The Minnesota Transportation Framework

Contents

Section 1: Introduction

1.1 -- Executive Summary

The **Minnesota Land Management Information Center (LMIC)** and cooperating agencies received support from the **Federal Geographic Data Committee (FGDC)** to examine the premise that local, regional and state needs can be adequately aligned with the framework data concept of the National Spatial Data Infrastructure (NSDI). An objective stated in the project abstract is as follows: local, regional, and state acceptance and support of framework will be evaluated, and issues identified that require resolution for local, regional and state needs to align with the framework.

The scope of work performed relative to framework transportation data included review and preparation of materials, and information collection. Materials reviewed include (digital and paper) documentation obtained from federal agencies, the Minnesota Department of Transportation (MnDOT), MetroGIS, and other regional or local organizations which use spatial transportation data in Minnesota. Interviews with spatial transportation data users and managers from state, regional and local organizations focused on identifying data used to meet critical business needs and any relevant standards or specifications to which the organizations subscribed. Other topics included identification of problems encountered with these specifications when gathering, processing, integrating or distributing these data, and data sharing.

Review and analysis of materials and interviews suggest the following conclusions:

1. Many organizations have utilized road centerline and related data that has become readily available to them, rather than creating new spatial databases based on application requirements. In many cases data that has been readily available has been MnDOT road centerline basemap data; in others, larger-scale data (rights-of-way, parcels, utility lines, etc.) has been available from engineering offices. In some cases commercial enhancements of US Census Bureau TIGER data have been utilized.

2. User organizations have in many cases converted, adapted, or enhanced these data to support applications for mapping, planning and infrastructure management. These may be applications for which the data was not intended and may not have been well-suited. As a consequence almost all users identified problems in integrating these data with other spatial and non-spatial databases. All recognized that the databases didn t exhibit the precision, or completeness, or topology, or attribution necessary to support many of the key business applications they had identified.

3. Few users have systematically envisioned and planned the transportation-related business applications which they would like to provide; many are fully occupied in simply standardizing their data sets, sustaining several current applications, and attempting to be ready to meet the next high-priority application opportunity which presents itself.

4. Users find that fast-changing technology and the available opportunities to marry geographic information systems (GIS) technology with legacy databases and applications consume many of their resources. Specifications or standards relating to database or application design, or to integration with non-spatial systems generally have not been identified or used. Therefore their efforts have often focused on what appear to be unique problems and solutions.

5. The identification and implementation of specifications or standards which will reduce or simplify these challenges in the future would be welcomed by users, but have not received a lot of their attention. Many local and regional users recognize that their application requirements may be very similar to those of like jurisdictions. They believe that awareness of best practices, pilot projects, guidelines, specifications, or standards would help them more effectively address future database development, application, and data sharing requirements.

1.2 -- Description , Scope and Methods

The goal of the overall Framework Demonstration Project is to examine the premise that local, regional and state needs can be adequately aligned with the NSDI framework data concept. An objective stated in the project abstract is as follows: local, regional, and state acceptance and support of framework will be evaluated, and issues identified that require resolution for local, regional and state needs to align with the framework.

The scope of work performed relative to framework transportation data included review and preparation of materials, and information collection. This report was then drafted, reviewed by interview subjects, and revised. Materials reviewed include documentation obtained from federal agencies, MnDOT, MetroGIS, and other regional or local organizations using spatial transportation data in Minnesota. Information collection included in-person and telephone interviews with key personnel using spatial transportation information at state, regional and local government levels in Minnesota, email, and review of WWW sites.[1]

This report summarizes analysis of interviews and documents with regard to the following questions:

What are key transportation data in your local, regional, state organization, and how are they being used? What business needs are being met?

What formally or generally accepted data standards or specifications exist for transportation data at this level? What is the source for those specifications?

Do you experience problems with these specifications when gathering, processing, integrating or distributing these data?

How are these data being shared?

[1] See Appendix B: Information Sources

Section 2: Framework Transportation Data

2.1 Description of Types of Data

Transportation is one of seven themes identified within the concept of a national framework of spatial data.[2] NSDI Framework transportation data features are described in Figure 2 (below).

Interviews covered a broad range of transportation-related applications and spatial databases in use or envisioned by public organizations in Minnesota. In many interviews the focus returned to road centerline or street name and address range databases as uniquely important data resources.

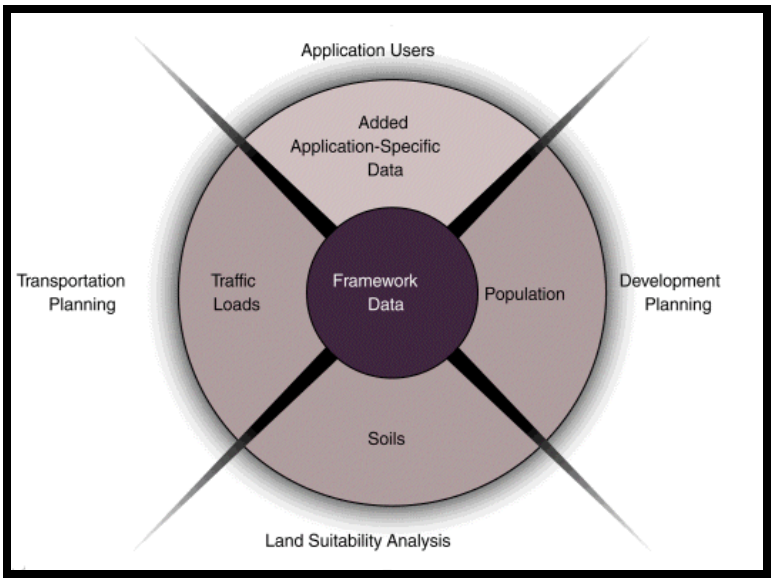


Figure 1 A representation of the NSDI Framework

In some cases discussion of data describing other transportation features followed; in other cases discussion focused on spatial databases describing parcels, populations, or other non-transportation themes. The interviewer encouraged interviewees to describe the full range of data sets which they considered within the domain of their transportation applications. Several respondents representing regional groups highlighted development of bike trail data. Arrowhead regional GIS applications will require

The **NSDI Framework** transportation data include the following major common features of transportation networks and facilities:

roads -- centerlines, feature identification code (using linear referencing systems where available), functional class, name (including route numbers), and street address ranges;

trails -- centerlines, feature identification code (using linear referencing systems where available), name, and type;

railroads -- centerlines, feature identification code (using linear referencing systems where available), and type;

waterways -- centerlines, feature identification code (using linear referencing systems where available), and name;

airports and ports -- feature identification code and name; and

bridges and tunnels -- feature identification code and name.

