Proceedings and Final Report of the

NSDI Framework Road Data Modeling Workshop

December 3-5, 1997
Wrightsville Beach, NC

Written and compiled by
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and Participants

for
Federal Geographic Data Committee

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Acknowledgments

The **Federal Geographic Data Committee** (FGDC) has come to provide instrumental leadership in helping public agencies, the vendor community and academic practitioners of geographic information systems (GIS) technology to tackle numerous and thorny problems. Many of the problems that are encountered in the development of transportation spatial data bases -- more exactly, road centerline data -- are both technical and institutional in nature. The FGDC organized this workshop to bring together individuals representing governmental agencies -- at the regional, state, and federal level -- organizations which are actively addressing these problems in their attempts to build, maintain and share road centerline data within and around their jurisdictions.

Many of the problems which you experience in your daily work with GIS and road centerline data may or may not be unique to your data and data-sharing environment. You — **the reader** — have ventured to open this report because you may be curious as to whether the ideas and experiences of these individuals can help you to better meet your needs. You will have to determine whether or not the work accomplished in Wrightsville is, in Eigen's words quote below, "Irrelevant."

So it is to the **meeting participants**, their employers and their sponsoring organizations that we all owe thanks for the time they took to come together, to share their experiences and perceptions, and to create observations and recommendations to share with you. The value that you find in this report comes from the energy and ideas they have contributed, whereas faults and omissions in the composition and organization of this report are due to me.

This workshop could not have been held without the leadership of Mike Domaratz of FGDC, who assembled a highly knowledgeable, diverse, and hard-working group of participants. The workshop would not have had its sharp technical focus without the presentations made by Mark Bosworth, Bob Nagel and Steve Sharp. Further, the group facilitation offered by Keven Roth, Steve Davis and Jim Werle, and small-group recording and presenting by Rob Surber, Bill Johnson, and Dan Walters, were crucial contributions to the workshop.

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— Bruce Westcott, Meeting Facilitator
Burlington, Vermont
December 1997

"A theory has only the alternative of being right or wrong.
A model has a third possibility: it may be right, but irrelevant."
-- Manfred Eigen, quoted in The Physicist's Conception of Nature, Jadish Mehra (ed.), 1973

Meeting Participants

- Nancy Armentrout - Maine Department of Transportation
- David Blake - Utah Department of Transportation
- Mark Bosworth - Metro Portland
- Fred Broome - Geography Division, US Bureau of the Census
- Jay Clark - Puget Sound Regional Council
- Steve Davis - University of Georgia
- Mike Domaratz - Federal Geographic Data Committee
- Charles Fleming - Georgia Department of Transportation
- David Giordano -North Carolina Center for Geographic Information and Analysis
- Stephen C. Guptill, PhD. - U.S. Geological Survey
- Bill Johnson - New York State Department of Transportation
- Bob Nagel - Utah Automated Geographic Reference Center
- Zsolt Nagy - North Carolina CGIA
- David Painter - Federal Geographic Data Committee
- Keven Roth - U.S. Geological Survey
- Steve Sharp - Vermont Center for Geographic Information, Inc.
- Ed Shuller - North Carolina DOT/GIS Unit
- Bruce Spear - USDOT/BTS, GIS Unit
- Rob Surber - Michigan Information Center
- Chris Tilley - North Carolina DOT/GIS Unit
- Dan Walters - Maine Office of GIS
- Jim Werle - Associate of Monterey Bay Areas Governments (AMBAG)
- Jimmie Wright - U.S. Geological Survey

Meeting Staff

- Facilitator: Bruce Westcott — Vermont Center for Geographic Information, Inc.
- Meeting Planner: Sharon Valentine, assisted by Laura Williams

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Executive Summary

The NSDI Framework

The purpose of the NSDI Framework concept is *"to organize and enhance, throughout all levels of government and the private sector, the collection, maintenance, and dissemination of basic, consistent digital geospatial data."* The "Framework" facilitates data sharing and provides a base on which an organization can accurately register and compile other themes of data or add application specific information. Shared collection and maintenance

- reduces expenditures for data collection and integration,
- allows organizations to focus on their primary business,
- expands the user base for data being collected, and
- increases data availability over broader geographic areas.

Local, regional, state, and federal government agencies and other organizations that use geographic information systems have a recurring need for "Transportation" data -- one of the seven themes of the NSDI Framework. Transportation Framework data includes the centerlines of roads, trails, railroads, and waterways; airport; ports; bridges and tunnels. The Framework approach seeks to find a minimal common set of geographically-related road information on which organizations can pool their resources and collaborate on data development and maintenance. Many organizations which have invested in building the NSDI Framework agree that *database specification* and *data modeling* efforts need to be focused on transportation — most especially on the centerlines of roads — if this collaboration is to be realized.

Workshop Purpose and Activities

The FGDC hosted a two-and-a-half-day **NSDI Framework Road Data Modeling Workshop** in Wrightsville Beach, NC in early December 1997. Its purpose was:

- *to compare and contrast road data models developed by those working on Framework projects, especially elements of feature and attribute definition, and feature representation rules, and*
- *to examine different approaches to documenting data models, by comparing the documentation components, approaches and styles used in their projects.*

The FGDC invited representatives of agencies working on road-related Framework projects; agencies of local, state and the federal governments were included. Participants were asked to:

- prepare in advance by reviewing briefing materials and responding to questions about their current activities, and their expectations for the workshop,
- review the responses of co-participants, and provide other documentation in digital format — for access on a workshop-focused "home page" on the WWW,
- be prepared to share their experiences, questions, and concerns about the concepts and strategies discussed in the paper, and related issues, and
- to help identify and describe the characteristics of a consensus 'data model' which could be used in sharing transportation data within the NSDI Framework.

The workshop included plenary sessions conducted in a meeting room set up for face-to-face discussions. Plenary sessions included structured presentations, facilitated discussion, presentations by reporters for small groups, and group generation of ideas. The workshop participants divided into three smaller groups for some working sessions. These groups maintained membership throughout several working sessions during the three days, and devised their own leadership and reporting methods, with support and assistance from the workshop facilitator.

Plenary sessions included technical presentations and commentary on three multi-party Framework transportation projects in Oregon, Utah and Vermont. Discussion was focused on sets of questions related to:

1. Framework Road Entities and Attributes,
2. Characteristics and Attributes of Framework Road Entities
3. Elements and Requirements of A Framework Road Data Model, and
4. Framework Road Data Model Documentation.

Each workgroup used the experiences of its members and the material presented to try to address the same set of questions, identifying components and concepts they felt should be included. Many participants were eager to contrast the concepts and models with which they were familiar with the road data model presented in NCHRP 20-27[1]. Others were not familiar with the detailed content of this document, or felt work was necessary on topics not covered within it.

Workshop Consensus and Recommendations

The workshop was an experience in exploring road centerline data structures and data modeling concepts new to many participants. Workshop participants enthusiastically completed the analytical tasks assigned to their workgroups. Virtually all agreed that they would eagerly and productively continue their work, were it not for the workshop schedule. Most were truly surprised and excited at the degree of commonality across the analyses presented by the three groups. The need for an accepted vocabulary, and the need for additional time to clarify technical concepts across workgroups were identified as barriers to reaching true consensus on many points.

The workshop concluded with the generation of a list of tasks which should be slated for further work. Participants identified three tasks as being those most important for the further advancement of road data modeling concepts and practices discussed at the workshop. These were:

1. Sharing of concerns and conclusion reached at the workshop with a broader audience of transportation GIS professionals,
2. Identification of a process for consolidation of a consensus model based on the NCHRP 20-27 data model and workshop "sketches," utilizing further iteration(s) by a small group and review by transportation GIS professionals, and
3. Development of instructions, templates, and other tools to help practitioners utilize and adapt the model within their operations, leading to "pilot" implementations of the model.

[1] "A Generic Data Model for Linear Referencing Systems," National Cooperative Highway Research Program of the Transportation Research Board (National Research Council), September 1997.

Section I — Workshop Goals and Plans

A. Prospectus

Workshop planners formulated a one-page description of the workshop objectives, which was provided to participants as a "Prospectus" in advance of the workshop. Those invited to attend include leaders of projects which characterized themselves as developing and using Framework transportation data. It was on the basis of this "Prospectus" that participants were asked to begin thinking about what they could contribute and what they'd like to achieve at the workshop. (See Section I.B - *Survey of Workshop Participants*, on the following page.)

"Local, regional, state, and federal government agencies and other organizations that use geographic information systems have a recurring need for a few common themes of data. These data provide a 'framework' to which attribute information can be attached and other thematic data can be registered. They also serve as a locational reference for displays of other geographic information.

"One theme of acute interest is that of transportation, especially road data. These data support not only transportation applications, but also disciplines ranging from natural resources to emergency services to banking and finance. Many different organizations often produce similar data over the same geographic area. The framework approach seeks to find a 'minimal' common set of geographically-related road information on which organizations can pool their resources and collaborate on data development and maintenance. This common data also would provide sufficient means for each organization to add applications-specific data required for their business purposes.

"To continue progress on the framework, and especially the ability of organizations to develop and maintain geospatial road data collaboratively, many in the community have urged that a road data model that supports the framework-like data development and maintenance be articulated. The purpose of this workshop will be:

- to compare and contrast road data models developed by those working on framework projects, especially elements of feature and attribute definition, and feature representation rules, and
- to examine different approaches to documenting data models, by comparing the documentation components, approaches and styles used in their projects.

"The outcomes of the workshop are anticipated to include:

- the identification of content and definitions that are common to the projects,
- an understanding of the basis for differences among the projects, and
- an understanding of whether multiple data models might exist to meet different needs within different jurisdictions, which might be more appropriate for varying circumstances, and the Framework implications of this diversity.

"The following will be developed during and after the workshop:

- an inventory of the variety of documents, diagrams, modeling prototypes currently in use and envisioned by Framework projects and their utility to others,
- recommendations for means of documenting and implementing a road data model that are useful to the community, and

- the identification of specific further activities needed to develop 'consensus' regarding the components of a useful road data model, and the content of each component.

"Groups invited to participate in the workshop include those working on road-related 'framework' projects from the States of Vermont, Maine, Connecticut, North Carolina, Georgia, Oregon, New York, and Utah; metropolitan areas in Washington, Oregon, and California, and federal agencies."

B. Survey of Workshop Participants

Each workshop participant was asked to respond to the following questions about a month in advance of the workshop. Their responses — including documents provided in response to Question 4 — were shared on a WWW home page, and are reproduced in this report. (See Section V.B - *Survey of Workshop Participants*, and Section V.D - *List of References / Sources*.)

1. Can you provide a description (about 500 words) of activities or plans within your organization for implementing a framework "road data model" for your jurisdiction? Also please give us some idea of what your personal role is in the development or implementation of these activities.

2. What can you contribute to the workshop? What kind of experience or specialized knowledge have you acquired in your work in framework-like environments? How could this be of valuable to the rest of the participants and contribute to the workshop purposes (see attached *"Prospectus"*)? This is no place to be shy.

3. What questions do you hope this workshop can help answer for you, and for your project or organization? What specific outcomes or products would you like to see the workshop generate?

4. Do you have documents you can share with other participants to help them learn about your project or your framework road data model? Can you share a project description, data dictionary, process flowchart, or other document? Please either provide a digital attachment to your email or a URL (an FTP address or Web server). Or let me know if you'd rather provide paperwork.

C. Agenda

All participants arrived onsite the day before the workshop, and all were able to attend through the scheduled adjournment time of Noon on December 5.

December 3

I.	8:00 AM	Registration (for late arrivals)
II.	8:15	Review of Handouts, Facilities & Workshop Logistics
III.	8:30	Welcome; Overview of Workshop Purpose -- (Domaratz)
		▸ Review of Framework Concepts and history;
		▸ Can we better understand how we are "doing" Framework?
		▸ Can we define a more useful data model in response to demand from the spatial data community?
IV.	9:00	"Resource Inventory" exercise: WHO is here? HOW can we benefit from their experience? WHAT questions do we share?
V.	*9:45*	*Break*
VI.	10:00	Presentations of three Framework roads data models
		Open Discussion: What key concepts, tools, processes do I know about that were not covered?
VII.	*12: 00 PM*	*Lunch break*
VIII.	1:30	Respondent Panel
		▸ What are the points of commonality & conflict in the presentations?
		▸ What are the most important tasks we can take on at this workshop, in order to meet our objectives?
IX.	2:30	Definition / Selection of three "working teams"; review of:
		▸ team goals and deliverables,
		▸ suggestions for team process,
		▸ designated roles & responsibilities
X.	*2:45*	*Break*
XI.	3:00	**Team Session A**: Determine your game plan
XII.	4:00	Re-convene -- Team check-in; Plan for Thursday

December 4

I.	8:00 AM	Re-convene: Informal discussion; logistics & announcements
II.	8:15	**Team Session B**: Create the Outline of the Data Model(s)
III.	*9:45*	*Beverages available to Teams (in Lobby)*
IV.	11:00	Re-convene; Team check-in
V.	*11:30*	*Lunch*
VI.	12:30 PM	**Team Session C**: Fill in the blanks — individually — of the Outline; Identify the variances within each team.
VII.	*1:45*	*Beverages available to Teams (in Lobby)*
VIII.	2:00	Re-convene; Team Reports & discussion
IX.	3:30	**Team Session D**: Review the variants within your team, and the activities of other teams. Are they really significant? Do they lead to multiple models?
X.	4:30	Re-convene; Team check-in;
		Review of progress; identification of outstanding issues; planning for Friday wrap-up

December 5

I.	8:30	Team Presentations
II.	*10:00*	*Break*
III.	10:15	Brainstorm outstanding issues. Develop a list of issues / statements / recommendations / specifications which should be included in the Workshop Report
IV.	11:30	Assessment of Workshop; Identification of Follow up activities
V.	*12:00 PM*	*Workshop conclusion*

Section II — Daily Overview: Plenary Sessions and Workgroups

A. Wednesday, December 3

The day opened with a welcome by workshop organizer Michael Domaratz (FGDC), and announcements about the workshop agenda and logistics. Mike followed this with a presentation reviewing the goals of the NSDI Framework and the purposes of the workshop.[1] This presentation included:

- a review of the overall goals of the NSDI Framework,
- review of the definition of specific transportation features which are a part of the Framework,
- history of Framework-related initiatives of the FGDC,
- an overview of some of the complex technical components of data models -- entities, relationships, attributes, and metadata,
- Two questions: *"What, if anything, else is required in a useful data model?"* and *"Who are the users, and how can we work with them to maintain the data?"*

Following this presentation participants introduced themselves to one another, referenced the background materials they had provided in response to the "Survey," and highlighted questions most important to them.

A.1 -- Presentations

Three participants had been invited to make presentations of their work in progress, highlighting areas in which these project are or are not useful as "data models" for others. Mike Domaratz emphasized that no one had been asked to conform to an explicit definition of a "data model" and its components, but had been asked to address the following four issue areas:

1. Framework Road Entities and Definitions

- Do we share a useful consensus definition of the basic entity 'road' (or related term)?
- What are the parameters or bounds on this definition of 'road'? (All roads? Only public? Includes trails? Etc.)
- What are the related entities (road segment, route) — if any — which must necessarily be defined in order to advance the Framework?
- Do we know what rules define single instance of each entity? What's the atomic unit?
- What relationships exist between these entities?
- Are these two dimensional (points, lines, areas)? If so, how are they used to reflect three dimensional reality (overpasses)?

(continued on next page)

[1] Section V.C - Workshop Presentations contains reproductions of presentation slides prepared for this "Overview," and for the three project presentations summarized on the following pages.

2. Characteristics and Attributes of Framework Road Entities
- What attributes are attached to which entities for framework purposes?
- What definitions and domains are established for each?
- What attributes are provided to allow 'non-framework' information to be linked to the roads?

3. A Framework Road Data Model
- What elements -- other than entity definitions and attribute specifications -- are necessary components of a useful data model?
- Who are the users of these models? What do they need to be able to do, and how does such a model help them do it?

4. Framework Road Data Model Documentation
- What style or technology or methods are useful in documenting a road data model?
- How is the documentation maintained?

Presenter #1[2] — Mark Bosworth (Metro Portland, OR), described the work of the **Oregon Road Base Information Technical Subcommittee**, or "ORBITS".

Project Objectives -- A geographic road base of the state which could be used by as many organizations as possible:
- Updated by the agency responsible for the change
- Stored in a central clearinghouse
- Varying accuracies - the most accurate available for the area
- Review of Linear Data Models
- Develop a Data Model/s to achieve Statewide goals
- Establish Pilot Projects, including multi-level jurisdictions
- Motto: "We are doing it anyway..."

Mark reviewed the institutional landscape and the diversity of data development and update responsibilities in Oregon.

ORBITS Data Model Goals
- Facilitate data sharing
- Enterprise-Wide (state-wide) Solution
- Transportable
- Simple/Fast/Easy

ORBITS Data Model Principles
- Attributes separate from Geometry
- Bottom Up Approach

[2]See Section V.C - Workshop Presentations for materials used in this and subsequent presentations.

- Multiple Representations of the Network (Not necessary from local perspective)
- Minimum set of attributes to pass along

Mark described the local government perspective, applications, and data processing environment. He contrasted that with the regional (METRO Portland) perspective, which relies on a *"Dynamic Segmentation Data Model."*

He closed with some final thoughts:
- Framework efforts in Oregon (and elsewhere) work from the ground up;
- Local and Regional organizations are already in the business of sharing data;
- Multiple representations of the network are necessary to meet the needs of all users;
- Multiple LRSs exist and need to be accommodated in the model.

Presenter #2 — Steve Sharp described the work of the **Vermont Spatial Data Partnership Project** and its **Transportation Theme Expert Group**.

Steve described Vermont's Framework Demonstration Pilot Project, the history of roads data development in Vermont, and the formation of a technical committee to focus on related issues:

TTEG Mission: Develop a roads data management strategy which assures that compatible, useful, and shareable data is available to the GIS community.

TTEG Primary Objectives:

1) Designate & define a "master" road centerline data layer for Vermont
2) Determine "how" this data layer will be maintained.
3) Determine "who" will maintain this data layer

He described the compilation of a *"Technical Manual for Development & Maintenance of Vermont Road Centerline Spatial Data*" and its contents. He provided the definition of a "Road Feature," the definition of road feature attributes and associated database tables. He described other road model elements and attributes including intersections and routes. He described the "road entity feature tracking" system envisioned in order to maintain traceability through changes in the Vermont roads (RDS) data layer. He closed by addressing two other issues raised in the initial questions:

Who Are The Users of This Model? The "*Technical Manual for Development & Maintenance of Road Centerline Spatial Data*" is designed to help guide future road centerline activities. VCGI, VAOT, and E-911 (and others) will continue toward implementation of this "proposed" road model. Modifications to the model will be required as organizational and technical "issues" arise during implementation.

How Has The Model Been Documented? The model has been documented via Corel

WordPerfect 7.0 and Visio Technical 4.0 software. These tools have provided the necessary functionality to document the "model".

Presenter #3 — Bob Nagel described the work of the **Wasatch Front Transportation Data Integration and Generalization Project** in Utah.

As suggested in the project title, Bob emphasized the dual goals of the Utah collaborators. He listed the following objectives:

- Help all project participants increase their awareness for and experience in accommodating data contributions from geographically distributed organizations.
- Provide important documentation and experience in implementing many of the Framework goals.
- Accommodate resolution and format disparities.
- Investigate the integration of digital orthophoto image data.
- Test *Area Integrator* responsibilities.
- Develop a "proof of concept" framework data set for evaluation by the user community.
- It will help to increase the amount of reliable data available through the National Geospatial Data Clearinghouse.

He provided additional detail on project objectives relating to data integration:

- Assemble the "best" data available of these four counties
  Some will come from locally-generated sources
  Some from USGS Digital Line Graphs (DLGs)
  Some from the State Geographic Information Database (SGID)
  Some from USFS Cartographic Feature Files (CFFs)
  Some from DOQs where available
- Develop the proper tools and procedures for integrating the date from these various sources.
- No new data will be created as part of this project.
- Document data using the FGDC Content Standards for Digital Geospatial Metadata
- Integrate into a contiguous patchwork where it will be checked for any edge matching conflicts with other data.
- Contributing parties have the greatest familiarity with their data and know how best to join together disjoint lines representing roads.
- Helps point out problem areas.

Bob provided detailed tabular information illustrating the attribute structures used to achieve these objectives.

A.2 -- Commentary and Discussion

Workshop planners asked three other individuals to begin general discussion with their views of the commonalities and differences in the presentations, and key issues raised. Nancy Armentrout (ME Department of Transportation), Bruce Spear (USDOT, Bureau of Transportation Statistics), and Jay Clark (Puget Sound Regional Council) initiated the discussion, and invited comments and questions from others. The discussion was wide-ranging; its purpose was to begin an exchange of ideas, not to draw any conclusions. Some key points were made:

- The presentations were different; despite efforts to address the same issues, there was not a lot of commonality;
- Several people noted the need to arrive at a definition of the "atomic unit" from which road segments are made. The three presentations illustrated ways of identifying segments of road based on jurisdictional changes, based on changes in various attributes, or based on definitions of nodes. One listener asked rhetorically whether the use of *different* atomic units in different jurisdictions would in fact have a negative impact on the building of Framework data.
- Listeners noted that Utah and Vermont identify the road geometry as the common unit; in contrast, Oregon views the linear referencing system(s) (LRS) as the commonality.
- Consideration of issues brought about by the need for data maintenance is necessary, but was discussed only in the Vermont presentation. Others are of necessity concerned with these issues, but they have not been identified.
- There was general agreement that the work presented in these three jurisdictions were each implemented within a vendor-specific software environment. One commentator stated the need to step back from the limitations of the current technology, and to build a model that tells the vendors what the user community would like to see.
- There was general agreement that a consensus model needs to include physical features which utilize permanent identifiers not tied to the cartographic layer (line segment) or a road name.
- There was general agreement that a data model has to be extensible; we will want to add features and applications that we don't have or envision now. It needs to allow the "extension" of network connectivity, and the "extension" of LRS or address ranges.
- One commentator noted the absence of discussion about "anchor points" as a concept different that simple nodes that terminate line segments.
- Another commentator noted that units of local government will have to have reasons to contribute to the framework, and that many local applications seem to be address-centric. He felt that consideration of addressing — as attribute structures, a unique identifier, or as part of an LRS — must be central to the model.

A.3 — Small Group Organization

The remainder of the workshop's first day was spent in the formation of small group teams, their organization, and preliminary planning of their work. Individuals who had volunteered service as leaders, recorders and presenters stepped forward and participants were divided into three teams of equal size. Division into groups was non-systematic, but personnel working at local/regional, state, and federal levels were counted among each group. The workshop facilitator reviewed working guidelines for the entire group:

1. Roles of small group leaders, records and presenters were reviewed, and all the tools available (laptops, breakout rooms, marker pens and pads, etc.) were inventoried;
2. Members were to remain working within their team for the rest of the workshop, and the whole workshop group would reconvene several times over the next two days for periodic status reports, and for a final session.
3. The goal of each team was to describe the elements of a road data model -- drawing on their own experiences, the presentations made and reading materials offered — by addressing the same four question areas addressed by the presenters (see pages 1-2 of this Section.) The workshop would end following final reports from each team, summarizing their successes and failures in meeting this goal.
4. Teams would meet for four separate sessions over the next day; the purpose of the sessions were: **A** — Determine the Game Plan, **B** — Outline the Data Model, **C** — Fill in the Blanks of the Model, and **D** — Review Variances within the Team.

B. Thursday, December 4

The second day of the workshop began with a brief meeting regarding logistical arrangements, and ended with team check-in and planning of the final day's presentations. Otherwise the day was for the most part consumed with focused working sessions for each team, punctuated by refreshment breaks. Part-way through the day, following one such break, each team was asked to offer a group response to the following question:

"What are the three questions your group feels that the other two groups <u>should</u> be considering?"

<u>Team One</u>

- Are we considering the <u>real</u> business activities that will drive people to work together?
- Are there different *levels** of information in the Framework, or just one?
- Does the *Anchor* concept help us to work together and to share data?

* more detailed content, <u>or</u> based on "size-o-chunk", <u>or</u> business-differentiated

Team Two

- What are the parameters of the Framework? Do we risk making our "data model" too complex if we step over them?
- How will we communicate data from the model(s) to one another? How easy will it be to communicate, and will other parties understand each others' models?
- How is the process for assigning *Anchor IDs* controlled?

Team Three

- Must an *Anchor point* have (at least):
  - ☞ an x-y coordinate,
  - ☞ a measure of precision,
  - ☞ a physical description,
  - ☞ other attributes?
- In the context of data sharing, what entities need exist in the "data model" other than *anchor points* and *anchor segments*?
- What is the universe of possible Linear Referencing Systems that people might use?
- Is the cartographic representation (of a line) an entity or an attribute?

C. Friday, December 5

The workshop's final day consisted of team presentations, workshop evaluation, and identification of follow up activities. Team presentations are included in **Section III** of this report; the follow up activities identified during the workshop, and a summary of the workshop evaluation is provided in **Section IV**. Workshop time limits did not permit discussion, ranking, or further planning of follow up activities; however this section includes observations of the workshop facilitator and others about follow up activities.

Section III — Workgroup Presentations[1]

A. Presentation by Team Three

Charles Fleming and Steve Davis presented the team's work, using computer slides and paper diagrams. They stated that the teams goal had been try to show what they defined as a model, why they eventually decided it was flawed, and what they did to "test" how maintainable it was.

What is a Road?
- Linear Centerline Pathway
- Start & End Points
- Length & Direction
- Supports travel by motorized vehicles (regulatory restriction)
- Still an extensible model

Related Entities:

Anchor Points
- Stable location
- Recognizable in the field
- Can be shared by more than one section
- Coordinates optional…???

Anchor Sections
- Defined by two anchor points
- Mutually exclusive
- Totally exhaustive
- Non-branching
- Cartographically independent

Mandatory attributes (proposed)
- Unique IDs (points and sections)
- Coordinates (points)???
- Length (sections)???

Others are application dependent

[1]The computer slides utilized by teams one and three are summarized in this section but are reproduced in Section V — Appendices of this report.

A Modest Proposal:

Implement "Internet Style IDs" as a schema for unique addressing of anchor sections; i.e. a multi-sectioned unique numeric identifier in the format *"aaa.bbb.ccc.ddd"*, in which one section is the standardized FIPS code for State/County

Our Conclusions:

- The model works
- Supports 2027 structure (conceptually)
- Anchor points and nodes can coincide
- Links and sections can coincide
- Real-world implementation will vary

Remaining Issues:

- What is the optimal anchor section size??
  - Optimize for data user or data producer
  - Based on cost
- Implementation *now* may be different from the model
- What do we need to produce in the meantime to guide current implementations to a framework consensus?

B. Presentation by Team One

A Road consists of Stable Segments

- Maintainable - Change Management
- Ideal form for area of framework responsibility
- Simplicity of form
- Understandable to users

Consensus Definition of Road:

"A road is a singularly designated path or paths through a road segment network."

- The designation must include name, and may also include route number.
- A road should not contain gaps, overlaps, branches, or loops.

No consensus existed on the smallest length of a road. Ranges existed from 26 ft to 1/10 mile.

Entity Definitional Bounds

- The definition of boundaries of road entities will be different depending on the agencies involved. The fundamental constraints will most likely be governed by the business needs of the framework producer.
- Group consensus centered on public roads.
- Areas of difference were in the private roads. Our sense is that variability is allowed as long as it is well-commented.

Rules Defining Atomic Unit

Shared Management Unit (SMU) refers to continuous linear roadway segments in the transportation system or the numbers that represent them. (This could be extended to inter-modal).

- An **SMU** has always one direction, an origin point and one end;
- A **SMU** has a unique segment of roadway and no roadway segment has more than one **SMU**;
- An atomic unit of a road can be identified by a physical reference number + **From_Pt_ID** and **To_Pt_ID**. However, not all **To_Pt_ID**s are as stable as the **From_Pt_ID**;
- Segmentation will be highly dependent on the extent to which area integration is being done by the agency doing framework activities and business activities.

Attributes on Framework Entities

1. Minimum set of attributes could be:
   a. Physical Reference Number
   b. Point ID's
2. Highly desirable attributes could be:
   a. Road Name
   b. Address Range
   c. Ownership
   d. Functional Class
3. Attributes Allowing Non-Framework Attributes to Link
   a. Road Name
   b. Address Range
   c. ZIP_Code
   d. Measurement

Relationship of Point ID/PR to Anchor Point/Anchor Segment

- Point_ID is very much equivalent to Anchor Point.
- Guiding question to Anchor Segments is "How do they behave under change?"
- Anchor Segment is in a broad sense similar to **SMU** except in the area of trying to achieve maximum stability for change management (especially from an Area Integrator standpoint).

With these goals in mind, some suggested guidelines:

- Create fewer new **SMU**s;
- Create longer **SMU**s;
- Start **SMU**s at intersections with another **SMU**.

Documentation -- simplicity is the key; it should include three elements:

- Simple model
- Example (real world)
- Narrative explaining both

C. Presentation by Team Two

Steve Guptil described **Network Datum Points** and **Segments,** as they had been discussed by the team:

NETWORK DATUM POINT (NDP)

DESCRIPTION: Field recoverable point at intersections on the network or at stable field recoverable positions

ATTRIBUTES:

- Unique ID
- Description of location
- Coordinates (X,Y,Z) - including projection, datum, etc...
- Coordinate precision
- Date/time stamp

NETWORK DATUM SECTION (NDS)

DESCRIPTION: Non-branching path connecting 2 Network Datum Points

ATTRIBUTES:

- Unique ID
- ID of beginning NDP
- ID of ending NDP
- Description of path between the NDPs
- Distance measure (optional) - including source and measurement system
- Directionality is implied by the beginning and ending NDPs

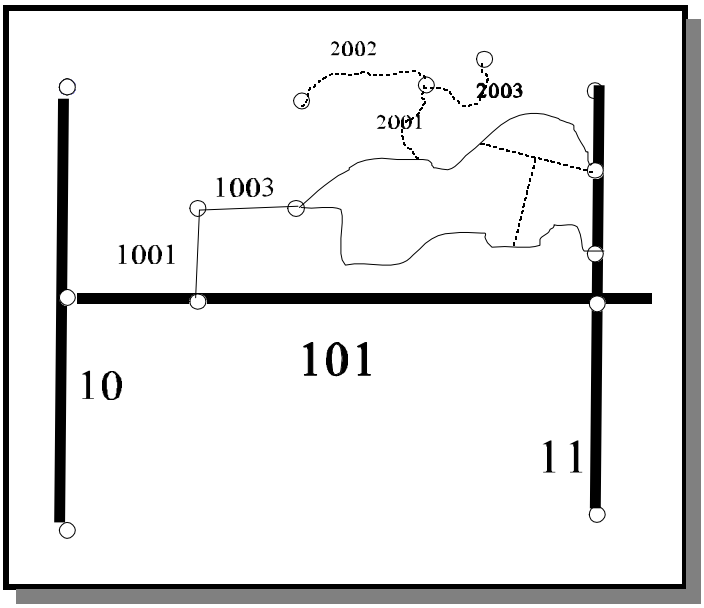


Figure 1 — Network Datum Points established by a hierarchy of Authorities

- *Network Datum Points / Segments* are maintained by a hierarchy of authorities;
- "New" segments occur as events along existing segments. These events can by considered or ignored by other parties, according to their business needs;
- Applications build networks for their business activity — as needed — from the hierarchy of pieces available.

