

ISSUE 2. JULY 2018

LEAPFROG WORKS

UNEARTHED

Special report

THE AGE OF DATA



PLUS

Exclusive Interview

Craig Fenton

Google Director of Strategy and Operations

Technology and innovation for the Civil Engineering and Environmental industries

Brought to you by Leapfrog, the world's smartest geological modelling solution

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WELCOME



Hi, I'm Daniel Wallace and I am the General Manager for the Civil and Environmental industries here at Seequent, looking after our innovative solutions to solve problems that relate to geology in Civil Engineering and Environmental applications.

I'd like to welcome you to our second edition of Uearthed. For those who haven't seen Uearthed before, it is a special report designed to bring you innovative thinking and industry relevant perspectives, for those who have an interest in what's going on beneath the surface.

After such a fantastic response from our inaugural edition of Uearthed, where we focused on digital transformation, **we have chosen to focus this edition on data and the challenges and opportunities it brings to our industry. This is a key topic our customers tell us is on their minds.**

In this edition, we have some great perspectives from experts within Seequent, within the civil engineering industry and a really insightful interview with the

Director of Strategy and Operations at Google – who know a thing or two about data and how to use it!

We are delighted to say that since we launched Leapfrog Works just a few months ago, the response around the globe has been amazing. Take a look at some of the interesting stories from our customers in this report.

As always, we would love to hear your feedback on our solutions and of course any interesting stories we can bring to our next edition of Uearthed!

Warm regards

Daniel Wallace





29,000FT

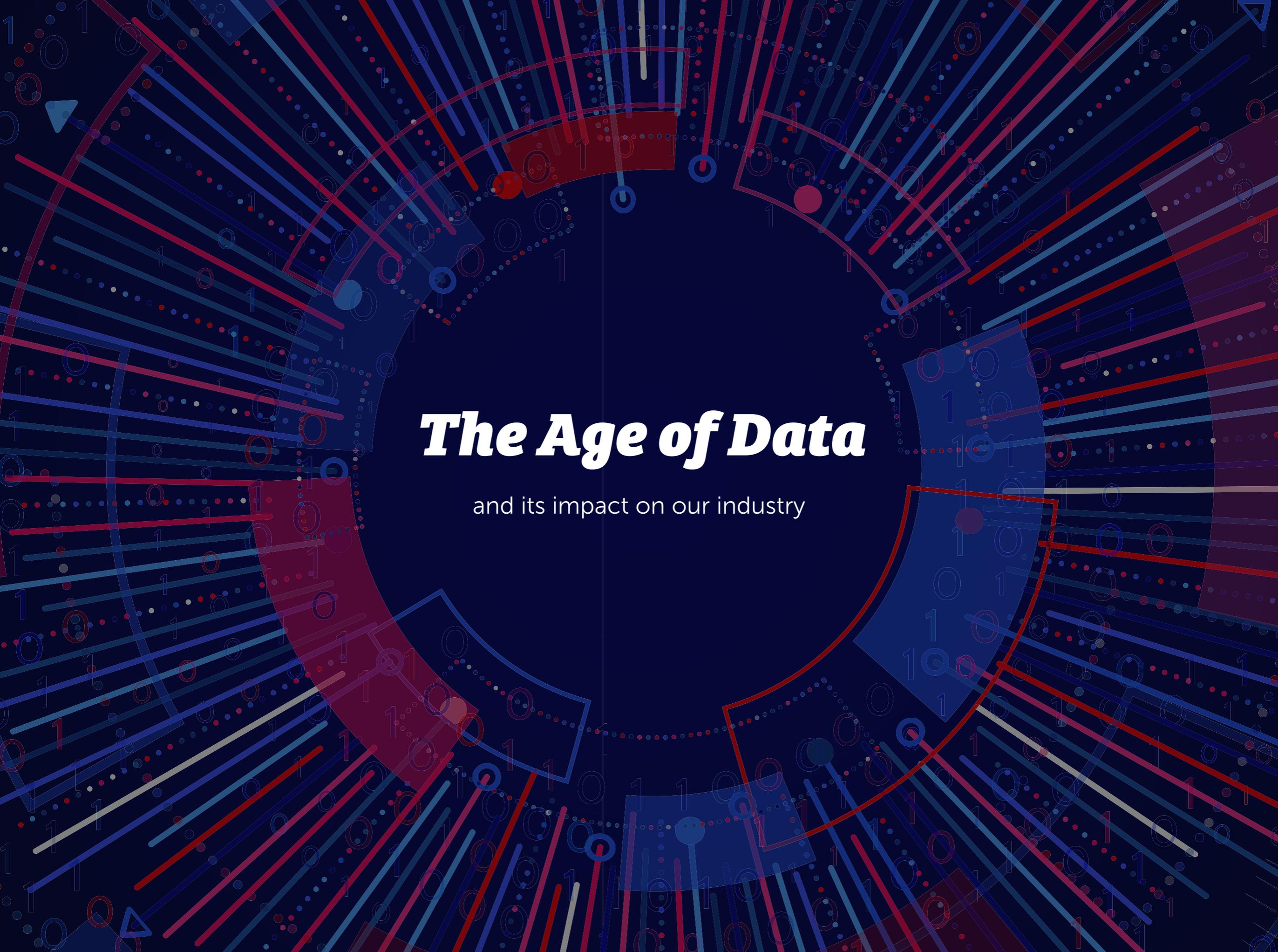
(or 8.8km)

Since the early 1960s nearly 20,000ft (6km) of sewer pipe have lain a few metres below the surface of Oregon's Lake Oswego, transporting flows to Portland's water treatment plants. But by 2009 Lois, (that's the Lake Oswego Interceptor Sewer) could no longer meet demand. It had also corroded badly and risked spilling **millions of gallons** of raw sewage into the lake. The answer? Replace it with 29,000 ft of buoyant pipe that would float just under the surface, tethered to the lake floor by 428 anchors. Cunningly its **serpentine design** still maintained the gravity line that meant elevation changes from west to east would keep material moving without pumping (saving \$20m in pumping stations and costs). The \$100m project was completed on time, 10% under budget, and won an innovation award from the American Public Works Association.

20,000 WORKERS

The \$80 billion expansion of Jubail in the Eastern Province of Saudi Arabia is one of the largest civil engineering projects ever seen. Jubail 2 - which includes the addition of two ports, a 9km causeway, more than **860 kms of roads** and 63 bridges – called for more than 20,000 workers at its peak, and will double the size of the city. Construction began in 2014 and has been broken into four phases, with the final 50,000 residential units expected in the mid 2020s. The earthworks alone will move more than **30 million m³ of aggregates**, while a desalination plant will process 800,000 m³/d of water and generate 2,750 megawatts of electricity. The resulting 83km² complex is the **world's largest single industrial development project**.



The background is a complex, abstract digital composition. It features a dark blue base color with a dense network of lines and shapes. The lines are primarily in shades of blue and red, radiating outwards from the center. Interspersed among these lines are numerous binary digits (0s and 1s) in white and light blue. There are also several semi-transparent, overlapping shapes in shades of blue and red, some resembling stylized data paths or network connections. The overall effect is one of dynamic, interconnected data flow.

The Age of Data

and its impact on our industry

Learning to thrive in the data ecosystem



Richard Ertel,
Chief Information
Officer, Seequent

“We certainly see differences in attitudes towards data within the industries we serve. This includes their willingness to take on risk with new technology as well as how they’re using data.”

FROM OPENNESS TO ETHICS, THE ISSUES THAT SWIRL AROUND DATA ARE VAST AND VARIED.

In this edition of Unearthed we take a look at some of those questions - from data’s growing adoption within our industry, to why interoperability is still an issue for Civil Engineering. We also share an exclusive interview with Google’s Craig Fenton, one of the biggest data players in the world.

Value not volume

A strong message we get from our customers is that they are simply overloaded with data. A substantial increase in field automation and advances in technology mean they are struggling to use and make sense of its proliferation. Turning it into valuable insights becomes more difficult, both from the perspectives of computation and timeliness of communication.

We are also seeing challenges with data sovereignty especially with the processing of personal data at a global level. As new data privacy laws are introduced, and countries begin to put constraints around where their citizen data is stored and processed, much greater responsibility is placed on our customers to ensure they know where their data is and how it is being used.

This complexity will only grow. Customers will need to ensure that their solutions for managing data and compliance are able to meet this additional complexity,

so they are looking for their partners and suppliers to demonstrate compliance with the new regulations and laws.

The importance of openness

Data interoperability is essential for the future success of any industry, and ours is no different. The days of having closed off, proprietary formats are over.

One of the major reasons Seequent has found success has been our philosophy of data openness. We spend a lot of time ensuring that our products are able to import and export information in many different formats. We recognised early on that building up artificial walls to our competitors in the form of a closed file format would mean that ultimately our customers would suffer through an inability to exchange information freely.

Having open standards for data exchange helps promote a healthy ecosystem of innovative products and services that ultimately benefit the customer.

You can witness this data ecosystem developing elsewhere too. For example, it’s exciting to see government organisations increasingly open their non-personal data. The UK’s data.gov.uk site is a great example of how governments can be open about the information they have and let people use it. This openness builds a strong sense of trust and creates a platform that allows everyone to innovate. Hopefully we will start to see more private organisations participate in this open data society.

Changing attitudes

We certainly see differences in attitudes towards data within the industries we serve. This includes their willingness to take on risk with new technology as well as how they're using data.

Historically the mining industry has been slow to introduce new operational and information technology into operating mine sites due to several factors like location and technology constraints. Because of these constraints, each mine site would often operate independently from one another, creating data flows, processes and systems specific to their operational needs.

However, we do see the mining industry accelerating its adoption of technology to connect and automate mines. Through investment in better internet infrastructure, mining companies are now able to move their data around more freely and have started introducing more innovative technologies and processes globally, resulting in considerable increases in productivity.

Contrast that to the Civil and Environmental sectors where the desire and capability to adopt new technologies is much higher. These sectors don't often have the same physical isolation as the mining industry but will likely have a much broader set of groups involved in projects. The focus here comes down to being able to share, collaborate and communicate information effectively across a number of stakeholders.

The Seequent direction

Today at Seequent we are looking at how our technology and the tools of our partners can be utilised to help industries make better decisions about their data. That doesn't mean that we are building the solutions ourselves, but it is about ensuring that our customers have access to the products and services they need to get that insight, and make decisions faster.

Personal data – why it's different

On May 25th 2018 the General Data Protection Regulation (GDPR) came into force across Europe - you probably received a few hundred emails about it. Personal data is different to other types of data that a business may hold, principally because a business cannot "own" personal data and the rights of the data subject take precedence over the rights of the business.

Most jurisdictions in the world have some form of data protection or privacy law which gives protection to citizens' data. An early driver for these laws was the protection of individuals from profiling by state agencies, but with the development of technology in the late twentieth century - and the rise of the internet - the focus has moved to the private sector (in particular social media and digital businesses). Much of the law around personal data is directed at global corporations that analyse huge amounts of personal data for the purposes of selling to or influencing consumers. This is why we see an increase in the reach that new laws such as the GDPR have from a geographic perspective and also with respect to the magnitude of penalties available.

One impact of this is that all organisations, not just the big guys, have to achieve a much higher level of compliance and in some cases that compliance is with multiple, possibly conflicting, regulatory regimes. For organisations like this the key is to focus on "privacy by design" when looking at their customer or HR data management systems (customer and employee data being the two main sets of personal data that most companies hold). Building these systems in a way that helps a business demonstrate the steps it has taken towards compliance will put them in a much better position with respect to regulators and help build customer confidence. This is not that different to making sure your business data is managed securely, but with the key difference that in the case of personal data you have obligations to the data subject as well.

How will smarter data transform Civil Engineering in the next five years?

WE ASKED SIX EXPERTS "WHAT DO THEY SEE IN THEIR DATA CRYSTAL BALL?"

