



Standardizing Geodata Transfer and Storage

In this heavily data-driven era, businesses can find tremendous opportunities in using their data to operate efficiently while gaining significant competitive advantages through the use of analytics and smart predictions. However, the first step in realizing these opportunities is to organize existing information and convert it to data that can be analyzed.

This article describes a data transfer standard that is gaining widespread acceptance in the geotechnical and geoenvironmental communities. The deep foundations industry represents one such community that could benefit significantly from using a common language to transfer and store files. The outcome has been the

development of a framework called Data Interchange for Geotechnical and Geoenvironmental Specialists (DiGGS), which can be used to compile geotechnical, foundation and load testing data; to assess project performance and safety; to track productivity; and to compile load test results and quality assurance information (e.g., verticality and alignment, depth, concrete properties and quality control tests).

Data Management Approaches

Engineers and contractors alike recognize the need to collect and manage information for a given project, if for no other reason than to comply with the reporting and submittal requirements imposed by

owners, regulators and others. However, conventional data management usually utilizes information reporting systems that are convenient and/or familiar and that allow the user to manipulate information as wanted to maintain maximum flexibility. All too often, the project data (e.g., geospatially referenced results in an electronic format) is managed and transmitted as project information (e.g., paper copies of forms and PDF copies of test results). This historical practice has drawbacks regarding data completeness, the need for manual entry and re-entry of key data, ineffective data compilation,



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transfer and reuse, uncertainties regarding data ownership, and ad hoc data management strategies. As we look to the future, a key question arises: How do we change the state of this ineffective practice, particularly while literally being inundated with project-related data?

The problem could be resolved easily if every stakeholder utilized the same relational database for storing and managing data, a database with standardized field titles, content format, etc. Although this may be a noble goal, it does not reflect reality. An alternative to a standard relational database for storing, managing and/or transferring data is the eXtensible Markup Language (XML), a common language used by computer scientists, which defines a set of rules so that data may be stored easily in files. This is where DIGGS enters the picture.

How DIGGS Works

DIGGS was originally envisioned by a coalition of government agencies, universities and industry partners with the goal of it becoming an international transfer standard for the geotechnical and geoenvironmental data that is routinely needed for transportation-related projects. DIGGS is *not* a database, but rather a specific set of instructions to organize and represent data using an XML framework. This approach allows data to be transferred or shared by any number of software applications, including established databases.

In 2005, the Federal Highway Administration funded a pooled fund study for DIGGS development, which the Geo-Institute (G-I) of the American Society of Civil Engineers became involved in in 2013. DIGGS became operational in 2016, and is managed by the DIGGS Development Team of the G-I.

By design and intention, DIGGS is open source, freely available and requires no proprietary software to use. DIGGS serves as a framework that ensures nothing is “lost in translation” when storing and transferring data. It defines the names and properties of standardized fields for values to be stored. It also defines which fields are required to have meaningful information.

In a simple sieve analysis, for example, DIGGS provides the instructions on how the relevant data for this test should be stored, as well as rejecting test results that are missing basic data, such as the size of the sieve screen openings.

Most data of interest to geoprosessionals has a spatial and/or geometric component (i.e., coordinate location and elevation and potentially structures and features that can be modeled with geometric shapes such as lines or polygons). Because of this, DIGGS was developed with a Geography Markup Language (GML) application schema. This schema utilizes standardized XML grammar for encoding geospatial information. XML and GML provide the rules for communicating data across the internet and between software systems, regardless of how the data are generated. By selecting XML and GML as the language-of-choice for developing the DIGGS schema,

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the following two significant hurdles for acceptance and adoption were addressed:

Simplifying Data Export. Data are often generated in the field or in the laboratory as millivolt signals, amperage readings and frequency measurements on data collection and recording equipment (e.g., survey total stations, piezometers, load cells, flow meters, slope inclinometers, pressure transducers, etc.). Some of this equipment is attached to drill rigs to provide instant feedback to the operator. After signal processing, these analog or digital signals can be converted to engineering units and stored for eventual transmission to a readout unit, text file, data storage device, etc. At this point, the equipment vendor or user could simply elect to generate a DIGGS XML file that contains the collected results. As the Open Geospatial Consortium (OGC), an international group of companies, governmental agencies and universities seeking to develop similar open-source

platforms, reported, having such standards will “enable developers to make all types of sensors, transducers and sensor data repositories discoverable, accessible and useable via the Web.” Therefore, using industry-accepted protocols, equipment vendors and users will be able to easily export GML-compliant DIGGS data files from their equipment. Data that are not generated using sensors are often collected manually and recorded electronically. These data can similarly be used to generate GML-compliant DIGGS data files for electronic transfer.

Easing Import to Different Software.

