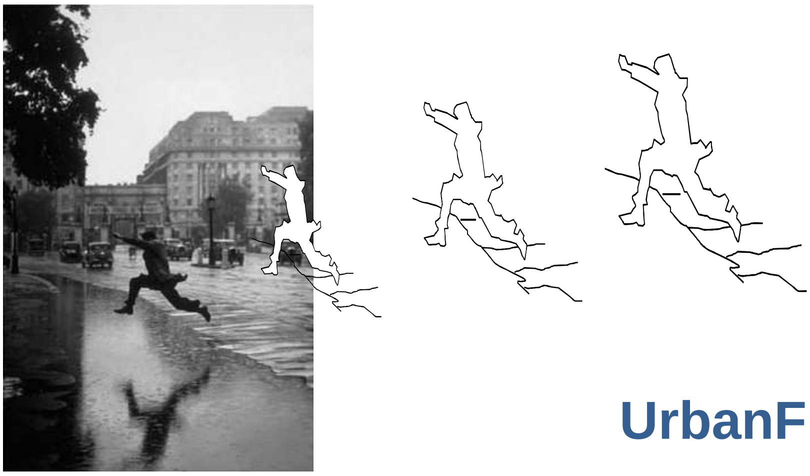

UrbanFlood Workshop

Intelligent dike monitoring for the 21st century – the UrbanFlood project

- Experience in Embankment Monitoring -

Date

Workshop: Thursday 3rd November 2011

Location

Waternet
Korte Ouderkerkerdijk 7
1096 AC Amsterdam
The Netherlands

Goals of the workshop

Dissemination of UrbanFlood interim results; learning from others in the field; looking for possibilities to cooperate in further projects and activities. During the breaks UrbanFlood applications will be demonstrated, and there is an opportunity to visit the poster presentations and info market.

Useful information

For the most up to date information visit the UrbanFlood website at www.urbanflood.eu.

Information on public transport in the Netherlands: www.journeyplanner.9292.nl
Information on trains in the Netherlands: www.ns.nl

Workshop Programme

Thursday 3 November 2011

09:00 to 09:45	*Registration / coffee*
09:45 to 09:50	Welcome (Peter Jansen, Waternet)
09:50 to 10:00	Agenda and goals for the workshop (Nico Pals)
10:00 to 10:30	About UrbanFlood (Prof. Rob Meijer)
10:30 to 11:00	Key note presentation (Prof. Tarek Abdoun USA)
11:00 to 11:20	*Coffee break + demo + poster presentations + info market*
11:20 to 11:35	The UrbanFlood Common Information Space (Bartosz Balis)
11:35 to 12:05	Urbanflood demos (Jeroen Broekhuijsen, Robert Belleman, Bartosz Balis)
12:05 to 12:30	Next steps of the IJkdijk program (Ludolph Wentholt)
12:30 to 13:30	*Lunch break + demo + poster presentations + info market*
13:30 to 13:55	Fiber optic system for monitoring large earth structures (Aleksander Wosniok)
13:55 to 14:20	Experience in embankment monitoring (Rob van Putten)
14:20 to 14:45	Understanding flood defence using monitoring systems (Jonathan Simm)
14:45 to 15:15	*Coffee break + demo + poster presentations + info market*
15:15 to 15:40	Signal processing for earthen dam measurements analysis (Alexander Pyayt, Ilya Mokhov, Alexey Kozionov, Victoria Kusherbaeva, Artem Ozhigin)
15:40 to 16:05	Lidar change mapping of dikes under stress conditions (Stefan Flos)
16:05 to 16:30	SmartGeo: An interdisciplinary approach to earth dam & levee monitoring research (Mike Mooney USA)
16:30 to 17:30	*Drinks + demo + poster presentations + info market*

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Version: 30 October 2011

Overview of the presentations

Thursday, 3 November

Key note presentation

Prof. Tarek Abdoun - Rensselaer Polytechnic Institute, USA

The theme of the second UrbanFlood Workshop on 3 November is: Intelligent dike monitoring for the 21st century - the UrbanFlood project - Experience in Embankment Monitoring. Keynote speaker will be Dr. Tarek Abdoun, Rensselaer Polytechnic Institute, USA. He will present the unique intercontinental cooperation that resulted in the installation of a combined NL, FR and US trial sensor network using different instruments in a dike in Boston, England this year. The data are monitored with the UrbanFlood Early Warning System in the Netherlands and the UK, and by US systems in New York. This is the second example of intercontinental dike monitoring; the first was a dam in Australia, monitored from the Netherlands.