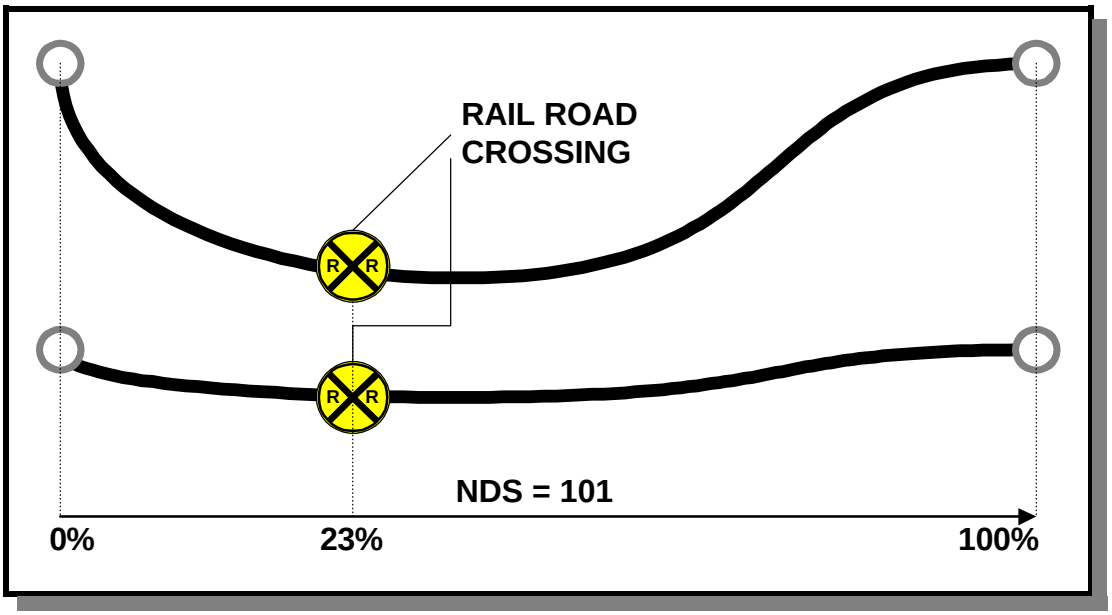


Figure 2 - Associating a railroad crossing on two different "cartographic" representations of NDS 101, utilizing *Percentage of NDS*

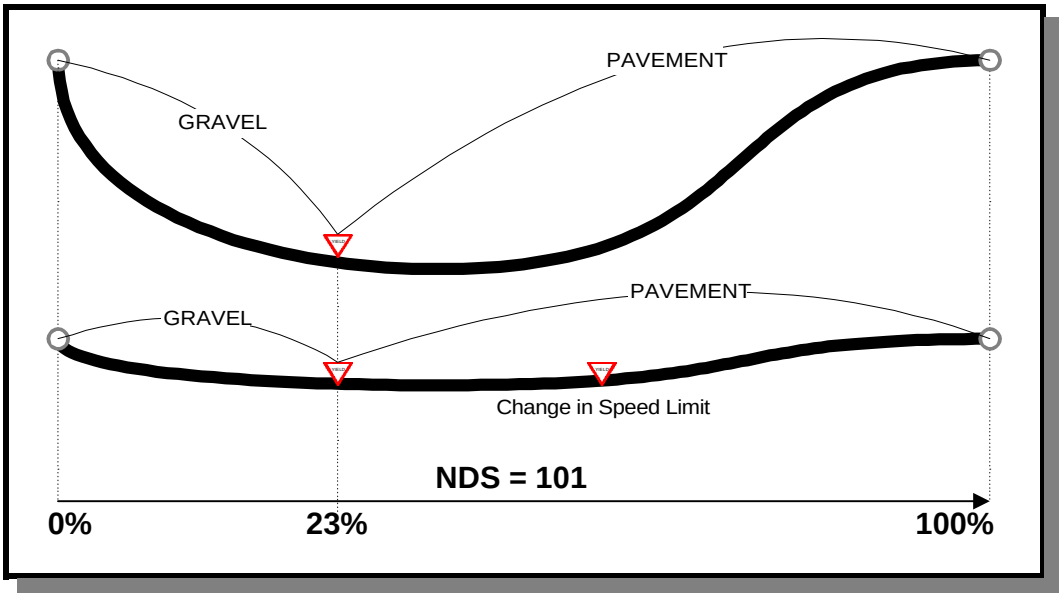


Figure 3 - Associating pavement type on 2 different "cartographic" representations of NDS 101

- Directionality is implied by Begin_NDP & End_NDP
- Additional attribute values (Speed Limit) can be represented on a representation of NDS 101 by computing another percentage value

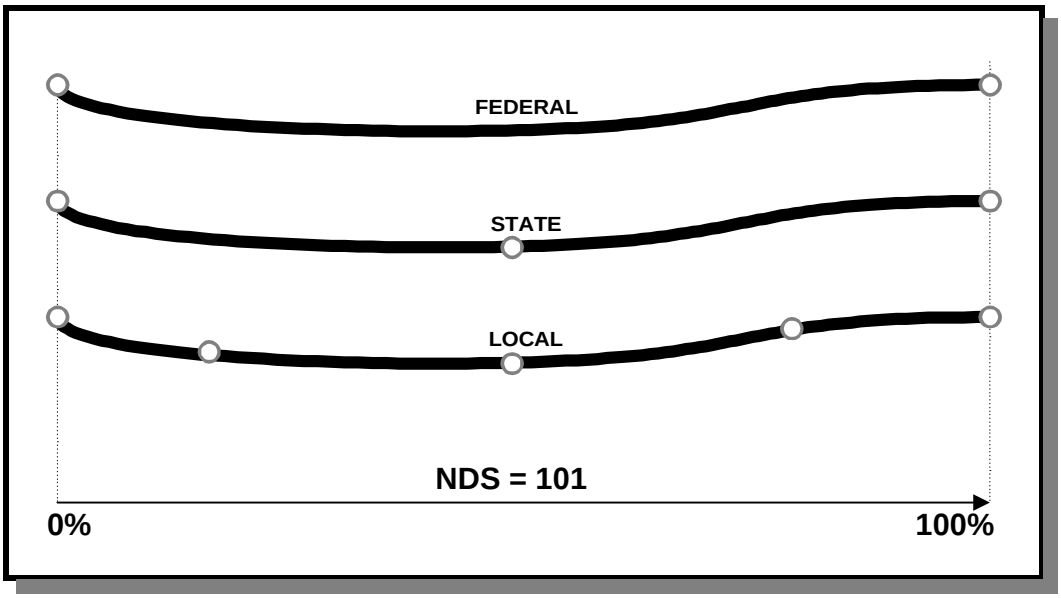


Figure 4 - Different stake-holders can sub-divide as they wish; it does not impact NDS 101

TO DO:

- Need to define method of associating shape and other attributes to the NDS
- Need to determine content of **Framework** (i.e. "driveable" roads, trails, etc.) roads — a *subset* of the total information base
- Need to determine framework attributes and coding schemes, rules, or descriptions (metadata)

OTHER IDEAS:

- *Network Datum Points / Segments* are maintained by a hierarchy of authorities; i.e., responsibility for assignment of blocks of ID numbers is broken down within each state;
- "New" NDSs are associated along existing NDSs as "events". These "events" and NDSs can be considered or ignored by other parties, according to their business needs;
- Applications build networks for their business activity — as needed — from the hierarchy of pieces available;
- The "model" needs to be independent of the content; therefore, it should also be sufficiently robust to include roads, trails, bike paths, bus routes, etc.

D. Questions & Discussion

The time available closed with a good bit of open discussion of some of the diagrams presented by the workgroups. Much of it was concentrated on the road network diagramed below, with emphasis on the maintainability of "Anchor Points" and "Anchor Segments" and of hierarchies of cartographic representations and LRSs.

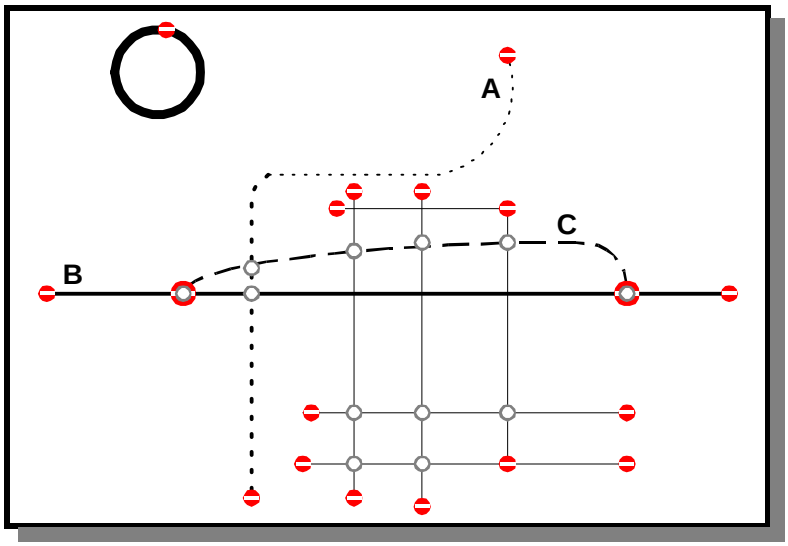


Figure 5 - A complex maintenance scenario

The session concluded with the development of a list of "next steps," which is covered in Section IV of this report. However, in the course of discussing the team presentations, there was general agreement that three follow up steps would be particularly worthwhile:

- Participants felt that development of a "straw man" document(s) incorporating the features of the "20-27" model and the ideas set forth at this workshop should be drafted for review and comment by participants and others;
- Participants suggested that Framework sponsoring agencies develop a TIGER-based data set utilizing Anchor Points, Anchor Segments and other concepts from the model; and
- Many favored additional workshop(s) in which practitioners could actively use these and other materials and develop consensus around particular questions and issues defined here.

Section IV — Conclusions and Next Steps

A. Next Steps

At the final plenary session workshop participants were asked:

> *"Think about the three presentations you heard Wednesday, today's Group Presentation and your own experience. What is your list of issues that remain to be resolved, questions that need to be answers, or actions that should be taken? State each as a question (if possible). If you can, indicate who should answer it, and by when."*

The list of responses they generated follows:

1. How do we complete the data model implementation guidelines, examples, specifications for attributes, metadata and features?

2. How do we define the process of assigning IDs to anchor points and sections? Options: start with TIGER.

3. How do we develop an implementation plan incorporating nested roles?

4. How do we communicate with those who could be involved?

5. What is the appropriate size for an anchor segment?

6. How do we distill these three models into a model that will work for the most people?

7. What issues or topics might FGDC / FDPP (Framework Demonstration Pilot Project) pursue / fund?

8. What limitations (if any) might be encountered in existing software when trying to implement the models?

9. Can anchor points/anchor segments handle loops without coordinates which describe the segment?

10. Should the framework content and model be adopted through some formal process (including sign off), or should they just be formulated as a "guideline"?

11. What is the framework data set content for "the masses"?

12. Can we provide guidelines for choosing SMU (shared management unit) size?

13. How do we resolve technical problems we've all avoided? (In concept and in pilot projects)

14. What incentives can be provided to get the greatest range of organizations to participate?

15. After resolving the issues and testing implementation, who/how will we test the utility (of the model(s))?

16. What is the impact of this on participating agencies? What problems will they encounter? What can "you" do?

17. How do we gather the existing literature to bring consensus across participating groups?

18. Are address data best handled with the scheme(s) discussed in this workshop, or is another approach needed?

19. Given that we're not far along, how do we apply these concepts now?

20. What attributes are used in business practices and should be shared; can they be standardized?

21. Would it be useful to have a layered model?

22. Should ID assignment be implemented top down, or allow for multiple assignments authorities?

23. Should there be a Feature classification attribute assigned to anchor sections?

24. Can we disaggregate this discussion of data exchange models (from technical issues) so we can make some kind of statement? If so, what?

25. What groups that should be considering this are not yet engaged in these discussions?

26. Does the model support "nested" datums?

27. How easy will it be to transition from a core model to implementation?

28. Should length be required for anchor sections, or is a percentage good enough?

29. When does an anchor section or point get retired?

30. How can we present the model to "the masses," and do we need to?

31. How/when do we get software vendors involved?

32. How does this model relate to other linear Framework features?

33. Can we agree on common terminology?

34. What are appropriate locations for anchor points?

35. Do all other transportation attributes link to anchor sections via LRS (linear referencing systems)?

(Participants agreed that their understanding of these issues would benefit from taking the time to review this list, discuss and explain many of the points, consolidate those that are similar, and perform a ranking exercise. However this list was developed at the final session of the workshop, and time was unavailable to complete these tasks.)

B. Participant Evaluation

Near the end of the final Workshop plenary session participants were asked to respond to questions evaluating the workshop facilities, process, and content. All but a few of the participants provided anonymous opinions and suggestions. About half of respondents used the suggested numeric responses -- “1-Excellent” to “5-Poor” -- to the evaluation questions asked. On all but one of the evaluation questions, average numeric rankings fell between "1" and "2".

Facilities and Logistics — Most respondents provided positive comments about the hotel, meeting room, accommodations and the assistance provided by the meeting planners. In contrast with earlier FGDC Framework workshops, much of the pre-meeting communication relied on email and Web tools, rather than FAX and email. Planners of future meetings should note that -- although these technologies worked well for almost all participants -- a few attendees were left "out of the loop" until quite late in planning stage. These failures in communication generally resulted from changes or errors in email addresses; in the future planners should be prepared to use express mail or fax as communication tools to "back up" electronic communications.

Although everyone was pleased with the facilities in Wrightsville Beach, about a quarter of respondents did not find flying to Wilmington to be convenient. Several objected specifically to the high ticket prices charged to FGDC, or noted the difficulties of getting to Wilmington on many of the major airlines. Representative comments:

- *“Maybe a location near a major airport; although I liked the quietness of an away location.”*
- *“[The people in charge of logistics were] very professional and courteous.”*

Meeting Process — Meeting planners recognized that the meeting would proceed within certain constraints. For example:

- two-and-a-half days, plus travel time, was the established time frame;
- no more than 25-30 persons could be accommodated;
- on-site printing & duplication facilities, plus projection of computerized presentations and physical transparencies, were planned for;
- large writing pads were provided for plenary and small-group sessions;
- notebook computers were available for all small groups (with some variation in the software and skills available);
- some other techniques and facilities were considered but not included, for reasons of cost and convenience.

The agenda called for a mixture of plenary and small-group sessions. The number of participants allowed for three small groups; membership in each was assigned randomly, but individuals stayed with their groups throughout.

Plenary sessions during the first and second day were utilized for presentations to the whole group, and clarification of assignments made to small groups. Later plenary sessions were used for sharing issues and problems identified within small groups, and for reporting small group

deliberations and recommendations. Comments follow:

- *"Small groups seemed to be VERY effective; this means six people or less in each is GOOD!"*
- *"Workgroup process is very beneficial, especially the small working groups. These groups are where we 'rolled up our sleeves.'"*
- *"Tools OK, process OK, but timing on small groups should have been a little longer.. Maybe an extra day."*
- *"A bit more focus is needed in defining the problem to be addressed up front."*
- *"Need more time to review agenda and focus discussion. We should have all read the "20-27[1]" report before coming, and should have had the author(s) to make a presentation."*
- *"I would have appreciated longer mid-day breaks to enjoy the amenities of the beach, and to facilitate informal group interactions."*
- *"I liked the process -- it provided an opportunity for ALL to contribute."*
- *"[There were] "Few digressions or 'personal position preaching.'"*

Content — Workshop planners agreed that the content of the meeting would be based upon three presentations made and the plenary discussion on the first day, and on the sharing of ideas among the three workgroups. Planners hoped to foster information-sharing and analysis by providing documentation from various projects digitally[2], using a workshop WWW site, in advance. Some comments related to the content are included below:

- *"I expected more of the theoretical modeling, but was glad to see that we weren't limited to that."*
- *"Nice job with the establishment of a web site. Continue the web site prior to (future) meetings. Place results on the site."*
- *"Perhaps more lead-in with examples of past efforts as examples. But I think the value of these workshops lies in NOT leading the participants down a particular path; just keeping them on a path."*

[1]The Research Results Digest *"A Generic Data Model for Linear Referencing Systems"*, which describes the findings of the National Cooperative Highway Research Program (NCHRP) Project 20-27, was made available to participants at Wrightsville Beach, and was the subject of much discussion.

[2]The *Appendix* Section of this report includes materials made available to workshop participants in advance. Section V.B - *Survey of Workshop Participants* was generated by participants an put on the Web site prior to the workshop, as were numerous technical documents they contributed, which are listed in Section V.E - *List of References / Sources.*

- *"I think the groups were able to thrash through a lot of concepts with a good degree of flexibility and still end up with coherent results. The processes and discussions were actually more valuable to me than the distillation at the end."*
- *"Need more work in other areas: attributes, common business practices."*

Improvements — Participants were asked how they thought workshops could be improved:

- *"I think the requests for agenda items, suggestions, etc. before the workshop are very important, even if you have to nag people to provide input."*
- *"Allow more time for 'What are we doing?' and 'How can we understand what others are doing?'"*
- *"[We need post-workshop] Follow on: narrow focus on problem areas for resolution. A technical areas focus."*
- *"Should have had a presentation on current work; the "20-27" report is two years old."*
- *"It might be useful to have workshops in major application areas and then a general workshop to consolidate common concerns."*
- *"Keep focusing on very narrow framework areas."*
- *"Subsequent road model workshops should focus on questions raised in this one."*
- *"Build on the past [workshops]; take the commonalities and use them as the starting point for the next, so the old ground isn't covered again."*
- *"Someone needs to test the concepts developed in this workshop."*
- *"My mind is numb from the outstanding ideas here presented."*
- *"Perhaps next time we could develop some working models on the fly? Develop a test data set we can show our ideas implemented on. . .probably too hard to accomplish."*

Other Comments — Finally, participants had the opportunity to provide other comments. Many covered the same general areas as included above, but several looked to the future:

- *"How will this be followed up? We need to clearly state the next steps or we'll lose progress made."*
- *"Next steps need to be identified, agreed to(or at least discussed) and perhaps responsibilities assigned."*
- *"What's the process after the workshop? Where is the FGDC going with the ideas generated?"*

C. Facilitator's Observations

(The Workshop Facilitator's role included responsibility for producing this Report. In other Report sections I have tried to report the activities of the Workshop and the contributions of the participants. I have indicated consensus only when it was apparent to most participants or was developed in a ranking exercise. In contrast, the "Observations" contained in this section are my own, and do not necessarily represent the opinions of FGDC or the Workshop participants.)

— Bruce Westcott

After reviewing the goals for the Workshop (as provided to participants before the event in the "Prospectus") and the efforts of the participants in Wrightsville Beach, clear achievements of the Workshop can be noted:

- Experienced representatives of agencies and programs which consider themselves to be building and using spatial transportation data consistent with NSDI Framework specifications[3] came together. They share detailed information about the similarities and differences of their work, and were surprised at the degree of consensus achieved in defining the characteristics of a Framework Transportation Data Model.
- They outlined elements important to such a model, and identified areas in which any of the existing models or data structures in use are insufficient. They "brainstormed" a list of helpful next steps and tasks which should be accomplished.

The workshop did not achieve some of what it might have. However many participants felt that they were ready and able to continue work on several of the very specific technical tasks outlined, but that the two-and-a-half-day time frame planned necessarily ended their work.

- Participants identified the need for consistent and precise terminology in defining the elements of the model, and were eager to both learn and use a common language in analyzing their needs and problems.
- Participants in each small group felt that the work of the other groups was quite similar to theirs in many respects. They regretted their inability — again because of time limitations — to more closely analyze and synthesize elements of the three separate models envisioned.
- Several participants recognized that greater advance preparation — in particular the establishment of some shared level of understanding of the work of NCHRP Project 20-27 — would have tightened the focus of their discussions.

Several observations and recommendations can be drawn from the experience of facilitating this Workshop:

[3]See the FGDC report *"Development of a National Digital Geospatial Data Framework"* (the "Blue Book"), April 1995.

Facilities

1. Selection of sites near airports providing access by more than one major carrier will reduce FGDC costs and increase participant convenience. Use of conference facilities at which some meals — particularly "short order" lunches — are available without leaving the facility allows participants to stay on schedule and focused on their work.

2. The privacy of dedicated breakout rooms, and the use of laptop computers and projector panel(s), on-site printing and duplication, and resultant on-site development of workshop materials enliven the articulation and sharing of the substance brought to the workshop by diverse participants.

3. Use of facilities which encourage informal exchanges among participants *contribute substantially to the work accomplished*. Pleasant out-of-doors settings, undisturbed group work areas, and informal lounging, workout, and dining facilities are important support systems for between-session networking and group assessment of ideas and progress.

4. Some technical topics may be best presented and analyzed by participants with the use of specialized computer software for presentations and diagraming. Future workshops may benefit when plans call for the inclusion of participants who are fluent in using these tools.

Meeting Process

1. Most Wrightsville Beach participants demonstrated willingness to contribute and digest written materials in advance of the workshop. Such work in advance directly increases the engagement of all participants and the amount and quality of work they can accomplish onsite.

2. Future workshop planners should assure hardcopy (fax or postal) backup to any or all materials exchanged over the Internet. The Wrightsville Beach participants included some representatives of public agencies for which email and WWW access is not yet fully available. In several cases materials did not get to them, or arrived late, because of failure to anticipate this problem. Use of email and a website is *very convenient and efficient* for most participants, but should not constitute barriers to participation by others.

3. Planning and participant selection should be done with greater lead time. Particularly because of the intervention of the Thanksgiving Holiday, time for invitees to make plans to attend and to devote time to preparation was too short. Shortness of time contributed to a more complex set of planning questions, which should be examined afresh in planning subsequent workshops:

   - To what degree should participants be encouraged to contribute to, or even be asked to take responsibility for workshop agenda planning and development of presentations?
   - Can the final determination of workshop objectives be left to the participants themselves, as part of their on-site work together?

In general planners should consider the role of participants in setting the agenda and defining the goals of workshops. As part of their evaluation several Wrightsville participants expressed frustration that agenda and goals were not clear to them, in advance. It is possible that some invited participants were unable to attend because they felt the lack of clarity precluded their being able to justify the activity.

4. Issuance of an agenda well in advance of the meeting will reduce the anxieties of some participants. The "Prospectus" issued in advance was quite helpful as to content, but some participants would fine useful a traditional agenda, i.e. a schedule of sessions, in advance — even if it is subject to change on-site.

5. More substantial involvement of participants in establishing elements of the agenda, goals, and group processes to be used was suggested by several participants. Such involvement would certainly require more effort — in the form of conference calls, circulation of and response to drafts, and consensus-building — in advance. Such effort should be considered when planning future meetings, but may not be appropriate. Sometimes — as was the case for this workshop — meeting planners wish the formulation of specific goals and deliverables to be a part of the meeting process itself. In this case such efforts might have proved a disincentive for much of the creative work which was actually accomplished.

6. Designation in advance of small group facilitators, recorders and presenters was helpful to the workshop process. All who performed these duties did so willingly and energetically, but not all were judged equally successful by participants. Additional focus on selection and briefing of these individuals would be effort well-spent. Specifically, preparation for future workshops should include either conference call(s) or a pre-workshop on-site session in order to enhance their effectiveness.

7. Finally, workshop planners agreed that small-group work would be extensive, and that selection of groups would be unsystematic. Some participants felt that selection based on ideas or personalities or skills would be more useful. Such a selection process should be considered for future meetings; however, attempts to make systematic selections may offer more pitfalls than solutions.

Personal Observation

It was a privilege, as well as great fun, to play a part in facilitating a meeting of individuals who worked as hard and as productively as did those who participated in the Wrightsville Beach workshop. Their individual enthusiasm and dedication supports my expectation that their work will prove to be a substantial contribution to the ultimate development and implementation of Framework Transportation geospatial data.

D. Participant Follow Up

Two workshop participants prepared additional comments at or immediately following the workshop. Undoubtedly other participants were also stimulated to further thought, but these two provided the facilitator with prepared materials. Although they were not discussed at the workshop, they include valuable ideas for consideration.

Zsolt Nagy pondered during the workshop questions related to the implementation of Framework practices across organizational partners. He formulated a number of questions related to organizational concerns, offers some prospective answers, and provides a view of the Framework in the larger context of organizations and society.

Practical Questions:

1. What does the Framework data set look like to each group in government & society?
2. Who (or what) is the "Framework provider?"
3. Have we agreed that Framework data can be anything that the data provider needs it to be?

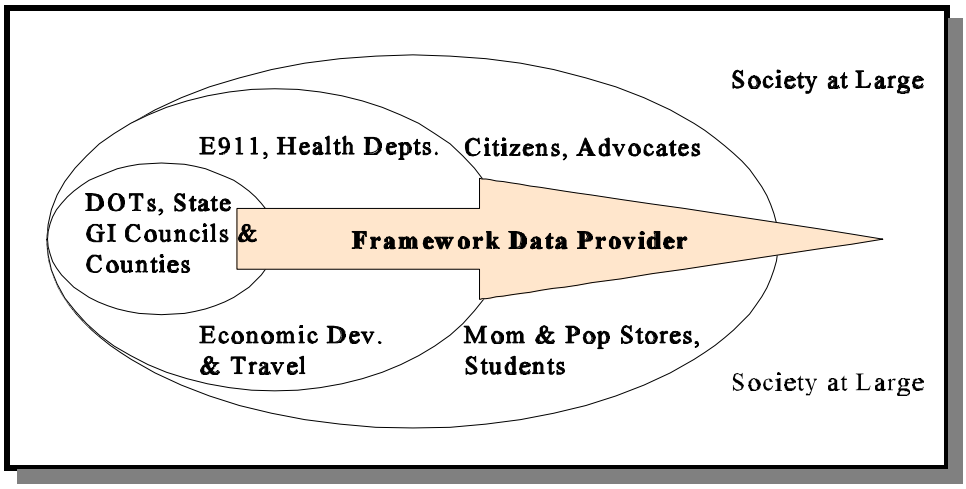


Figure 1- A "Practical View" of the NSDI Framework

Organizations view the Framework Differently:

- A very few -- one or two -- organizations (at left) have robust requirements and are often willing and able, or are positioned to, be a provider of Framework data set(s);
- More organizations have expectations of Framework data sets, based on specific functional requirements. These agencies need to be able to link their attributes to the Framework;
- Many more organizations and individuals (at right) will use the Framework data sets when they are available, making use of whatever content they contain. They may not be in a position to articulate requirements, and their use of Framework is serendipitous.

Dan Walters offered the following discussion of anchor points and anchor segments in a memo entitled *"Reflections on Wrightsville Beach:"*

> A very simple, yet powerful, data model emerged from the combination of concepts proposed by the three groups. A multi-tiered system of "monuments" much like the one used by the Geodetic Survey (HARN, primary, and secondary), both in concept and ownership, with Internet address style IDs[4] provide a great model to share and maintain the geographic data and attributes associated with any "road". We [Maine OGIS] are using an Internet style of nomenclature to code our 1:24,000-scale hydrography. In this case the codes distinguish between different stream orders ....first, second, third etc. Thus far, it appears to be a logical way to code these data. The levels of proposed trans framework system could be as follows:

- represent interstate transportation features and US routes,
- anchor points would occur at:
  1) the state boundary of each,
  2) where they intersect each other,
  3) at a state route, and/or
  4) at their end point;
- an anchor segment would be defined between each pair of anchor points.

1- Level 0 Anchor Points and Anchor Segments

- represent state highways
- anchor points would occur at:
  1) the state boundary,
  2) where they intersect each other,
  3) at a county road, or
  4) at their end point;
- an anchor segment would be defined between each pair of anchor points.

2- Level 1 Anchor Points and Anchor Segments

[4]A typical Internet protocol (IP) "address" assigned to any device consists of up to four numbers separated by decimal points, as in "132.198.131.51". Assignment of addresses follows a logic dictated by the hierarchy of "domains" in which the device resides.

- represent county highways
- anchor points would occur at:
  1) county boundaries,
  2) where they intersect each other,
  3) at local roads, and/or
  4) at their end point;
- an anchor segment would be defined between each pair of anchor points

3- Level 2 Anchor Points and Anchor Segments

- represent local roads;
- anchor points would occur at:
  1) town boundaries,
  2) where they intersect each other,
  3) at private ways, and/or
  4) at their end point;
- an anchor segment would be defined between each pair of anchor points

4- Level 3 Anchor Points and Anchor Segments

1. All anchor point IDs are permanent based on Internet address style coding
2. Anchor segment IDs are unique but not permanent. They will change as new road anchor segments are added or the road is realigned.
3. Because anchor point IDs are permanent, it does not matter if the anchor segment IDs change, as any data user can attach transferred data, geographic or attribute, based on the anchor point IDs. This simplifies road framework data maintenance.

5- For All Levels

Section V -- Appendices

Section V.A — The FGDC Framework — An Overview

What is the Framework?

http://www.fgdc.gov/Framework/Overview.html

Seven themes of digital geographic data used to provide:

- a "geographic data base" to which an organization can add geographic details and attach attribute information needed for an application.
- a "base map" on which an organization can accurately register and compile other themes of geographic data.
- a "reference map" to show the location of the results of an analysis of other data.