Figure 2 -- NSDI Framework transportation data content for further information see http://www.fgdc.gov/framework/frameworkintroguide/chapter3.html

[2] Framework Introduction and Guide, Federal Geographic Data Committee (FGDC), Washington, DC, 1997.

data describing all transportation features related to moving goods in and out of the Port of Duluth. Finally, MnDOT applications will utilize data describing all of the features listed below.

2.2 Minnesota Transportation Data Characteristics

Two databases available from Federal agencies are in use all across the country; these are the Digital Line Graph (DLG) data (available from the National Mapping Division of the US Geological Survey) and TIGER[3] data (available from the Bureau of the Census). Neither are widely used in Minnesota, but both served as historic source materials for transportation databases that are used. This section will discuss the MnDOT basemap data, the Lawrence Group (TLG) roads database supported by MetroGIS, and the large-scale and small-scale data used by other local and regional governmental units.

MnDOT Basemap Data -- The basemap data distributed and maintained by MnDOT was initially developed from 1:24,000 scale DLG source data and enhanced to support MnDOT mapping applications. MnDOT enhancements were aimed at assembling a seamless statewide road centerline coverage including all state trunk highways, creating limited topology, and adding limited attributes. Limited resources were devoted to achieving relative completeness, currency and spatial accuracy. Basemap data was made available to others by MnDOT, and is cited as a primary source database by many GIS users; most users agree that it has been the best available source for transportation base data in rural areas, or areas where gaps between more current or spatially accurate data exists.

In 1998-99 MnDOT is devoting resources to management project P181 - GIS Basemap Enhancement; the project goal is to enhance the MnDOT basemap database to provide location data needed for a GIS production environment. The project will document the positional accuracy, attribute accuracy, topological accuracy and completeness of the existing data. The project will assess generalization methods and implement the method that minimizes the size of the database without significant loss of positional accuracy. The project will combine existing data layers to create a continuous, statewide transportation network that includes roadways, railroads, and navigable waterways. Road data generated at local or regional levels will not be incorporated in the course of this project.

TLG Street Centerline and Address Ranges MetroGIS is a GIS project that is helping local governments and other organizations share data in the seven-county Twin Cities area. It provides access to many types of information including property records, natural resources, public works, demographics, education, and other areas. The mission of MetroGIS is *"to provide an ongoing, stakeholder-governed, metro-wide mechanism through which participants easily and equitably share geographically referenced graphic and associated attribute data that are accurate, current, secure, of common benefit and readily usable."*

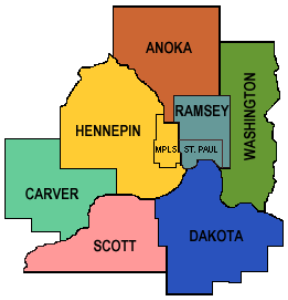


Figure 3 - The MetroGIS Counties

[3] TIGER stands for Topologically Integrated Geographic Encoding and Referencing.

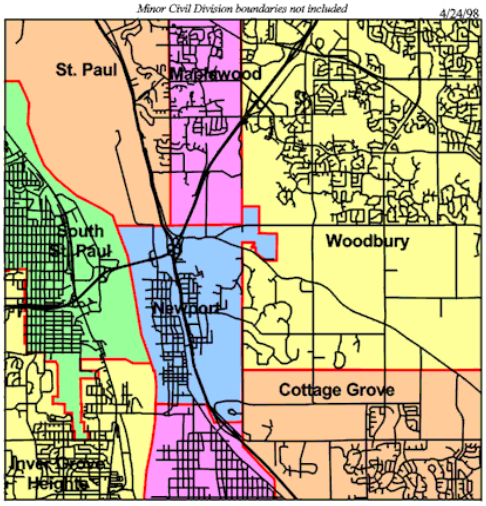
The TLG data set covers the Twin Cities metropolitan area.[4] This data set was developed with the support of MnDOT, the Metropolitan Council and others for use in automated routing, address matching, and other GIS applications within the Twin Cities area, as well as to allow for the integration of relational data sets. Features and their attributes are added and updated continuously. Updating occurs on a city by city basis; therefore, data currency varies. Throughout the course of a year, TLG completes an update of the entire 7-county Twin Cities Metro Area.

The database contains street name annotation. Additional related data sets provided along with the street centerline data include landmark information such as schools, shopping centers, hospitals, cemeteries, lakes, streams, railroads and various other areas and points of interest. (Metadata conforms to the Minnesota Geographic Metadata Guidelines; metadata for the related data sets is provided separately.) Some typical applications that utilize the data set are automated routing and address matching applications.

Figure 4

A Sample of The Lawrence Group (TLG) Street Centerlines Dataset

Minor Civil Division boundaries not included 4/24/98



Metropolitan Council

In May of 1997, an agreement for the use of TLG Street Centerline data was completed by Metropolitan Council, MnDOT and TLG. The agreement makes TLG Street Centerline data available to all State and Local Government agencies and Colleges and Universities in the State of Minnesota. MnDOT and the Metropolitan Council have funded the licensing of the TLG Street Centerline data for use by these organizations to promote standardization and sharing of geographic information.

