Introduction: A 21st century approach to land surveying

To understand why land surveying office technology and practices can advance today instead of the past few decades, a lesson is needed about the history of surveying technology flaws that have stagnated progress.

Much of today's land measurements is not based upon the 100 foot tape, but the 66 foot surveyor's chain, commonly used in the 1700's. Land sections and their breakdowns were divisible by 66.

Many street right-of-ways that cities use today are 66' wide, the only logic being the stretch of a measuring device that has not been used for over a century, a distance determined hundreds of years before the invention of the automobile.

It is this type of logic, or lack of, to hold onto an obsolete measurement, concept, or mathematical model that prevents progress in our land based systems from surveying to community design.

Until recent history, there was little progress in surveying instrumentation.

In October 1970, Hewlett Packard introduced their 30lb (with power pack) Model 3800 EDM (Electronic Distance Measuring) reigning in a new era of technology for land surveying. In the early days I can remember many comments from surveyors distrusting electronic replacement of the metal surveyors tape. Yet, by the mid 1980' most had been won over, if anything simply to be competitive.

For the next three decades progress in office and field technology advanced so quickly that upgrading software and hardware every two or three years became mandatory just to keep up with competition. Investment in re-training time and money to keep one step ahead of obsolescence was significant.

As the founder of Land Innovation software it was embarrassing to display the latest hardware every year that was twice as fast as last years for the same or less cost when past customers attended demonstrations. Surveyor's investments in those days paved the way to the more affordable and more powerful technology today.

However, this past decade's computer technology (hardware and software) progress has not been significant, and we have heard many who use CAD for surveying and engineering complain that each update seems to be a step backwards. This de-stabilization of technology has brought significant disadvantages for the land surveyor and their clients.

This article series will address disadvantages, and provide an insight how they will be solved over the next few years.

The basis of improving an industry must start with the end user – in this case the customers hiring land surveyors. Nearly everything we can buy is significantly better than the past, yet the deliverables (the survey plan) is virtually identical in look and information as if they were done in 1954, or for that matter, 1914. Advancing land surveying requires a fresh look at what the client receives (deliverables).

The Surveyor's Client

A home buyer mandated to get a property survey as a requirement for their mortgage is not likely to care about the completeness or quality of the lot survey. However, the purchaser of any major real estate will benefit from having more complete information than typical of land surveying drawing 'minimums'.

The designer (planner, architect, or engineer) and GIS end user will all benefit by going beyond the expected surveying or deliverable product (expected plan). The developer who hires a land surveyor to subdivide their property places their success or failure on the shoulders of that land surveyor. The land plan is essentially the developers business model, thus a flawed (cookie-cutter) plan risks their success.

Advancing land surveying is simple: serve your end users – your customers better. Without fully grasping the problems facing todays surveying community, it is difficult to improve it. The roadblocks to progress can be broken down into the following categories:

- Technological barriers
- Human factors
- Industry limitations

Technology – Past and Present:

Software for land surveyors produced spectacular gains as well as failures. The surveying software industry has had many leaders that have toppled because of bad business decisions or complacency.

The number of companies who built this industry and failed, sold out, or may be still operating (but barely), is amazing considering how small the market is for this type of technology.

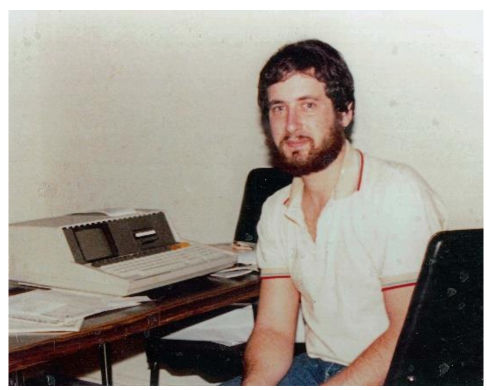
Software suppliers who did not continually improve their offerings welcomed others to take over their customer base. There are basically two era's for land surveying software – B.C. or 'Before CAD' and A.D. – or 'Automated Drafting'.

BC:

This era was dependent upon industry hardware leaders such as Ollivetti, Wang, and Hewlett Packard with either CPM or HP-Basic operating systems. Hewlett Packard was the only hardware company who survived this early era. Software leaders were HP, Hasp, Holguin, PacSoft, CivilSoft and the company I founded, Land Innovation. Software firms supplying land surveying solutions had to develop their own drafting abilities, or simply not offer any automated drafting. All of these early systems 'drawings' were derived directly from computed coordinates. It was this era that brought about the 'point number' based coordinate geometry used in today's software and field equipment.

Before this era land surveying had no 'point numbers'. In the early days of computers, packaged software was so rare that computers were often delivered with manuals on how to write software programs. Those using computers in the mid to late 1970's often had a good understanding on the basics of programming.

In the mid-1970's 'COGO' was the buzzword to describe a new era of surveying programs, however, the term COGO was for a specific way to program coordinate geometry. Early computers barely had enough memory to handle but just several hundred lines of code and none to save significant data. Thus, the technician still had to hand key in the northing and easting digits of a coordinate, or about 20 keystrokes - each subject to human error. It was not until the late 1970's that the strongest commercially available computers could store enough data to reference each northing and easting as a point number. One of the earliest point number based computer software I had the pleasure to use in the mid 1970's was developed by Hewlett Packard, which saved points in 50 block segments on a tape. Computing between point 1 and 20 was instant, but between 20 and 52, the painfully slow tape would whirl away.



By the time I had offered my first software in the late 70's called HP-85 CivilSoft (later renamed Site Computation because there was another 'CivilSoft' firm) there was enough internal memory to save 9,999 points and several thousand drawing 'figures' without having to access a tape. Using internal memory provided a significant speed advantage over the competition. Another unique aspect of the HP-85 software was that it could accurately, or accurately enough, plot an entire large drawing automatically by using the HP-85's built-in 4" wide thermal printer (as seen in this picture). While slow, a large plot could be printed overnight. The end user would come in the morning to find a pile of thermal paper with 'cut-lines' that could be carefully taped together for a draftsman to trace over, eliminating the need to invest in a drafting plotter, which in those days were prohibitively expensive. The above picture shows me developing the software on my kitchen table in the Dallas apartment I rented in the late 1970's.

AD:

At the beginning of the 1980's specialized hardware and software reigned supreme for surveying applications. Hewlett Packard who revolutionized surveying technology sold out to Wild Instruments, and afterwards formed a two decade long collaborative relationship with Land Innovation which kept HP at the forefront of office technology advancements, and our firm in the lead for software innovation.

Shortly after the start of the 1980's a new era was brought about by the IBM PC, and DOS (disk operating system). In 1984, when introduced, AutoCAD failed to make an impact on land surveying but slowly infiltrated the industry, as software suppliers serving surveying slowly migrated to AutoCAD as the demand for surveys being delivered to architects and planners in their unique data (DXF and DWG) structure grew. Many competitors in the software industry no longer wanted to write a 'drafting software' to tie into their geometry interfaces, and sought out CAD to make their software writing much easier. Those who chose to still write their own 'drafting' had to 'plot' as good or better than AutoCAD's continual advancements to compete, a significant time and financial commitment.

Those who depended upon a CAD vendor to supply their drafting needs (AutoCAD, Intergraph or others) brought about new software companies such as DCA, Eagle Point, Carlson, and many more.

Two camps were formed

In Camp A, software suppliers refused to separate the coordinate geometry and drafting with today's survivors being Traverse PC, SiteComp, and LandMentor (developed by founders of Land Innovation).

Camp B comprises of software dependent upon a third party CAD system such as AutoDESK, Bentley, Intergraph and others which comprise the vast majority of today's land surveyor software users.

From a pure business perspective, Camp B software suppliers require a CAD system to operate and yet invest enormous time and energy to develop products that compete directly with those already offered from the major CAD suppliers they must depend upon! While seemingly a dumb business move to rely on a vendor who is your direct competition, it's not too much different than one automotive company using another's major parts or technology to reduce economic burdens of bringing a product to market. However, any change in data structure means complete software retooling causing significant delays and expense with the likelihood of new bugs needing to be discovered.

To many, software is a voodoo science, so it is easier to explain how software works compared to our physical world. The least number of steps, the greater the potential of the software. To visualize this, think of a mechanical device. The simple on-off device has a single lever that when flipped completes the circuit and allows energy to pass through it in one step. This is what software in Camp A does by deriving the drawing from the base coordinates. A complex switch where flipping a lever pushes a rod that presses against another lever that completes the circuit is how Camp B works by separating the coordinate geometry and drafting data structures. As an example, this is why Camp B requires tract areas to be manually defined by polylines, thus increasing user's burden and potential for errors. As a general rule the more complex the data structures, the more cumbersome, slow, and complex the software.

For land surveying it is particularly problematic because of the point description…

The CAD coordinate is in an X (easting), Y (northing) and Z (elevation) format. There is no internal data structure for what that location represents (the description). Airplane wings, a floor plan, or a 3D detail of a bracket need not describe points like 'found iron rod', 'Top of Curb', 'cl road', or 'building corner'. Another important factor in the difference between Camp 'A' and Camp 'B' software development is that in CAD based systems, there are two and three dimensional data structures – in coordinate geometry based systems, all coordinates are three dimensional, thus no reason to have special data structures.

Nor does a draftsman who draws airplane wings, a floor plan, and a detail of a bracket (or for that matter a GIS map), need to certify the drawing for accuracy as does a land surveyor! Again Camp A software that derives the drawing from the three dimensional coordinates (that also include the point description) have greater potential for software simplicity and expansion of functionality than possible in Camp B. So how can CAD based software compute properly if CAD data contains no description, nor is the elevation internally guaranteed to exist? The answer is that it can't. This is the reason that CAD based software has to contain an entirely different data structure than the CAD (drawing) data to develop the surveying functions – typically 'blocks' of data (point number, northing, easting, elevation, and description) that must 'hook' onto the drawing's entity end or join. Sound complex? You betcha!

In Camp A, both SiteComp and LandMentor use CDIS (Coordinate Design & Information System) technology where land areas are named and derived by the lines and arcs created by the surveyed and computed coordinates. It was interesting that in a 2004 software review of SiteComp Survey by Joe Bell, the most powerful feature which was the precision parcel generation (and related reporting) that separates CDIS from CAD /GIS was not even mentioned!

