Autodesk University 2012

From Pixie Dust to AutoCAD® Civil 3D®: Theme Park Design from a Civil Engineer's Perspective

Eddie Moreno – Walt Disney Imagineering
Pedro Velasco – Walt Disney Imagineering

CI6740

This class will demonstrate the unique form of civil engineering that is done at Walt Disney Imagineering and how AutoCAD® Civil 3D® software has helped to create the complex infrastructures that are a part of Disney's theme parks and resorts. The modeling engines in Civil 3D® are taken to the limit to meet the immense design requirements. With drawing data containing over tens of thousands of model objects, built to real-world specs and spanning multiple projects, the "I" in Building Information Modeling (BIM) has taken on a whole new meaning: Intelligence. In this discussion, we will focus on a project-specific journey and see how the age-old profession of civil engineering uses the capabilities of Civil 3D® to meet these unique demands.

Learning Objectives

At the end of this class, you will understand how to:

- Build a civil base design from 2D to 3D
- Combine Civil AEC models with other disciplinary models to refine the design
- Use data sharing to more efficiently collaborate with other discipline models
- Enable the Civil 3D virtual site; to cancel issues, and to use for visualization.

About the Speakers

Eddie Moreno became an Imagineer in 2008. As a Senior Designer he has collaborated on the latest Theme Park attractions, including Carsland, and World of Color in California, and now the newest Shanghai Disneyland Resort in Shanghai, China. With Civil 3D, he has helped foster the civil BIM model into maturity and make it an integral part of the BIM pipeline.

Pedro Velasco, P.E., has been with Imagineering for over 22 years and has worked on attractions and theme parks around the world, such us Walt Disney World, Florida, Disney's California Adventure in California, Tokyo Disney Seas in Tokyo, Disney Studio in Paris, Hong Kong Disneyland in Hong Kong, and the latest Shanghai Disneyland Resort in Shanghai. He currently holds the position of Director of Civil Engineering at Walt Disney Imagineering.

Patty Wines has spent the last 21 years at Walt Disney Imagineering, marveling at what her peers and coworkers are able to do with software, creativity, and the will to innovate. As a CAD manager, she supports staff from all over the company, an amazing group of Imagineers from 140 disciplines of work, designing theme parks and resorts around the world.

A Brief History of Civil Engineering at Walt Disney Imagineering

"Curiosity keeps moving us down new paths. We're always exploring and experimenting. We call it 'Imagineering' - the blending of creative imagination with technical know-how."
~Walt Disney

When Walt Disney first dreamed of creating a one-of-a-kind Theme Park, I'm pretty sure the first thing on his mind was not drainage, infrastructure, utilities, or in general, civil engineering. We work in the entertainment industry. Let's face it; civil engineering is not the first thing or second thing for that matter, people think of when they hear the word "entertainment". The 'imagine' part of the process is celebrated, not so much the solid engineering skill it takes to make those dreams real. Walt and his team realized that in order to make all those wonderful designs by all those talented artists a reality, they needed some engineer's to help with all that pixie dust.

"Fellas…we're definitely going to need some help making this!"

Don Edgren: the first chief engineer for Imagineering. Civilizing it since 1954.

In 1952, Walt Disney founded Imagineering (or WED as it was originally called) to help oversee the production of Disneyland Park. Since then, Imagineering has been (Wikipedia says it the best) "the design and development arm of the Walt Disney Company, responsible for the creation and construction of Disney theme parks worldwide."

In 1954, Walt hired Don Edgren to help design Disneyland Park until it's completion in 1955. With that he became the first 'quintessential engineering captain' for Imagineering. After his "engineering baptism" in the Theme Park business, he continued leading civil teams through such legendary projects as Pirates of The Caribbean in Disneyland, the initial master planning for Walt Disney World in Florida, Space Mountain in Magic Kingdom (1974), Tokyo Disneyland (1979), and many others. Don eventually retired his slide rule in 1987 and was later inducted as an Imagineering Legend in 2006.

Don's honorary window on Main St USA, Disneyland.

So as you can see, us civil people have been here from the beginning; 58 years to be exact! One would never guess but civil engineering has become the cornerstone by which all theme park designs at Imagineering are started, and finished. This is a pretty hefty responsibility when you can take in the size of it all. In addition, collaborating with every discipline that can be imagined under one roof, plus battling over "creative intent" vs. "what works", it is truly a unique and challenging role for a profession whose sole responsibility throughout the centuries has mostly been keeping civilization working.

From 2D to 3D – Building a Base and Still Keeping it Civil

Theme park plans start with a working base. What is a base? It's the intended design of everything guests and cast members eventually will see or walk on inside the park. Think of it as a site design that includes planters, walkways, facilities, landscaping, proposed attractions, maintenance areas, cast member ingress and egress, and so forth. Since so many disciplines build their designs based off of this base, it is critical that it is shared in a way that does not hinder the process.

Civil Engineering has always been a step behind the rest in terms of full-force 3D design, including BIM. Architects, I hate to say, have been the leaders in this field (even though they use inches…but I digress). Even more still, the manufacturing industry has us all beat by several decades.

How is this possible?

Profits? Sure, when aren't they. However, looking more closely other reasons begin to surface. CAD/CAM processes and necessities for off-site fabrication have had a great deal to do with this. Whereas Architects and Manufacturers have a need for custom fabrication, civil engineers really never did. Our designs are calc'ed, designed, and built in the field. It's as simple as that. A manhole, is a manhole, is a manhole.

Or is it?

After seeing the type of challenges faced here at WDI and how 3D has helped overcome those and help lower costs, I can definitely say no. What works for one project never works for another. Boiler plate is just a phrase that should be relegated to specs and notes, so please do not use it around here! Integrating BIM into the civil industry is not just a necessity, but common sense. In the end, or better put from the beginning, BIM starts from the ground down.

Getting Started

The majority of designs at WDI had always been drawn in 2D, including the civil department's drawings. With that said, the first and most obvious challenge for us was "How do we deviate from the old way of thinking, and transition to the new 3D way".

Civil Engineering drawings at WDI (Walt Disney Imagineering) had always been done in 2D, even up until very recently. One of my responsibilities when I came to WDI was to help the department not only transition to 3D, but how to do it somewhat smoothly. Luckily for me the old ways worked well, such as project directories, working file methods, drawing standards, and file naming conventions. We just had to find a simple way to make both the 2D and 3D worlds work together. I had to suppress my inner 3D evangelist and think a little more realistically. They both had to be civil (no pun intended).