Other Data Large scale data is compiled by county engineers and municipal officials in many areas of Minnesota. Very often these data are developed to support high-accuracy municipal infrastructure management needs, or are intended to be compatible with detailed parcel maps. A CAD (computer-aided drafting) system may be the native data environment. Such CAD data often do not include topology, registration to geographic coordinates and other traits of geospatial databases. However such data can be imported into many geographic information applications, and integrated or conflated with geospatial data. This large scale data will continue to be maintained and used for specific large-scale applications on a local level. It is currently being utilized as source data for regional GIS transportation data development[5], and is an important potential source of future updates in any county, regional, or state data sharing efforts.

Finally, some rural areas of Minnesota utilize vendor-specific packages of GIS products and services. In some cases these packages include data bases, most often pre-assembled from public information. Transportation data included most often are derived from TIGER data, even though these data may be spatially imprecise and lack many important features and attributes. Such

[4] The extent of the data set includes the twelve Minnesota counties of Anoka, Carver, Chisago, Dakota, Hennepin, Isanti, McLeod, Ramsey, Scott, Sherburne, Washington, and Wright. The western portions of the Wisconsin counties Pierce, Polk, and St. Croix are included; TLG may at any given time have other MN counties under development.

[5] Transportation data bases maintained by TLG and the Arrowhead Regional Development Council both utilize locally-generated CAD files, where available.

local or county organizations may use this data (despite its limitations) to support GIS applications, and simultaneously work to improve the accuracy and content of the data. The detail that they add to these databases may also be an important potential source of future updates in any county, regional, or state data sharing efforts.

Section 3: Uses of Transportation Data

3.1 -- The Minnesota Department of Transportation

The Mission Statement of the Minnesota Department of Transportation says that *MnDOT will help increase Minnesota's economic competitiveness by improving the transportation systems. To address the future, MnDOT will. . .better connect and coordinate transportation systems and services using shared information. .* [6]

MnDOT currently uses locational data to support a large number of transportation applications within the Agency. Starting with its 1995 Strategic Planning Process, continuing with the (1996) development of a linear location data model and the issuance of Requests for Proposals for a Unified Transportation System (1997) and a Location Data Management System (1999), MnDOT has been working toward sharing of databases with a locational component.

Figure 5 - Overview of UTS Functional Areas

Figure 5 describes MnDOT s view of the functional areas in its enterprise information system. The fundamental layer -- locational data -- is defined as follows: *Creation and maintenance of data about the existence, location, history, and names (including aliases) of transportation facilities. Stable and accurate location and history data is the prerequisite which enables data integration to correlate data from many subject areas pertinent for a given analysis. . . . Location translation services are software which translates a location in one location system to a location in another location system (e.g. a coordinate to/from a route/milepoint.). . .*

MnDOT s current Implementation Plan for Shared Information Resources provides a comprehensive listing of internal development projects; some represent computer applications currently running within legacy systems, and which need to be re-designed to share locational and other data[7]. An MnDOT interviewee identified those which are dependent on locational data, and which will be benefit from dependency on a common Location Data Server:

[6] For further information, see http://www.dot.state.mn.us/mission.shtml .

[7] MnDOT s information architecture planning work is acknowledged in the report of NCHRP 20-27(2) Development of System and Application Architectures for GIS in Transportation (1998). This report describes generic, spatially oriented models of DOT data and activities, based on study of activities in several states.

MnDOT Sites & Buildings
Crash Analysis
Traffic Events & Flow Problems
Traffic Counting & Volume Estimates
Traffic Control
Sign Inventory; Overhead Sign Structures
Pavement Markings & Condition
Materials Stocking & Resource Consumption
High Resolution Centerline (basemap data development for support of display and data translation)
Hydrography & Hydraulic Features (Utilize data developed through efforts of the GCGI Hydrography Committee for support of display, planning & analysis)
Drainage Permits
Facilities Inspection
Bridge & Asset Management
Railway & Bikeway Data
Roadside Obstructions
Transportation Network Modeling
Freight Movements
Public Transportation Assets
State Aid Needs Determination
Sufficiency Ratings
HPMS Reporting
Station Location Translation
Detour Management
Winter Maintenance
Survey Control Point Management
Weather Sensing & Reporting
Speed Zone Analysis

MnDOT generates internally many elements of the transportation data which are required to support these applications; a current focus is to create the systems that more efficiently share common data across these internal applications. In addition MnDOT has long had a data-sharing relationship with county land surveyors, who have provided highly-accurate public land survey data, and MnDOT explicitly plans for a data-sharing relationship with the steward(s) of the proposed statewide NSDI Framework hydrography data set.

Implied for the future (but not explicit) is an expectation that updates to local road locations, names, and perhaps other important data will evolve into a systematic data-sharing procedure involving local officials. However MnDOT applications identified in the current plan do not require the precision and detail of local updates; therefore, it is not clear that there is a business justification for expending resources to obtain them. MnDOT is a financial supporter of the Lawrence Group street centerline development efforts in the Metro region. Although users assume that MnDOT will be able to utilize this rich data resource, procedures for routine acquisition and use of this data have not been established.

Finally, MnDOT is engaged in project P181 - GIS Basemap Enhancement; it will improve the statewide basemap data originally developed at 1:24,000 scale. The project will:

> document positional accuracy, attribute accuracy, topological consistency and completeness to create a continuous statewide transportation network including roadways, railroads, and navigable waterways,
>
> assign a unique street identifier (name, address, and/or route information) to each road, and a unique reference identifier to each segment of railroad and waterway, and
>
> expand data content from the Trunk Highway system to all Minnesota public roads.

MnDOT has shared its statewide basemap with local, county and regional officials and the public since 1996, and plans to do the same with the enhanced product, which is scheduled for July 2000 completion. Its functionality and attribution will be quite similar to the characteristics described in the NSDI framework model.

Successful implementation of the MnDOT Location Data Server project will allow a variety of internal data attributes to be linked to the basemap, and will support sharing of this information with other users of the basemap. However MnDOT and users of its current basemap data have not identified procedures to disseminate this information, or applications external to MnDOT which will benefit from access to it. Also, the enhanced base data set may not systematically utilize more current and more detailed source materials which could be obtained from local, county or regional agencies.