Once data are collected, they need to be processed, viewed, stored and managed. Typically, professionals utilize proprietary spreadsheet formats, local databases or customized computer software programs for these activities. If these software products can accept DIGGS files for import, and export data in a DIGGS format, then the data can be seamlessly transferred without manual re-entry into a vendor-specific format. In this way, the data becomes “software agnostic” and users need not change from their current favored software.

Among other advantages of DIGGS data is users’ ability to implement new and better tools that may come to market without worrying about data compatibility issues. Owners can also require that all consultants and contractors submit valid DIGGS files as part of project delivery so that the owner now has all data from all projects in a consistent format. Not only is this a significantly more efficient way of doing business, it also addresses many problems of previous data management strategies. In effect, DIGGS becomes the common language that facilitates communication among any number of software applications.

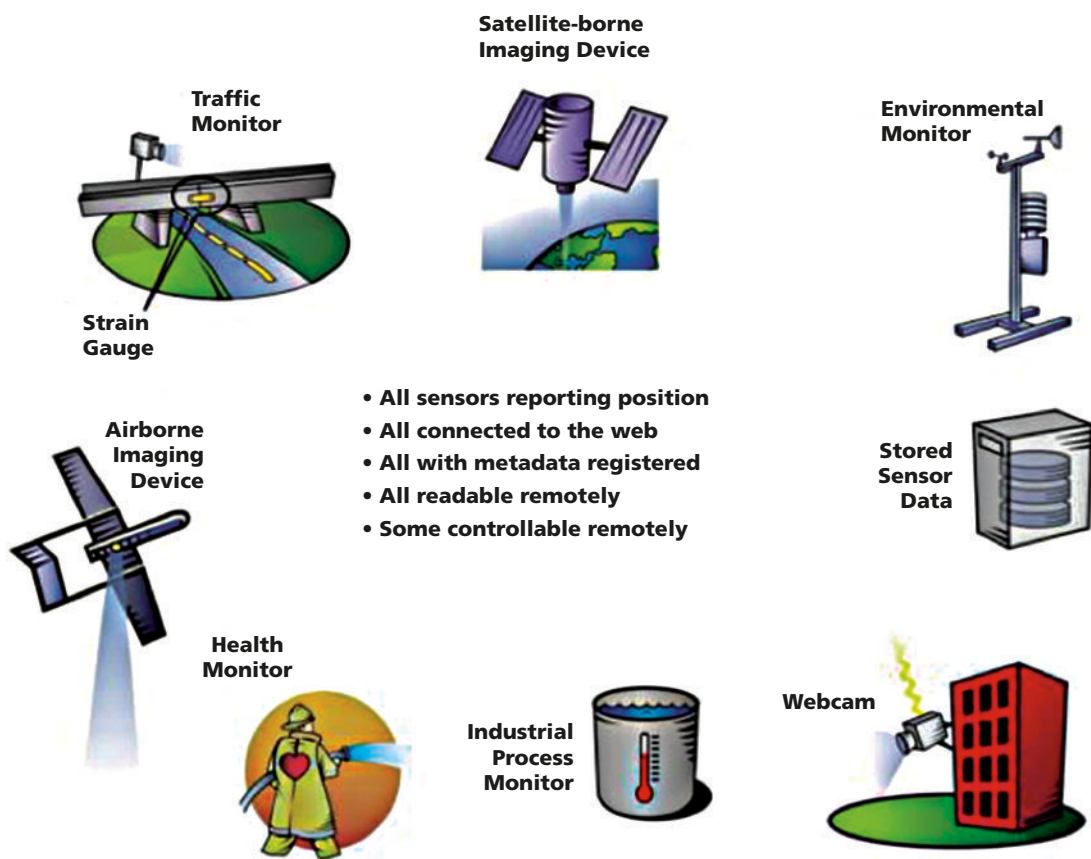
DIGGS v 2.5.a is readily available for use by the geoprosession. DIGGS has already been used to implement dozens of test procedures. In addition, its schema is continually being expanded with more tests and procedures, including construction and performance data regarding deep foundations. DIGGS is available at a website managed by G-I at www.diggsml.org.

Deep Foundation Applications

DIGGS offers significant benefits to virtually all geotechnical and geo-environmental practitioners, whether the practice relates to testing, field monitoring, construction or quality control and assurance. The following are three examples of adoption of DIGGS by the deep foundations community for real-time construction control systems, subsurface characterization data and load testing data.