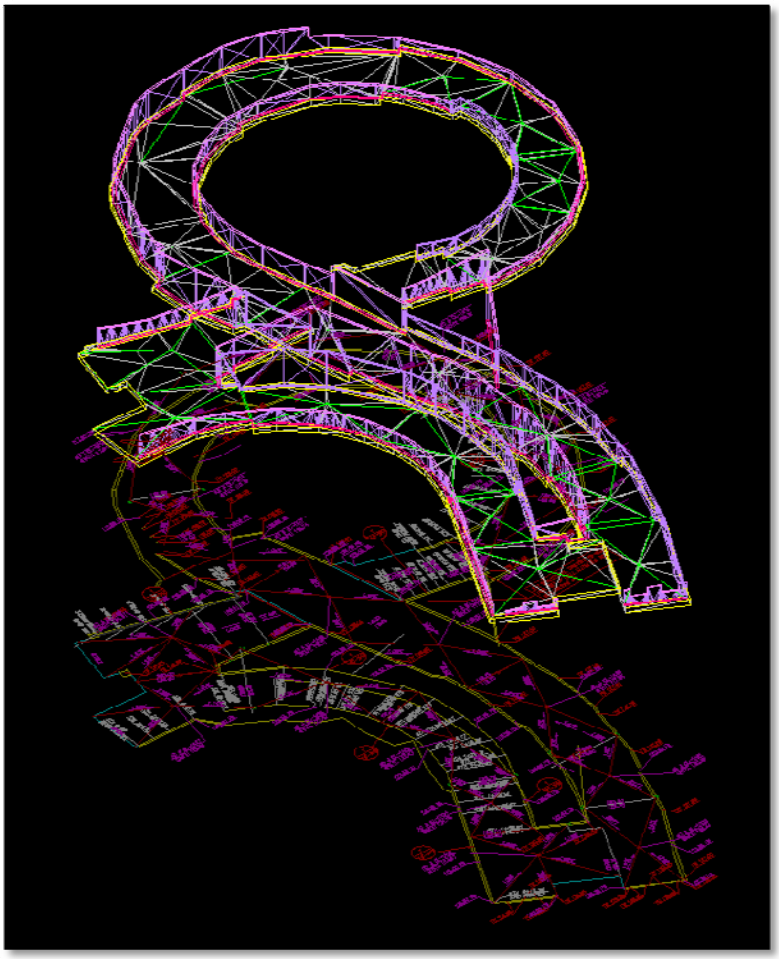


Figure 1: 3d models are based off the 2d CAD work. This "second phase" portion of trough for the Racers attraction in Carsland was created entirely from feature lines and surfaces, using a 2D drawing as the foundation.

Do not neglect the 2D side of the force

The file organization at WDI was very well thought out from the beginning. That's where it all started for us, data management. We had a good foundation. If we could make our new 3D system work as well as the 2D system, we'd be in the money. Our 2D drawings were like anybody else's; they represented all our calculations and designs graphically and were used for construction documentation. We had to continue using them for these reasons and because so many other disciplines had them referenced into their drawings. If we totally transitioned to an all Civil 3D AEC format, they'd all have some serious things to say to us. Yes, there are Object Enablers that Autodesk makes readily available to all of us but the reality is not all are so quick to change. The accelerated workload and back to back deadlines further called for simple, quick to implement, and workable solutions. There are those that say just go all 3D, but you still need old reliable on your side. Our solution was to keep using the 2D files and continue exporting them as external references.

Start with a good template

In order to create the 3D files, an empty template was opened which was then populated with the appropriate 2D files as external references. The 3D data was then drawn over the 2D drawing, copying the horizontal information, and later populated with the desired Z values (See Fig1). This rule was applied to both utilities and surface grading designs. The drawings containing the 3D data were then saved using the same name as the 2D drawing but with a *3DM suffix to distinguish it from the 2D group. The 2D files were still used as they were traditionally while the 3D files were used to further the design and later enhance the BIM capabilities of our office. This simple method was the basis for managing our drawings through the initial transition period and beyond. Initial startups rarely have anything to do with the software but more to do with simple solutions, data management, and reduction of learning curves. Reinventing the wheel isn't the only way to innovate, plus it can be done transitionally instead of abruptly.

Combining the Civil With the Not-So-Civil – Our Models Meet Their Models

There are over 140 disciplines at Imagineering. The civil engineering department is just a small part of the ED&E division (Environmental Design & Engineering) at Imagineering. The ED&E building houses about every engineering discipline that you can think of. You can say our building makes it work. I've always been told by other Imagineers that "Collaboration is key." and for good reason too.

Deep inside the mysterious lairs of the ED&E building reside Mechanical Engineers, Structural Engineers, Electrical Engineers, Architects, Landscape Architects, BIM Managers, CAD Managers, Graphic Designers, Signage Specialists, Interior Designers, Lighting Designers, etc. and etc., all pushing together towards a common goal.

"Hey…what do you mean this won't work?"

This unique form of collaboration has fostered some interesting changes; not only in the way we work, but also in the way we look at design. I worked for many years on the "outside" so I know it's common to only work with the people you see on a daily basis. At Imagineering, you're either under the same roof or a stone's throw away from everybody. This type of togetherness accelerates the exchange of information and also the way we have to work with it. Architects are actually easier to deal with when they are right down the hall from you, Structural Engineer's actually make sense, and Landscape Architect's actually understand what you're talking about. Wow! Everything I always assumed otherwise was totally wrong! (well, at least behind these walls it is)

"It's about the presentation and how well it marries with the rest of the cast"

As Civil Engineer's we are used to looking at the world in a very standardized, safe, and logical way. Installation of utilities, manholes, and drainage structures such as catch basins is usually determined by the location of the pipe, street, or sidewalk. In a Theme Park, design is ruled by how it interacts with the "show" going on

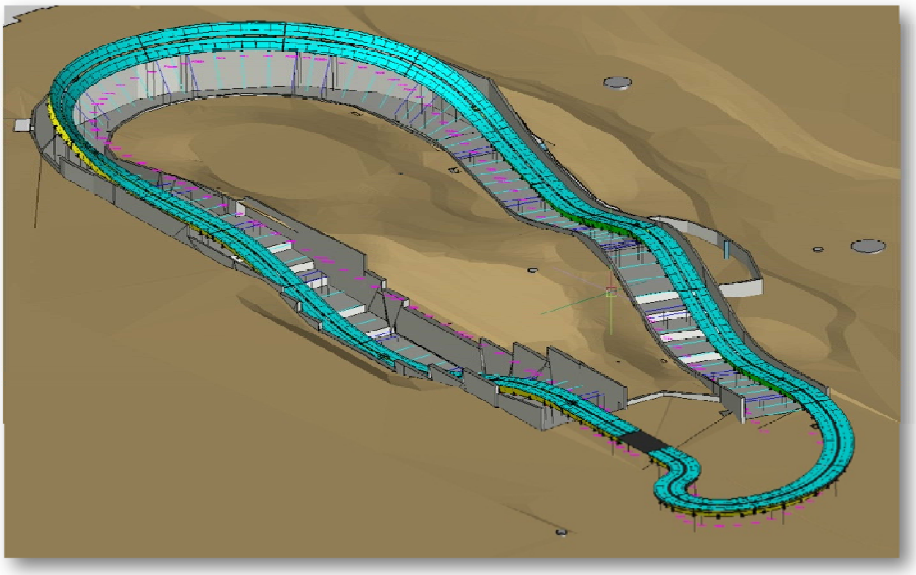


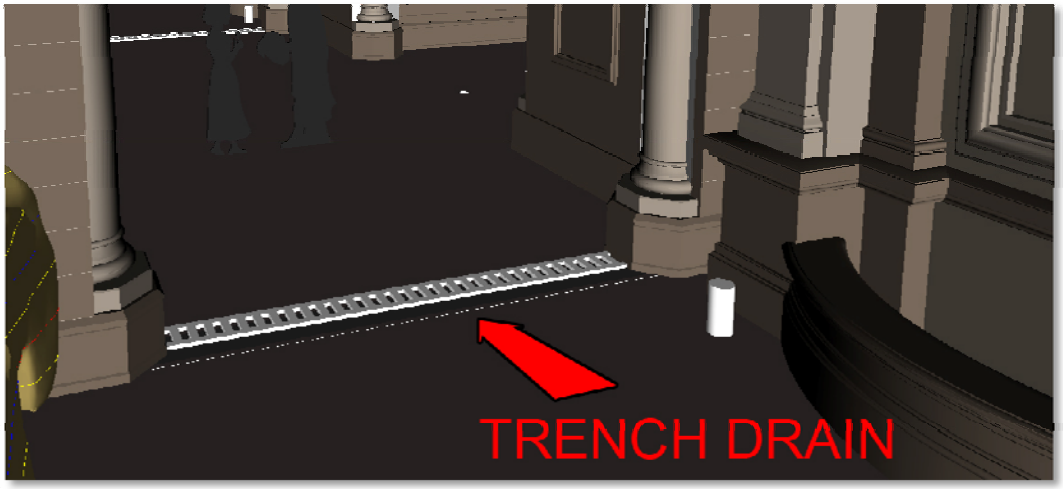
Figure 2: Combining models from other disciplines within Civil 3D makes for a more intelligent design. This "first phase" portion of the Racers ride trough was combined with Ride Mechanical's track model. Note the TIN surface as well as tops of underground utility structures.

above. It's not just about streets, sidewalks, or how it works; it's about the presentation and how well it marries with the rest of the cast in creating a believable story.