3.2 -- MetroGIS

In 1996 the Metropolitan Council (current home to MetroGIS) assessed the feasibility of adopting a shareable transportation data set for the Twin Cities region. The Council worked with MnDOT and other partners to assess several potential data sources (to be used alone or in combination). Data available from the Lawrence Group, Navigational Technologies, MnDOT, the Council, and ETAK were evaluated for functionality, performance, the ability to share data between users, upgradability, availability within a short time frame, life cycle costs, usability, and customer preference.

An agreement for the use of The Lawrence Group (TLG) Street Centerline data was completed in May 1997 by the Council, MnDOT, and the Lawrence Group. The agreement makes TLG Street Centerline data available to all state and local Government agencies and Colleges and Universities in the State of Minnesota at no cost[8]. MnDOT and the Metropolitan Council have funded the licensing of the TLG Street Centerline data for use by these organizations to promote standardization and sharing of geographic information. There are currently 69 licensed users, out of an estimated 400+ eligible organizations. Data specifications[9] are as follows:

> Completeness -- Updated quarterly, the data will contain 95% of all roads that have been open for more than one year.
>
> Currency – Additions and changes submitted to TLG will be available in the first quarterly update that occurs 90 days after the changes are submitted.
>
> Positional Accuracy -- Roads will be located to within the approximate center of county digital right-of-ways, when available. Other areas will use best available sources and be within ten meters of the road center.
>
> The physical extent of the street centerline data which are required to comply to these standards includes the counties of Anoka, Carver, Chisago, Dakota, Isanti, Hennepin, Ramsey, Scott and Washington. Additional street centerline data may be available for other parts of the state of Minnesota and the three Wisconsin counties of Pierce, Polk and St Croix.
>
> Attribution -- The street centerline attributes include: Comprehensive Street Name, (prefix direction, street name, street type, and suffix direction); two alternate street names; left and

[8] The data set, as well as a variety of digital and cartographic products created by the Lawrence Group, are available at cost to the general public.

[9] Detailed information which conforms to the Minnesota Geographic Metadata Guidelines is available from TLG or the Council.

right codes for county, city and five digit zip; city or township name; and left from & to address and right from & to address.

Attribute Completeness and Correctness -- Full address range information will be available for 97% of the included roads.

Optional Attribution -- As available, the following attributes will be included as street centerline attributes: feature class generalization as defined by the U.S. Census Bureau, generalized speed limits based on feature class codes and one-way status using a 3 class system.

Related Data Sets -- Other data provided with the street centerlines include landmark information such as schools, shopping centers, hospitals, cemeteries, lakes and streams. Landmarks are represented by areas, lines, points as appropriate. Some county and municipal boundary information will also be available.

Other Relations Unique identification number will be maintained to allow data files to be related which refer to a unique road segment for use with road maintenance link node modeling and other applications. The unique identification number may be attached to end user data files and distributed without violating license.

Data Structure – The structure of the centerline data is designed to allow its use in networking and routing applications.

A primary purpose behind the support of this uniform data product was to offer all public agencies operating in the Metro area a single shared basemap to which all could attach business data elements, enhancing their shareability. Applications which use this data base will vary widely, as do the functions of organizations eligible to become licensed users. Some typical applications that utilize the data set are automated routing and address matching applications. TLG and MetroGIS recently worked together to develop an off-roads bike trail database integrated with street centerlines; they expect it will help support a variety of recreational planning and mapping uses.

3.3 -- Other Jurisdictions

GIS transportation data users in the City of St. Paul, the Arrowhead Region, and Olmstead and Otter Tail counties contributed information about applications of transportation data in their respective areas. Applications common in several local areas or regions include:

rural addressing,

enhanced-911 (E911) dispatch and routing, school bus routing, and commercial routing and delivery

pavement inventory and planning,

support for integration of land records data,

bikeways mapping,

infrastructure planning and management (telecommunications, water, sewer),

transit planning and routing, and network analysis.

In many areas GIS work is focused on integrating unlike databases provided by different government organizations. For instance, in Olmstead County a single GIS program serves some needs of the City of Rochester, Olmstead County, and the Metropolitan Planning Organization (MPO). The area covered includes one central city (Rochester) with 425 miles of roadway in the urbanized area, plus seven smaller cities and eighteen rural townships which have 780 miles of roadway. The GIS program is attempting to combine and update the best available roads data from three sources: the City, the County, and MnDOT. The goal is to develop an intelligent roadway network which has highly accurate digital linework and directional centerlines on all divided roads, which can easily be integrated (vertically) with other databases, and which contains network topology.

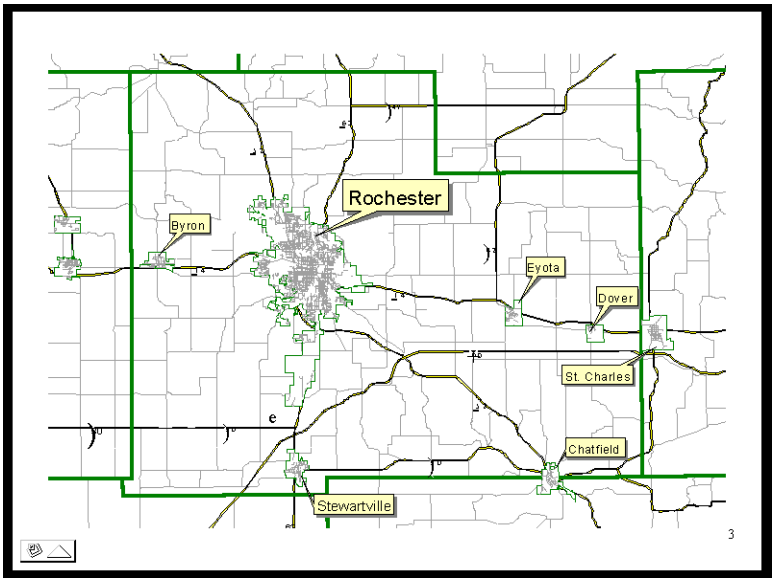


Figure 6 - Olmstead County roads data

Olmstead County envisions using this data to support call dispatch and routing functions including E-91 I (fire/ambulance/police), transit real-time or near-time ridematching, and school bus routing. The Olmstead County vision includes development of a spatial basemap for use by a regional Intelligent Transportation Systems (ITS) initiative to support Internet and cable television applications that deliver real-time transit system information and information on active roadway work zones and incidents. Further, users envision a data base on which network applications for sewer / storm sewer / water / fiber optic system management can be built.