Procedures, guidelines, and technology that will:

- allow accurate, detailed data being produced by participants to be certified and integrated into a data framework that will be trusted and widely used by the community.
- provide a means by which users can update their data holdings from the framework data.
- provide a means by which users can attach additional information to the framework data.

Institutional relationships and business practices that will:

1. **Create, maintain,** and **distribute** framework data for a geographic area by:
   - integrating data that are available from local, regional, State, and Federal government agencies, and private sector and other organizations.
   - organizing partnerships to create needed data that do not exist.
2. **Encourage** widespread use of the framework data by:
   - being responsive to the needs of the community.
   - avoiding restrictive policies for data access and dissemination.
   - providing data at low cost.

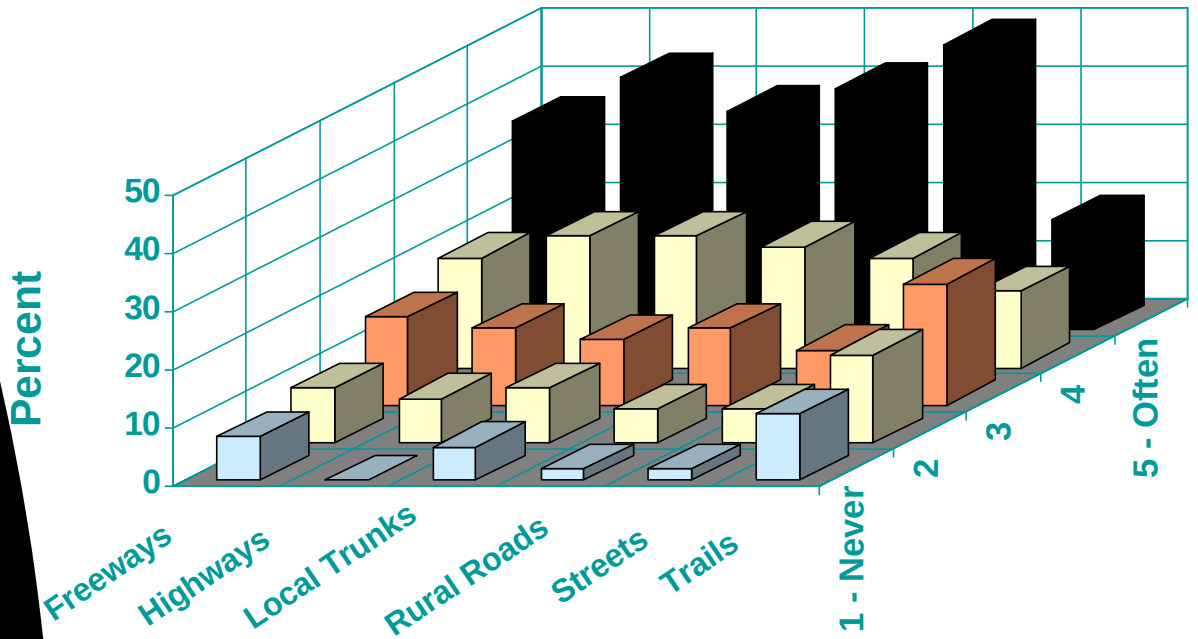
Framework Road Data Models

Michael A. Domaratz
FGDC Secretariat

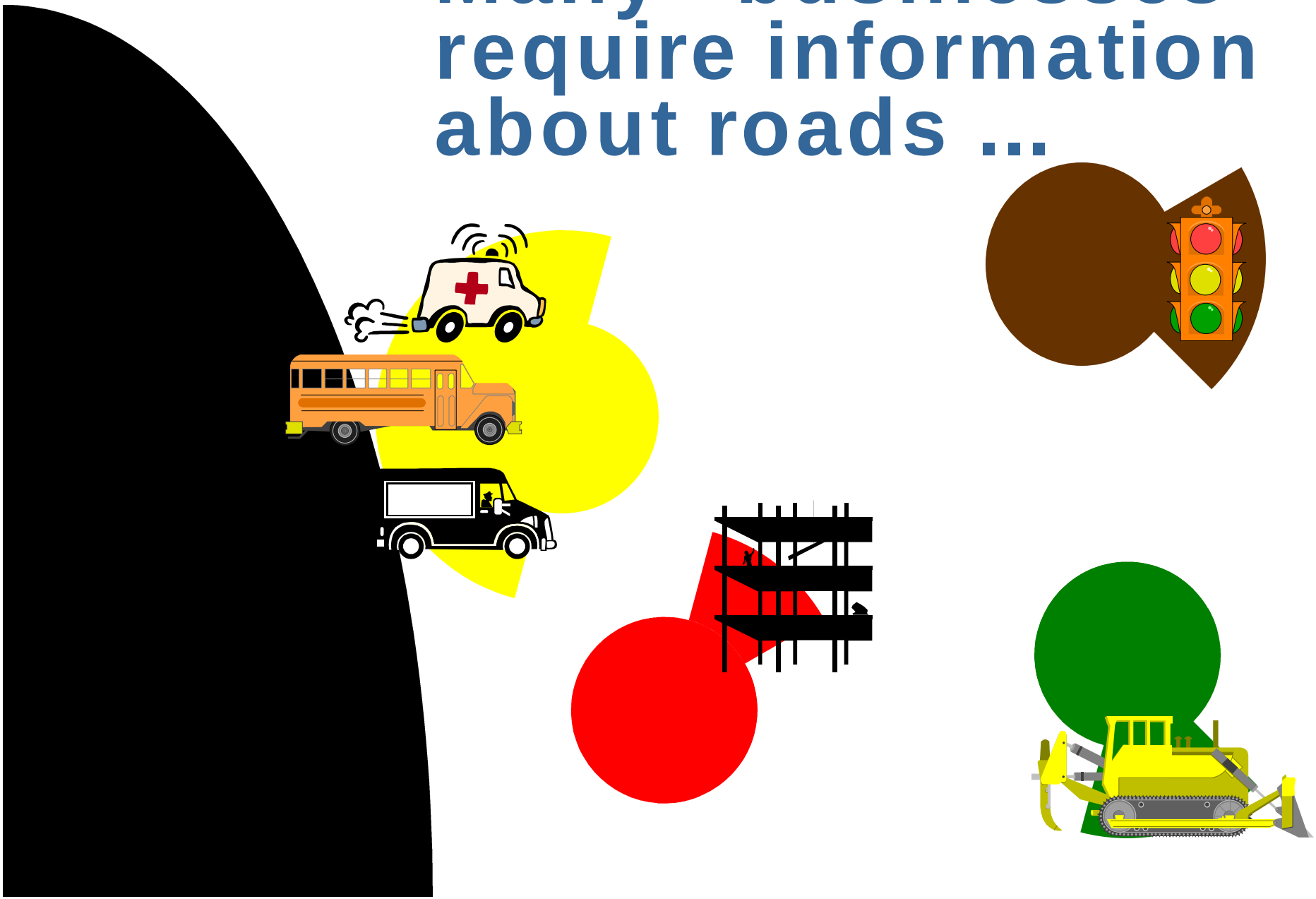
Topics

- Remember the framework?
- Data model? We can do that …
- Towards a data model that helps us with the framework ...

How often do you use transportation geographic data?



Many “businesses” require information about roads …



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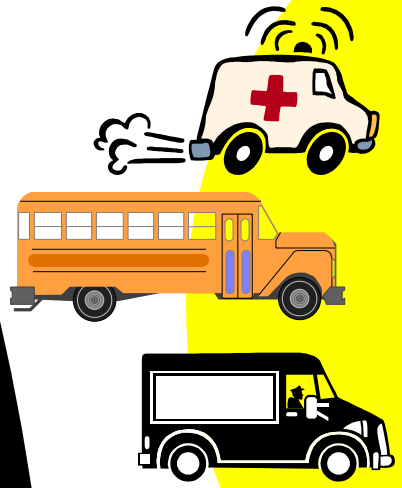

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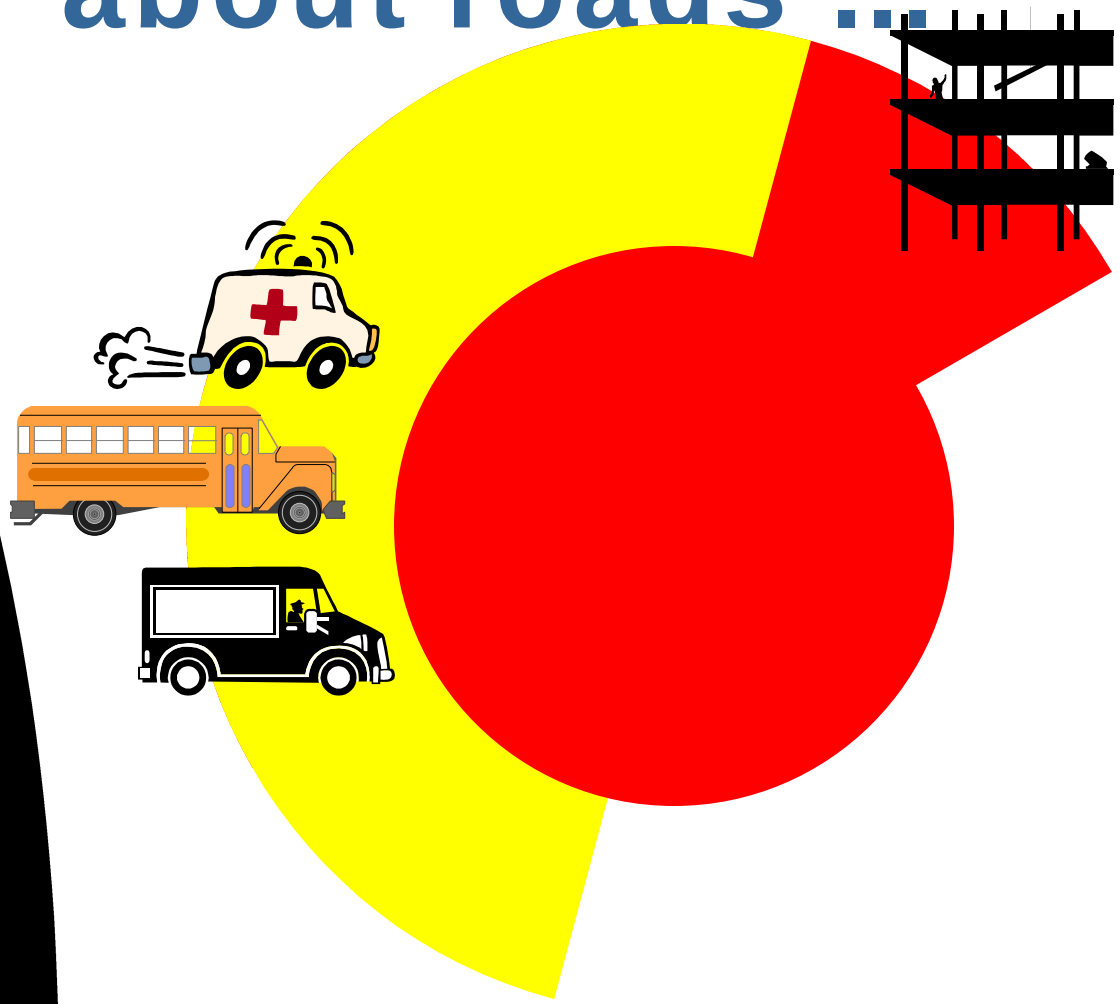
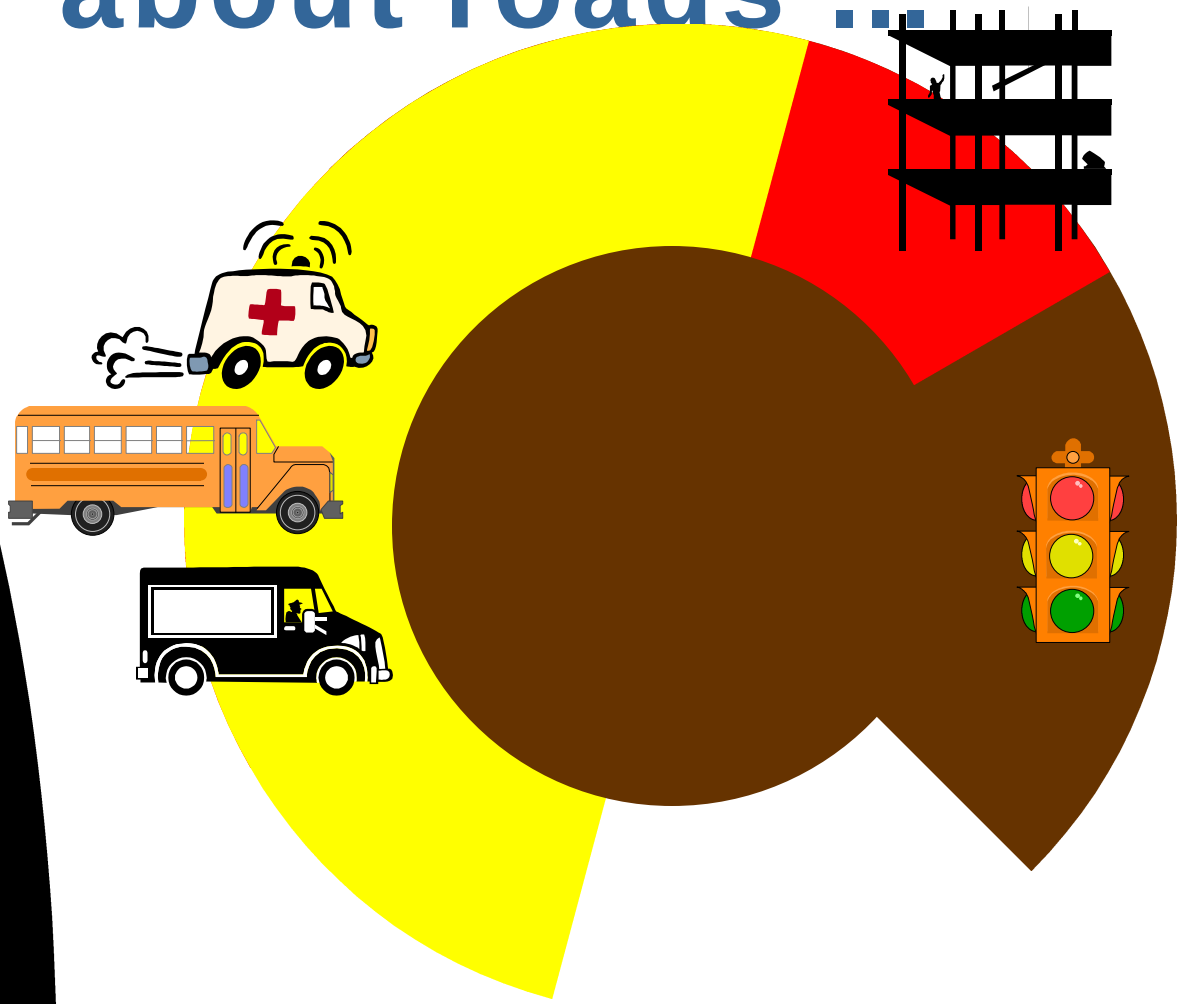
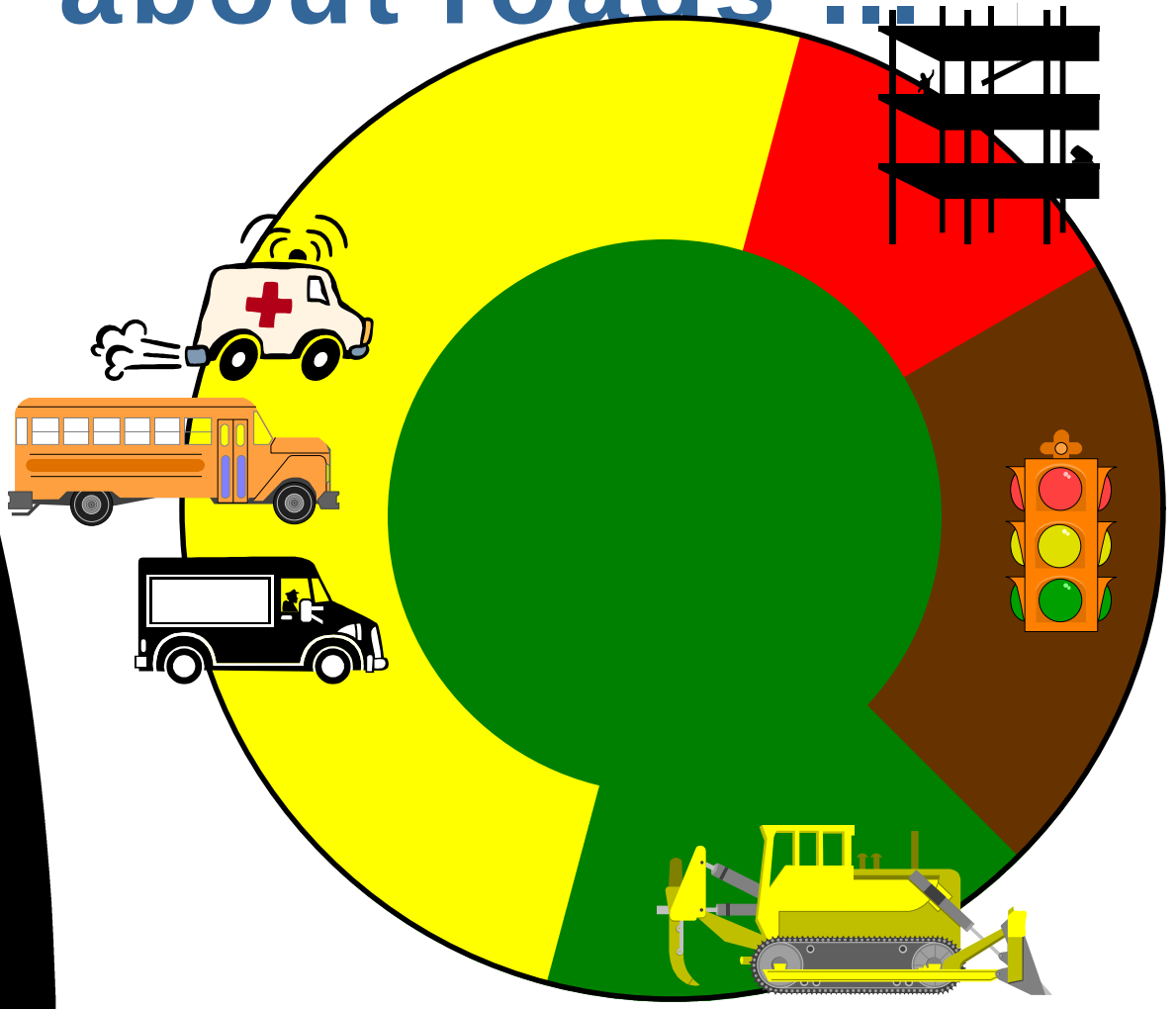


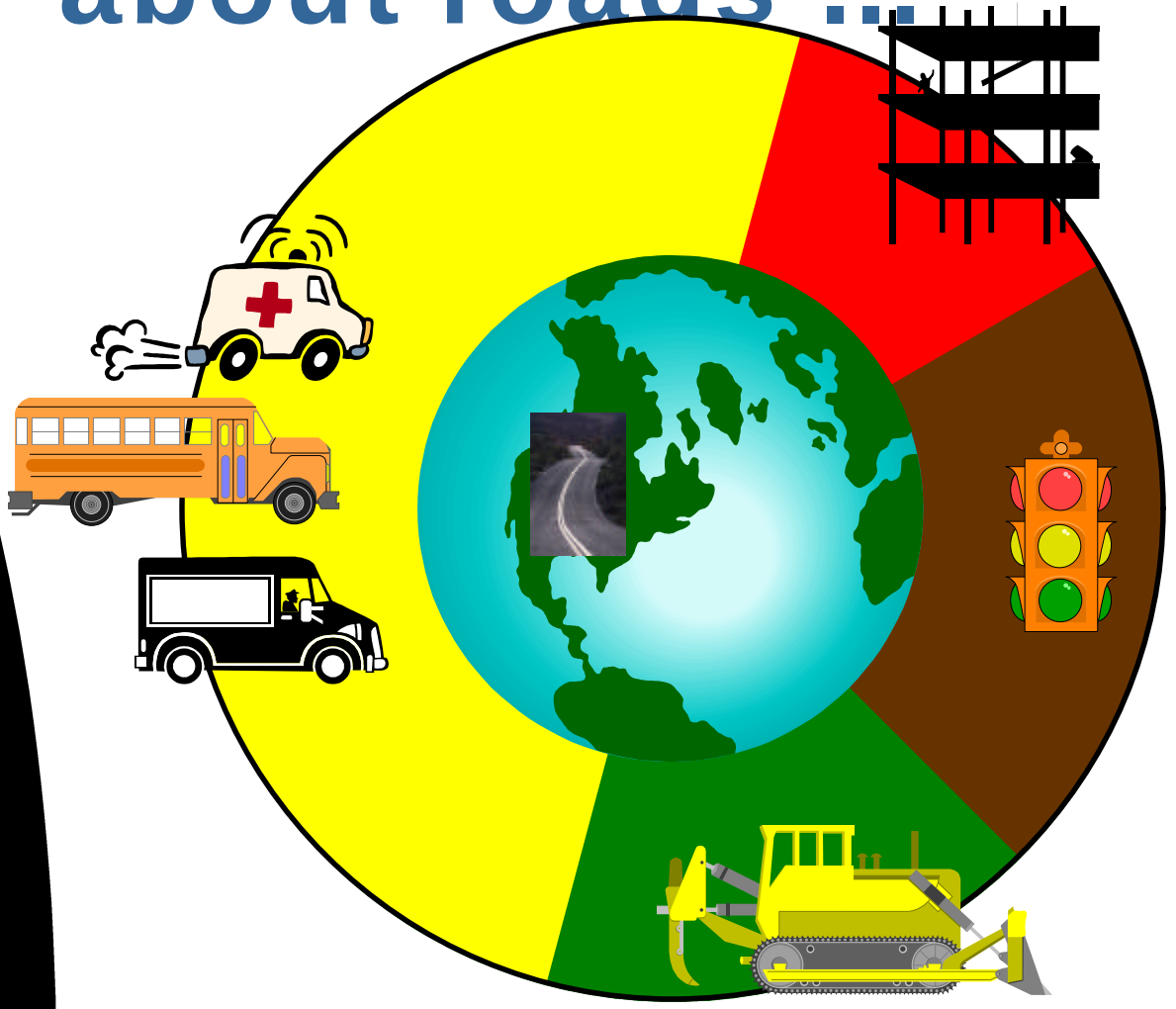
Many “businesses” require information about roads …



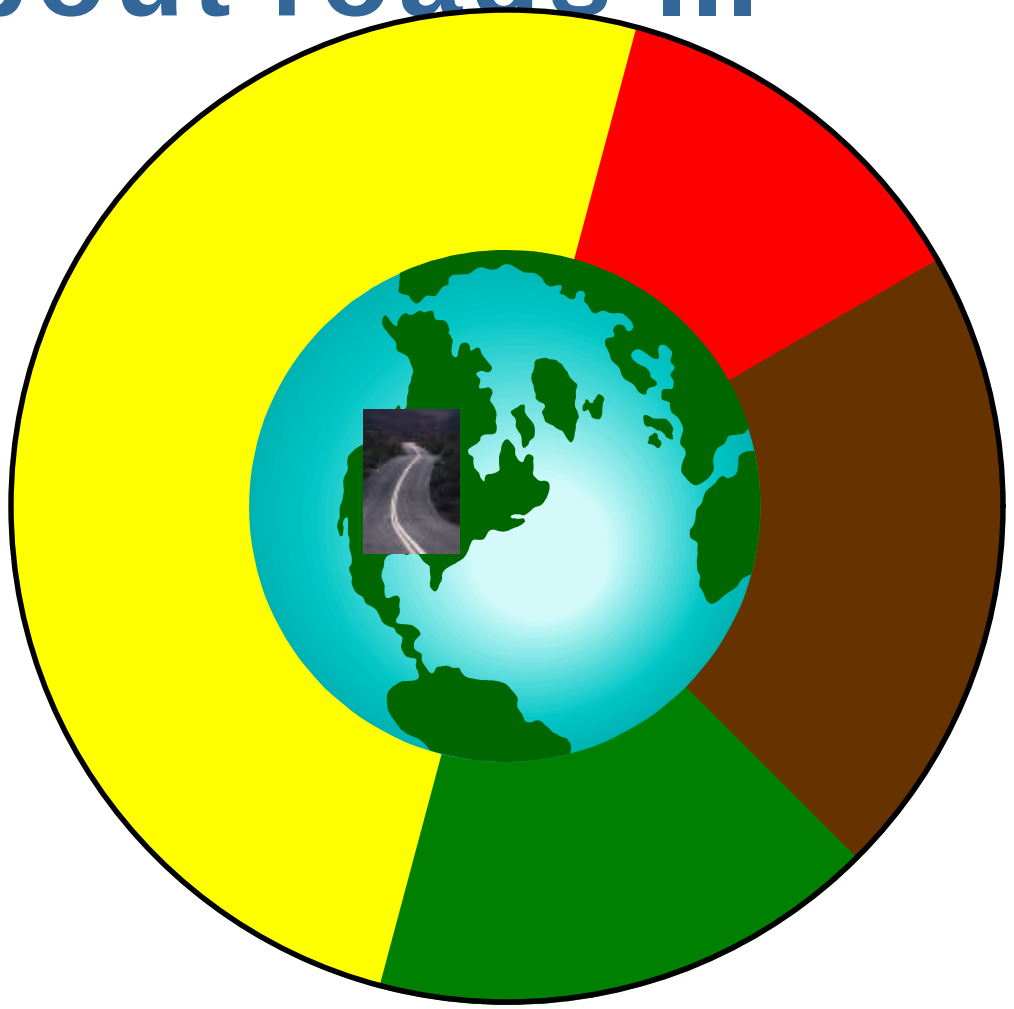
Many “businesses” require information about roads …