Human factors – Past & Present

As noted above, in the review of SiteComp Survey, it's most valuable feature is the ability to generate land areas from the lines and arcs of the drawing which are created by the original surveyed points as well as precision computed coordinates reducing time and chance of mistakes. Yet Joe Bell, one of the most prolific reviewers of surveying software completely missed this critical feature! From Newton's law we know an object in motion stays in motion unless acted upon by force. Unfortunately our minds also work the same way, and when we have something so completely new, we tend to keep doing things the old way unless acted upon to be pushed into a new direction. Thus software provides a tool, but without the knowledge provided with that tool, we will continue to go down the exact same but wrong path. Imagine using a total station for the angles, but measuring all distances with a tape, it's that sort of analogy. Thus it is our past that can hold back future progress. New software MUST include the necessary training!

Years ago software was packaged with manuals on its use. Today, the manuals are on board in digital form (to save money) resulting in under-utilization or miss-use from the software user (you). For what land surveying software costs today, to package it without paper manuals and initial training video's is an insult to the customer but that is exactly how technology is delivered, except LandMentor.

Continuing on this 'thought in motion' theory, people also tend to think linear and apply one method we learn to other areas of daily tasks. For example, a surveyor who does property splits for farms who obtains work subdividing a 200 lot subdivision may think in similar terms both geometrically and in process of design. The 200 lot subdivision is likely to ignore or sacrifice vehicular and pedestrian connectivity (and curb appeal) in exchange for getting the design automated for faster turnaround, like a farm split.

Complacency is another roadblock to progress. Would you be upset if you discovered that $4,400 of the cost of your own home could have been eliminated because someone was complacent about the design of the neighborhood you purchased your house within? Recently we were contracted to design a small neighborhood in Texas that initially yielded 35 homes. We were directed to use a 0.6 acre minimum lot size. This was for an initial 'sketch' drawn before the site boundary was verified. After we received the correct information we were told that the lot minimum would be ½ acre outside any easements. The only easement was a 12' wide utility easement that paralleled the front lot line. We designed the site holding every lot exactly ½ acre to the edge of the easements and gained two lots over the original plan. The thought bothered me… wasn't I also supposed to hold 0.6 acre minimum? I E-Mailed the engineer to double check with them. They reiterated the minimum lot size would need to be 0.6 acres or 26,000 square feet. A 0.6 acre area is 26,136 square feet. Asking again for clarification, what came back was that the 0.6 acres was a 'general rule' as to easily factor in any excess from the 12' front yard easement! The large 'fudge factor' is because using their CAD based coordinate geometry it is quite cumbersome to develop lot areas, and to duplicate a net and gross area for each lot doubled their effort. Thus to save 'effort' the client would have lot two less lots (at $75,000 each) or every home would have increased the price of their lot by $4,400. The extra effort to work simultaneously in both gross and net lot areas did not add but 15 minutes to the total site plan production using a CDIS based technology ($10,000 a minute).

Adversity to technological change has not been a problem with land surveyors who historically have spent enormous amounts in both office and field technologies in relationship to what fees are charged. However, we have found servicing the industry for almost ½ century that engineers, planners, and architects are more adverse to investment and change, even though their clients would greatly benefit.

Industry limitations

Land surveying is but a single 'cog' in the transition from raw land to developed (and sold) property. When everything was hand drawn, planners and architects traced plans for their designs. Inaccurate drawings were the norm, with a high possibility of transposition errors, from field note entry to the last line drawn on a survey plan. Before CAD systems, there was no question as to the lack of accuracy of a land planner's and architect's drawings. CAD changed everything because it provided a common communication platform to share information – but did it? The problem arises that the common CAD platform which allows data to flow so easily can actually proliferate an enormous amount of bad data. Architects and planners using CAD think their work is accurate just because they are using CAD, yet as we all are too painfully aware, nothing is further than the truth. If that was not bad enough, the proliferation of GIS shape (often inaccurate) polygons, along with on-line mapping has made a bad situation terrible.

The public (average person – or your 'clientele') begins to wonder why land surveyors are needed! This miss information feeds upon itself deflating the importance of surveying.

Data overload is another problem

The other day I imported a survey CAD (.dwg) file into LandMentor which clones the CAD layers. There were over 700 layers, why so many? It was national standards! I can hardly remember 20 layers – how can anyone possible manage - 700? How much time is wasted in extra layer management which at the end of the day is pretty much meaningless for non-governmental work?

What about LiDar data? Remember when an on-ground topographic survey on 100 acres could be accurately represented with just a few hundred points? Now the same contours can be generated with a few hundred thousand points in the same space – ***but with less accuracy***… is that progress? Those few hundred surveyed ground shot points would locate top of curb and bottom with precision, now those several hundred thousand points taken every few feet diffuses the accuracy so details previously created with 1/1000th of the data is lost! It's a good thing today's computers can be bought with 2 terabytes of disk space – with LiDar you're going to need it. That speedy 4th Gen Intel I7 processor will stall quickly when trying to create a DTM of millions of unfiltered LiDar points. Have you noticed the jagged contour lines on the plans drawn using LiDar appearing as if someone on 'crack' drew the plan? Progress?

Intentional complexity is another huge problem

Imagine you have a product that the entire world has pretty much standardized upon saturating the marketplace. There are four main business models that assures software business to stay profitable:

1. Continually improve your product to justify continual update income.
2. Force upgrades by making new versions incompatible with older version data structures.
3. Intentionally making your product complex, cumbersome, and difficult to learn and use.
4. Stop selling a software product and instead force customers into a subscription model.

If you are reading this article, you most likely already have land surveying software – at least three of the four models will be familiar to you.

What if software was simple – eliminating complexity and long learning curves?

We are living in the 'smartphone' age where technology is more powerful yet easier than ever to use. We are entering a new era for land surveyors that solves many of the roadblocks to progress.

This article will explain what will be required to bring land surveying into the 21st century and beyond.

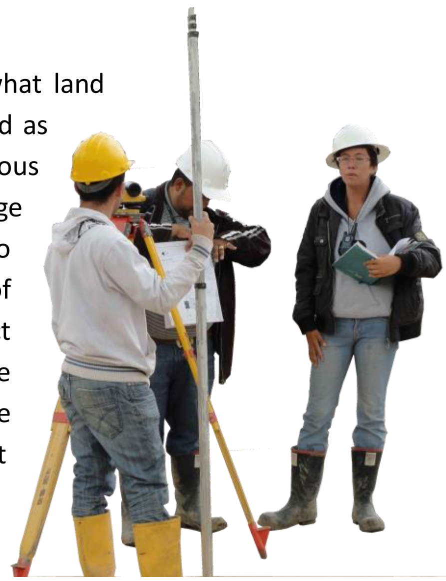
While concentrating more on the important human factors, it will address industry limitations and new technologies.

The 21st Century Land Surveyor:

After taking an afternoon nap, you wake up and discover the office is empty, but your co-workers clothes are piled up in their chairs. Panicked, you rush home dodging many others also looking for their families. Your home is empty with just piles of clothes where your wife and children were. The apocalypse arrived and you have been left behind. The good news is that all of the developer clients you wished you had were also left behind. You are the only land surveyor! Assuming this scenario is unlikely to happen, the reality is your businesses must compete to survive. To thrive you need to perform well above others.

If you have been in the land surveying business since the 1960's you may have likely lived through the greatest revolution in office and field technology in human history - unlikely to be repeated in the future. Change often coincides with introducing new forms of problems, some due to the use or misuse of technology, but most are human factors that can be solved.

The typical surveyor <u>client</u> has little or no understanding of exactly what land surveying actually does. People (clients) can relate to architecture, and as such Architects enjoy a respect of the public that is equaled only by religious leaders. Most of your builder and developer clients or city staff, are average people. They don't think of all the steps needed to go from field data to the survey plat. They cannot comprehend the complex tasks of determining a properties borders when neighboring survey plats conflict with the angles and distances from past surveys demanding that the surveyor need to determine the clients actual meets and bounds and solve these conflicts. This 'art' is unlike any other in the land development industry, yet all the client see's that same black and white paper plan they would have seen if it had been done a century earlier.



To prove the point that the average citizen does not understand 'land surveying issues', we look back to the days when GIS was first making inroads into city offices. By the late 1990's several GIS software vendors competed in this emerging market. There were competitors who had extremely accurate systems emulating land surveying coordinate geometry with precise areas (Land innovation, UltiMap, Intergraph etc.), and those that could only define a tract by a polygon (ESRI). If all land consisted of only straight lines, a polygon based solution would be sufficient, but our world includes curved streets and property lines. To influence a city to purchase a polygon solution was to convince the decision makers that maps could be quickly developed for now and fixed later on when accurate control was available. In the future when accurate 'corners' are located, the map could stretch (rubber sheeting) to those control points.

To the average decision making person it seemed logical that rubber sheeting would accurately correct the hand digitized map. *Yet rubber sheeting makes all data inaccurate!*

If the decision maker had knowledge of land surveying, it's more likely UltiMap, which was more 'parcel' based, would be today's GIS industry leader. That was over 20 years ago, and there has been change since then, *but not change favoring land surveyors*…

Recently I had the opportunity to be 'sold' on BIM (Building Information Modeling). The demonstrator (likely with an architectural background) demonstrated how a building designed in Tampa could be placed on a site in South Dakota for construction purposes. After showing me the architectural plans, he calls up a Google Earth tract of land in Sioux Falls to 'accurately' place the building on a tract. This was a professional person who clearly lacked knowledge of land surveying importance or accuracy. Yet his very job was to spread misinformation to other decision makers, several times daily, demonstrating the 'accuracy' of BIM using Google Earth information!

Even those people who understand online mapping is unreliable may think the cities GIS map replaces the need for a surveyor. Most of the digital data is easily available today via GIS online sources.

Land Surveying has always been the POB, 'Point of Beginning' on the process from conveyance of property to the last home sold. For the past two decades the surveying industry has been headed towards the POE ('Point of Ending') because of technical change.

To reverse this trend land surveyors must elevate their profession in the eyes of the average person and more important in the eyes of developers, architects, engineers, and planners. This demands an 'attitude' change not for them, but for you, the surveyor. This also requires an overhaul of our educational system. Land development has to be the most uncollaborative and dysfunctional industries of all.

A Land Development 'Common Knowledge Base'

Land surveying needs to be valued which means that an outreach to developers, architects, engineers and planners must be accomplished. Those professions need to be made aware of the critical importance of the accuracy and information derived from the land surveyors work (requiring a new standard for the deliverables). Schools that teach architecture, urban planning, and civil engineering and land surveying should also teach a 'common land development knowledge basis' for every student, and the professors need to encourage a new age of collaboration by having a at least a few common assignments. Collaboration begins at the educational level. The common knowledge base should include:

- ✓ Land surveying – how land is subdivided, and why on-line sources are not reliable.
- ✓ Basic civil engineering principals – drainage, utilities, street design, and site grading.
- ✓ Land development economics – rough construction costs, and the economic impact of waste through the process.
- ✓ The importance of accuracy – how inaccurate design increases workload or changes design elements when engineers and surveyors have to make bad data work.
- ✓ Environment – how land development can become more environmentally responsibe.
- ✓ Coordinate Geometry and DTM principals – using the tools to expedite the above goals.

