Open Geospatial Consortium (OGC) Call for Contribution

Modernizing NSDI's and SDI's: A Surface Fabric/Wireframe – Tile Approach

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A long-sought goal of the world's geospatial community is to find efficient and effective ways to implement comprehensive Spatial Data Infrastructures (SDI) at local, regional, national, and international levels. This OGC Call for Contributions asks for ideas for accomplishing this objective. We all hope to soon have a number of compatible, converging pathways that nations around the world can take to realize the full benefits of geospatial capabilities with a focus on data and technology, governance, and people. For this purpose, the team of Alan Leidner and Josh Lieberman propose what we are calling a Surface Fabric/Wireframe – Tile approach to building SDI's.

<u>Introduction: The Surface Fabric/Wireframe – Tile Approach</u>
Historically, geospatial data has been represented in a flat or planar map form that treats the surface of the earth as a digital version of a paper map. Even today, with 3D representations of physical features increasingly common, the vast majority of mapping products are in two dimensions. Such maps are extremely versatile: able to show not only surface characteristics, but also the reflection of above ground and the projections of underground features as footprints on a flat map. This form of geospatial representation and the analytic capabilities of GIS software make possible an enormous variety of productive applications that yield enormous ROI for users in all sectors and for the public in general. An advance beyond 2D maps is the digital incorporation of elevation (z) into the xy planar representation, thus creating a shaped fabric that can closely adheres to the true height variations to be found on the earth's surface, from mountain tops to low lying valleys. Elevation data significantly multiplies application options.

<u>Surface Fabric Component</u>
We propose that a map representing the surface of the earth as either a 2D plane or a 3D fabric is an excellent starting point for developing SDIs anywhere in the world. A foundational layer of this map should be the most current and accurate imagery available with the highest available resolution. For the U.S. this will likely mean piecing together the best existing imagery from states and local governments with imagery programs, USDA NAIP imagery, and a variety of other Federal, Local, Tribal, and Private data. We now know through a map compilation put together by ESRI, that it is possible to build an imagery-based map of the U.S.

with greater than 85 percent coverage. This imagery can be enhanced by integrating it with elevation data captured through the use of LiDAR from programs including the USGS 3DEP initiative. The combination of imagery and elevation forms the basic elements of a contoured Surface Fabric. We envisage these layers being subject to a process of continuous improvement. Such imagery will then make it possible to extract many types of visible features either as points, polygons, or 3D objects, with high absolute and relative accuracy. Slivers, gaps, and overlaps in coverage can be systematically corrected by the capture of supplemental imagery obtained through the use of aerial sensors mounted on satellites, aircraft, and drones.

<u>Wireframe/Tile Component</u>

Boundaries and Borders are an essential component of any SDI. The ability to differentiate between different jurisdictions, service areas, neighborhoods, statistical areas, PSAPs, and election districts is essential for almost every function of government and the private sector. The Census Bureau over the past decades, working with State and Local governments, has developed and refined a Census Boundary and Border layer (the Boundary and Annexation Survey) covering the entire U.S. Census also creates and manages Census tracts and blocks within its boundary layer, for which enormous amounts of invaluable information about demographics, housing, health, and economic well-being are captured on a regular basis. We believe the lines from the Census Boundary and Border file can be fitted with relative ease onto the Surface Fabric, creating a "wireframe" which demarcates the interior "tiles" comprising all the nation's jurisdictions. We have also seen this in action through a mock up put together by ESRI. A particularly important characteristic of the Census' border and boundary file is that the shared borders between adjacent jurisdictions are represented as one, single, identical line. This promises to make possible the assembly of adjoining jurisdictions into larger, seamless mapping coverages to support regional use cases including common operating pictures (COP) for disaster preparedness and response, and crime patterns across regions. For jurisdictions which currently have limited spatially enabled data, combinations of state, federal, and private data can be "gifted" through a geospatial starter kit to help improve spatial capabilities.