This presents a challenge by the normal sense of things. As engineer's our designs are restricted by certain natural and unnatural factors; basis of design, hydrology, catchment areas, available resources, and the list goes on. Unlike the normal circumstances, our parameters although still in the scientific realm tend to bleed over or are bled through by the creative arms of the company. I wouldn't say it's a love-hate relationship, but it definitely can be like a dysfunctional family with budgets and deadlines involved.

Above, Figure 2 shows the beginning stages of model coordination efforts for the recent addition of Carsland at California Adventure. This image shows elements of the Racers attraction that include a ride trough, elevated track surface, 3D TIN surface, and modeled utility structures, all making for a first phase look at object relationships. This same coordination is later brought to a more detailed, "story" orientated, site model during our later phases of design.

How civil culture affects the overall story is a very important issue at Imagineering. Model coordination has been a valuable asset in determining this and keeping the story relevant. The image below shows how important this issue can be.



Function is in the lead but form is always close behind

Testaments to this are the many different themed paving patterns throughout the lands in the parks. Typically, aesthetic elements such as this are ignored for sake of functionality. At WDI great lengths are taken to make this union a harmonious one.

Made to simulate all types of substrates, these patterns vary from brick arrangements, cobblestone, asphalt, unpaved roads, to even mud roads (see Fig.3). The looks of walkways, paths, and roads are an important part of the story telling and so have to be taken into serious consideration when placing any structures at finish grade.

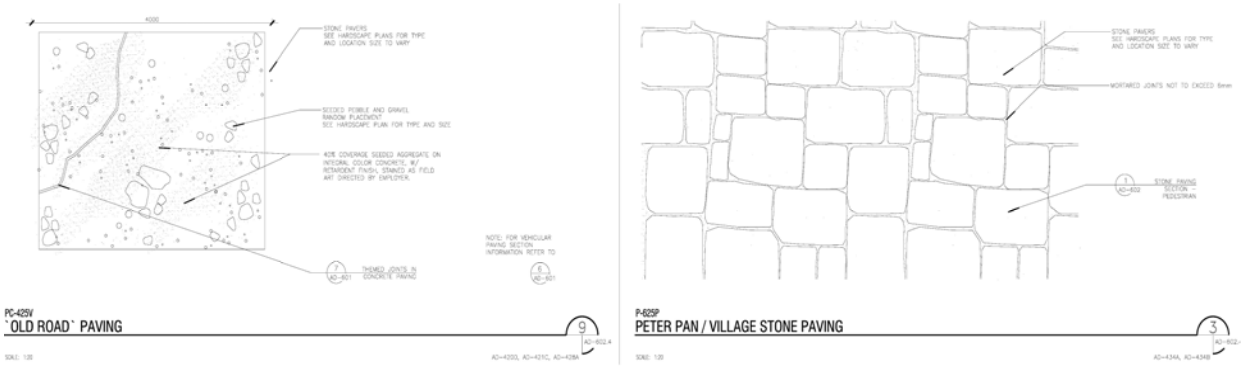
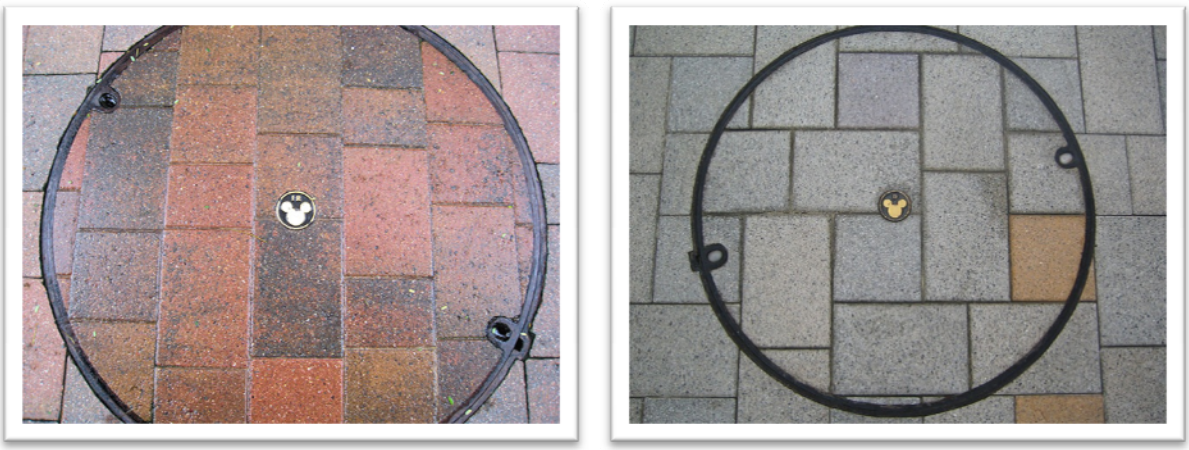


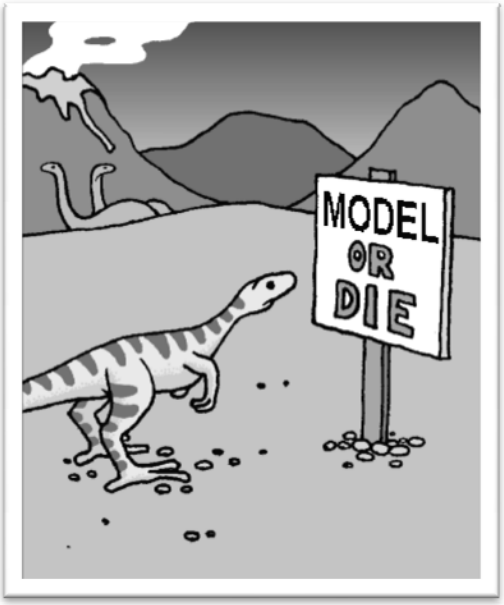
Figure 3: Two sample details of paving patterns simulating a dirt road and stone paving.

It wouldn't make much sense, story-wise, to place a standard iron manhole lid in an area such as Adventureland. It also has to be themed. For what? It's a manhole cover, for goodness sake, the kind of thing that is not intended to be seen or to stand out. That is not the case here. Special In-Fill manhole lids are used to aid in bringing a consistent look to themed paving areas as well as concealing the obvious, as seen below.



It's this attention to detail, first established by Walt himself, which makes it very important we model all structures or elements that come to grade. If it can be seen it can affect. Combine this with triangulated surfaces and it makes for good uses to both our civil drawings and for visualization by the BIM team.

Push Civil 3D to the limit, Model Everything!



Within the world of civil engineering, just as in other fields, there are those who occupy the trenches and those that delegate from the command post. To the delegate it might seem a very ideal novelty of having all things that exist or will exist modeled. To the experienced individual in the trenches, knowing the work it actually takes to achieve such a thing, he/she might have a total different opinion. It's not automated; we still have to draw it in essence. The difference now is the intelligence factor that is involved. This is the real meaning for the "I" in BIM.

With this, and given the BIM development within the AEC community and at WDI, it was in everybody's best interest now to perform this task. To not would be folly given the implications that can be avoided. Although there are more upfront costs, the end product is much more rewarding. The modeling should only include structures or elements that directly affect civil engineering. Anything else should be modeled by the discipline responsible for design. This also makes the case for having an internal BIM team. This is how it's been implemented at WDI.