Instead of learning the above values, what many have been taught is how to become a CAD or GIS technician (a more elegant term for 'draftsman') where the mechanics of going from raw dirt to developed city is the result of what the software developer allows the end user to (quickly) accomplish.

Schools have been creating a generation of robotic employees that might get hired because every employer uses the technology the students are being trained on. Sure they might get drafting jobs, but will not offer more value than the current multitude of potential employees already in the marketplace.

That stated, what if the students possessed skills, talents, and abilities above that of the norm which could help a consultants business grow and their client profit more? Certainly they would be hired and at better initial wages than the CAD/GIS user. Unfortunately today, this is not how schools operate, but should.

Elevating the Land Surveying Industry – it's in the Deliverables

How can Land Surveying progress in the eyes of the client when they get essentially the same looking drawing lacking critical decision making information than before automation? Simply - it can't.

In 2015, it is time to change the client's expectation of what a Land Surveyors deliverable is. CAD and their multitude of add-on vendors have promised a 3D world of images for well over two decade. When was the last time you used software for virtualization of your normal surveying tasks promised by the vendors you have been supporting this past two decades?

In a recent speech at the Arizona Planning Association 2014 Conference, we displayed a slide of a 3D site plan using an AutoCAD advertisement. In a room full of planners I asked if anyone had just once presented a 3D site plan – none ever had seen one presented in the city they worked in – including planners from large cities such as Phoenix and Tucson! Why? No land development client would be willing to spend the enormous investment in 3D. Thus the transition from 2D to 3D is overly complex and intentionally cumbersome to generate training and support income which encourages a profitable subscription model – for the vendor (but not you or your clients).

That black and white 'As Built' drawing you deliver to your clients– does it define every man-made hard surface and its impact? Does your client need all that data? Perhaps not, but what harm does it do to furnish more data than expected. Certainly you do not have the time or patience to create a CAD polyline to individually define each and every surface, but that is exactly the point – CAD technology has had its run for Land Surveying. It's now time to embrace a better core technology designed specifically for land development, not airplane wings, not car fender's, nor brackets for some mechanical device.

Perhaps because every time CAD's ability expands, it needs to tie into more separate data structures to expand its capabilities, and because land surveying is a miniscule market compared to the general industries CAD is used for, it's maxed out for land development and design purposes. A coordinate geometry core technology, as was originally commonplace for land based software system, possesses the abilities to simplify everything.

We live in a surface based world – not a linework world

Look around you what do you see? How many lines and arc's are around you? The world is made of surfaces not lines. Since the advent of communication, these surfaces were represented by lines and curved lines, for the most part in 2D on paper (or paper-like) deliverables.

When the surveyor delivered a paper survey plan to their client in 1914, the lines and arcs represented limits of property at a minimum, and more often what 'things' surrounded, abutted, and was within that property. In other words we deliver a representation of the owned surface and related surfaces (or objects, which contain 3D surfaces) that either effect ownership of items or potential conflicts. Not only has there been no change a century later – the drawing is virtually unchanged.

Yet the client see's not the work to create the 2D black & white drawing which is difficult for them to decipher, but only the drawing their grandfathers grandfather would have been satisfied with.

The future of Land Surveying depends upon technology that is surface based and includes a proper education in how to add value for clients. This requires a much easier way to define owned areas other than using manually entered 'polylines' to append on top of a CAD drawing to generate defined areas.

The Concept of Fused Corners

Why can't CAD or for that matter GIS easily generate exact area?

With CAD, each 'entity' is independent. Thus if 10 lines appear to join at a single location, there is actually 10 independent occurrences of the same (hopefully) point in memory – getting worse if curves are used. Thus, while a common point appears on the screen, there is none, and areas must have another way to be defined requiring a polyline or similar structure on top of what already exists.

In (ESRI based) GIS, all linework is exactly that – lines. Actually not lines but polylines which is a single entity that begins at one set of coordinates and ends at either the beginning coordinate (a closed parcel) or somewhere else. What about curves? There are none!

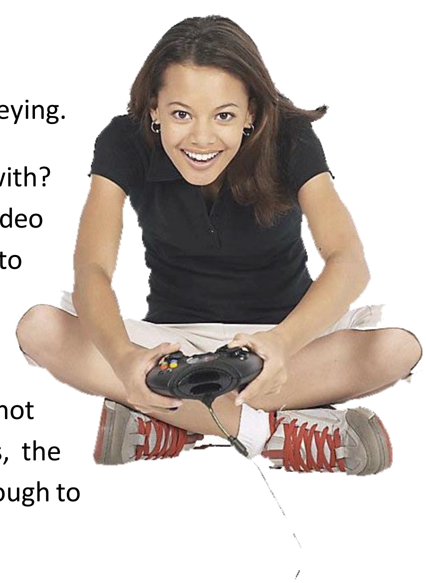
With CDIS technology, lines and curves are drawn to a single point in memory, somewhat 'fusing the corners' and eliminating the above restrictions. Different CDIS software uses various methods to define the individual point. For example, SiteComp software defines a specific point number to a location. Thus the 10 lines extending from point '1024' intersect at the same location, essentially fusing lines and arcs – but only as long as that same location is not being used by more than one point number - something also commonplace and somewhat cumbersome to discover or fix.

LandMentor's patented CDIS software introduces a new way to look at coordinate geometry – not by point number, but by a single location on earth. Doing away with a point number dependent coordinate geometry system eliminates the problem stacking point numbers being used for the same location.

Whether a point number or positional based fusing of linework, once each corner is defined by a single location, the ability to quickly develop precision spatial data structures is a simple programming exercise. A simple user interface (more on that later) makes the creation of 'surface' based intelligence a by-product of the normal workflow, eliminating the tediousness of CAD area generation.

This new form of geometry would have been impossible to develop just a decade ago. It was not until computers were fast enough to run through every coordinate in memory to determine if that location was unique that a 'positional' based coordinate geometry was possible. Creating such a technology was thought of decades ago, but not possible until recently (circa 2005), but even then, limited to somewhat small sets of coordinates. This timing of increased computer capacity also coincided with another speed dependent technology to replace CAD's complex and cumbersome 3D – Video Gaming.

The Future Land Surveyor / Gamer



It is no secret that young people are not filling enough roles in land surveying.

What technology is every young (even middle age) person familiar with? Video Games. What technology are your clients likely to be using? Video Games. What can replace 3D CAD technology that can take months to learn and years to master? Video Games.

What gives this Video Gaming technology its speed? Mathematical processes with integer based mathematics, thus Video Gaming is not accurate enough for the demands of engineering or surveying. Thus, the powerful Video Games software engines are not sufficiently accurate enough to be used for land development calculations.

But for the deliverables to the client –who cares?

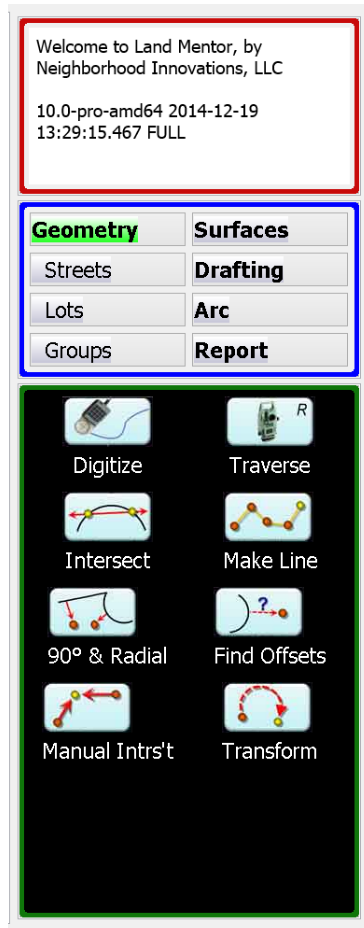
It is likely that 2D plan delivery will remain the norm, but also providing the client with a virtual file (and free software downloads) to view the site survey (existing or peek into the proposed future) using Video Gaming will certainly be valued.

The ability to pull this off without adding to the time to compute and deliver the information (compared to existing CAD technology) requires a level of automation much greater than has ever been accomplished before in land surveying – or for that matter, any technical software.

A single bulldozer and backhoe can easily do the work in one day that it would take hundreds of workers with shovels. So how can we create a similar situation in the development of analytical and design coordinate geometry based software? In this case, speed = better quality, not just faster output.

To create more useable technology the software developer must simplify automation eliminating complexity – but also long learning curves (and potential training and support income). In the age of 'smart phone' simplicity, surveying software must also use the same level of elegant design.

This simplification also has the benefit of making land surveying easier to learn and understand to design professionals (i.e. architects and planners). When architects and planners understand the basics and needs of the land surveyors, they can also understand the importance of accuracy – breaking down the barriers to collaboration.



To develop a new form of user interface, we depended upon a focus group of beta users. Instead of using those within the land development profession, the beta group were waitresses, convenience store clerks, and janitors – seriously! This not only included software, but also the training to use the software and create higher standard of deliverables – from land survey plats to large scale development designs!

We began with a look at the early versions of PowerPoint, a software so easy to grasp most of the early users had no formal training. Not only what made it originally unusually intuitive, but what made it less intuitive and difficult at each update. The PowerPoint of today is more cumbersome and while more powerful, less likely to produce faster presentations.

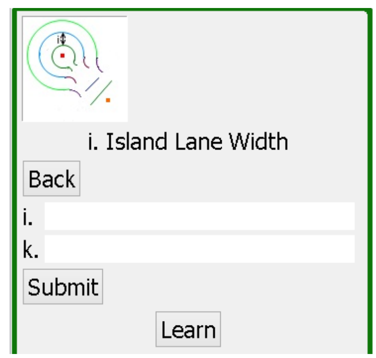
Thus, there is a need to balance power, with intuitiveness yet not introduce hand holding, that once learned becomes a burden to the advanced user. Another source of user 'irritation is excessive pop-ups – which are overused in software development. Software developers often think these are cool – they are not if excessive.

Another concern with today's software is the miniscule text of input and output. Sure if someone has eagle vision or is young and brought up with itsy bitsy letters and numbers they may be able to decipher what is on the screen, but the reality is most of us as we age have worse vision – not better.