Many “businesses” require information about roads …

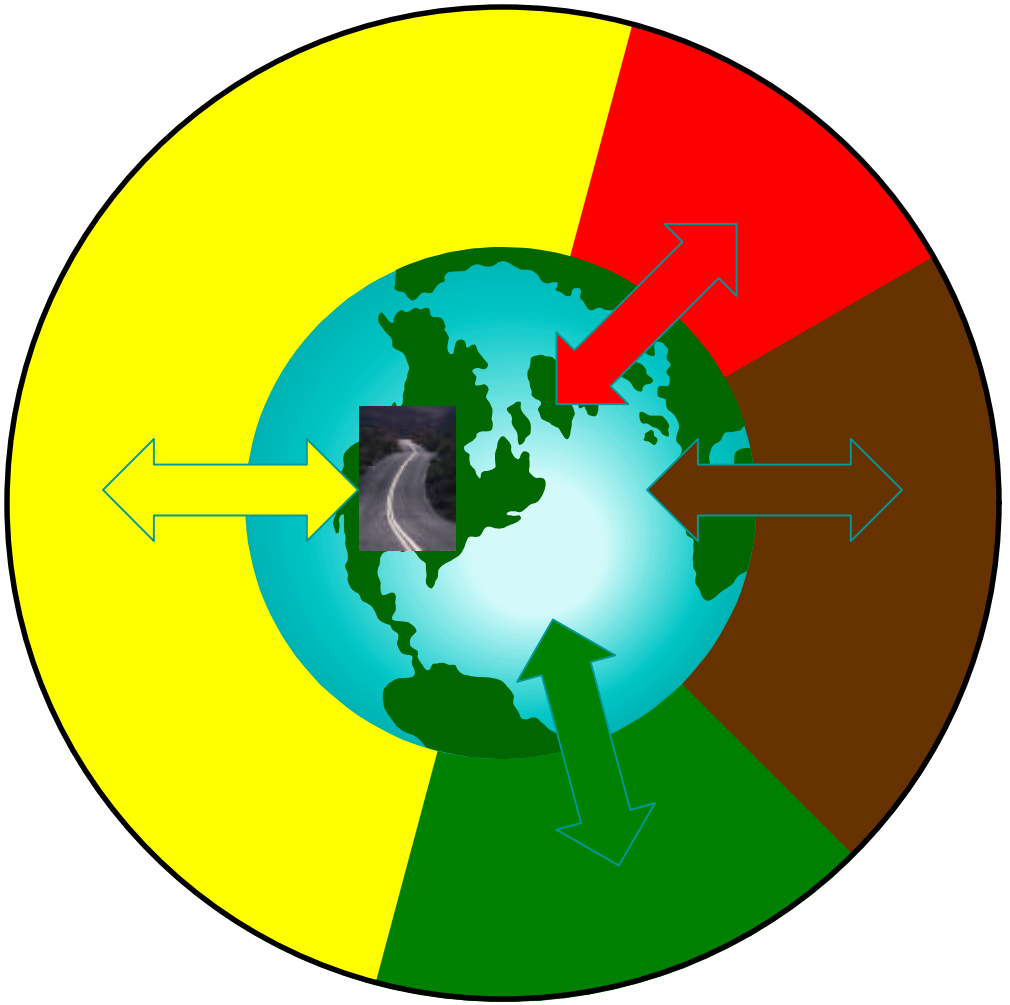


Many “businesses” require information about roads …

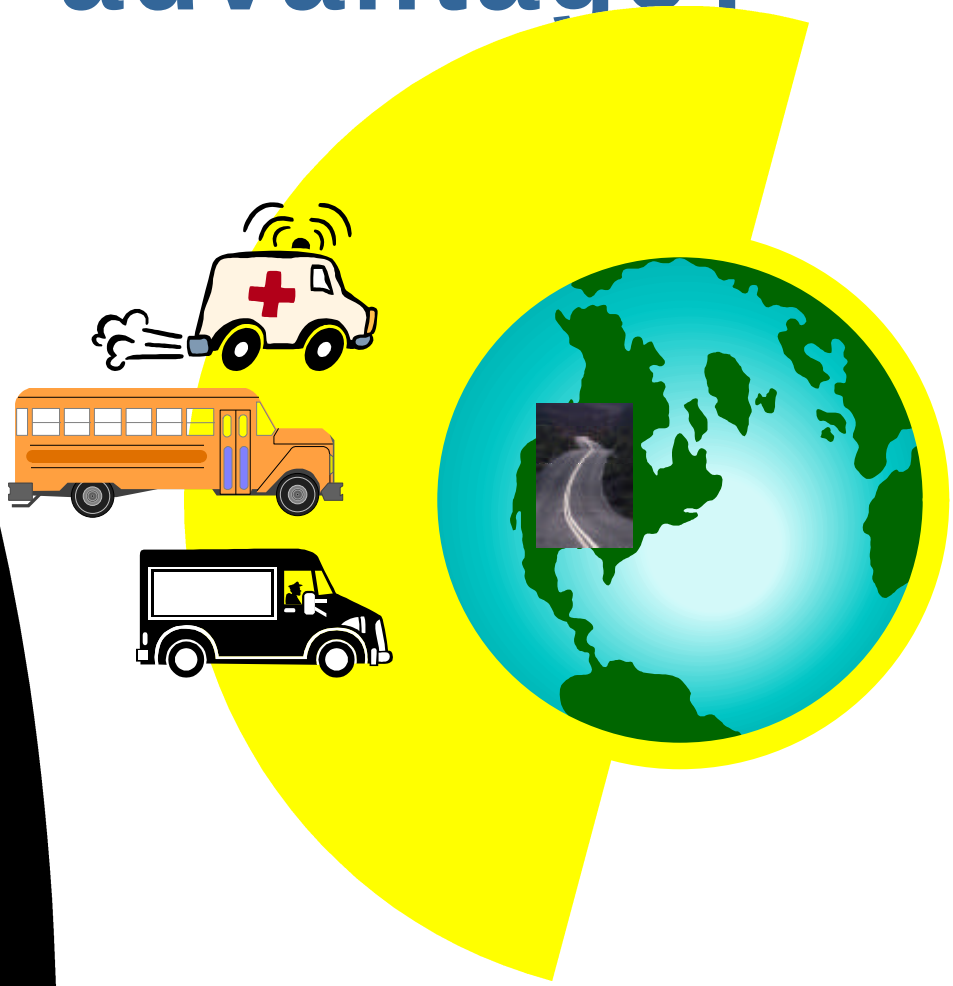


… is there a road ‘framework’ that they can share …

… cooperatively maintain …

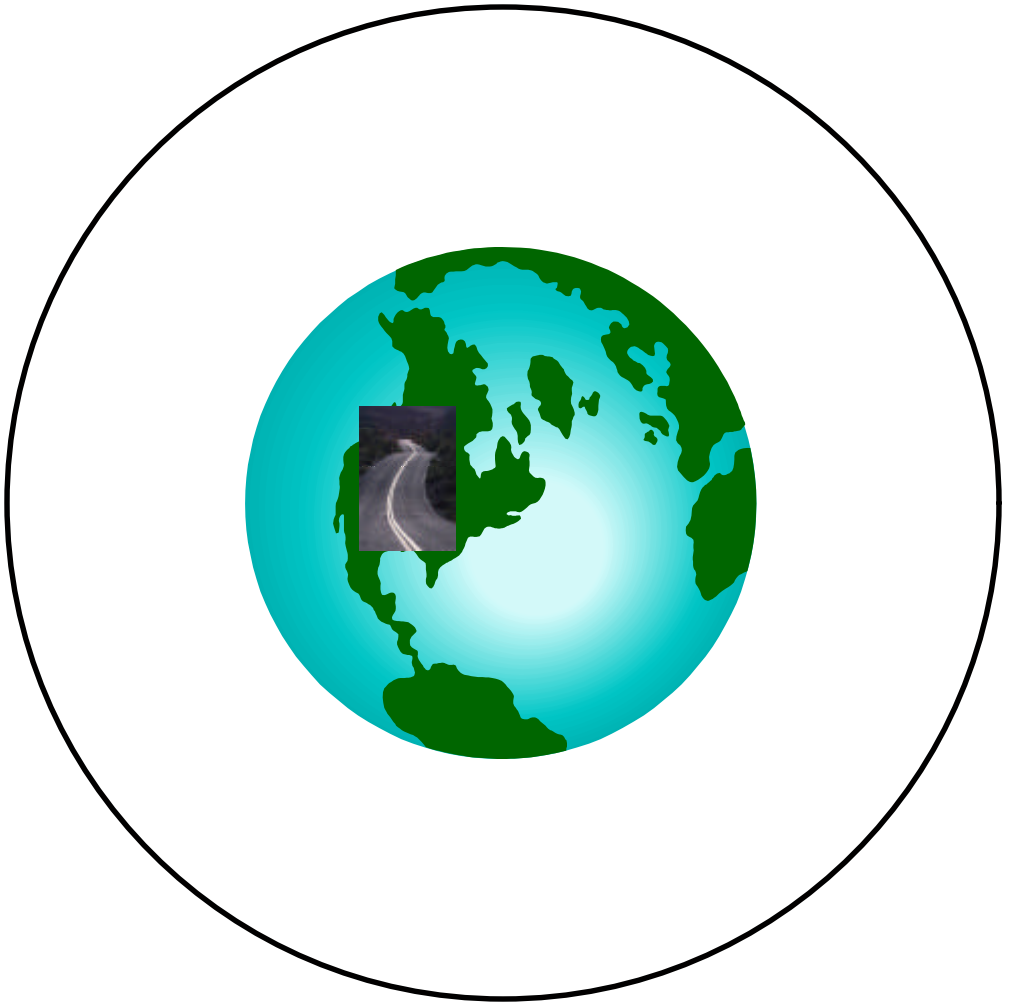


… and of which can each take advantage?

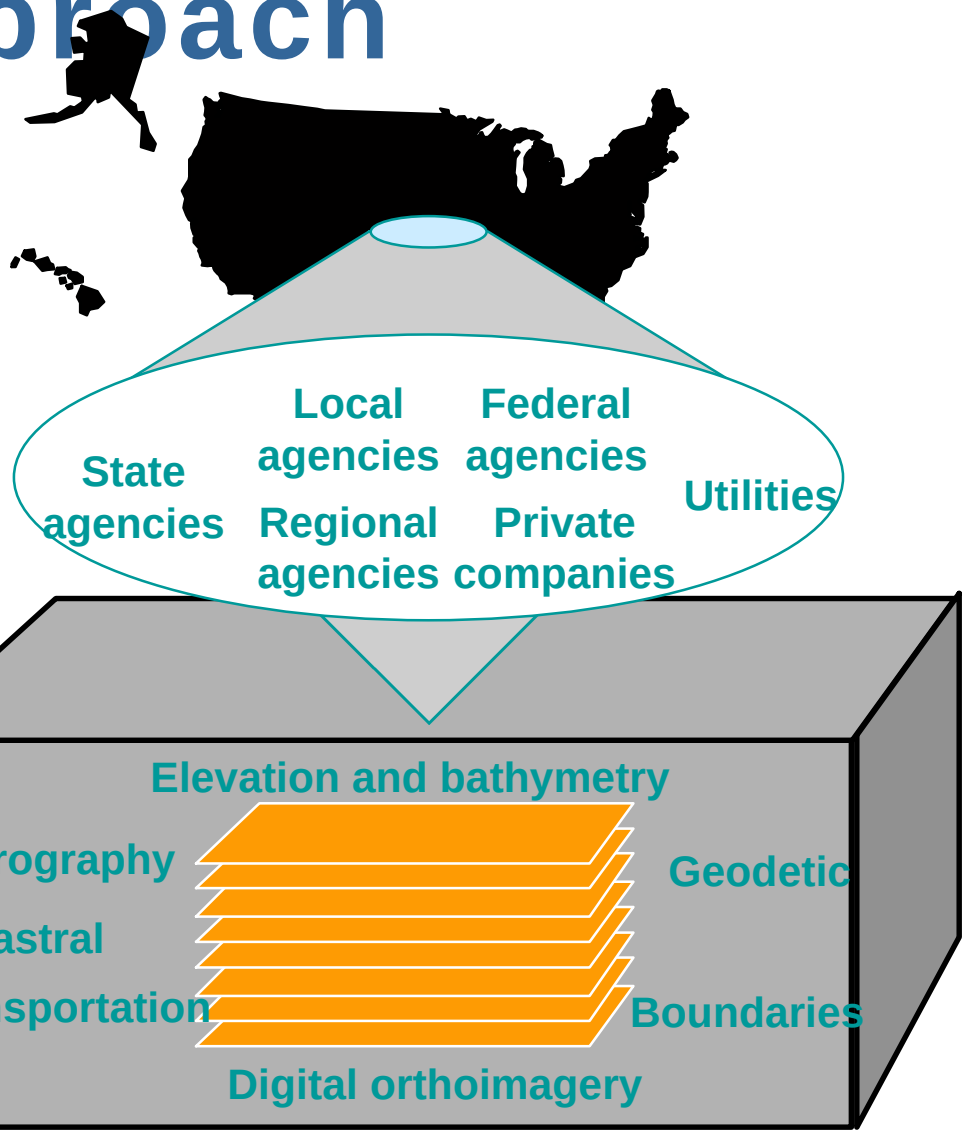


… and of which each can take advantage?

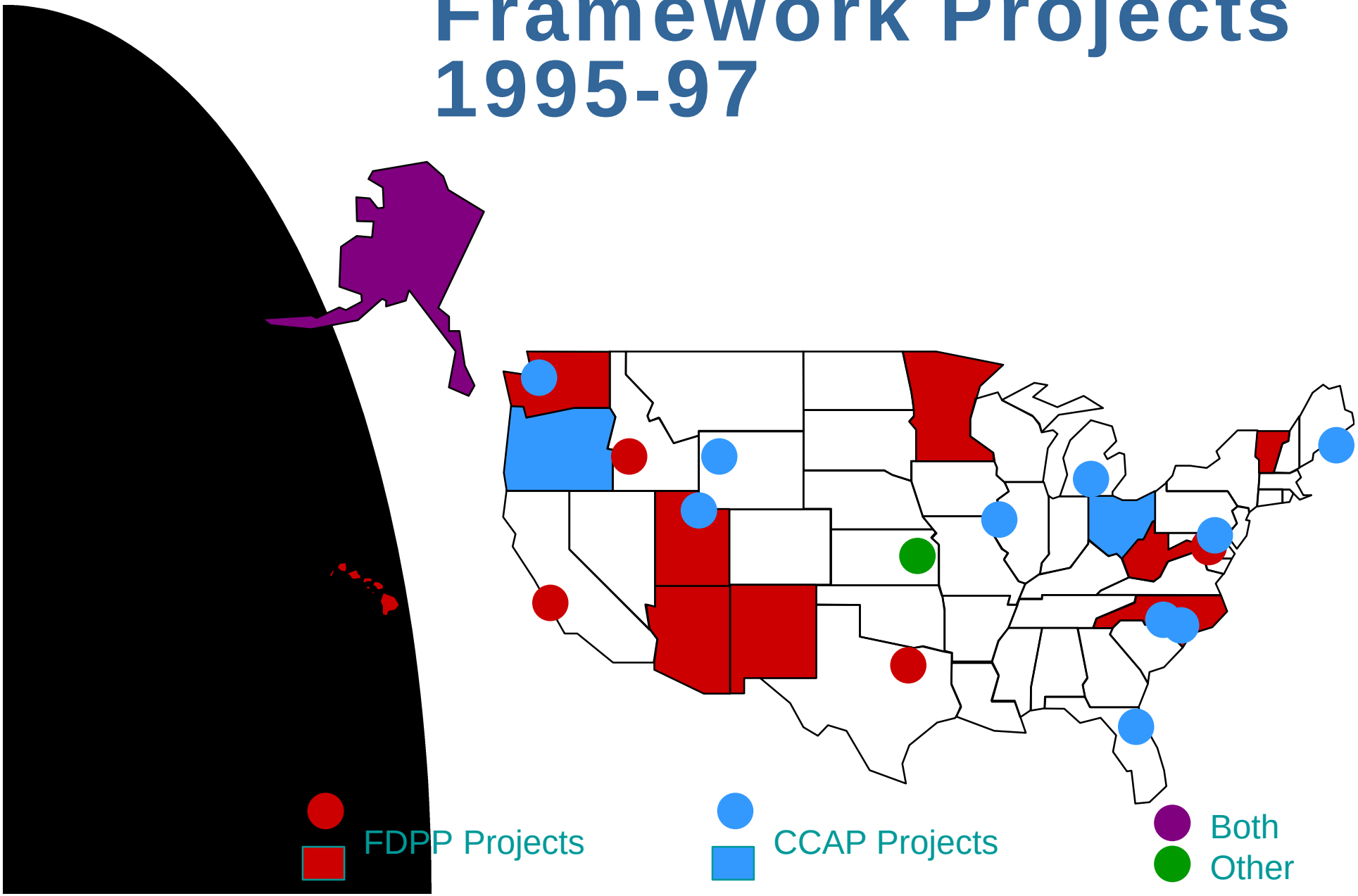
Sure … what is it?



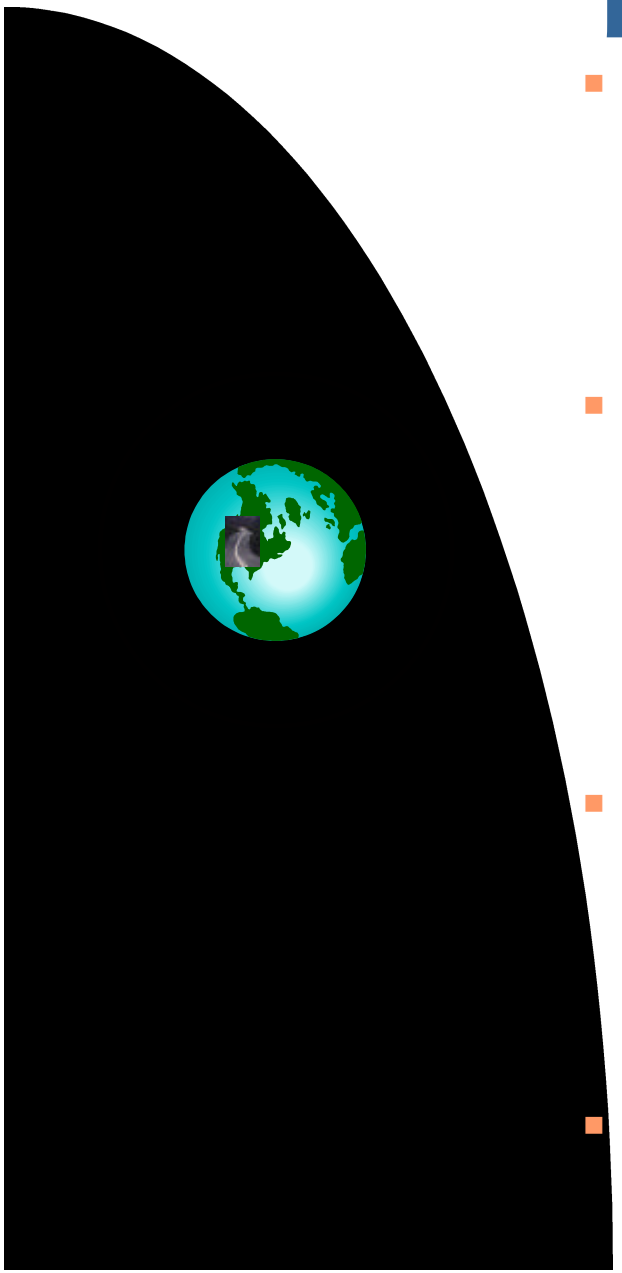
Framework Approach



Framework Projects 1995-97



From the “blue book”

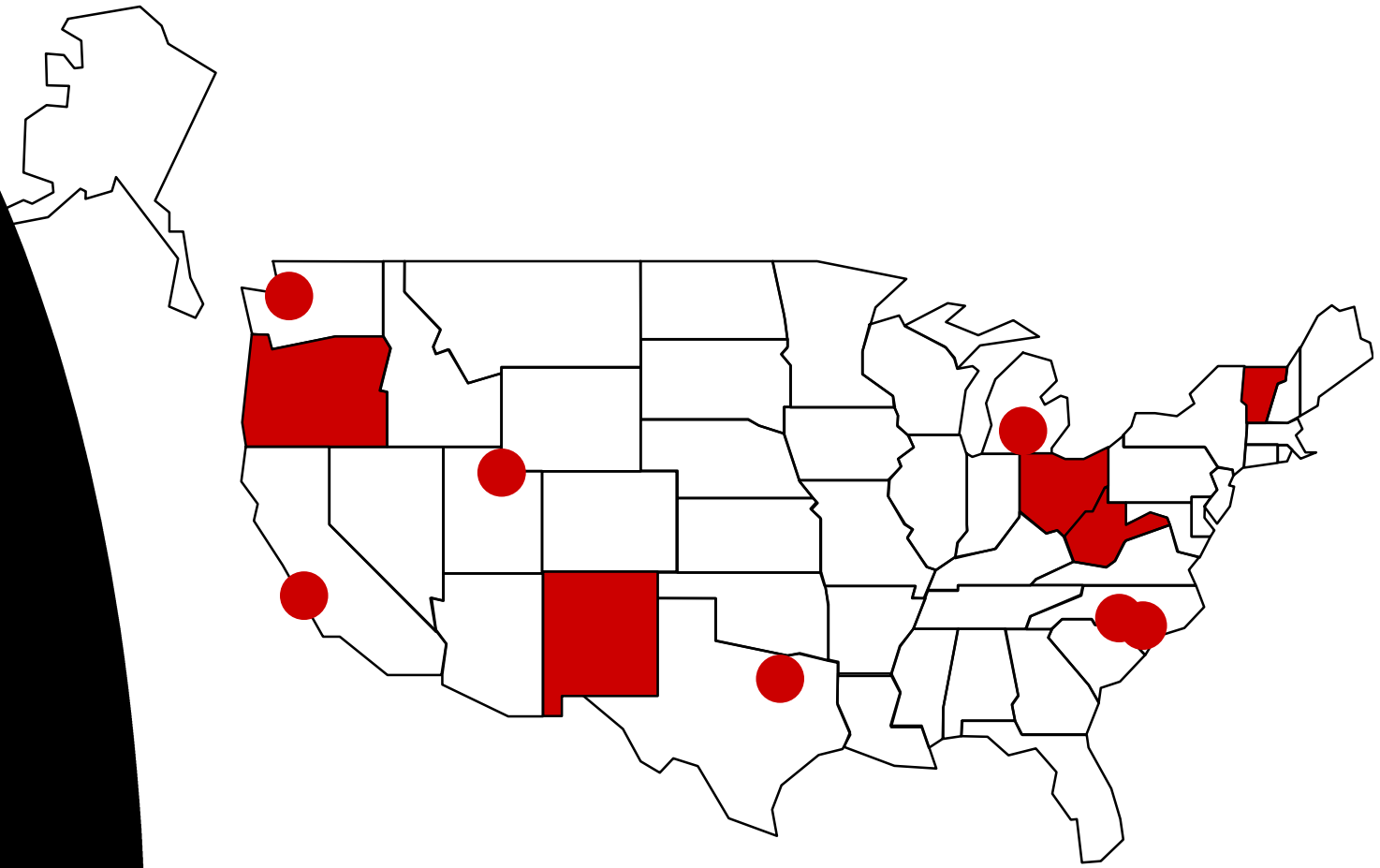


- “The framework transportation data includes the centerlines of roads, trails, … and two types of supporting structures: bridges and tunnels.”
- “Roads will have the attributes of feature identification code (using linear referencing system(s) where available), functional class, name (including route numbers), and street addresses.”
- “Trails will have the attributes of feature identification code (using linear referencing system(s) where available), name, and type.”
- “Bridges and tunnels will have the attributes of feature identification code and name.”

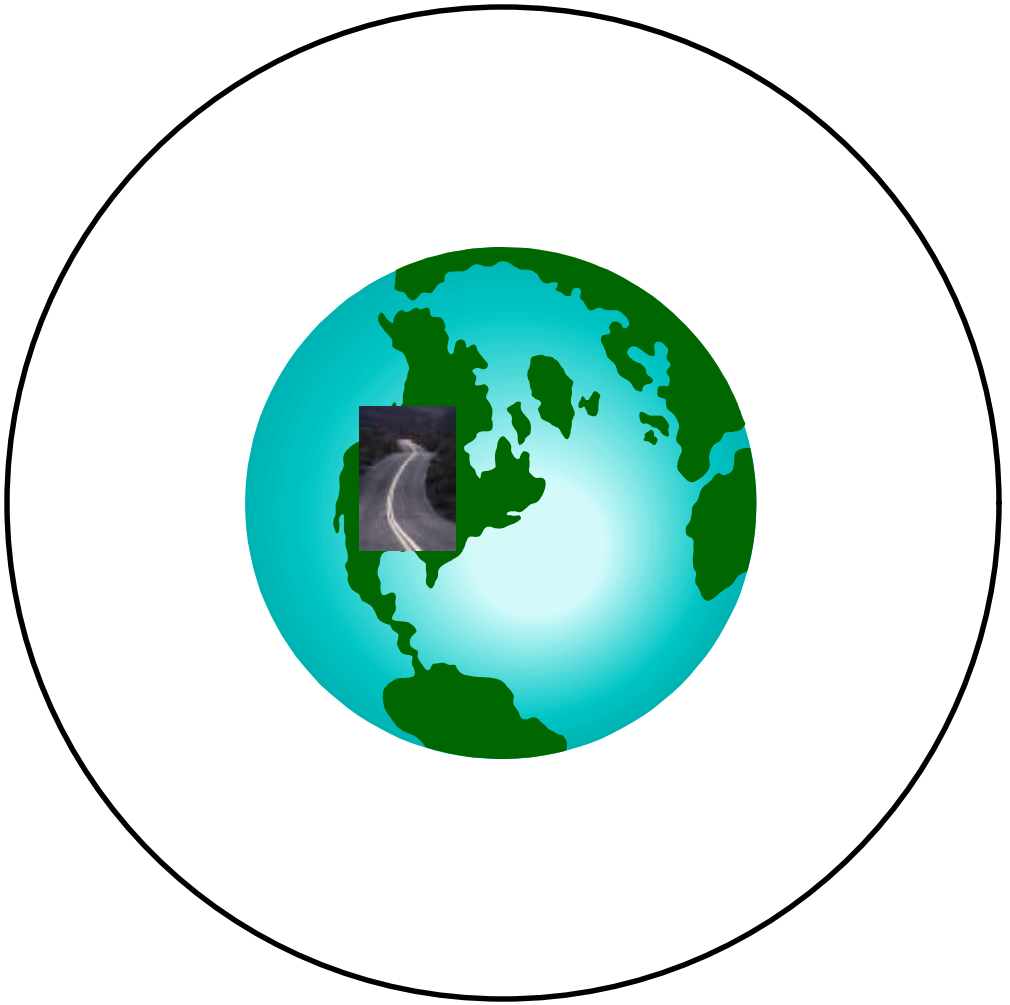
“Need a little more detail here…”

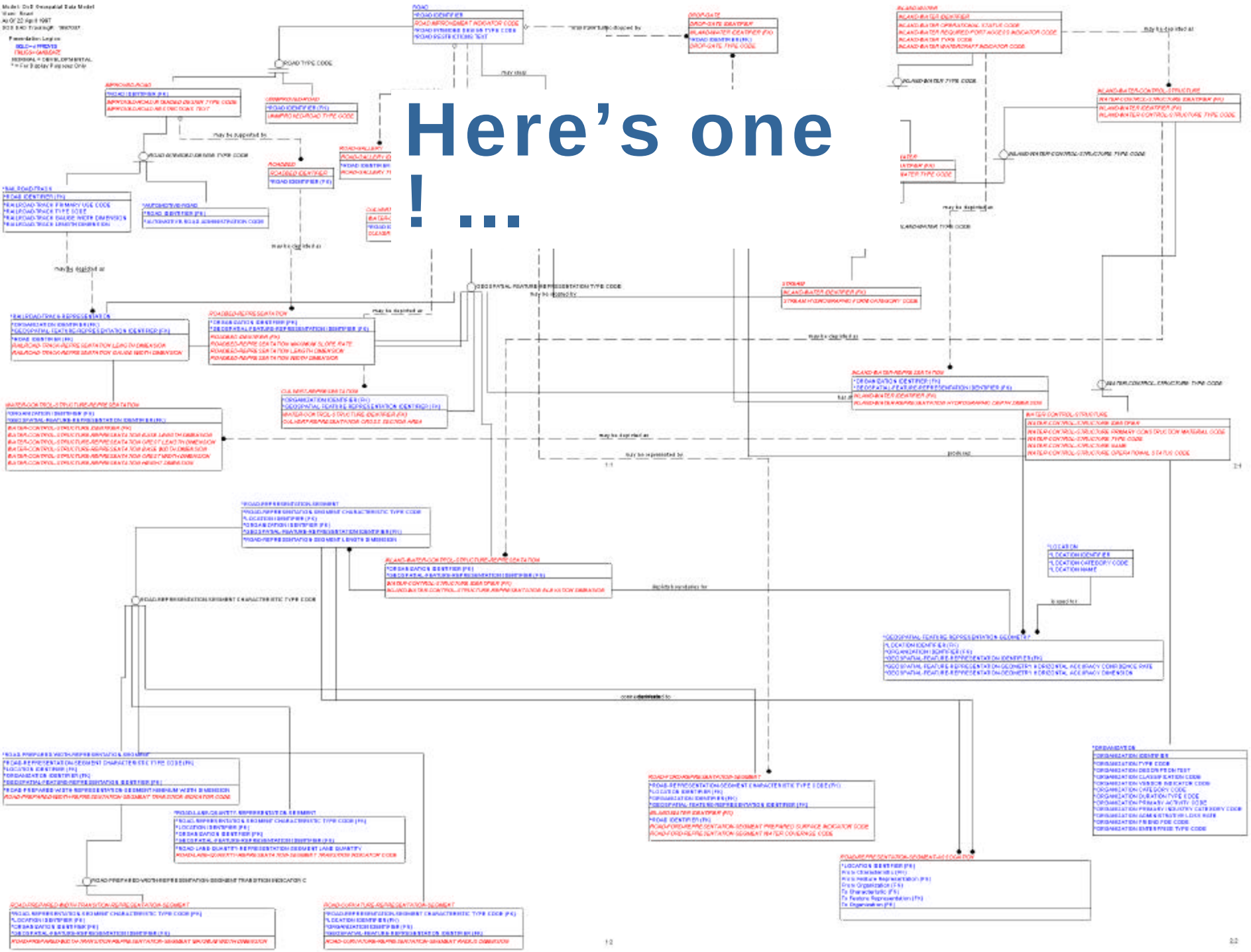
- Sept 1996: “Pilots” outline a data model development process; vote transportation as highest priority.
- Aug 1997: Feature maintenance workshop identifies need for data models within 18 months.
- Sept 1997: New England workshop identifies lack of standards for feature representation and definition, and attribute definition.

Framework Projects That Include Roads

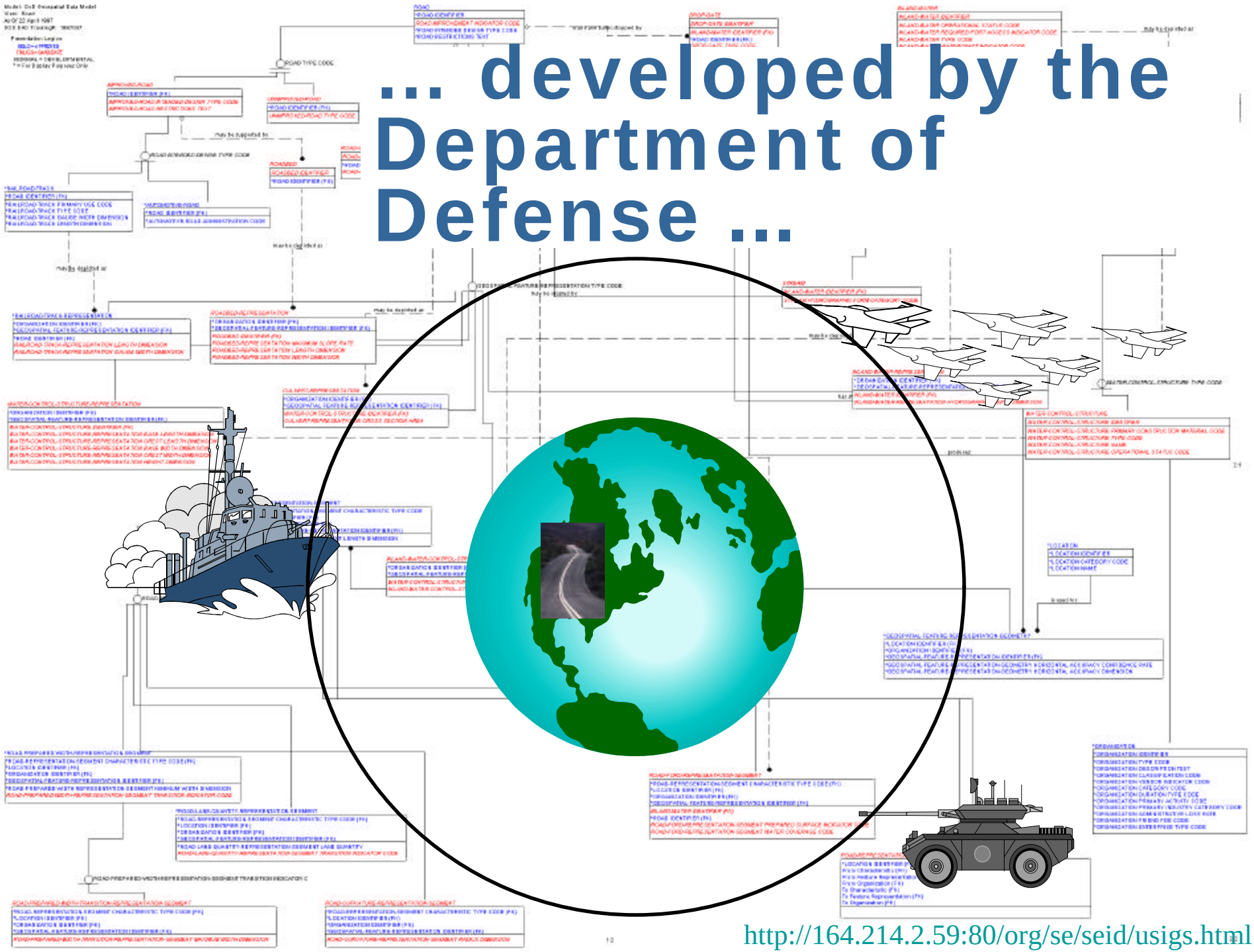


Data model? We can do that ...




