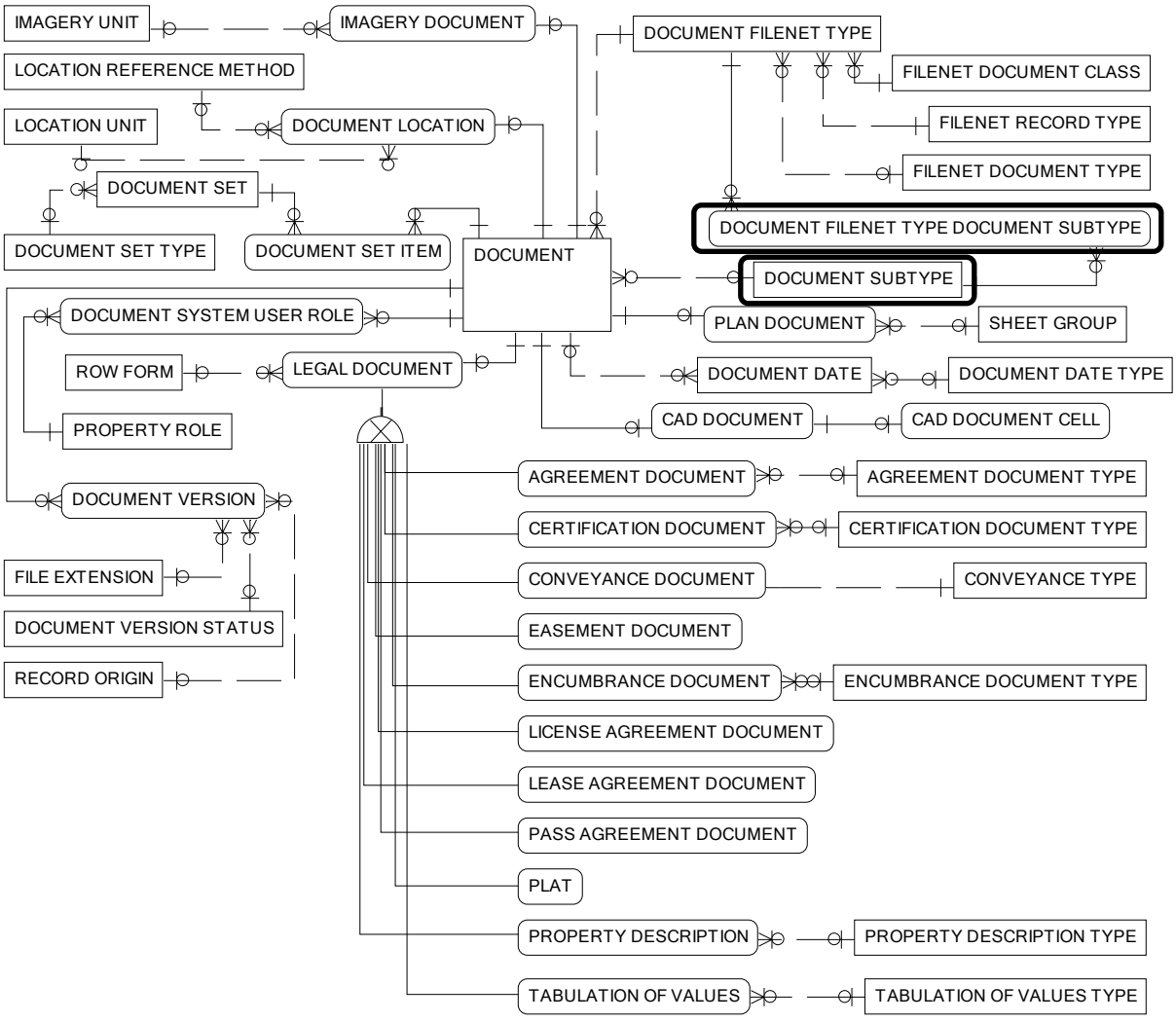


Figure 27. Right of Way Asset Data Model – Document Subject Area (Alternative A).

Table 13. Document Subject Area (Alternative A) – Entities Not Provided in Table 10.

Name	Definition
DOCUMENT SUBTYPE	A DOCUMENT SUBTYPE is a disaggregation or further characterization of a document type in cases where the document type by itself would not be sufficient to describe the document. For example, the document type "Deed" could be further characterized by a DOCUMENT SUBTYPE "Deed-Quitclaim."
FILENET DOCUMENT TYPE DOCUMENT SUBTYPE	A DOCUMENT FILENET TYPE DOCUMENT SUBTYPE is a mapping that represents the many-to-many relationships between a DOCUMENT FILENET TYPE and a DOCUMENT SUBTYPE. DOCUMENT FILENET TYPE DOCUMENT SUBTYPE enables the identification of DOCUMENT FILENET TYPES associated with a DOCUMENT SUBTYPE and the DOCUMENT SUBTYPES associated with a DOCUMENT FILENET TYPE.

Table 14. Sample Right of Way Record Types and Document Types (Adapted from [*28*]).

Document Class	Record Type	Document Type	File Code
Right of Way	Eminent Domain Litigation	Conveyance or Title	13.3.11
Right of Way	Encroachments	Conveyance or Title	13.4.1
Right of Way	Non-ROW Acquisition	Conveyance or Title	13.8.4
Right of Way	ROW Acquisition Project Files	Conveyance or Title	13.11.4

Document Subject Area (Alternative B)

Alternative B is a significant departure from the basic tested model, which recognizes the fact that the actual implementation of the FileNet library at TxDOT is a simple non-relational table that lists document classes, record types, document types, and file codes. In contrast, the basic model provides a full relational construct of the FileNet library structure by using document class ID, record type ID, and document type ID attributes (and a corresponding set of lookup document class, record type, and document type entities). Alternative B is also different in that the DOCUMENT entity includes attributes that are common to all document classes, and there is an additional entity called ROW DOCUMENT that only contains attributes that pertain exclusively to right of way documents.

Figure 28, Figure 29, and Table 15 show the Alternative B structure. As mentioned above, DOCUMENT includes attributes that are common to all document classes (the first 13 attributes in Table 8, i.e., from Title to Ending Date). For completeness, in order to make DOCUMENT relational, DOCUMENT has a primary key (DOCUMENT UNIQUE ID). The ADDRESSEE TO, AUTHOR FROM, and CC entities correspond to FileNet multi-value attributes (Table 8). To comply with relational database requirements, the researchers created separate entities for these multi-value attributes.

There is no relationship in the model between DOCUMENT and DOCUMENT FILENET TYPE, even though DOCUMENT includes record type, document type, and file code attributes, all of which come from DOCUMENT FILENET TYPE. The referential integrity between DOCUMENT and DOCUMENT FILENET TYPE must be maintained through code.

FILENET DOCUMENT is a supertype entity that only exists in the logical data model (i.e., the entity is collapsed during the generation of the physical model, and all its attributes are "rolled down" to the subtypes). This entity includes document class, document subtype, and review flag attributes that are currently not part of the standard right of way document attribute list (Table 8).

ROW DOCUMENT includes all the attributes that are specific to the current Right of Way document class (from External Document Location to County in Table 8). BUSINESS FUNCTION and PROGRAM PROJECT NAME correspond to multi-value attributes that require separate related entities. In addition, some of the right of way attributes are attributes that could be referenced from other entities in the architecture, such as PARCEL NUMBER (using the ROWIS entity PARCELS) or CSJ (using DCIS DATA WAREHOUSE). However, it is unclear whether the FileNet implementation at TxDOT would include the mechanism to reference those systems. Quite likely, the referential integrity would need to be maintained through code.

In addition to the standard attributes in ROW DOCUMENT that are associated with the current Right of Way document class, ROW DOCUMENT includes several attributes the researchers identified during the analysis of sample right of way documents (and which were treated mostly through separate subtype entities in the basic tested model). In most cases, those additional attributes only pertain to certain types of right of way documents. However, for simplicity and for consistency with the FileNet implementation at TxDOT, the researchers decided to include the attributes with the rest of the Right of Way document class attributes.

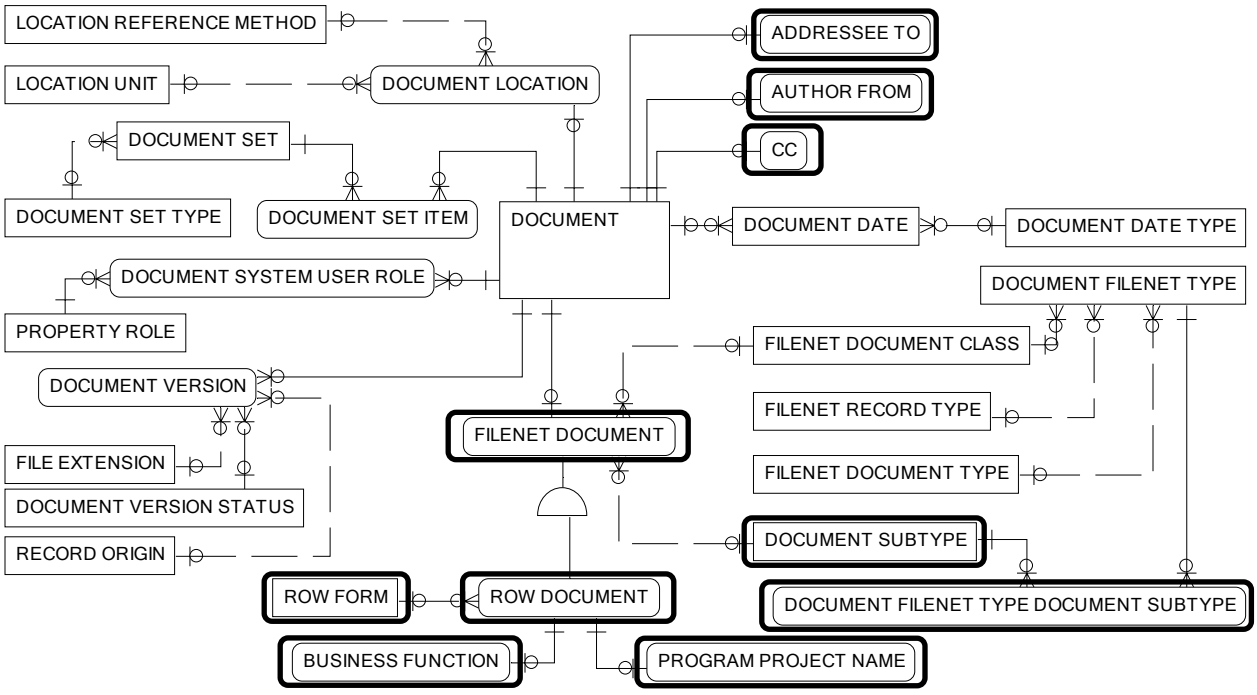


Figure 28. Right of Way Asset Data Model – Document Subject Area (Alternative B).

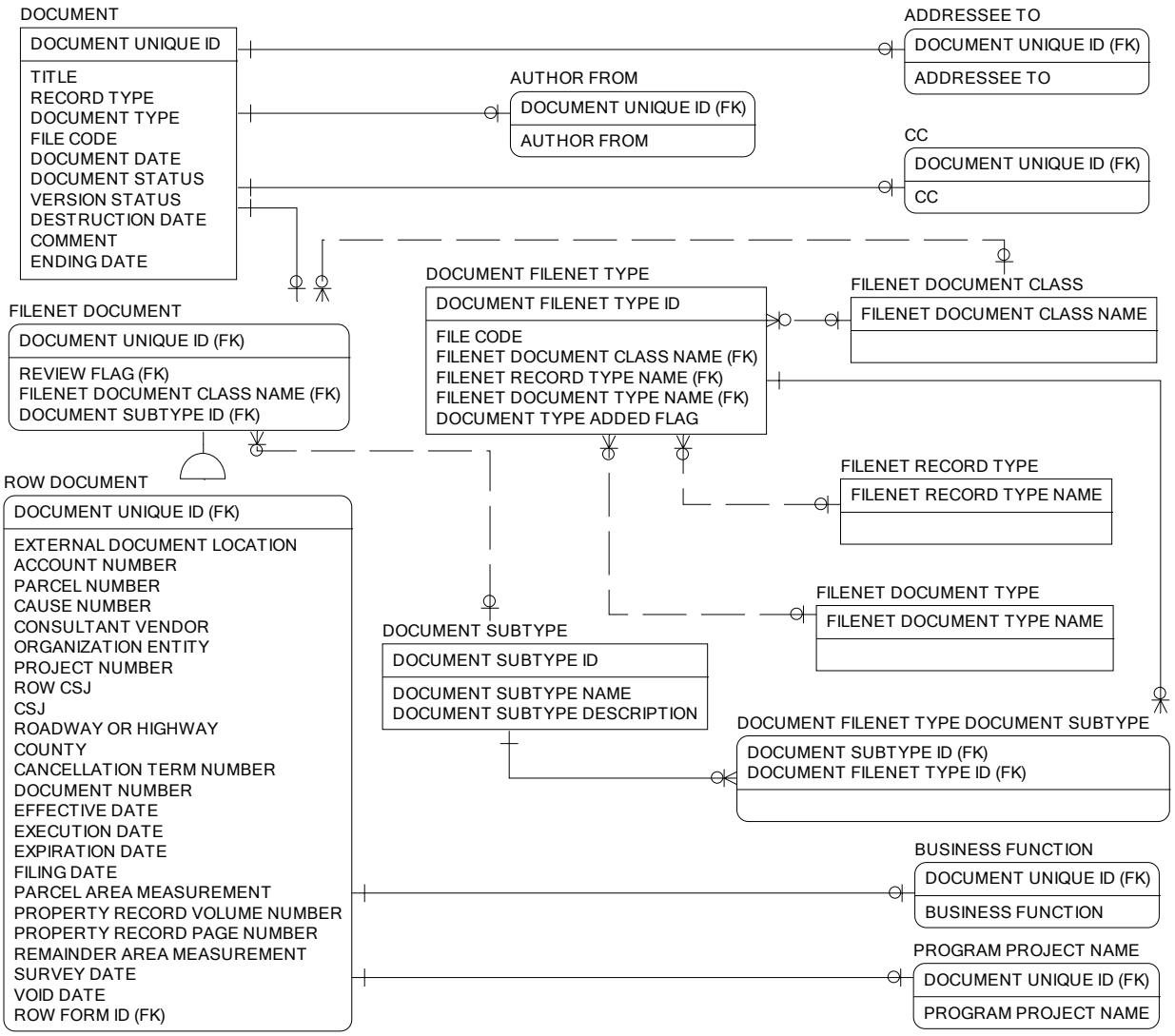


Figure 29. Right of Way Asset Data Model – Document Subject Area (Alternative B) Partial View of Attributes.

Table 15. Document Subject Area (Alternative B) – Entities Not Provided in Table 10.

Name	Definition
ADDRESSEE TO	An ADDRESSEE TO is the recipient of a document or email in the FileNet system. ADDRESSEE TO is a multi-value property that can be used for multiple FileNet document classes. Source: Adapted from EDTIS: Content Services Library Standards (*28*).
AUTHOR FROM	An AUTHOR FROM is the originator of a document or email in the FileNet system. AUTHOR FROM is a multi-value property that can be used for multiple FileNet document classes. Source: Adapted from EDTIS: Content Services Library Standards (*28*).
BUSINESS FUNCTION	A BUSINESS FUNCTION is a custom property that identifies the associated business function(s) in the FileNet system. BUSINESS FUNCTION is a multi-value property that can be used for multiple FileNet document classes. Source: Adapted from EDTIS: Content Services Library Standards (*28*).
CC	A CC is the name of a recipient that was copied on a document or email in the FileNet system using the "CC" field in the GroupWise email system. CC is a multi-value property that can be used for multiple FileNet document classes. Source: Adapted from EDTIS: Content Services Library Standards (*28*).
DOCUMENT SUBTYPE	A DOCUMENT SUBTYPE is a disaggregation or further characterization of a document type in cases where the document type by itself would not be sufficient to describe the document. For example, the document type "Deed" could be further characterized by a DOCUMENT SUBTYPE "Deed-Quitclaim."
FILENET DOCUMENT	A FILENET DOCUMENT is a tangible product in printed or electronic format that is archived using the FileNet electronic document management system.
FILENET DOCUMENT TYPE DOCUMENT SUBTYPE	A DOCUMENT FILENET TYPE DOCUMENT SUBTYPE is a mapping that represents the many-to-many relationships between a DOCUMENT FILENET TYPE and a DOCUMENT SUBTYPE. DOCUMENT FILENET TYPE DOCUMENT SUBTYPE enables the identification of DOCUMENT FILENET TYPES associated with a DOCUMENT SUBTYPE and the DOCUMENT SUBTYPES associated with a DOCUMENT FILENET TYPE.
PROGRAM PROJECT NAME	A PROGRAM PROJECT NAME is a textual description of a TxDOT project in the FileNet system. PROGRAM PROJECT NAME is a multi-value property that can be used for multiple FileNet document classes. Source: Adapted from EDTIS: Content Services Library Standards (*28*).
ROW DOCUMENT	A ROW DOCUMENT is a tangible product in printed or electronic format related to district right of way operations, projects to acquire right of way and dispose of surplus right of way, easements, and programs related to junkyards and sign regulation. Source: Adapted from EDTIS: Content Services Library Standards (*28*).
ROW FORM	A ROW FORM is a document in a standard format that TxDOT uses for ROW purposes.

CHAPTER 5. PROTOTYPE DATA MODEL TESTING

TESTING ENVIRONMENTS

The researchers used three different environments to test the right of way asset data model database design, examine potential implementation and integration issues with other systems, and demonstrate the model to a variety of audiences: Access, ArcGIS, and Internet Explorer. In line with the scope of the research, the testing effort focused on the data model architecture rather than the user interfaces (although, by necessity, the researchers designed and built the testing user interfaces in a way that could support the testing effort efficiently). During implementation, the design and testing of user interfaces would need to undergo a formal process that identifies comprehensive user interface needs and relies on actual links to systems such as DCIS, FileNet, MST, and ROWIS.

Each testing environment fulfilled a role in the testing process. The Access and ArcGIS testing environments focused on basic database design and relationship testing using a variety of "ready-made" tools that expedited the testing process. For portability, the researchers created a physical data model from the logical data model developed in Chapter 4 and used the physical definitions in an ESRI personal geodatabase (in Access format). This portable configuration enabled the demonstration of the right of way asset data model to audiences in situations where online access was not possible.

The Internet Explorer testing environment focused on the examination of implementation and integration issues with other systems and on the demonstration of the model performance in a web-based environment (which proved useful during discussions with TxDOT officials when issues such as model implementation, portability, and functionality were raised). As mentioned before, several TxDOT systems, e.g., TxDocsOnline, Plans Online, and MST, use web-based protocols. During the research, it was therefore important to develop an understanding of the degree to which the right of way asset data model could support those protocols, which was critical for the formulation of potential recommendations for implementation.

SAMPLE PROJECT DATA

For this project, TxDOT provided sample data associated with highway projects in four TxDOT districts: San Antonio, Odessa, Beaumont, and Dallas. The researchers supplemented these data with TxDOT-provided sample data from other research projects.

