DIGGS:
Setting the Standard for Geotechnical and Geoenvironmental Data Management

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ABSTRACT

The Federal Highway Administration (FHWA) in conjunction with the Ohio Department of Transportation formed a work group comprised of 11 State DOTs, United Kingdom Highway Agency, USGS, USEPA, US Army Corps of Engineers, FHWA Ohio Division, and FHWA Office of Federal Lands Highway to oversee the development of data dictionaries and data formats for geotechnical management systems through Transportation Pooled Fund (TPF) project TPF-5(111) "Development of Standards for Geotechnical Management Systems". One of the products being produced through the pooled fund project is a geotechnical and geoenvironmental data exchange standard called Data Interchange for Geotechnical and Geoenvironmental Specialists (DIGGS). The first version of DIGGS is being released in 2008 and will include standards for borehole, laboratory test, deep foundation, and borehole geophysics data.

DIGGS provides a standardized means of geotechnical and geoenvironmental data exchange between disparate databases. There are several significant advantages to the user of DIGGS including: ability to exchange data between databases within an organization and with external organizations, ability to efficiently incorporate data from consultants into any database, ability to perform software-automated data checks, ability to exchange data between compatible software packages, and the ability to merge databases and incorporate software into an integrated geotechnical management system. DIGGS facilitates the seamless flow of geotechnical and geoenvironmental data from point of generation, through project usage, to storage, and then reuse.

Several DIGGS compatible tools will be available at the time of the release of DIGGS version 1.0. These tools include: a database with GIS interface for state transportation agencies, software for subsurface data reporting, a virtual data center that enables data exchange across organizational boundaries, and the United Kingdom Highway Agency geotechnical management system. Several geotechnical and geoenvironmental software vendors have already included DIGGS translators in their software.

INTRODUCTION

Many agencies, companies, and organizations are struggling with managing increasing volumes of geotechnical and geoenvironmental data, geo-structural assets, and geo-hazards. The ultimate answer to addressing many of the associated frustrations is a comprehensive, electronic geotechnical management system (GMS) capable of managing, evaluating, and manipulating data sets. The development of such a system requires a significant investment of time and money, along with specialists with expertise in software and database development, geotechnical and geoenvironmental knowledge, and geographic information systems (GIS). Currently, many state transportation agencies are in various preliminary stages of developing geotechnical management systems. These systems will provide the means for efficient data storage, retrieval, and utilization for enhanced decision making.

Geotechnical activities and features are typically on the critical path during the design and construction phases of projects. These activities and features represent a notable percentage of the design and construction costs as well. Consequently, geotechnical information represents an essential risk management aspect during design and construction.

Five transportation agencies have evaluated the impacts of a GMS on their operations, and have estimated their savings. Examples of estimated savings include:

- The United Kingdom Highway Agency has a Geotechnical Data Management System (GDMS) for management of subsurface exploration data and management of slopes and other geotechnical features. They estimate that by using the management system to initiate proactive maintenance, they save 80% of the cost of slope repair system-wide.

- The Ohio Department of Transportation (DOT) estimates that they can save $12 million to $24 million per year by using previously collected subsurface exploration information. In the past, 90% or $52 million worth of subsurface exploration data was discarded annually because it was not in an electronic format and there was no effective means to store it.

- The Florida DOT estimates that they will save $250,000 to $500,000 for subsurface investigation of a project for widening and reconstruction of I-595 by using previously collected exploration data recently made available in an electronic database. They also saved several hundred thousand dollars on a project for widening a bridge on I-75 by using historical boring information.

- Missouri DOT estimates an annual savings of $81,000 in preparing boring logs by electronic entry of data in the field by 4 crews. In addition, they estimate an annual savings of $20,000 by reducing boring needs by 10% to 15% for 10 to 15 structures per year by using historic boring data.

- Minnesota DOT estimates that by using its electronic database, in lieu of hard copy information, they save $20,000 per year in personnel time alone to look up boring information.