Support for Early Warning Systems with the Common Information Space Framework

Bartosz Baliś (1,2), Marek Kasztelnik (2), Tomasz Bartyński (2), Grzegorz Dyk (2), Tomasz Gubała (2), Piotr Nowakowski (2), Marian Bubak (1,3)
(1) AGH University of Science and Technology, Department of Computer Science, Krakow, Poland
(2) AGH University of Science and Technology, ACC CYFRONET AGH, Krakow, Poland
(3) Informatics Institute, University of Amsterdam, The Netherlands

As science increasingly relies on large-scale, collaborative computations which integrate results from many disciplines, the Service-Oriented approach has been recognized as a promising paradigm for scientific computing [2]. **The Common Information Space (CIS)** is a service-oriented software framework facilitating development, deployment and robust operation of complex systems which rely on scientific computations on top of clouds. Examples of such systems are Early Warning Systems which leverage CPU-intensive computations and real-time processing of data from sensors.

CIS organizes systems into a collection of services, as shown in Fig. 1. The **basic services** (aka appliances) encapsulate the computational backend of a system. They are typically legacy scientific applications wrapped as virtual images (containing platform, software and configuration necessary to run the application) and exposed as a service which means it can be accessed through the network. Existing services can be composed and published as a **composite service** (aka system parts). CIS supports three approaches for service composition: (1) orchestration (BPEL workflows), (2) integration patterns, and (3) loosely-coupled publish-subscribe-based data exchange through a message bus.

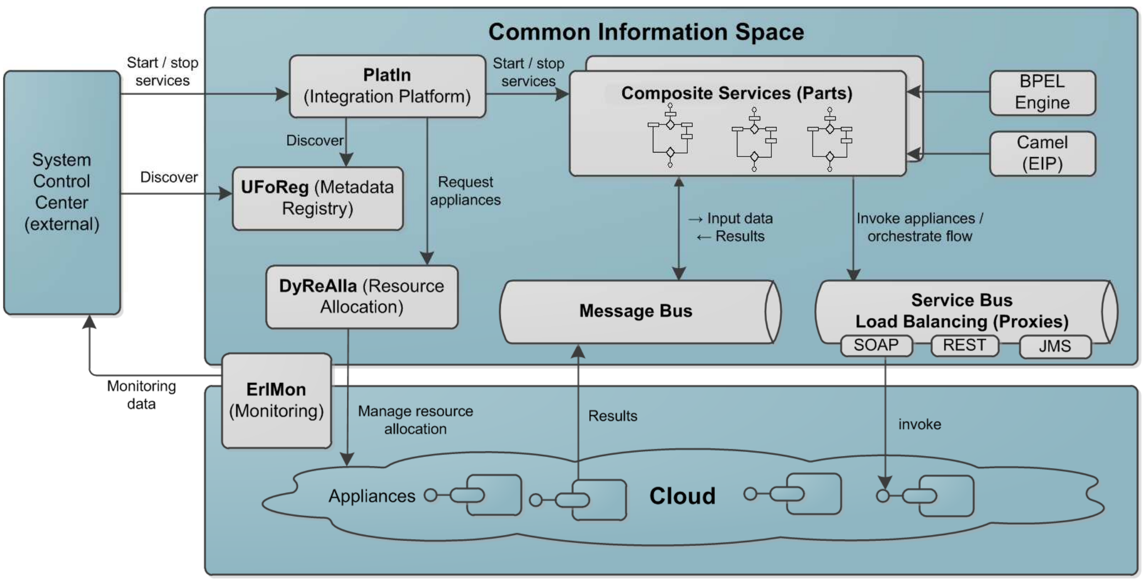


Fig. 1: Architecture of the CIS framework for Service-Oriented scientific computing.

Thanks to employing virtualization at the level of basic services, CIS manages resource allocation at this level by dynamic deployment of virtual appliances to a cloud infrastructure. This allows to control the amount of resources allocated to a system, prioritize the execution among concurrent systems, and respond to variable resource demands.