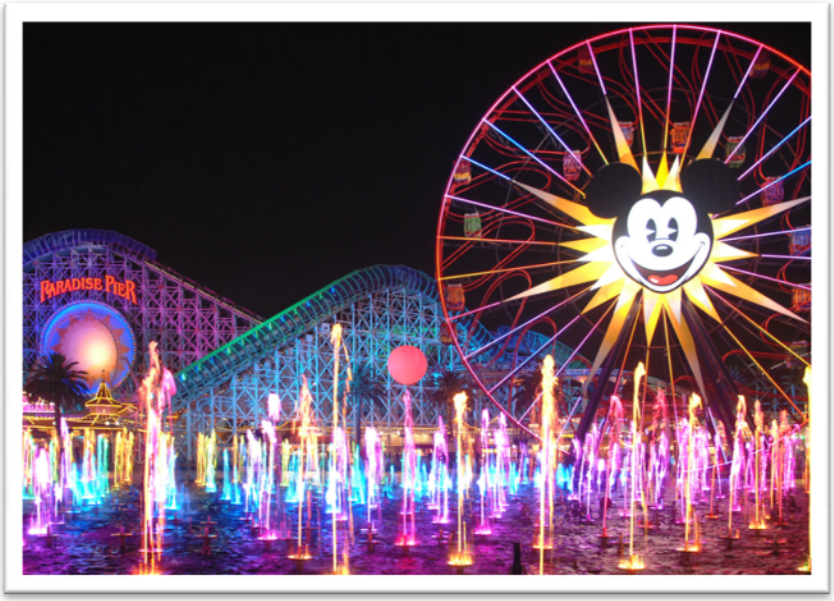
Making the case for all that "extra" work

In the latter part of 2008, a concentrated effort was made at WDI to go completely 3D. When we first started using Civil 3D we were only modeling what we needed to. In other words, if it wasn't being represented in a profile then we didn't touch it with our prepubescent 3D fingers.

The reason: the seemingly daunting task of having to model the 10's of thousands of 3d objects that would represent our park utility infrastructure, coupled with computer performance issues, and plain lack of knowledge but not lack of appreciation. The appreciation of the art was there, but how did we start and turn that appreciation into production?

Once we had our parts catalog setup, and template made, we jumped right into our first 3D project.

World of Color, Disney's California Adventure, Anaheim, CA



Our first effort using Civil 3D was World of Color. This was the first phase of the California Adventure redevelopment project. At the time, BIM was a relatively unknown term including how it pertained to civil engineering.

At WDI, utility design is one of our biggest responsibilities. If you were to take a look underground it would basically look like spaghetti. Not always is there a main utility corridor. As much as we may try to maintain one, lines eventually criss-cross apple sauce every which way (If you have kids you'll know what I'm talking about).

The old standard was that only utility lines that had a crossing would be profiled vertically. The rest would be given inverts or bottom of duct elevations in plan view only. This was how it was always done, so that's how we did our models. If it didn't have a crossing it wasn't modeled, plain and simple. At the time, it made sense and since you needed a line modeled in order to profile it, in helped strengthen this belief.

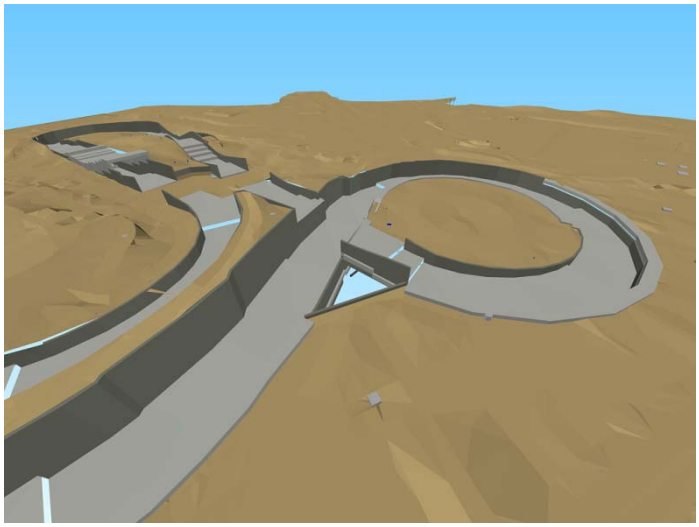
<<insert image from world of color showing partially modeled lines>>

Lessons Learned:

Partially modeling any design is like designing a car and leaving some of the parts out. The car will still roll but it isn't quite useful. Depending on what part you leave out it might even be a bit harmful. The time we saved to make deadlines didn't quite pay off when things went to the field for construction. RFI's and conflicts soon gave light to why modeling the entirety of a project not only makes for better design, but in the end will save costs.

Carsland , Disney's California Adventure, Anaheim, CA

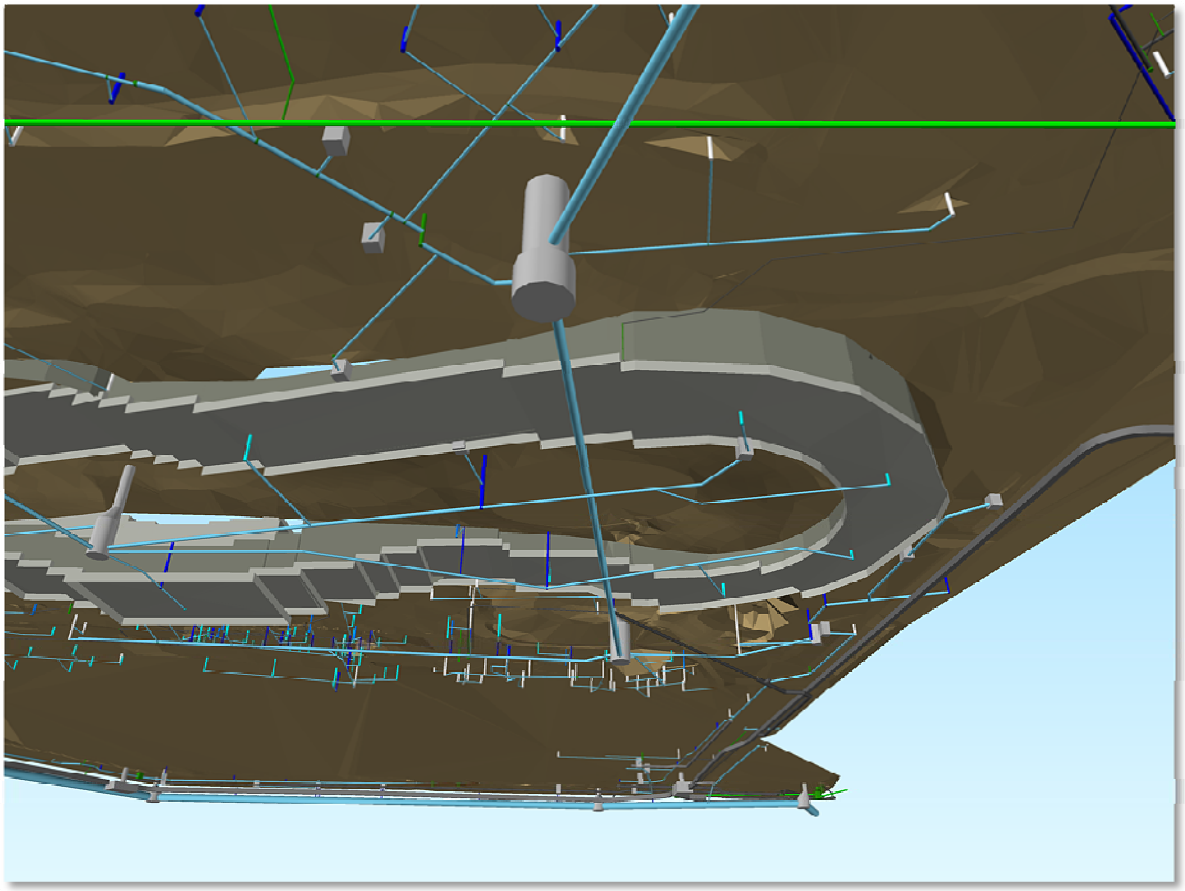
Speaking of cars, our second effort with Civil 3D was Carsland at California Adventure.The entire DCA redevelopment was a challenge because it was all in-fill. There were thousands of existing lines and conditions that had to be taken into account. Our discoveries with World of Color made us understand that the old standard, of modeling only what was crossed, wouldn't work anymore.