Trevor O'Shannessy,

Principal Geotechnical Engineer, Golder Associates

Integration and compatibility "We deal with a large amount of data that describes the ground and its engineering behaviour, both current and archival (e.g. borehole logs, lab testing, in-situ testing, proof loads, etc). In modern society there are increasing time constraints in distilling and processing ground data to a point where it provides a timely answer of useable output for our clients.

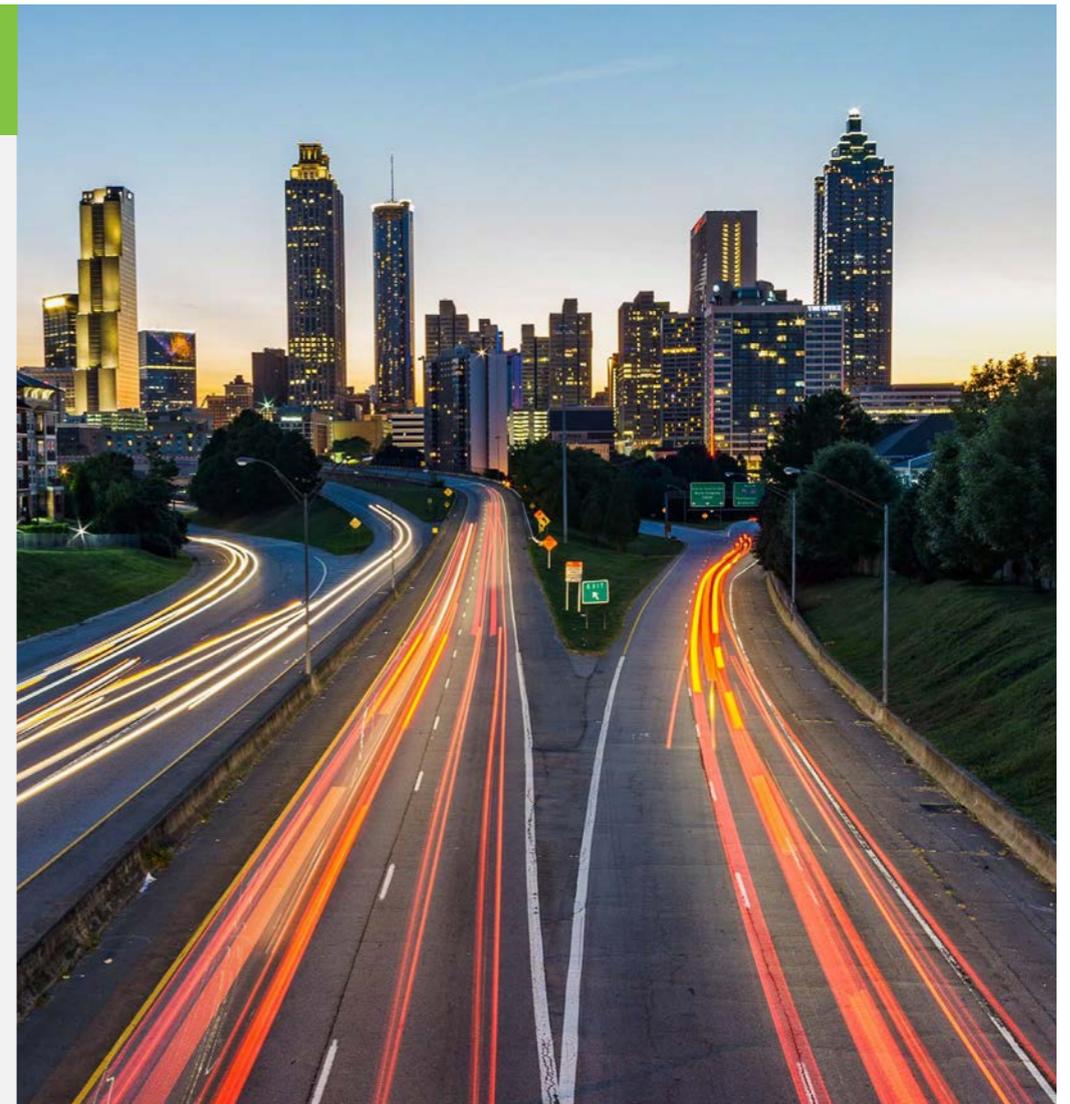
"In the next two to five years I'd like to think we'll become increasingly smarter about storage and recall of archival data so it can be quickly acquired and integrated seamlessly with current project data collected and transferred electronically in the field.

"At the back end of this process is data portability and having the flexibility to 'pump' the models created in a package such as Leapfrog directly into other platforms. As an example, I often now tell people that the 3D model is not the software; it's management of

the 'bucket' of data. A software platform is just one specific tool with which to manipulate it.

"Some platforms are easier to work with than others and the model may pass through a number of software platforms and tools before it's in a form that conveys the desired outcome. Examples of this are interpretation of the geological layer (geological model), or the way groundwater flows (hydrogeological model), or its relationship to ground support and predicted ground strain (geotechnical engineering model).

"I'd like to think the age old problem of user and software incompatibility and how software packages speak to each other will finally disappear. I think the market is forcing this compatibility in order to make the transitioning of data smoother and faster, by competitiveness, and by project tools and technologies like BIM."



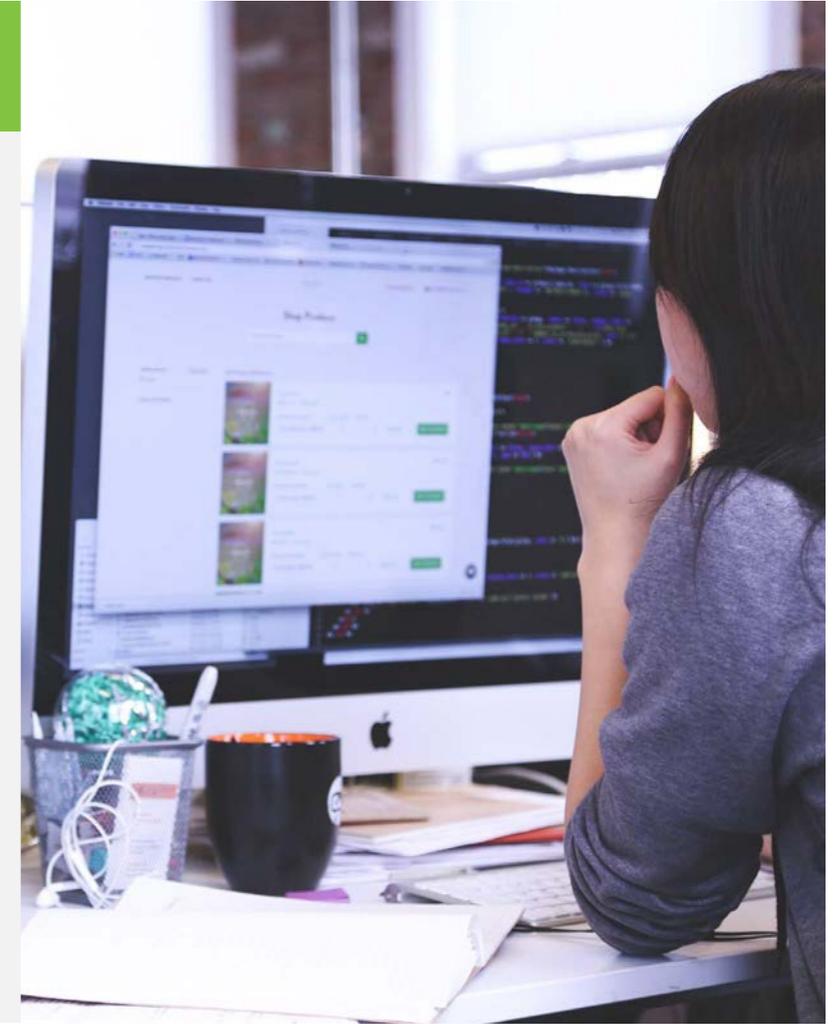
“We’ll become increasingly smarter about storage and recall of archival data so it can be quickly acquired and integrated seamlessly with current project data”

Pat McLarin,

Product Manager, Civil and Environmental, Seequent

Community and collaboration “We have a fantastic and passionate user group willing to provide feedback on the problems they are trying to solve and the product features they want us to deliver. We are aiming to make it easier for our users to do that because better data on what they need and how they interact with our products enables us to create better solutions. Enabling a user community that can see what feedback others are providing and say ‘hey, I have that exact same problem’ provides a voice for the silent majority as to what is valuable, or painful, in our current workflows. That collaboration is incredibly important to us.

“My dream is that digital data can make civil projects go completely 3D. After all we live in 3D, we model in 3D, we design in 3D, we build in 3D. 2D plans and sections are really artefacts of the limitations we had in the past - an inability to handle 3D on a static piece of paper, or the lack of processing power required to handle calculations in three dimensions. So, a shift to where we do everything in 3D would be my vision.”



Scott Houston,

Chief Technology Officer, Seequent

Deeper immersion “I’ve been programming since 1981 (batch Cobol) so am a bit of a data geek really. What attracted me to Seequent was our focus on the three dimensional interpretation of data and then adding the 4th dimension, time. With 3D models the complex interface between man made structures and the ever-changing geology becomes much clearer to all stakeholders.

“I worked for Silicon Graphics in the late 1990s and back then we were able to immerse ourselves in a reality center and literally walk around inside a model. However, the computing and graphics power needed to drive one of these experiences was tens of millions of dollars... Today with products like View, it costs just a few dollars. I think that within the next two to five years 3D will be table stakes for any major project.

“The reality is that geology is always changing so these digital models can never be static representations of a snapshot in time. Increasingly our customers will demand that the geological models on which large infrastructure projects are dependent will need to be hosted, analysed, updated and collaborated on in real time, and not just for the duration of the project but for the entire life cycle of whatever they are building.”



Graham Irvine,

Senior Engineering Geologist South Queensland, GHD

Virtual site visits “The common thread of compatibility between software tools is always there. The ability to export or import any number of file formats is important to create a smooth workflow. Limitations on compatibility of data between packages only reduces how fluid the exchange of data should be. I hope that we can move towards physical interaction with data to create a more immersive experience and understanding of the information we use. The ability to do a virtual site visit with multiple users interacting in real time with data and collaborating on solutions and ideas seems to be the next natural evolution of data utilisation.

“Also, the more I work with compiling archival data to build 3D representations of ground conditions in Leapfrog, the more I realise that the final model is only one part of the puzzle. Many of our projects have archival data from as far back as the 1940s. Clients typically have difficulties in compiling and understanding the relationships between all this old data and how it relates to new information. Having a 3D representation or library of existing information and being able to layer new data on top of it has proven indispensable. It provides a powerful way to easily digest the special relationships to data that may have been collected decades ago and compare it with a borehole drilled yesterday.

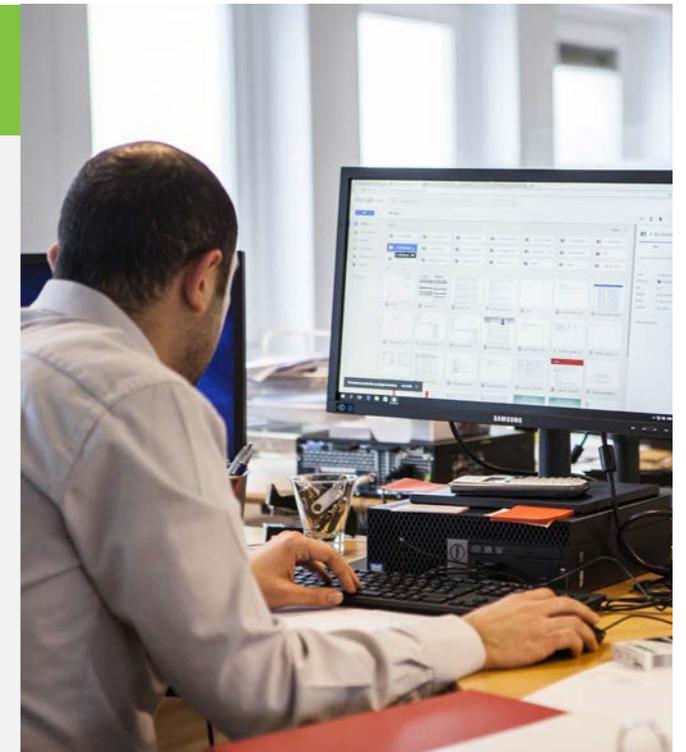
“With this in mind, I wonder how data we capture today will be used decades from now?”