<u>Building State, Tribal, and Local Tiles to fit on the Surface Fabric and within the Wireframe</u>

Since the early 1990's an enormous amount of spatial data building has taken place federally, by states and tribal nations; by counties and municipalities, by private firms, and NGOs. A number of states have rolled up data layers from their local governments to create state-wide coverages of parcels, roads, and buildings. In some cases, Councils of Government (COGs) that cover multi-state regions have also combined the data from their participating jurisdictions.

We need to identify these initiatives and understand the techniques and technologies used to make them work.

At the same time, the Federal Government has produced hundreds of nation-wide coverages of features important to their operations. For example: the DHS HIFLD program has developed over 700 national infrastructure layers, more than 400 of which are available for public use. Also, the National Geospatial Intelligence Agency is starting to make available satellite imagery to the public entitled the National Unclassified Data Lake (NUDL). The combination of state and local data fitted into their proper wireframe tile, plus existing Federal national coverages and satellite sensor data, when registered to the authoritative national Surface Fabric, can create a valuable starting point from which the National Map can continue to evolve since all new spatial data created will have a consistent and standardized wireframe space within which it can be properly fitted.

<u>The Roles of Single and Networked Features</u>

Many of the features that populate local and national SDIs are in the form of a building, structure, or parcel footprints that are limited in extent and generally do not cross borders. For example, the vast majority of residential, commercial, and industrial buildings can be represented by a point or a 2D polygon, each of which generally resides within a single jurisdiction. Basic national standards for these features need to be established so that similar features can be mapped consistently across multiple jurisdictional boundaries, making visualization easy and allowing their attributes to be statistically aggregated. **However, there are other kinds of features that are connected together into networks and often cross borders. These include roadways, water bodies, and utility lines, both above and below ground. For the building of the national map, it will be important to maintain topological connection between networked features and to make sure that the points where they cross borders are highly accurate and consistent between jurisdictions. These networks can then help to fine tune the wireframe, improve Census boundaries and borders, and ensure that the different tiles fit together with great precision.**

Demonstrating the Surface Fabric/Wireframe – Tile Approach

We now know that it is possible to put together key framework layers including imagery, elevation, borders and boundaries, and roadways that form both a surface fabric and a wireframe. We also know that there are many state and local jurisdictions, within accurately delineated borders, that have significant enterprise GIS data holdings which could be fitted into their own tiles and connected to adjacent tiles. To demonstrate the viability of this approach it would be necessary to identify key areas comprising multiple states and jurisdictions, provide each with their portion of national framework layers, and insert tiles of

local data within the wireframe, making sure that networked features connect across borders. This could be done in the NYC Metro Area by combining NYC's and Westchester County's mature enterprise GIS' along their ten-mile border. Other similar examples can likely be found in the D.C. Metro Area, and in the metro areas in states including North Carolina, Texas, California, and Washington. Statewide layers formed by aggregating county and municipal data can be found in Kansas, Oregon, Massachusetts, Montana, New York, Tennessee, Indiana, and Utah, among others. Pilots in these or similar areas would help define governance principles and could also address the "people" part of the NSDI equation, according to FAIR principles. These demonstrations should also be designed to show that local and state governments can design their SDI's to both fit into the NSDI, while also maintaining the flexibility to customize their data so that it satisfies their own unique needs. Follow these links to see what is already being done by ESRI in this area: Introducing Esri Community Maps; https://livingatlas.arcgis.com/esri_ngda_datasets/

Governance and Architecture

This submission has thus far focused on proposing a method by which the national map – a central part of any SDI/NSDI - can be rapidly prototyped and prepared for wider implementation. But there are numerous other components of NSDI, in addition to the data itself, that will need to play critical supportive roles. We will briefly identify them below and would be happy to expand upon them as requested.

Performance Specifications: The national map and NSDI needs to be built to support use cases and applications that matter to the nation by delivering ROI, supporting economic development, saving lives, promoting health, and improving public and private work processes. Standards and data models will need to be designed that encourage data development that can deliver tangible results. For example: the NSDI needs to be built so that satellite imagery can be rapidly integrated when dealing with disaster events of all types – not in hours and days, but in minutes.