However, should the contractor wish to integrate data from different systems, it is extremely difficult because of the proprietary nature of the software. If a DIGGS format were to be adopted that has a DIGGS-export option included by the vendor, then the contractor would be able to readily import data related to the project, output data from the vendor's system, and then integrate these data into the system managed by the contractor and the owner.

site conditions for a bid, proposal or presentation, they have to manually re-enter the information into a proprietary software package, or into a generic spreadsheet selected by the contractor. This is an inefficient and time-consuming activity that is prone to transcription errors. If geotechnical data were instead transmitted electronically in a DIGGS format, and if the contractor's software vendors had a DIGGS-import function, then significant time and energy could be saved on the owner's side from not having to compile specific project documents (PDF



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files), and on the contractor and consultant's side because they now have readily available data for use. The DIGGS functionality thus offers untold benefits to both communities.

Information sharing benefits of standardized web-connected sensors (Credit: OGC)

Real-time Control Systems

Most contractors have included automated control and monitoring equipment in parts of their construction practice. These systems include instrumentation that provides in-cab or at-plant monitors for verticality, crowd, energy, flow and load. Most of these systems are custom designed by specific hardware and software vendors and involve proprietary systems for data collection, processing and reporting. These systems provide a level of quality control that was unheard of just 10 years ago.

Subsurface Characterization Data

When responding to project opportunities, contractors need information regarding subsurface conditions at the project site. As part of bid packages, owners typically provide results of subsurface drilling activities, and results from in-situ and laboratory tests. In most cases, these results are provided as paper copies or, if transmitted electronically, as PDF documents. Should the contractor (or its consultant) desire to graphically present results, develop cross sections or summarize

Pile Load Test Databases

Most contractors and geotechnical engineers recognize the benefits of deep foundation databases that provide a historical perspective of deep foundation selection and performance. Unfortunately, their practical value is currently limited to basic information retrieval, despite numerous attempts to address this limitation. Author Nikolaos Machairas and his colleagues have spent most of the past 3 years seeking to rectify this problem, ultimately concluding that a standard data

transfer protocol (like DIGGS) is a valuable and necessary component of efforts going forward. Widespread adoption of DIGGS and its expansion to accommodate pile data could be used to upgrade existing (and to set up future) pile load test databases. Specifically, DIGGS can be used to import and export information from pile load test databases. Because of the diversity and proprietary nature of nonstandardized databases, the seemingly simple task of data transfer is currently a time-consuming and complicated effort. With support from software vendors, these data could be loaded on popular foundation design and analysis software, as well as in-house design algorithms. DIGGS could also facilitate automated and highly reproducible processes that allow analyzing pile data in batches. As a result, workflow efficiency could be dramatically increased, while reducing manual entry errors. Beyond efficiency, the batch analysis process opens up opportunities for a high-level evaluation of the performance of foundations by statistical analyses over a large volume of results.

Moving Forward

DIGGS is now ready for general use. On the DIGGS website, instructions are provided for the user to become familiar with the DIGGS framework (i.e., the schema), and there is a “data dictionary” to identify the rules for the specific data elements. The website also offers access to tools (i.e., DIGGS Feedback Tool and DIGGS Toolbox)

to allow users to generate DIGGS files (i.e., XML files) that can be used to populate tables, generate plots, and/or interface with software that will accept XML-structured DIGGS data.

During development of DIGGS, the G-I committed to providing web-based tools for generating and using DIGGS files. The DIGGS Development Team is also committed to maintaining and expanding the DIGGS schema, supporting the development of user-friendly interfaces, providing recommendations for data management and training for developing and

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using DIGGS files, working with software developers to include DIGGS-formatted data as acceptable imports to (and exports from) their programs, and establishing a sustainable business model to allow for the future growth and adoption of DIGGS. This offer of support extends to the deep foundations community.

Deep Foundations Institute (DFI) is supporting this effort with the recently funded project titled DIGGS Scheme for Rock Grouting Data Transfer through the DFI Committee Project Fund. This project will utilize the geotechnical and temporal instrumentation features currently available in DIGGS, along with monitoring while drilling (MWD) concepts, to develop the first foundation construction scheme within the DIGGS platform.

Conclusion

In order for construction-related businesses in this data-driven era to operate at maximum efficiency, they must first organize existing information and convert it to data that can be analyzed. The authors believe that the common language that DIGGS provides can prove invaluable in this effort for the deep foundations industry and beyond. The reasons include the open-source nature of the DIGGS framework and its ability to enhance data transfer and storage by making data export easier and allowing data import to multiple software applications.

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Editorial Submissions

Want to share your expertise, project experience and product information with the deep foundations community? DFI is always interested in editorial submissions for *Deep Foundations* magazine. We are particularly interested in articles on state-of-the-art projects (big and small) and new

techniques, products and technology. Guidelines for writing feature articles are available on www.dfi.org — select ‘Publications’ and then navigate to ‘DFI Magazine.’ To discuss an idea for an article, contact the executive editor, at mageditor@dfi.org.