It is critical in a working environment not to display information that is not clear and concise, nor too small to make out. Squinting as we work is not a desirable quality (unless intentional complexity is the business model of the software vendor).

It used to be that software had a screen location for input and output. Many CAD systems today vary where input and output of data occurs, which is especially cumbersome as displays get ever larger and resolution is higher. It is much easier for the user if there is one location for output.

While developing LandMentor we used 4 decades of software experience in supporting thousands of users in land surveying and design to anticipate user mistakes. A better user interface must analyze what has been entered and determine what mistake was made and if possible take corrective action to fix the mistake, warn what the mistake was, or prevent the data from being executed.



Another advancement to ease the use of software (patented) was the development of graphical interactive input and display areas. While intended for the new user to ease the learning process, these interactive interfaces also clarify what is being entered and what will happen next, all in a manner that will be appreciated by entry level and advanced users.

To solve industry problems is to simplify the terminology used in surveying and design with the development of the training to create a common knowledge base for architects, planners, surveyors and civil engineers.

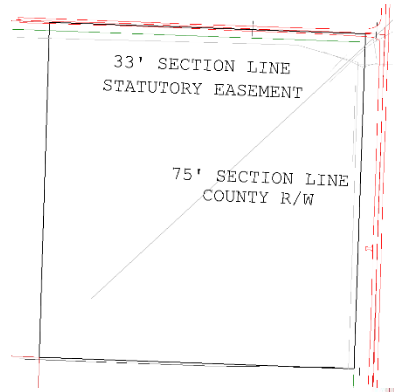
Lastly, the technology must be self-aware as to its intended use – thus automatically trapping and either preventing an error or at a minimum warning (if the error might be possible) of a problem. This would be impossible to create in CAD, because something allowed in the design of an airplane wing would not allowed in the geometrics of a land survey. Much of this automation is embedded within the ‘surface based’ geometry…

Surface Based Coordinate Geometry

The mention of positional coordinate geometry before, ultimately translates into a new way for land surveyors to think. Land Surveying is not about generating lines and arcs, but in fact about defining various physical surfaces (previously only delivered in the form of lines and arcs).

One reason that (ESRI) GIS data structures cannot be used for land surveying applications was mentioned before – no curves. The other reason is duplication of data. For every line or arc that defines parcel of land, another parcel abuts that line or arc. A ‘polyline (or polygon) based data structure requires a closed circuit, thus every adjoining ‘parcel’ duplicates the data along the adjoining line. There is not one line, but two. If a curve is defined by 40 points, (40 lines), an adjoining property will have the same data duplicated… maybe. There is no guarantee that adjoining properties are using the same data locations, especially if the original data was sourced from traced information.

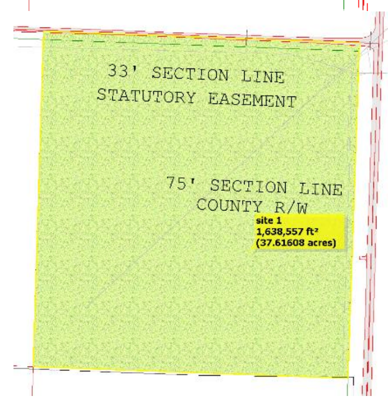
With CDIS, precision lines and arcs created directly from the coordinate geometry, the 'surface' can be used for a wide variety of purposes. In each update (iteration) of LandMentor the surface based geometrics offers endless growth of the core technology for land based functions – ultimately to obsolete current GIS systems as well.



Let's explore a site in Watford, North Dakota as delivered in CAD:

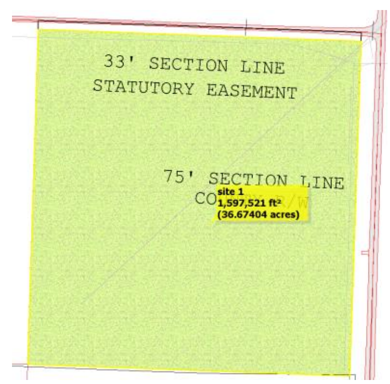
A client is in the process of purchasing '40' acres for residential development. From the linework shown (and interestingly not described in anyway other than being on a 'utility' layer), we can see limitations with the site.

Since we are using a CDIS based system, after importing the data, the corners are 'fused' (if there are no CAD based errors). We instantly create the first 'surface' by pointing within the 'closed' boundary and assign the name 'site' which has a green 'texture' to it:

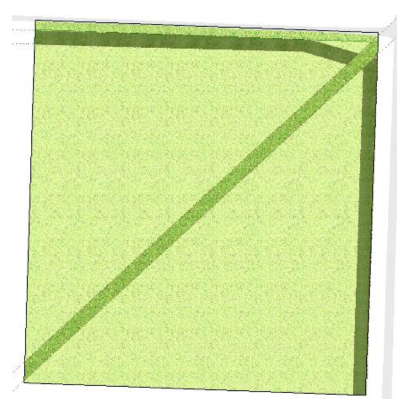


In LandMentor, the coordinates are to a 20 decimal place accuracy, so the 37.61608 acres is reliable, but only IF the original CAD linework matches the meets and bounds dimensions which is not always the case. This is because as mentioned before the drawing and the calculation data structures are separate. Thus in CDIS technoloy, the lineowrk still need to be checked to assure it's actually correct!

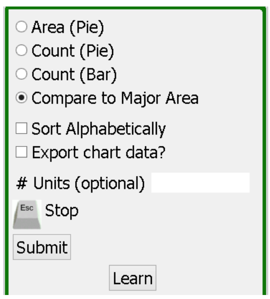
Right away we see that the client is not actually buying 40 acres. But also note that the site desicription goes to the centerline of a major street – or a statuatory easement – (essentially a right-of-way). The actual land the developer is buying is not 40 acres, but 36.67 acres. But still, not all of that land is useable because there are existing utilities crossing the properties meaning there must be easements. The land surveyors responsibility is to provide all information that has impact on the site – yet the client did not know enough to demand this information from the surveyor!



Easements limit the use of land. While not technically a Right-of-Way, these easements prevent full use of the property and the configuration can significantly restrict a design resulting in a loss of density. All of this takes away from the value of the land. But easement 'areas' are not a required information item on survey plats, and it's a good thing for CAD based survey software users because on complex sites, creating the descriptions can be a nightmarish and time consuming task. However, a CDIS based system simply defines the 'surface' by pointing inside a closed area, taking just a few seconds to complete.

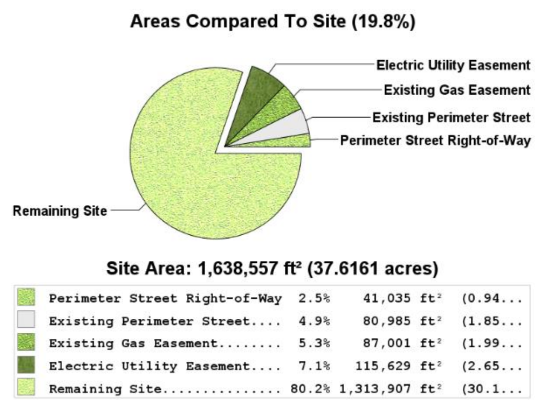


All that is required is to 'name' what the surface represents. For example, the land surface for the gas line is named as such. Once created it is then stored for use on any other future job. Each name is then associated with a color or texture. If the area closes then it is colored in with the associated color or texture. If the area does not close arrows will display on the screen showing where possible problems exist. Because all linework is developed directly from the coordinte geometry, the results are reliable. To develop a report on the impacts of the easements and right-of-ways, all is needed is to press the CHART button under a REPORTS button:



The charting function allows a graphical representation of a wide variety of relationships that can be computed from surface data. The default mode (not chosing any specific type of chart) is to go through all physical surfaces tagged as 'impervious' (manmade) and report the environmental and economic impact of land improvements (existing or proposed).

In this case we need to find out how much impact the easements have compared to the total site area…



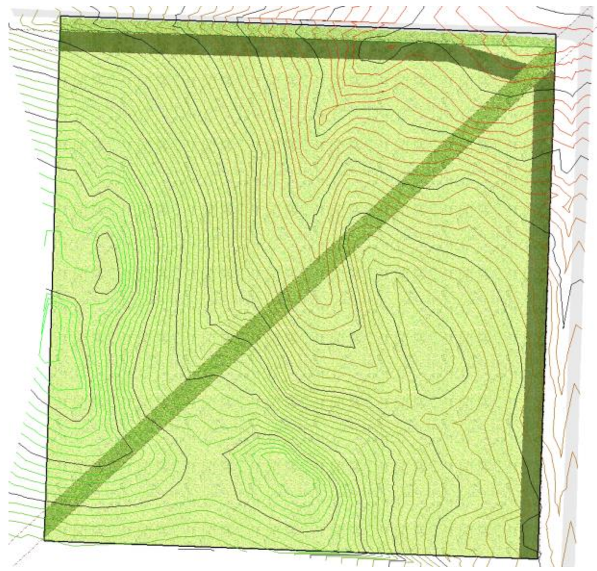
The client originally was told that there was 40 acres for sale. From the total gross land surface the chart shows that 37.61 acres is the total land for sale, but only 80.2% of that site (30.1 acres) is useable because of existing right-of-way and easements that negatively impact the use of the site.

The useable land is ¼ less area than the original 40 acre claim.

If the land was offered at $50,000 an acre and a land survey was not completed, the client would pay two million dollars for the property. The embellished information allows half a million dollars of negotiation!

Topography – The Contour of the Land

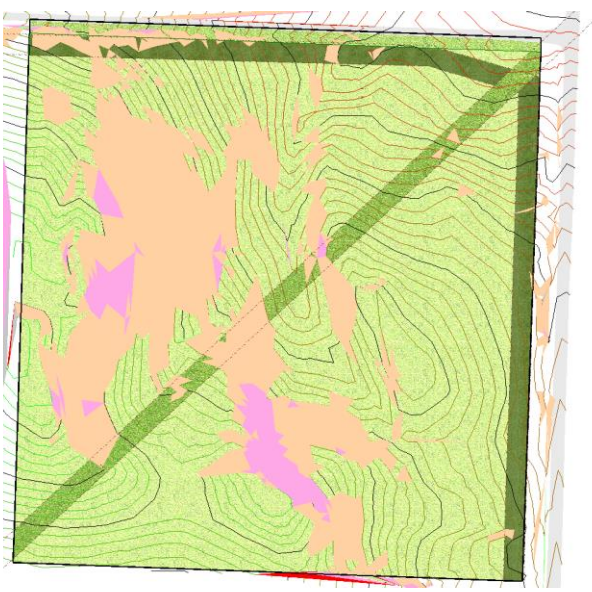
Unless you live on one of the few 'flat' ares of the country such as Houston, Texas, the remaining nation (world) can be adversly impacted by the natural terrain, and that is especially true of the above site located in the rolling hills of Watford.