Data Models: Data models identify the data categories, features and attributes within a domain like underground infrastructure, and their functional relationships to each other. They help guide data development that is comprehensive and effective, and can be applied to a variety of different use cases. CityGML and MUDDI are two examples of data models, created by the Open Geospatial Consortium, with functional purposes in mind. Variations in how features can be represented can be described in feature-oriented maturity models. (E.g. A building can be represented as a point, a grid cell, a footprint, and a 3D representation depending on capabilities and need.) A properly designed feature maturity model can ensure that, when necessary, common features, regardless of their representation, can be made interoperable.

Data Standards: Standards and requirements apply to data quality, detail, and completeness, particularly related to location accuracy and quality. For example: ASCE 38 standards for Subsurface Utility Engineering (SUE) focuses on the evaluation of utility location data by the level of reliability (A,B,C,D) of its sources. Paper maps are classified at the D level while utility features identified by geotechnical means such as ground penetrating radar or direct observation, are rated A.

Map Indexing System for Easy Search: The national map will undoubtedly require the assembly of many dozens (or hundreds!) of data layers from each of thousands of jurisdictions. Finding the data needed for problem solving, predictive analysis, and operations support will require an indexing system where every data layer comprising the national map has an identification number and metadata that will allow rapid searching by location and content. Ultimately, AI tools will make the process of data discovery increasingly rapid. Geospatial initiatives like the Big Ten Academic Alliance Geospatial Information Network, led by the University of Minnesota' are ideally situated to create such a national reference system, having already done so for a consortium of Big Ten states.

Architecture: As the various components of the national map are built, there needs to be a storage, update, access, and transmission architecture that allows the data to be rapidly found, assembled, downloaded, and utilized. We strongly suspect that federated data repositories in "The Cloud" managed by federal, state, tribal, local, and private organizations, will be linked for cross sector searching and integration. For example: During disaster events, emergency support function (ESF) managers will have the ability to amass the data they require rapidly, to properly carry out their missions. We continue to believe that a Geospatial Concept of Operations (GeoCONOPS) is necessary to properly choreograph the movement and analysis of data to deal with complex events such as disasters.

Transportation Mapping: Authoritative national transportation coverages are the framework layers that include the street and highway network, rail freight and passenger lines, and fuel transmission pipelines. Accurately registered to the imagery and boundary layers, such transportation coverages add enormous value to the national map for vehicle routing, 9-1-1 response, and supply chain analytics to name just a few use cases. A number of agencies, private, and public organizations have developed "their versions" of a transportation layer created to support use cases like vehicle routing (private sector) and street and highway construction, operations, safety, management, and maintenance (Local and State DOT's, Federal DOT). Of value would be a data model that organizes features and attributes for a master transportation layer for the national map. Success would depend upon bringing all the currently active players to the table to design a comprehensive data model that supports all key use cases and assigns responsibility for keeping the different spatial data sets up to date. Also addressed could be the design features necessary to support autonomous vehicles, and up to date mapping of refueling stations for electric vehicles.

Spatially Supported Disaster Response: It is easy to see how, in the response to a large-scale disaster event like a hurricane or earthquake, spatial data from all affected jurisdictions might be rapidly combined to create a common operating picture. This disaster data foundation (before the disaster) then needs to serve as the basis for mapping and analyzing the data generated by the initial and continuing effects of the disaster, whose volume on a daily basis can be greater than the data volume preceding disaster onset. Special provision must be made for this influx of information and for the plethora of analytic products that must be created and distributed, often on an hour by hour basis. This cannot be accomplished without an effective national map and key NSDI governance provisions including suitable GeoCONOPS.

Conclusion

We believe the approach outlined above adds to the discussion of how best to build SDIs and NSDIs. Among its benefits would be the ability to incorporate much of the data already created by federal, state, tribal, local, and private organizations over the past decades thus preserving years of investment. The value of this data is in the hundreds of millions of dollars, while the benefits that can be realized by making this data interoperable, in the form of an integrated, interoperable NSDI, has benefits in the many billions of dollars annually. Moving forward now with a program of demonstration projects could see significant results well within one-years-time, given that so much of the data that would be needed already exists.