Civil 3D was used to great effect in modeling the Racers ride trough. A submerged channel made to house the ride track and all its components. Note the phase 1 test track in the background, upper left side of the image.

This was where we began to understand the concept of information modeling. The contractor in charge of construction management had their own BIM team. This forced us to switch into gear faster so that we could stay compatible and on schedule. Our models weren't just going to be looked at; they were going to be used for on-site field work as well. Modeling everything became a necessity now in order to facilitate this project efficiently.

Our modeling efforts and collaboration with construction management moved us into the uncharted areas of IPD. Our drawing sets for the project, each released at a certain percentage of completion, would also be accompanied with delivery of a BIM model to the contractor's BIM Coordinator. The BIM coordinator would then combine our models with theirs and analyze for anomalies or clashes. Navisworks was used primarily.



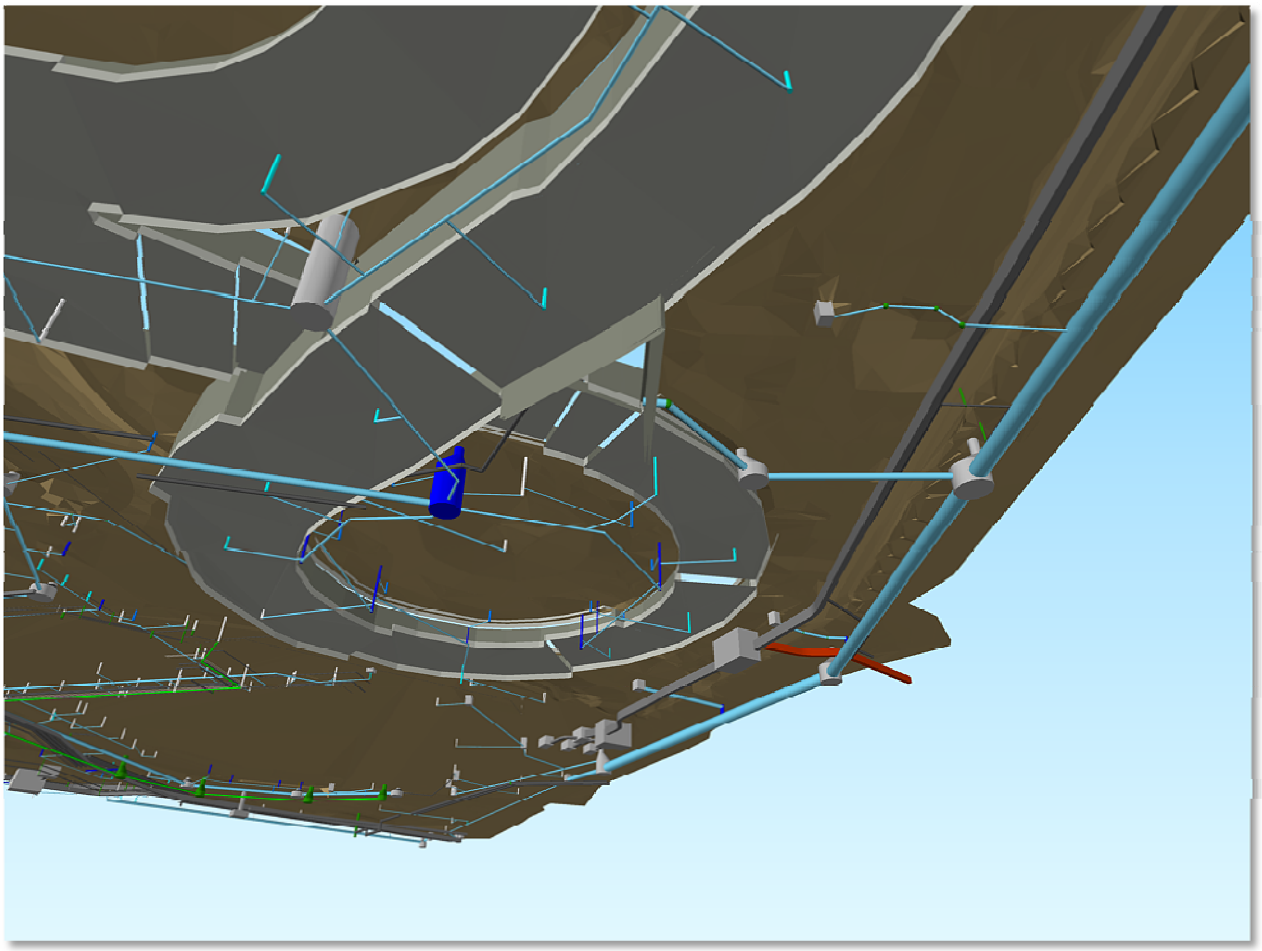
This is a bottom view of the same ride trough. It shows the web of stormdrain and sanitary sewer utilities underneath the concrete structure. In the foreground top center, there can be seen a custom part for a Stormceptor® system. On the right you can see Electrical Ducts designed in the site development portion of the project.

The amount of labor involved in modeling "everything" was well worth the effort. Our models were used extensively for collaboration between our department and the field office.