“I think that within the next two to five years 3D will be table stakes for any major project”

Jason McIntosh,

Application Specialist, Seequent

Machine learning “There is a wealth of information out there that has been collected and produced for historic earth modelling projects. This data has often had humans applying their knowledge to it in order to extract meaningful outputs – but it can be hard and time consuming. As Craig Fenton suggests elsewhere, I would love it if machine learning could automate the more basic decisions that humans made for similar historic projects. Also if one day we could see the design and construction phases drawn closer together as a result of two-way data exchange.”

**Ian Besford,**

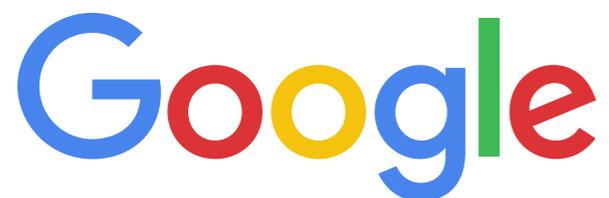
Projects Director, Mott MacDonald

Fresh interpretation “People are often heard referring to data as the new oil. The key difference is that data is reusable. Our ability to obtain, process and interpret data is increasing exponentially and we are continually identifying opportunities to digitise and interpret old data in different ways. This ability to reuse and add value from data we have that couldn't have been anticipated at the time of capture is invaluable. It means we are able to work with our partners to identify opportunities to improve safety, reduce cost, manage risk and optimize our solutions more quickly and more cost effectively than ever before. Within a five-year horizon this will shift from being the preserve of technical specialists towards being commonplace. Smarter data and smarter ways of processing it will democratize data analytics in the same way the PC did computing.”



Things to come

In an exclusive interview for Uearthed, Craig Fenton, Google's Director of Strategy and Operations in the UK, considers what the new Age of Assistance means for business and customers alike, and where data and creativity will meet "to delight and surprise us."



"We need to show up,
wise up and speed up"





IN ORDER TO LOOK INTO THE FUTURE, I THINK IT'S HELPFUL TO LOOK BACK.

What we regard as 'modern computing' is really only 30 years old. The Internet is a 20-year story. Smartphones are just 10 years old. Haven't we come a long way in that time?

The topic of data, which I know you're talking about in this issue of *Unearthed*, has absolutely exploded in that time. More data will be created in 2018 than in the previous 5000 years of human history.

But what's happened relatively recently is that computing power to deal with this data has finally caught up with the technology thinking that's been around for quite some time.

Modern techniques of machine learning, which is a type of artificial intelligence, combined with the availability of data and the power of today's computers to deal with it in smart and mindful ways, means we have reached a real turning point.

We have also cultivated a new set of expectations among consumers, and among businesses too. We turn to our devices in the 'moments that matter': when we want to know something, do something, go somewhere, or buy something. And businesses are meeting those expectations in ways that delight us.

What that's led to is a consumer and user group – and all of us who work in business are consumers too – that is very curious. We search on an ever more expanding set of things. Google gets around 44,000 searches every second, and almost 20% of those we have never seen before.

We have also become more demanding users. We expect a frictionless, seamless, delightful user experience.

And we are impatient. We know that 53% of people will leave a mobile website that takes longer than three seconds to load. However the average load time for mobile websites in the UK is more like 11 seconds....

That impatience applies not only to the speed of the digital interface consumers are using, but also to the services themselves. Modern eCommerce has taught us to expect next day delivery, and in some cases the opportunity to pick something up within an hour of ordering it online.

I think it's also interesting that we are starting to interact in a more organic way. We began by typing into our computer desktops and laptops, then swiping and gestures on our smartphones, and now I talk to my phone more often than I type or swipe.

Using your voice to ask for things and have conversation with a digital assistant like Google Assistant or Siri or Cortana or Alexa is more organic and it's spreading across devices. Not just smartphones but tablets, laptops, TVs, cars and any number of so called Internet of Things devices. Some estimates say there will be more than 30 billion of them by 2020.

So the Internet is becoming ambient. It has left our devices and now travels with us across digital "surfaces" – smartphone, TV, car, wearable. It's also highly personalised to your specific interests. It's an "Internet of Me".

So what does that mean for us as businesses, organisations, governments or other entities? I'd argue it means we need to show up, wise up and speed up.

To meet ever more curious customers, as businesses we need to show up in those moments that matter. Whether B2C or B2B customers, they will be looking to know something, find something, or buy something, and if you are not there in these moments that matter, your competitors will be.

Wising up means using the data available in a responsible and really intelligent way that creates an experience for a customer – again, B2C or B2B – that is delightful, valuable and relevant to what they are looking for, in the moment they are looking. That will mean very different things to a Civil Engineer doing a ground survey than to a holidaymaker looking for flights – but the principle is exactly the same.

Finally we need to speed up. We need to act in real time; react to those moments that matter at lightning speed.

In all of this what I'd say to businesses – and that certainly includes the Civil Engineering and Environment Sectors – is that technology in itself is not valuable. It's the way the technology is applied that counts.

So the first thing I would suggest is that you need to think very deeply about what the interests and needs of your customers are as they move forward, to really turn the spotlight on that and look at the tools available to you to surprise and delight them in better ways.

I'd also say that the new superpower in today's age is creativity. It's creativity that will allow you to imagine the dynamic, very fast moving environment that is coming, then do something wild and wonderful within it.

This is a mindset that needs to come from the top. Try stuff. Cultivate an environment in which intelligent risk taking is encouraged and failure is rewarded as it helps us learn and evolve. If we are not prepared to fail, then we will never come up with anything original. Don't engineer for perfection. Just get stuff out there and the market will guide you on what works, or how you need to change it.

I like to think Google fits into that mindset, but there are other good examples of companies that have made it their mission. For example, it's easy to forget that Netflix, which is now hugely successful, was once a mail order DVD company. Another example is 3M - which stands for Minnesota Mining and Manufacturing. They are now a global company, they no longer do significant mining and their manufacturing is unrecognizable compared to where it all started

And the good news is, I believe it's actually getting easier to innovate, not harder.

There are more tools available, with greater flexibility that allow you to do incredible things, so the limits on what companies, governments and social organisations can do is only defined by their imagination.

If you've got a smartphone and a good idea, you can start a micro multinational business tomorrow. You can become a creator; you can build a global audience. The barriers to entry are almost zero, and when I talk to my friends in New Zealand, that's a great story for them. Hitherto isolated countries with a smart, innovative and educated population can do amazing things because there are no barriers any more.

On the issue of data in business, I know some companies feel overwhelmed by the sheer amount of it. I hear some Seequent customers say that too. Or they may say 'we have lots of data, but not all of it is clean.' In the same way that you would refine a mineral or harvest a crop, that data needs to be cleansed and prepared so it's useable. It's understandable, and Google Cloud Platform has tools that help you prepare data so insight can be extracted (Cloud DataPrep).

Also, some of the issues you may traditionally have encountered with data are disappearing. There are now, more or less, infinite resources for storing it. Likewise processing and computing power is able to cope with large volumes of data better than ever before.

Increasingly applications such as machine learning are becoming important. In many ways it's just a smart technique for spotting patterns, but its ability to sift through the noise and draw useful predictive insights is hugely valuable

For example, we're doing work with the Moorfields Eye Hospital in London where we've developed a machine-learning algorithm that uses optical images, such as a scan of an eye, to spot diabetic retinopathy or macular degeneration. These eye diseases are extremely hard to detect and can eventually blind you. However, they are very treatable if you catch them early, so that's a life-changing event.





The algorithm can look at an image and compare it with all of the digital images of similar problems taken in all recorded medical history. That is something even the best physician in the world cannot possibly do. We also use machine learning to control temperatures in our data centres. It's a big problem because they generate a lot of heat, yet by applying machine learning we saw a 40% reduction in energy consumption.

It's an extremely powerful tool, not just for observation but prediction as well, and I'm sure there could be many applications for machine learning within Civil Engineering.

So where do I think this area of Intelligent Assistance could go in the next few years? Well we recently finished our annual Google I/O developer conference and there are certainly developments that are surprising and delighting me. I think they have huge potential.

One was a demonstration of Google Duplex where you can you ask your phone to make, say, a restaurant booking, or a hair appointment and it will go off in the background, make a call, and have that two way conversation in a very natural and intuitive way. That's an example of an extremely assistive consumer use of artificial intelligence. It will undoubtedly improve our lives as customers, but it can also make life more efficient for suppliers and partners as well.

There's some really interesting stuff around images where you can take an old black and white image and with the tap of a button, automatically colour that image and bring it to life. It's a consumer example, but you can easily imagine creative uses for business too.

Beyond that there is image search where you can hold your phone up and use its camera to look at an object and identify it – what kind of tree it is, is it a Monarch Butterfly, or maybe it's a restaurant that's had really good reviews so would you like to book it?

On the non-consumer side, what excites us at Google is the application of technology to really intractable human challenges. It's possible to make a real impact on things like mortality rates, people suffering from a whole range of afflictions, or whether people are blind or not, as I mentioned earlier. We see huge applications in medical spaces to improve our lives, and importantly because it's technology, once it's developed it's developed.

Digital technology is a wonderful democratizer. It lowers the barriers to entry and provides opportunity to global talent that only a decade ago did not have that opportunity. They can find a voice, build a global audience, start a micro multinational business. It's not something for an elite group, it's there for everyone, and that's a really powerful thing.

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Why is data interoperability still a thorn in the side of Civil Engineering?



Pat McLarin,
Product Manager, Civil
and Environmental,
Seequent

Pat McLarin tackles 5 questions on the Civil and Environmental Industries' elusive holy grail.

1) What does the industry want?

Principally, engineering geology and geotechnical practices want to be able to handle whatever data is thrown 'over the fence' at them. As service oriented departments or consultancies, they need to be able to say 'no problem' and get on with assembling and analysing data, identifying the gaps that need closing, and building an understanding of what lies beneath the surface.

What they don't want is to have to go back to a potential client and ask for the file in a different format. It just makes them look unprepared. They'll scour the Internet for free conversion software, or call a friend in the GIS or CAD department to do them a favour. Not a great solution...

On the flip side they want to be able to deliver the model outputs in a form that meets their clients requirements, without compromise. That means everything from a fully interactive 3D model in a web viewer, to a BIM federated model to cut and fill estimates in a costing spreadsheet, to a 2D cross section for inclusion in a report.

2) Why is it so complex?

Geological modelling typically requires every bit of data you can lay your hands on in order to shed light on what's going on beneath the surface. This means that modellers have to cope with some pretty disparate sources. They end up running the gamut of data from above and below the ground, as well as spanning the past, present and future.

Just think about ground surface data for a minute. It comes from GIS databases, geological maps, CAD plans and historical surveys, aerial photographs or satellite based raster images. Increasingly today it's also from drone-based aerial surveys, terrestrial scanners and mobile surveying and mapping applications, and they generate considerable quantities of data.