Here's one ! ...

… developed by the Department of Defense …



http://164.214.2.59:80/org/se/seid/usigs.html

… with entities …

Entity Description for UNIMPROVED-ROAD

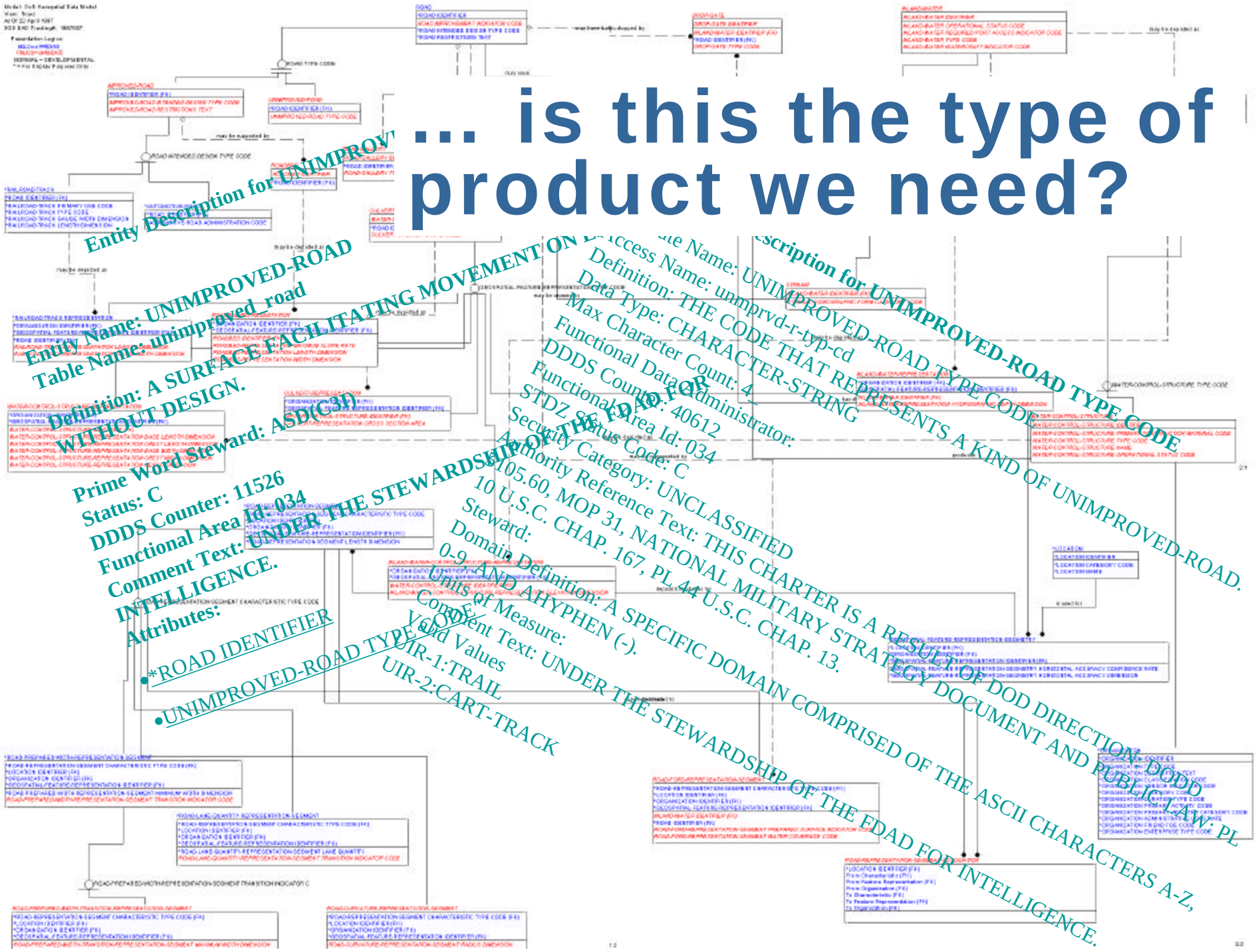
Entity Name: UNIMPROVED-ROAD
Table Name: unimproved_road
Definition: A SURFACE FACILITATING MOVEMENT ON LAND WITHOUT DESIGN.
Prime Word Steward: ASD(C3I)
Status: C
DDDS Counter: 11526
Functional Area Id: 034
Comment Text: UNDER THE STEWARDSHIP OF THE FDAD FOR INTELLIGENCE.
Attributes: ROAD IDENTIFIER

UNIMPROVED-ROAD TYPE CODE"

Attribute Description for UNIMPROVED-ROAD TYPE CODE

... and attributes ...

Data Type: CHARACTER-STRING
Max Character Count: 4_
Functional Data Administrator:
DDDS Counter: 40612
Functional Area Id: 034
STDZ Status Code: C
Security Category: UNCLASSIFIED
Authority Reference Text: THIS CHARTER IS A RESULT OF DOD DIRECTION: DODD 5105.60, MOP 31, NATIONAL MILITARY STRATEGY DOCUMENT AND PUBLIC LAW: PL 10 U.S.C. CHAP. 167, PL 44 U.S.C. CHAP. 13.
Steward:
Domain Definition: A SPECIFIC DOMAIN COMPRISED OF THE ASCII CHARACTERS A-Z, 0-9, AND AHYPHEN (-).
Units of Measure:
Comment Text: UNDER THE STEWARDSHIP OF THE FDAD FOR INTELLIGENCE.
Valid Values
UIR-1:TRAIL
UIR-2:CART-TRACK


... is this the type of product we need?
Entity Description for UNIMPROV
Entity Name: UNIMPROVED-ROAD
Table Name: unimproved_road
Definition: A SURFACE FACILITATING MOVEMENT ON
WITHOUT DESIGN.
Prime Word Steward: ASD(C3I)
Status: C
DDDS Counter: 11526
Functional Area Id: 034
Comment Text: UNDER THE STEWARDSHIP OF THE FDAD FOR INTELLIGENCE.
Attributes:
*ROAD IDENTIFIER
UNIMPROVED-ROAD TYPE CODE
Access Name: unmprvd-r-typ-cd
Definition: THE CODE THAT REPRESENTS A KIND OF UNIMPROVED-ROAD.
Data Type: CHARACTER-STRING
Max Character Count: 4
Functional Data Administrator:
Functional Area Id: 034
Status Code: C
Security Category: UNCLASSIFIED
Authority Reference Text: THIS CHARTER IS A RESULT OF DOD DIRECTION, DODD
5105.60, MOP 31, NATIONAL MILITARY STRATEGY DOCUMENT AND PUBLIC LAW: PL
10 U.S.C. CHAP. 167, PL 44 U.S.C. CHAP. 13.
Steward:
Domain Definition: A SPECIFIC DOMAIN COMPRISED OF THE ASCII CHARACTERS A-Z,
0-9, AND AHYPHEN (-).
Units of Measure:
Comment Text: UNDER THE STEWARDSHIP OF THE FDAD FOR INTELLIGENCE.
Valid Values
UIR-1:TRAIL
UIR-2:CART-TRACK
Name: UNIMPROVED-ROAD TYPE CODE
Description for UNIMPROVED-ROAD TYPE CODE
DDDS Counter: 40612

Towards a data model that helps us with the framework

...

- Entities and relationships?
- Attributes?
- Anything else?
- Style and maintenance?

Entities and Relationships?

- Do we share a useful consensus definition of the basic entity 'road' (or related term)?
- What are the parameters or bounds on this definition of ‘road’? (All roads? Only public? Includes trails? Etc.)
- What are the related entities (road segment, route) — if any — which must necessarily be defined in order to advance the Framework?

Entities and Relationships? (cont'd)

- Do we know what rules define single instance of each entity? What's the atomic unit?
- What relationships exist between these entities?
- Are these two dimensional representations (points, lines, areas)? If so, how are they used to reflect three dimensional reality (overpasses)?

Attributes?

- What attributes are attached to which entities for framework purposes?
- What definitions and domains are established for each?
- What attributes are provided to allow 'non-framework' information to be linked to the roads?

Anything else?

- What elements -- other than entity definitions and attribute specifications -- are necessary components of a useful data model?

Style and Maintenance?

- Who are the users of these models? What do they need to be able to do, and how does such a model help them do it?
- What style or technology or methods are useful in documenting a road data model?
- How is the documentation maintained?

Integration Strategies for Framework Road Data

Mark Bosworth
Metro - Portland, Oregon

A Brief History of ORBITS

- O
- R
- B
- I
- T
- S

A Brief History of ORBITS

- Oregon
- Road
- Base
- Information
- Technical
- Subcommittee

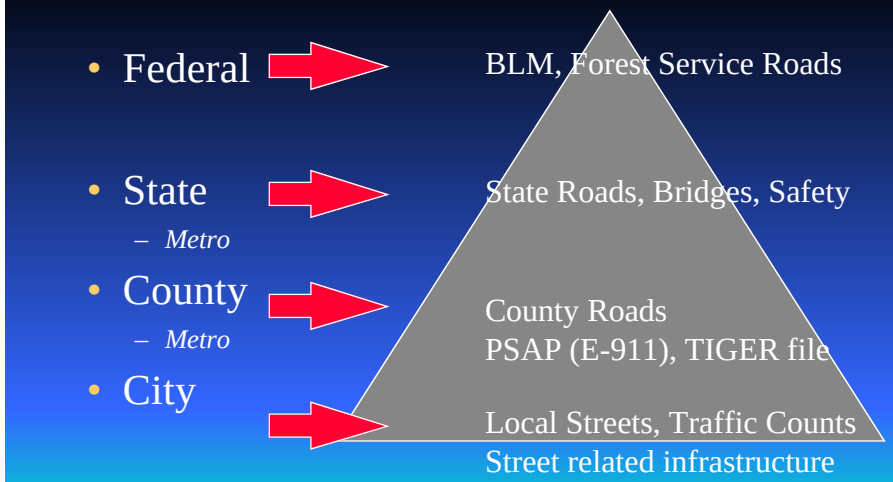
The ORBIT Project Objectives

- A geographic road base of the state which could be used by as many organizations as possible
  - Updated by the agency responsible for the change
  - Stored in a central clearinghouse
  - Varying accuracies - the most accurate available for the area

The ORBITS Objectives

- Review of Linear Data Models
- Develop a Data Model/s to achieve Statewide goals
- Establish Pilot Projects
  - multi-level jurisdictions
  - Motto: “We are doing it anyway...”

The Institutional Landscape



Oregon Road Miles

BLM	27,861.00
County Roads	27,138.62
USFS	13,422.00
City Streets	8,174.20
State Highways	7,485.16
Local Access Roads	6,846.71
State Forest Roads	3,037.72
Bonneville Power Administration	1,427.38
Bureau of Indian Affairs	739.00
Other Federal Agencies	425.72
State Park Roads	264.79
Fish and Wildlife Roads	137.50
Campus Roads	105.09
National Park Service	96.11
Other Local Agencies	85.03
Army Corps of Engineers	62.29
State Institutions	39.95
Military Roads	32.55
Total Road Miles	97,380.82

Data Model Goals

- Facilitate data sharing
- Enterprise-Wide (state-wide) Solution
- Transportable
- Simple/Fast/Easy

Data Model Principles

- Attributes separate from Geometry
- Bottom Up Approach
- Multiple Representations of the Network

(Not necessary from local perspective)

- Minimum set of attributes to pass along

Local Perspective

- Polk County
  - Data Developer
  - Integrated Road Information System (IRIS)
    - Statewide County Road Database structure

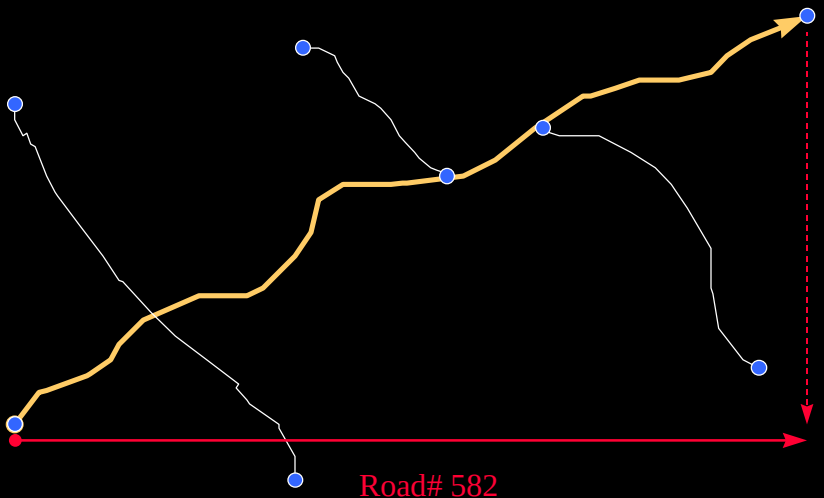
Local Perspective

-
  -
  -
  -

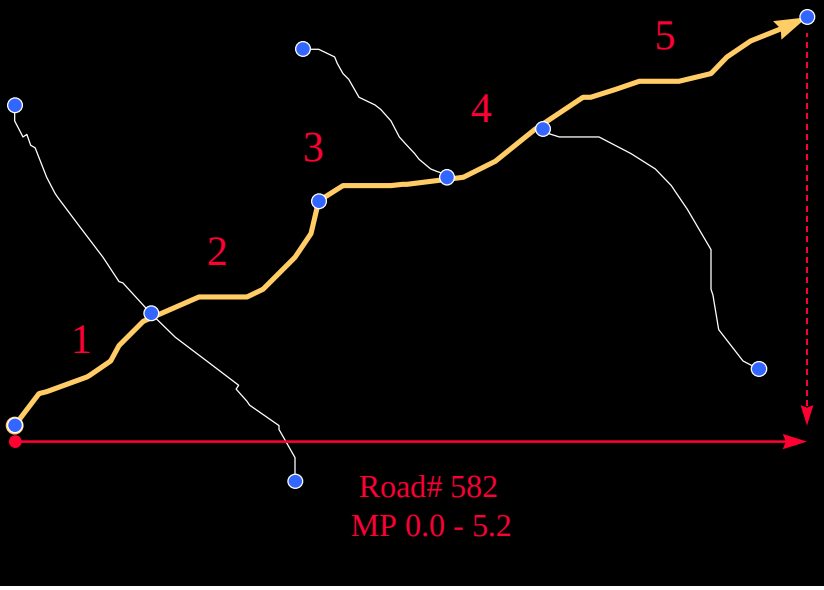
Local Implementation

- Simple, Feature Based Model
  - One Segment will have only one road number
  - One Measurement System

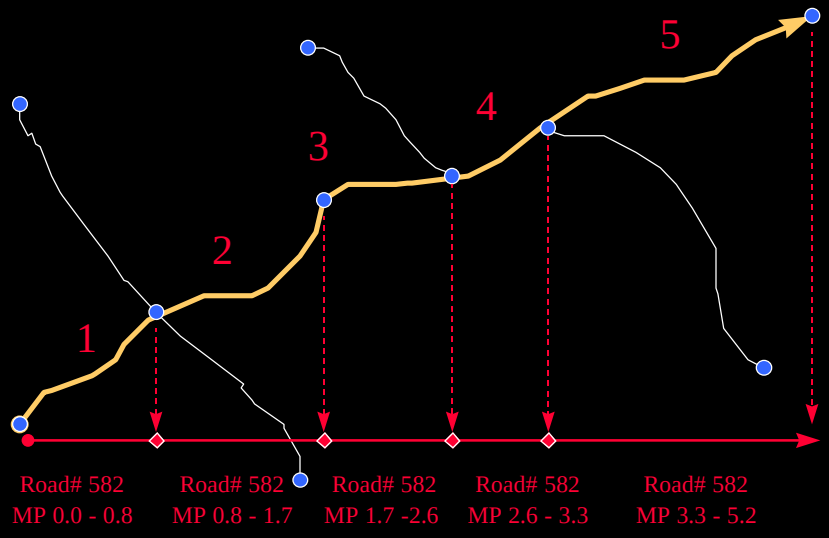
Road as Single Feature:



Road as Single Feature:
Ordered Segments



Road as Single Feature: Ordered Segments



Regional Perspective

- Metro
  - Develop and maintain a regional Reference Network
  - Integrate transportation related information into a cohesive database, useful for multiple applications in the region
  - Stored in a central location (warehouse)

Regional Perspective

- Bottom Up:
  - Incorporate highest quality (graphics, geometric control & attributes) available
  - Updates made by stakeholders with the “most to lose”

Regional Implementation

- Use Dynamic Segmentation Data Model
  - Maintain Minimum Mandatory (MMs!)
- Apply Generic Linear Reference System
  - Rosetta Stone of LRS

Linear Reference System

- A method of defining location based upon a distance along a linear feature
  - Road Name / Mile Point
  - Street Address system

Dynamic Segmentation

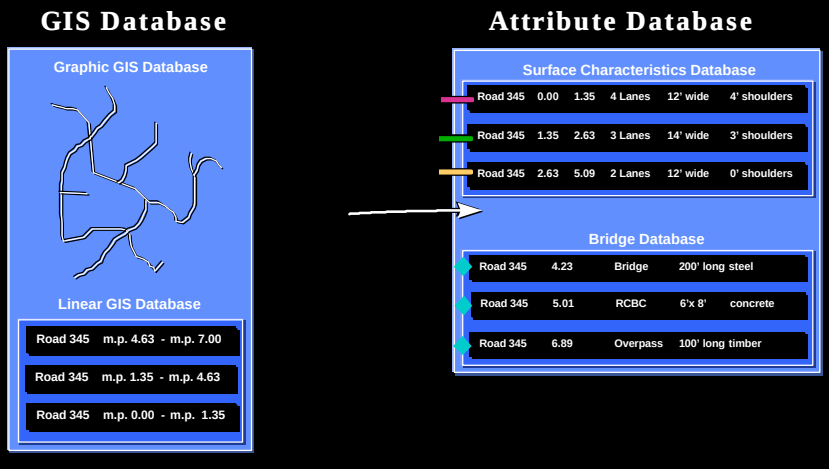
Data model that allows the ability to link attributes to linear features using a LRS; attributes can be associated with features dynamically, regardless of segmentation.

Dynamic Segmentation

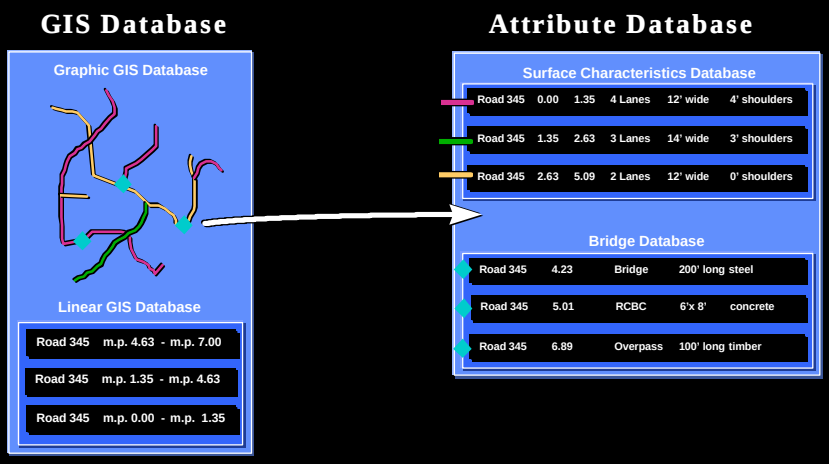
ATTRIBUTE DATA:

- Separate from the graphics
- LRS for linkage to specific network

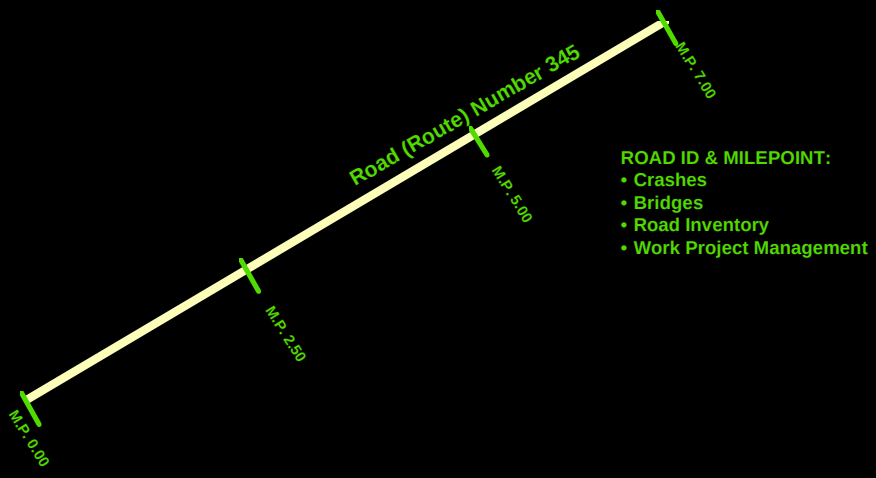
Dynamic Segmentation



Dynamic Segmentation

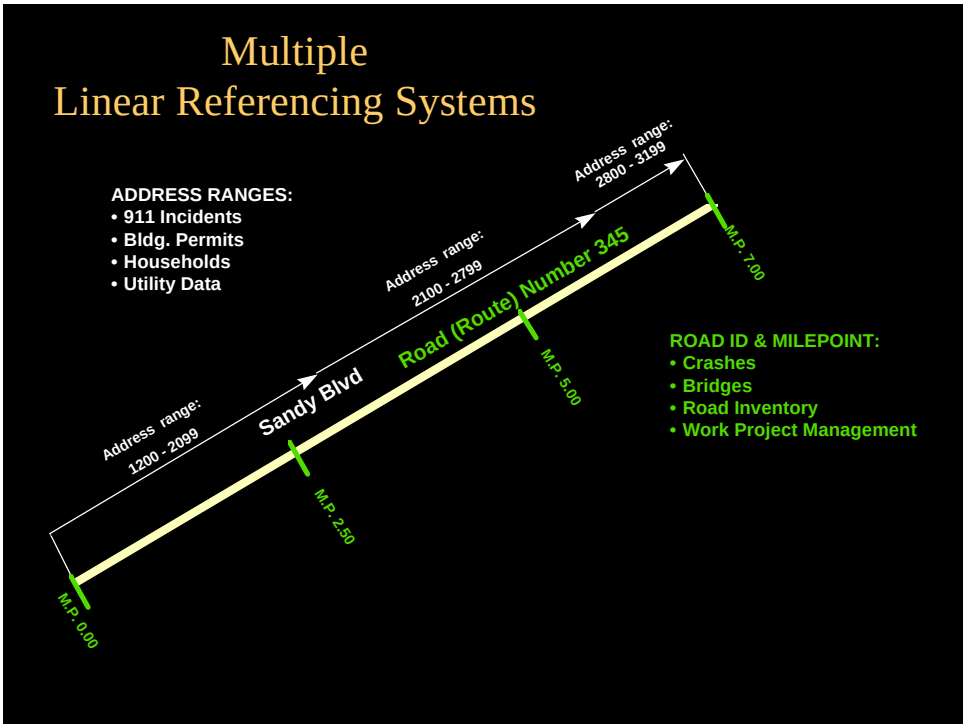


Single Linear Referencing System

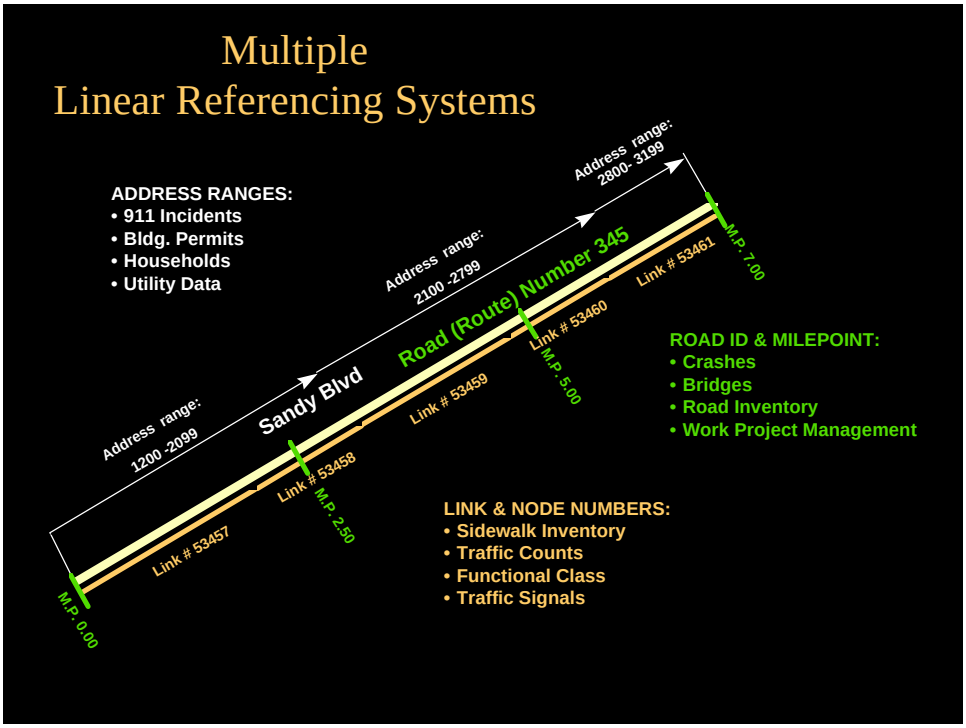


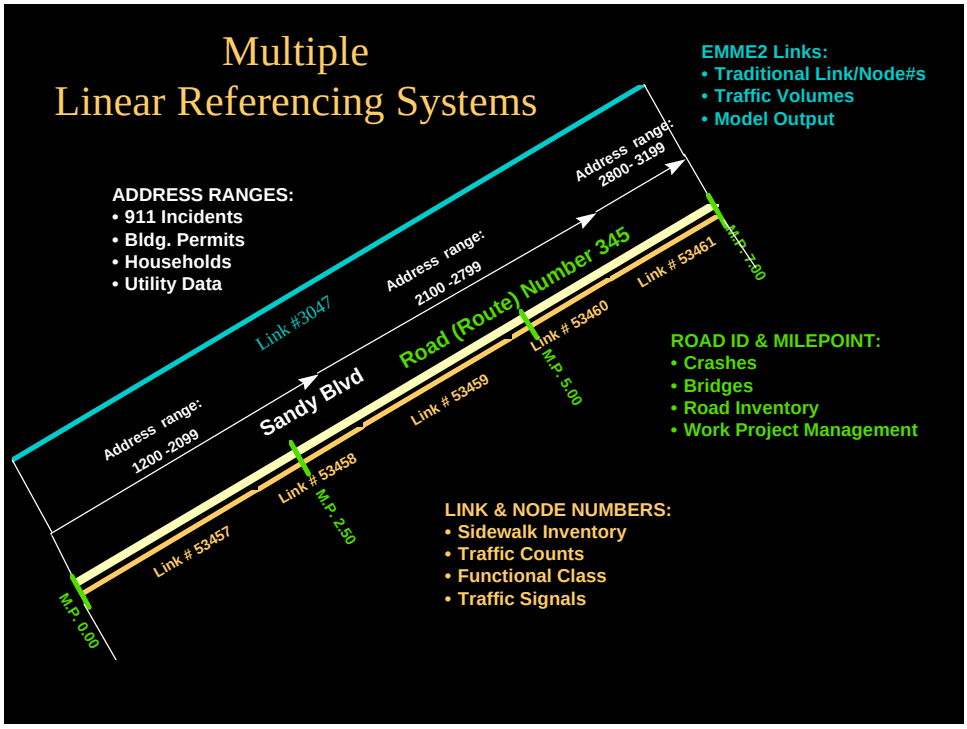
ROAD ID & MILEPOINT:
- Crashes
- Bridges
- Road Inventory
- Work Project Management

