Working THROUGH THE BARRIERS of 3D Laser Scanning Technology Using INNOVATION

A Problem to Solve

3D laser scanning technology is great, but it still has problems, and people tend to not like problems, as we know. However, I can't think of a job that does not have at its core a problem that needs to be solved. (Think about it, and if you come up with one send me a note: djohnson@sead.com)

It may seem strange that a couple of chemical engineers have devoted the last 8 years of their careers to the seemingly unrelated field of 3D laser scanning and people often wonder WHY we got into this. Our answer is simple—we believe we can develop a better way to solve problems.

I've always appreciated the quote "We haven't the money, so we've got to think," by Ernest Lord Rutherford, who was a physicist renowned for his brilliantly constructed (and cost effective) experiments. Rutherford proved that thinking saves money, but what drove him was his love of solving problems in more efficient and cost effective ways.

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Finding a problem to work on was pretty easy, nearly every design I was involved in as a chemical engineer required that new piping be integrated into an existing system. In most cases the cost associated with re-work and field fabrication consistently overshadowed other parts of the project. Hundreds of hours would be spent creating highly detailed piping isometric drawings only to have the words FIELD VERIFY stamped on every drawing. They were in essence a recommended routing with a bill of materials.

In 2000 I was introduced to 3D laser scanning and I immediately felt this had the potential to move the "FIELD VERIFY" step forward to before the Design Stage and certainly not after the construction had started. I was to become an "Early Adopter" of this powerful technology.

Early Adopter Pros and Cons Choices—Should We Stop or Become Innovators?

When you believe in a new technology and you have the resources and vision, you are willing to take on the pitfalls of early adoption. For 3D laser scanning, early adopters found the hardware and software to be expensive, slow and difficult to use. This limited the use to applications that could absorb the high costs while still realizing a good return on investment.

BY DARYL **JOHNSON**

For us it was the refining industry and although we had very successful projects, the "not so successful" projects were the result of attempting to trim costs and improve schedules by using less experienced people to turn as-found point cloud models into as-found CAD models for the project's design team to use. As long as the CAD models were good, everything went fine. One of the problems was that software and computing limitations kept the designers from being able to do their work in the point cloud and not working in the actual point cloud made QA/QC a big challenge, especially with tight schedules.

In 2007 we had a choice to make, either stop until these limitations were resolved or move from merely being early adopters to being innovators. We chose the latter, focusing on the software side while switching to FARO hardware as we felt they had the right corporate mindset to continue innovating on the scanner side while we innovated on the software side. As a side note. We were the first company to receive the Faro Focus3D 120 scanner in the USA. This scanner was innovation at its best!

Problems at the Edge—Where Innovation Started

In 2007, as we began to work directly with the raw scan data it became apparent that optical effects at the edges of scanned objects created mixed pixels that did not represent actual object surfaces. Not only did this make feature extractions, such as cylinder fits, more difficult and inconsistent, it added clutter and confusion for designers as they worked in the cloud.

We had to start at the foundational level of scan data, creating filters to resolve the "Problems at the Edge" which in turn helped as we began to

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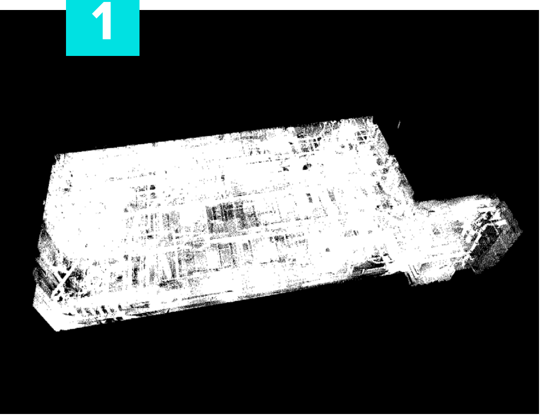

First, start with registered point cloud data. It is typically difficult to identify and to locate specific piping or equipment in what we refer to as "THE BLOB"

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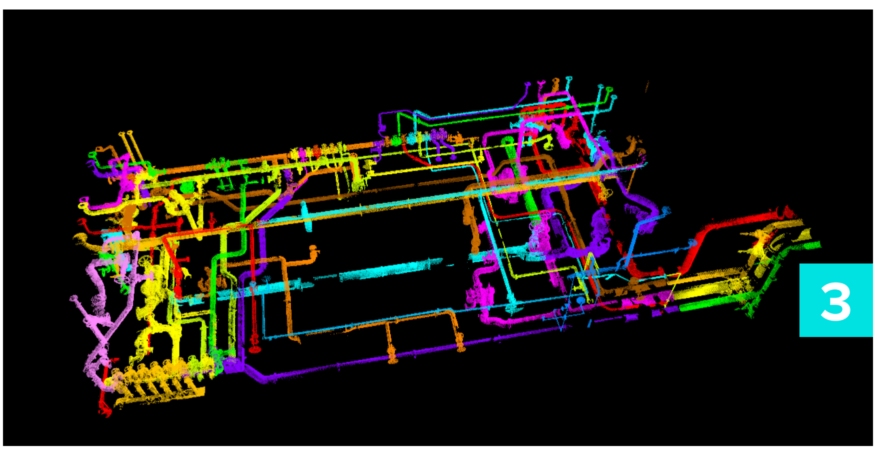
The systems of interest are isolated as point cloud vertex groups and can be tagged with identifiers such as line numbers and brought into programs like Navisworks. Background and routing information remains available to designers.