If it is to meet stated goals for supporting these applications, Olmstead County must be able to address several issues:

Should the basemap extend just to the County boundary, or 5-7 miles beyond in order to support EMS requirements?

Should the database use unique MPO route assignment or build on MnDOT Route assignment?

How fine a level of detail should be incorporated into the basemap (and with what spatial accuracy)?

How can multiple datasets be calibrated against the basemap and each other?

As data creators update databases with new links and/or nodes, how can unique identifiers by maintained?

What kind of technology infrastructure is necessary to support data exchange and access?

What procedures can assure the retention of database intelligence as CAD and GIS databases are combined?

In the more urbanized confines of St. Paul GIS data is required that can support applications for the engineering and public works. Data must integrate easily with large scale parcel data; property rights-of-way, sidewalks and other very local features must be locatable very precisely when used with transportation data. Applications which require the precise[10] location of underground infrastructure, pavement conditions, surface drains are important. The TLG Street Centerline data was clearly not designed with the spatial precision or level of detail needed to support such applications.

Section 4: Sources for Specifications

4.1 -- The Nature of Specifications

Users of geospatial information in all kinds of organizations seek to identify sources of guidance that will help them to successfully and efficiently perform their work. They may identify and embrace, create, or modify a number of such sources.

FGDC, USGS, MnDOT, LMIC and other federal and state agencies have formal processes for assessing, developing and adopting formal **standards**. Non-governmental groups such as the Open GIS Consortium (OGC) and the National Emergency Number Association (NENA)[11] also define standards which impact their membership or their industry. Standards formally recognized or adopted by organizations often have the authority lent by statute, regulation or funding to support their implementation. Adoption of such standards is mandatory for prescribed organizations in some circumstances. As a consequence their partners, customers, and other units of government are relatively attentive to these standards; they may understand and use them. In those cases where adoption is recommended but not mandatory, such guidance may be referred to as guidelines. The Minnesota Geographic Metadata Guidelines are an example of a non-mandatory standard.

GIS users also seek guidance, cost savings, and reduced uncertainty by voluntarily adopting or implementing guidance provided through other sources. Some public agencies, industry groups and dominant companies create explicit **specifications** for their own use and that of their customers, partners or constituents. Other organizations may discover, assess, and voluntarily adopt those specifications which they feel will be useful. Such specifications may become viewed as *de facto* standards. In some cases government agencies and companies create actual data sets or other products which adhere to published specifications. Within organizations that use GIS, data which conforms to widely-understood format and content specifications is common; two examples are DLG data and TIGER line data.

Finally, GIS users will often seek out and adopt sources of guidance which have no formal standing or widespread usage, but which are seen as having been helpful or successful in other projects or jurisdictions. When these appear to be replicable, such sources are often termed **models**, best practices, or pilot projects. Organizations seeking to use GIS transportation data at all levels of government in Minnesota are eager to learn about replicable applications and data models being used successfully by other comparable jurisdictions.

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[10] Horizontal accuracy of two feet or less is required.

[11] See Appendix A - Relevant Standards for further detail about these organizations.

4.2 -- Specifications impacting Minnesota Transportation Data

Standards and specifications embraced by **federal agencies** directly impact developers and users of transportation data in Minnesota. Local, country regional and state agencies utilize a range of federal data products: DLG transportation data, TIGER files, Digital Orthophoto Quarter Quadrangles (DOQQ) aerial photography, Digital Raster Graphic (DRG). These data are generated by the USGS National Mapping Division and other agencies according to explicit specifications. A variety of formal content standards and format standards describe these data. These and the FGDC Content Standard for Digital Geospatial Metadata guide, influence, or constrain development of transportation data in Minnesota.

> As an example, the DLG vector transportation data (which is also presented graphically in DRG files) was created at scales of 1:100,000 and 1:24,000, and is warranted to meet National Map Accuracy Standards for horizontal location. To the extent that these data are major sources for data development in Minnesota, the resultant data products cannot encompass any greater degree of accuracy. If some local government applications require data precisely located to within, for example, +/-4 feet, these data products will not be useful.

Specifications developed by **non-governmental entities** also provide direction or structure to data developed in Minnesota. Two examples follow:

> One important guide for data development within MnDOT is the data model for linear referencing systems known as NCHRP 20-27(2) [12]. This data model will serve as a basis for implementation and integration of numerous transportation-related databases within the MnDOT information infrastructure. It was developed by the Transportation Research Board, which is supported by governmental and commercial transportation organizations.
>
> Implementation of Enhanced-911 services is a widespread goal across local governments in Minnesota, and many organizations are seeking to develop or utilize road centerline, road name and address range databases to support this application. Some of these organizations and the vendors they employ have utilized guidelines for road naming and database design championed by the National Emergency Number Association (NENA).[13]

Standards developed by **Minnesota state entities** also provide direction or structure to data developed in Minnesota. The foremost example is the Minnesota Geographic Metadata Guidelines developed by LMIC. Numerous MnDOT standards for route identification, cartographic symbology, road segment attribution may become more useful in standardizing transportation data development efforts across Minnesota.

Section 5: Problems with the Specifications

Difficulties in using standards ro\\or specifications to support and improve sharing of transportation information in Minnesota fall into three groups: problems in managment and understanding, technical challenges, and data usability problems.

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[12] Give the full name here.

[13] More specifically, the TLG Street Centerline data utilizes the street type coding standard developed by the US Postal Service, and endorsed by NEMA.