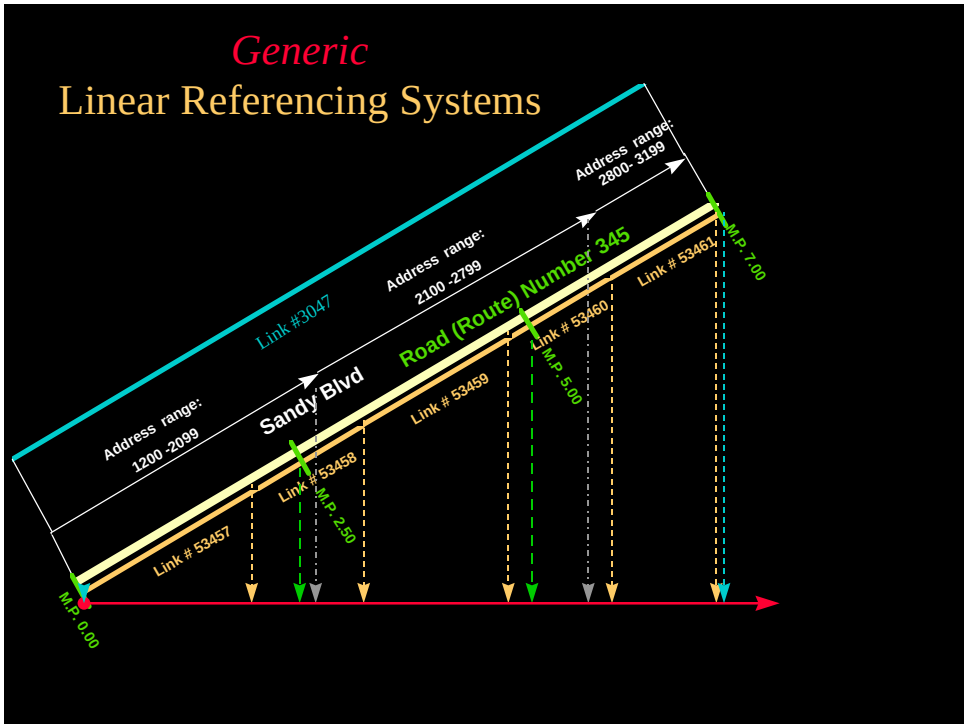
Multiple
Linear Referencing Systems



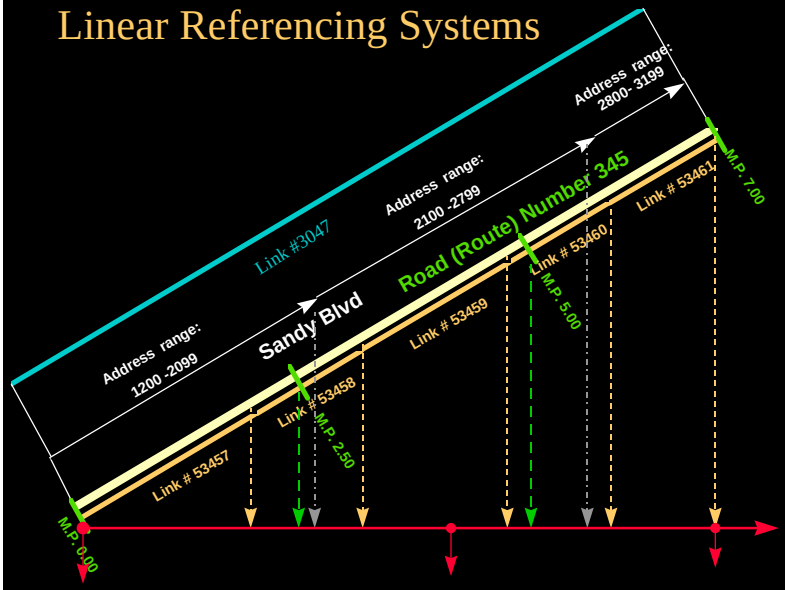
Multiple
Linear Referencing Systems




Multiple
Linear Referencing Systems
EMME2 Links:
• Traditional Link/Node#s
• Traffic Volumes
• Model Output
ADDRESS RANGES:
• 911 Incidents
• Bldg. Permits
• Households
• Utility Data
Link #3047
Address range: 2800- 3199
Address range: 2100 -2799
Address range: 1200 -2099
Sandy Blvd
Road (Route) Number 345
Link # 53461
M.P. 7.00
Link # 53460
M.P. 5.00
Link # 53459
Link # 53458
M.P. 2.50
Link # 53457
M.P. 0.00
ROAD ID & MILEPOINT:
• Crashes
• Bridges
• Road Inventory
• Work Project Management
LINK & NODE NUMBERS:
• Sidewalk Inventory
• Traffic Counts
• Functional Class
• Traffic Signals


Generic
Linear Referencing Systems
Link #3047
Address range: 2800- 3199
Address range: 2100 -2799
Address range: 1200 -2099
Sandy Blvd
Road (Route) Number 345
Link # 53461
M.P. 7.00
Link # 53460
M.P. 5.00
Link # 53459
Link # 53458
M.P. 2.50
Link # 53457
M.P. 0.00

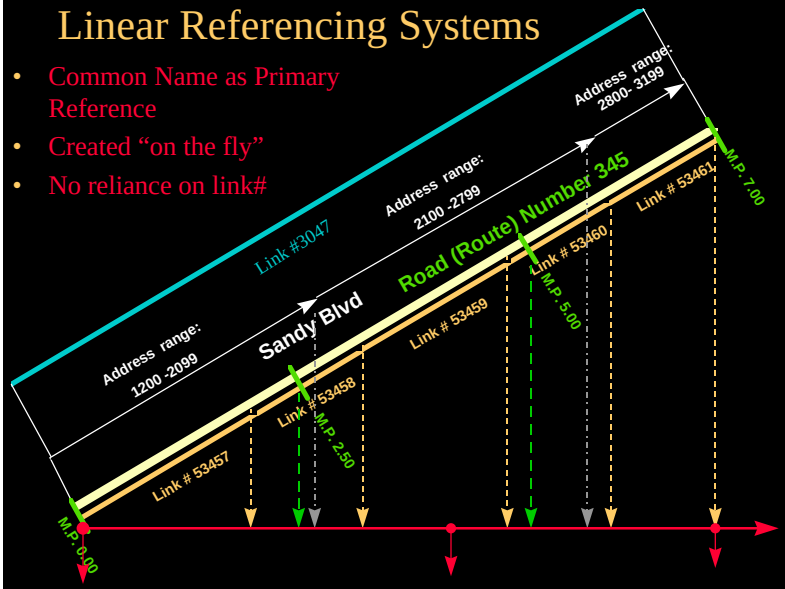
Generic
Linear Referencing Systems



5280.03 Sandy Blvd. 6280.03 Sandy Blvd. 7342.01

Generic
Linear Referencing Systems

- Common Name as Primary Reference
- Created “on the fly”
- No reliance on link#



5280.03 Sandy Blvd. 6280.03 Sandy Blvd. 7342.01

Conclusion

- Dynamic Segmentation implemented in a Generic, Regional LRS allows:
  - data sharing between multiple LRS
  - data maintenance in distributed environment
    - By the agency with the most to lose
    - Separate from the graphic representation

Final thoughts...

- Framework efforts in Oregon (and elsewhere) work from the ground up
- Local and Regional organizations are already in the business of sharing data
- Multiple representations of the network are necessary to meet the needs of all users
- Multiple LRS's exist and need to be accommodated in the model

Project Proposal:
NSDI Cooperative Program

Wasatch Front Transporatation Data Integration and Generalization Project

by

State of Utah
Division of Information Technology Services
Automated Geographic Reference Center

and

Listed Collaborators

MAJOR OBJECTIVES

Integration
Generalization

- Help all project participants increase their awareness for and experience in accommodating data contributions from geographically distributed organizations.
- Provide important documentation and experience in implementing many of the Framework goals.
- Accommodate resolution and format disparities.
- Investigate the integration of digital orthoimage data.
- Test Area Integrator responsibilities.
- Develop a "proof of concept" framework data set for evaluation by the user community.
- It will help to increase the amount of reliable data available through the National Geospatial Data Clearinghouse.

Integration:

- Assemble the "best" data available of these four counties
  Some will come from locally generated sources
  Some from USGS Digital Line Graphs (DLGs)
  Some from the State Geographic Information Database (SGID)
  Some from USFS Cartographic Feature Files (CFFs)
  Some from DOQs where available

- Develop the proper tools and procedures for integrating the date from these various sources.

- No new data will be created as part of this project.

- Document data using the FGDC Content Standards for Digital Geospatial Metadata

- Integrate into a contiguous patchwork where it will be checked for any edgematching conflicts with other data.

- Contributing parties have the greatest familiaritiy with their data and know how best to join together disjount lines representing roads.

- Helps point out problem areas.

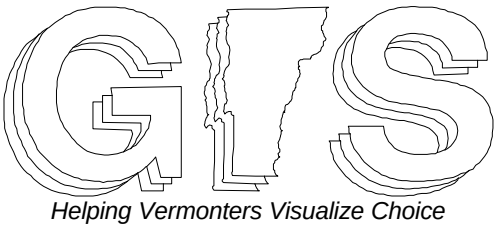
LAYER: ROADS AND TRAILS
FEATURE TYPE: LINES
FIELD: SHARE.FUNC
STRUCTURE: 2N
DESCRIPTION: Type of road or trail

	Description
1	Rural Interstate
2	Rur. Principal Arterial
6	Rur. Minor Arter.
7	Rur. Major Collector
8	Rur. Min. Collect.
9	Rural Local
11	Urban Interstate
12	Urb. Expressway
14	Urb. Principal Arter.
16	Urb. Minor Arterial
17	Urb. Collector
19	Urb. Local
30	Foot Trail
31	Motorized Trail

FIELD: SHARE.JURIS
STRUCTURE: 2N
DESCRIPTION: Responsibility for, or ownership of, road or trail

	Share Code
01	St. Hwy.
02	County
03	Town
04	Municipal
11	State Park
12	Nat. Park, Forest or Reservati
21	Other State Agency
25	Other Local Agency
26	Private
31	State Toll
32	Local Toll
60	All other Feds
62	BIA
64	USFS
66	NPS
68	BLM
70	DOD, MILIT, or COE
75	Sovereign Nation
80	RW2477

FIELD	DESCRIPTION
SOURCE_CODE	Describes source data
REVISION_DATE	Date of revision
SHARE.FUNC	Functional Share Code
SHARE_JURIS	Jurisdictional Share Code
SHARE_FROM_MP	Segment Starting Mile Point
SHARE_TO_MP	Segment EndingMile Point
SHARE_ROUTE	Agency Route Name



Vermont Road Framework Activities

Vermont Spatial Data Partnership Project

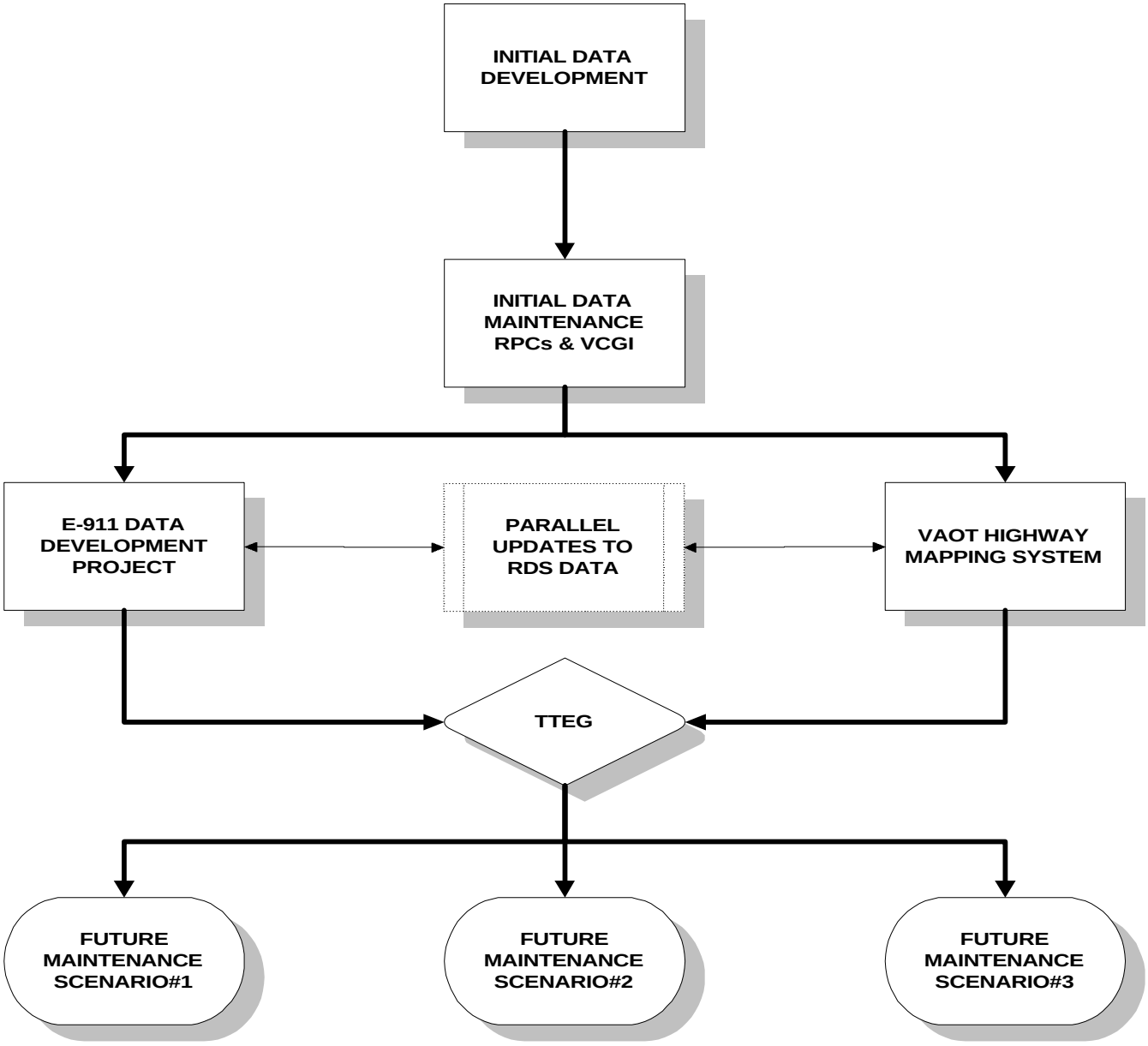
Spatial Data Partnership Project (VSDP): In Vermont, this project is working to bring stakeholders together to discuss how issues of data sharing, data development and maintenance, and data access can be addressed in a coordinated and efficient manner.

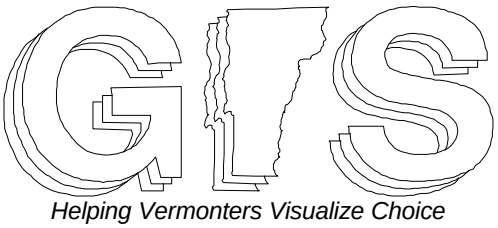
Historical Road Data Development Activities: The Vermont GIS Community has worked in cooperation over the past five years to develop and maintain a "master" road centerline data layer (RDS). This cooperative partnership has allowed Vermont to build an accurate data layer while minimizing cost and duplication of effort. However, recent initiatives by the Enhanced 9-1-1 Board and the Vermont Agency of Transportation have created an environment of uncertainty.

Transportation Theme Expert Group (TTEG): This group is a technical sub-committee of the VSDP. The TTEG is a forum for determining the future of Vermont's road centerline data layer(s).

Helping Vermonters Visualize Choice

Vermont's Road Centerline Data Layer
Current and Historical Activities





Vermont Road Framework Activities

Vermont Spatial Data Partnership Project

TTEG INITIATIVES: The TTEG includes representatives from VCGI, VAOT, RPCs, E-911, USGS, and the Census Bureau. The standards and recommendations developed by this group are helping to "mold" and "guide" future road centerline activities.

The TTEG was established in early 1997. Participants were recruited and a work plan was developed to help guide the group's activities.

TTEG Mission: Develop a roads data management strategy which assures that compatible, useful, and shareable data is available to the GIS community.

TTEG Primary Objectives:

1) Designate & define a "master" road centerline data layer for Vermont

2) Determine "how" this data layer will be maintained.

3) Determine "who" will maintain this data layer

ROADS MANUAL - TECHNICAL OVERVIEW: Specific portions of the "*Technical Manual for Development & Maintenance of Road Centerline Spatial Data*" have been extracted into this presentation.

Terminology

Road: An open public or private way for the passage of persons and vehicles

Road segment: Portion of a "road" defined by a beginning and ending point (node)

Route: Multiple "road segments" combined to define a single linear reference feature

Route section: Sections of a route

Arc: A representation of a line in the Arc/Info GIS, defined by a beginning and ending point (node). There is a one-to-one relationship between "road segments", "route sections", and "arcs"

Feature: Representation of a "real-world entity" (e.g.: "road," "road intersection," "building," etc.)

Feature Tracking: Tracking of changes to individual features in the data layer; i.e., road segments

Event Table: A tabular database containing information that can be associated with a linear reference system

A. Road Feature Definition

Road Feature: A digital representation of a "real-world" entity called a "road". A road feature is defined by “road segments”. Road segments have uniform attributes. They are represented by a line (arc). The beginning and ending point of a road segment is defined by a "node". Each road segment has a unique identifier (FIPS8 + ARCID) used for feature tracking. Figure 1 illustrates the relationships between road segments.

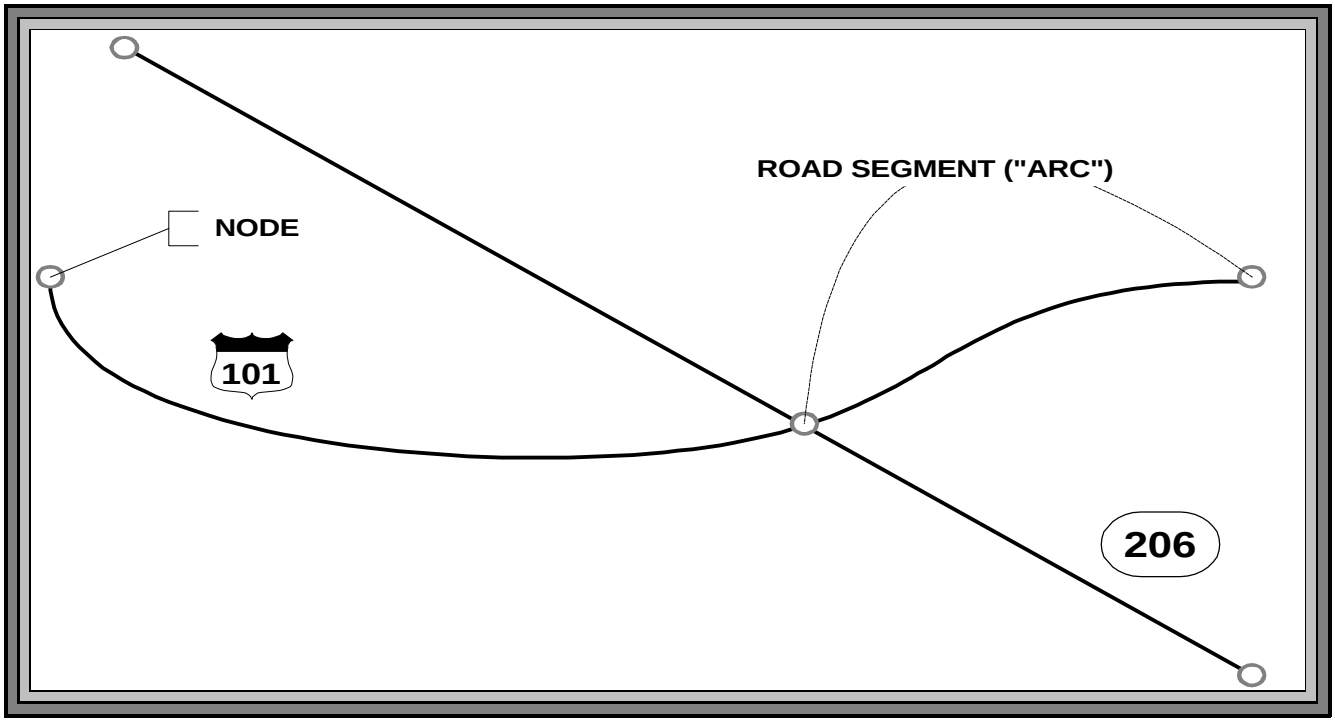


Figure 1

B. Road Feature Attributes and Associated Tables

The RDS data model makes use of multiple inter-related attribute tables. Each table has a different function. The table below provides a brief description of each attribute table.

TABLE NAME	DESCRIPTION
RDS.TIC*	Registration point attribute table
RDS.BND*	Boundary attribute table (defines spatial extent of data layer)
RDS.AAT	Arc attribute table (road “segment” attributes)
RDS.SECRDNAME	Route “section” attribute table (RDNAME route feature)
RDS.RATRDNAME	Route attribute table (RDNAME route feature)
RDS.ADD	RDS address database table (used for address-matching)
RDS.RDNAMES	Road name lookup table (includes alternate names and route info)
RDS.NAT	Node attributes table (used to store "intersection attributes")
RDS.TRN	Road turn table (controls turn impedance)

* The RDS.TIC and RDS.BND tables are default Arc/Info tables incorporated into all vector data layers.

The structure and items included in these tables are outlined below. The fields with an asterisk "*****" in the RDS.AAT file are added via "post-processing" once the data has been updated.

TABLE NAME: RDS.AAT (Arc Attribute Table)

COL	ITEM NAME	WDTH	OPUT	TYP	N.DEC	ALTERNATE NAME
1	FNODE#	4	5	B	-	
5	TNODE#	4	5	B	-	
9	LPOLY#	4	5	B	-	
13	RPOLY#	4	5	B	-	
17	LENGTH	4	12	F	3	
21	RDS#	4	5	B	-	
25	RDS-ID	4	5	B	-	
29	RTNAME	8	8	C	-	RTNM
37	*RTNO	4	4	C	-	NO
41	CLASS	2	2	I	-	CL
43	AOTCLASS	2	2	I	-	ACL
45	SURFACE	1	1	I	-	SURF
46	FUNCL	2	2	I	-	F
48	NHS	1	1	I	-	
49	SCENIC	1	1	I	-	SC
50	LR_ETE	11	11	C	-	LRID
61	*CTCODE	4	4	C	-	CTC
65	UA	1	1	I	-	
66	RDNAME	6	6	I	-	RD
72	*RDFLNAME	30	30	C	-	RDF
102	LOCMETH	2	2	I	-	LM
104	SRCORG	2	2	I	-	SO
106	FIPS8	8	8	I	-	
114	ARCID	4	4	I	-	AID
118	UPDACT	1	1	C	-	UPD
119	*ARCMILES	7	7	N	3	RDM
126	AOTMILES	7	7	N	3	AOTM
133	L-ADD.FROM	7	7	I	-	LADF
140	L-ADD.TO	7	7	I	-	LADT
147	R-ADD.FROM	7	7	I	-	RADF
154	R-ADD.TO	7	7	I	-	RADT
	** REDEFINED ITEMS **					
108	FIPS6	6	6	C	-	
106	FAID	12	12	C	-	
50	LR_ETE_TYP	1	1	C	-	
51	LR_ETE_NUM	3	3	C	-	
54	LR_ETE_MOD	1	1	C	-	
55	LR_ETE_DIR	1	1	C	-	
56	LR_ETE_SUBT	1	1	C	-	
57	LR_ETE_NID	3	3	C	-	
60	LR_ETE_AID	1	1	C	-	

C. Other Road Model Elements and Attributes

Route Feature: The RDS data layer has a “route feature” called RDNAME (Road Name Route). Multiple road segments with the same road name have been defined as individual “routes”. All routes have a starting point and ending point as well as a primary direction. Routes also have a defined measurement system. The RDNAME route feature uses the cumulative "arc-length" converted to miles as the measurement system/units (refer to ARCMILES attribute in RDS.AAT file). Each route consists of one or more route "sections". There is a one-to-one relationship between route "sections" and road "segments" (Refer to Figure 2.).

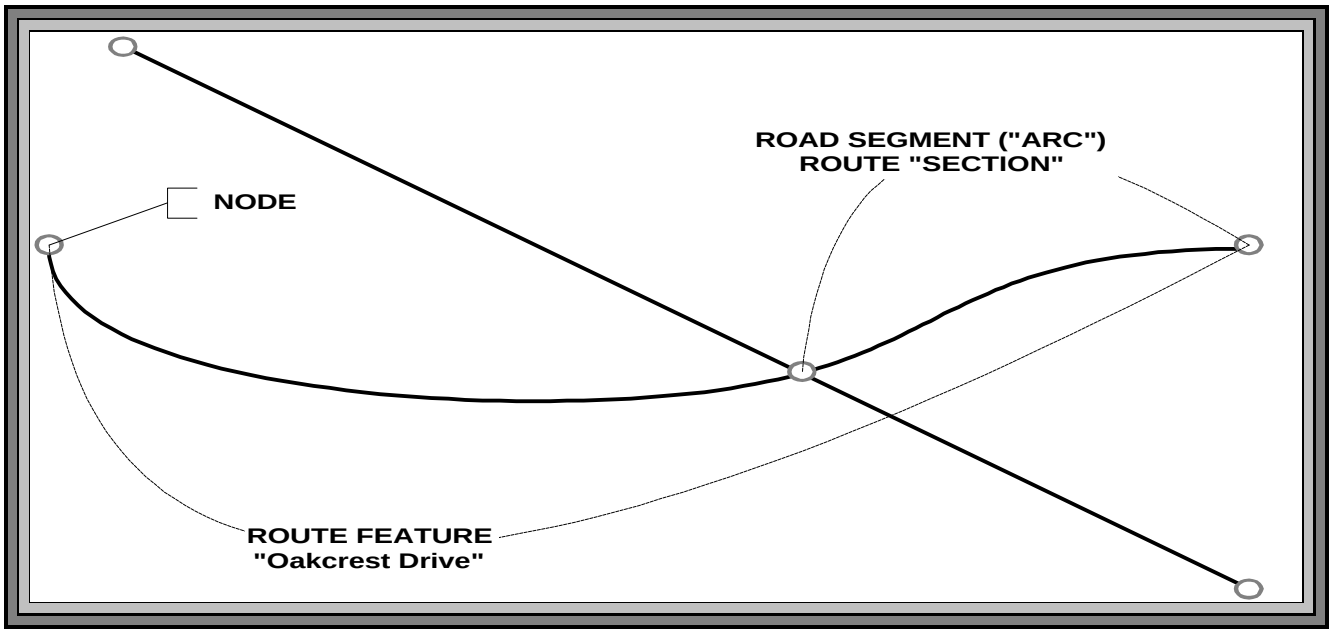


Figure 2

Intersection Feature: Road intersections are represented by a "node" at the convergence of three or more road segments. Refer to Figure 3 below.

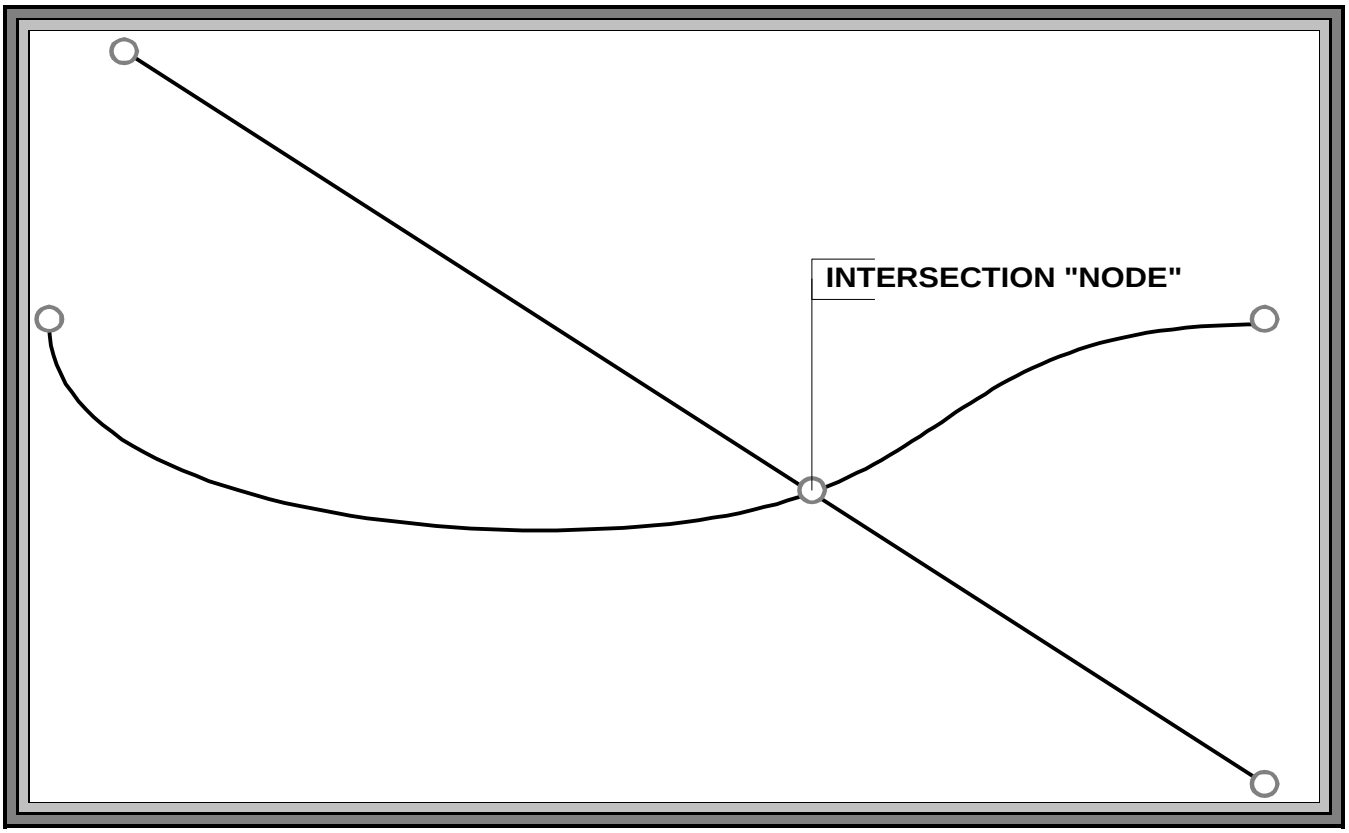


Figure 3

TABLE NAME: RDS.NAT (Node Attribute Table)

COL	ITEM NAME	WDTH	OPUT	TYP	N.DEC	ALTERNATE NAME
1	ARC#	4	5	B	-	
5	RDS#	4	5	B	-	
9	RDS-ID	4	5	B	-	
13	INT-TYPE	2	2	I	-	
15	INT-ID	4	4	I	-	

D. Road Entity Feature Tracking In order to maintain traceability through changes in the RDS data layer, the following tables have been added.