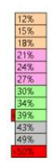


CAD is particularly problematic when dealing with topography as it introduces even more data structures on top of the already complex data structures required for land surveying applications.

From the above example there is half a million dollars in negotiating room before the client commits to the purchase, but there is more to this story…

… the contours shown are quite intense, but what does that mean in terms of site restrictions to the use of the land. In CAD, one must zoom in and read the elevations of the lines to determine what is uphill or downhill. With CDIS technology, red is low and green is high (redefinable for color blind users).

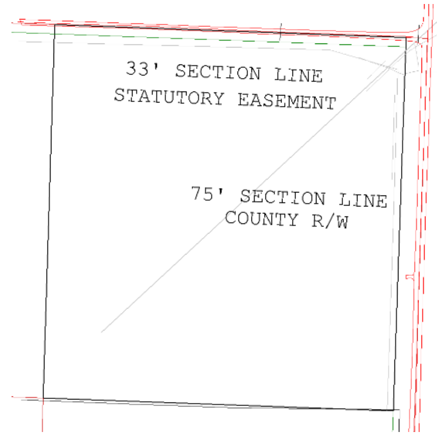




If the land is restricted by ordinance (or clients comfort level in building in slopes) to be undevelopable above 12% slope, then this slope study clearly shows that a large portion of the 'developable' land is not buildable.

Unlike easements which are exact, slope determination is only a good as the precision of the contour data (more on this later). While subjective, this image speaks for iteself when negotiating the land price, and if anything, can leverage the full half million dollar discount off the original asking value.

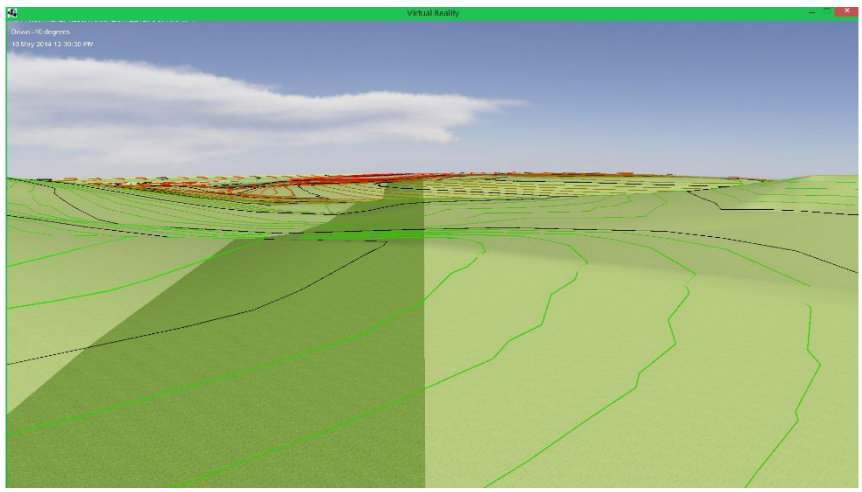
This is the original data furnished to the client by the land surveyor – not even showing the gross area of the land.



Even if the requsite information showed easement lines critical decision making information would have been missing. In 1915, when all data was hand calcualted with log tables, it was understandable. But this is 2015 – so why does land surveying still hold to standards centuries old?

By creating a new standard for deliverables, we arm the cleint with amunition for critical financial and environmental decisions.

This simplistic actual example on this small site clearly demonstrates the need to exceed expectations of what the land surveyor delivers to the client.



With one button press, in less than a minute, the surface data is draped over the digital terrain model (DTM) and transferred to the Video Gaming engine.

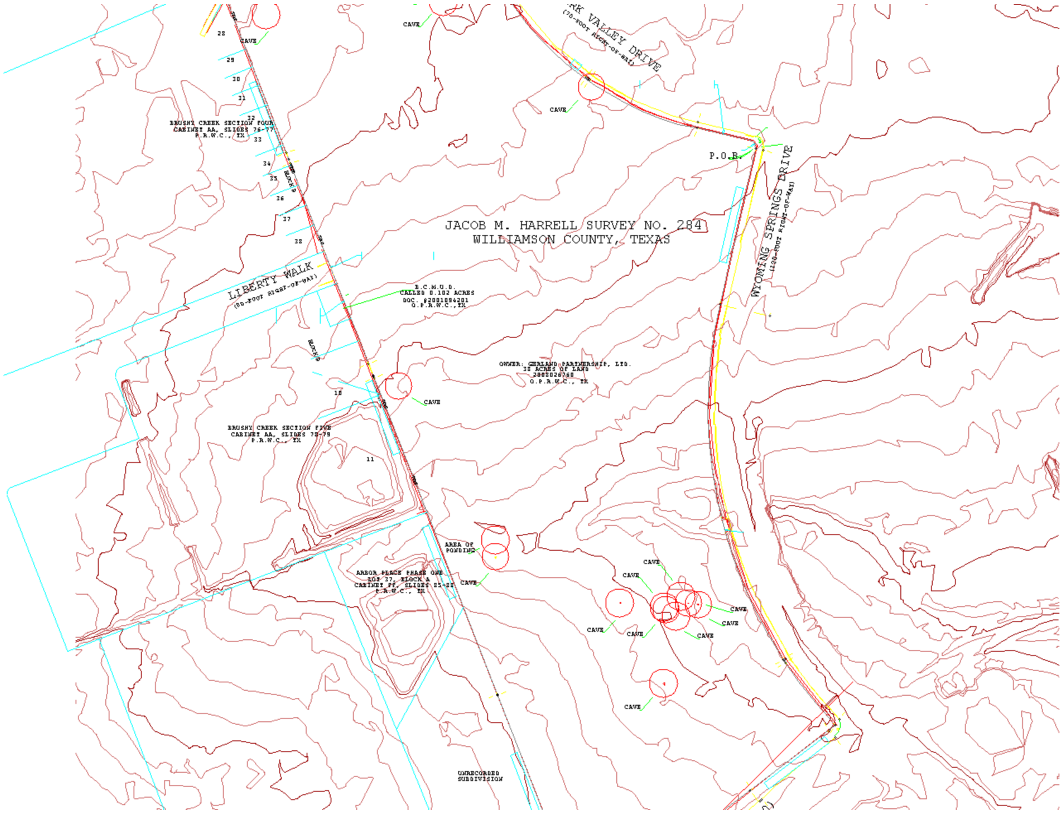
Not only does the client have the ammunition to renegotiate the 'value' of the land, but they have the tools to 'walk through' the site with the seller to demonstrate the limitations!

Solving Technological Topographic Problems

Since all CAD and GIS software is a compromise in the use of land based surveying and development design, the situation is almost out of control when it comes to the generation of topographic information. Again, this is an opportunity for land sureyors to effectively increase the importance (value) of their profession, but instead has let technology run amuck allowing the deflation value.

LiDar is one case that technology is ruining land surveying with data overload of vague information that is both misunderstood by those paying to access the data and for those providing this excessive information.

Again, CAD and GIS systems are already plagued with a core technology that is not tied to the coordinate geometry duplicates and adds complexity.



The above drawing shows contours that have been run through a 'filter' derived from LiDar. However, even filtered, there are over 43,000 points required to draw the contours. Had the data not been filtered there woud have been at least a quarter million points to show the exact same topography!

How do we know the data was derived by LiDar? The tell-tale signs are evident. The frantic zig-zag of the contour lines is common – which would not happen in nature, but is routine when software is overloaded with excessive data, as well as the lack of detail along the perimeter roads (lacking top of curb and gutter detail). An on the ground survey would have created a much higher degree of detail for engineering of the site with about 500 total points determined by on the ground by the land surveyor!

In other words, with about 0.2% of the unfiltered data of LiDar (or 1.1% of the filtered data), a land surveyor can deliver a much better plan with more useful information than the LiDar data.

Assuming that the information will be used eventually for some sort of design or site improvement, all of this excessive data will only serve to slow down all other processes, that is IF the CAD software can even handle that enormous amount of information! Any savings using LiDar is thrown out when ultimately the client pays for excess data (and user time).

While 43,000 points is certainly better than 250,000 it is still far too excessive for use in virtual reality applications. To further 'filter' the data to a more usable form takes time. This 'editing time' is ultimately charged to the client. In this example, the initial data is clipped to the area of the subject property, then manually filtered and edited to create a much more efficient base data without sacrificing the accuracy of the surface for planning and engineering.

The 250,000 points were filtered and delivered down to 43,000 points which in a few hours manually filtered down to just under 2,500 points (1% of the unfiltered LiDar data).

This essentially reduces the contours to emulate the land surveyors breakline data used in the design of the site delivered in less than a day's work using Landmentor as shown below.

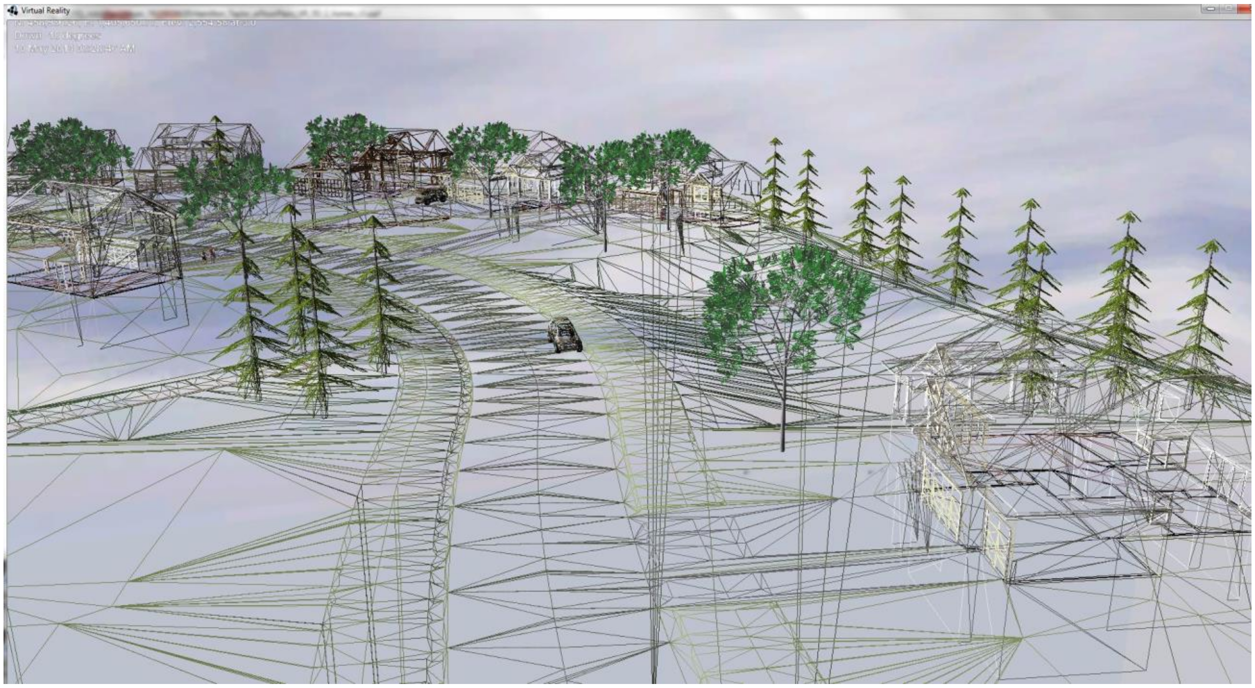
Again, LandMentor core technology changes the expectations of deliverables from the land surveyor.