5.1 Management Problems

Management may not be aware of the current and latent demand for sharing geospatial transportation data across contiguous jurisdictions and levels of public agencies ranging from municipal to federal. They may not have fully thought through long- and short-term benefits which would flow from the development and use of data which is sufficiently robust to meet the multiple application needs of multiple user agencies and the public-at-large. Depending upon their position within public agency structures, they may not be aware of methodologies which can uncover net benefits associated with such activities as:

joint development of database specifications,

adoption and adherence to formal or de facto standards,

standardized documentation of existing and planned databases, and

participation in data sharing mechanisms, both institutional and technical in the form of formal cooperative agreements, working committees, and data access (clearinghouse) services.

Inconsistent or unclear local policies covering the recovery of data development, maintenance and dissemination costs create uncertainty for decision-makers, and impede sharing of digital data. Such policies are evolving as government authorities become better-informed about digital data technology. Also, they are evolving in the shadow of state law which may be contradictory, and which is subject to change in the short term. Some Minnesota local or county government departments currently share data selectively, expecting or requiring monetary compensation. Also, the Lawrence Group and other firms play an important role in transportation data development within Minnesota. Some public organizations believe that their data have commercial value to these firms and to their non-governmental customers. This belief sustains data sale practices which limit data sharing.

5.2 Technical Problems

A variety of common technical problems inhibit data sharing at very least, they cost time and effort in exchanging data; at most, less-sophisticated users cannot overcome them. Increased ability to transfer data files over the Internet (using email, FTP or HTTP services) has reduced well-known barriers imposed by incompatible hardware and removable magnetic media. Differences in operating systems deployed by different users more often create differences in terminology or procedure, but many software utilities and applications are capable of utilizing data generated within a foreign environment.

The largest problem of incompatibility is that of file format; that is, users of one software application may not have either the software tools or the conceptual understanding to effectively receive and utilize data developed in other application environments. Minnesota users identified a small variety of frequently-encountered file formats: ArcInfo (native), ArcInfo (shapefile), MapInfo, Intergraph DGN, and CAD (DXF). Each of these and other formats have particular characteristics; effective use of any of them in a foreign software application require the user to have some particular knowledge. For example, even though ArcInfo (shapefile) and DXF formats are acknowledged to be useful de facto standard data formats, some other vendor

applications cannot utilize them, and others presume that the user has knowledge of how to effective utilize the data.

Documentation describing technical details of existing databases and replicable pilot projects is not widely available. The frequency and volume of actual (and potential) data sharing may not be as high as they would be if such documentation was available. As an example, many Minnesota counties may be implemented in implementing E911 services, and might benefit from sharing data with peripheral jurisdictions and with other agencies operating within the county. But in the absence of detailed reports or analyses of technical success or failure scenarios, or the data specifications upon which other applications have been built, county officials may not be aware of resources (data and specifications) which might simplify their implementation task list.

Finally, users acknowledge differences in some technical characteristics of the data that they do share with one another. Over the geographic extent of Minnesota data users often develop data using a particular projection that may not be suitable for others. As an example, the Lawrence Group develops street centerline data in Minnesota South State Plane Coordinates (NAD83), even though MnDOT or the various counties may actually use the data in systems based on local or UTM projections. And shared databases often differ in their scales varying from databases developed for purposes of local infrastructure management at a scale of 1:600 to databases used for purposes of statewide mapping and analysis at a scale of 1:24,000. Users who share databases across scale differentials are routinely faced with the challenges of data generalization and/or limitations on appropriate use.

5.3 Usability Problems

Data users often have no choice other than to utilize shared databases, not matter how well the actual data content is suited to meet particular application needs. They may not have the time or dollars which would be required to create or acquire a preferred alternative data resource. Routinely the scale of the available data set implies an accuracy which limits its usefulness. For example, local or county-level applications of roads data need to be wary of utilizing TIGER roads data developed at a scale of 1:100,000. It may lack many detailed features and overlay inaccurately upon other data layers developed locally at larger scales.

Data currency is another attribute of data content which is not immediately apparent. Users may share databases which have not been maintained for years; as a result, more recent additions, deletions, or changes to features will not be reflected. Some data is also subject to cyclical variation, so that data describing such features as snow cover, land use, or surface waters may vary noticeably according to season. Potential users unaware of this temporal issue may share data with one application use in mind, and find that the data generates an unforeseen result.

Appendix A -- Relevant Standards[1]

One objective of this project was to identify standards and specifications relevant to transportation, which might be recognized, adopted, or in development on the part of federal government agencies, or other organizations outside of Minnesota. The following inventory includes standards, data models and products, or other reference documents mentioned by interviewees, as well as others of which some Minnesota GIS professionals may not be aware.

1 International Standards

1.1 International Standard ISO 15046 Geographic information -- prepared by Technical Committee ISO/Technical Committee 211 Geographic information/Geomatics

There are 20 separate parts to this extended effort; Part 15 - Metadata has attracted recent interest, as FGDC has indicated that the existing spatial metadata content standard will be reconciled with this in the near future. Other parts of the TC211 efforts may also move to eventual adoption as international standards.

Further information is available at http://www.statkart.no/isotc211/welcome.html .

2 National Standards (FGDC)[2]

2.1 Content Standard for Digital Geospatial Metadata (Revised) FGDC-STD-001-1998

OBJECTIVES: The objectives of the standard are to provide a common set of terminology and definitions for the documentation of digital geospatial data. The standard establishes the names of data elements and compound elements (groups of data elements) to be used for these purposes, the definitions of these compound elements and data elements, and information about the values that are to be provided for the data elements.

SCOPE: This standard is intended to support the collection and processing of geospatial metadata. It is intended to be useable by all levels of government and the private sector. The standard is not intended to reflect an implementation design. An implementation design requires adapting the structure and form of the standard to meet application requirements.

Further information is available at http://www.fgdc.gov/metadata/contstan.html .

[1] URLs provided in this paper were last validated 6 April 2000.

[2] Numerous standards and proposed standards are detailed on the Standards page of the FGDC Website (http://www.fgdc.gov; what follows is a partial listing. Several of the FGDC references which follow are midstream in the FGDC-defined process for review, comment, and (possible) adoption. They may or may not move forward to the point of impacting transportation-related data and applications.