TABLE NAME: RDS.DEL

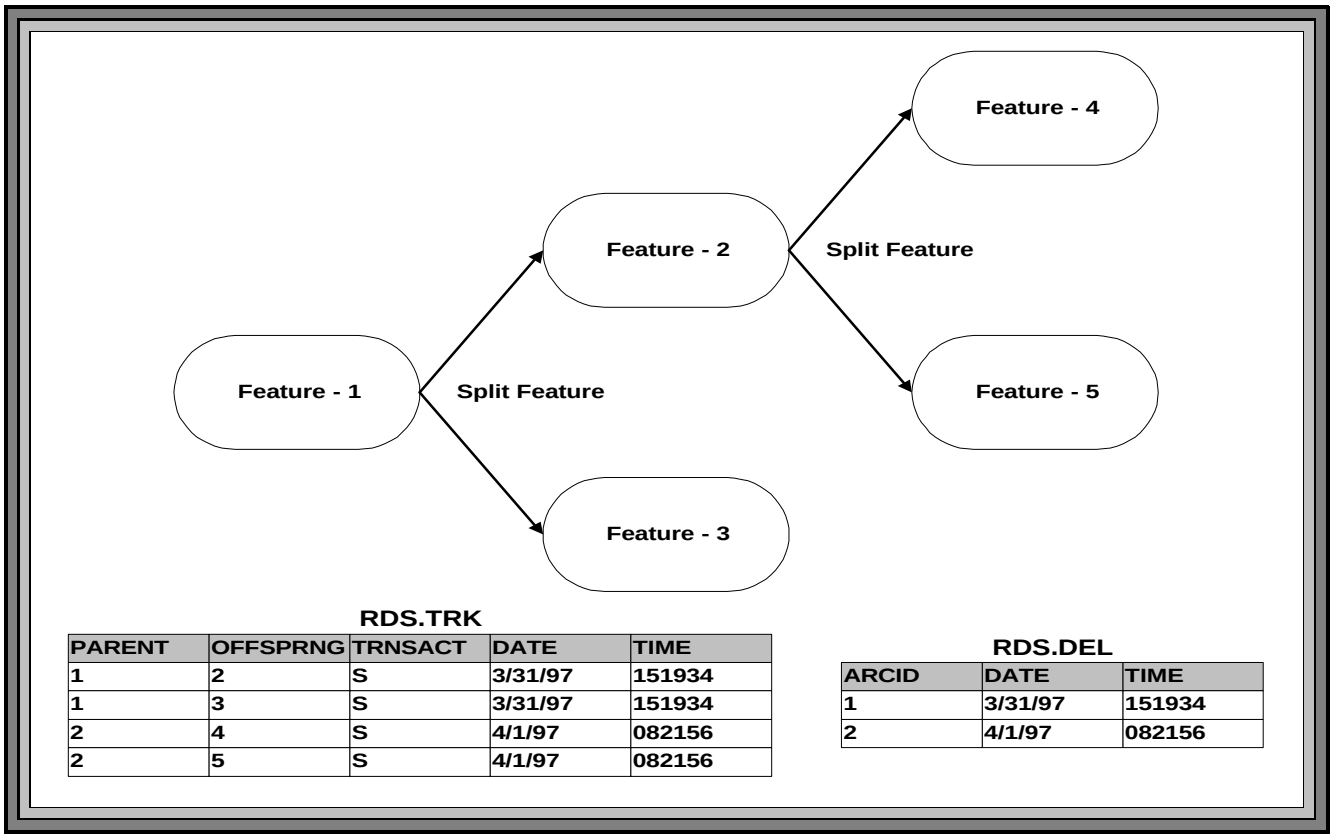
COL	ITEM NAME	WDTH	OPUT	TYP	N.DEC	ALTERNATE NAME
1	FIPS8	8	8	I	-	
9	ARCID	4	4	I	-	
13	DATE	8	8	D	-	
21	TIME	6	6	C	-	

TABLE NAME: RDS.TRK

COL	ITEM NAME	WDTH	OPUT	TYP	N.DEC	ALTERNATE NAME
1	FIPS8	8	8	I	-	
9	PARENT	4	4	I	-	
13	OFFSPRNG	4	4	I	-	
17	TRNSACT	1	1	C	-	
18	DATE	8	8	D	-	
23	TIME	6	6	C	-	

- The RDS.DEL table will keep track of deleted "arcs/road segments". ARCIDs will be permanently retired (never reused) for deleted features. As new features are created, the next highest ARCID available will be used.

- The RDS.TRK table will be used to document the life cycle of a feature. The PARENT item is the ARCID of the feature prior to modification/re-delineation. The OFFSPRNG item contains the ARCID value for the newly created feature. The TRNSACT item documents the nature of the transaction. Figure 4 & 5 are illustrate how these tables work.



RDS.TRK

PARENT	OFFSPRNG	TRNSACT	DATE	TIME
1	2	S	3/31/97	151934
1	3	S	3/31/97	151934
2	4	S	4/1/97	082156
2	5	S	4/1/97	082156

RDS.DEL

ARCID	DATE	TIME
1	3/31/97	151934
2	4/1/97	082156

Figure 4 - Feature 'Split' Lineage

The TRNSACT field in the RDS.TRK database utilizes the following coding scheme:

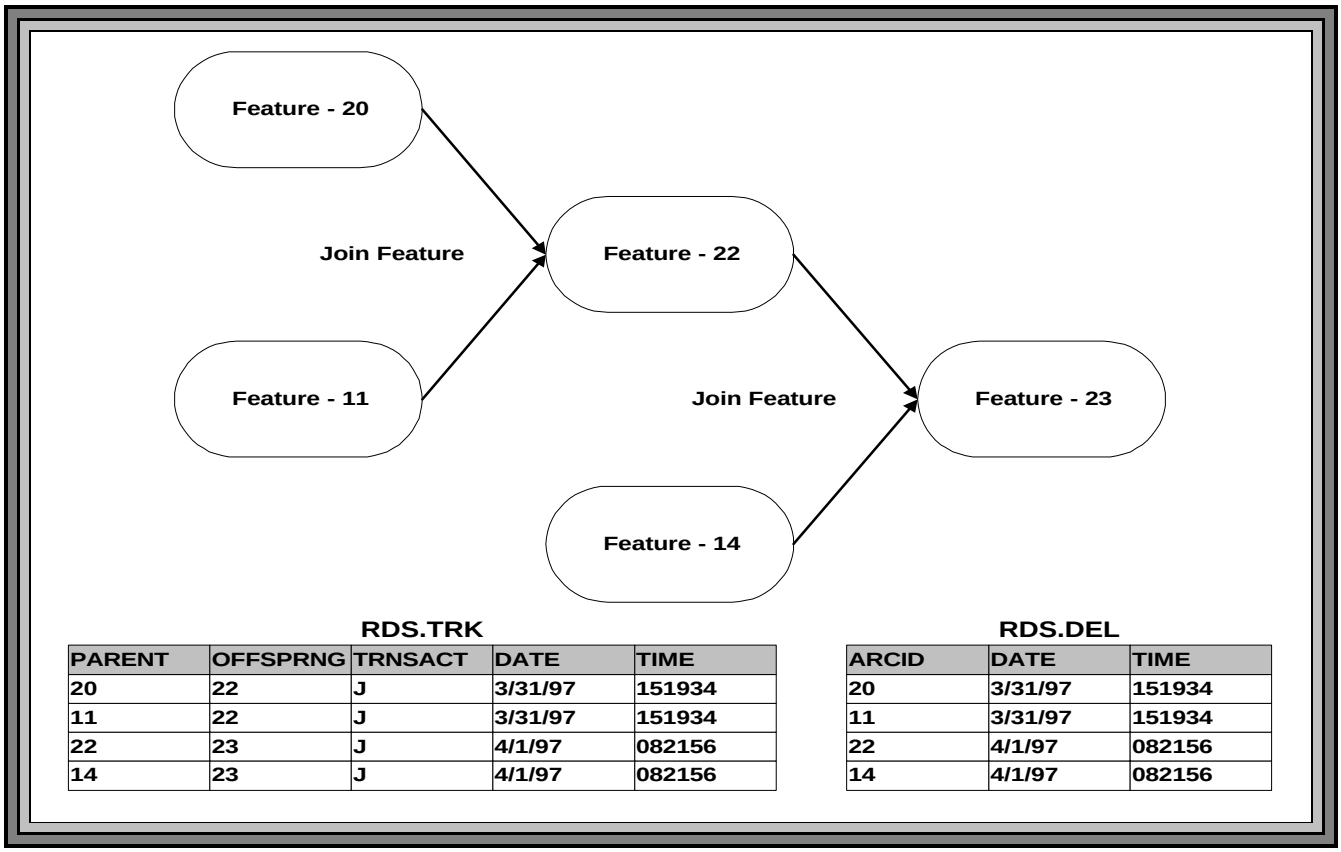
TRNSACT Action

A Added arc (i.e., a new arc)

M Moved arc (by reshaping the arc, moving a node, moving or deleting a vertex, or other action altering the shape of the arc)

S Split arc

J Joined arcs (originally 2 or more arcs)



RDS.TRK

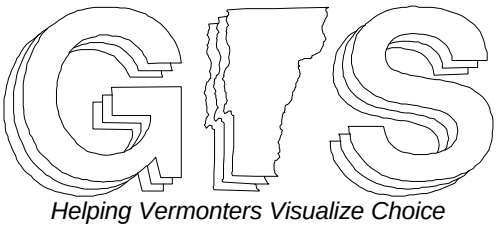
PARENT	OFFSPRNG	TRNSACT	DATE	TIME
20	22	J	3/31/97	151934
11	22	J	3/31/97	151934
22	23	J	4/1/97	082156
14	23	J	4/1/97	082156

RDS.DEL

ARCID	DATE	TIME
20	3/31/97	151934
11	3/31/97	151934
22	4/1/97	082156
14	4/1/97	082156

Figure 5 - Feature 'Join' Lineage

Updated data sets received by VCGI will be compared against the original data set provided to the data developer, and a record of changes made to the data will be saved (RDS<fips8>.TRK<updset>). This includes attribute and topological changes to the data. VCGI will also verify that the changes recorded in this table are consistent with "actual" changes to the data.



Vermont Road Framework Activities

Vermont Spatial Data Partnership Project

WHO ARE THE USERS OF THIS MODEL: The "*Technical Manual for Development & Maintenance of Road Centerline Spatial Data*" is designed to help guide future road centerline activities. VCGI, VAOT, and E-911 (and others) will continue toward implementation of this "proposed" road model. Modifications to the model will be required as organizational and technical "issues" arise during implementation.

HOW HAS THE MODEL BEEN DOCUMENTED: The model has been documented via Corel WordPerfect 7.0 and Visio Technical 4.0 software. These tools have provided the necessary functionality to document the "model".

NSDI Framework Road Data Modeling Workshop

Small Group #1 - Final Presentation

December 5, 1997 / Wilmington, N.C.

A theory has only the alternative of being right or wrong. A model has a third possibility: it may be right, but irrelevant.

--Manfred Eigen

Guiding Principles

- Stable Segments
- Maintainable - Change Management
- Ideal Form for area of framework responsiblility
- Simplicity
- Understandability

Consensus Definition of Road

- A road is a singularly designated path or paths through a road segment network. The designation, at a minimum, will include name but may also include route numbers. A road should not contain gaps, overlaps, branches, or loops.
- No consensus existed on the smallest length of a road. Ranges existed from 26 ft to 1/10 mile.

Entity Definitional Bounds

- It appears that the definitional bounds will be different depending on the agency. The fundamental constraints will most likely be governed by the business needs of the framework producer.
- Group consensus centered on public roads.
- Areas of difference were in the private roads. Our sense is that variability is allowed as long as it is well-commented.

Rules Defining Atomic Unit

- Shared Mgmt. Unit (SMU) refers to continues linear roadway segments in the transportation system or the numbers that represent them. (Could be extended to intermodal)
- A SMU has always one direction, an origin point and one end.
- A SMU has a unique segment of roadway and no roadway segment has more than one SMU

Rules Defining Atomic Unit (cont.)

- An atomic unit of a road can be identified by a physical reference number + From Pt ID and To Pt ID. However, not all To Pt IDs are as stable as the from Pt ID.
- Segmentation will be highly dependent on the extent to which area integration is being done by the agency doing framework activities and business activities.

Attributes on Framework Entities

- Minimum set of attributes could be:
  - Physical Reference Number
  - Point ID's
- Highly desirable attributes could be:
  - Road Name
  - Address Range
  - Ownership
  - Functional Class

Attributes Allowing Non-Framework Attributes to Link

- Road Name
- Address Range
- ZIPCode
- Measurement

Relationship of Point ID/PR to Anchor Point/Anchor Segment

- Point ID is very much equivalent to Anchor Point.
- Guiding question to Anchor Segments is “how do they behave under change?
- Anchor Segment is in a broad sense similar to SMU except in the area of trying to achieve maximum stability for change management (especially from an Area Integrator standpoint)

Relationship of Point ID/PR to Anchor Point/Anchor Segment

- With these goals in mind, suggested guidelines might be to:
  - Create fewer new SMUs.
  - Create longer SMUs.
  - Start SMUs at intersections with another SMU.

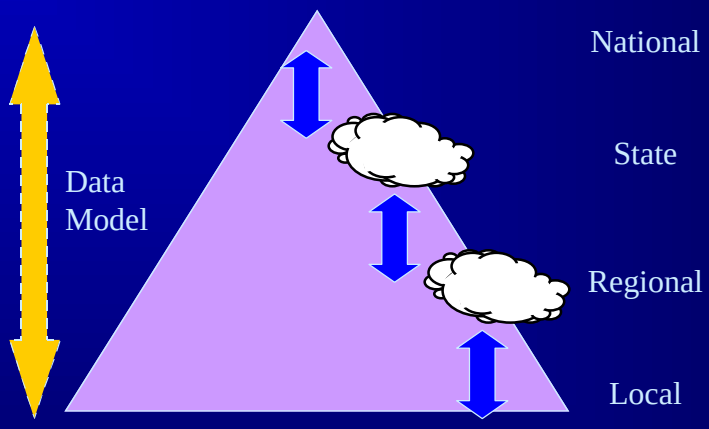
Documentation

- Clearly simplicity is key
- Should include 3 elements:
  - Simple model
  - example (real world)
  - narrative explaining both

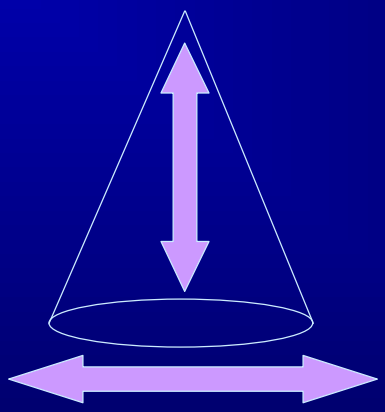
NSDI Framework Road Data Modeling Workshop

December 5, 1997
Working Team #3
Final Presentation

What is a data model?

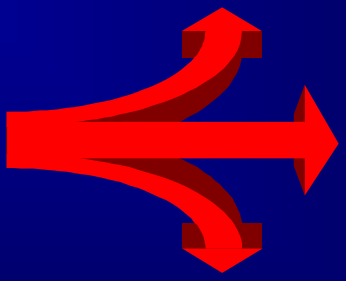


Reality Check?



What is a Road?

- Linear Centerline Pathway
- Start & End Points
- Length & Direction



Parameters and bounds

- Supports travel by motorized vehicles (regulatory restriction)
- Still an extensible model

Related Entities

- Anchor Points
- Anchor Sections

Anchor Points

- Stable location
- Recognizable in the field
- Can be shared by more than one section
- Coordinates optional...???

Anchor Sections

- Defined by two anchor points
- Mutually exclusive
- Totally exhaustive
- Non-branching
- Cartographcally independent

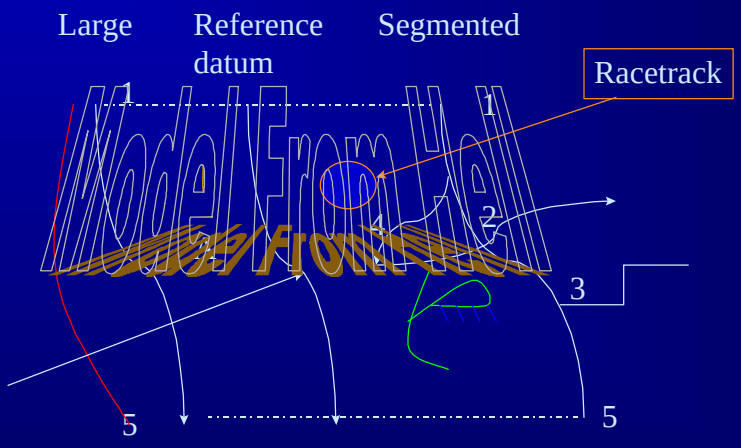
Attributes

- Mostly application dependent
- Mandatory
  - Unique IDs (points and sections)
  - Coordinates (points)???
  - Length (sections)???

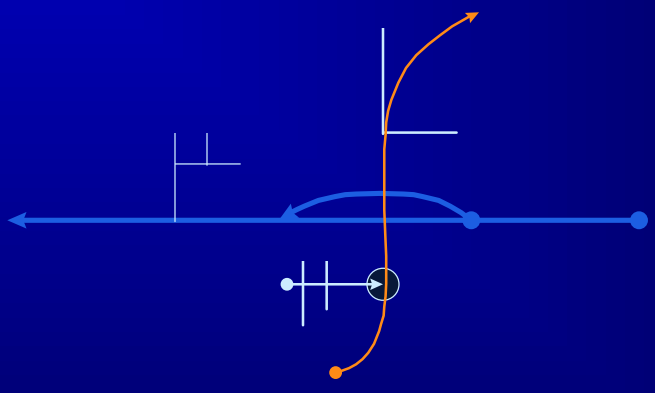
A Modest Proposal

- Implement Internet Style Ids as a schema for unique addressing of sections....
  - FIPS code for State/County ...

Two views of anchor sections



A Real World Example



Our Conclusions…

- The model works
- Supports 2027 structure (conceptually)
- Anchor points and nodes can coincide
- Links and sections can coincide
- Real-world implementation will vary

Remaining Issues

- What is the optimal anchor section size??
  - Optimize for data user or data producer
  - Based on cost
- Implementation *now* may be different from the model
- What do we need to produce in the meantime to guide current implemenations to a framework consensus

Section V.B — Survey of Workshop Participants

About a month before the workshop all participants were asked to respond to the following questions. Most responded before the workshop; several others did at or after registration. Their responses — along with digital documents and Web page links — were made accessible on a WWW workshop "home page," for access prior to the meeting.

Survey Questions

1. Provide a description (about 500 words) of activities or plans within your organization for implementing a framework "road data model" for your jurisdiction? Also please give us some idea of what your personal role is in the development or implementation of these activities.

2. What can you contribute to the workshop? What kind of experience or specialized knowledge have you acquired in your work in framework-like environments? How could this be of valuable to the rest of the participants and contribute to the workshop purposes (see attached "*Prospectus"*)?

3. What questions do you hope this workshop can help answer for you, and for your project or organization? What specific outcomes or products would you like to see the workshop generate?

4. Do you have documents you can share with other participants to help them learn about your project or your framework road data model? Can you share a project description, data dictionary, process flowchart, or other document? Please either provide a digital attachment to your email or a URL (an FTP address or Web server).

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1. For several years now, Maine DOT has been developing a road data layer for use throughout the department and to provide back to OGIS for public distribution. Our road layer includes our linear referencing system. We are finishing up an effort to adapt our LRS, in use for 20 years, to our GIS road centerlines. We are toward the end of the development effort and have now moved into a quality assurance mode. We have updated, and will continue to update. centerline data from DOT construction records and our yearly interaction with municipalities. MeDOT also maintains a rich set of attributes for Maine's roads some of which should be part of the framework data model. Our role in Maine's geodata community is to provide up to date road centerline and a standard set of attributes, yet to be determined, to other agencies and the public through the Office of GIS. Although by necessity Maine OGIS has begun to maintain a road layer as well, the two agencies are now working to bring the two existing data sets into one value added layer. My role at MeDOT is to:

- coordinate development, update, and standardization efforts within the dept. and across agencies,
- develop processes and mechanisms by which data are updated and quality controlled within the department,
- provide software, training, and support to department staff.

2. I'm not really sure what my contribution will be but I am in the thick of trying to make something work for Maine. MeDOT is involved in implementing a road base map for use by the department and to provide back to the state geodata clearinghouse (Maine OGIS). Both MeDOT and OGIS have been

building a road base map somewhat independently in the past but now trying to bring them back together as one layer with the best of both. This layer will be what is maintained and available for public distribution. We are dealing with a number of issues such as standardizing feature attributes and feature metadata, determining how basic attributes developed through dynamic segmentation would be preserved, determining a methodology for inclusion of linear referencing capabilities. I am not yet convinced of the need for, and viability of, unique, permanent, feature identification in the road layer, so I would like to discuss this further with other states.
3. I have been out of the NSDI framework loop for some time and need to find out where the transportation framework standards are going so that MeDOT doesn't go off in a direction that doesn't fit well. Also, our need for data and data continuity does not always end at the state border, it would be very useful to us to be able to easily integrate other state road data with ours.
4. Probably not much today but in the near future we will have some new standards documents, e.g. standards for adapting LRS to GIS road centerline data. A list of core attribute fields and coding for feature level metadata - in process of being standardized by a group with members from a cross-section of organizations in Maine. We have a list of desired attributes developed by the Maine GIS User Group in 1996. It would be available if anyone wanted it.

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1. Utah DOT has been actively involved with our State AGRC. They have a framework grant to work on the Transportation Data Layer. We have supported them in this effort. They have been very helpful in helping us understand the role of framework data layers. We have also worked with other Federal Agencies within the State of Utah to form partners for transportation share code fields. This should assist us in obtaining and sharing transportation data within and among various agencies.
2. Utah has been working with unified data bases for a number of years. We have received several FHWA grants to share our experiences with others and further develop our own data structures. We have been involved with linear referencing systems for over 20 years and have considerable experience in this area. We can contribute the aspect view of a transportation agency who collects and distributes transportation data attributes.
3. We are interested in the progress of other agencies and what problems they have encountered. We are especially interested in the solutions that they have derived. Our actions will be provided in written form in our Framework, transportation pilot project.

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1. Metro, the regional government for the Portland Oregon metropolitan area, maintains a TIGER like street Network file for the three counties (Multnoman, Washington and Clackamas Co.) within its jurisdiction. The file is cooperatively maintained with various partners including the City of Portland DOT, county planning departments and local E-911 agencies. Our role in the framework effort locally is to act as a data integrator.
2. I have been involved at the state level with framework efforts for a number of years. The Oregon

Road Based Information Team (ORBITS) has been working for the past two years to develop a framework-like structure for a shared road base layer statewide. Specifically, I have been chair of a sub-committee involved with developing a data model to support the vision of a shared road database.
3. My expectation for this workshop is that I will come away with a better understanding of how our efforts at the regional level can be integrated into the larger picture. I would also hope that my participation would direct some attention to the unique problems associated with data sharing from a bottom up approach. There is a great deal of activity and energy at the local level, and ultimately, that is where the most detailed, accurate and reliable data exist (one hopes!).
4. I will be presenting to the workshop my proposal for a regional Generic Linear Reference System that we use as an integration tool at the regional level. This recognizes that multiple reference methods exist, and as an integrator, our job is to respect those systems, yet be able to access them easily. Also, I will describe a simple data model in use at a local Oregon county. Polk County GIS coordinator, Dean Anderson, has worked closely with the ORBITS team, and has contributed his working model for roads.

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US Bureau of the Census

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1. The U.S. Bureau of the Census plans to utilize framework road data to improve TIGER and the framework road data model for exchange of road data. Unfortunately, a data set and supporting system as massive as TIGER cannot accommodate a new model in a short time -- years. However, when we implement a model, we expect it to be national. My role, as that of other Census staff, is to work with those at all levels of government, in academia and private industry interested in a workable road data model and to assure that it is implementable.
2. My contributions are based upon extensive experience as a data product producer, a data exchanger, and a data product user. Current experience and responsibilities may be the best indicators of the value of any contributions; hence they are merely listed in no particular order:

- Chief, Geospatial Research & Standards Staff, Geography Division, Census Bureau
- Editor for the ISO (International Standards Organization) Technical Committee 211 Geographical Information/Geomatics -- Quality Procedures Standard
- Chair, FGDC Subcommittee on Cultural and Demographic Data (responsible for developing address data standard)
- Adjunct faculty in GIS and Automated Cartography, University of Maryland

Add to this, 30 years in the trenches, including surviving the Address Coding Guides, GBF/DIME files and TIGER.
3. The key question for us is multi-part. First, is the question of a road data model, "What is the agreed upon model?" The second and related question is, "How many Federal, tribal, state and local agencies will describe their data according to the model?" -- "And when?". The final question an internal one, "When can we, the Bureau, take advantage of this model both internally and for exchange?" Unfortunately, the answer to the latter will probably be driven more by timing rather than resources or desire. In short, the Census 2000 is upon us.
4. Our data model treats road data much in the same fashion as all our geographical data. It is the TIGER model. Since this is a somewhat well known data model, most of the documentation is on-line -- much at *http://www.census.gov*. Therefore, in the interest of protecting trees, we direct your attention to that source.

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2. The Street Centerline Data/Linear Referencing Systems sub-group of the Regional Council's GIS Working Group is looking at ways to improve how we share and integrate surface transportation data. This Street Centerline sub-group identified the need for a street centerline data model that can handle most types of data attribution. Cities and counties in the State of Washington maintain data describing many characteristics of roads, including functional class, presence of side walks, accident locations and number of lanes. However, techniques of capturing and maintaining this information vary greatly and lead to redundant efforts. The Regional Council contracted with GIS-Trans Inc. to develop a methodology to integrate disparate transportation data. These types of disparate efforts prevent GIS data from being easily portable to other information systems. The enclosed table list common transportation data sets in the State of Washington.
3. Our organization can communicate the diverse uses for a road data model. We are working with the Dueker/Buter transportation data model and would like this model to gain some serious consideration. We can speak about our experiences in applying the basic Dueker/Butler model to a couple of our transportation data sets.
4. For any type of road data model, we envision a need for standard road identifiers and methodologies for calibrating different types of linear referencing systems. We would like to discuss several national efforts that revolve around the use of anchor points and standard transportation feature identifiers. We will also like to address how transportation features are depicted in a GIS. Two counties in our region represent interstates as a single line. The other two counties depict interstates as two separate lines, one each for north bound and south bound lanes. Can a data model work with these two different interpretations of a road network? Can it work with complex networks that detail interchanges and all lanes of travel (high occupancy vehicle lanes, express lanes). We will also want to discuss how the roadway component of a transportation network fits with other components such as passenger and freight rail, and bike trails.

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1. ITOS has been working with Georgia DOT for several years now assisting them in the development of their roads database. This database includes all city, county, and state roads in Georgia and is implemented using a dynamic segmentation data model with intersection-level calibration. Over the last couple years, Georgia has formed a GIS Advisory Committee (GISAC) and, through this committee, developed a three-year Base Map Development Plan. The existing GaDOT database was chosen by GISAC as the starting point for development of the new statewide base map. In cooperation with-and with funding from-USGS National Mapping Division, the State's base map will also be developed to conform to the USGS DLG-F (i.e., feature) content standard. ITOS is currently under contract to both the State and NMD to revise and convert the existing roads database to the DLG-F standard.

My personal role has included development work on the existing GaDOT roads database, participation in

GISAC to establish the new Base Map Development Plan, and initial design work for the DLG-F effort. My current position is database manager for the Georgia GIS Data Clearinghouse. In this position, I will be responsible for quality control of data flowing from the base map development effort, and documentation and integration of this data with the GIS Clearinghouse data library.
2. Through development work on the GaDOT roads database, I have gained a good understanding of the problems and issues associated with creating a roads data model. In my current role with the GIS Clearinghouse I've also gained an understanding of user needs in the larger GIS community.
3. Has Georgia taken a sound approach in developing its existing roads database? What things do we need to be doing in order to make this database easily transferrable/shareable with other organizations? What do we need to be doing to facilitate the incorporation of data from other organizations into our database?
4. We have data templates that we've developed to link the design of the existing roads database to the DLG-F content standard. We also have sample data that we've already worked through the template process.

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1. Early this year, the Georgia Department of Transportation, GDOT created a new office of Information Services. This office consolidated the functions of data collection, database management and GIS/MIS services under one roof. Under appropriation from the state legislature, we have begun the implementation of a Transportation Information System, or TIS. The TIS is a multi faceted approach to managing all of the departments information resources. Implemented in a phased approach, the TIS will initially focus on the physical and usage data associated with our multi modal transportation system, and this will include major work in the areas of geospatial metadata standards. As an agency, GDOT is working with other state agencies to develop statewide data standards. The primary geographic linkage mechanism for GDOT data is an LRS based on route systems. We are currently wrestling with the issues of dynamic segmentation verses coordinate data, and have begun to collect data in both. During the past 5 years, the department has worked with consultant and internal resources to produce a transportation layer for the state's GIS uses. Under an innovative partnership agreement with USGS and several state agencies, GDOT's transportation data set will be enhanced to become a common base layer for use by the USGS and the state. I have been involved with information management at GDOT for the past ten years, including time spent in applications development, systems and network management and database design. My current position is that of Information Technology Resource Bureau Chief, and in this capacity, I structure the work of the database and GIS/MIS development.
2. I have been working with GDOT databases and LRS issues for a number of years. I hope that my experience in dealing with conversion issues and standards development will be of value to others.
3. As we move forward in the development of our TIS, my hope is that we will be able to adopt metadata standards that will allow for broader data sharing and modeling. We are at a crucial stage in our project where we must set a direction for data`standards, and it is my hope that this workshop will give me a good feel for the directions we need to go.
4. I do have a several page document describing our LRS and current database implementation, which I can make available if it will be of use.

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1. The North Carolina Dept. of Transportation develops and maintains transportation features within the state. Additions, changes, and/or deletions to those features are reflected in the North Carolina Geographic Database (CGDB), of which transportation features are a part. The NC Center for Geographic Information and Analysis received an FGDC CCAP grant in 1996 to explore using locally produced transportation features as a basis of framework. The databases of the participants in this project will be joined to the transportation feature geometry, therefore allowing each participant to access the same transportation features, while still accessing attributes relative to their own applications. I am not involved in the production of transportation features for the CGDB, however I actively participate in NCCGIA's CCAP grant.
2. Using GIS on a daily basis, I can provide technical input towards transportation features. Since NCCGIA's CCAP project is the first framework project I have been involved with, my experience is very limited.
3. How are other states going about maintenance of transportation features? Workshop generated products: A final document. (Similar to the one produced for the "Framework Feature Maintenance Workshop" in Kansas City.)
4. I have attached an ASCII file containing the project description and objectives for NCCGIA's 1996 CCAP grant "Transportation Framework Data Development in North Carolina."

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1. As one of the principle authors of the original framework document and contributor to the NSDI debate, I have a good understanding of the issues in play in this workshop. I also have a background in data modeling and an understanding of transportation (ITS) issues that may be useful in forming "consensus" opinions on model and content issues.
3. Desired outcomes (personal opinion): Hopefully agreement on a common data model and content, with a clear strategy on how these might be implemented/institutionalized.