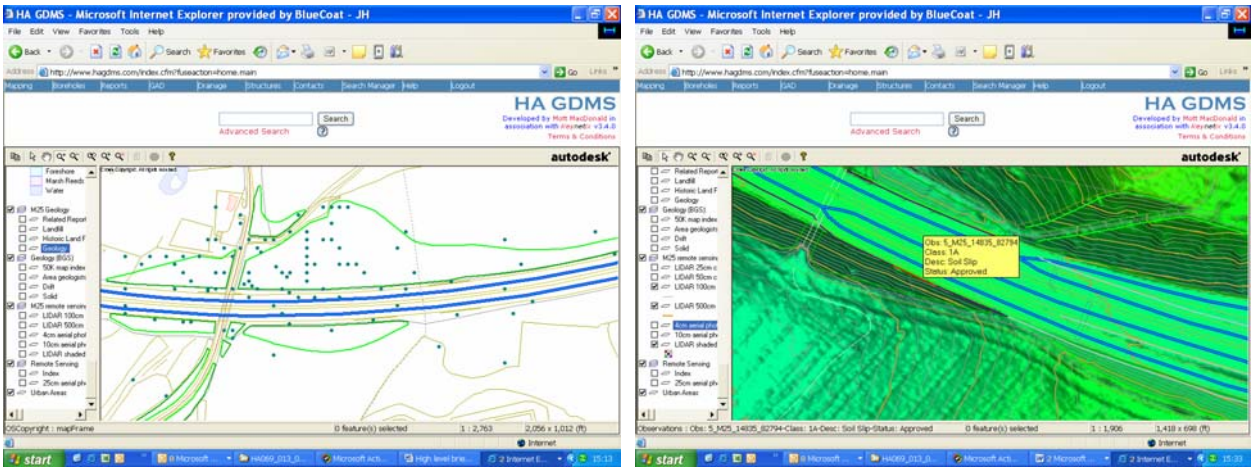

Figure 1 – The United Kingdom Highway Agency Geotechnical Data Management System gives easy access to borehole, LIDAR, and other information through a GIS application via the World Wide Web.

The state DOT examples of projected savings only account for using subsurface exploration data from their own records. A key element for a successful GMS is the ability to receive data from, and send data to, other entities outside of the organization owning the management system. There is an opportunity on many projects to use exploration data from other state, local, and federal agencies if that data can be readily obtained and easily accessed in a usable form. Data interchange standards are necessary to allow this exchange to occur efficiently and effectively.

The Federal Highway Administration (FHWA) Office of Federal Lands Highway (FLH) represents an example for highlighting the potential benefits of sharing geotechnical information across organizational boundaries. This office primarily develops, delivers, and administers a coordinated transportation program for roadways within, and accessing, federal land management areas comprising thirty-percent of the country. Many of the roads and bridges on this federal network intersect and border state and county owned roadways. The ability to easily and efficiently share existing geotechnical information between state and federal agencies could optimize all available geotechnical-related resources and activities considered in program development and project delivery nationwide. With a transportation program approximately the size of the thirteenth largest state DOT, the potential for savings is considerable.

A successful GMS must be able to share data between diverse data bases within the management system. In addition, it must be able to transfer data into and out of software programs and between various software packages that are used in project development and management.

Without transfer standards, data in one database must be manually mapped directly to another database, a difficult and time intensive process which must be repeated for each database accessed. With a data transfer standard, each database only needs to be mapped once to the standard. Afterwards, the database can be accessed by any application through the data exchange standard.