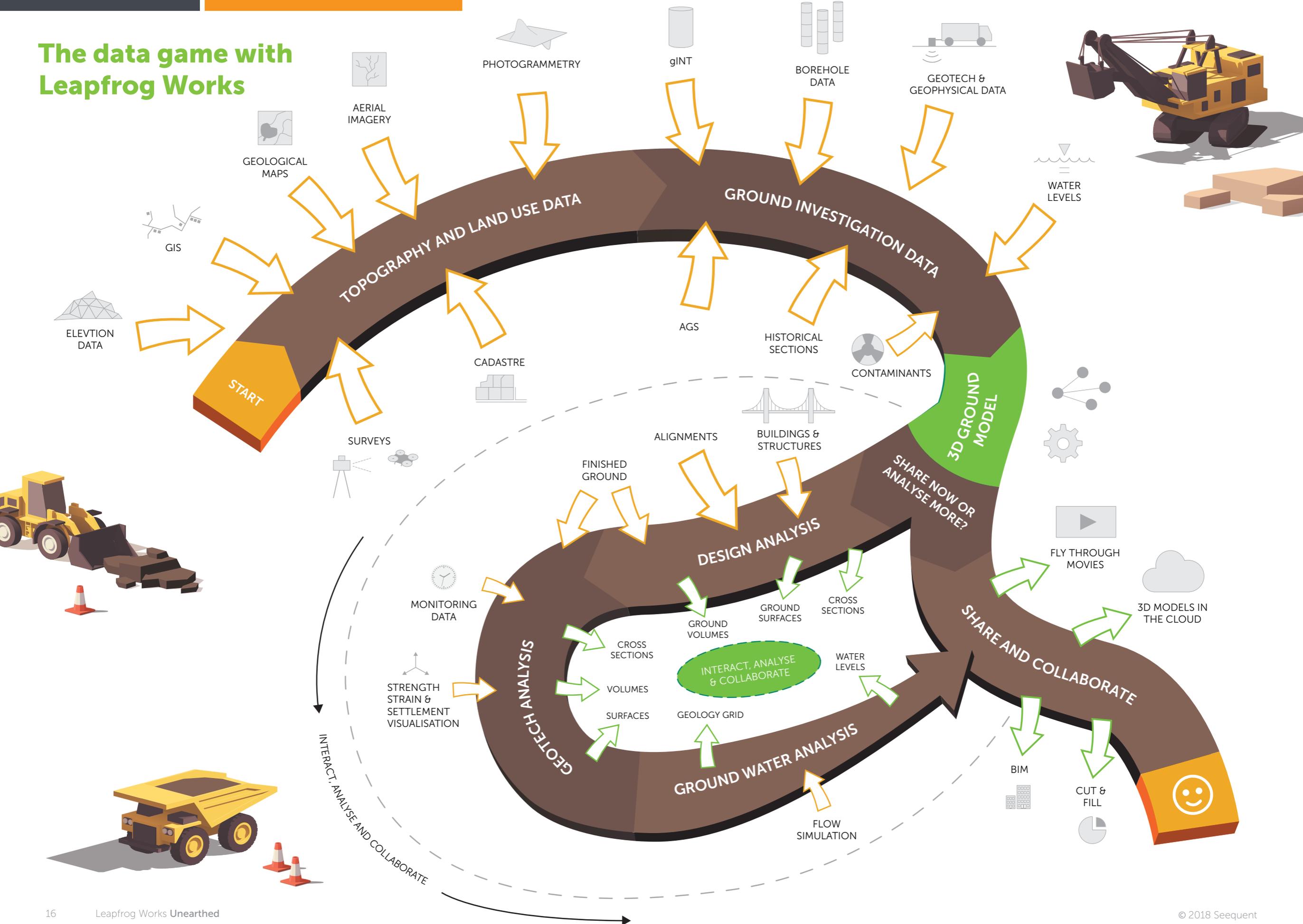
The same goes for subsurface data. The AGS data format for example contains dozens of different data types for ground investigations. In fact it is itself a response to the complexity of ground investigation data types by the industry.

So why don't we all natively use a common format to make it easier to share information? Well the complexity comes because each individual data source tends to be optimized to make its part of the puzzle more productive and valuable. And these optimizations are actually quite beneficial to the industry.

An example of this would be our own FastRBF™ surfaces that we generate in Leapfrog Works. Because we control the mathematics behind the surfaces we can optimize the performance, which in turns makes fast dynamic geological modelling accessible to the industry, However the same type of surface wouldn't suit the CAD world which is more about drawing straight lines and regular shapes of manmade structures.



The data game with Leapfrog Works



The trick is to also support and contribute to the development of open exchange formats so that the models can be shared in all their 3D glory. Yet at the same time you're supporting traditional modelling outputs like 2D cross sections for inclusion in paper based reports that are still a standard part of industry practice.

3) What are the main challenges?

There are certainly ongoing issues around the direct support of the many data sources that are available; to cope with ever increasing amounts of data; and to handle continual updates in data. Right now, a key challenge is for the ground engineering disciplines to participate as an equal partner in BIM-style workflows on major construction projects.

On infrastructure projects, uncertainty and risk relate to how well you are able to successfully predict the ground conditions. However, communication between ground engineers and their civil and structural counterparts regarding the degree of risk is subject to miscommunication.

Adopting a BIM philosophy helps all disciplines in a project get on the same page by creating a single source of truth, so it is a natural extension to integrate the ground model in these workflows. In fact it's long overdue. It's also worth noting that BIM standards are much more advanced for vertical infrastructure, so there is work to be done to standardise what it means to be an interoperable ground model.

4) What is Leapfrog doing to help?

A lot of the work last year was about removing barriers to interoperability through the support of key formats needed by the industry. Among others we support...

- geodatabase and shapefile formats for GIS data
- dxf and dwg CAD formats for incorporating engineering design data
- and AGS and gINT database formats for direct connection to the source of truth for ground modelling.

We have always been a 3D centric company, so for us 3D comes easy. But there is still a need to create 2D cross section outputs for interoperability with other workflows like 2D geotechnical analysis, or for baseline reports and structural engineering analyses.

It's interesting and refreshing to see more and more workflows completed in 3D as digital data becomes more prevalent and computers ever 'grunter'. However we still envisage a continued need for 2D outputs in the foreseeable future, so we'll continue to improve our cross section feature set.

Right now, though, we are prioritising BIM interoperability and support of the IFC format for 3D ground models. It means geotechnical professionals will have an equal footing and position with the inclusion of their own geological interpretations directly in the project BIM environment.

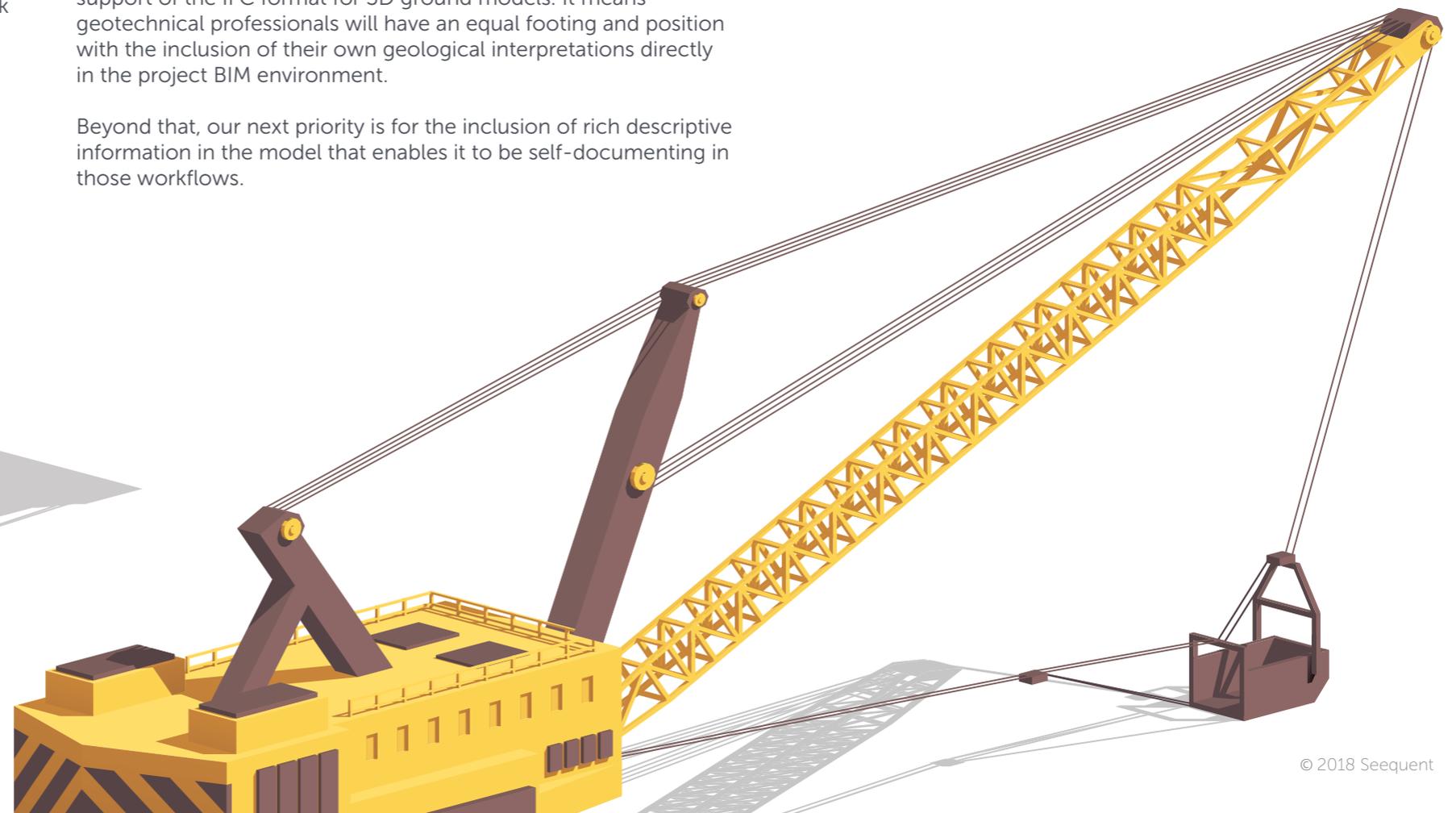
Beyond that, our next priority is for the inclusion of rich descriptive information in the model that enables it to be self-documenting in those workflows.

5) Why is interoperability important?

At the end of the day it is about improving understanding in both directions. The geotech understands what is planned to be built, and where, and can share what will be encountered and the risk or opportunity that comes with it. All that is enabled by taking a pragmatic and open approach to data interoperability.

To be realistic, it's not practical to directly support every last format that anyone might want to bring into a Leapfrog project, so we'll continue to rely on and support industry standards for data exchange.

But overall our goal is to empower geotechnical professionals with the tools that help them understand what is going on with the other disciplines on the project, and share and tell the story about what is happening beneath the surface that other disciplines and project stakeholders need to know.



Not just for the big projects



Chris Hibbert,
Plant Design and
Manufacturing Manager,
Roger Bullivant

“Collaboration is getting easier on large infrastructure projects through the steady implementation of BIM, but BIM isn’t filtering down to the smaller construction sites such as housing.”

Smarter use of data should benefit construction projects at all scales, but it’s not an advantage that’s always passed down the chain. What about more modest schemes such as small and medium-sized housing estates? Chris Hibbert of UK-based foundation and piling engineers Roger Bullivant explains how they are successfully applying data at this level, but why more could still be done.

What do you do for Roger Bullivant?

“As Plant Design and Manufacturing Manager I manage a small design team of engineers designing our own piling and foundation equipment and associated tooling. Having our own bespoke machinery allows us to optimise our designs in terms of machine size, transport weight and ground pressure.”

“This makes our machines ideally suited to the small to medium sized housing sites on which we work as well as the larger industrial sites. We can also rapidly develop our equipment in response to suggestions and observations received from their use and maintenance in the field.”

What changes have you seen in your sector of the industry?

“Regarding foundation engineering specifically, the biggest change must be the **more widespread use of instrumentation** and digital data collection for remote access and monitoring.”

“Roger Bullivant Limited have used instrumentation on rotary rigs for years but have only recently started to use this technology on our driven rigs. In the past two and half years we have generated over 50,000 pile records from just six machines.”