Table 16 summarizes the data used for each sample project area. Of the 135 documents obtained, most of these documents were property descriptions, parcel plats, right of way maps, or deeds. Certain legal document types (e.g., pass document and license agreement) and subtypes (e.g., height restriction encumbrance document) as described in Chapter 4 are not typical for every project and were unavailable for the sample project areas in this prototype.

Table 16. Summary of Sample Project Documents.

Available Documents	District				Total
	Odessa	San Antonio	Beaumont	Dallas	
Acknowledgement - appraisal report	1				1
Acknowledgement - deed			1		1
Acknowledgement - lease			1		1
Agreed judgment deed			1	1	2
Appraisal report	1		1		2
Appraisal review report	1				1
Award of Special Commissioners Deed			1		1
Closing instructions	1				1
Control of access agreement		2			2
Cover sheet - lease			1		1
Cover sheet - parcel negotiation	1				1
Cover sheet - title payment	1			1	2
Deed resolution	1				1
Deed without warranty			1		1
Drainage easement			1		1
Easement access and lien subordination			1		1
Easement access maintenance			1		1
Easement release		1			1
Judgment in absence deed				1	1
Lease agreement			1		1
Lease plat			1		1
Lease property description			1		1
Lease request			1		1
Lease tabulation of values			1		1
Lien document		1	1		2
LPA contractual agreement			1		1
LPA minute order			1		1
LPA resolution			1		1
Memorandum of Agreement (MOA) or Memorandum of Understanding (MOU)	2		1		3
Negotiator's certificate	1		2		3
Negotiator's report	3		8		11
Ordinance				1	1
Parcel plat	2	6	4		12
Payment request form	4				4
Property description	2	7	11		20
Purchase offer	1				1
Quitclaim deed			1		1
Railroad deed without warranty			1		1
Railroad exchange agreement			1		1
Relocation informational notice	1				1
Right of way map		17			17
Right of way survey		3	1		4
Standard TxDOT deed	1	4	1		6
Tabulation of values	2		1		3
Title commitment	3		2		5
Title company closing statement	1		1		2
Title company payment	1				1
Title company payment billing statement				1	1
Title company payment closing statement				1	1
Title insurance policy	1		1	1	3
Total	**32**	**41**	**55**	**7**	**135**

A brief description of the projects associated with the data provided follows (except for Dallas, where the amount and type of sample documents were not enough to generate parcel features and other property right features of interest).

San Antonio District: SH 16 and Spur 66

The sample project area covered highway segments around the intersection of State Highway (SH) 16 and Spur 66 south of San Antonio in Bexar County (Figure 30). SH 16 is a north-south corridor that was expanded from a two-lane facility to a four-lane facility in 1978. Spur 66 was a fast-track new location/retrofitting project on Watson Road, driven by the construction of a new truck assembly plant. Letting took place in August 2003. As part of another research project, the researchers already had CAD and digital letting plans for the Spur 66 project (*82*).

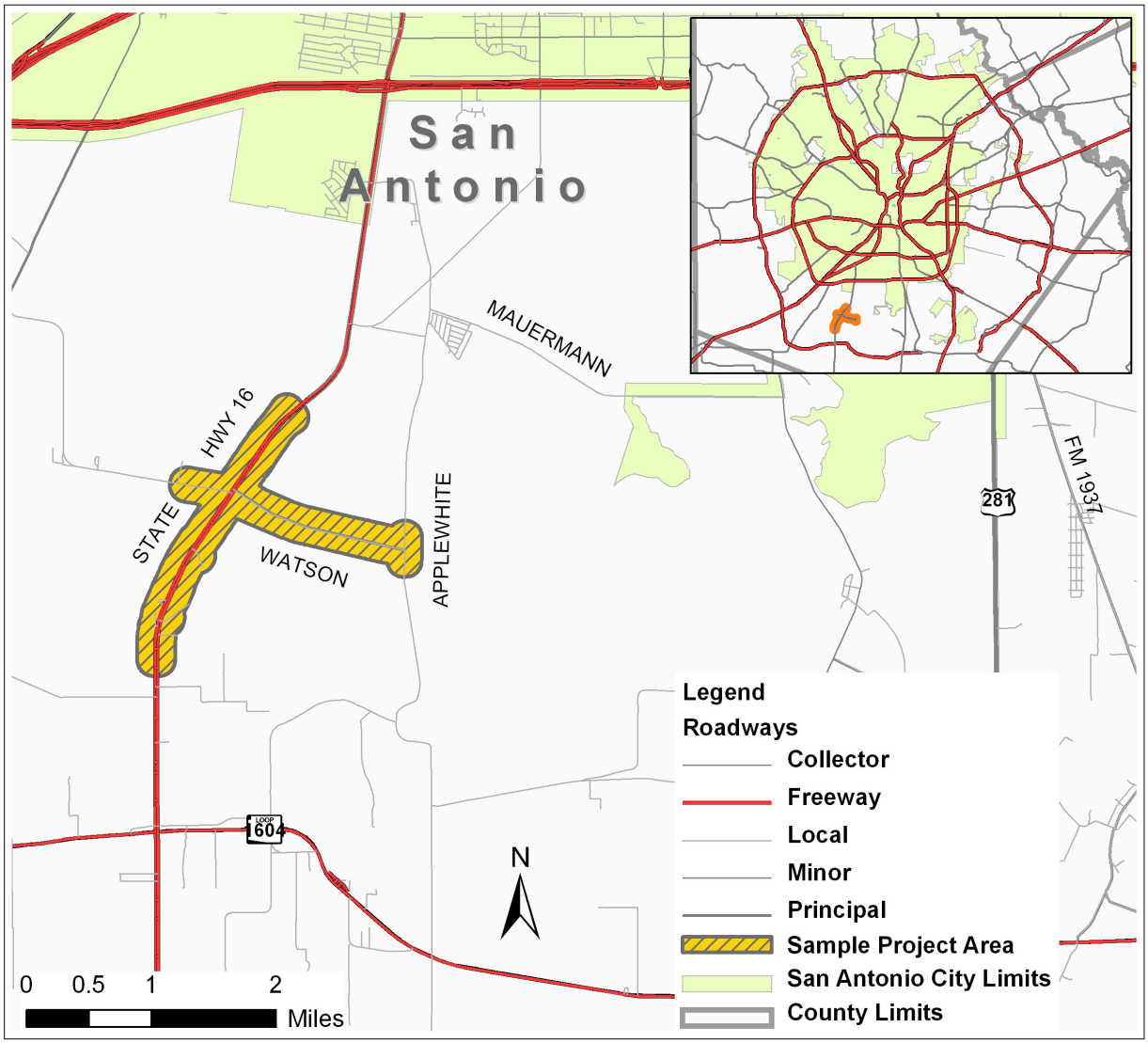


Figure 30. San Antonio District Sample Project Area.

Odessa District: FM 1379 and SH 349

The sample project area covered a reconstruction, rehabilitation, and widening project to extend FM 1379 to SH 349 in Midland County (Figure 31). Letting took place in September 2006. As-built plans were not yet available via Plans Online.

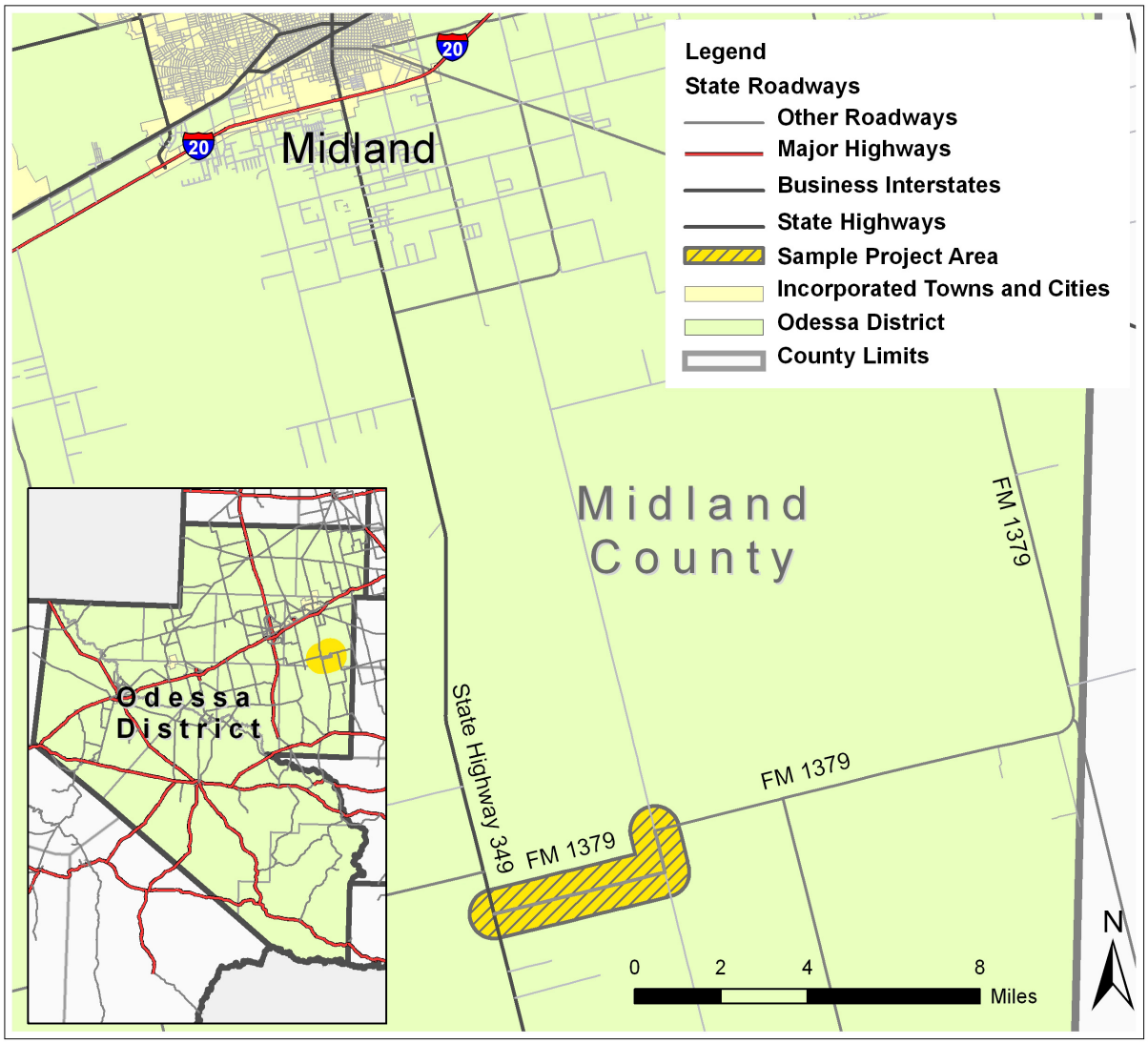


Figure 31. Odessa District Sample Project Area.

Beaumont District: SH 87 from FM 105 to Business US 90

The sample project area covered a reconstruction, widening, and railroad grade separation project along SH 87 from FM 105 to Business U.S. Highway (US) 90 in Orange County (Figure 32). Letting took place in August 1999.

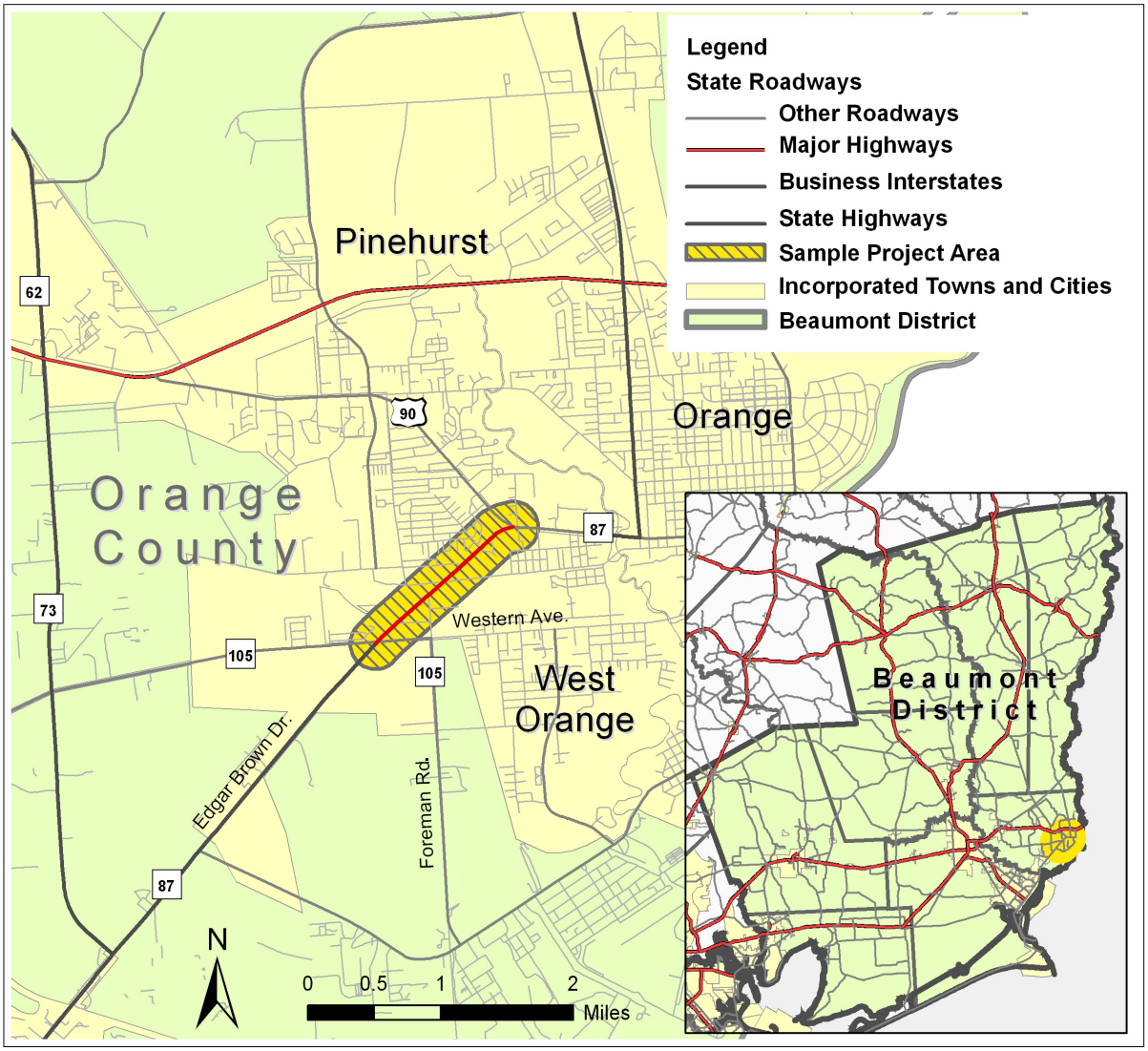


Figure 32. Beaumont District Sample Project Area.

INTEGRATING PROJECT DATA IN THE DATABASE

TxDOT provided basic DCIS project data for the project areas analyzed (Table 17). With the data provided, the researchers populated the DCIS_PROJ and PROJ_ANCESTOR tables. These tables enable the association of project with parcel data. As mentioned previously, integrating project data into a database that manages parcels and other property rights is important because project information is a critical cornerstone that provides proper background and context to the right of way acquisition process. Readers should note that, during implementation, DCIS project data are already available. As a result, the only piece of information needed to create a link between a parcel and the corresponding project is a single record in table PROJ_FEAT, (i.e., entity PROJECT FEATURE in Figure 21 and Figure 22) containing the parcel ID and the project CSJ number.

Table 17. Basic Sample Project Data in DCIS.

DCIS Field Name	Spur 66	SH 16 [1]	SH 349 @ FM 1379	SH 87 @ FM 105
PROJ_CSJ_NBR	029112001	N/A	238301018	030601041
ROW_CSJ_NBR		061301028	238301020	030601052
DT_EST_COST	10/06/03		06/07/06	05/14/99
LMT_FROM	0.27 Miles West of SH 16		End of State Maintenance on FM 1379	FM 105
LMT_TO	Applewhite Road		SH 349	BU 90-Y (Old LP 358)
LAYMAN_DSCR1	Construct Spur to Replace Watson Road		Facility Upgrades to Meet Non-freeway Standards	Reconstruct to Six-Lane Undivided Urban
LAYMAN_DSCR2				and Railroad Overpass Structure
CNTRCT_CSJ	029112001		238301018	030601041
DIST_LET_DT	01-Oct-03		01-Sept-06	01-Aug-99
ACTL_LET_DT	01-Oct-03		01-Sept-06	01-Aug-99
LET_SCH_1	2004	1978	2007	1999
BEG_REF_MRKR_NBR			348	480
BEG_REF_MRKR_DISP			0.013	–0.482
END_REF_MRKR_NBR			348	482
END_REF_MRKR_DISP			5.159	0.848

[1] Data not available in DCIS. ROW CSJ data available from the ROW maps.

INTEGRATING DOCUMENT DATA IN THE DATABASE

The researchers used the current EDTIS content services library standards (*28*) to fill the DCMNT_FILENET_TYPE, FILENET_DCMNT_CLASS, FILENET_RCRD_TYPE, and FILENET_DCMNT_TYPE tables. Then, they mapped the sample project documents to the EDTIS classification scheme and populated the DCMNT table with the appropriate EDTIS file code. As Table 18 shows, there were several cases where characterizing individual files was not straightforward or possible; e.g., if a single document could potentially match multiple FileNet document types, the correspondence between the document and FileNet document type was not necessarily intuitively clear, or it was not possible to match the document to any FileNet document type. Addressing this problem would involve developing an inventory of right of way

real property document categories and modifying the EDTIS classification scheme to handle these categories. The end of this chapter discusses this issue further.

Table 18. Sample Project Documents Mapped to FileNet Document Types.