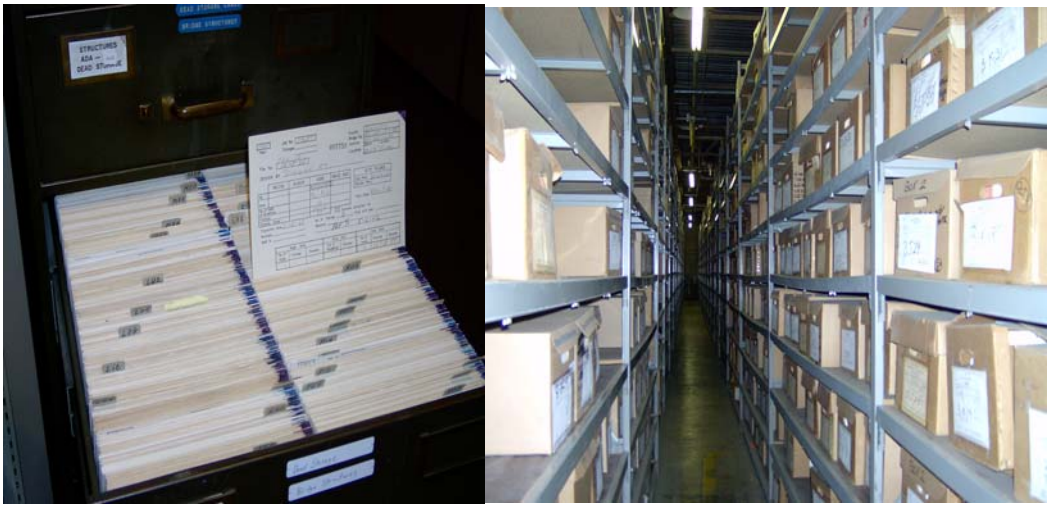

Figure 2 - Paper storage and retrieval is cumbersome and labor intensive. Electronic storage and retrieval significantly increases efficiency and accessibility.

An example of data interchange using a data standard is the use of a PDA in the field. The subsurface exploration data can be entered at the drill rig as the boring is being conducted. The data can then be sent electronically through the web via the data standard to the DOT office where it is electronically checked and validated with software, entered into a database along with pertinent project information, and used for boring log generation and/or modeling applications. The data can be maintained electronically in the database and retrieved when needed for future use.

Figure 3 – With a data interchange standard, data entered in the field can be sent, used with various software programs, stored, and reused.

A data interchange standard is more than a “cradle to grave” solution; it is more like a “delivery room to cryogenics” solution. It handles the data from point of generation, through project usage, and then allows it to be accessed and used for future purposes.

An advantage of a data interchange standard is that it allows the user to create or purchase software that performs data validation quality checks. This is possible because all of the data is in a standard format. The data validation can then be automatically performed by software at the point of generation, or performed as it is received or transferred.

Data interchange standards will have significant implications for software vendors and packages, and software customers by permitting interchange of data between individual software programs and databases. It will no longer be necessary to obtain an entire suite of software from a single vendor in order to assure seamless data compatibility. Nor will it be necessary to incur the cost and frustration of attempting to develop conversion programs to transfer data from one software program to another. Also, historical data will not be lost when changing from the software of one vendor to another vendor. A larger market will be open to vendors because the software will be able to access any database that is mapped to the standard. Software customization time and costs will be reduced as a consequence.

POOLED FUND PROJECT

In June 2004 FHWA brought together state and federal agency representatives by co-hosting the *National Geotechnical Management Workshop: Archiving and Web Dissemination of Geotechnical Data,* in partnership with the Consortium of Organizations for Strong-Motion Observation Systems (COSMOS) and the Pacific Earthquake Engineering Research (PEER) Center Lifelines. This workshop brought together a wide range of individuals, organizations, agencies, and companies interested in electronic interchange of geotechnical data. Based on interest expressed during a breakout session of state DOT and FHWA representatives, the FHWA and the Ohio DOT formed a GMS Group and began the steps necessary to formalize a transportation pooled fund project.

The goal of the GMS Group is to develop an open framework geotechnical management system that can be web enabled; can be used to store, manipulate, manage, and validate data; provides a means to efficiently and proactively manage geotechnical assets and geologic hazards; can be used as a tool to share information among interested entities; and can accommodate modifications to meet local needs.