So how are you turning that to your advantage?

“All our new machines are being fitted with instrumentation which enables real-time monitoring of the piling process. We are incorporating this data into our Big Data platform, which can collate, interrogate and present a range of standard and user defined dashboards and reports.”

“This will put the data in full view of our employees so they can see real-time progress reports at any time on any device. We are also looking at incorporating other machine data into this system to monitor engine performance, fuel use and key hydraulic pressures.”

Does better technology make for better collaboration?

“Collaboration is getting easier on large infrastructure projects through the steady implementation of BIM, but BIM isn’t filtering down to the smaller construction sites such as housing where Roger Bullivant does most of its work.”

“Additionally, many housing sites don’t have significant Site Investigation (SI) available. However, this isn’t stopping us developing the use of Leapfrog as we are also using it to model three dimensional records of our piles. We can use these to identify changes in ground conditions and to create a searchable database of our previous contracts.”

“Another area of enormous potential would be the use of AGS data, which is an electronic format for Site Investigation (SI) records. It has been routinely created by numerous SI companies for years. This allows the data to be input in a fraction of the time. However, this data is **often not provided to piling companies** due to issues of ownership. Moreover, when it is provided it doesn’t always include accurate co-ordinates for the boreholes.”

“If there was better collaboration in these areas I think we would see rapid and significant improvements in both time savings and accuracy due to the removal of potential errors from manual data transcription.”

Roger Bullivant has started using Leapfrog Works. What has this enabled you to do?

"Leapfrog has demonstrated the possibilities available to us for creating sub-surface models based on our pile records and available Site Investigation (SI). As I mentioned earlier, this would be massively improved by the availability of AGS formatted Site Investigation records.

"It's a very clear and exciting way for us to present our data - providing we can automatically transfer that data from our instrumentation system at or near real time with little or no interaction.

"If this can be achieved then over a relatively short-time **the majority of the UK could be modelled** and continually developed to higher and higher resolution. Thus, allowing our project estimates and pile designs to be refined further and further. Better data equals better decisions, but only if we use it!

What key challenges do you think the foundation engineering and wider civil engineering industries currently face?

"Health and Safety is always an important driver and environmental issues are another major challenge but one key influence is understanding how to leverage the rapidly changing, innovative technologies such as Big Data, 3D modelling, additive manufacturing, virtual and augmented reality and the use of drones which can all come under the broad heading of **the 4th Industrial Revolution**.

"I believe we have made some impressive progress using Leapfrog over the past few months, we have obtained SI data in AGS format for a contract we are tendering for and have very quickly created a 3D geological model based on these boreholes. We have also created a 3D scale model of the individual geological layers for the site using our in-house 3D printer which we will use to fine tune our pile design and to help demonstrate the three-dimensional nature of the geology beneath this site.

"I believe there is a paradigm shift in terms of generating, collating, interpreting and utilizing the huge amount of data that our businesses generate. Technology is changing fast and we need to keep pace."



When data goes bad

And finally, it's worth remembering that whatever errors and false conclusions inadequate data might have led you to in the past, there's always someone who's managed worse...

A textbook mistake?

In September 1999, the Mars Climate Orbiter entered the planet's atmosphere full of potential and scientific endeavor – and plunged to a fiery and \$125 million dollar doom. The reason? Almost unbelievably, the power the thrusters needed to deliver for a successful manoeuvre had been calculated in pounds of force, but a separate piece of software had taken the data in as Newtons. Basically, they forgot to convert to metric. NASA engineer Roger Cook later said, "everyone was amazed we didn't catch it." Which is perhaps putting it mildly.



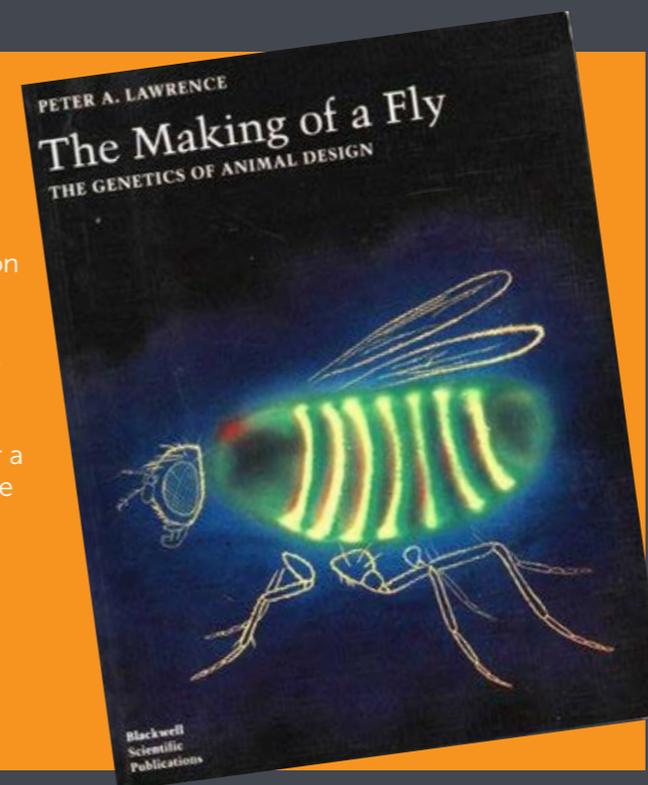
You never know what old data could be worth

Pity James Howell from Newport, England. In 2009 he obtained 7,500 Bitcoins for virtually nothing. He stored the data on a hard drive, popped it in a drawer and forgot about it. By 2013 they were worth £4.6m (around \$7.5m at the time). However, he'd thrown the hard drive away. He even went to the landfill site in South Wales where the drive had ended up, but confessed to the BBC "It was about the size of a football field. I took one look and thought 'no chance'."



\$23million dollars for a single book

In 2011, Peter Lawrence's biology textbook "The Making of a Fly" appeared on Amazon on sale for the modest sum of \$23,698,655.93. (Plus shipping, of course.) Two automated bidding programmes from competing sellers had run constantly and uncorrected for 10 days, each nudging up the price. Amazon reviewers demonstrated their usual talent for a put down with one reporting: "I was fortunate enough to buy this at the bargain price of \$19,087,354. Must have been a sale on. The next day it was \$23m!"



Accurate entry is everything

One Thursday, late in 2005, a Mizuho Securities trader on the Tokyo Stock Exchange set about selling 610,000 shares in recruitment firm J-Com Co at 1 yen each. Unfortunately the data had been typed in incorrectly. What he'd wanted to do was sell every 1 share at 610,000 yen each... By the end of the day Mizuho Securities had lost \$225 million.



Better poor than perished

In 2016 a data glitch informed some senior citizens in Michigan that their benefits would be cut. 12,000 of them. They each received a letter erroneously announcing that their income would be reduced. The Michigan Department of Health & Human Services had been trying to bring its database in line with federal statutes and one small error had triggered an avalanche of false results. Unpleasant, but perhaps not as bad as when the St Mary's Medical Centre (also in Michigan) mistakenly informed 8,500 healthy patients and their insurance companies that they were, well, dead. They did at least refer to the demises as 'unfortunate' when they sent the notifications out.



There should definitely be a Stanislav Petrov Day

On September 26, 1983, Petrov was on duty at a Russian command centre when its computer told him (incorrectly) that America had launched a missile attack on his country. It was Petrov's responsibility to inform his superiors and so initiate a counter attack. The fact that we are all still here and there wasn't a World War III is down to Petrov having "a funny feeling in my gut" (seriously) that it was a false alarm, and disobeying his orders. He was of course right. Later in the 1990s, when the incident came to light, Petrov largely played it down saying that the famous red button launcher that would unleash nuclear Armageddon had never worked properly anyway.



And finally

It's 1979. You are Ross Perot and you own Perot's Electronic Data Systems. You're looking to invest in a small computer company up for sale. You study the market, you analyse the data, but decide the \$50m the firm is asking is too much. So you turn down Bill Gates and Microsoft.



Microsoft



A scenic mountain landscape featuring a winding asphalt road with a metal guardrail on the left and a yellow dashed line on the right. The road curves through a valley with green grassy slopes and rocky outcrops. In the background, there are large, rugged mountains under a cloudy sky. A river or stream is visible on the left side of the road.

In Action

How Leapfrog is contributing to some of the world's most ambitious civil engineering and environmental projects.

The Auckland City Rail Link...

... is New Zealand's largest ever infrastructure project. It will transform the downtown area's rail connections by creating a 3.45km, twin-tunnel underground link running up to 42 metres below the city centre. When completed, CRL will double the number of trains on the network, boost their capacity to 30,000 people an hour and bring the city centre within 30 minutes of thousands more commuters. However, the geology the project needs to contend with is especially complex... including three volcanoes. The role of Principle Technical Advisor, and responsibility for the reference design, went to Aurecon. They adopted Leapfrog Works to deliver a detailed technical analysis of the formidable ground conditions.

NZ\$3.bn

Total cost of the project



The Challenge

Auckland's trio of volcanoes have left a geological heritage of ash and lava deposits mixed with soft sediments from historical swamps and ponds, plus hard basalt rock and sandstone. Characteristics to the north and south of the rail alignment vary considerably.

Engineers and constructors needed to see how these ground conditions would interact with the structures planned in order to make informed decisions on structural design, services relocations and construction methods.

"Leapfrog Works has been an instrumental tool to support our ground engineering team, who are the interface between science and engineering," said Philip Kirk, Aurecon Geotechnical Team Leader. "This is a linear infrastructure so there's no escaping challenging ground conditions when you're building an underground railway. We didn't want the construction team to encounter unexpected ground conditions that would compromise the project or delay it. We had to get it right."

The Investigation

Aurecon's team undertook an extensive drilling programme to provide key data

- **200 boreholes were drilled as part of the process to build the model**
- **Around 5km of core was recovered**
- **Historical records of 1000 boreholes from the wider area and 21km of core were incorporated into the analysis**

The Response

Aurecon used Leapfrog Works to prepare 3D geological models for parts of the CRL alignment. "A lot needs to happen in order to construct the tunnels in the area with the most complicated geology on the project," said Anita Nagy, Engineering Geologist with Aurecon. "This includes relocating stormwater and bridges and constructing several new structures within a tight corridor.

"Leapfrog Works really supported the ground engineering team by facilitating better communication and interaction with our engineering design colleagues. The team were immediately surprised by how effective it was as a communications tool. This richer output of information is a vital tool for communication with project stakeholders. But even more importantly it's about getting the designs right from the start".

200

Boreholes drilled as part of the investigation

3

Number of volcanoes

that needed to be factored
into the ground model

The Outcome

Using Leapfrog Works enabled the Aurecon team to make vital changes to the reference design that saved City Rail Link both time and money. For example, revising the design to allow for ground risks around the project's Water Street shaft prevented the use of inappropriate construction methods, therefore, avoiding delays.

The dynamic nature of Leapfrog Works meant the ground model could be updated immediately, based on live data coming from the onsite shaft borehole drilling. As a result, the types of pile used were changed, saving the project team days and making sure the structure was as accurate as it could be.

"The 3D geological model was an invaluable tool to communicate ground risks to both stakeholders and contractors during the procurement phases," said Tom Ireland, Aurecon Project Director for the PTA. "Better understanding of the ground conditions results in much better time and cost certainty."

The Future

Aurecon are continuing to use Leapfrog Works as the CLR construction advances. "In fact we hope this is just the start of using 3D visualisation to communicate risks within a project and to help clients and contractors make sense of them," concludes Philip Kirk. "This is the power of combining technical eminence and digital technology."

42

Metres

How deep the link will
run beneath Auckland

Leapfrog Works

is built specifically for the Civil Engineering industry, to provide a complete solution for fast and dynamic modelling of ground conditions, analysis of the interactions with the engineering design, and intuitive 3D visualisation.