Available Documents	Total	File Code	Document Class	Record Type	Document Type
Acknowledgement – appraisal report	1	13.11.2	Right of Way	ROW Acquisition Project Files	Appraisal
Acknowledgement – deed	1	13.11.4	Right of Way	ROW Acquisition Project Files	Conveyance or Title
Acknowledgement – lease	1	3.9.3	Contracts, Leases, and Agreements	Leases	Lease Agreement
Agreed judgment deed	2	13.3.11	Right of Way	Eminent Domain Litigation	Conveyance or Title
Appraisal report	2	13.11.2	Right of Way	ROW Acquisition Project Files	Appraisal
Appraisal review report	1	13.11.2	Right of Way	ROW Acquisition Project Files	Appraisal
Award of Special Commissioners Deed	1	13.3.5	Right of Way	Eminent Domain Litigation	Award
Closing instructions	1	13.11.9	Right of Way	ROW Acquisition Project Files	Negotiation
Control of access agreement	2	13.11.13	Right of Way	ROW Acquisition Project Files	Request Notice or Access Permission
Cover sheet – lease	1	3.9.3	Contracts, Leases, and Agreements	Leases	Lease Agreement
Cover sheet – parcel negotiation	1	13.11.9	Right of Way	ROW Acquisition Project Files	Negotiation
Cover sheet – title payment	2	6.2.10	Finance	Billings and Payments	Payment
Deed resolution	1	13.11.9	Right of Way	ROW Acquisition Project Files	Negotiation
Deed without warranty	1	13.11.4	Right of Way	ROW Acquisition Project Files	Conveyance or Title
Drainage easement	1	13.2.3	Right of Way	Easements	Drainage Easement
Easement access and lien subordination	1	N/A			
Easement access maintenance	1	N/A			
Easement release	1	13.2.4	Right of Way	Easements	Release of Easement
Judgment in absence deed	1	13.3.11	Right of Way	Eminent Domain Litigation	Conveyance or Title
Lease agreement	1	3.9.3	Contracts, Leases and Agreements	Leases	Lease Agreement
Lease plat	1	3.9.3	Contracts, Leases and Agreements	Leases	Lease Agreement
Lease property description	1	3.9.3	Contracts, Leases and Agreements	Leases	Lease Agreement
Lease request	1	3.9.3	Contracts, Leases and Agreements	Leases	Lease Agreement
Lease tabulation of values	1	3.9.3	Contracts, Leases and Agreements	Leases	Lease Agreement
Lien document	2	N/A			
LPA contractual agreement	1	3.1.5	Contracts, Leases and Agreements	Agreements	Agreement LPA Acquisition
LPA minute order	1	13.13.3	Right of Way	ROW Releases	Minute Order
LPA resolution	1	3.1.5	Contracts, Leases and Agreements	Agreements	Agreement LPA Acquisition
MOA or MOU	3	13.11.9	Right of Way	ROW Acquisition Project Files	Negotiation

Table 18. Sample Project Documents Mapped to FileNet Document Types (Continued).

Negotiator's certificate	3	13.11.9	Right of Way	ROW Acquisition Project Files	Negotiation
Negotiator's report	11	13.11.9	Right of Way	ROW Acquisition Project Files	Negotiation
Ordinance	1	N/A			
Parcel plat	12	13.11.10	Right of Way	ROW Acquisition Project Files	Property Description or Plat
Payment request form	4	13.11.2	Right of Way	ROW Acquisition Project Files	Appraisal
Property description	20	13.11.10	Right of Way	ROW Acquisition Project Files	Property Description or Plat
Purchase offer	1	13.11.9	Right of Way	ROW Acquisition Project Files	Negotiation
Quitclaim deed	1	13.11.4	Right of Way	ROW Acquisition Project Files	Conveyance or Title
Railroad deed without warranty	1	N/A			
Railroad exchange agreement	1	N/A			
Relocation informational notice	1	13.11.12	Right of Way	ROW Acquisition Project Files	Relocation
ROW map	17	13.12.1	Right of Way	ROW Map	Map
ROW survey	4	13.11.10	Right of Way	ROW Acquisition Project Files	Property Description or Plat
Standard TxDOT deed	6	13.11.4	Right of Way	ROW Acquisition Project Files	Conveyance or Title
Tabulation of values	3	13.11.2	Right of Way	ROW Acquisition Project Files	Appraisal
Title commitment	5	13.11.4	Right of Way	ROW Acquisition Project Files	Conveyance or Title
Title company closing statement	2	13.11.4	Right of Way	ROW Acquisition Project Files	Conveyance or Title
Title company payment	1	6.2.10	Finance	Billings and Payments	Payment
Title company payment billing statement	1	13.11.4	Right of Way	ROW Acquisition Project Files	Conveyance or Title
Title company payment closing statement	1	13.11.4	Right of Way	ROW Acquisition Project Files	Conveyance or Title
Title insurance policy	3	13.11.4	Right of Way	ROW Acquisition Project Files	Conveyance or Title

INTEGRATING SPATIAL DOCUMENT DATA IN THE DATABASE

It is possible to overlay a range of right of way real property documents in a GIS environment, such as aerial photography, as-built plans, parcel plats, right of way maps, and right of way surveys. In general, there are two types of spatial documents: documents that contain all the necessary data (either embedded in the file or stored in a companion file) and are, therefore, geo-referenced; and documents for which the spatial data component is missing, incomplete, or incorrect, and it becomes necessary to apply a procedure to geo-reference the files.

Displaying several spatial documents, e.g., large aerial photographs, as well as maps, plats, surveys, and schematics in PDF, in a GIS environment can degrade interface performance because of the time it takes to render the images on the screen. In addition, overlaying many spatial documents at once can be confusing to users. To address these issues, the researchers generated geo-referenced outlines that represented the spatial boundaries of those documents and provided links to enable users to access the documents on an as-needed basis. In general, the

procedure to generate the spatial outlines was to geo-reference the documents first and then extract the corresponding spatial boundaries.

Geo-referencing Spatial Documents

As part of another research project, the researchers already had geo-referenced right of way and easement lines in MicroStation format as well as letting plans in TIF format for the Spur 66 project in the San Antonio area (*82*). All the geo-referenced documents were in State Plane Texas coordinates (South Central). For CAD documents in "surface" coordinates, it was necessary to apply a scale transformation using a combined adjustment factor (CAF) (*15*). Because the actual CAF value for the San Antonio project was not available, the researchers calculated a CAF value (*15*). The resulting CAF value was 0.99983610. During implementation, analysts will need to rely on actual project-specific CAF values provided by district surveyors.

To apply the transformation using the CAF values, the researchers created companion world files with the same name as the corresponding files processed, except the world files had a .wld extension. Each world file contained the following information (*82*):

$X_{1a},Y_{1a}\ X_{1b},Y_{1b}$
$X_{2a},Y_{2a}\ X_{2b},Y_{2b}$

where

X_{1a},Y_{1a} = point No. 1 coordinates ("surface"),
X_{1b},Y_{1b} = point No. 1 coordinates ("ellipsoid"),
X_{2a},Y_{1a} = point No. 2 coordinates ("surface"), and
X_{2b},Y_{2b} = point No. 2 coordinates ("ellipsoid").

The researchers normalized the process by creating generic world files that contained the following information:

0,0 0,0
1,1 <CAF>,<CAF>

There were also datasets, e.g., the right of way maps in TIF format available through the Right of Way Map Locator system (*40*), which did not have a defined coordinate system or adequate control points with which to conduct an accurate transformation. To geo-reference these documents, the researchers relied on a number of procedures depending on the information available. For example, in San Antonio, the researchers first assigned existing world files from geo-referenced raster documents to the "unregistered" documents to provide a first approximation regarding the general position of the documents. Then, the researchers used a standard geo-referencing tool in ArcGIS to translate, scale, rotate, and/or "rubbersheet" raster documents to their correct location. A combination of 6-inch resolution orthophotography (available through Bexar Metro 911), parcel features from the Bexar County Appraisal District, and MicroStation CAD drawings provided additional references to determine approximate control point locations with which to apply the transformation.

Extracting Spatial Document Outlines

The extent of a spatial document is a property that defines the limits of a spatial document as a rectangular box that uses maximum and minimum *x* and *y* coordinates (Figure 33). While adequate in some situations, using the extent to define the document outline can easily misrepresent the actual contents of the document, particularly in situations where the general spatial orientation of the document is not in the north-south or east-west direction. ArcGIS does not have a standard tool to generate outlines from both vector and raster feature classes. For this research, the researchers traced the boundaries of geo-referenced TIF documents. As part of a related project, the researchers developed a script in ESRI ModelBuilder™ to automate the extraction of spatial document outlines (*82*).

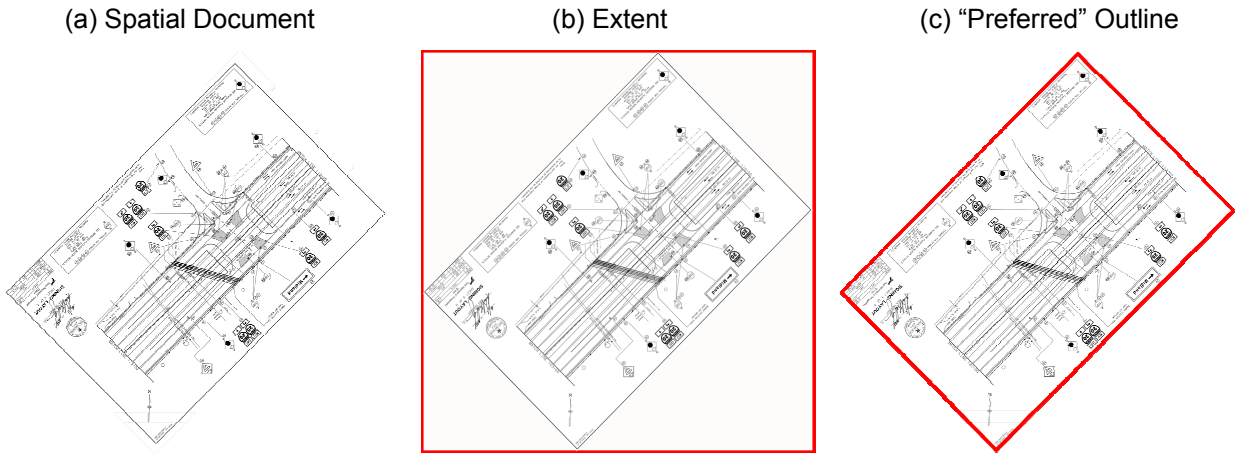


Figure 33. Geo-referenced Spatial Document with Extent and "Preferred" Outline.

The researchers geo-referenced raster documents and stored spatial outlines for each document in the DCMNT_POLY geodatabase feature table. The researchers also updated the DCMNT_OUTLN_FLG attribute in the DCMNT table for these raster documents.

CREATING FEATURE DATA IN THE DATABASE

Asset Features

The next step was to generate records for several right of way–related asset feature tables. To ensure consistency in the process, the researchers used the following general rules:

- Polygon feature boundaries must close. This rule already applies by default when creating polygon features in a GIS environment (i.e., the feature editor always closes polygons when creating polygons from scratch). The issue becomes important when importing graphics that represent polygons from other applications such as MicroStation.

- Adjacent parcels must have coincident boundaries, with no overlaps or gaps.

- Right of way lines and access right lines must match the alignment of parcel boundary lines that abut the right of way.

- Right of way lines should be as continuous as possible, except where breaks are necessary, resulting in additional features in the right of way feature table (without leaving overlaps or gaps between adjacent right of way line segments). Figure 34 shows a few sample cases. In general, it is necessary to break right of way lines in the following cases:

    - **Intersections that involve two state roads**. The simplest case is where there are no cutbacks. In this case, the corner of the intersection defines the break point for the right of way line. When the intersection of two state roads results in cutbacks (e.g., 45 degree lines at intersection corners), the right of way line features are broken in such a way that the cutbacks are assigned to the roadway where the most recent right of way acquisition took place.

    - **Right of way acquisitions**. In order to populate the "to date" field in the feature table, it is necessary to break the right of way line at locations where the state acquires land and becomes the owner on both sides of a right of way line segment (effectively "absorbing" the old right of way line).

  It is not strictly necessary to break right of way lines at driveways or at intersections between a state road and a local or county road.

- Access right lines are only depicted at locations where TxDOT denies access to the state right of way, either by purchasing the access right or by invoking police powers.

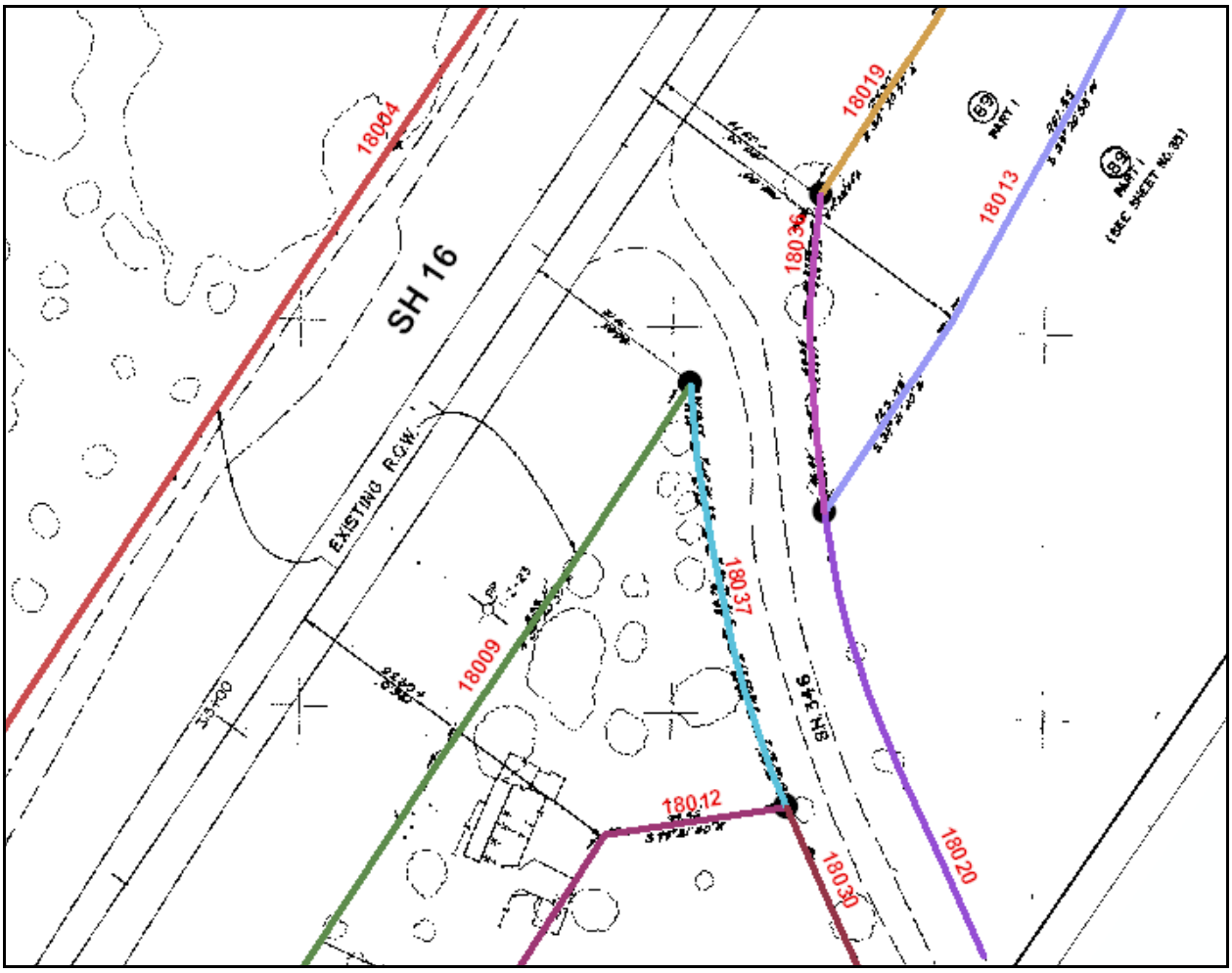


Figure 34. Right of Way Line Break Points (SH 16 and SH 346 in Bexar County).

San Antonio

For the San Antonio sample project area, scanned right of way maps, aerial imagery, and MicroStation CAD files were available to generate asset feature records. The procedure to generate asset feature records for this sample project area included the following activities:

- Geo-reference the scanned right of way maps using a combination of aerial imagery and CAD files. Older right of way maps along SH 16 included identifiable features outside the proposed right of way, such as houses, barns, and local roads, which helped in geo-referencing the right of way maps. Unfortunately, newer right of way maps (i.e., those on Spur 66) did not include identifiable features outside the proposed right of way and, therefore, were more difficult to geo-reference.

- Using the geo-referenced right of way maps and CAD files, heads-up digitize parcel and easement features, snapping to CAD file right of way lines and nodes along Spur 66 and the intersection of Spur 66 and SH 16.

- Generate polygon water and mineral right features from parcel features. In the absence of additional information, the researchers assumed natural resource right boundaries to be the same as the corresponding parcel boundaries.

- Generate additional features such as easements and access right lines.

- Populate non-spatial attributes of right of way asset features.

Odessa and Beaumont

For the Odessa and Beaumont sample project areas, survey plats in TIF format and metes and bounds descriptions were available. The procedure to generate asset feature records for these sample project areas included the following activities:

- Geo-reference the available survey plats using a combination of aerial imagery and parcel layer data. Having at least two reference control points with coordinates would simplify and increase the accuracy of the geo-referencing process.

- Generate individual parcel and easement features from the metes and bounds descriptions by using bearing and distance calls. This process resulted in polygon features that were correct with respect to size and shape, but not accurately geo-referenced.

- Align individual parcel and easement features. For both sample project areas, the researchers rotated and moved parcel features to align with the aerial imagery and the geo-referenced survey plats. For the Beaumont sample project area, the researchers rotated and scaled a parcel that had a CAF value and mapping angle in the metes and bounds description. The researchers also used a commencing point on the geo-referenced survey plat to provide a first approximation for the correct location of the parcel. The process also involved adjusting the geo-reference of the survey plat given the relatively low resolution and accuracy of the aerial imagery used in the process (Figure 35).

- Generate polygon water and mineral right features from parcel features. In the absence of additional information, the researchers assumed natural resource right boundaries to be the same as the corresponding parcel boundaries.

- Generate linear features such as right of way and access right lines from parcel features, in addition to heads-up digitizing over gaps and intersections between parcels.

- Populate non-spatial attributes of asset features.

Figure 35. Geo-referenced Parcel and Survey Plat for the Beaumont Sample Project Area.

Feature Metadata

In addition to populating feature tables for the right of way asset data model, the researchers documented those datasets. As described in Chapter 2, a component of the data design process is a data dictionary that includes entity and attribute definitions (for logical data models) or table and field definitions (for physical data models) (*31*). Unfortunately, this requirement does not address specific metadata requirements for spatial data (e.g., coordinate systems, boundary extents, lineage, and accuracy). To address this issue, the researchers developed metadata documents for all feature entities in the right of way asset data model using the *Content Standard for Digital Geospatial Metadata* (CSDGM) (*55*). In addition to basic definitions, CSDGM covers aspects of metadata such as identification, data quality, spatial data organization, spatial reference, entity and attribute information, distribution, and metadata reference.

To create metadata documents, the researchers used ESRI ArcCatalog™, which includes a CSDGM-compliant metadata editor. The researchers populated the metadata documents using a

combination of entity and attribute definitions from the right of way asset model, ERwin logical model file, custom text specific for this research (e.g., contact information), and automated information populated through ArcCatalog tools (e.g., coordinate system). Figure 36 shows a view of the metadata document for the PARCEL feature entity in FGDC format.