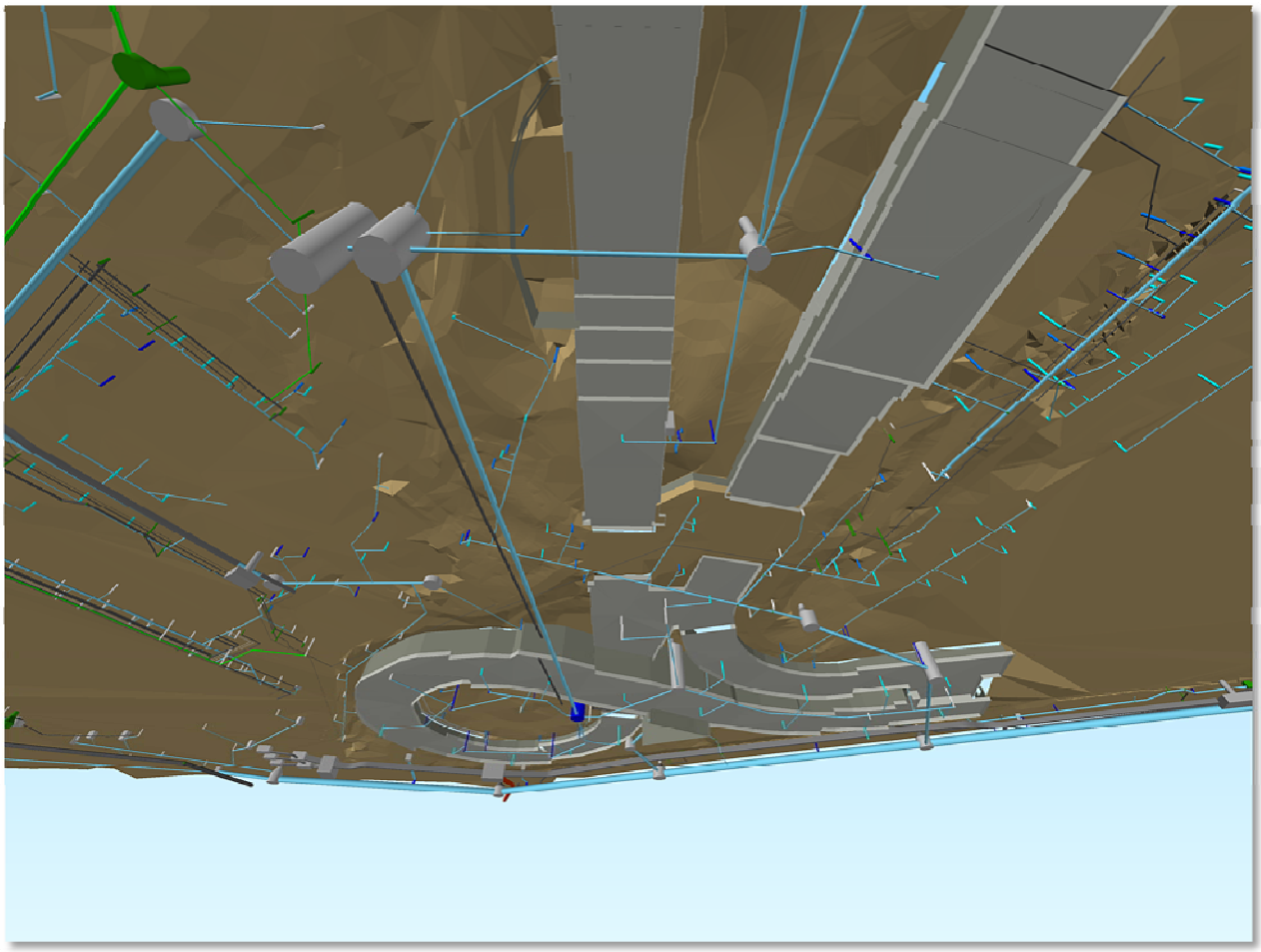
Our unconventional use of surfaces to create the ride trough gave a unique intelligence to the model. It made sense; since we were attempting to build something unconventional why not just become unconventional. No one else was modeling it anyways, so why not. There was not one constant length on this entire structure.

The tops of the walls would go from a stepped configuration and then, where it followed the track, would transition back to a curved section. To add to the challenge, a percolation pit was designed and built as an integral part of the structure.

Profiles of the walls were created and included in the drawing sets and the actual model itself was adopted by the contractor as a means to extrapolate the surface data.



Here is another bottom view of the ride trough. Foreground center you can see the triangular percolation pit without a bottom floor. The floor of this pit was filled with gravel and so was not represented. On the right and off to the distance you can see the early site development lines which include large RCP pipes, electrical manholes, communication manholes, and their associated duct banks.



Here is an overall view showing the extensive network of utilities. Most of our utility drawings contain over 500,000 objects.

Lessons Learned:

Real-time collaboration for construction and model distribution based on CD release schedules advanced our knowledge and understanding of the BIM process and helped us gain valuable knowledge as to where civil lied in the whole grand scheme of things.

Training and in-house support by power users further advanced the project in keeping up with the fast paced environment.

Modeling everything also forced us to build our library and parts catalog to match the demands and to push forward with creating the virtual site.

Keeping the mistakes in the office and out of the field

Placement of utilities and structures throughout the Theme Parks is a very carefully coordinated act. There are so many elements that can interfere with the story of an attraction. Engineering culture was never designed to be aesthetically pleasing or eye catching, but rather functional and cost effective. A light pole is a light pole, a gutter is a gutter, and a manhole lid is a…I think I covered this already.

With this challenge in mind, it was only natural for Landscape Architects and Civil Engineers at Imagineering to become very good design partners. At Disney, there is nothing more important than storytelling and the experience the guest receives from it. Immersing a guest into a fantasy world takes a lot as far as what kind of visuals a guest is subjected to. It can take something as simple as an improperly placed drain to take the attention away from the story, and back to reality. We try to avoid this as much as possible through careful coordination.

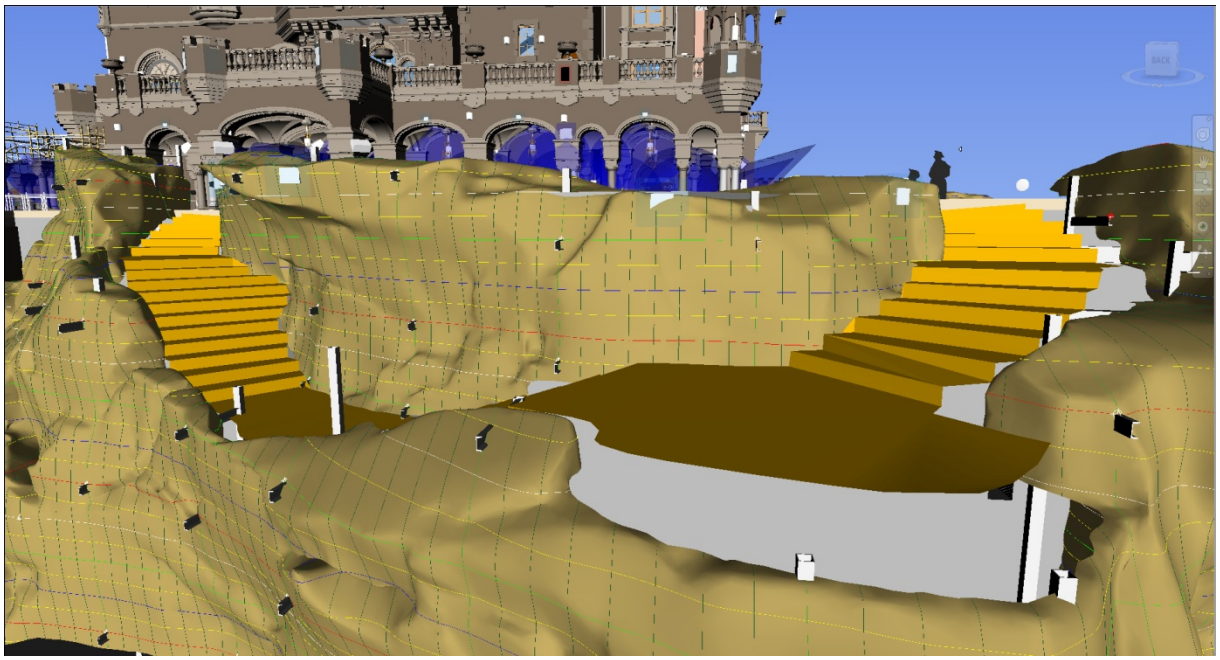


Figure 4: Civil 3D's modeling capabilities are taken beyond what it is normally designed for. Here a flight of stairs are created as a TIN surface and merged together with adjacent rockwork models.

It is imperative that our data, now in the form of models, be as accurate as possible. We go through great lengths to ensure that the modeled drawings done in Civil 3D not only work, but also makes sense when put together with the other modeled drawings from the other disciplines.

In Fig. 4, a flight of stairs are shown running under a proposed abutment of rock. The stairs, belonging to a paved area that requires grading, are modeled by the civil department. The ownership of the design is usually what determines who models what. In this particular case, there are 2 areas that stand out between the two models as seen in Fig. 5.

1) A massive difference in elevation between a mid-level landing and the rockwork.

2) The outer edges of the stairs do not align with those of the rockwork.