Members of the Geotechnical Management System Group:

- California DOT (CALTRANS)
- Connecticut DOT
- Florida DOT
- Georgia DOT
- Indiana DOT
- Kentucky DOT
- Minnesota DOT
- Missouri DOT
- North Carolina DOT
- Ohio DOT
- Tennessee DOT
- FHWA Ohio Division
- FHWA Federal Lands Highway
- United Kingdom Highway Agency
- United States Army Corps of Engineers
- United States Environmental Protection Agency
- United States Geological Survey

Figure 4 – GMS Group Members

The first priority of the group is to develop geotechnical and geoenvironmental data interchange standards through pooled fund project TPF-5(111), "Development of Standards for Geotechnical Management Systems". The name of these standards is Data Interchange for Geotechnical and Geoenvironmental Specialists (DIGGS).

diggs | data interchange for geotechnical and geoenvironmental specialists

Figure 5 – DIGGS Draft Logo

DIGGS is being developed through a cooperative effort of owners of existing data interchange standards such as the Association of Geotechnical and Geoenvironmental Specialists (AGS), United States Environmental Protection Agency (USEPA), United States Army Corps of Engineers (USACE), Consortium of Organizations for Strong-Motion Observation Systems (COSMOS), University of Florida, and others, as well as geotechnical and geoenvironmental specialists with an interest in data interchange standards. The organizations involved in the development of DIGGS have agreed to adopt it as their standard for use following it's completion. Throughout the development of DIGGS, the GMS Group has had full, open communication and cooperation with representatives from the National Cooperative Highway Research Program (NCHRP) Project 20-64 *TRANSXML: XML Schemas for Exchange of Transportation Data*.

The ultimate goal of DIGGS is to include all geotechnical and geoenvironmental related data. The broad categories of data include geotechnical exploration data (collected from boreholes, test pits, laboratory tests, in situ tests, geophysical testing, etc.), geo-structural assets (such as

deep foundations, shallow foundations, and retaining walls, and their associated construction control testing data), geo-hazards (such as landslides, rock slopes, karst, mines, etc.), and geoenvironmental data (from field and lab testing of soil, groundwater, and surface water and water level gaging). The data standards are being developed in a staged process by technical groups called Special Interest Groups (SIGs). The first SIG combined and modified existing standards for boreholes, laboratory and in situ tests, borehole geophysics, and deep foundations. Another SIG is combining and modifying standards for geoenvironmental data.

DIGGS utilizes Geography Markup Language (GML) compliant eXtensible Markup language (XML) schema conforming to standards developed by the Open Geospatial Consortium (OGC). The OGC is a non-profit, international, voluntary consensus standards organization. XML is a means to represent information, such as data, along with the role that the information plays. For example, for a borehole, the XML schema would indicate how a sample relates to the hole and how a test relates to a sample. XML was developed to facilitate data interchange between different databases and systems, particularly using the internet. GML is an XML schema containing a defined set of geographic tags to locate the data geospatially.

DIGGS will provide a standardized format for geotechnical and geoenvironmental data exchange between disparate databases. Significant advantages to the user of DIGGS include: ability to exchange data between databases within an organization and with external organizations, ability to efficiently incorporate data from consultants into any database, ability to perform data validation checks, ability to exchange data between software packages, and the ability to merge databases and integrate software into a geotechnical management system.

DIGGS VERSION 1.0

DIGGS is being developed and released in a phased manner. The first version of DIGGS is a consolidation and expansion of existing standards developed and used by the AGS, COSMOS, and University of Florida.

DIGGS version 1.0 covers borehole data, in situ tests, laboratory tests, borehole geophysics, and deep foundations. The draft version is currently being reviewed through a limited distribution to GMS Group members and selected individuals and organizations. Following receipt of comments and subsequent corrections, final release is expected in early 2008.

Several DIGGS compatible tools will be available when DIGGS version 1.0 is released. These tools include: a database with GIS interfacing for state transportation agencies, software for subsurface data reporting, a stand-alone data checker that allows viewing/editing of data as well as implementation of business rules, a virtual data center that enables data exchange across organizational boundaries, and the United Kingdom Highway Agency Geotechnical Data Management System.

The database tool mentioned above is being developed by the University of Florida for Florida DOT. The North Carolina DOT is developing and adding the GIS interface. The database will accommodate all data included in DIGGS version 1.0 and will be made available to any state DOT.

A Geotechnical Virtual Data Center (GVDC) is being developed through a COSMOS/PEER Lifelines Project. The project is currently developing a pilot web-based system linking example geotechnical data sets from Pacific Gas & Electric (PG&E), CALTRANS, California Geological Survey (CGS) and USGS. The ultimate goal of this project is to extend the pilot system and develop a web-based system linking multiple data sets, capable of serving the broad needs of practicing geotechnical and earthquake hazards professionals for efficient access to geotechnical data. The GVDC uses DIGGS as its standard for data interchange.