Both basic and composite services contain mechanisms for monitoring and management. Self-monitoring, applied to services and the CIS infrastructure itself, includes collection of information about availability, health, performance, and also provenance tracking. Services are manageable; they provide well-defined interfaces for starting, stopping, and changing configuration. Configuration parameters are exposed and can be adjusted on-demand (in some cases even during runtime, e.g. endpoints of invoked services). Each service (basic or composite one) can be executed in many instances with variable configurations. Running instances can be dedicated or shared between multiple systems.

The CIS framework has been employed to implement a Flood Early Warning System [1] which monitors selected sections of dikes through wireless sensor networks and detects anomalous dike conditions. Anomaly detection triggers further analysis which includes CPU-intensive inundation simulations used for prediction and damage assessment in the event of a dike failure.

Acknowledgements. The research presented in this paper has been partially supported by the European Union within the IST-248767 project UrbanFlood.

References

[1] B. Balis, M. Kasztelnik, M. Bubak, T. Bartynski, T. Gubala, P. Nowakowski, and J. Broekhuijsen. The UrbanFlood Common Information Space for Early Warning Systems. *Procedia Computer Science*, 4:96-105, 2011. Proceedings of the International Conference on Computational Science, ICCS 2011.

[2] I. Foster, C. Kesselman, Scaling System-Level Science: Scientific Exploration and IT Implications, Computer 39 (11) (2006) 31–39.

UrbanFlood demos

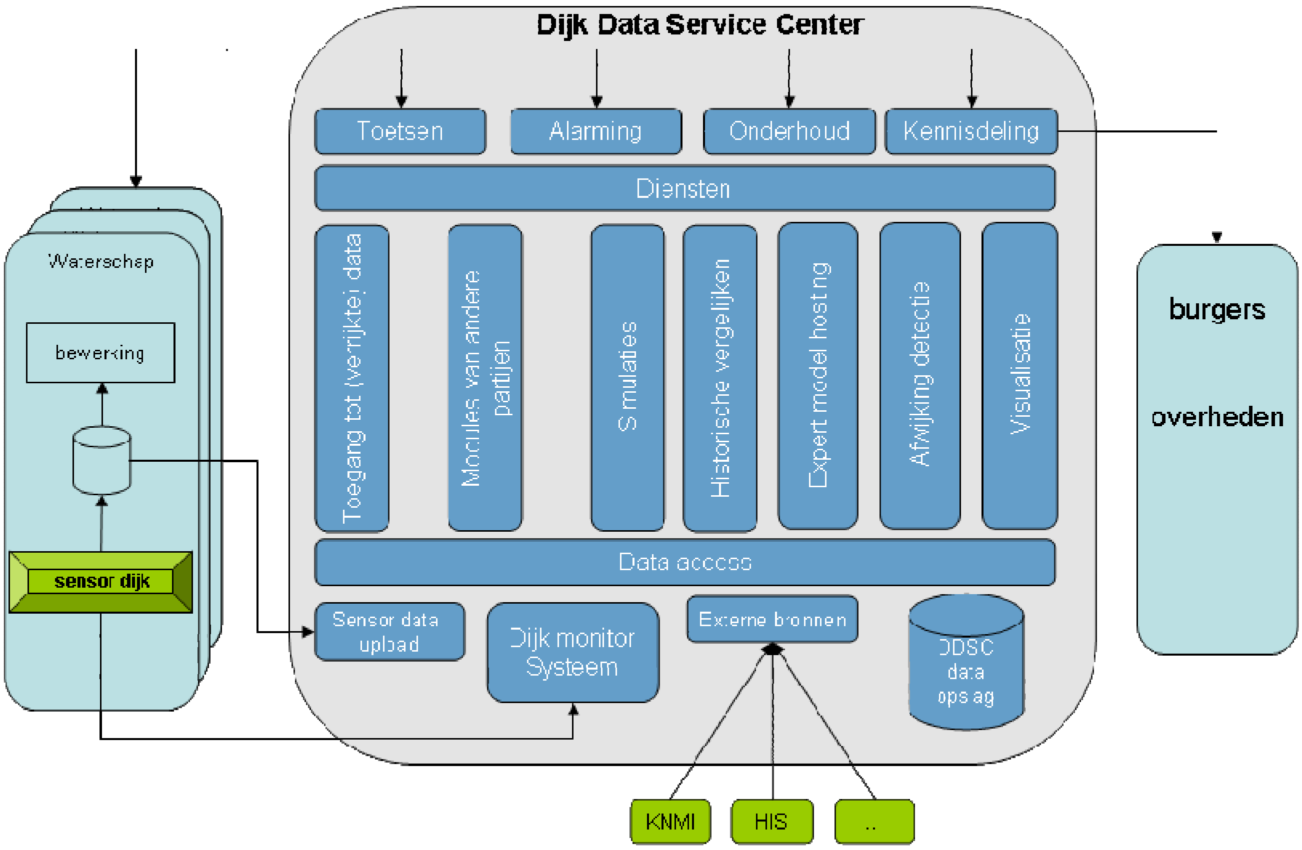
Jeroen Broekhuijsen (1), Robert Belleman (2), Bartosz Balis (3)
(1) TNO, the Netherlands
(2) University of Amsterdam, the Netherlands
(2) Cyfronet AGH, Poland