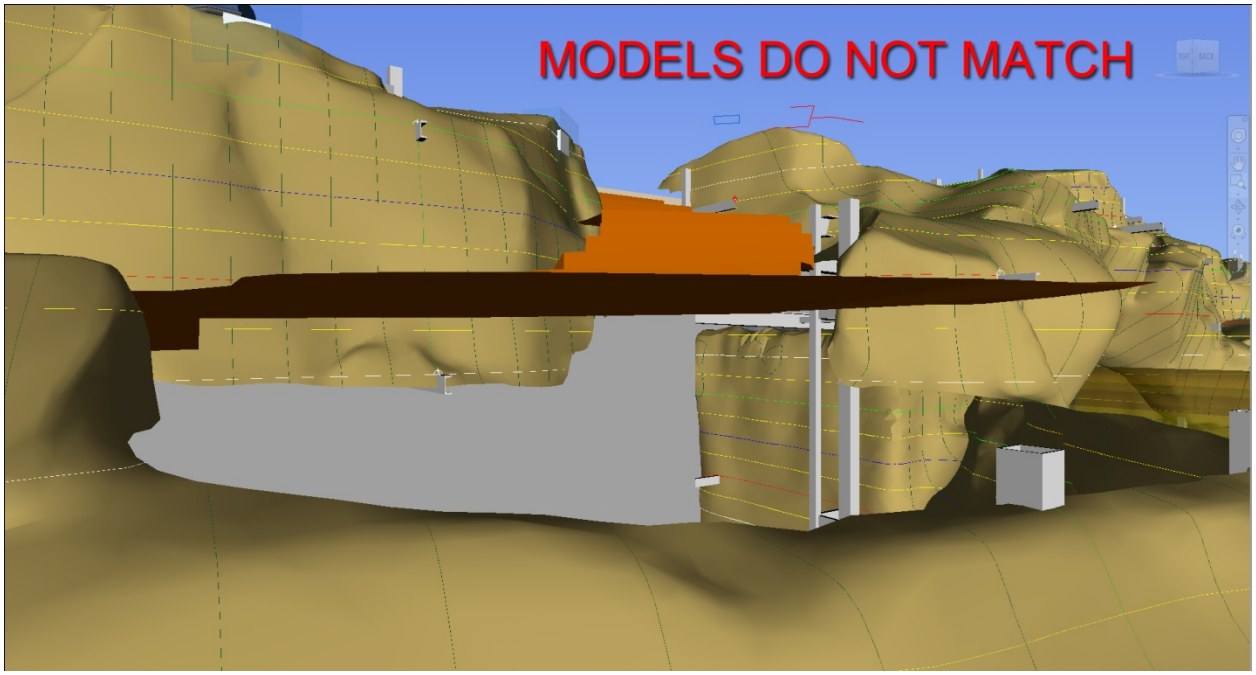
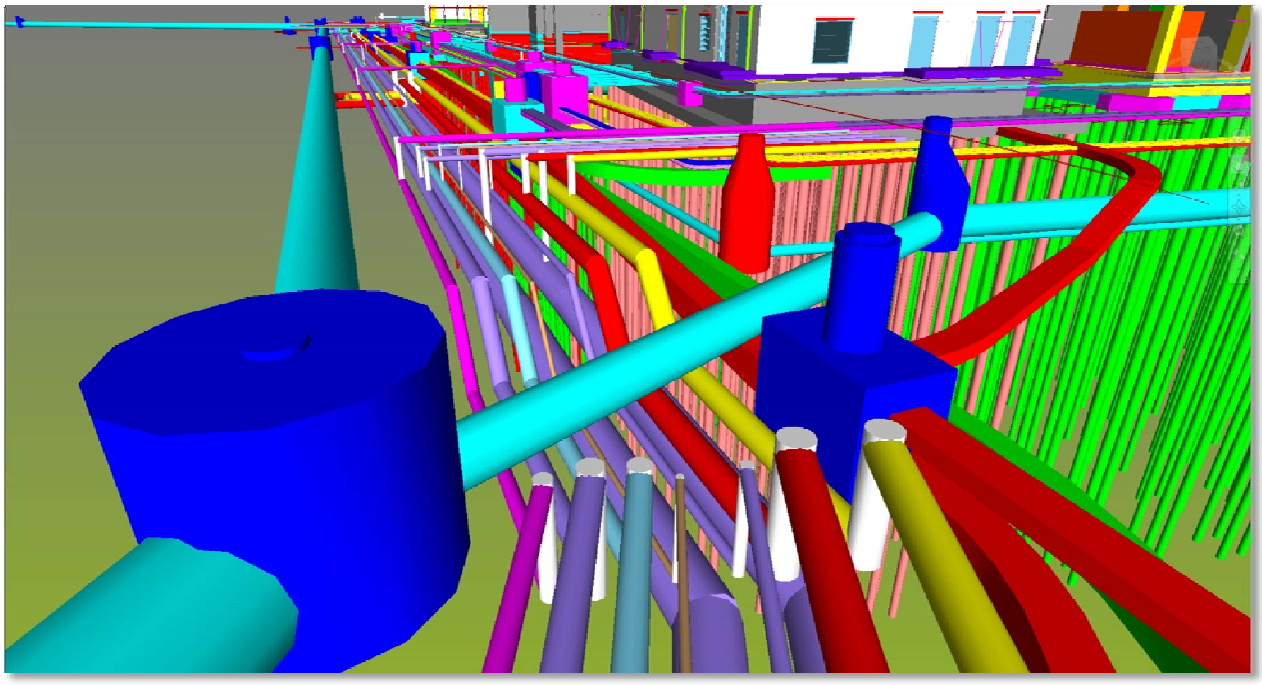


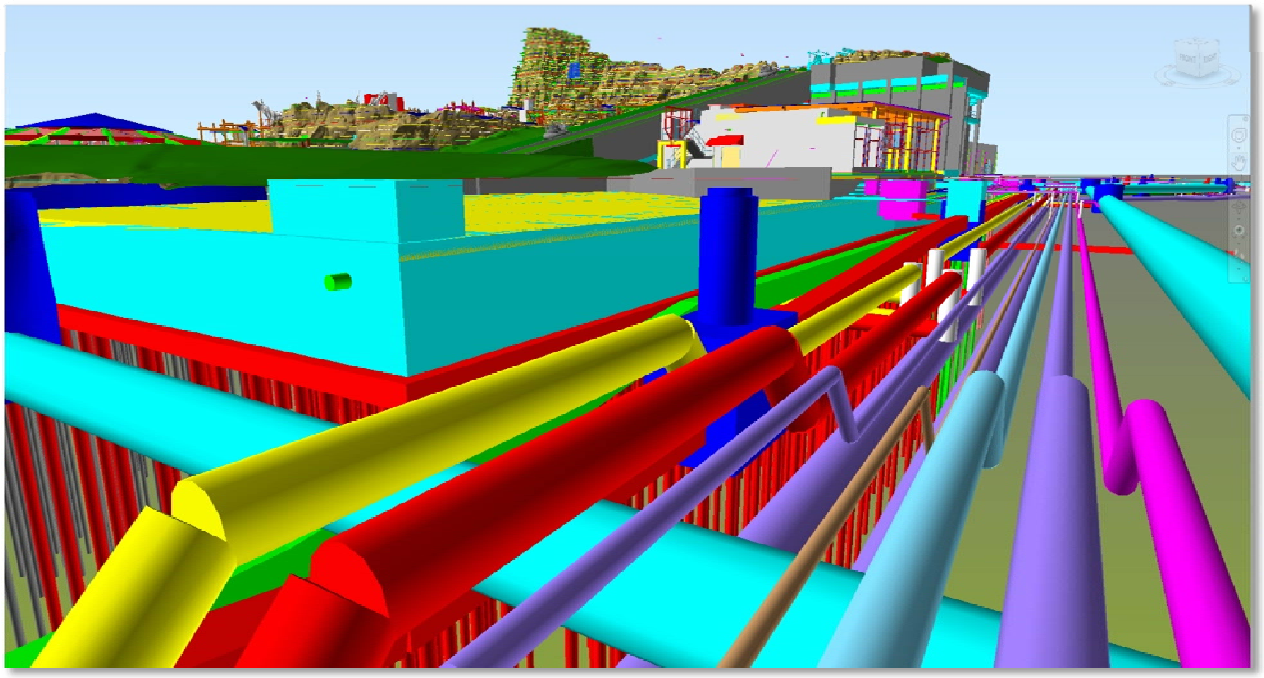
Figure 5: Occurrences like this are better seen during the design phase and not as RFI's. Also seen in the background are structural elements "poking" through the rockwork mesh. Being able to see this so early in the project is critical to cost and the formation of the story.