Software vendors are cooperating with the project and have been providing significant assistance with the development of DIGGS. Several vendors have already added the translation capability for DIGGS to facilitate the exporting and importing of DIGGS files by their software.

GEOENVIRONMENTAL DATA

The geoenvironmental component of DIGGS is being developed considering existing data exchange standards and the needs of data providers and data users. Several data exchange standards were looked at but the primary standards considered were the Association of Geotechnical and Geoenvironmental Specialists – Environmental (AGS-E), the Standard Electronic Data Deliverable (SEDD) developed by USEPA and USACE, and the EQuIS UK EDD.

SEDD is a comprehensive data exchange standard currently used by the USEPA for receipt of data. It was developed in response to the flood of test data being submitted for super fund sites. Since no common data format existed at the time, the data was being received in the format used by the particular lab. There are at least 220 different electronic data formats being used by environmental laboratories in the United States. Several laboratories have implemented SEDD and are inputting SEDD files into electronic review software. Preliminary results show a 30% to 50% cost savings when compared to the same level of manual review.

FUTURE WORK

New opportunities for collaboration occur regularly. All development efforts are taking into account data interchange structures developed by others to avoid conflicts and duplication of effort. DIGGS is building upon the successful work of others.

Immediately following completion of DIGGS version 1.0, the project will begin work on two-dimensional (2D) generic data standards for planar data such as test pits. Subsequent work, following geoenvironmental and 2D development, will include geophysics, geo-structural assets, and geo-hazards.

DIGGS is being reviewed by Joint Technical Committee 2 (JTC2), Representation of Geo-Engineering Data in Electronic Form, for adoption as an international standard. JTC2 is a Joint Technical Committee of the International Society for Rock Mechanics, International Society for Soil Mechanics and Geotechnical Engineering, and International Association for Engineering Geology and the Environment. The aim of JTC2 is to oversee the development of an

internationally agreed form of representation of geo-engineering data that can be used to store such data on the World Wide Web and transfer data between computer systems.

The GMS is investigating a potential association or compatibility with GeoScience Markup Language (GeoSciML). GeoSciML is a geology data interchange standard being developed under international collaboration through the Commission for the Management and Application of Geoscience Information, under the International Union of Geological Sciences. It began as a North American Data Model developed by the USGS, Geological Survey of Canada, and the Association of American State Geologists. A potential for merging of geologic and geotechnical data presents a promising and powerful opportunity.

SUMMARY

DIGGS provides a standardized means of geotechnical and geoenvironmental data interchange. It is a tool that can be used by geotechnical and geoenvironmental specialists to improve planning, design, construction, preservation, and overall decision making. DIGGS will allow geotechnical and geoenvironmental data to be electronically retained and geospatially referenced while providing the utility of data interchange between disparate databases and across organizational boundaries. Consequently it allows the creation of seamless management systems with free data flow between databases and software packages.

Some of the many benefits of using DIGGS include:

- Database interfacing – the ability to exchange data between different databases regardless of structure
- Software interfacing – the ability to exchange data between software using different databases or other incompatibilities
- Automatic data validation through independent software
- Eliminate the need to manually re-enter data at different points in the data usage chain

State DOTs, FHWA, and the United Kingdom Highway Agency have identified the following benefits of a DIGGS compatible Geotechnical Management System for their organizations:

- Feed information seamlessly to Asset Management Systems, such as Pavement Management Systems (PMS) and Bridge Management Systems (BMS)
- Proactively manage geotechnical assets: data, geo-structures, and geo-hazards to significantly reduce costs
- Better estimate project schedules and costs during program development
- Reduce (or eliminate) subsurface explorations by re-using their own data, and using the subsurface exploration and feature installation data collected by other organizations
- Accelerate design schedules while reducing design costs
- Mitigate schedule, cost, and safety risk during design and construction
- Improve records management
- Reduced personnel time for data search and for data entry

Additional information regarding DIGGS can be found at: **www.diggsml.org**