The Urban Flood Decision Support System (DSS) and Early Warning System (EWS) help professionals and water managers guarding the flood defences in real-time and enables decision makers to explore scenarios to help protect the area. To make this work the Common Information Space of the Urban Flood system provides self-monitoring to ensure the Early Warning Systems are always working and if a flood defence requires more attention will automatically scale up needed resources for Super Computer analysis.

Next steps of the IJkdijk program

Ludolph Wentholt – STOWA, The Netherlands

Strong and smart levees, that's the device for the future. Monitoring technologies applied in existing levees can help water managers get a better notion of strength and condition of the levee. Stichting IJkdijk is an international cooperation between research institutes, government and companies to develop and validate new inspection and monitoring technologies for water barriers. On October 4th, 2011 a National event for innovations was held in Rotterdam. The State Secretary of Infrastructure and Environment Mr. Atsma announced support for the Stichting IJkdijk with a 3 million Euro grant. As part of the program Stichting IJkdijk has started the next phase in the development of a Dike Data Service Centre (DDSC), which will help to standardize the data streams and to make information available to water authorities. Realization of the DDSC will help water managers to gain more information about the behaviour of the levees, in order to get a better notion of flood risks. Furthermore, construction and management of the levee can be aligned with assessed flood risks. Recently a first phase requirements study was delivered indicating the need for a DDSC to manage increasing data volumes from sensor systems in levees.



Fiber optic system for monitoring large earth structures

Aleksander Wosniok, BAM Federal Institute for Materials Research and Testing, Germany

We report on the development of a fiber optic distributed sensing system especially designed for monitoring tasks within large earth structures, such as dams, river and coastal dikes.

The measurement technique employs stimulated Brillouin scattering in silica optical fibers to perform distributed measurements of temperature and deformation of the monitored structure over a length of more than even 20 km with a spatial resolution down to 0.5 m – 1 m. For application in the field, the fiber optic sensing cables are embedded into geosynthetics in order to provide adequate force transfer from the structures to the sensors without complicating the application procedure on the construction site.

We present the overall system concept, details on the measurement unit and the cabling and embedding technique together with results from laboratory and field tests which demonstrate the feasibility of the system.

Experience in embankment monitoring

Rob van Putten - Waternet, The Netherlands

Waternet is the leading waterboard in the Netherlands using sensor technology for the optimization of levees. In the last two years Waternet has applied sensors and studied the impact on regular levee maintenance. In this presentation Waternet will show the vision on future dyke maintenance and show some of the benefits of the usage of sensor technology up to the current date.

Understanding flood defences using monitoring systems – experiences from UrbanFlood

Jonathan Simm – HR Wallingford, UK

The UrbanFlood project is creating an Early Warning System framework that can be used to link sensors via the Internet to predictive models and emergency warning systems. The data collected from the sensors will be interpreted to assess the condition and likelihood of failure; different models will be used to predict the failure mode and subsequent potential inundation in near real time. Through the Internet, additional computer resources required by the framework are made available on demand. The project includes three pilot sites to apply and validate at full scale the technology being developed in the project: Amsterdam (Netherlands), Boston

(UK) and St Petersburg (Russia). This presentation focuses on a description of the sensor instrumentation installed at one of the pilot sites, Boston, and the emerging conclusions from the results obtained so far.