The Hong Kong-Zhuhai-Macau Bridge



Ruby Forrester,
Customer Solutions Specialist, Civil
and Environmental, Seequent

The Hong Kong-Zhuhai-Macau Bridge connects Hong Kong Airport to Macau and Zhuhai across the Pearl River Delta. Its unusual construction combines three cable stay bridges, one tunnel and a trio of man made islands. At 55km long it forms one of the longest fixed-links in the world and opens to traffic in July. Seequent's Ruby Forrester explains what fascinates her about the project.

55km
long

110bn
Yuan (\$17bn)

THE BACKGROUND



Why it fascinates me

"Since I left university, I seem to have always lived with other civil engineers! We've always had engineering magazines on the table and watched shows such as Megastructures on TV. I imagine I heard about this project through one of those, but I remember thinking that no one had done anything like this before. Combining two civil infrastructure types that even on their own can be complex, was ambitious and innovative. Building just one bridge high enough to let ships pass underneath was not an option, as it would have exceeded the height limit for structures near Hong Kong Airport. But the combination allows ships to cross over the tunnelled portion and into the Pearl River Delta. Very clever."

An incredible project to be part of

"It would have been very interesting to be part of the design team for the bridge-tunnel connection. Developing the structural design of the connection between bridges and the tunnel must have been hugely complex. The manmade islands help, but the potential settlement and coastal erosion would then have dire consequences for the structural integrity of the bridges and tunnel. The transition from caisson foundations for the bridge, to overburden of the soils overlying the tunnel would have been a particularly interesting challenge. Coming from a geotechnical engineering background, I would have loved to help solve these challenges, as I think they're an opportunity to try something creative."

How Leapfrog could have helped

"I would have loved to see the entirety of this project built in a Leapfrog model. I think the addition of a sea floor survey with the seabed geology could have been very useful for the bridge design, which could have been informed not only by the geology, but the depth of the water (and the associated horizontal pressures from the water flow). Being able to show the manmade islands in 3D alongside all the other elements would also have been cool. Maybe one day!"



4,000
ships a day

expected through the
waters above the tunnel.

400,000
tons of steel.

Enough to build
60 Eiffel Towers.

How to...

An Unearthed Extra on getting the most from your Leapfrog software.

THE CHALLENGE

We look at both ends of the data interoperability spectrum:

Part 1: Prepare your data for 3D modelling

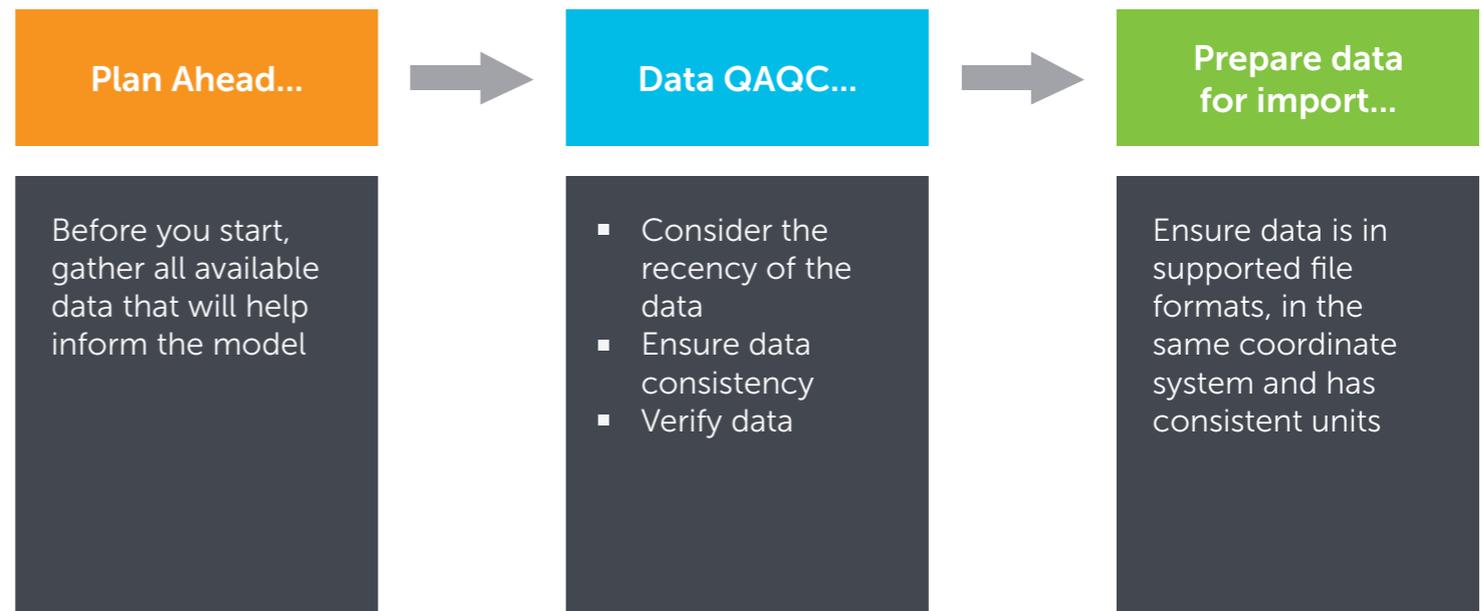
Part 2: Share interactive 3D views via the web

Prepare Your Data for 3D modelling

Having a clean and well-prepared dataset available before you start modelling is very important; the reliability of your entire project depends on the quality of the input data.

This guide covers best practices when preparing data for modelling, to help you get started on the right foot. It will also cover some common problems that you can avoid by preparing your data before importing it into the software.

You can easily avoid costly mistakes and time lost trying to fix errors when you are half-way through your model by simply preparing your data before you even start working on a project. We believe that following these steps will help you make modelling process a breeze!



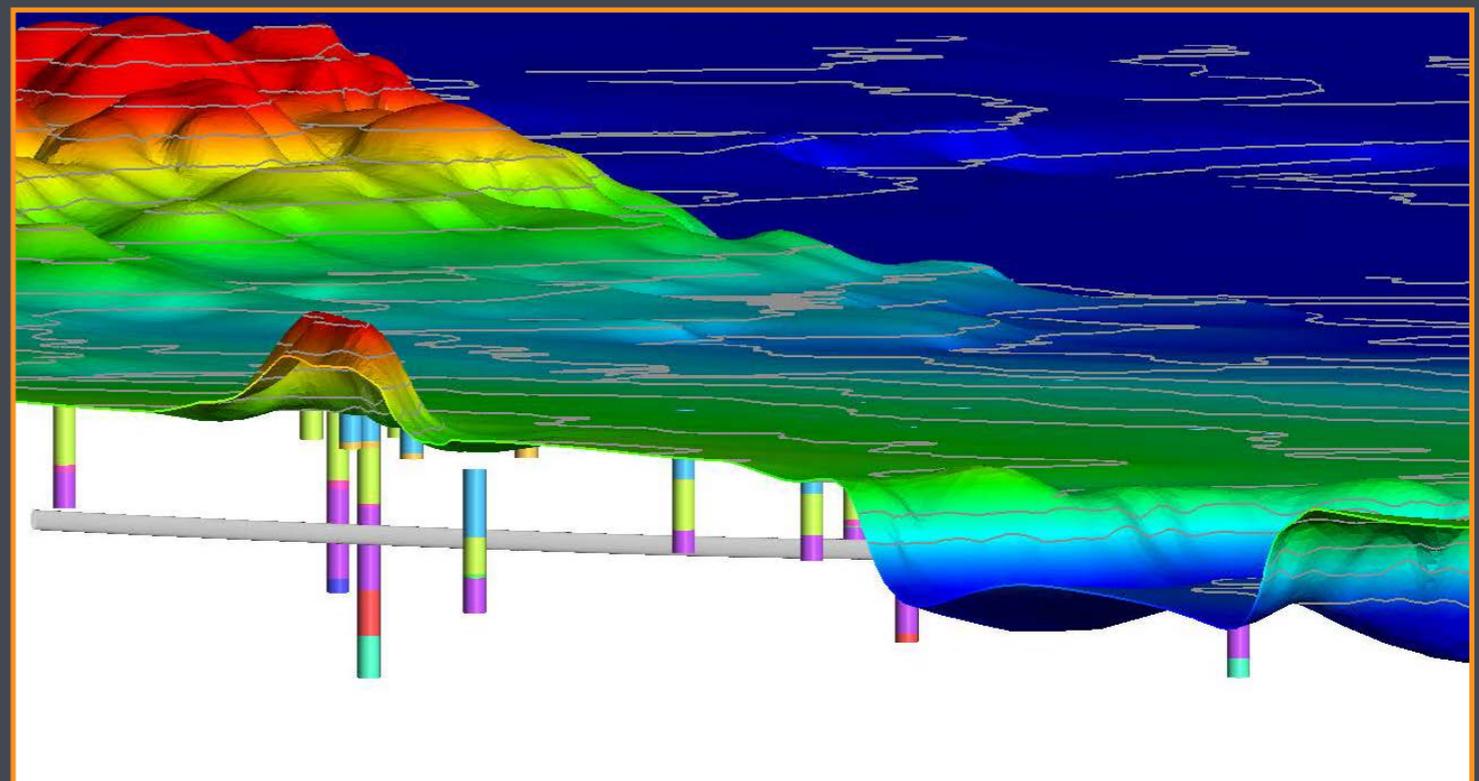
STEP 1 Plan Ahead

Before you start working on your model in Leapfrog Works, it is a good idea to do some planning.

Think about the information you have available that can be used to support your model. This may include but is not limited to:

- designs
- ground investigation data (boreholes, CPT data, etc)
- GIS data
- photos
- cross sections
- field mapping data etc.

Don't limit yourself by only considering data that is already in digital format. Historical borehole logs held in paper or pdf format can be easily transcribed into text based tables for input into Leapfrog Works, while scanned maps, aerial imagery and even geological cross sections can be georeferenced directly in 3D space in Leapfrog Works.



STEP 2 Data QAQC

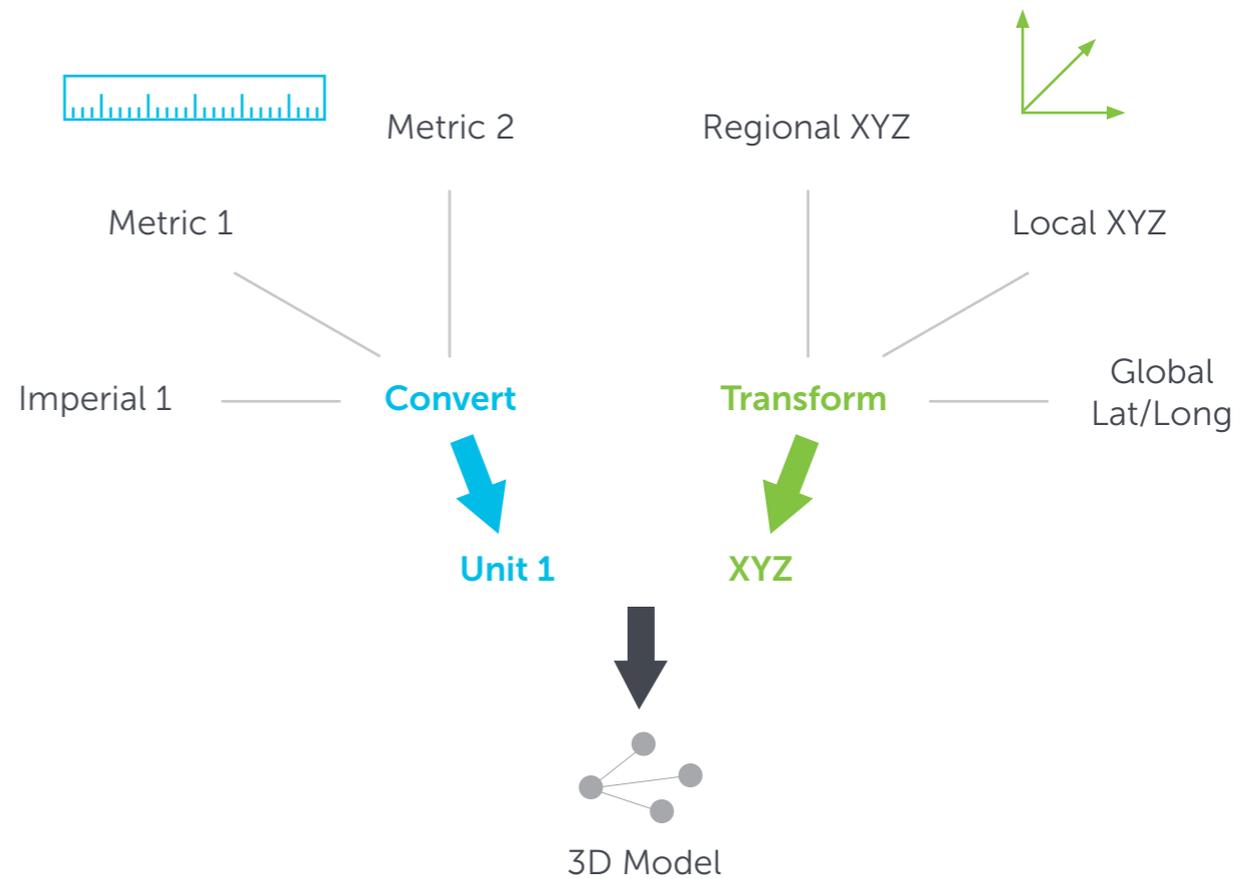
Now that you have gathered all the available data, it is time to ensure that the data you have is of the highest quality and can be reliably used to inform the model.