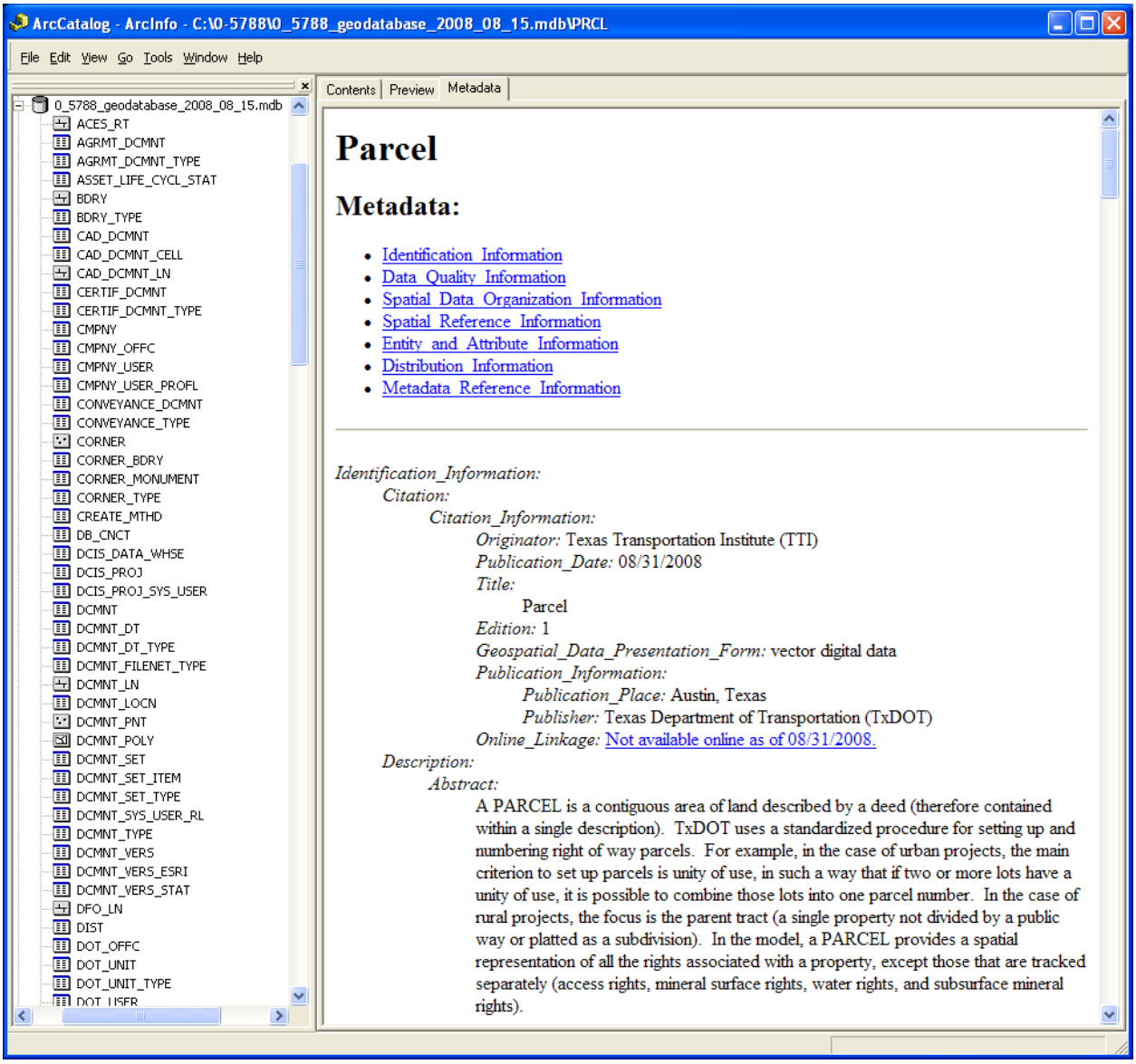


Figure 36. ArcGIS Metadata View.

Disclaimer Text

The *Manual of Practice for Land Surveying in the State of Texas* (*46*) makes a distinction between survey products and mapping products in relation to the use of GIS/LIS for surveying applications. According to the manual, a GIS/LIS survey product is "a map, plat, report or other representation, which may include geodetic control data and/or other data, which would appear

to the general public as being authoritative as to the actual location of property boundaries and/or other property rights and interests, or the relative location of man-made objects or natural features, of which the use of or reliance upon could potentially affect the health, safety or welfare of the general public." A survey product must be transmitted to the client in a hardcopy plot and must contain an original signature and seal. The manual indicates that the product may also be provided to the client in an appropriate digital format. The survey product must also include metadata and the following certification:

> I, , a Registered Professional Land Surveyor in the State of Texas, do hereby certify to the following layers or themes included in this work product: , that this product represents the results of a (boundary or geodetic) survey performed under my direct supervision and meets the minimum requirements of an on-the-ground survey as promulgated by the Texas Board of Professional Land Surveying.

According to the manual, a mapping product is "a map, schematic, report or other geospatial representation prepared and provided for public availability, conforming to a published standard, for the purpose of depicting the general location of man-made objects, natural features or areas depicting unique classifications." A mapping product usually includes a map, a schematic, or other geospatial representation, and may be transmitted to the client in a hardcopy plot and/or appropriate digital format. A mapping product must also include metadata and the following disclaimer:

> This product is a graphic representation of the data shown hereon. It does not represent an on-the-ground survey; is not a Survey Product and only represents the approximate relative location of property boundaries and/or natural and man-made features. This product does not conform to a Class A, GIS/LIS Survey Product as defined in Category 10 of the TSPS Manual of Practice and shall not be relied upon for uses which could affect the health, safety or welfare of the general public.

A common characteristic of the certification and disclaimer texts above is that their use is primarily intended as a label on a printed product, which corresponds to the traditional delivery method of survey and mapping products. The manual highlights that electronic delivery is also acceptable, but it does not provide guidance on how to add the label to the electronic product. In the case of CAD applications, adding the label is straightforward, and the only challenge a practitioner needs to address is what level, layer, and text style and font to use. Once the label is part of the CAD drawing, the label becomes an integral component of the information product being assembled. In other words, from a content perspective, the label becomes a descriptor of the drawing just like other graphical elements in the CAD drawing.

In the case of GIS applications, as long as the mapping product is limited to the production of standalone maps (in paper or digital format, e.g., PDF of tiled image), a label containing a certification or disclaimer text becomes a map descriptor. For all intents and purposes, it is the same as if the label had been added to a CAD drawing. The difficulty arises when GIS applications are used in an interactive fashion that involves access to a database that enables selective filtering, querying, displaying, and feature extraction. In this case, there is no certainty that the label might be always associated with whatever features are displayed on the screen and/or extracted from the database.

To address this situation, it would be necessary to add certifications or disclaimer texts at several levels, including the following:

- **Feature level**. The certification or disclaimer text would be added as an attribute value associated with each feature in the geodatabase. Presumably, if the location data of a feature changes, say from "non-survey" level to "survey" level, the attribute value would be updated to reflect the new status. The standard disclaimer text would be appropriate. However, the standard certification text would not be appropriate because it includes references to layers and themes (which do not apply in the case of individual features).

- **Metadata level**. The certification or disclaimer text would be included in an appropriate tag in the standard metadata file that accompanies each feature class in the geodatabase. Either standard certification text or disclaimer text would be appropriate, as long as every feature in the feature class belongs to the same level ("survey" level or "non-survey" level). A consistency issue appears in the case where some features in the feature class are at a "survey" level while other features in the same feature class are at a "non-survey" level.

- **Standalone map (in paper or digital form, e.g., PDF or tiled image).** The certification or disclaimer text would be added as a label that is always displayed with the product. Either standard certification text or disclaimer text would be appropriate, as long as every feature in the feature class belongs to the same level ("survey" level or "non-survey" level).

Taking into consideration the needs associated with these levels, the researchers recommend using the standard disclaimer text included in the TSPS manual without any changes. The researchers also recommend using a modified version of the standard certification text that would be appropriate for all three levels, as follows:

> I, <first and last names>, a Registered Professional Land Surveyor in the State of Texas, do hereby certify that this product represents the results of a (boundary or geodetic) survey performed under my direct supervision and meets the minimum requirements of an on-the-ground survey as promulgated by the Texas Board of Professional Land Surveying.

The proposed change essentially deletes the reference to layers or themes included in the work product.

TSPS is proposing a bill to the Texas Legislature, which would amend Chapter 552 of the Government Code by adding Section 552.013, to require the following disclosure in relation to mapping products:

> A governmental body which provides geographic information systems/mapping products to the public that appear to represent property boundaries, such as appraisal district maps, shall also provide the following disclosure: "This product is a graphic representation of the data shown hereon. It does not represent an on-the-ground survey and only represents the approximate relative location of property boundaries and/or natural and man-made features. The product shall not be relied upon for uses which could affect the health, safety or welfare of the general public."

The researchers' opinion is that this proposed text does not offer any significant advantage compared to the standard disclaimer text mentioned previously.

INTEGRATING USER DATA IN THE DATABASE

For the right of way asset data model, the researchers identified users or parties, along with the role each user or party plays on specific features or documents (Table 19). In general, the sample project documents provided basic information, such as names, titles, affiliated company names, and company addresses for users. However, other information (e.g., phone/fax numbers, email addresses, and TxDOT addresses) was missing from these documents. For missing information, the researchers either left the fields blank or used TxDOT district/division office addresses for TxDOT district/division users. For the right of way asset data model, based on the definition of the COMPANY entity, the researchers considered TxDOT a company and created a record for TxDOT in the CMPNY table.

Table 19. Right of Way Asset Data Model User Property Role Types.

User Role Types			
Giving	**Receiving**	**Other**	
Addressor	Addressee	Appraiser	SUE Provider
Condemnor	Condemnee	Lienholder	Surveyor
Grantor	Grantee	LPA Party	System Administrator
Lessor	Lessee	MOA Party	Underwriter Agent
Payor	Payee	MOU Party	Utility Company
Seller	Buyer	Negotiator	Utility Consultant
		Owner	Utility Contractor
		Project Manager	Utility Coordinator

In the model, documents and features are associated directly with users who represent agencies, companies, or themselves. This presents unique challenges for several legal documents, such as deeds, where one of the parties is an agency, e.g., the State of Texas. To address the issue where one of the parties is the State of Texas, the researchers created a record in the CMPNY table with a company name of "State of Texas" and an associated record in the CMPNY_USER_PROFL table with a title name of "Governor."

LINKING PROJECT, DOCUMENT, FEATURE, AND USER DATA

The last step in the database population effort was the population of the tables that define the following many-to-many relationships:

- **Between system users, roles, documents, and features, i.e., DCMNT_SYS_USER_RL and FEAT_SYS_USER_RL.** The researchers populated the DCMNT_SYS_USER_RL table by identifying the System User ID and Property Role ID for each document in the prototype. The researchers also populated the FEAT_SYS_USER_RL table by identifying the System User ID and Property Role ID

for each asset feature in the prototype. For these features, the researchers assigned the State of Texas as Grantors since the State of Texas has ownership.

- **Between projects, documents, and features, i.e., PROJ_DCMNT, PROJ_FEAT, and FEAT_DCMNT.** In general, the process involved adding records to the main anchor tables first (i.e., PROJ, DCMNT, and FEAT) and then running SQL scripts to extract relevant data and populate PROJ_DCMNT, PROJ_FEAT, and FEAT_DCMNT.

ACCESS TESTING ENVIRONMENT

As mentioned previously, Access testing involved the development of a number of queries and forms to test items such as database design and compliance with database integrity constraints. For illustration purposes, this section describes three main forms that document interrelationships among features, parcels, and projects by using queries, forms, and subforms. (Note: A separate research product, Product 0-5788-P1, includes the actual forms and queries in Access format.) While the forms are simple and basic, it is quite likely that any implementation that uses the tables involved will need queries and forms similar (in structure, if not in appearance) to those discussed in this section.

Feature Information

Figure 37 shows a form that lists features as well as documents and project data associated with a feature. This form is composed of a main form that shows basic feature data and two subforms that list feature documents and feature projects, respectively. Data for the forms come from the following queries:

- **Feature Information**. This query retrieves data associated with a feature.

- **Feature Documents**. This query retrieves document versions associated with each feature.

- **Project Features**. This query retrieves features associated with a project.

The form includes a hyperlink attribute (i.e., Version Address) that enables opening and viewing documents in their native applications and/or a suitable viewer.

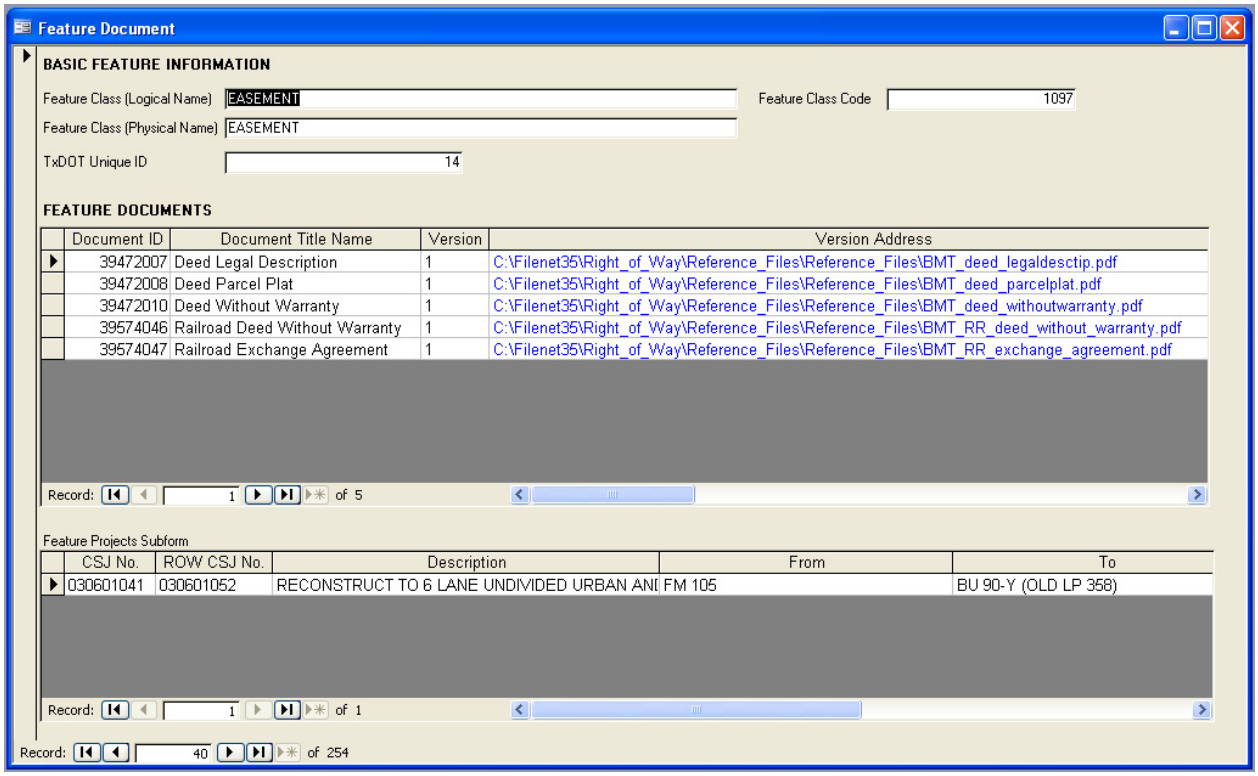


Figure 37. Feature Information Form.

Parcel Information

Figure 38 shows a form that lists parcels as well as documents and project data associated with a parcel. This form is composed of a main form that shows basic parcel data and two subforms that list parcel documents and parcel projects, respectively. Data for the forms come from the following queries:

- **Parcel Information**. This query retrieves data associated with a parcel.
- **Parcel Documents**. This query retrieves documents and document versions associated with a parcel.
- **Parcel Projects**. This query retrieves projects associated with a parcel.

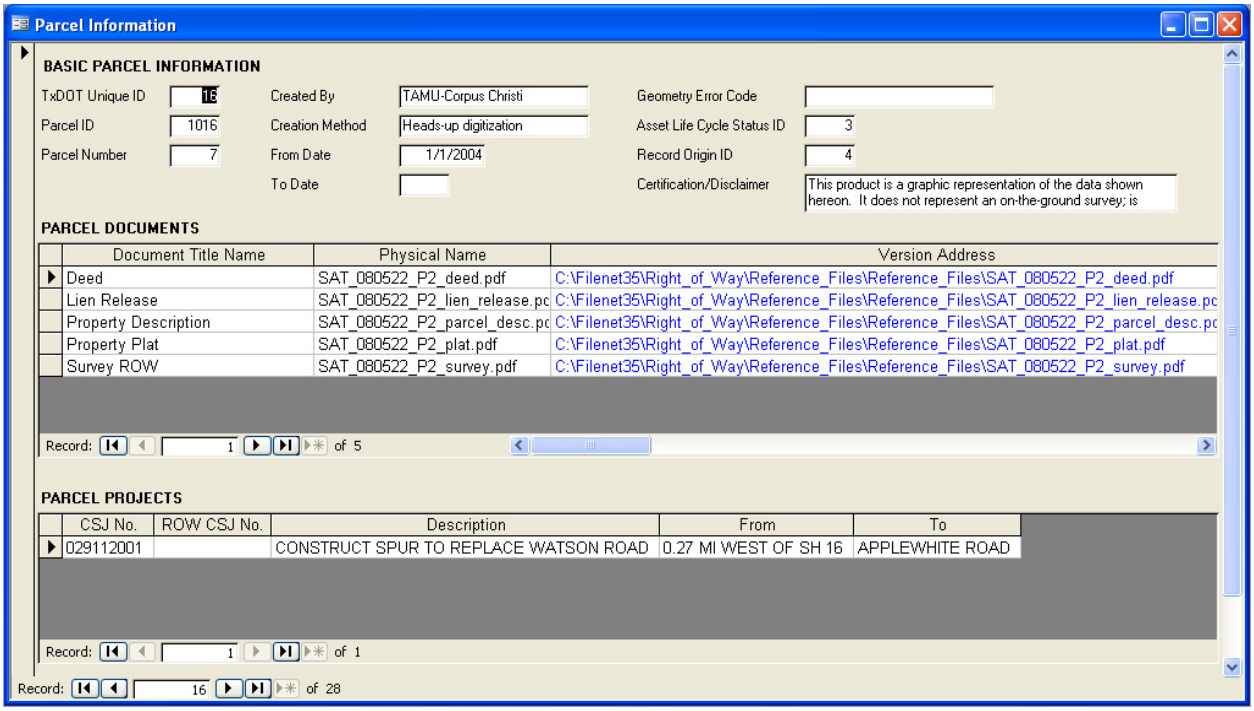


Figure 38. Parcel Information Form.

Project Information

Figure 39 shows a form that lists projects as well as features and documents associated with a project. This form is composed of a main form that shows basic project data and two subforms that list project features and project documents, respectively. Data for the forms come from the following queries:

- **Project Information**. This query retrieves data associated with a project.
- **Project Features**. This query retrieves features associated with a project.
- **Project Documents**. This query retrieves documents and document versions associated with a project.