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The isolated piping systems can be viewed without the surrounding data. The layered and decluttered 3D Point Cloud model makes it easier to visualize, define and confirm scope. The tagged vertex groups can also be linked to scheduling programs like Primavera. There is no CAD modeling done at this point.

develop software solutions so that our CAD designers could work directly in the point cloud model. (It should be noted that since this point in history the scanner vendors have greatly improved their own mixed pixel filtering.)

In the earlier days of 3D laser scanning it was common for laser scanning software to generate intermediate models from the scan data which could be then loaded into CAD, but without the scan data. Such models could be subject to interpretation and simplification by the modeler who was often not a designer.

As a result, we had learned (the hard way) that the further the designer was removed from the point cloud data, the more likely simple, yet costly, design mistakes would be made. To allow the designer to work in the cloud we needed to have data sets that AutoCAD could handle. We also needed a way for our clients to direct their project scope AND to see the progress of the design efforts.

So we developed algorithms to efficiently isolate (or segment and classify) individual items and piping systems into isolated vertex groups thus separating the point cloud model into individual layers where they could be brought into AutoCAD and visualized in Navisworks without bogging down the computers to an un-workable point.

This was especially helpful in removing items that were to be demolished, as not only would we show the DEMO scope, we could remove it from the scan data so it did not interfere with the CAD models of the new design.

Figures 1–5 show how isolations help on a typical piping project.

We Still Needed a Coherent Solution

But even with these options the designers were still tracing and eyeballing the new design over the scan data. We needed algorithms to give the designers consistent, statistically valid feature extractions from the point cloud models. We called these feature extractions "Basic Modeled Parts" or BMPs which included such things as cylinder fits and pipe centerlines. These BMPs provided "snap to points" in AutoCAD. In addition we found that loading high resolution "corridors" or volume boxes of specific areas within the point cloud model provided designers with the detail they needed to "thread the needle" on tight pipe routings while at the same time maintaining reasonable stability and performance speeds of the CAD system. These software innovations provided Summit Engineering and Design a much needed, coherent, consistent, practical solution to a barrier

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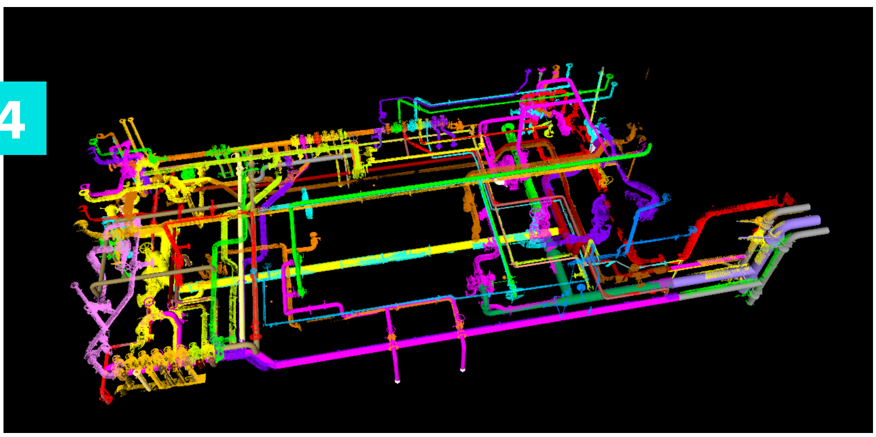

Relevant systems are modeled as needed. Background data remains available for routing and clash detection purposes. Point cloud data is used instead of modeling for those systems not requiring fabrication, such as systems to be demolished or unaltered systems.

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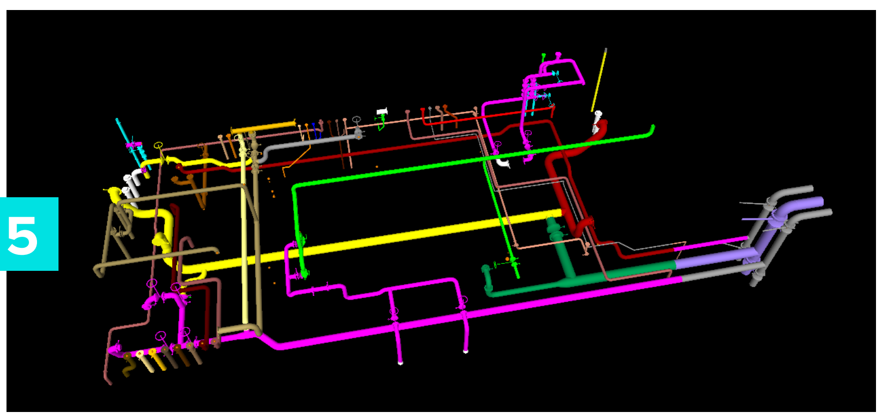