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1. The New York State Dept of Transportation (NYSDOT) has implemented a dynseg-based GIS covering approximately 15,000 centerline-miles of state highways (incl Interstates and other Principle Arterials), and is in the process of creating dynseg routes for another 11,000 miles of federal-aid eligible routes (Collectors up to PA). Our road data model is an implementation of the ESRI route feature class, with 2 LRS's encoded (milepoint and Reference Marker). The use of a dynseg-based road data model has enabled NYSDOT to bring major legacy data systems into GIS with virtually no disruption of the

data collection or custodial processes. In addition to the dynseg routes, we have the entire road network (approx 115,000 miles) digited at 1:24,000 scale, though there is very little up-to-date attribute intelligence on the local road network. At this point, we have not implemented street addresses in our road network. The Mapping & GIS Section is responsible for the development and maintenance of all base mapping used in the agency's GIS activities, including the dynseg routes.
2. I am god-like in my knowledge and understanding of mapping issues (you said this is no place to be shy!). Seriously, I am. Not. Now that I have no credibility left, I believe I can offer a solid understanding of the mapping issues involved, based on an academic foundation in the mapping sciences and 13 years of involvement in production and direction of a state base mapping program. I also have ASPRS certification as a Mapping Scientist, GIS/LIS. Beyond that, I have a DOT perspective on the business needs for a robust road data model, and a clear understanding of the conceptual and practical issues involved in implementing Linear Referencing Systems in a GIS. I'm not a GIS "propellor head", but understand the data models and technical issues.

Recently, I've been very active with our state GIS council in developing mechanisms for data sharing, and more importantly, shared data maintenance over the long term. We have created something we're calling the New York State Data Sharing Cooperative, which as far as we can determine, is unique in it's approach to these issues. It might be of particular relevance to a national road data model discussion to talk about how the concepts of our Cooperative might be used as a model for national maintenance of a roads database. I believe the data maintenance issue is the Achilles Heal of NSDI, and needs much further development. I could bring along a brief digital slide-show on the Cooperative concept, if anyone thinks it would be a useful part of the discussion.
3. I hope that my participation can help keep this workshop from being too conceptual, and instead stay focused on the practical issues that will be faced by organizations such as the state DOTs if they are to implement a new road data model. To this end, we need to be clear about the *business needs* that drive the development of data models. Strategies to provide incentive to organizations to transition to a new data model also need to be part of the discussion. Bottom line for NYSDOT is that if the outcomes are not clearly understandable, practical, and cost-effective, they probably won't stand much chance of being implemented.
4. There's information on the NYS GIS Data Sharing Cooperative on New York's GIS Clearinghouse website *(http://nysgis.nysed.gov/gis)*, including a couple of "white papers" on the rationale behind the Cooperative. The federal Bureau of Transportation Statistics did a site visit last winter and has a write-up of their findings on their website *(http://www.bts.gov/gis/state/visit.html)*, which includes a decent overview of how we are dealing with some of the road data issues.

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1. Contact information is correct.
2. I act as area integrator for the State of Utah. Our plans for implementation of a framework data model involves the following:

a. Completion of a pilot transportation Framework project covering 4 counties. It involves the cooperation and contributions of a number of Federal, State and local agencies, as well as private organizations.

b. The pilot will also involve generalizing the 24k scale (or better) road data collected for this project to a scale of 100k for a portion of the area.

c. The outcome (results, documentation, and recommendations documents) will provide a guide for extending Framework to transportation for the entire state.
3. Our work in Utah has involved transportation--related activities that encompass school bus routing; transit routing and planning; Statewide transportation network maintenance and update through the state's database; as well as specific transportation activities for various committees. In the private sector, my experience has been in assisting various state DOTs in implementing applications, investigating alternatives for database design and creation, and demonstrating various manifestations of transportation data management. Transportation in this sense extends also to utility distribution networks as well.
4. I'm looking for the basics of what others are considering "framework" models, and whether Utah's implementation is reasonable.
5. We can provide project description/overview, and will be able to provide documentation results of the pilot in the future. For now, bnagel@dpagr7.itas.ex.state.ut.us is the electronic contact. (I can send the exact URL for the project web pages.)

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1. The North Carolina Center for Geographic Information and Analysis, or CGIA, is the lead GIS agency in North Carolina. One of CGIA's primary responsibilities is to coordinate the development and maintenance of geo-spatial data and related technology among all stake holders. This includes public, private, quasi-public, and academic entities. CGIA fulfills the coordination responsibility with the guidance of the North Carolina Geographic Information Coordinating Council (GICC). The GICC adopted a strategic plan (1994) for geographic information coordination in North Carolina as a means to guide the coordination initiative.

Development of the North Carolina Corporate Geographic Database (CGDB) is the primary component the strategic plan and the coordination initiative in North Carolina. The CGDB is considered to be a component of the National Spatial Data Infrastructure. The CGDB is supported by multiple entities (agencies) either by direct funding of specific data layers or by a partnership in North Carolina called data custodians. More than 70 data layers are part of the CGDB and nearly one-third are supported, in part, by data custodians.

The data custodian for the road centerline dataset is the North Carolina Department of Transportation - GIS Branch. NCDOT has taken the lead role in developing the roads data model in the state. In the spirit of the strategic plan and under a NSDI framework CCAP project, NCDOT is working with CGIA staff in cooperation with other roads data producers (state agencies and counties), on the development of a prototype framework dataset for demonstration purposes. The technical and institutional model being developed is one that NCDOT may implement statewide under partnership with CGIA, other state agencies, and local governments in the future.

As Principal Investigator for the NSDI Framework Project, and as the Coordination Program Manager at CGIA, my primary role is to foster the development of the framework road centerline dataset as a component of the Corporate Geographic Database and the NSDI, in close cooperation with the DOT and with participation of all relevant federal, state and local organizations.
2. My contributions to the workshop will likely come from the experiences I have gained as participant

in the FGDC framework workshop series (held 1995-96), as a member of the NSDI Framework CCAP Project team in North Carolina, and from experiences related to coordination, development and use of the North Carolina Corporate Geographic Database. I feel it is imperative that (at least in North Carolina) we continue to place emphasis on the development of framework solutions in the local-state government context. The issues here pertain to both technical (data model) and institutional aspects of the framework. We should be careful not to disrupt local-state progress with stringent enforcement of technical protocol, but rather support/nurture collaboration activities through our findings and actions.

The data model currently being developed by the NC DOT as a component of the NSDI Framework CCAP Project in North Carolina, will be presented by DOT staff at this workshop.

3. Here are some questions important to me:

- How close are we to agreement on one framework road centerline conceptual data model?
- Will several co-exist across the nation?
- What federal technical or policy issues exist (or may be planned) that will influence the development of road centerline data model in states?
- I would like to know how you want to document/illustrate the data model?

4. The NCDOT will supply a document pertaining to the data model work in the NSDI Framework CCAP project for North Carolina.

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(Ms. O'Neill was invited, but unable to attend.)

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1. The USGS is working with several States with existing road databases to look for common approaches to defining road segments, roads, and routes and to understand how users attach and reference information, such as pavement management data and street addresses, to the geospatial data. For the past several years, the USGS has been developing a new feature-based data model that is more flexible than the current DLG model, which is based on attribute codes linked directly to spatial elements. The new feature-based model allows for features and compound features to be defined and has a much more robust system of attribution. The goals of the framework have heavily influenced the implementation of the new model. Concepts such as permanent identifiers and the ability to provide updates as transactions are being actively investigated. I have been actively involved in the development of the standards for both hydrography and transportation data using the new model and have been a USGS representation on

many framework related activities. The USGS plans to perform data assessment on several states* data holdings for the purpose of defining commonalities and to produce pilot data sets. Each of these pilots will be made available for comment on the Internet and will be used by USGS representatives in discussion with our customers concerning their needs. Each pilot will build on the input from the previous pilots and our discoveries as we assess more states/partner's data.
2. Much of my effort the past three years has been on developing a framework approach to hydrography. I have worked with USEPA and several states to synchronize existing data sets and to agree on a common model, content and unique identifier for hydrography. I have also worked with the development team at USGS who are developing the database and the tools to maintain large holdings of feature-based data in a distributed environment. The USGS has specialized knowledge of the feature based concepts and has been investigating maintenance scenarios. Issues that have been discovered while making an effort to manually conflate Census and Georgia data. We hope to learn during the data assessment of various customers data.
3. The USGS has traditionally developed general-purpose products with a primary goal of providing a consistent, national view of the landscape. The USGS is still geared towards ensuring national geospatial data. The work on the new feature-based data model has produced a fairly straight-forward data model that defines a compound feature (a feature that can be composed of many segments) that can be given a permanent ID and that would be maintained and would serve as the link to more specialized data.

- To that end, the USGS would like to understand if transportation data users typically define a *significant stretch of road* and assign an identifier to this feature.
- If they do, what does the identifier look like and how did they decide what was *significant*?
- If users have different ways to define *significant* what problems, if any, does this create?
- How do users maintain specialized data about the roads in their network?
- Many users have separate databases that link to this identifier. Are there other approaches?
- What are the common features that everyone needs to do their job on a daily basis. For example, do bridges and tunnels need to be maintained as separate features?

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1. The Vermont Center for Geographic Information, Inc. (VCGI), with support from VT's Regional Planning Commissions (RPCs), the VT E-911 Board, the VT Agency of Transportation (VAOT), and the VT Automated Library System, received a 1996 Framework Demonstration Project grant through the National Digital Geospatial Data Framework Initiative (supporting the creation of a National Spatial Data Infrastructure) of the Federal Geographic Data Committee. The purpose of the Framework Demonstration Project is to show how innovative institutional arrangements can ensure a robust and well-maintained framework of digital geospatial data.

In Vermont, this project is working to create the Vermont Spatial Data Partnership, which is bringing stakeholders together to discuss how issues of data sharing, data development and maintenance, and data access can be addressed in a coordinated and efficient manner. The Transportation Theme Expert Group (TTEG) is a technical sub-committee to this group. The Vermont GIS Community has worked in cooperation over the past five years to develop and maintain a "master" road centerline data layer (RDS). This cooperative partnership has allowed Vermont to build an accurate road centerline data layer while minimizing cost and duplication of effort. However, recent initiatives by the Enhanced 9-1-1 Board and the Vermont Agency of Transportation have created an environment of uncertainty. The Transportation Theme Expert Group has provided a forum for determining how this important data asset will be

maintained. My role is as acting "chair" of the group. I have been heavily involved in the creation of all TTEG documents. The TTEG includes representatives from VCGI, VAOT, RPCs, E-911, USGS, and the Census Bureau. In early 1997, TTEG participants developed a work plan and adopted "operating procedures" (voting rules, etc.). The group has been focused on development of a comprehensive road centerline data model and maintenance standard (*Technical Manual for Development & Maintenance of Road Centerline Spatial Data).* The group has been challenged by many technical and organization issues. The standards and recommendations developed by this group are helping to "mold" and "guide" future maintenance and enhancements to Vermont's road centerline data layer.
2. My experience with the TTEG has given me some great insight into both the technical and organizational changes of integrated maintenance between more than one organization. I can share how the group has approached these issues. I can discuss Vermont's approach to handling things such as unique feature identifiers and feature "life cycle" tracking. Discuss how I have integrated some of the concepts discussed at the last "Feature Maintenance Workshop" into our documents and standards.
3. I'm primarily interested in what other states are doing. How do they handle updates between multiple organizations? What kind of feature identifier do they use? Do they generate transaction records for updates? Do they track the "life-cycle" of features? Is the data in one single data set, or is it "tiled"? I don't think specific outcomes are realistic. I think of this as a "brain sharing" opportunity.
4. Yes, much of this will be provided with my presentation. However, the following link provides access to the TTEG web page and discussion group: *http://geo-vt.uvm.edu/vcgi/proj/tteg.htm.*

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1. We are developing the data model and implementation issues report for the NC Transportation Framework project in Moore County. We are also working with a consultant to address linear referencing system issues leading to implementation on all roads in the State. This work has been the basis for some of our thinking on the framework data model.
2. I am responsible the HPMS data base and am charged with working with other DOT units to address linear referencing in their data base development. I am also responsible for GIS development in DOT which is based upon a complete road system of all public travelway. I also am responsible for providing digital environmental data needs of the DOT. These responsibilities have caused a long term involvement with other state and federal agencies, county and local governments in cooperative efforts such as standards setting, data exchange, and data capture. This working model is similar to that required for framework.
3. Agreement on a content standard for spatial elements and attribution.
4. We can provide a draft of the Moore County Framework Committee working paper.

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1. BTS is the lead agency for coordinating ground transportation geo-spatial data within the Federal Geographic Data Committee (FGDC). As director of GIS in BTS, I am the principal liaison between the

Department of Transportation (DOT) and the FGDC. I chair the FGDC Ground Transportation Subcommittee, which has overall responsibility for coordinating and promulgating standards relating to transportation geo-spatial data. I also represent the transportation theme on the FGDC's NSDI framework focus group. I also participate in an informal Federal Interagency Task Force comprised of representatives from the DOT, U.S. Geological Survey, and Census Bureau, to agree on a common national road database that can be maintained jointly and used as the default framework data for those geographic areas lacking higher resolution road databases.

2. In my roles both as director of the BTS GIS Office and as chair of the FGDC Ground Transportation Subcommittee, I am strongly committed to the development of a viable national road centerline database that can satisfy a variety of potential applications, including cartography, geolocation of other features based on linear references and addresses, and network modeling. To satisfy all of these goals, road centerline database development efforts must involve coordination among a number of state and local agencies, especially the State DOTs, who maintain most the roadway attribute data. There must also be a minimal set of standards to enable road centerline data to "connect" across jurisdictional boundaries. These standards include, common or translatable feature definitions (e.g., what is a road segment?), some basic feature representation rules (e.g., should divided highways be represented by one or two centerlines?), and common methods for linear referencing and addressing. Without these basic standards, the difficulty of matching databases across jurisdictional boundaries will undermine most of the potential benefits envisioned for the NSDI. I believe that my principal contributions to this workshop will be to: (1) provide a national level perspective on coordination activities, standards development, and research related to the integration and use of transportation spatial data; and (2) to provide a mechanism, through BTS and the FGDC Ground Transportation Subcommittee to carry forward the recommendations emerging from this workshop.

3. I am hoping that this workshop will help identify a set of common elements used by the various framework projects that can be transformed into a standard conceptual model road centerline databases. This model could then be the basis for a standard transportation network feature model that the Ground Transportation Subcommittee would promulgate as an FGDC standard.

4. There are several national level documents relating to standards efforts by the FGDC Ground Transportation Subcommittee. All of these documents currently are posted on the BTS GIS Web Site *(http://www.bts.gov/gis/reference/)*.

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1. The Michigan Information Center (MIC) as a part of the Michigan Department of Management and Budget is the responsible lead agency in the development of a "road data model" for Michigan. The development work is being done as a part of a project entitled "Michigan Geographic Framework Project - Transportation Component." This project is a cooperative project that involves many agencies at different levels of government including the Michigan Departments of Transportation, Natural Resources, and Management and Budget and the Southeast Michigan Council of Governments (SEMCOG). The fundamental design of the road data model is being driven by the needs of the Michigan Department of Transportation in conjunction with one of the principal partners - the SEMCOG. These needs center around the task of establishing a linear referencing system useful for the statewide Transportation Management System and the Traffic and Safety crash location process. In my position as Geographic Services Manager, I have oversight on all of the activities associated with this program. My participation has been administrative as well as technical to the point of writing the code necessary for implementing this model.

The primary role of the MIC is to serve as an "Area Integrator" for the different themes of data including the road centerline.
2. Our organization can contribute lessons learned and some initial design considerations for the establishment of a statewide linear referencing system that has as a foundation a unique identification system that should allow for transactional updating. Also, our effort can provide some examples of our initial attempt at defining what a framework transportation model looks like. This effort has focused mainly on definitions that work within the business needs of county through state level agencies.
3. Our project team needs to learn from others in this group how we can bring more of the local data into the statewide framework effort. In our experience the different business needs of the local agencies require different data models. How can we best bridge this gulf through creative institutional incentives and programs? We have some initial thoughts on this matter but hope to learn much more from others in the group.
4. I can provide several documents that outline our standards and methodology. The first of these is entitled: *"Standards for Establishing and Modifying Physical Referencing Numbers, Mile Points and Point IDs in the MDOT Road Referencing System"* - July 1996. Another document outlines an initial attempt at establishing a minimum standard as to what is included in a statewide framework transportation model. This is entitled: *"Road Network Classification Standards"* - July 1996. The project also has a sample county coverage for review at the following anonymous ftp site: *http://www.michigan.state.mi.us* in the "outgoing/mecosta" subdirectory. There is a table layout of the fields for the road network and other features in the framework file (includes many more fields than will undoubtedly be found on final deliverables). This data dictionary is entitled: Description Table for Mecosta Framework Coverage Fields.

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1. My primary task for the last year has been the creation of a working LRS for NCDOT. Working with DOT personnel and a consultant team, a usable LRS for internal DOT use is in the last planning stages. Recently, I have been introduced to the CCAP initiative. I have attempted to merge these two "Monsters" together and am now striving to create a working system that will encompass both parameters. NCDOT is contemplating a link identifier concept to be used to join attribute data from different sources onto a common geospatial data file. This will allow for internal DOT data to be linked and for a LRS to derive from this linkage. Other agencies using the shared geospatial file can also use the link identifier to join internal ,or external, attribute data. The base shared geospatial file will evolve first from the agency with the most accurate digital line work. Additional linework not supported in the initial base digital file will be appended from all other cooperating agencies. A link identifier will be added to road segments between physical intersections(roads, rail roads, bridges, and ramps). County and state boundaries will also be used because of data sharing responsibilities and ,for the time being, simplicity of handling data. A great emphasis will be given to communication between member agencies. Software and hardware will be implemented to allow for this data sharing arrangement.

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1. The Maine Office of GIS has been working with state partners to develop framework GIS layers since 1990. Statewide transportation features, including roads, are among the layers that have broad applications statewide. The framework we are establishing consists of the transportation features shown on the 1:24,0000 scale USGS quadrangles. Our first milestone in this area was reached last year when our contractor digitized the last of the 709 quadrangles covering Maine.

Enhancements to create a statewide 1:24,000 scale framework road layers have been underway for several years as a result of two separate, but cooperative initiatives. First the Maine Office of GIS is working with the State's Emergency Services Communication Bureau to assist towns with readdressing to support statewide E911 telephone services. One of the program outcomes will be a statewide road centerline file consisting of all public and private roads composing Maine's E911 network. A standard list of attributes and spatial characteristics important to E911 and other general applications has been developed. A unique process including ongoing town input, GPS technology and GIS processes are being utilized to achieve program goals.
More recently, Maine DOT has begun further enhancements of the centerline file. The enhancements include adding node and arc attributes that provide a linkage to transportation databases necessary for transportation planning and emergency services. Maine DOT, Office of GIS and Emergency Services Communication Bureau are continuing work to derive a spatial and attribute model and maintenance processes.
2. Contributions OGIS can make to this workshop derive from our collective experience over the past 7 years in developing, maintaining and distributing road centerline data. During this time we have worked with organizations at all levels concerning their needs for transportation related data and applications. The work undertaken by the staff of the Office of GIS to develop the initial road centerline framework combined with the ongoing work to enhance these data through the statewide E911 project has exposed us to almost all important facets of this kind of work. We may not have all the answers, but we have uncovered most of the problems and are seeking solutions day by day.
3. Other workshop participants are facing the same problems we are and also seeking solutions that will allow their applications to move forward and ensure linkage to other jurisdictions. The workshop prospectus outlines a number of goals and anticipated outcomes. My interests are directly in line with those provided.
4.The url to the E911 project is *http://apollo.state.me.us*. Go to the projects page to view information about E911. The page will be updated soon.... so stay tuned.

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1. AMBAG staff and our member agency staff use numerous road data sets. Within our three county region (Santa Cruz, Monterey, and San Benito Counties) the Census Bureau's TIGER file is the most widely used road file, but several commercial "enhanced" TIGER files are used in addition to two or three commercial road files created from scratch and numerous road files created by public agencies at

the local and state levels. The TIGER files are not used for all applications because they are spatially inaccurate and the address data is also less accurate and up to date when compared to some of the commercial “enhanced” TIGER files.

In our current “Framework” project, we plan to “conflate” our spatially accurate street centerline files with the TIGER files in order to create a TIGER file that is spatially accurate and registers well with our other data sets, especially our digital orthophotos, and our parcel coverages. We will also be reviewing the address information in the improved TIGER file to insure that the attribute information is up to date and accurate as well. Our member agencies will then be able to use the TIGER file as their primary road files and have more incentive to keep them accurate and up to date.

As the GIS Analyst for the regional planing agency, my role is to help coordinate our members’ activities, and to provide technical assistance, and training. We have been working for the past two years to create uniform parcel and street centerline coverages that are registered to the best available orthophotography for the area.
2. I have worked in GIS and with TIGER type files for thirty years. Over the past ten years, about half of the applications that I have worked on involved transportation planning. Most of my work in GIS has been with small to medium sized local jurisdictions and I think that I have a fair understanding of their requirements and concerns. During most of the eighties, I also wrote and marketed commercial GIS software and completed a number of major data conversion projects which gave me a good understanding of the software development and consulting side of the industry.
3. I would like to see this workshop develop standards to facilitate the update and exchange of road data among various levels of government. I would like to see an environment created in which local agencies can update and maintain federal data sets such as the TIGER files.
4. A copy of the three page project summary for our framework project is attached.

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1. We have implemented a spatial data warehouse for the North Texas GIS Consortium (NTGISC). The consortium is composed of over thirty cities, counties and regulated utilities covering the Dallas-Fort Worth Metroplex. The cities and counties within the consortium all desire to use street centerline information for routing applications, with E-911 being the most critical concern. This use of the centerlines will probably be associated with computer aided dispatch software (E-911 and dispatch software). A second major use of street centerlines is for routing uses by the regulated utilities for customer location and service vehicle dispatch. This includes such activities as electric, telephone, water, sewer, etc. Spatial location is a major consideration for this use. This use will probably be associated with another software product to provide specialized processing (i.e. work order systems, customer service and etc.).
The third major use of street centerlines is for street maintenance applications, specifically for pavement management activities. You will note that these uses are widely divergent on their data needs. The routing applications depend heavily on accurate addressing information, connectivity of street segments, accurate development and recording of street attributes important for routing (i.e. speed limit, one-way streets, turn impedance and etc.). The accurate spatial location is less important than the attributes that provide the ability to transport "things" across the street network. It is important to note that this type of use for street centerlines carries a potentially high liability cost (i.e. response to life and death situations). On the other hand, the pavement management functions depend heavily on accurate spatial location as

well as the descriptive information that describes the street itself (i.e. year constructed, material used, depth of material, type of surface, surface conditions, ride quality, width of roadway, number of lanes, and etc.). The spatial location is of greater importance due to association with other spatial themes (i.e. street signage, traffic signals, street lights, storm drains right-of-way, and etc.). Liability considerations for these uses is relatively low. As the GIS Manager for the Bruton Center of the University of Texas at Dallas, my role is to provide the technical expertise necessary to the North Texas GIS Consortium to facilitate the adoption of a street centerlines standard for the consortium. In addition, my role is to develop, and populate a street centerline layer in the spatial data warehouse that will provide the basis for member development of these various applications. I lead the effort to create and maintain a street data layer to provide highly accurate spatial location to make every effort to provide the attributes that are common between the competing uses of the data.
2. I have been using GIS (specifically Arc/Info) since 1983 and have experience with both natural resource applications (with the Oregon State Water Resources, with BLM and as a consultant working with USGS, U.S. Fish and Wildlife, and Alaska Dept. of Fish and Game), and urban application (with the Municipality of Anchorage '87-'95, and currently with the North Texas GIS Consortium). I have taught Arc/Info courses under contract to ESRI and am currently a certified ESRI instructor for ArcView. My expertise is primarily GIS database design and development and that expertise was developed the hard way, by doing it. While at the Municipality of Anchorage (as manager of the GIS database for Public Works - and by default the city) I lead the development and implementation of a highly accurate urban database covering some 3,500 square miles. Our development efforts won many local and national awards. Important applications of the GIS database were in the Anchorage E-911 system for the Police and Fire departments and in the development of a pavement management system for the Public Works department. Other less visible projects were the development of a street lights application and a storm drain application. Currently, at the North Texas GIS Consortium we are developing a spatial data warehouse that will contain data for the Dallas-Fort Worth metroplex, covering four counties (Denton, Tarrant, Collin and Dallas). It is our objective (under a grant from the USGS) to develop a spatial data warehouse and provide access via the Internet. It is our goal to develop the data layers for the warehouse consistent with the Framework. In addition, as a clearinghouse node we are keenly interested in development of spatial data standards for spatial data. Our contribution to the workshop is experience with database design in both natural resources and urban applications of GIS, and depth of experience in developing applications that utilize street centerlines.
3. Our desire for this workshop is to participate in the decision process that will determine the array of attributes and other standards that are developed. We are specifically interested in the Framework attribute data standards.

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1. The USGS, through its National Mapping Division, is actively pursuing the development of national "framework" databases in partnership with other Federal, State, local, and private sector organizations. The national Hydrography data set (NHD) based on the DLG-F model is the first of those databases. Evaluation is underway to develop a transportation model in DLG-F to serve as the transportation "framework" database. I am assigned to the DLG-F software development group at the EROS Data Center. I function as a consultant to the DLG-F development organization, with views toward the future in regard to the data model, system integration/development, data maintenance, and the resolution of "science" oriented issues.
2. I spent nine years, prior to coming to EROS, working on a large project that used a feature based

data model. In that environment I was exposed to a multitude of data conversion problems, data extraction criteria definitions, system design and integration scenarios, etc.
3. Since I am fairly new to the DLG-F arena as well as the world of transportation, my intent is to gain as much knowledge about the needs of the transportation community, make as many contacts as possible, and provide inputs concerning the DLG-F model where appropriate.
4. I am assuming that other USGS personnel that are attending the workshop will provide the USGS transportation model templates. I will bring slides (both overheads and floppy) describing the conversion of DLG-3 to DLG-F and the overall DLG-F production system. If it is appropriate or useful I can share them.

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Section V.E — List of References / Sources

The following materials were contributed by participants in advance of the Wrightsville Beach Workshop, and were referenced in their discussions. These and other related materials about the NSDI Framework and Transportation can be accessed at *http://www.fgdc.gov/Framework/.*

Association of Monterey Bay Area Governments (AMBAG) -- The "Project Summary" describing the Framework Demonstration Project addressing use of TIGER files and digital orthoimagery in the region.

Maine -- Road Centerline Attributes "Wish List for Attributes on Road Centerlines" from the Maine GIS User Group - April 1996

Michigan

1. *Physical Reference Standards* -- Proposed standards for Shared Management Units (SMUs) and Point IDs (Anchor Points). The SMUs are referred to here as Physical Reference Numbers.
2. *Roadnames* -- Michigan Geographic Framework Project's attempt at establishing some standard for road names. Please note that MALI stands for Michigan Accident Location Index and Act 51 are the maps used to certify mileage on roads in a county
3. *Table Descriptions* -- A table of the fields associated with the Michigan Framework Transportation coverage at the segment level. Please note that this continues to be a work in progress and some of the fields associated with file development are for internal use only.
4. *Roads Classification* -- The Framework Project in Michigan has attempted at establishing the outer bounds of what could be considered a road. This document provides definitions and examples of different candidates and is intended to be used by agencies interested in adding new features to the framework. Again, please note that this is a work in progress and is still being tested.
5. *Sample GIS Coverage* -- An example of a framework transportation coverage that follows the standard mentioned in the documents above can be found at the Michigan Information Center's FTP site. The coverage is of Mecosta County in an Arc/Info interchange format. This site can be reached at: host: *www.michigan.state.mi.us*; username: *anonymous*; password: *[your email address]*; directory: */outgoing/mecosta*. File(s) available include: *p2a107.e00* (oblique Mercator) NAD27 *p2a107ll.e00* (latitude/longitude) NAD27 *readme.txt* (explanation on coordinate systems, field names, etc.) *readme.wpd* (Word Perfect version of the same file).

North Carolina

1. NC Transportation CCAP Project Description Initial proposal for "Transportation Framework Data Development in North Carolina," intended to "address the development, maintenance, and use of local government transportation (street centerline and rail line) datasets as a base component of the NSDI.
2. NCDOT Data Model -- "Recommendation for Data Model, Management Procedure" related to the CCAP proposal

North Texas Consortium

1. *Street Address Attributes* -- Proposed attribute structures for the centerline data layer.
2. *Standard for Street Centerlines* -- A proposed definition of the street centerline data layer for the North Texas GIS Consortium (NTGISC). The standard will describe attributing, processing, reporting, and application considerations for street centerlines.

Polk County, Oregon

1. *Project Plan* -- An plan laying out participants and requirements for an integrated, multi- user digital transportation data base (September 1996).
2. *Physical Data Base Design* -- A detailed data base specification (June 1997).

Puget Sound (WA) Regional Commission

1. *Draft: Transportation Data Integration* -- A discussion of LRS and Unique Identifier schemes
2. *Detailed Data Layer Description* -- Complete description and attributes for the Road Centerline data set
3. *WA Transportation Data Sets* -- A Table detailing all transportation data sets available in the State of Washington

Vermont -- *Vermont GIS Roads Manual* -- All documentation and references related to the development and maintenance of Vermont's road centerline spatial data bases. It outlines the structure of Vermont's "master" road centerline data layer, herein referred to as RDS. It also includes update procedures to be used when performing updates to this data layer.

Additional Resources

Additional documentation resources were provided to participants before and at the workshop; these include:

1. "Transportation Spatial Data Dictionary," available at *http://www.bts.gov/gis/fgdc/pubs/tsdd.html*
2. "BTS Data Dictionary & Data Formats," available at *http://www.bts.gov/programs/gis/ntatlas/datadict.html*
3. "A Generic Data Model for Linear Referencing Systems" — Research Results Digest #218 of the National Cooperative Highway Research Program, of the Transportation Research Board (September 1997)
4. "Linear Referencing Discussion Group," available at *http://www.bts.gov/programs/gis/HNDocs/discussion.htm*
5. "Seattle NSDI Framework Workshop — Final Report (September 1996)," available from the FGDC, contains a section entitled "*Common Transportation Data Model - Draft for Workshop Discussion.*"
6. "Standards for National Transportation Dataset," a DRAFT publication of the National Mapping Division, USGS (December 1997)