Another example of needless data overload is in the misuse and understanding of digital terrain modeling when considering new 3D information. Keep in mind that all of the examples in this document are not from students, but large established consulting firms with great reputations hired by our clients to work with us in the land development process. Thus, every job introduces new CAD data that must be checked for errors. The examples we are using are not rare, but routine in the consulting industry. As part of our design services we require accurate boundary and topography before beginning any design – from a land surveyor. Anything less would be wasting our client's money and our time.

The LandMentor technology is intentionally designed to import 'all' of the CAD data and attempt to fuse corners automatically. It does not filter out mistakes. This is intentional, as most CAD systems block these errors from view, and as such, enormously large CAD files may be large because the end user is not aware of excess data being created but not apparent. If LandMentor screened this data, there would be no mechanism to make the CAD based consultant aware of the mistakes which are likely user based errors.

A good example of using a proposed DTM from an engineer in 3D is seen from this data furnished by Short Elliott & Hendrickson who is a LandMentor user.

The ground abutting the street shows the proposed grading detail derived by the proposed DTM. In LandMentor while in the Video Gaming window, pressing [W] allows the wirelines that created the 3D to appear…



This view allows you to more clearly see the imported DTM from CAD. Note the vertical lines that seem to occasionally plummet down below the surface. These are actually from the CAD file (again LandMentor does not fix bad CAD data). When the 3D surfaces are textured, they are hidden from view, but in Wireline Mode, the errors become apparent. Is this a bug in CAD? Probably. We communicated this problem to the person who developed the DTM – it is up to them to discuss it with their CAD supplier. Again, the more complex the systems, the more possibility of something going wrong.

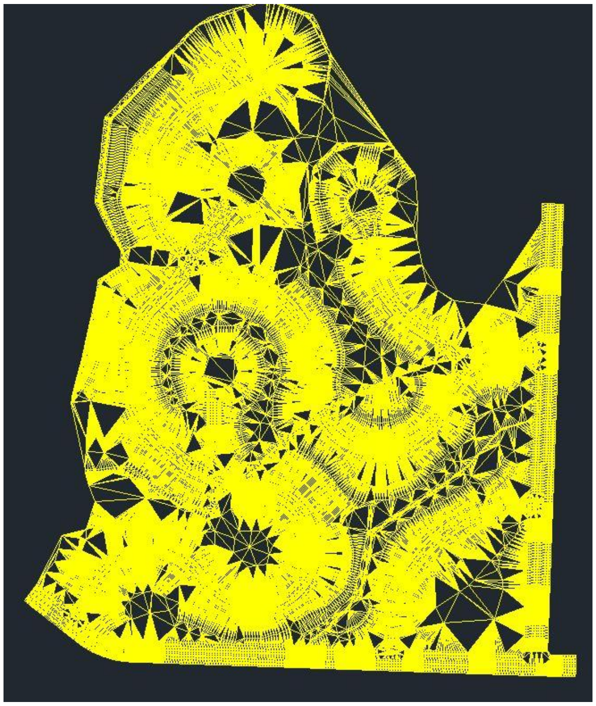
The houses, cars, trees, and people above were imported from SketchUp and 'dropped' onto the site. This process took all of just 10 minutes, hardly enough time to justify billing the client, thus virtual reality is often a 'deliverable' and added non-billed value.

The process to filter and fix excessive data is of course billable. On one site in South Dakota, it took over 60 man-hours billed to the client to reduce the LiDar's 36 million points to just over 25,000 to create the exact same topo. But what if there was no excessive data to begin with? The goal developing LandMentor was to solve roadblocks to better results that technology has made worse and eliminate the problems or reverse the trends that have been prevalent for over two decades of CAD and GIS domination.

What if the excessive data was intentional?

In this next example, Civil 3D was used to create the proposed contours on a site in Nebraska we designed using the advanced sustainable development design methods taught in the full (limited distribution) LandMentor system. The site data is exported to AutoCAD, then the consultant used their system for street, utility, and grading plans. It is best to use proposed DTM if available to create the virtual reality of the site. The proposed DTM file size was unusually large (36 megabytes) – the first warning sign that something was very wrong – but what?

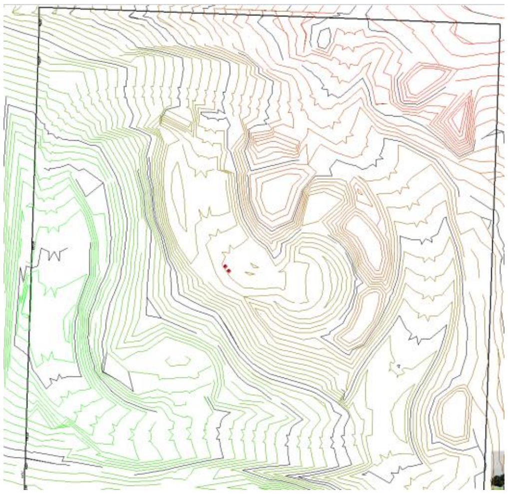
A quick look at the data in this AutoCAD screen snip shows excessive information, but the question remained – why?



A quick phone call to the consulting engineer who created the data came up with the explanation. The sampling of the data which would commonly be done every 25 or 50 feet along the centerline was instead done at a much lower interval distance so the contours would show more 'smoothly'. The resulting 1,256,000 points (after eliminating a cul-de-sac with 900,000 points) make such a small difference that the scale the deliverable construction plans would be drawn it would not be noticeable. But generating 20 to 50 times the necessary data would significantly slow down every process tied to the proposed surface DTM, such as earthwork with an insignificant difference in calculated output. Also remember 50 times the data is potential errors waiting to happen!

Contrast the above proposed DTM with the one shown on the left on the previous Watford example. The street cross sections are created by a roadway design function, which emulate cross sections of surveyors obtaining existing ground information. The other lines (proposed homes shown in color) are essentially 'breaklines' to guide proposed contours. The triangles around the borders are existing ground DTM outside the 'design' area. In all, this 36 acre area needed only 2,311 total points to create the basis for proposed and blended existing ground surface data. In other words the correct method to create proposed ground emulates a surveyor's field collection of an 'as built' land survey.

The resulting surface DTM provides a significant precision compared to the overloaded site above. Because of the integration of survey geometry and internal DTM modeling, any contour resolution is available on call without generating a single extra point other than that of the original topo. Again as stated previously, red indicates the lowest elevations and green indicates the highest.



As the basis for the base information for the Virtual Reality (video gaming) interface, a single keystroke drapes the proposed design surfaces (streets, driveways, ponding) with the DTM. SketchUp models are dropped in resulting in…

The above site was generated with less than 2,400 total points which 1/3rd of those points are existing ground surfaces.

The proposed ground is the basis for earthwork volumes:

By having the core technology always address the base coordinate geometry with the drawing as a by-product and not the other way around, we develop more powerful technology…

The Power of Point Descriptions

CDIS was intended to simplify land surveying and land development calculations. Before the advent of computerization, field work was basically the collection of physical items or defining change of grade. Each point in the field was hand entered in a field book and appeared like this example.

Low Rod 65.75"

HI					
74 7/8"	A @ well Mon 1 BS Random	0.00 00	75.98	-7.06	
Hi Rod 175.25"	208 48 36	119.70	119.68	-1.64	PT A
	203 48 19	57.70	57.58	3.66	PT B
	0 16 15	73.70	73.32	-7.52	well mon 2
HI 61"	A @ PT B BS Mon 1	57.60	57.50	-3.42	
Rod 65.75"	343 22 55	76.28	76.10	-5.14	℄ gutter
	342 47 57	75.96	75.82	-4.62	TC Back
	334 11 13	74.62	74.50	-4.16	Edge Pkwy
	329 27 47	57.92	57.88	-2.38	Edge Pkwy
	339 52 34	53.98	53.92	-2.56	TC Back
	340 33 54	53.76	53.68	-3.02	℄
	335 30 51	36.88	36.84	-1.72	℄
	334 28 31	37.06	37.04	-1.24	TC Back
	317 12 43	40.58	40.56	-1.54	EG Parkway
	305 18 57	23.58	23.56	-1.00	Edge Pkwy
	331 25 37	20.92	20.92	-0.32	TC Back
	333 16 30	20.88	20.86	-0.80	℄ AC
	41 10 37	7.22	7.22	0.04	℄ AC
	43 05 31	6.60	6.58	0.54	TC Back
	151 14 54	9.68	9.68	0.36	Edge Pkwy
	101 46 05	13.64	13.60	1.16	up 6" 12" x 18" water meter
	100 14 30	15.14	15.10	1.08	12 x 18 water meter
	117 11 49	25.56	24.56	0.52	Edge Pkwy
	85 10 53	20.72	20.70	1.04	TC Back
	83 01 55	20.76	20.76	0.58	℄ AC
	81 27 09	30.46	30.46	0.76	℄ AC

Note that there is an angle and distance to a description of what was collected. No point numbers appeared in land surveying. Not until computers contained enough memory to save the data in a memory location. In other words point #560 would be the 560th point in memory or on a file.

Over time after total stations first appeared, this point numbering was the means of communicating between field and office. Eventually this led to the concept of grouping types of data by groups of point numbers, increasing the complexity of land surveying.