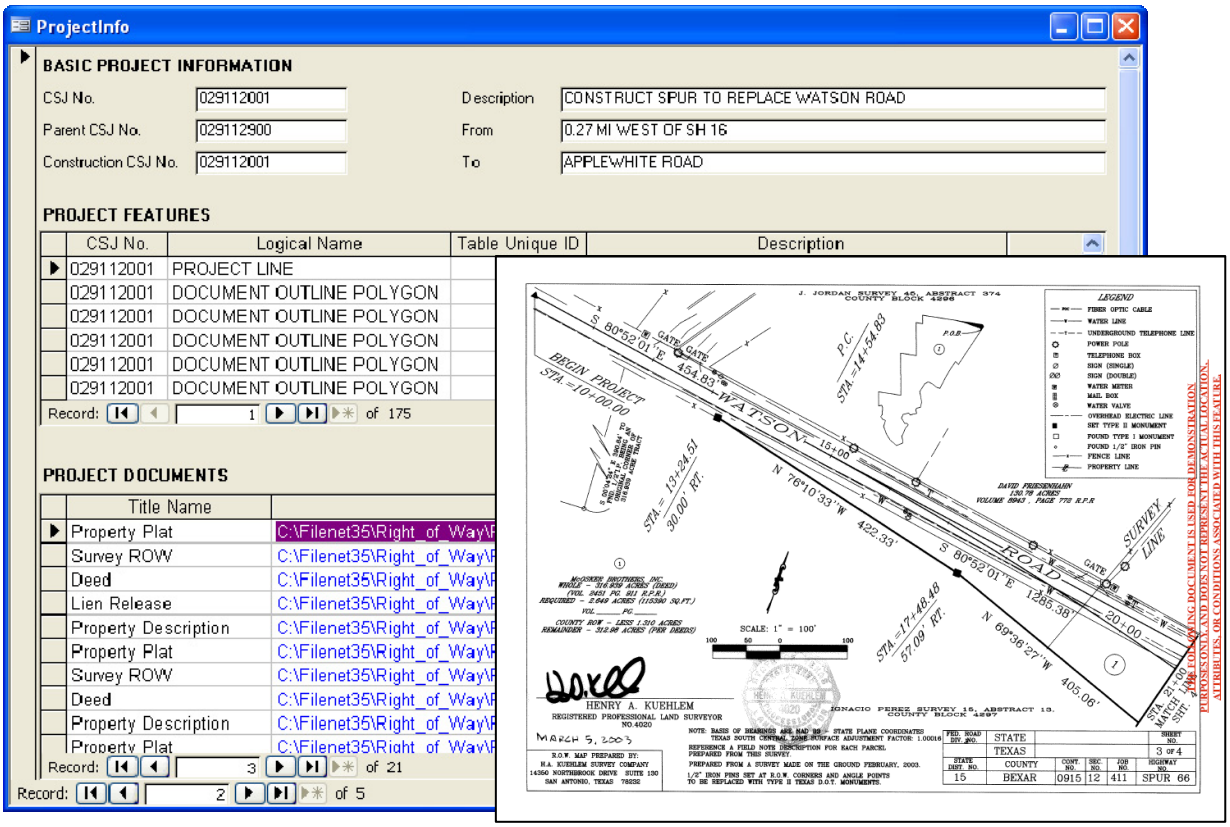


Figure 39. Project Information Form.

ARCGIS TESTING ENVIRONMENT

While the purpose of the Access testing environment was to test non-spatial relationships, the purpose of the ArcGIS testing environment was to test spatial relationships in an offline, portable environment. ArcGIS testing involved developing "joins" between GIS feature classes and non-spatial tables such as DCIS_PROJ, PROJ_DCMNT, and DCMNT_VERS in order to retrieve project and document data when querying features using the GIS user interface.

Without extensions, custom code, or the use of ESRI relationship classes, ArcGIS has limited table-joining capabilities. When joining tables, ArcGIS appends the fields of one table to those of another through their common field. If the common field of one table has duplicate values, the join function appends the attribute values of the first matching record. Because the purpose of the ArcGIS testing environment was to retrieve project and document data when selecting a feature using the GIS interface, for simplicity, the researchers joined feature-specific pre-joined tables to feature class tables. Specifically, for each feature class, the researchers created joins with the DCIS_PROJ, PROJ_DCMNT, and DCMNT_VERS tables.

Figure 40 shows a view of the ArcGIS testing environment. For readability, the name associated with each layer added to the interface is the same as the feature class logical name. Using the Identify tool to query a feature opens a separate window that shows all the attribute values associated with that feature along with attribute values associated with any joined table. For

example, Figure 40 shows the result of querying the SH 16 project line. The DCMNT_VERS_LOC_ADDR field is a hyperlink that enables opening and viewing documents in their native applications and/or a suitable viewer on the client computer. Because of the limitations of the join function in ArcGIS, as described above, the query only produced one document associated with the SH 16 project line record. To retrieve all the documents associated with that project using the GIS interface, it would be necessary to write code to customize the Identify tool and/or use ESRI relationship class constructs.

For simplicity, the prototype included a few critical feature classes. In practice, it is possible to add many layers to the map. Examples include feature classes in the geodatabase, physical files stored locally or on a network drive (e.g., ESRI ArcView™ shape files, MicroStation or Autodesk AutoCAD® CAD files, aerial imagery, and other geo-referenced files), and layers available through web-based map services (e.g., ArcIMS or ESRI ArcGIS Server™) that provide live access to spatial data stored at remote locations. As an illustration, Figure 40 shows a local copy of the Original Texas Land Survey layer (*83*) as well as zoning and parcel layers available through a live connection to an ArcIMS-based web mapping service (WMS) from the City of San Antonio (*84*). A sample of websites that support WMS is available elsewhere (*85*). Additional information about WMS, as well as other related OpenGIS® standards, specifications, and initiatives, is available on the Open Geospatial Consortium (OGC) website (*86*).

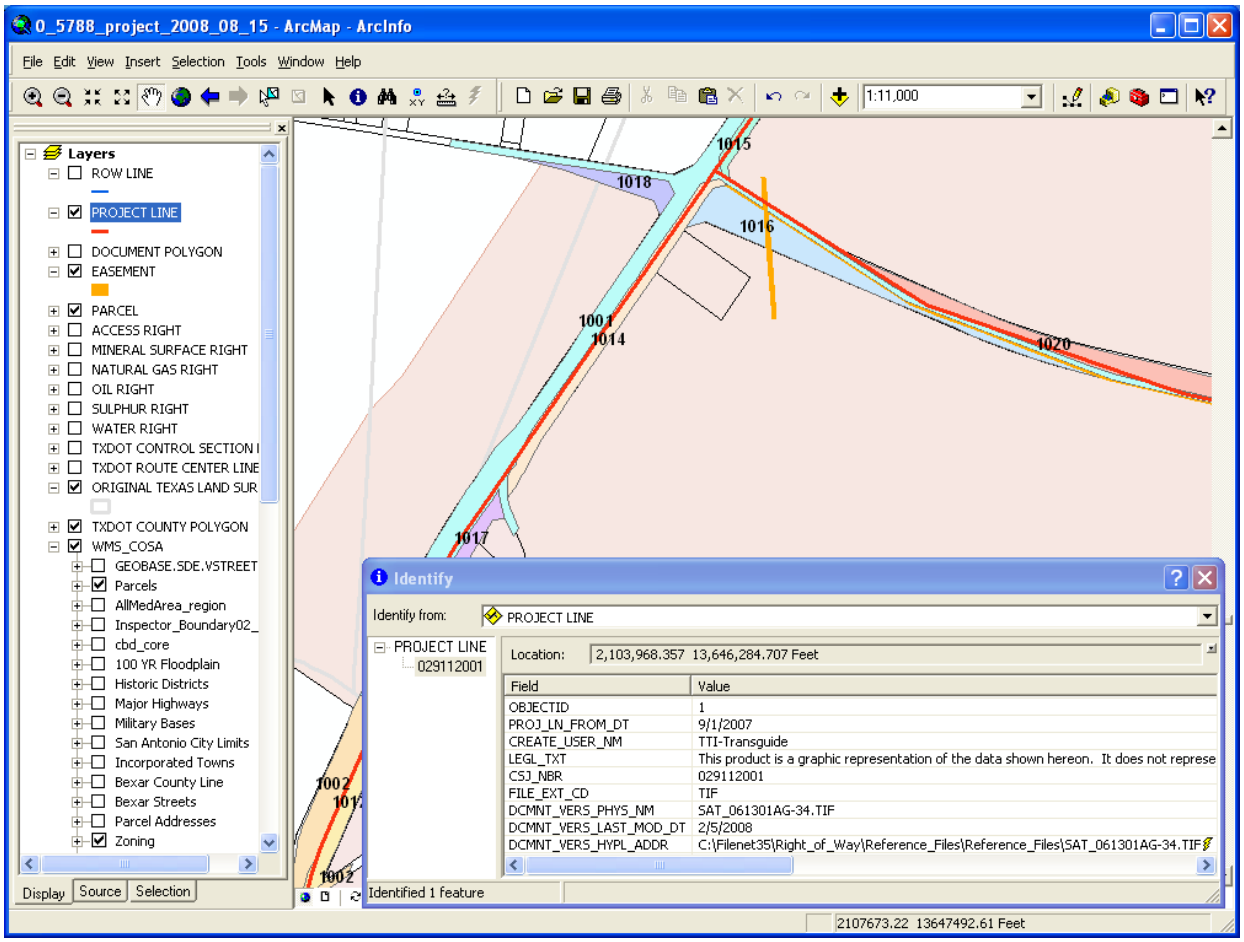


Figure 40. ArcGIS Testing Environment View.

INTERNET EXPLORER TESTING ENVIRONMENT

Internet Explorer testing involved the development of a customized web application that enables the retrieval of feature- and project-related documents using tabular and/or map views based on a number of queries, including those described in the previous section. To the extent possible, the web application used web forms and source code the researchers had already developed for other TxDOT research projects (*82*). In some cases, it was necessary to develop and/or customize forms and functions. However, the level of customization was kept to a minimum.

The web application includes an interactive mapping component (Figure 41), which provides a navigable map that enables users to identify and query features. For example, Figure 41 shows the project line for the sample project in San Antonio (in red). Selecting the Identify tool and highlighting a project line feature opens a window that displays project data for all the projects located near the point selected (Figure 42). Selecting the View Project Documents tool in Figure 42 displays an expandable list of document folders that follows the FileNet file structure and a list of documents within each folder for the selected project (Figure 43). Clicking a document name enables opening and viewing of the document in its native application and/or a suitable viewer on the client computer. As needed, the interface also displays clickable document versions. Clicking the metadata icon opens a window that displays basic information associated with a document (Figure 44).

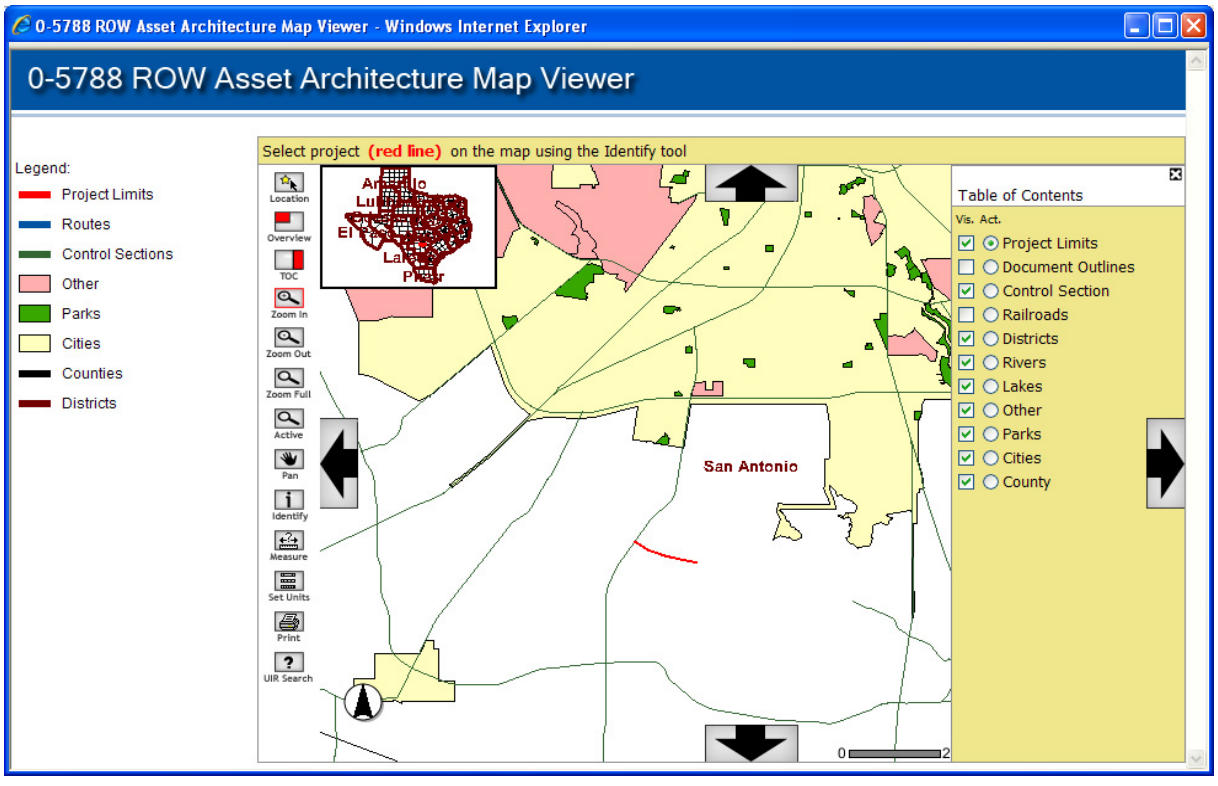


Figure 41. Interactive Map Viewer.

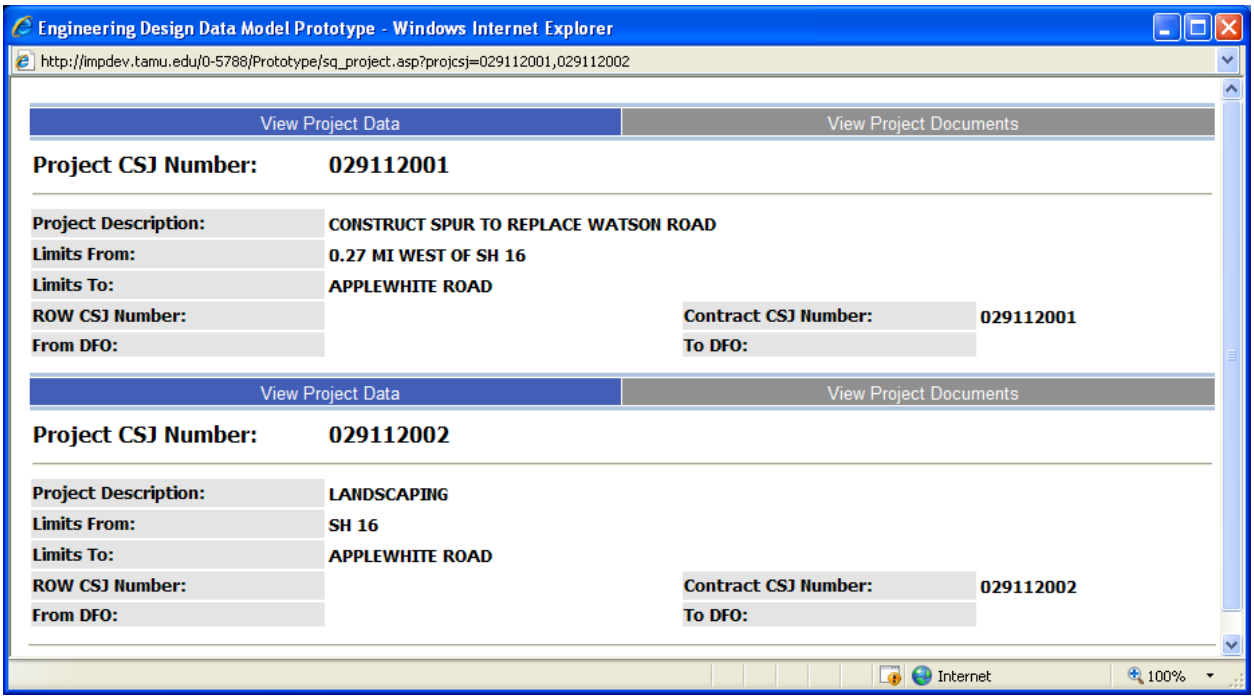


Figure 42. Interactive Map Viewer – Project Feature Query Results.

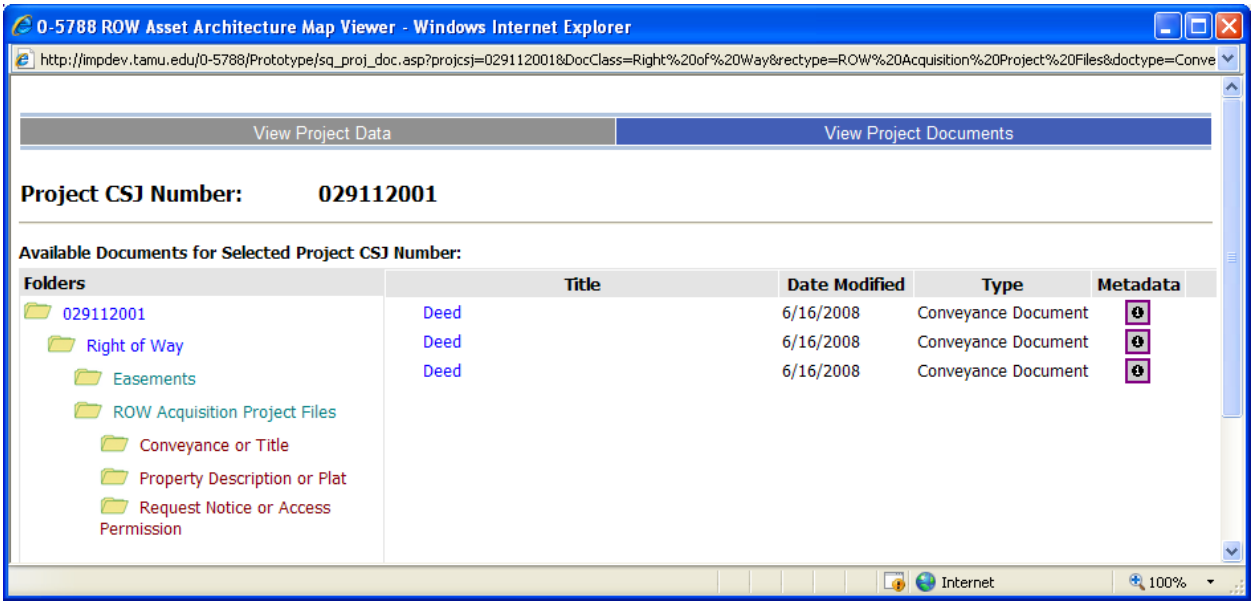


Figure 43. Interactive Map Viewer – Project Document View.