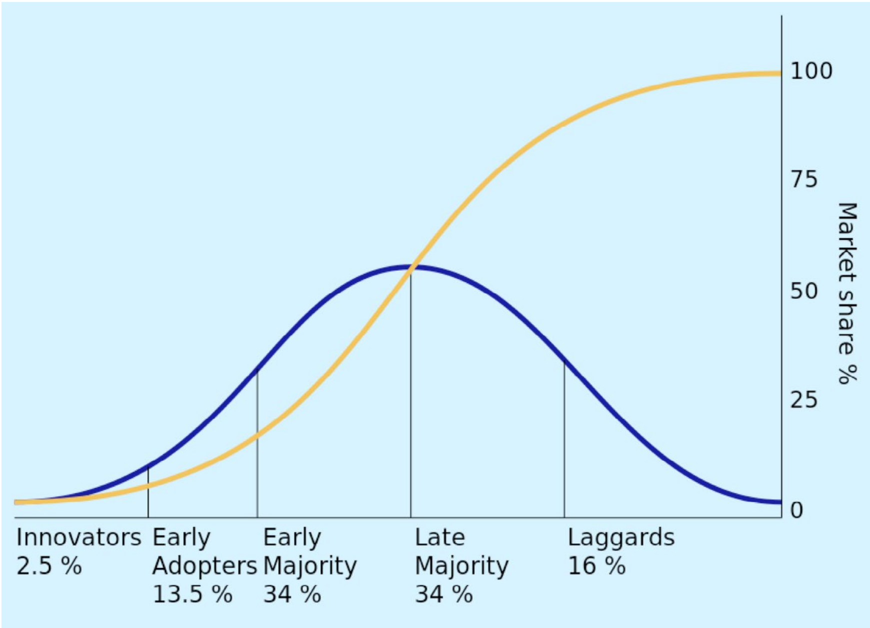
The new systems are modeled in 3D using CAD programs like AutoCAD Plant 3D. Fabrication ISOs can be generated from these smart models.

that limited the effective use of the extremely powerful technology of 3D laser scanning.

Taking Innovation Into the Mainstream

As a relatively new technology, how is 3D Laser Scanning doing in overcoming the barriers to going mainstream? Although the percentages will vary, the following "Diffusion of Innovations" curve is widely accepted as representative of how new technology spreads.

Although we have a long way to go, it's great to see 3D laser scanning beginning to move into the mainstream. The innovators are providing more cost effective solutions and the early adopters are providing much needed capital and product feedback. So what will it take for the early majority to step in and take this technology into the mainstream?



The diffusion of innovations according to Rogers. With successive groups of consumers adopting the new technology (shown in blue), its market share (yellow) will eventually reach the saturation level. The curve is broken into sections of types of adopters.

Hardware

Although laser scanners have become much more cost effective and easy to use it is still the early adopters who are buying most of the scanners. The fact is the actual scanning really isn't a very big part of the project costs. In fact, for remote scanning projects the travel costs are often equal to or exceed the cost of scanning. The more mainstream the scanners become the more owners and clients will have their own scanners ready to scan areas of interest, like they currently use digital cameras. By the way, when did you buy your first digital camera? Were you an early adopter (20 years ago) or a laggard? (you have one, but it's part of your phone and you don't know how to use it)

Computing Power

We can always use more computing power but fortunately, thanks to gamers, computing power improves on a daily basis so we just get to go along for the ride on this one!

Software

Visualization software such as Autodesk Navisworks™ and ReCap™, Bentley Pointools™, Aveva LFM Server™ and others have greatly improved the ability of project managers and team members to visualize and work within the 3D point cloud models.

Feature extraction software has grown considerably over the last few years and is available from such companies as Kubit™, Innovmetric™, Edgewise™, Aveva LFM, Inovx™ and Kohera3D Piping™, to name a few. Improvements in functionality, ease of use, platform compatibility (way to go ASTM E57!) and price points are moving the technology further into the mainstream.

The Final Hurdle

Okay, this isn't actually the final hurdle but it seems like a good way to wrap up this article. One of the biggest hurdles we need to work on as innovators and early adopters is our propensity to Over Promise and Under Deliver on the cost, application and problem solving capabilities of 3D laser scanning technology. We need to ask a lot of questions and understand the business case for the scanning. The more we understand our clients and the more they understand the value and the true cost the more 3D laser scanning will move into the mainstream.

Daryl Johnson has over 30 years of management, engineering and design experience in the refining, power, marine, process and integrated chip industry. He started Summit Engineering and Design, LLC in 1998 and was first introduced to 3D laser scanning in 2001.