Since there are no standards for point grouping, each company would devise their own system, thus one company's points 500 through 800 might be reserved for building corners whereas another might be for existing ground shots.

The increase of mental gymnastics coincides with the increase of potential mistakes. The problem with a point numbering system is that it adds one more element to be dealt with.

LandMentor is the first land based technology to eliminate the need for point numbers (well, eventually).

Look around you. Earlier we explained that we live in a world made up of various forms of surfaces (defined on paper as lines and arcs). Each surface has edges, most have corners which are unique locations on earth. A table can be moved changing the location of its coordinates, but the items collected by a land surveyor are stable – not changing until there is new construction or demolition. In positional coordinate geometry, it is the point description that matters – not the point number. The only reason LandMentor mimics a point number based coordinate geometry is that currently all survey instrument data collectors require this form of point information.

The creation of boundary work as well as definition of the natural ground can be easily edited by isolating point description. No need to remember point numbering. If one point is translated to another's location, there is no 'stacking' or duplication of data.

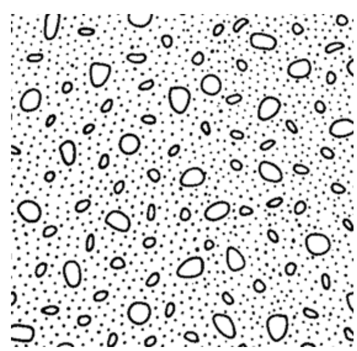
Isolating points by description reduces (mostly eliminates) the need to zoom up and look at point description and prevents the snapping to the wrong point which can cause litigation later on!

Newly created points would be tied to linework of a particular layer. Thus, points on the building layer would be 'building' points. Points on the centerline layer would be named 'centerline'. Stakeout of the site is easy, just send over the type of points to the data collector by what they are described.

No need to manage point numbers – ever again!

Redefining Computer Graphics for Land Surveying

There were two ways to describe the graphics required for land surveying (all land development) applications. In the beginning of automated plotting for land surveying 'pen' plotters zipped back and forth – to and fro – to eventually create a drawing to exact scale. Because ink could only flow so fast, a 'plot' would take quite a while. Still, the accuracy and speed would be much faster than a plot done by hand. The 'vector' graphics would begin at one location and end at another. Curves were (and still are) defined by small increments of lines. There was no good mechanism to 'scan' data into the computer, so large scale 'digitizers' were used to 'trace' information into the computer. Another form of graphics using dots was called 'raster' graphics. Raster graphics is more associated with photographs. The individual dots on your computer screen are essentially raster graphics. Plotting a line on the screen using vectors (starting at one screen coordinate and ending at another) highlighted the closest 'dots'. Even with today's high resolution screens a close look shows the changing of dots, especially when close to north/south and east/west directions.

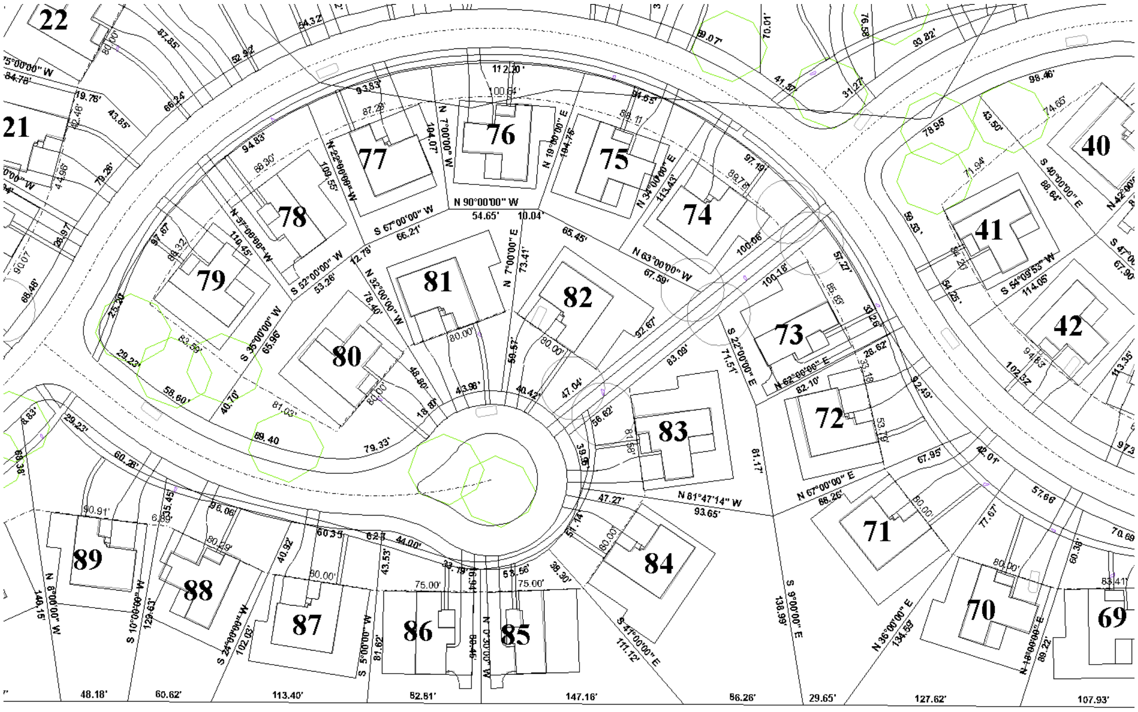


Clear plastic overlays called Zip-a-Tone patterns as shown here was often used with pen plots to overcome limitations of vector graphics. Computer lettering in the early days looked computer generated and many survey draftsmen also embellished the drawings with press-on lettering.

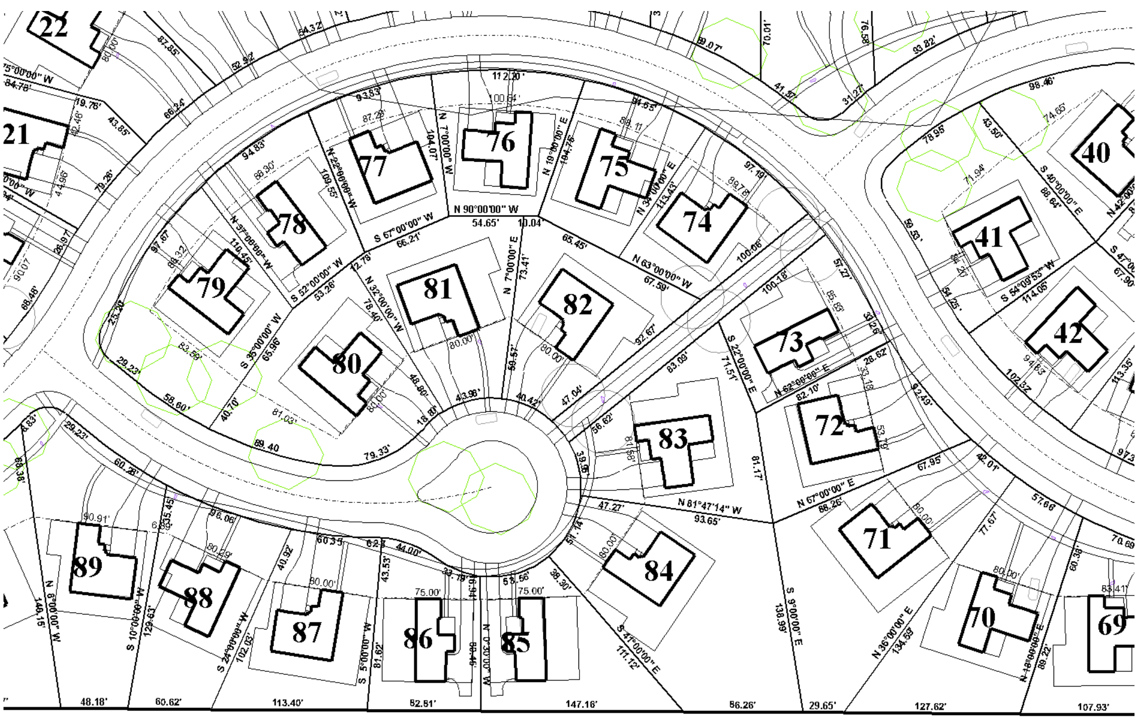
It was not until advancements in both software and hardware with high resolution raster graphics obsoleted the pen plotter.

If you do an internet search for 'as built survey' hundreds of examples will appear, mostly black and white, and almost all using vector graphics with cross hatching emulation of the zip-a-tone of yesteryear.

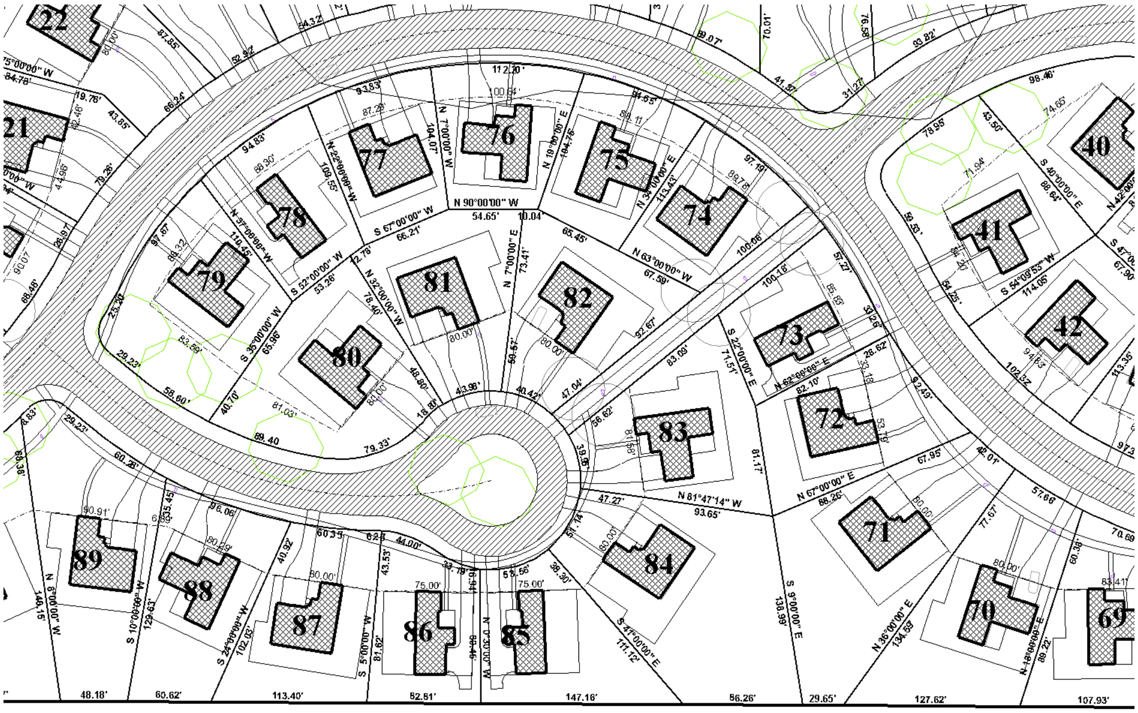
LandMentor can also display this familiar format…