For our department, almost everything that is modeled is exported as data shortcuts and kept entirely in a Civil 3D format. Any AEC models that want to be used by other disciplines for design purposes are generally exported as 3D faces. This includes pipe networks and surfaces. We like 3D faces because it eliminates any hang-ups with file compatibility.

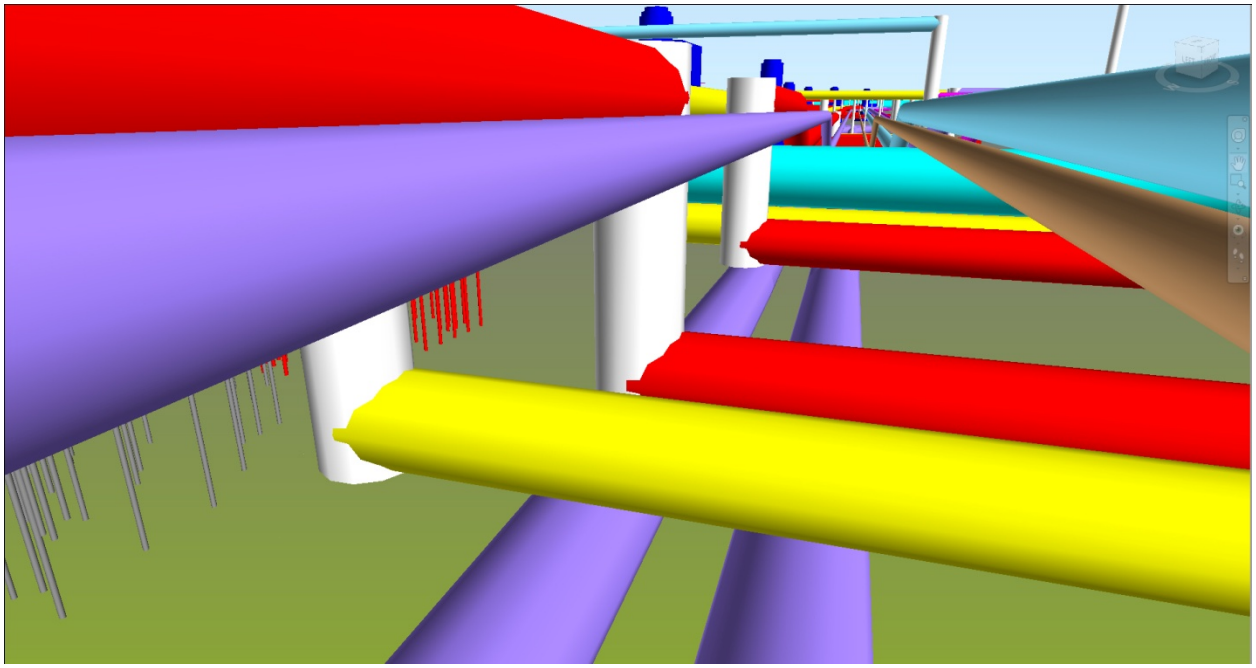
Just how extensive is it?



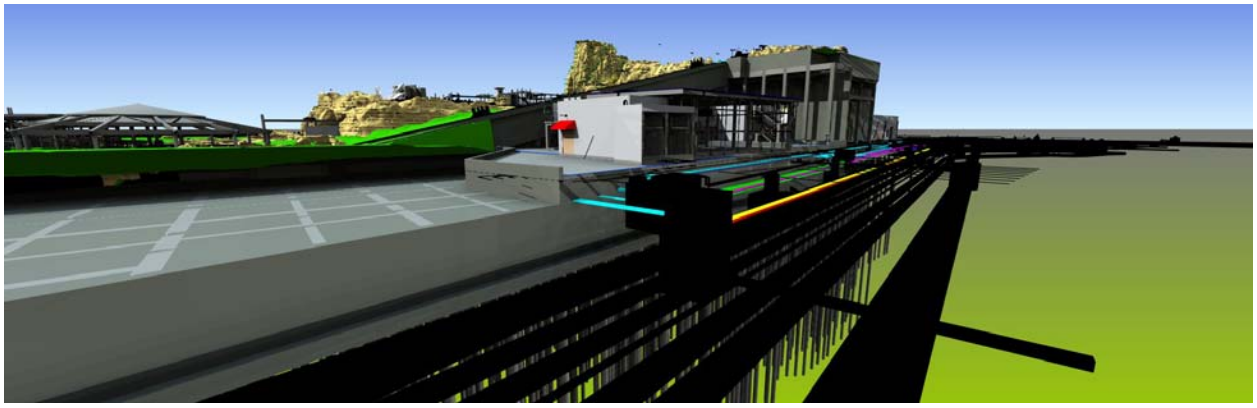
An image capture showing one of our more recent projects shows how extensive our utility systems can be. Custom parts based on real-world manufacturer's specs helps create the reality we need to make the magic. With Civil 3D we represent all utilities;



stormdrain, sanitary sewer systems, electrical and communication, and even pressure systems. Although Civil 3D 2012 (which is what we run) does not yet support custom fitting for pressure lines, we still make it happen. By simulating the fitting, based on our design specs, we can create the pipe as needed.



The above figure shows a utility corridor.



Overall our models have become an integral part of the BIM environment.

It takes a lot of people to make a park but it can take even more utilities to keep it running.

Virtually Finished – BIM the Civil Way

Integration of BIM into civil design has enormous potential as it has proved for us. I have no doubt that, when applied appropriately, it improves communication, fosters teamwork, and allows teams to demonstrate their expertise and experience. The key is to know when this tool makes sense from a cost-benefit perspective. These are a few factors that we've found that make the case:

Find what works for you; if possible avoid reinventing the wheel

We didn't reinvent the wheel, we just plussed it. Walt Disney coined the term plussing as a way of making an idea even better. Rather than opting to eliminate we retained a lot of the old ways of CD documentation. We improved on them by paralleling CAD designs with their 3D counterparts. This made transitioning into the new way more natural, and with less learning curve.

Inter-departmental support; find a go-to-person

Make sure you have a power user on deck that understands the 3D process well. That they understand Navisworks is a major plus. Knowledge of 3D file compatibilities is key to working well with Civil 3D. The questions will be many and real problems tend to arise outside of formal training sessions, so having quick answers is essential.

Model Everything

If it affects your design in any way, model it. If it is in close proximity to your design, model it. There is no other option now when you take into account the amount of data that is being asked for by other disciplines. Working in a vacuum is a thing of the past. Real-time collaboration through complete design models is the norm now.

Keep the Mistakes in the Office

Take advantage of Civil 3D's clash detection. Although your BIM team will take part in doing this, exporting out a flawless model is essential. Make Navisworks a part of your design tool set. It really goes together well with Civil 3D.

Train all the Time

Keep your staff up to date on all aspects of the software. With all the advancements that are being made everyday it's almost impossible to keep up in an ad hoc way.

Thanks and have a magical day.