The key points you want to be paying attention to should include but are not limited to:

- **Recency of the data** - Are you using the most recent version of the data? If you're using historic data, is it still valid? Depending on potential differences between the recent and historic data, problems may arise when models are updated with the new data, if inconsistencies aren't identified prior the modelling is commenced.
- **Consistency** – Leapfrog Works requires that all input data is in consistent units and coordinate system, i.e. do not mix metric and imperial systems and be consistent in the units used (don't mix metres and millimetres), and ensure all of your data is referenced in the same XYZ based coordinate system.
- **Data verification** –It is always a good idea to verify the data you are using in your project with any available additional information, e.g. if you are working with borehole information, you could verify it by, tunnel wall mapping, geophysical data such as borehole geophysical survey or Ground Penetrating Radar data etc. This is especially important when working with historic data. Due to limitations in data acquisition methods available in the past, historic data may be less accurate and of lower quality compared to that collected using contemporary techniques.

TIP

Even though Leapfrog Works can detect errors in your data, we recommend you fix errors outside of Leapfrog Works in your database software for data integrity reasons. In cases where changes to an original dataset were made within Leapfrog Works, it is important to keep your master database up to date with any changes and use 'export changed fields' to extract data from Leapfrog Work, so it can be later uploaded into your database.



STEP 3 Preparing Data for Import

It is important to ensure that data is in a format supported by Leapfrog Works. There are many data types that can be imported into Leapfrog Works and the format will depend on the kind of object you are trying to import.



The Data game with Leapfrog Works

The data types that are typically incorporated into a Leapfrog Works model are illustrated in the 'Data Game' graphic on page 16. You can easily find the exact file formats supported by Leapfrog Works on our website at <http://www.leapfrog3d.com/products/leapfrog-works/specifications>, or simply search the Help for your format of interest.

Share interactive 3D views via the web

View is a web-based model sharing platform that allows you to visualise 3D models, share them with collaborators, and discuss the data all in one online view.

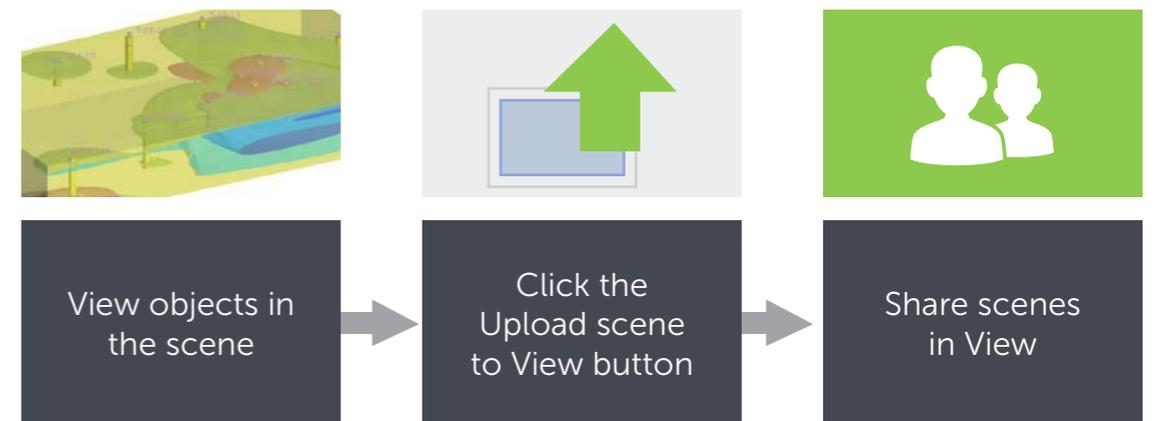
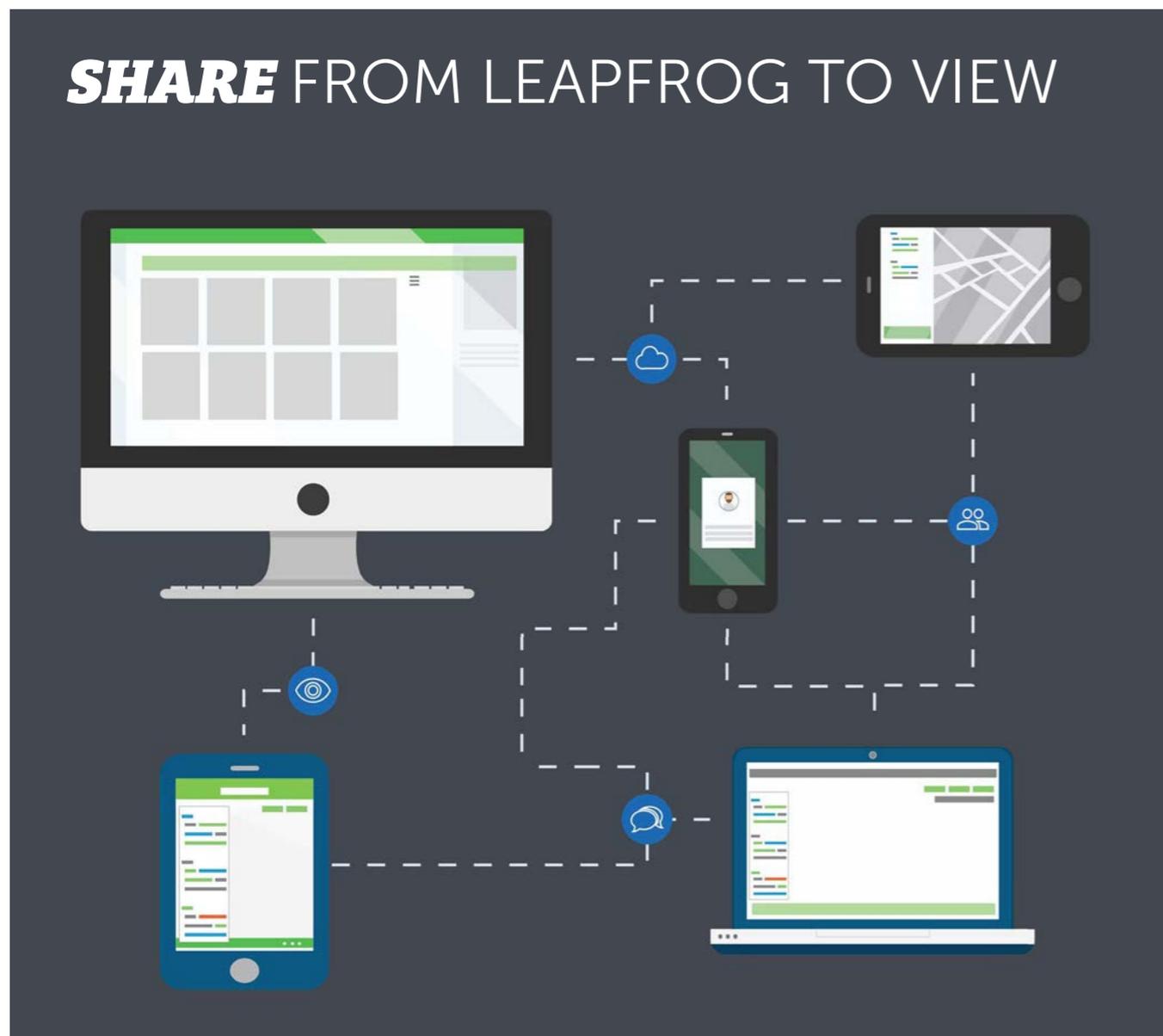
Efficiently share and discuss your models with your project lead, your client, your contractor or any other stakeholders, using View.

Scenes from Leapfrog Works can be uploaded to View for sharing with the click of a button.

Let's say you recently started work on a new project and wanted to share a preliminary model with a client to receive some initial feedback.

The client doesn't have access to Leapfrog Works but would still like to be able to interactively review the model.

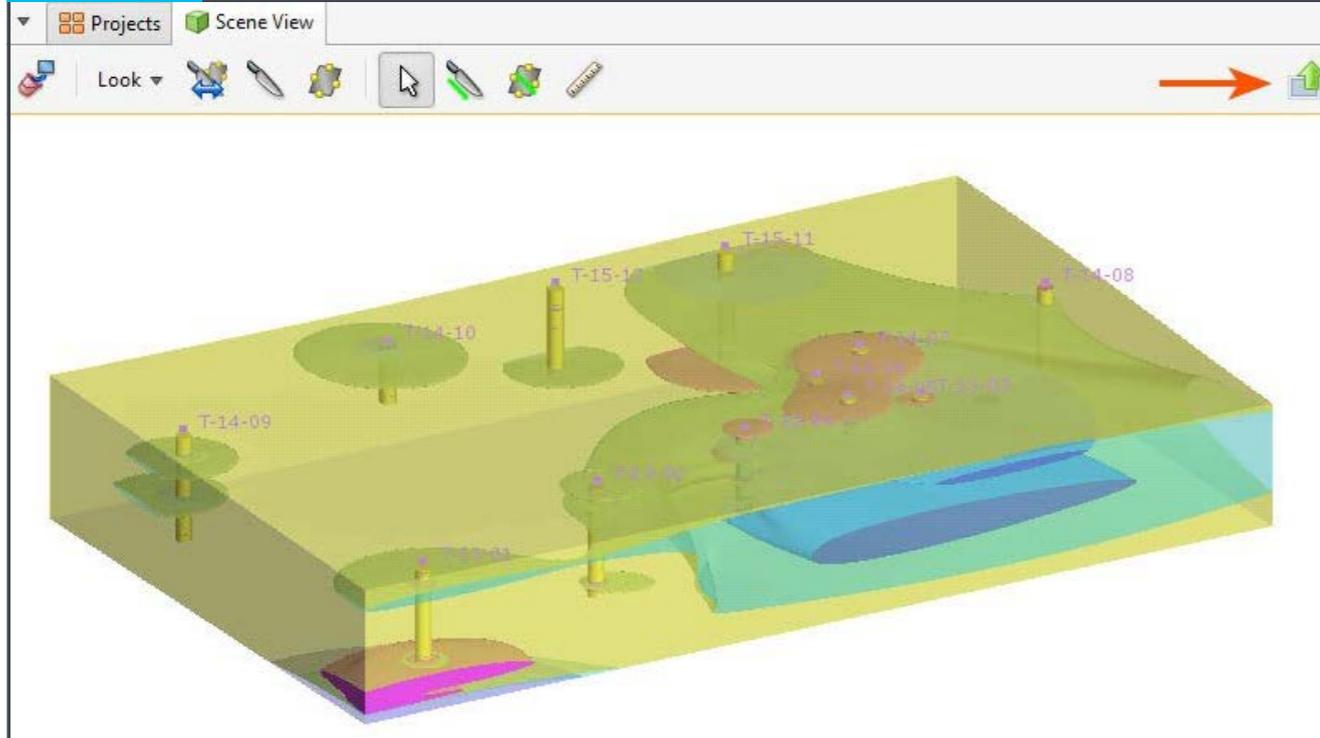
You can view all the pertinent objects in the scene window in Leapfrog Works and click the Upload to View button in the top right-hand corner of the scene.