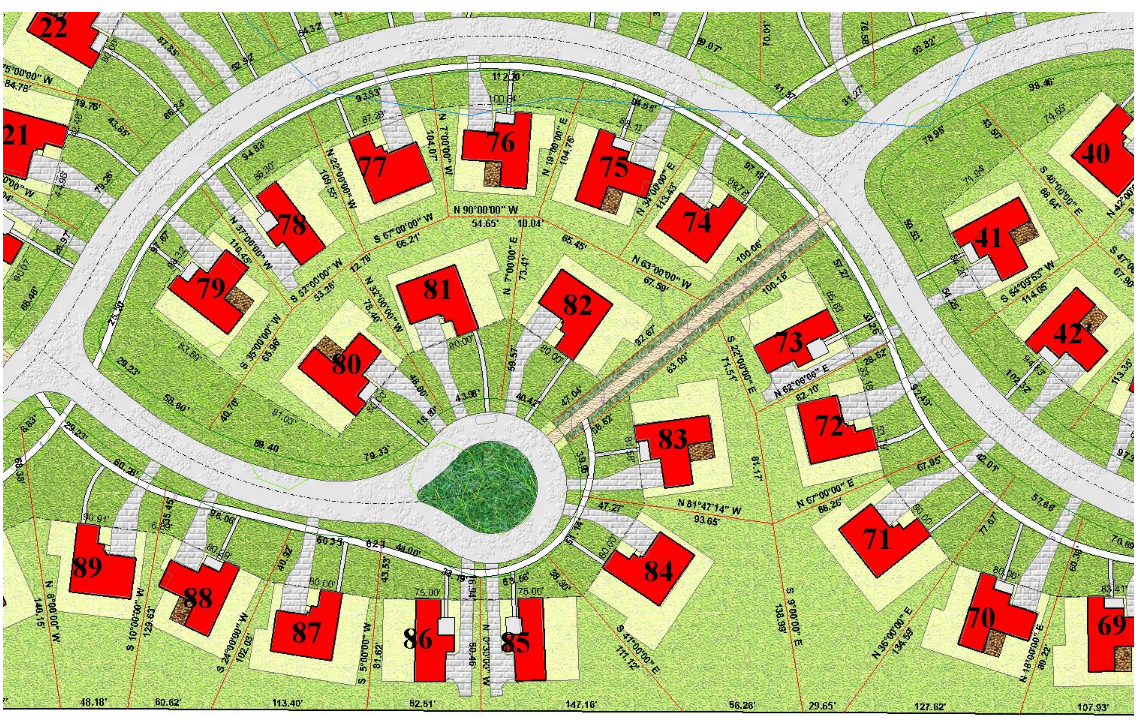
While the above is familiar, it is also difficult to decipher what is what. In CAD color variation defines line width, but in LandMentor line width is accurately displayed and color = color, significantly reducing mental gymnastics. Varying line width helps separate some data:



The cross hatching is how for centuries more ‘elegant’ land survey plats are delivered to the clients:

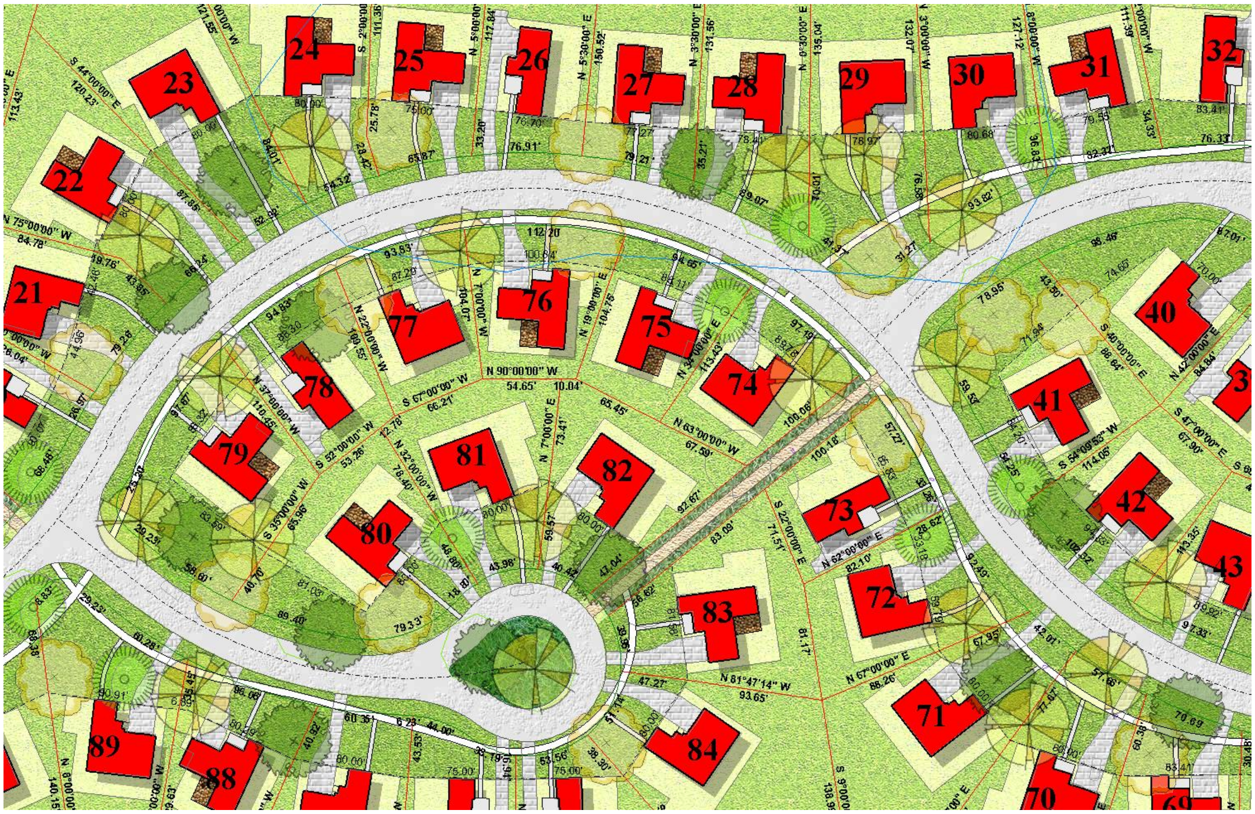


LandMentor is a vector based system that always displays in raster graphics allowing land survey plats to represent something easier to understand and visualize:



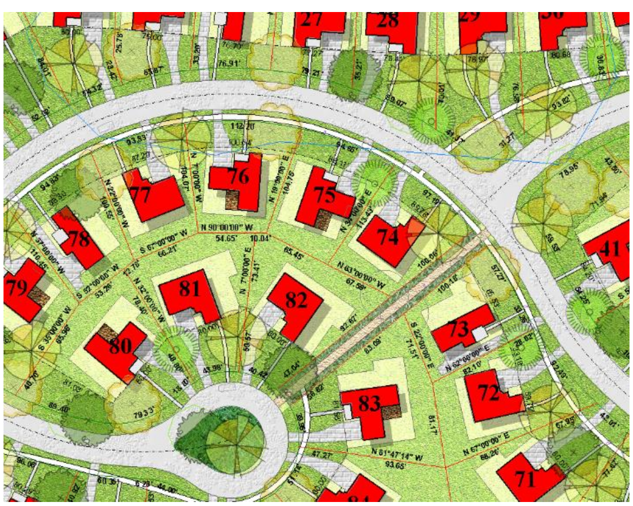
Each color above is a defined ‘surface’ tied to a texture, thus it also verifies the geometry!

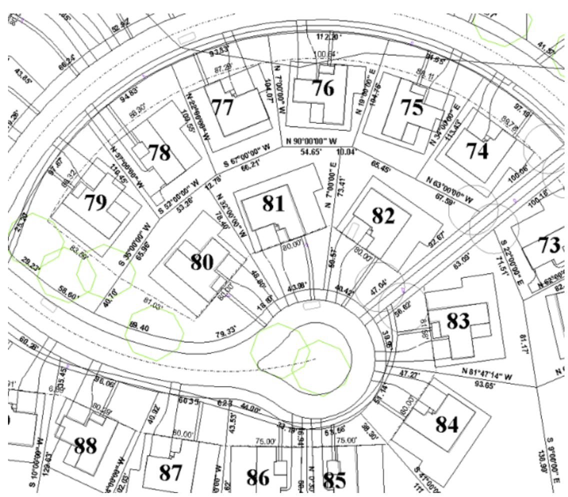
Colors and textures are not limited to preset image maps and transparencies can be applied:



In the above example we set a 'shadow' at 135 degree angle with a 30% transparency for all 'house' surfaces. We then overlay landscaping which would typically hide dimensions and overpower the site plan, but instead set transparencies to allow dimensions to be read and not overpower the plan.

Since the image of a land surveying company to the client (and public) is entirely within the deliverables, which do you think will impress?





The black and white plat is created for filing purposes, the client see's a much different image.

Again, in just minutes the deliverable would also include full interactive video gaming of the clients site:

In addition to the embellished deliverables, as a spin-off in the process of as-built surveys and design situations, critical information missing in traditional (expected) deliverables but included in this new era will be of immense value to your private developer or for public clients for their decision making.

Changing the Clients Perspective on Land Surveying.

LandMentor was created to reverse the deflation of the land surveying and design industry caused by automation and miss-use of CAD/GIS based systems. Without intervention, the general public will continue to think 'google earth' will be good enough!

It is time that land surveying as an industry reclaims its position as both the point of beginning (of the entire design process) as well as the point of ending in construction stakeout.

In the one simple example used in Watford, we demonstrated how just one feature could have been used to negotiate a half million dollars advantage for the client compared to the survey plat lacking critical information.

This new system is far more than just a software technology, but a complete package including hardware and training to inflate the importance of land surveying while bringing passion back into the industry.

LandMentor is a product of Neighborhood Innovations, LLC.

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LandMentor solutions are only sold as a complete system including software, hardware, and training.

It is non-modular, thus no options or 'modules'. No CAD is needed.