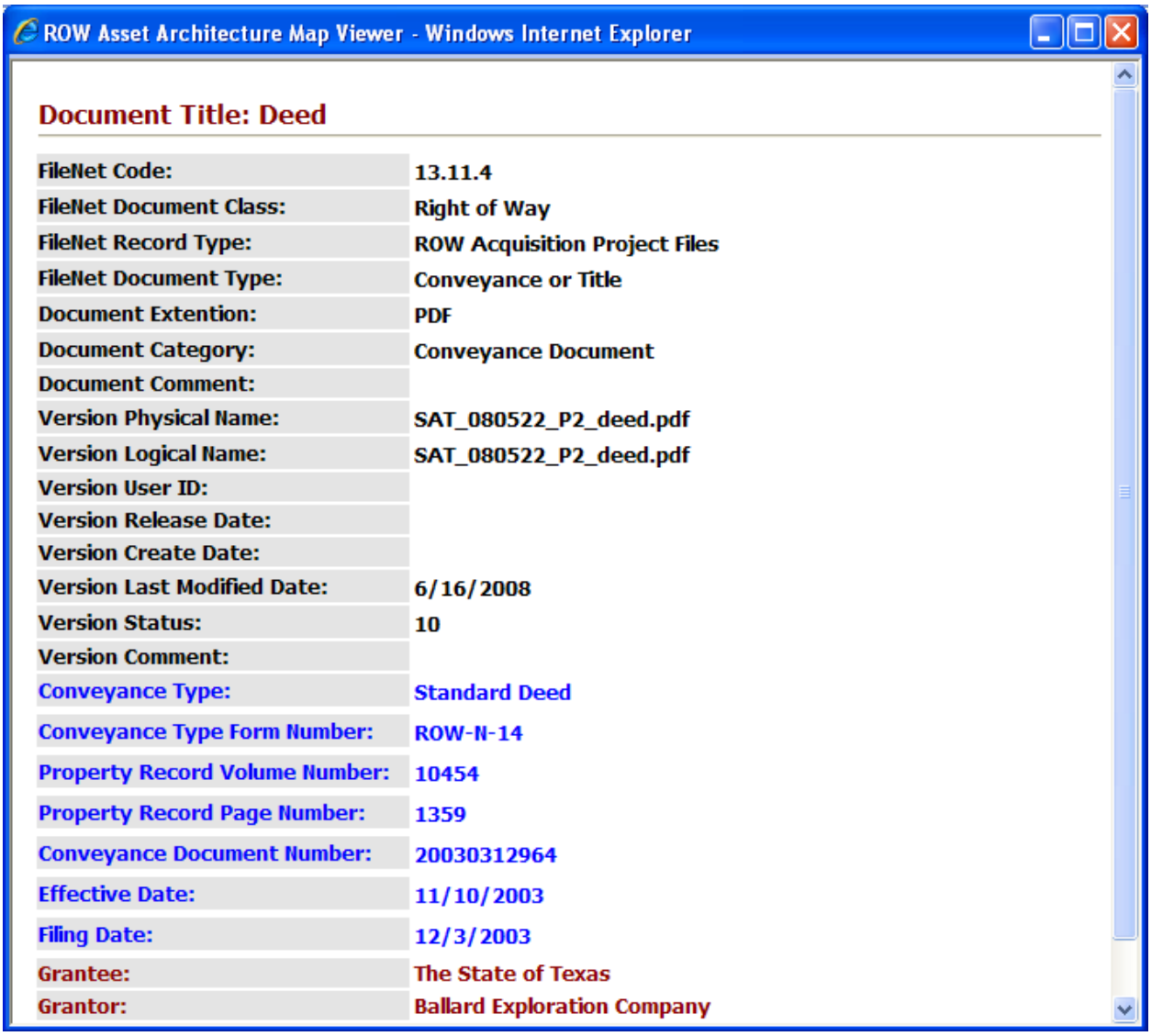


Figure 44. Interactive Map Viewer – Project Document Metadata View.

The interactive map viewer also includes a variety of document outlines and real property–related asset features. For example, Figure 45 shows document outlines (mainly right of way map outlines) for the San Antonio project area. Figure 46 includes a zoomed-in view that shows parcels, easements, and right of way lines for the same project. In general, selecting the Identify tool and highlighting a feature opens a window that displays attribute data and metadata associated with that feature.

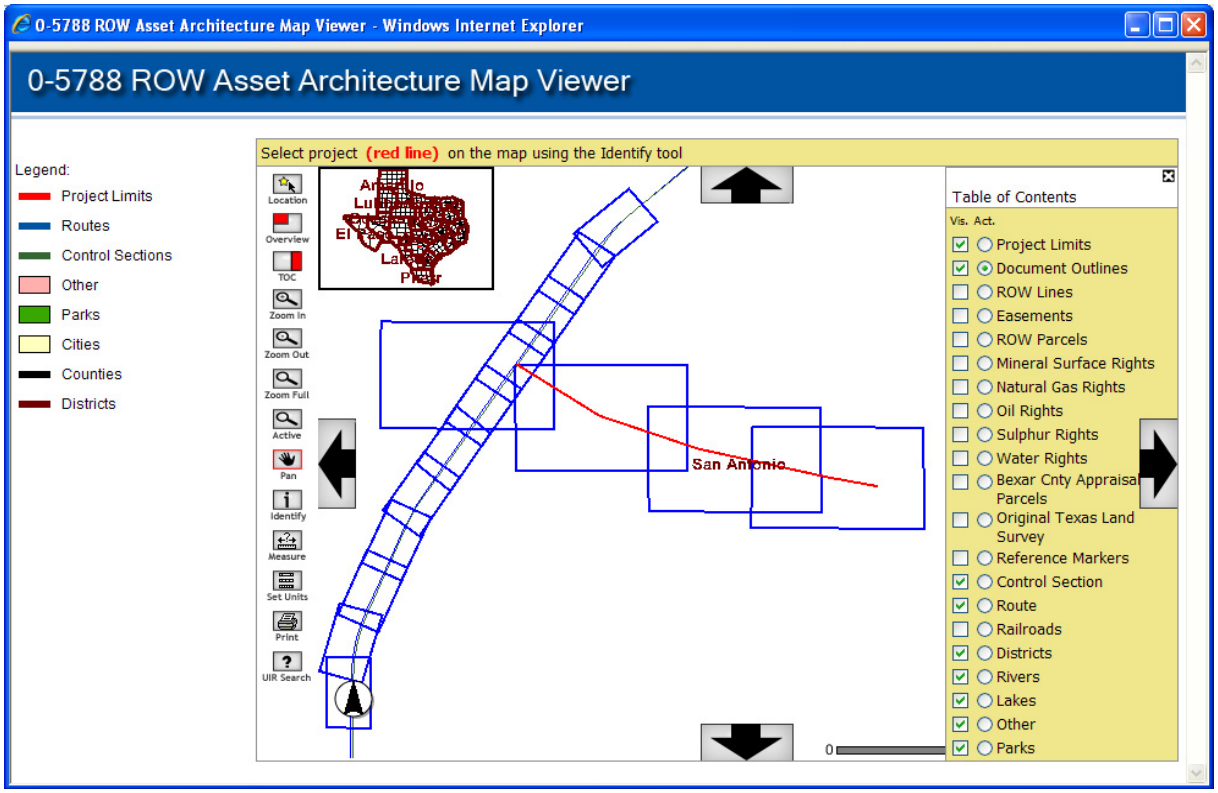


Figure 45. Interactive Map Viewer – Document Outline View.

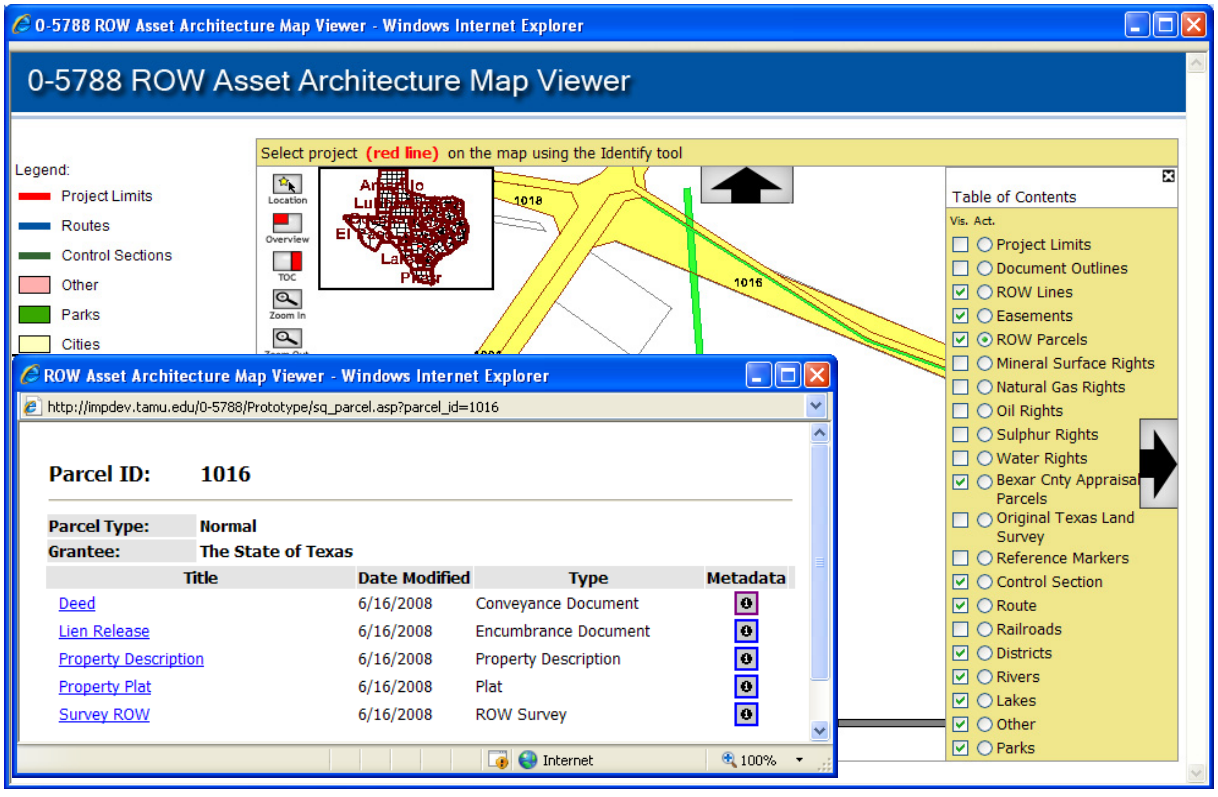


Figure 46. Interactive Map Viewer – Parcel Document View.

RIGHT OF WAY DOCUMENT FILENET STRUCTURE ANALYSIS

As mentioned previously, the researchers used the current EDTIS content services library standards (*28*) to characterize sample documents. There were several cases where mapping individual files to the FileNet file structure was not straightforward or possible (Table 18), as follows:

- **Multiple matching**. In this case, a single document could potentially match multiple FileNet document types. During implementation, this type of problem could result in document-mapping errors.

- **Matching not intuitively clear**. In this case, the correspondence between the document and FileNet document type was not necessarily straightforward or intuitively clear, which during implementation could result in confusion and/or mapping errors.

- **No matches**. In this case, it was not possible to match the document to any FileNet document type.

In an effort to understand the problem, the researchers evaluated the FileNet Right of Way document class in more detail. Table 20 shows all the document types associated with each record type in the Right of Way document class.

Table 20. Right of Way FileNet Document Type versus Record Type Matrix.

Current Right of Way FileNet Document Types	Current Right of Way FileNet Record Types																		
	Certifications	Easements	Eminent Domain Litigation	Encroachments	Inverse Condemnation	Junkyard	Municipal Sign Oversight	Non-ROW Acquisition	Property Management and Disposal	Reference Files	ROW Acquisition Project Files	ROW Map	ROW Releases	Sign Inventory	Sign Permit Activity Reports	Sign Permit Files	Sign Reimbursements Relocations	Utility Accommodation	Working Papers
User Defined										X									X
Abstract			X		X														
Adjustment																		X	
Advertisement									X										
Affidavit			X		X						X							X	
Annual Review							X												
Appeal			X		X														
Appraisal								X			X								
Appraiser Evaluation											X								
Attorney Certificate			X																
Attorney Certificate City County		X																	
Attorney Certificate State		X																	
Award			X		X														

Table 20. Right of Way FileNet Document Type versus Record Type Matrix (Continued).

Current Right of Way FileNet Document Types	Current Right of Way FileNet Record Types																		
	Certifications	Easements	Eminent Domain Litigation	Encroachments	Inverse Condemnation	Junkyard	Municipal Sign Oversight	Non-ROW Acquisition	Property Management and Disposal	Reference Files	ROW Acquisition Project Files	ROW Map	ROW Releases	Sign Inventory	Sign Permit Activity Reports	Sign Permit Files	Sign Reimbursements Relocations	Utility Accommodation	Working Papers
Bid									X										
Billing Statement Form 132								X											
Blueprint								X											
Bond																X			
Brief			X		X														
Certificate			X		X														
Certification							X												
Checklist			X		X														
Citation			X		X														
Compensable Interest Certificate																		X	
Complaint			X		X														
Compliance Monitoring						X													
Consultant Contract Review																		X	
Conveyance																X			
Conveyance or Title			X	X				X			X								
Copy of Ordinance and Amendments							X												
Correspondence			X	X	X												X	X	
Cost Estimate																		X	
Data Sheet Settlement			X																
Date of Eligibility Request																		X	
Decision			X		X														
Deposition			X		X														
Determination of Eligibility																		X	
Discovery			X		X														
Docket			X		X														
Drainage Easement		X																	
Encroachment	X																		
Enforcement Action						X													
Exhibit			X		X														
Existing Constraints and Structures											X								
Form 1134, Request to Sell Right of Way Improvement Acquired									X										
Form 1135, Photographs									X										
Funding													X					X	
GIWW Dredge Disposal Site								X											
Hearing			X		X														
Illegal Sign Notice																X			
Improvement Removal Plan											X								
Improvement Survey											X								
Inspections						X													
Insurance								X											
Inventory									X										
Layout Schematic or Drawing																		X	

Table 20. Right of Way FileNet Document Type versus Record Type Matrix (Continued).

Current Right of Way FileNet Document Types	Current Right of Way FileNet Record Types																		
	Certifications	Easements	Eminent Domain Litigation	Encroachments	Inverse Condemnation	Junkyard	Municipal Sign Oversight	Non-ROW Acquisition	Property Management and Disposal	Reference Files	ROW Acquisition Project Files	ROW Map	ROW Releases	Sign Inventory	Sign Permit Activity Reports	Sign Permit Files	Sign Reimbursements Relocations	Utility Accommodation	Working Papers
Legal Action Request																X			
Letter of Authority																		X	
Location Map									X										
Map								X			X	X	X						
Meeting Minutes and Notes																		X	
Mineral Interests								X											
Minute Order													X						
Municipal Enforcement Plan							X												
Negotiation								X			X								
Notice			X		X				X										
Notice or Notification																		X	
Offer			X		X			X											
Order			X		X														
Owner Title Policy			X																
Payment													X						
Permit Application																X			
Permit Activity Report															X				
Permit Report																X			
Permit Transfer																X			
Petition			X		X														
Plan																		X	
Property Description and Plat								X					X						
Property Description or Plat									X		X								
Receipt											X								
Registration																X			
Release			X																
Release of Easement		X																	
Relocation	X										X							X	
Removal				X												X			
Removal and Disposal									X										
Report							X												
Request for Easement		X																	
Request Notice or Access Permission											X								
Resolution									X				X						
Right of Way	X																		
ROW Release													X						
Sale				X															
Schematic											X		X						
Screening Plan and Specifications						X													
Settlement			X		X														
Sign Inventory														X					
Specification																		X	
Statement			X		X														

Table 20. Right of Way FileNet Document Type versus Record Type Matrix (Continued).

Current Right of Way FileNet Document Types	Current Right of Way FileNet Record Types																			
	Certifications	Easements	Eminent Domain Litigation	Encroachments	Inverse Condemnation	Junkyard	Municipal Sign Oversight	Non-ROW Acquisition	Property Management and Disposal	Reference Files	ROW Acquisition Project Files	ROW Map	ROW Releases	Sign Inventory	Sign Permit Activity Reports	Sign Permit Files	Sign Reimbursements Relocations	Utility Accommodation	Working Papers
Submission								X	X										
Subpoena			X		X														
SUE Deliverable																		X	
SUE Media Information Form																		X	
Survey																		X	
Tax Appraisal or Statement								X											
Temporary Easement		X																	
Transcript			X		X														
Utility	X																		
Utility Conflict Check																		X	
Utility Coordination																		X	
Utility Easement																		X	
Utility Exception Request																		X	
Utility Standard Sheet																		X	
Violation Notice						X										X			
Waiver of Damages																	X		

An analysis of the document type versus record type matrix yields the following observations:

- **Lack of consistency in record type designations**. Although there is not an "official" document that requires record types to correspond to functional areas at TxDOT, many record types (not just those associated with the Right of Way document class, but other document classes as well) do seem to correspond to functional areas. Examples of record types in Table 20 that describe functional areas include Eminent Domain Litigation, Junkyard, and Property Management and Disposal. However, other record types actually are (or should be) document types, e.g., Certifications, Easements, and ROW Map. The list of document types already includes documents such as certificates, drainage easements, and maps.

- **Redundancy in document types**. There are several examples of document types with very similar meaning. For example, for schematics or plans, the list of potential document types includes Blueprint, Layout Schematic or Drawing, Location Map, Map, Plan, Schematic, and Screening Plan and Specifications. There is not a clear or single reason that explains the apparent redundancy in document types, although it is interesting to note that several document types with similar meaning are associated with different record types, perhaps indicating that different groups were in charge of compiling document types for different record types independently.

- **Lack of document subtypes**. The list of document types does not provide an efficient mechanism for dealing with document subtypes. For example, although there is a document type for drainage easements, the list does not include options for other types of easements, e.g., right of way easement, utility easement, or air easement. One way to deal with document subtypes would be to have several document types starting with the same key word, e.g., Easement, followed by a dash and the corresponding document subtype, e.g., Easement – Drainage, Easement – Right of Way, Easement – Utility, and Easement – Air. Another way, as described previously, would be to list only one document type, e.g., Easement, and add document subtype to the FileNet document attribute structure.

- **Lack of consistent support for right of way forms**. The right of way management process at TxDOT is characterized by the use of multiple standardized forms (the current catalog includes close to 250 right of way forms). The list of document types does not provide a reliable mechanism for mapping all the different right of way forms that TxDOT uses. This lack of mapping increases the chances that documents based on standardized forms might not be properly classified in FileNet.

- **Coordination with other document classes**. The Right of Way document class includes legal documents, e.g., easements and title transfers, but not other legal documents such as leases and agreements. At the same time, the Contracts, Leases, and Agreements document class handles documents such as leases and agreements, but not other legal documents such as easements or licenses (although there is a document type called "License" under the Administrative document class). Strictly speaking, assigning right of way–related documents to document types under different document classes is not a problem *provided* users have access to all the relevant document classes. In practice, access to different document classes may be limited. For example, right of way officials at a district would only have access to documents from the Right of Way document class, but not documents from the Contracts, Leases, and Agreements document class. A solution to this issue would be to add all the necessary document types to the Right of Way document class to avoid having to use document types from other document classes. The downside to this solution is some redundancy in the FileNet database if different groups catalog the same document separately under different document classes.

Developing alternatives for the document type versus record type matrix for right of way documents was outside the scope of this research. Nonetheless, the researchers discussed the issue with TxDOT officials. The preliminary conclusion is that there is a need to develop a new list of record types (more than likely reducing and consolidating the number of options) as well as review and update the list of document types to properly account for the wide range of right of way–related documents at the department. Document type updating options would include adding, deleting (if needed), consolidating, and renaming.