2.2 Geospatial Positioning Accuracy Standard, Part 3, National Standard for Spatial Data Accuracy - FGDC-STD-007.3-1998

OBJECTIVES: The objective is to facilitate sharing and interoperability of geospatial data by providing a flexible and inclusive standard for testing and reporting accuracy of maps and geospatial data.

SCOPE: The National Standard for Spatial Data Accuracy (NSSDA) implements a well-defined statistic and testing methodology for positional accuracy of maps and geospatial data derived from sources such as aerial photographs, satellite imagery, or maps. Accuracy is reported in ground units.

Further information is available at http://www.fgdc.gov/standards/status/sub1_3.html .

2.3 Facility ID Data Standard

OBJECTIVE: To develop a facility identification data standard that supports identification of place-based objects that are generally known as facilities.

SCOPE: This geospatial standard will consist of a set of standardized data elements which identify and locate place-based facilities. This includes a core set of identifying information such as a standard identifier, latitude longitude, name, and facility type.

Further information is available at http://www.fgdc.gov/standards/status/sub3_3.html .

2.4 Address Content Standard

OBJECTIVES: To provide consistency in the maintenance and exchange of address data and enhance its usability.

SCOPE: The Address Content Standard (the Standard) will be an FGDC data content standard. The Standard will provide semantic definitions for components determined by the participants to be integral to the creation, maintenance, sharing, usability, and exchange of addresses and/or address lists. Within this scope, addresses are broadly defined as locators to places where a person or organization may reside or receive communications, but excluding electronic communications. An address list consists of one or more addresses. The Standard will additionally define an entity-relationship model for address data.

Further information is available at http://www.fgdc.gov/standards/status/sub2_4.html .

2.5 NSDI Framework Transportation Identification Standard

OBJECTIVES: To provide a logical data model for identifying unique road segments which are independent of cartographic or analytic network representation. These road segments will form the basis for maintenance of NSDI framework road data (through transactions or other means), and for establishing links among road segments and attribute data.

SCOPE: In accordance with the FGDC Standards Reference Model, the NSDI Framework Transportation Identification Standard being proposed under the classification of a data content standard. However, it also includes mandatory standards for assigning and reporting

identification codes as well as voluntary guidelines for data collection under the classification of a process standard.

Further information is available at http://www.fgdc.gov/standards/status/sub5_7.html .

2.6 Background Information[3]

2.6.1 Federal Agency Needs for Ground Transportation Networks and Network Attributes (9/93) prepared by Federal Geographic Data Committee Ground Transportation Subcommittee

This report presents a summary of Federal agency needs for ground transportation networks and network attributes. It represents an initial step toward the development of an overall requirements document for spatial data related to ground transportation.

Further information is available at http://www.bts.gov/gis/fgdc/pubs/fgdcneeds.html .

2.6.2 Position and Recommendations on Linear Referencing Systems (10/94) prepared by Federal Geographic Data Committee Ground Transportation Subcommittee

Further information is available at http://www.bts.gov/gis/fgdc/pubs/lrs.html .

3 National Standards (Other Organizations)

3.1 US Bureau of the Census

The term **TIGER** is an acronym for Topologically Integrated Geographic Encoding and Referencing, which is the name for the system and digital database developed at the Census Bureau to support its mapping needs for the Decennial Census and other Bureau programs.

What Is TIGER? -- The TIGER/Line files are a digital database of geographic features, such as roads, railroads, rivers, lakes, political boundaries, census statistical boundaries, etc. covering the entire United States. The data bases made available to the public (TIGER line extract files) contain information about these features such as their location in latitude and longitude, the name, the type of feature, address ranges for most streets, the geographic relationship to other features, and other related information.

Further information is available at http://www.census.gov/geo/www/tiger/overview.html .

[3] These two documents pre-date the definition of an NSDI at the federal government level, but are useful for background reading about transportation requirements.

3.2 US Postal Service

Postal Service offices at the state and regional levels can provide local governments with information helpful in naming roads and establishing address ranges. Most helpful in rural parts of the country, postal standards and practices cover a variety of topics which can provide local officials with de facto standards and practices which they can utilize in implementing rural addressing. These include standards and practices covering road and structure signage, road naming conventions (direction, prefix and suffix portions of the name), last line identity and other areas. The current national standard for address structure is **USPS Publication 28**. It is available at http://pe.usps.gov/cpim/ftp/pubs/Pub28/pub28.pdf . Additional information is available at http://www.usps.gov or from local postal authorities.

3.3 Digital Metadata for NHPN Version 2 Release 2

U.S. Department of Transportation

Data Set Description: The National Highway Planning Network is a comprehensive network database of the nation's major highway system. It consists of over 400,000 miles of the nation's highways comprised of Rural Arterials, Urban Principal Arterials and all National Highway System routes. The data set covers the 48 contiguous States plus the District of Columbia, Alaska, Hawaii, and Puerto Rico. The nominal scale of the data set is 1:100,000 with an maximal positional error of about 80 meters.

Further information is available at http://www.fhwa.dot.gov/hep10/data/nhpnmeta.html .

NHPN Table of Contents is online at http://www.fhwa.dot.gov/hep10/data/nhpntoc.html .

3.4 National Mapping Program Standards

Further information on a variety of standards embraced by the National Mapping Program of the USGS is available at http://rockyweb.cr.usgs.gov/nmpstds/dlgstds.html .

Many GIS users are familiar with the US National Map Accuracy Standards (NMAS) promulgated by the US Bureau of the Budget over 50 years ago, which define accuracy standards for published maps, including horizontal and vertical accuracy, accuracy testing method, accuracy labeling on published maps, labeling when a map is an enlargement of another map, and basic information for map construction as to latitude and longitude boundaries. Further information on NMAS is available at http://rockyweb.cr.usgs.gov/nmpstds/nmas.html .

3.5 Part 3 - Transportation, Standards for 1:24,000-Scale Digital Line Graphs - 3 Core (DLG-3)

NMD offers several DLG-related standards; further information on this standard is available at http://rockyweb.cr.usgs.gov/nmpstds/acrodocs/core3/3CR30197.PDF .

