Responding Organization:

Public Works, City of Saint Paul, Minnesota.
Bob Basques
GIS Systems Developer.

Summary of interest:

Our interest in underground modeling is focused on rendering the many digital datasets we've collected over the last couple of decades into a single seamless (3D) view. You'll note references to “3D viewing” in various locations in this response. This is an important next step in our rendering capabilities for future development.

Another big aspect of our records schema design has been to allow for the capability to view above ground well as the underground datasets in a seamless view. While we're primarily interested in viewing and lookup tasks of our data currently, there are obvious design/build aspects that would utilize a underground data model as well.

Use cases for underground mapping and modeling:

- Infrastructure Inspection Processes.
- Augmented Reality Interface Design.
- Damage Assessments.
- Wayfinding Tool Development.
- Emergency Response Application Development
- Infrastructure System Monitoring.
- Dispatching.
- Work Order System Integration.
- 3D Visualization Tool Development.
- Diggers Hotline (call before you dig)

Any model design needs to be able to integrate and/or overlay onto other mapping and spatial data collections. 3D is an obvious approach to rendering underground infrastructure such as Sewers, Water and Utility services. As well as ground contamination and soil types.

Here in the City, we need specific capabilities related to underground viewing. The ability to draw a section of ground and display as a profile, as well as see potential interferences for construction and disaster response. One call diggers hotline inpectors are another user of this type of data model, for locating and visually viewing via augmented viewers.

Two new technologies coming into wider use recently are LIDAR data and Augmented Reality. Both of these new technologies have specific needs related to representation in an underground model/viewer design process.

Architectures, standards and technologies:

Open Software Stack

MapServer, GeoMOOSE, Postrgres/PostGIS, OpenLayers, Apache, etc. . . . These components and more, allow us to connect to all major Commercial database vendor instances as well as intewgrating their data formats into our system for collection.

Open Data Standards
- OGC compliant Services (WMS, WFS, WCS, etc . . .), X3D
- Dedicated and Federated Services Architecture.

Online, web enabled data access.
- Javascript, WebGL (for 3D)
- Services separated based on usage needs.
- Easy push/pull services in/out of main stack as needed for upgrading/updating.
- Multi-nodal Services Infrastruture.
- Data/Services nodes auto-replicated for Archiving and redundancy.
- Distributed Authoring System for Data Maintenance.
- Services and Datasets assigned for management at User/Author Level.

Portable data nodes:

Our system is set up with portable data node replication processes, where data service replication can be utilized in the field from a portable server (something like a Raspberry PI for example).

Implementation examples:

http://www.pwgeo.org - (main (2D) Mapping Interface)

This interface already has some datasets and 3D capabilities built into the backend. It's currently being used for publishing of 2D mapping data but is close to being ready for 3D visualization as well. Initially this service would use a high resolution surface model to project a 2D infrastructure below ground. This type of projected data rendering would be mixed in with 3D models and LIDAR data to render a seamless 3D view.

http://www.pwgeo.org/datasets/ - (Online GeoData repository and Services)

Data is stored in a SVN repository and published via WebDAV for easy Author interaction and updating. Author/Owner assignment is set at the Folder Level. Edits to the Data and their respective published Styles and maintenance are enabled for handling at the Author/Owner level. The reaseon to describe the aobve here is to reinforce the need to have data conversion processes to and from any new data format in place in order to gain wider acceptence of a new format.

http://www.pwgeo.org/apps/ - (Online Companion Mapping Services)

Services for accessing other Map/location based materials and documents are managed as separate services. Each Services has it's own web container for HTML, cgi-bin, and other system resources (/bin, /var, /etc . . .)

The entire service node is auto replicated with it's own configuration file for the choosing of Services, Datasets, and mapping interfaces.

Response Elements:

- Existing Data Models and Software

We've put quite a bit of effort into identifying the best 3D formats, which we believe is an essential piece of the equation for underground data storage and visualization, as well as for use on the web. This is our desired method for publishing of this type of data.

Our assessments have pushed us towards the X3D format for 3D and consequently, underground data recording and visualization tasks. There are many existing convertors and more than one web Browser already has native support for the format.

- Current state of city infrastructure mapping and data management

  Data is currently in multiple geo-enabled formats. A short list would be: SHP, Postgres/Postgis, Oracle Spatial, DWG, Raster, to name a few.
  We use our Open Software Stack to homogenize and convert these source datasets on the fly per request. This leaves the data owner/publishers the option of keeping their data in their preferred format for updating. This is where it's important to have data convertors for any new format to be available during the initial launch of said format.

- Technology trends that anticipate future interoperability requirements

  LIDAR data is coming on strong. Methods for Publishing, archiving and maintenance of the data over time are needed. As well as being able to mix in the LIDAR points with more conventional 3D model formats. X3D has been identified to already enable this type of data mixing for publication, but only to a point.

  Separating out the data schemas on an Author/owner model allows us to authenticate each data access service individually. Any new data format should be able to handle the data access methods in a similar way.

  There are numerous existing online services for sensor and sensor types of data that we are already ingesting into our system. There are many more proposed services that will be coming online as well. All of these “big” data services will require a means to separate them into their types/uses, as well as be able to combine them back together for visualization and reporting purposes.

  All underground visualization and spatial data aspects will be enhanced by providing a method for visualizing the data in a 3D space. This is a must in our opinion.

  Much of our system is automated in it's current form. We have a very low administrative overhead compared to the number of services, datasets, and layers that are published.

- Continuity/connectedness of below and above ground assets and structures.

  In our observations, it should all be in the same model type, or be easily rendered alongside of other data formats. Where possible. Some aspects like the quality of the data for underground infrastructure will undoubtedly require some extra classification steps as well as a means to apply certain disclaimers about the accuracy and resolution of the data available.

- Infrastructure relationships to the natural environment

  River Levels. Flooding and bad weather monitoring is tied into the underground infrastructure to a large degree and needs to be considered when designing a data model. General Weather conditions might also be considered for inclusion in a model.

- Combined asset and supply management data

  We have the majority of our physical infrastructure items within the public right-of-way in a digital and Geo-enabled database data format(s). Other than line capacities for Sewer and Water networks, we don't currently have a need for representing this type of data, but It can certainly seen that this would be useful from the design side of the equation.

- Relationships between networks,

  With our services approach to defining a GeoLayer for publishing. All aspects point towards the general idea of integration of services over a network. Similar open services can be tied into our existing services structure because each data group is a services unto itself. By separating out each services structure it makes it much easier to add (and take away) services as needed over the life of the system.

  Our current data retention and archive model is very accommodating related to integrating like network datasets across jurisdictional or ownership boundaries.

- Workflows

  We've implemented a rather unique and stable environment for storage and maintenance of datasets as well as their respective metadata. This environment utilizes many key open source tool such as:
    - WebDAV enabled online Repository.
    - SVN for version control of data and system configuration setting such as CSS and Service conections.
    - Automated spatial Indexing and data crawling for the building out search engine indexes.
    - Multiple data formats supported by publishing system all at the same time.
    - Methods for mixing the archived data with other datasets to produce new hybrid datasets for analysis and trend finding.

- Statutory/legal requirements

  No comment (yet). Interested in working out the publishing details first. I see this effort being beneficial to City personnel even if wide use is not enabled either by open statute of legal limitations.