Boston (UK) is a town on the east coast of England located with a long history of floods. More than 50% of homes (i.e. more than 15,000 homes) are at significant risk of flooding from a combination of high tide and storm surge in the North Sea. The main area of the town is a little inland from the coast but is affected by tidal rivers in which the spring tide range is about 6m. Levees have been constructed on superficial alluvial deposits of sand and clay beneath over glacial boulder clay. A mixture of different levees exist, but for this project a simple embankment was selected at a location with a history of instability on the riverward face.

The instrumentation was selected on the basis of previous experimentation and comparison of instruments installed in full scale dike failure tests in the Netherlands (IJkDijk). Installed in CPT holes were

- Dutch developed MEMS modules (GeoBeads) able to detect local tilt, pore pressure and temperature, the latter as a proxy method for detecting water flow
- Two types of US-Canada developed Shape Acceleration Arrays able to measure three-directional soil deformation profile and one type also able to detect pore pressure

In addition, sensor enabled-geotextile strips based on fibre optic sensing technology, able to detect soil strain by distributed light back-scattering, were installed along the entire 300m in the crest and front slope of the embankment. This technology allows longer stretches of embankment to be monitored at low cost.

The gathered data is being used to detect anomalies, supported by an Artificial Intelligence system. If an anomaly is detected, this then triggers assessment of the likelihood of levee breach. If breach is likely, the consequences in terms of flood propagation and damage in the defended urban area are assessed via high speed computer modelling.

Initial results are on a superficial examination dominated by the direct ('elastic') response of the structure and pore pressures to the strong tidal forcing. However, the results also suggest that the instrumentation is able to pick up slow ongoing plastic movement of the embankment including 'hot spots' of deformation. Emerging analysis of the pore pressure response is suggesting that the changes in the phase lag in pore pressure response between borehole locations may provide a useful indicator of deterioration.

Results are being displayed on the project website. There are also plans to set up a visitor centre in the town where this information is made available and is linked to future plans for improvement of the levees in Boston.

Lidar change mapping of dikes under stress conditions

Stefan J. Flos - SJF projects&support, The Netherlands

The year 2011 has been an eventful year for dikes in the Netherlands. High water in January, an extreme dry spring season, followed by an extreme wet summer. These events result in stress on the various dike systems. Drought has a high impact on a typical dike-water system called boezem-systems. These systems are the typical result of the Dutch polder system, where the surrounding land has been taken away (peat harvesting) and has subsided, where the river system remains on it natural level.

These systems are composed of elevated waterways enclosed with an embankment. These systems have a more or less constant water level on the inside. The total height of water table difference inside and outside of the system can be up to several meters.

The boezem system is typically situated in peat area and is therefore naturally vulnerable to stress resulting from drought. Either because the boezem-dikes are peat-dikes themselves, peat-dikes with a clay-cover or clay dikes upon a peat underground. Because these systems are under constant water pressure, changes in the soil moisture in or around the dike can have various effects. One such effect is cracking. Cracks can have a large variety of orientations, form and length and can be generally seen as an indicator of changes in the size and form of the dike-profile (subsidence). One such changing behaviour is shearing. A crack and shear profile usually involves a larger area than the crack alone. Visual inspection of cracks and shear is typically preformed by two inspectors with one following top of the dike and one following the base, observing the total area.

Dutch water boards have a long tradition of digitally monitoring the height and form of dike systems. From 1999 this was started with corridor mapping of dikes. Nowadays water boards work together to collect national digital elevation data in a five year cycle.

Based on the existing experience and digital elevation datasets a first experimental data acquisition flight was performed to collect height data of boezem dikes under drought stress conditions. Data was collected at the peak of the draught on May 30 2011. In this run a section of 3,5 kilometer of boezem system was collected, covering about 7 km of dikes. The aim was to collect data to support a larger experiment covering a larger area and a larger variety of dike systems.

The results are very promising and are a clear demonstration of the benefits of this technique. Also the points of attention become clear (lessons learned). In summary:

1. elevation data collection is fast and provides a continuous, complete overview, including hi-Res areal photo's and video.
2. data processing is easily performed, simple and a continuation of existing techniques and software (the dataset is 'more of the same' type)
3. data presentation is typically on three levels:
   A. change map (area): a color map with indications of the level of height difference since the last recorded dataset
   B. cross-profile (line) generation (very 2 meters) with all available elevation data presented
   C. point dataset with indication (color) of difference between reference level (this can be a last recording or a water level

The results show that the behavior of dike systems is not uniform. Specific stretches of dikes, sometimes 50 meter in length or less, can behave a-typical and result in accelerated deformation of the dike. This can be spotted easily. Thus change information can be used as input in visual (draught) inspection. Also inspection results can be input for studying the change maps more closely. This results in a better understanding of reading and using change information and elevated safety awareness based up on objective measurements.