To begin, ensure View is enabled (Settings > View > Enable View Integration)

STEP 1 View the objects you'd like to share in the scene.

STEP 2 Click the Upload scene to View button.



STEP 3 Ensure the objects you wish to upload are selected and give the scene a title and meaningful description.

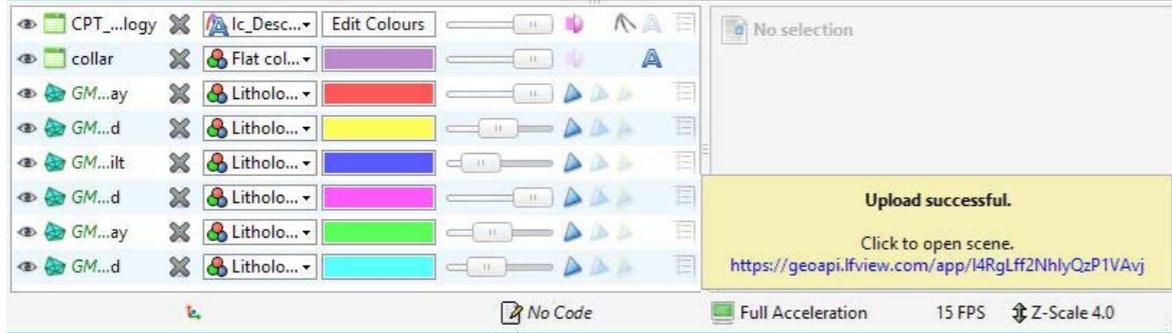
Upload to View ✕

Objects	Size
<ul style="list-style-type: none"> ▼ Borehole Data <ul style="list-style-type: none"> ▼ Boreholes <ul style="list-style-type: none"> <input checked="" type="checkbox"/> collar 0.00MB <input checked="" type="checkbox"/> CPT_geotech_lithology 0.02MB ▼ Geological Models <ul style="list-style-type: none"> ▼ GM <ul style="list-style-type: none"> ▼ Output Volumes <ul style="list-style-type: none"> <input checked="" type="checkbox"/> GM: Sands - clean sand 2.47MB <input checked="" type="checkbox"/> GM: Clay - silty clay to clay 0.11MB <input checked="" type="checkbox"/> GM: Silt mixtures - clayey silt to silty clay 1.57MB <input checked="" type="checkbox"/> GM: Sand mixtures - silty sand to sandy silt 5.95MB <input checked="" type="checkbox"/> GM: Silty sand 8.00MB <input checked="" type="checkbox"/> GM: Gravelly sand to dense sand 4.88MB 	
<p>Totals: 9 objects (maximum 100) 23.00MB (maximum 100MB)</p>	
<p>Title: <input type="text" value="CPT Data Model"/></p>	
<p>Description: <input type="text" value="First draft geological model from CPT data"/></p>	
<p>Signed in as: lana.strato@gmail.com</p>	
<input type="button" value="Help"/>	<input type="button" value="Cancel"/> <input type="button" value="Upload"/>

STEP 4 Click Upload and your scene will be uploaded to View.

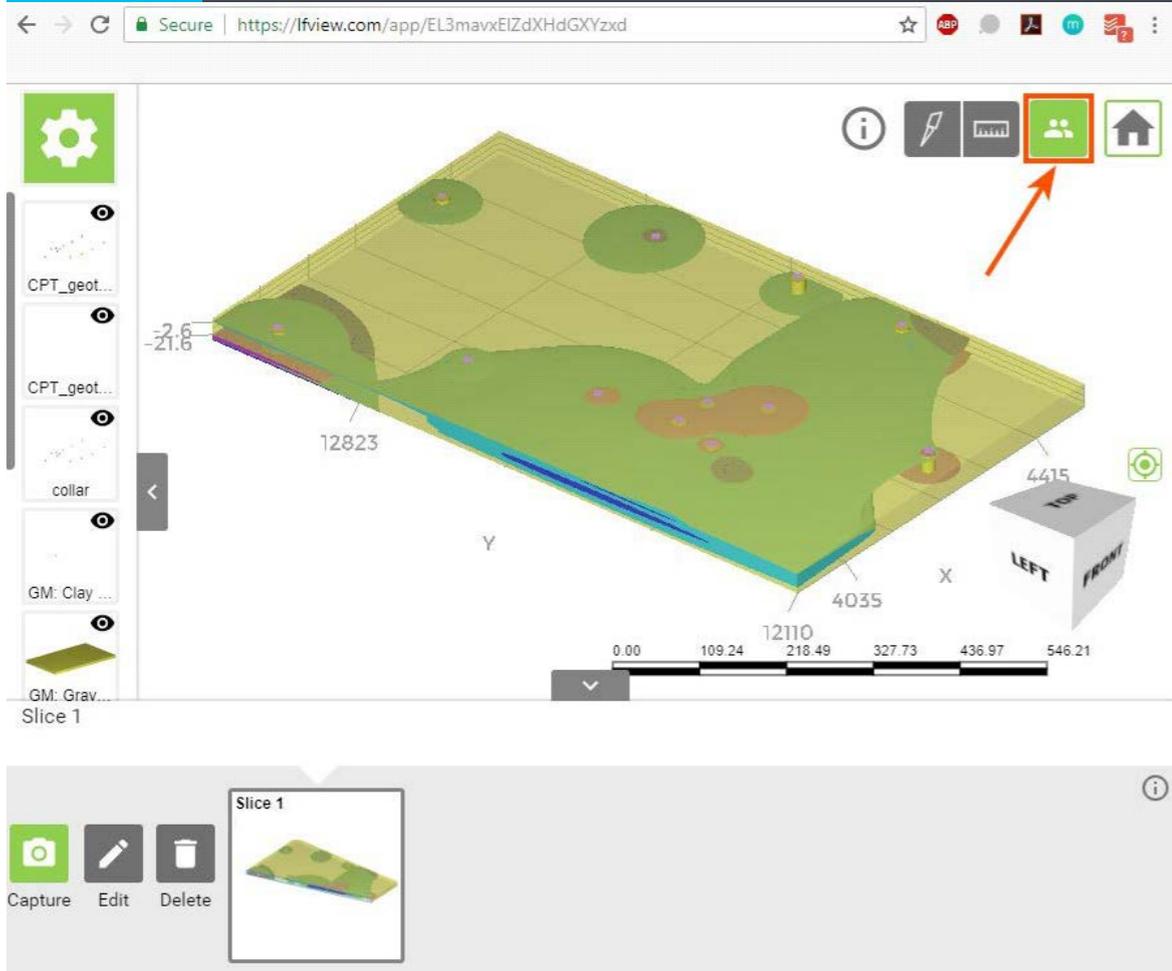
To begin, ensure View is enabled (Settings > View > Enable View Integration)

STEP 5 Click the link that appears in the lower right hand corner of the Leapfrog Works window or go straight to www.lfview.com

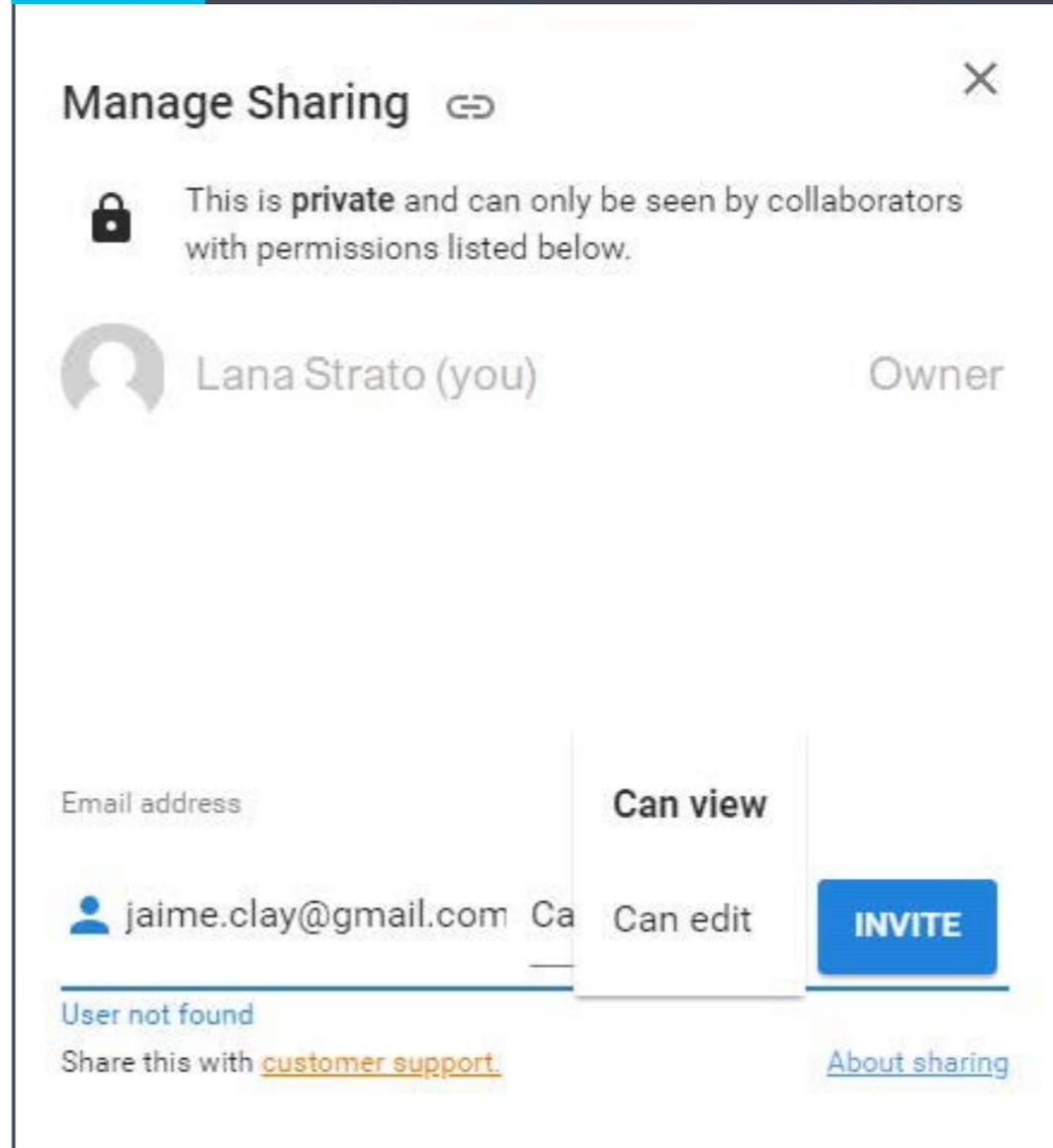


STEP 6 Review the scene in View.

STEP 7 Share your scene by clicking the Share button.



STEP 8 Invite users to either view or edit the scene.



Learn more about sharing you models with LF View - <https://lfview.com/demo>

If you have feedback, questions or any thoughts on what you'd like us to cover in future editions, please contact:

support.civil@leapfrog3d.com
leapfrog3d.com/works

COMPLEXITY TO CLARITY

Seequent is a global leader in the development of visual data science software and collaborative technologies.

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