CHAPTER 6. CONCLUSIONS AND RECOMMENDATIONS

SUMMARY OF FINDINGS

TxDOT is responsible for managing 1.1 million acres of land that provide right of way for approximately 80,000 centerline miles of state-maintained roads. Management of the huge right of way asset involves considerable resources and the coordination of numerous business processes. There is an urgent need to develop a right of way asset data architecture to facilitate the inventory and management of TxDOT right of way assets. This architecture would facilitate the identification of current right of way boundaries, tracking of right of way boundary changes, automatic mapping of right of way surveying data to other layers of information such as control section job and route number locations, and complete attribution of right of way assets. It would also simplify the production of reports, including those needed to address financial reporting requirements.

As part of the research, the researchers evaluated current right of way data practices at TxDOT and other agencies, and developed and tested a prototype GIS-based right of way asset data model. The data model included a logical model, a physical model, and data dictionary, following current TxDOT data architecture standards and findings from recent research and implementation projects.

Right of Way Asset Data Management Practices at TxDOT

The preparation of the right of way map and associated documentation (including property descriptions, deeds, and other related instruments) is a highly structured process. Detailed requirements and procedures for the production and submission of these documents are available in the *TxDOT Survey Manual* (*15*) and Volume 1 (Procedures Preliminary to Release) of the *Right of Way Manual* (*8*). At TxDOT, property descriptions for right of way projects include metes and bounds descriptions and parcel plats prepared on letter size sheets (*15*). Among other requirements, property descriptions must include descriptions and plats tied to the Texas State Plane Coordinate System, reference metadata used in preparing the survey, and describe the type of public record referenced (e.g., deed records, official records, real property records, and/or plat records) as well as volume and page data.

TxDOT has specific requirements for the use of MicroStation files to support the preparation of right of way maps (*15*), including requirements for base files, topographic files, title sheet files, map sheet files, cells, levels, labels, line weight and symbology, and whole property sketches. Of particular interest are the requirements for cells and levels because of the ramifications for the conversion of MicroStation-format features into GIS features. TxDOT maintains a large cell library that includes hundreds of cells that depict a variety of mappable objects on the ground (*20*). Many of those cells pertain to right of way–related features, including right of way lines, access denial lines, blocks, easements, fences, property lines, subdivisions, survey lines, and monuments. In MicroStation, the cell name is a property of each cell added to the file. This characteristic makes it possible to automate the import of MicroStation-format features into a geodatabase by executing a query in the GIS environment that only selects features that match certain cell names.

TxDOT also uses a variety of levels to display features in MicroStation. With the introduction of MicroStation version 8, it became possible to use levels outside the traditional 63-level structure. By default, MicroStation resolves the level to use as a function of the cell name. In addition, TxDOT has configured its cell library structure so that certain cells are automatically assigned to the same level. This automatic level placement can facilitate the import of MicroStation features into a GIS environment.

TxDOT uses a variety of information systems to support project development and asset management processes. Of particular interest here are DCIS, ROWIS, TRM, FileNet, Plans Online, MST, and Right of Way Map Locator. DCIS enables users to track projects throughout the project development process (*25*). DCIS includes a large number of project, contract, and utility screens that enable authorized users to complete data inputs and updates and run queries and reports. The screens cover a wide range of topics, including project identification and evaluation data, project planning and finance data, project estimate data, and contract summary data.

ROWIS enables users to capture, track, and report data related to right of way parcel development during events such as negotiations, settlements, and eminent domain proceedings (*26*). The Right of Way Division also uses ROWIS to track reimbursable utility agreement payments. The main function of ROWIS is to support the TxDOT right of way acquisition process. It provides very little support for the management and inventory of right of way assets after the conclusion of the acquisition process. In addition, ROWIS does not have functionality to display (or to provide a link to) right of way parcels or utility adjustments on a map. In fact, the Parcels entity in ROWIS does not contain any spatial data except for a general description of the physical location of the parcel. ROWIS is not compatible with GAIP and cannot make data available to TxDOT users through MST. In addition, ROWIS handles property right encumbrances (e.g., easements) as an acquisition interest code in the Components entity, which simply references the parcel ID without any detailed spatial information. As a result, a user cannot visualize the location and spatial extent of the encumbrance without physically finding and reviewing the parcel's conveyance document.

TRM is a mainframe-based system that documents physical and performance characteristics of the state-maintained highway network using the statewide reference marker network as a geo-referencing tool (*27*). TRM is the major repository of state highway network and associated data. Several data attributes in TRM are directly relevant to this research, including right of way width, surface width, roadbed width, and section length. However, while TRM provides data for a wide range of reporting options, the structure and characteristics of the data have shortcomings that limit the usability of the system for right of way asset management purposes.

TxDOT is implementing FileNet statewide to store and archive electronic documents. In the TxDOT implementation, the system stores document-related data in a centrally located SQL Server database and documents in dedicated servers at every business unit where TxDOT has implemented FileNet. Currently, TxDOT uses two FileNet configurations: a "thick-client" configuration (which involves the use of a special-purpose client application on user computers) and a "thin-client" configuration called TxDocsOnline (which is web based and uses an Internet

Explorer browser to interact with the database and the FileNet file server). Following the EDTIS Project Content Services library standards, FileNet uses document classes, record types, and document types to organize documents (*28*, *29*).

Plans Online enables users to manage the storage, archival, and delivery of project plans and related documentation to internal and external users (*30*). Internet access to Plans Online is limited to letting documents for construction and maintenance projects as well as post-letting bid tabulation and bid total data for a limited number of months. Plan sheets are available in two formats: TIF and PDF. Intranet access to Plans Online is much more comprehensive and includes pre-letting, post-letting, and archived documents and data.

MST is a web-based application that enables spatial intersect and relational queries for the production of tabular and mapping reports (*38*, *39*). TxDOT has incorporated a number of GIS-based datasets into MST, including bridges, roadbeds, right of way maps, recycled material facilities, and primary survey control points. Historically, TxDOT's GIS infrastructure has relied on the traditional linear distance-based geo-referencing method. Through GAIP, TxDOT developed a framework to reduce the department's dependency on the traditional linear referencing method (*36*, *37*). In GAIP, each data element of interest can be managed through a separate table that contains both spatial and non-spatial attribute values that characterize each record spatially and temporally.

Right of Way Map Locator is a web-based application that enables the delivery of copies of right of way maps to interested users (*40*). The system provides an interactive map that enables users to navigate and zoom to a specific control section. Clicking a point along a control section displays a list of right of way map image files the user can view, download, or print. The system is GAIP compliant and is included in the MST portal. Currently, the system includes data from three districts: San Antonio, Fort Worth, and Pharr. TxDOT is extending the system statewide.

Right of Way Asset Data Management Practices at Other Agencies

Chapter 3 documented several examples of parcel data modeling efforts, including the National Integrated Land System, the FGDC Cadastral Data Content Standard, the Cadastral National Spatial Data Infrastructure, the ArcGIS cadastral data model, and cadastral initiatives at other states. In general, different models follow different approaches for the modeling of parcels, property rights, and encumbrances. For example, the FGDC Cadastral Data Content Standard provides semantic definitions of objects related to land surveying, land records, and landownership information (*49*). Basic definitions in the standard include definitions for cadastral data, parcels, rights and interests, and restrictions. The standard includes logical-level ER diagrams that describe entity names and relationships for parcels, legal area descriptions, boundaries and corners, and agents and geopolitical places. The model provides some basic attribution for parcel data, including parcel ID, actual and legal area, parcel transactions, restrictions, and rights and interests. The relationship between parcels and restrictions is one to many (suggesting that a parcel can be subject to many different restrictions). By comparison, the relationship between parcels and rights and interests is many to many, requiring the use of a third entity to represent that relationship.

The ArcGIS parcel data model is in many ways similar to the FGDC Cadastral Data Content Standard (*51*). For example, both models account for parcels, rights and interests, restrictions, corners, and boundaries. However, the treatment of these entities in the ArcGIS parcel data model is different. For example, the ArcGIS parcel data model assumes parcels, encumbrances, and separated rights are independent geographic feature classes, which might have different corners and boundaries. At the same time, the model is somewhat limited in scope in that it does not specifically handle property descriptions (although it does handle corner, boundary, and PLSS data) or parcel transaction data.

There is a wide range of right of way asset management practices at DOTs around the country (*60*, *61*, *62*). Chapter 3 describes practices at a sample of state DOTs, including Arizona, California, Illinois, Maryland, Minnesota, Nevada, New Mexico, Oregon, Pennsylvania, Virginia, and Washington. Several states still use paper-based procedures or rely on mainframe legacy systems. However, in most cases, states are in the process of modernizing or updating their right of way information systems. Some states also rely on desktop databases and other applications for specific right of way–related processes. Typically, states develop their own systems (e.g., RWMIS in California, MdProperty View in Maryland, or RUMS in Virginia). However, some states license applications developed by others (e.g., Minnesota implemented REALMS, which is a customized version of Virginia's RUMS, and Pennsylvania implemented Bentley's Right of Way Office). Some states are incorporating GIS-based mapping components into their right of way management systems, as in the case of ALAS in Illinois, MdProperty View in Maryland, Right of Way Mapping and Monitoring in Minnesota, and IRWIN in Nevada. The use of document management systems to support right of way functions is also increasing, as in the case of Oregon, which is developing a right of way management system that uses several FileNet tools along with basic GIS functionality.

Chapter 3 also included a discussion about the data modeling effort in NCHRP Projects 8-55 and 8-55A. NCHRP Project 8-55 included a high-level characterization of the appraisal, right of way acquisition, relocation, and property management processes, as well as a compilation of data elements for each area identified in the high-level business process model. The data elements in NCHRP Project 8-55 included some information about entities, primary keys, and attributes. In general, the modeling approach uses a spatial entity to manage parcels and a spatial entity to manage highway project alignments. Additional non-spatial entities that point to the parcel and project entities in a one-to-many fashion handle different aspects of the right of way management process. NCHRP Project 8-55A (currently active) is expected to provide more detail to the business process model and develop an enterprise-level logical model (*80*).

Prototype Right of Way Asset Data Model

For the development of the prototype data model, the researchers took into consideration the following general requirements and guiding principles:

- **Focus on asset data architecture, not on graphical user interfaces**. At TxDOT's request, the research focused on asset data architecture modeling and identification of implementation issues, not on GUI development or business processes needed to support the implementation of the right of way asset data model. An additional requirement was

to focus on long-term asset data management issues (more specifically, related to the spatial component of the assets) after the completion of the right of way acquisition phase.

- **Data integration**. The researchers identified integration points with TxDOT's existing systems, such as DCIS, ROWIS, FileNet, and MST. In general, the researchers created placeholders in the prototype database structure for tables and fields that are related to project data (which are DCIS or ROWIS related) or engineering documents (which are FileNet related).

- **Compatibility with existing TxDOT information systems**. The data model developed in this research is compatible with existing TxDOT data architecture requirements (*31*), as well as other existing data standards, e.g., TxDOT's CAD standards (*20*) and right of way map production standards (*8*, *15*).

If the state owned all right of way parcels in fee simple, parcel outlines would provide all the information needed to represent TxDOT's real property interests spatially. In practice, it is necessary to deal with property rights that are not only separated from the parcel but that might also have a different spatial outline from that of the original parcel. In general, the modeling approach was to model encumbrances independently of property rights, while enabling a linkage between property right and encumbrance through separate database procedures, e.g., regular many-to-many relationships or spatial overlays. This approach provides more flexibility because it allows generating encumbrance features in the database without having to create the corresponding property right feature first. It also makes it possible to model the spatial boundaries of encumbrances separately.

At the highest level, managing right of way assets systematically involves managing four types of data: data about features on the ground (normally on the state right of way); data about right of way asset documents; data about projects; and data about users who may need to interact with features, documents, or projects. In reality, features, documents, projects, and users are not standalone entities. For example, a project can have many documents and/or be associated with many features or users; a document can be associated with many projects, features, and/or users; a feature can be associated with many documents, projects, and/or users; and a user may be associated with many documents, features, and/or projects. As Figure 47 shows, the relationships among features, projects, documents, and users are clearly many to many.

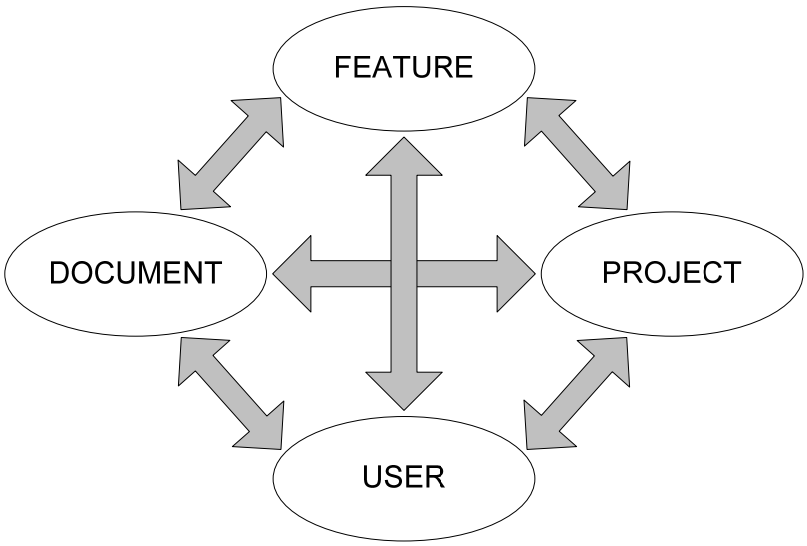


Figure 47. Right of Way Asset Data Model – Conceptual Design.

The researchers' approach to developing the prototype right of way asset data model was to consider not just the four main areas in Figure 47, but also the corresponding many-to-many relationships. Figure 48 shows a corresponding high-level logical data model, which also includes a few critical entities. In most cases, the entities shown (or groups of entities) have real-world information system counterparts at TxDOT. For example, the system counterpart for project-related entities is DCIS, the system counterpart for document-related entities is FileNet, and the system counterpart for feature-related entities is GAIP. This characterization enables a direct mapping between the model and those systems, and facilitates the interpretation of the high-level diagram in Figure 47 as a set of system placeholders for which the prototype right of way asset data model provides the connecting framework.

For clarity, the model includes four subject areas, one for each core entity in the model. The researchers developed the prototype right of way asset data model using ERwin Data Modeler.

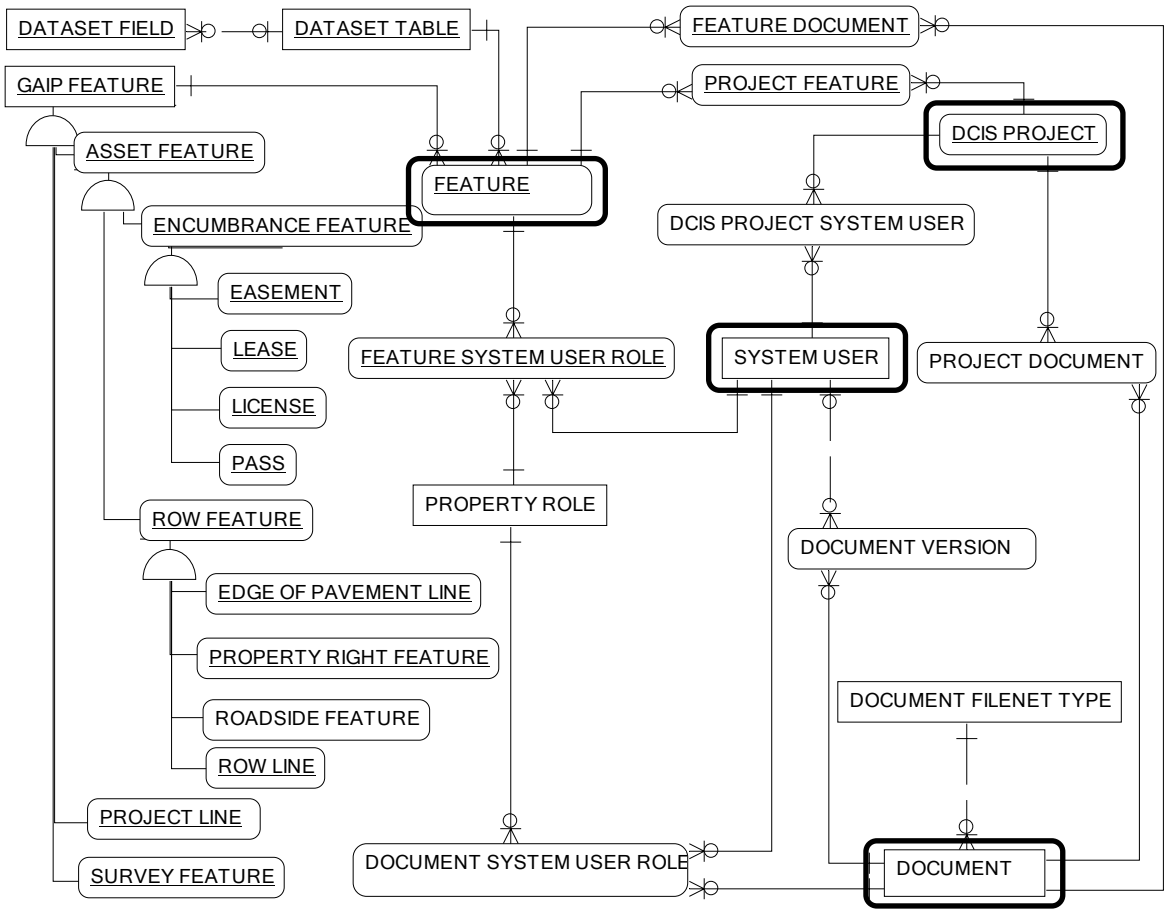


Figure 48. Right of Way Asset Data Model – High-Level Logical Data Model.

Prototype Data Model Testing

The researchers used three different environments to test the right of way asset data model database design, examine potential implementation and integration issues with other systems, and demonstrate the model to a variety of audiences: Access, ArcGIS, and Internet Explorer. Each testing environment fulfilled a role in the testing process. The Access and ArcGIS testing environments focused on basic database design and relationship testing using a variety of "ready-made" tools that expedited the testing process. For portability, the researchers created a physical data model from the logical data model developed in Chapter 4 and used the physical definitions in an ESRI personal geodatabase (in Access format). The Internet Explorer testing environment focused on the examination of implementation and integration issues with other systems and on the demonstration of the model performance in a web-based environment (which proved useful during discussions with TxDOT officials when issues such as model implementation, portability, and functionality were raised).

For this project, TxDOT provided sample data associated with highway projects in four TxDOT districts: San Antonio, Odessa, Beaumont, and Dallas. The researchers supplemented these data

with TxDOT-provided sample data from other research projects. Processing the sample data involved the following steps:

- integrating project data in the database;
- integrating document data in the database;
- integrating spatial document data in the database;
- integrating feature data in the database;
- integrating user data in the database; and
- linking project, document, feature, and user data.