Two points of attention are evident:

1. The change map is an accumulation of change since the last measurement. Sometimes the base map is 2-3 years old. Change is therefore difficult to pinpoint to a specific stress or change event. It is therefore recommended to update digital elevation base maps for stress-prone dyke systems more regular (preferably once per year under standard conditions (winter) as a basis for data collected in stress situations).

2. Low, thick vegetation can obscure a direct measurement of a bare dike section. Typically on the waterline and at the base of the dike vegetation can grow thick and height (grass, long grass and cane) and cross section and change maps are not clear on these spots. This is a challenge for lidar companies to find techniques to penetrate vegetation and measure the bare terrain.

The experiment has lead to a proposal to upscale the collection of elevation data under stress condition for a larger area of different dike systems.

This might include river dikes, where change maps could be made under high river water levels. Change measurements under stress conditions have never been made and provide a direct input into studies of the real behavior of dike systems under stress. Rate for change analysis could be input in computer models. A-typical dike sections can be identified for further diagnosis and prognosis studies. Selected sections could be monitored with sensors, since these sections have the largest change behavior.

The cost benefit of data collection is very promising because the data is an update of existing datasets and bring historic data in perspective. The data can be used for dike inspection (direct use) dike reparation (emergency repair) and in regular inspection and maintenance work. Last but not least: Every digital elevation dataset contributes to a better understanding of changes in dike sections: like the year-rings in a tree.

Signal processing for earthen dam measurements analysis

Alexander Pyayt (1, 2), Ilya Mokhov (1), Alexey Kozionov (1), Victoria Kusherbaeva (1), Artem Ozhigin (1)
(1) Siemens LLC, Russia
(2) University of Amsterdam, the Netherlands

In this work authors present current status of development and application of one the UrbanFlood (UF) Early Warning System (EWS) components - the Artificial Intelligence (AI) component. Main task of the AI component is detection of anomalies in on-line stream of measurements gathered from sensors installed in dike (earthen dam). Anomaly can be interpreted as deviation from previously known “normal” condition that can be a sign of developing failure. The AI component can use for anomaly detection raw data and/or extracted from time series features. One of the important tasks is identification of the features that are able to separate normal and abnormal modes in dike behaviour independently to changing external conditions. Authors present results of the AI component application to the real-world measurements analysis.

SmartGeo: An interdisciplinary approach to earth dam & levee monitoring research

Mike Mooney, Colorado School of Mines, Golden, Colorado, USA

SmartGeo is an interdisciplinary program of researchers from civil-geotechnical, mechanical, electrical, and geological engineering, as well as geophysics, computer science and geology working collaboratively to advance the practice of intelligent geosystems – engineered earth systems enabled to sense their environment and improve their performance. Intelligent earth dam and levee research is focused on advancing monitoring techniques through remote sensing and geophysical imaging, as well as characterizing the progression of internal erosion within earth dams and levees. This presentation will describe the interdisciplinary approach to earth dam and levee research and summarize the research efforts underway. The research presented includes: (1) characterization of seepage and internal erosion in controlled laboratory experiments using non-destructive electrical and acoustic sensing; (2) field scale characterization of seepage and preferred water flow through earth dams using electric self potential, electrical resistivity and seismic imaging; (3) terrestrial remote sensing of earth dam and slope deformation using LiDAR and radar; (4) advancement of wireless sensor networks for geophysical monitoring; and (5) public policy aspects of earth dam and levee monitoring.

Mike Mooney is a Professor of Civil Engineering and is the Director of the SmartGeo Program at Colorado School of Mines in Golden, Colorado, USA. He holds a Ph.D. in geotechnical engineering (Northwestern University) and a M.S. in structural engineering (University of California-Irvine). He is a registered Professional Engineer. Mike’s research includes monitoring of geoconstruction processes, non-destructive evaluation of geostructures, vibrations and wave propagation in geomaterials, and advancing relationships between geophysical data with geotechnical properties.