3.6 Spatial Data Transfer Standard (SDTS)

SDTS is a standard recognized by the American National Standards Institute, and has Federal Information Processing Standards (FIPS) and FGDC endorsements. The purpose of the SDTS is to promote and facilitate the transfer of digital spatial data between dissimilar GIS software packages, while preserving information meaning and minimizing the need for information external to the transfer. SDTS includes approved vector and raster profiles, and a (not-yet-approved) Transportation Profile that may be revisited in the future.

Further information is available at http://mcmcweb.er.usgs.gov/sdts/ .

4 Industry Standards[4]

4.1 OpenGIS Abstract Specification -- The OpenGIS Abstract Specification is a living document subject to changes and additions at each OGC Technical Committee Meeting. Only members of OGC can formally propose changes and additions.

OpenGIS Implementation Specifications OpenGIS Implementation Specifications are the result of OGC's Technology Development Process and are engineering specifications that implement part of the Abstract Specification for particular distributed computing platforms.

Further information is available at http://www.opengis.org/techno/specs.htm .

4.2 National Emergency Number Association (NENA) Recommended Standards are developed by the NENA Technical Committees: Network, Data, PSAP/CPE and ALEC/PS. Once approved by the NENA Executive Board, these recommended standards help ensure consistency in the 9-1-1 industry. Telcos, vendors and users all benefit from widespread adoption of the recommended standards.

Further information is available at http://www.nena9-1-1.org/Committee/Standards.htm .

[4] Numerous organizations research, propose, and adopt other standards which may be useful in building transportation databases. These include the American National Standards Institute (ANSI), the American Planning Association (APA), the National Cooperative Highway Research Program (NCHRP) of the Transportation Research Board (TRB), th American Association of State Highway and Transportation Officials (AASHTO), the National Institute of Standards and Testing (NIST), and others.

4.3 Intelligent Transportation Systems (ITS) encompass a number of technologies, including information processing, communications, control and electronics. ITS provides the intelligent link between travelers, vehicles, and infrastructure. When applied to transportation systems, these technologies can help reduce traffic congestion, reduce pollution, and improve safety and efficiency.

Among other services, ITS technologies:

- Assist drivers in reaching a desired destination with navigation systems enhanced with route guidance.
- Collect and transmit information on traffic conditions and transit schedules for travelers before and during their trips.
- Decrease congestion by reducing the number of traffic incidents, clearing them more quickly when they occur, rerouting traffic flow and automatically collecting tolls.
- Improve the productivity of commercial, transit, and public safety fleets by using automated tracking, dispatch and weigh-in-motion systems.

Further information is available at http://itsdeployment.ed.ornl.gov/spatial/files/ITSDEF.htm or http://www.nawgits.com/icdn.html .

4.4 Geographic Data Files format (GDF) is a European standard that is used to describe and transfer road networks and road related data. GDF provides rules how to capture the data, and how the features, attributes and relations are defined. GDF has been developed in a European project called EDRM (European Digital Road Map). Its primary use will be for car navigation systems, but it is very usable for many other transport and traffic applications.

Further information is available at http://www.ertico.com/links/gdf/gdf.htm .

Appendix B -- Information Sources

Information for this report was obtained from three types of sources: interviews, documents provided by those interviewed, and WWW pages. These sources are listed in this Appendix.

B.1 Persons Interviewed

Mike Barnes, Project Manager -- MnDOT (Engineering Services)
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Jeffrey Grosso -- City of St. Paul
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Jim Maxwell, VP - GIS Services The Lawrence Group
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Karl Olmstead -- MnDOT (Office of Information Resources Management)
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Jay Wittstock Dakota County Survey & Land Info Department
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Phillip Sailer -- Pro - West & Associates Inc.
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consult@prowestgis.com

Bob Vasques -- City of St. Paul
(651) 266-6188
bob.vasques@ci.saint-paul.mn.us

B2. Documents

1. -- , Positional Accuracy Handbook, GIS Standards Committee (Minnesota Governor s Council on Geographic Information), St. Paul (MN), October 1999.
2. -- , Issues and Guidelines for Working with Address Data (Draft), Standards Advisory Team (MetroGIS), St. Paul (MN), July 1997.
3. , Framework Introduction and Guide, Federal Geographic Data Committee (FGDC), Washington, DC, 1997.
4. , Request for Proposals for a Unified Transportation System, Minnesota Department of Transportation, St. Paul (MN), October 1997.
5. Barnes, M., Location Data Server (IRM P075) Project Plan, MnDOT, St. Paul (MN), June 1999.

6. Jacobson, Don, What Is Needed To Form a Partnership Between the Arrowhead Regional Development Commission and Mn/DOT District One, for the Implementation of A Geographic Information System, MnDOT District One, December 1994.

7. Lawrence Group, The, Metadata for the TLG Street Centerline and Address Ranges, Minneapolis (MN), June 1999.

8. MnDOT, Request for Proposal: Unified Transportation System (P074), St. Paul (MN), October 1997.

9. MnDOT, Implementation Plan for Shared Information Resources (4th Edition), St. Paul (MN), October 1998.

10. Reiter, Charles, Rochester - Olmstead Council of Governments: Roadway Network Project Presentation, July 1999.

11. Vonderohe, A. et al, A Generic Data Model for Linear Reverencing Systems Research Results Digest #218, National Cooperative Highway Research Program (Transportation Research Board), Washington (DC), September 1997.

12. Vonderohe, A. et al, Development of System and Application Architectures for Geographic Information Systems in Transportation -- Research Results Digest #221, National Cooperative Highway Research Program (Transportation Research Board), Washington (DC), March 1998.

B3. WWW Pages

1. Arrowhead Regional Development Council -- http://www.ardc.org/

2. Minnesota Land Management Information Center – http://www.lmic.state.mn.us/

3. Metropolitan Council (MetroGIS) -- http://www.metrogis.org/

4. Minnesota Department of Transportation -- http://www.dot.state.mn.us/

5. The Lawrence Group (TLG) http://www.lawrencegroup.com