Geo-referencing datasets, in particular right of way maps and other documents representing property interests, involved a combination of procedures given the wide range of data formats, completeness, and accuracy associated with those datasets. For example, there were geo-referenced CAD datasets containing right of way, parcel, and easement lines, which were in "surface" coordinates, which involved the use of a combined adjustment factor to convert all surface-level documents so they could display correctly in the GIS. There were also datasets, e.g., the right of way maps in TIF format available through the Right of Way Map Locator system (*40*), which did not have a defined coordinate system. In general, the researchers geo-referenced raster documents and stored spatial outlines for each document in the geodatabase.

There were also survey plats in TIF format and metes and bounds descriptions. In this case, the procedure to generate asset feature records included geo-referencing the available survey plats using a combination of aerial imagery and parcel layer data, generating individual parcel and easement features from the metes and bounds descriptions by using bearing and distance calls, and aligning individual parcel and easement features.

In addition to populating feature tables for the right of way asset data model, the researchers documented those datasets by developing CSDGM-compliant metadata documents for all feature entities in the right of way asset data model. In addition to basic definitions, CSDGM covers aspects of metadata such as identification, data quality, spatial data organization, spatial reference, entity and attribute information, distribution, and metadata reference. The researchers populated the metadata documents using a combination of entity and attribute definitions from the right of way asset model ERwin logical model file, custom text specific for this research (e.g., contact information), and automated information populated through ArcCatalog tools (e.g., coordinate system).

As part of the database population process, the researchers used the current EDTIS content services library standards (*28*) to characterize sample documents. There were several cases where mapping individual files to the FileNet file structure was not straightforward or possible, including cases of multiple possible matches, cases where matching was not intuitively clear, and cases where there were no matches. In an effort to understand the problem, the researchers evaluated the FileNet Right of Way document class in more detail, revealing problems such as lack of consistency in record type designations, redundancy in document types, lack of document subtypes, lack of consistent support for right of way forms, and lack of coordination with other document classes.

Developing alternatives for the document type versus record type matrix for right of way documents was outside the scope of this research. Nonetheless, the researchers discussed the issue with TxDOT officials. The preliminary conclusion is that there is a need to develop a new list of record types (more than likely reducing and consolidating the number of options) as well as review and update the list of document types to properly account for the wide range of right of way–related documents at the department. Document type updating options would include adding, deleting (if needed), consolidating, and renaming.

RECOMMENDATIONS

- **Implement a strategy for a permanent repository of electronic files that supports right of way asset management plans effectively**. The official record that documents right of way acquisition activities at the Right of Way Division is in paper format. As mentioned previously, TxDOT is implementing FileNet statewide as a mechanism to store and manage electronic documents. In the case of the Right of Way Division, it is reasonable to assume the process will include scanning paper documents such as deeds, property descriptions, and other supporting documents, and storing TIF or PDF versions of those files. At the same time, TxDOT uses Plans Online to store and archive project plans and related documentation in TIF and PDF. However, neither mechanism stores documents in a way that maintains the geo-reference of the original data. Although current right of way document submission requirements include the submission of geo-referenced MicroStation files, this information is lost during the generation of official paper-based documents. In addition, it is not clear to what degree the MicroStation files and supporting files (e.g., survey files) that districts receive and/or process are consistently sent to the Right of Way Division for final processing and archival.

  As this report documented, using original geo-referenced MicroStation files is one of the most effective mechanisms to generate right of way asset records in a GIS environment. Therefore, the researchers recommend implementing a strategy that (a) formalizes and/or tightens the requirement to submit MicroStation and supporting files to the Right of Way Division for final archival, and (b) develops protocols and procedures to archive those files in FileNet while ensuring those files will be accessible at any point in the future. In the short term, accessing those documents would be important in order to generate GIS records of right of way assets. In the long term, accessing those documents would enable officials to answer specific questions and/or address potential issues with the original GIS records.

- **Implement strategies to populate a right of way asset GIS database**. Realistically, populating GIS-based right of way asset records using geo-referenced MicroStation files will only be possible for new projects. For most of the state-maintained highway network, MicroStation files are either not available or not usable, but other documents are available. A number of possible implementation strategies based on the amount and quality of information are available, including the following:

  - **Strategy 1 (use geo-referenced MicroStation files)**. This strategy would apply in the case of new projects and would involve using geo-referenced MicroStation

files and other available supporting files. If the strategy is implemented correctly, the number of iterations (including going back to the field for additional surveys) can be kept to a minimum.

- **Strategy 2 (use existing paper records at the Right of Way Division)**. This strategy would involve gathering, cataloging, and reviewing available parcel acquisition documentation at the Right of Way Division, with a focus on right of way maps, property descriptions, plats, or any other piece of information that could be used to generate parcel records in a geodatabase. This effort would likely involve several passes to account for the different phases in which TxDOT has acquired highway right of way over the years. The accuracy of the resulting records could vary substantially depending on the amount and quality of the underlying information.

- **Strategy 3 (identify survey points in the field)**. This strategy would involve going to the field to identify the location of end points that may have been used for the survey of individual parcels or group of parcels being acquired. This activity would be needed in cases where property descriptions, plats, or right of way maps were based on an arbitrary coordinate system, and using ancillary data such as orthophotos would not provide sufficient information to infer the end point coordinates.

For the implementation of the strategies, TxDOT would need to take into consideration a number of practical issues, e.g., whether and how much data entry at the district level could/should take place and the validity and associated liability of the resulting data. The division of labor between districts and the Right of Way Division for parcel data entry in the geodatabase would depend on factors such as availability of personnel, level of GIS training, and availability of read/write access privileges to edit copies of the parcel geodatabase.

Regardless of strategy, the intended use of the parcel geodatabase is for asset management purposes. The location of the parcels in the GIS is a placeholder for links to attribute data and documents. Similar to a cadastral system used by appraisal districts, the geodatabase does not determine or confirm property rights (which is a matter of law and a fact to be determined by professionals licensed in boundary law and surveying).

- **Modify the Right of Way document class in FileNet**. The exercise of mapping sample right of way documents to the FileNet library structure prompted an analysis of the list of document types and record types in the Right of Way document class. This analysis led to the conclusion that there is a need for more consistency in record type designations; elimination of redundancy in document types; and increased support for document subtypes, right of way forms, and document type options.

  The researchers recommend developing a new list of record types (more than likely reducing and consolidating the number of options) as well as reviewing and updating the list of document types to properly account for the wide range of right of way–related

documents at the department. Document type updating options would include adding, deleting (if needed), consolidating, and renaming document types. To assist in the analysis, the researchers recommend using a document type versus record type matrix similar to that in Table 20.

The analysis of right of way documents such as deeds, property descriptions, survey and appraisal reports, right of way maps, and plats also led to the conclusion that there is a need for additional document attributes in the Right of Way document class to properly catalog and archive documents for long-term asset management (Figure 28, Figure 29). Examples of additional attributes include parcel area, remainder area, property record volume and page numbers, and right of way form ID, as well as several dates that are important to support right of way functions such as effective date, execution date, expiration date, filing date, survey date, and void date.

- **Add standardized certification and disclaimer text labels to all relevant geospatial documents (including documents in electronic format)**. Chapter 5 included a discussion about the distinction between survey products and mapping products in the *Manual of Practice for Land Surveying in the State of Texas* (*46*). In the discussion, the researchers concluded that the existing certification label (for use with survey products) and disclaimer text label (for use with mapping products) were appropriate for printed materials, but not necessarily for electronic documents in an interactive environment that involves access to a database that enables selective filtering, querying, displaying, and feature extraction.

  In the case of mapping products, the researchers recommend using the standard disclaimer text included in the TSPS manual (reproduced here for convenience) without any changes:

  > This product is a graphic representation of the data shown hereon. It does not represent an on-the-ground survey; is not a Survey Product and only represents the approximate relative location of property boundaries and/or natural and man-made features. This product does not conform to a Class A, GIS/LIS Survey Product as defined in Category 10 of the TSPS Manual of Practice and shall not be relied upon for uses which could affect the health, safety or welfare of the general public.

  In the case of survey products, the researchers recommend using a modified version of the standard certification text, as follows:

  > I, <first and last names>, a Registered Professional Land Surveyor in the State of Texas, do hereby certify that this product represents the results of a (boundary or geodetic) survey performed under my direct supervision and meets the minimum requirements of an on-the-ground survey as promulgated by the Texas Board of Professional Land Surveying.

  In order to use this modified certification label, it would probably be necessary to first amend the current TSPS manual. Therefore, TxDOT should recommend to the TBPLS the adoption of the proposed label instead of the current one in the TSPS manual.

Both the disclaimer text and the certification text above would be appropriate in a variety of scenarios and conditions, including the following:

- **Feature level**. The certification or disclaimer text would be added as an attribute value associated with each feature in the geodatabase.

- **Metadata level**. The certification or disclaimer text would be included in an appropriate tag in the standard metadata file that accompanies each feature class in the geodatabase.

- **Standalone map (in paper or digital form, e.g., PDF or tiled image**). The certification or disclaimer text would be added as a label that is always displayed with the product.

- **Clarify the requirements for topographic information outside the right of way.** Topographic information outside the proposed right of way facilitates TxDOT's assessment of the impact of parcel acquisition on the parent tract, helps with the valuation of acquired property parcels, and provides context for data users after the right of way acquisition process is complete. The *TxDOT Survey Manual* includes requirements for the collection of topographic data outside the right of way line (*15*). Unfortunately, these requirements are not consistent. For example, in one section the manual requires the location of improvements within 25 feet of the new right of way line. In other sections, the stated requirement is 50 feet outside the proposed right of way line. The manual also includes a requirement to provide "sufficient topography" to show the required right of way parcel and the parent tract of land or a distance of 600 feet from the highway centerline, whichever is lesser.

  This lack of consistency can cause confusion. In practice, the level of topographic detail on right of way maps varies. For example, using sample right of way maps, the researchers noticed that older maps frequently provided more detailed topographic information outside the proposed right of way (e.g., houses, barns, and local roads) than newer maps. In fact, some of the more recent right of way maps did not include any features outside the right of way, which made the geo-referencing process more difficult.

  TxDOT officials highlighted the need to include information related to improvements, such as fences, driveways, concrete flat work, water wells, and privately owned utilities. Information about land use is useful, as is the location of features that may affect the appraised value of the parcel(s) being acquired, such as economically valuable trees and sand or gravel pits. A depiction of watercourses and ravines is also helpful. Topographic information such as elevations and contour lines is not critical (although, if properly depicted in light gray tones to avoid clutter, it can provide background and context in situations where there are significant differences in elevation).

  To ensure consistency and completeness in the information provided on right of way maps, the researchers recommend including clear, consistent instructions in the *Survey Manual* regarding the type and level of detail associated with topographic information

outside the proposed right of way. Ideally, the instructions would include examples of the type of information that would normally be expected at increasing distances from the right of way line.

- **Modify Form ROW-MapCheck to address electronic file delivery requirements**. The only reference in Form ROW-MapCheck to the submission of electronic files is a checkbox to verify that graphic files submitted are "compatible" MicroStation files. The researchers recommend including a separate section in Form ROW-MapCheck to cover specific electronic document delivery requirements in more detail. Examples of checkboxes to include in that additional section are the following:

    - MicroStation files match the printed maps.
    - MicroStation files submitted match the list of files provided.
    - Line weight and symbology match TxDOT standards.
    - MicroStation files only use cells from the TxDOT cell library. Appropriate justification is included for any non-standard cells used. (Note: It would be advisable to develop a tabular form that contains official TxDOT cell names and checkboxes as part of the MicroStation document submission process. The form would also include blanks to enable users to provide justifications for cells used that are not part of the current TxDOT library.)
    - MicroStation cells used match existing or proposed features that the cells intend to represent.
    - MicroStation cells are correctly placed on their levels.
    - MicroStation features that represent parcels are closed-area features.
    - Parcel plat files match the printed versions.
    - Metes and bounds descriptions match the printed versions.

  Additional checkboxes would be necessary to address requirements associated with other electronic files such as survey files and/or supporting documentation.

  To assist in the verification of MicroStation file submissions, it may be advisable to use software tools to verify CAD standard compliance automatically, e.g., Bentley Systems MicroStation Standards Checker or Altiva Software CADconform™ (*87*).

- **Consider requiring the submission of right of way feature data in GIS format**. TxDOT should evaluate the feasibility of requiring the submission of right of way feature data in a GIS format at the time of submission of the documents to the district. Although TxDOT officials would need to conduct thorough quality control on any GIS data

submitted, the amount and type of quality control needed are actually similar to the quality control that districts should conduct in the case of MicroStation files. To facilitate this process, TxDOT could have a geodatabase template on its website, containing all the feature class and metadata definitions, along with instructions for their use, population of spatial and non-spatial data, and procedures for the conversion of CAD and survey data into a geodatabase format. It might be advantageous to consider the use of survey tools such as ESRI Survey Analyst™ within the ArcGIS environment.

The instructions for the population of spatial data should contain a description of the topological rules that should apply while generating features. Examples of topological rules include the following:

- All polygon features (including parcels) must close.
- Adjacent parcels must have coincident boundaries with no overlaps or gaps.
- Right of way lines and access right lines must match the alignment of parcel boundary lines that abut the right of way.
- In cases where TxDOT purchases access rights from adjacent landowners or uses police powers to deny access to the right of way, right of way lines and access right lines must match the alignment of parcel boundary lines that abut the right of way. In some situations, e.g., controlled-access facilities with main lanes and frontage roads, access right lines are also routinely placed on the median between the main lanes and the frontage road.
- Access right lines are only depicted at locations where TxDOT denies access to the state right of way, either by purchasing the access right or by invoking police powers.

- **Update ROWIS to support modernization initiatives at the Right of Way Division**. The main function of ROWIS is to support the TxDOT right of way acquisition process. ROWIS provides very little support for the management of right of way assets after the conclusion of the acquisition process. The system is not compatible with GAIP and cannot make data available to TxDOT users through MST. It has limited capabilities to handle property right encumbrances. Furthermore, ROWIS lacks the basic functionality to support other critical right of way–related functions such as property management, utility adjustments and management, and outdoor advertising sign permitting. This lack of functionality within ROWIS negatively affects TxDOT's ability to manage the right of way effectively.

  Through the research program, TxDOT has embarked on an ambitious research and modernization program of right of way functions at the department. Several of those initiatives have resulted in information products that are at different stages in development and implementation, as listed below:

- **Utility Installation Review**. UIR is a GIS-enabled web-based application that automates the utility-permitting process at TxDOT. UIR is currently online at five districts, with short-term plans for expansion statewide.

- **Utility Accommodation and Conflict Tracker (UACT)**. UACT is a prototype system that automates utility coordination and adjustment during the project development process.

- **GIS-based model for the inventory of utilities**. This model provides a catalog of feature classes, attributes, and MicroStation cells for the inventory of utility installations on the state right of way.

- **Construction specification and unit cost framework for utility installations**. This framework includes a list of construction specification requirements and bid items for water, sanitary sewer, and communication installations.

- **Right of way asset data model (developed in this research project)**. This model provides a GIS-based logical and physical model of right of way features such as parcels, property rights, and encumbrances. The model also provides a framework for the integrated management of right of way documents and project data.

The researchers recommend modifying ROWIS to address its current limitations and to provide adequate integration with these initiatives. Ideally, ROWIS could become an umbrella application or portal that provides access to a number of subsystems that handle specific activities, e.g., appraisal; right of way acquisition, negotiations, and eminent domain; right of way asset management; property management; utility inventory, adjustment, and permitting; and outdoor advertising sign permitting. Logically, the core of the updated ROWIS would be the data models developed in this research, including the conceptual model, which handles the interaction between features, projects, documents, and users (Figure 47), as well as the corresponding logical data model (Figure 48). As described in previous chapters, the model includes placeholders that represent integration points with other enterprise applications at TxDOT, e.g., FileNet, DCIS, and MST.

- **Develop and publish a manual explaining the CAD standards**. TxDOT has a web page that points to MicroStation and Bentley GEOPAK® files (e.g., cell library, level library, resource file, seed files, and basic GEOPAK training). Another page points to standard plan sheets, including bridge, roadway, traffic operations, and maintenance plan sheets. However, there is no manual or guidance that explains how to use the standards (if there is a manual, it is not published online or is not available on the pages that point to CAD standards or current TxDOT manuals). As a result, the burden is on the user to navigate through the available material and learn about the standards. In many cases, the materials are self-explanatory. However, in some cases, critical information is not available. For example, there is no information about the relationship between cell libraries and the corresponding default levels in MicroStation. There is also no

information about the status of individual cells in the cell library that could be helpful in determining, for example, which new cells are available or which cells are being phased out.

In the specific case of right of way–related documents, there is also a need for guidance regarding the use of MicroStation and GEOPAK to support the preparation and delivery of electronic documents, including documents intended for permanent archival at the Right of Way Division (following the recommendation above to implement a permanent repository of MicroStation/GEOPAK files). The current version of the *TxDOT Survey Manual* (*15*) states that information and requirements about text and label characteristics (e.g., font size, line spacing, and weight), line weight and symbology, and TxDOT standard levels are available in Volume 1 (Procedures Preliminary to Release) of the *Right of Way Manual* (*8*). However, the only information in this manual is a brief reference that the cell library is available for download.

The researchers recommend developing and publishing a CAD standard manual at TxDOT. This manual would be a valuable resource for internal users and TxDOT consultants, and could result in significant improvements in productivity and more effective quality control for CAD document delivery. Examples that could be used as a starting point for a CAD standard manual at TxDOT include those developed by the New Mexico Department of Transportation (*88*) and the Ohio Department of Transportation (*89*).

IMPLEMENTATION IMPACTS AND SCHEDULE

Different recommendations have different priorities and anticipated impacts (both in terms of benefits and costs), as well as different implementation schedules. For convenience, Table 21 lists the recommendations described in the previous section, along with an indication of the researchers' perception regarding relative investment levels (in terms of time, personnel, and money), relative return on investment (ROI), and anticipated timeframe for implementation.

Table 21. Research Recommendation Summary.

Recommendation	Investment[1]	Anticipated ROI[2]	Timeframe[3]
Implement a strategy for a permanent repository of electronic files that supports right of way asset management plans effectively	$$	High	Mid-term
Implement strategies to populate a right of way asset GIS database	$$	Very high	Long term
Modify the Right of Way document class in FileNet	$	Medium	Short term
Add standardized certification and disclaimer text labels to geospatial documents (including documents in electronic format)	$	High	Short term
Clarify the requirements for topographic information outside the right of way	$	High	Short term
Modify Form ROW-MapCheck to address electronic file delivery requirements	$	High	Mid-term
Require the submission of right of way feature data in GIS format	$	Medium	Mid-term
Update ROWIS to support modernization initiatives at the Right of Way Division	$$$	Very high	Mid-term
Develop and publish a manual explaining the CAD standards	$	High	Short term

[1] Investment indicates the relative amount of resources (time, personnel, and money) needed to undertake a recommendation.

[2] Anticipated ROI indicates potential benefits associated with a recommendation relative to the level of investment needed for its implementation.

[3] Timeframe indicates the approximate completion time for a recommendation, where "short term" is 1-2 years, "mid-term" is 3-5 years, and "long term" is 5 years or more.

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