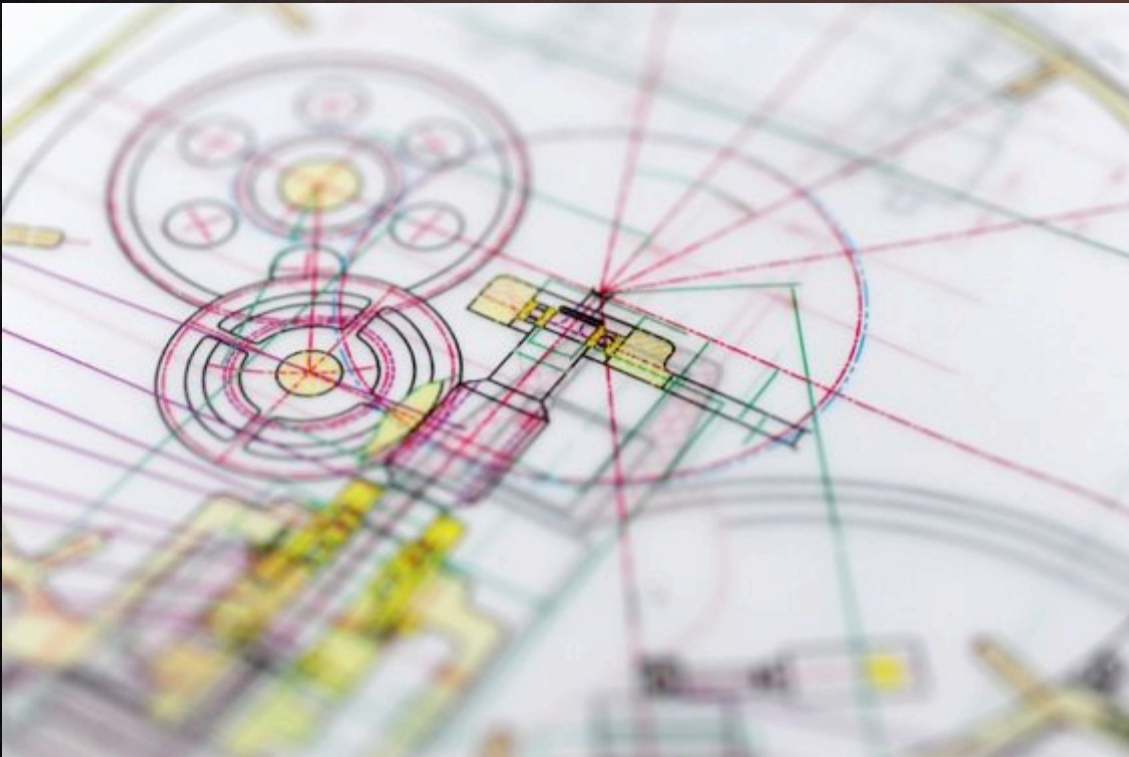


REINVENTING 2D CAD:

EMPOWERING TROUBLE-FREE 2D DRAWING CHANGE



To date, engineering organizations have compromised between Drafting Tools that cannot drive intelligent change and Feature-based Sketchers whose performance degrades with the hundreds if not thousands of 2D geometry entities on drawings. A third alternative, Direct Sketching, promises to power smart yet fast change for drawings, eliminating such time wasting efforts.

Published by:



REINVENTING 2D CAD: EMPOWERING TROUBLE-FREE 2D DRAWING CHANGE

Product development runs on drawings made from 2D geometry.

There is no argument: today's preferred means of designing products is 3D modeling. Feature-based modeling captures design intent so 3D models can react to change in smart ways. Direct modeling provides quick and easy ways to push and pull geometry of 3D models.

However, it is hard to argue that product development doesn't run on engineering drawings composed of 2D geometry. Even when a 3D model is available, the deliverable more frequently used by many downstream departments is based on 2D geometry. Manufacturing leverages drawings to develop production plans.

Purchasing utilizes drawings in technical packages. Quality, technical publications and marketing transform parts of drawings into many derived publications. That's quite a lot. But that's not the only application of drawings in companies.

Think about all of the drawings made up of 2D geometry that were generated before engineering organizations started building 3D models. Most manufacturers literally have thousands of such drawings that were developed over the course of many years. For the products that are still sold and serviced, that is sometimes the only documentation that exists. Those drawings must be put into circulation within the company for any change processes or refits.

What's the point in all this? It is simple.

If drawings based on 2D geometry are still so prevalent, why are our tools still so poor at manipulating them?

Think about the tools that organizations have on hand to modify drawings composed of 2D geometry. There are

Drafting Tools that trim, cut, merge and extend 2D geometric entities one by one, offering no intelligent change, that was developed back in the '80s. Then there are Feature-based Sketchers that offer intelligent change, but are easily overwhelmed by large numbers of 2D geometric entities, that was developed back in the '90s when parametric feature-based modeling first emerged. In short, organizations must compromise between outdated tools from completely different eras.

Next, consider what's occurred in the CAD industry over the past few years. There are new innovations surfacing left and right. Yet why has no progress been made on the front of modifying drawings constructed from 2D geometry?

The good news is that this story is still being written. Direct Sketching, an alternative for working on drawings built on 2D geometry, has arrived. It powers fast and intelligent change to these deliverables in ways Drafting Tools and Feature-based Sketchers cannot.

That's where this eBook comes in. It provides research findings on just how widely drawings based on 2D geometry are still being used. It dissects how and why Drafting Tools and Feature-based Sketchers fall short. It delves into Direct Sketching, which offers new approaches to creating and editing drawings made with 2D geometry.

Don't lose hope just yet. Don't just assume wasting inordinate amounts of time working on 2D geometry is just a cost of doing business. Because the story is still being written.

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Are 2D Drawings Really Still Prevalent?

Given all the talk about 3D modeling today, it is a fair question to ponder. Findings from the 3D Collaboration and Interoperability study, shown in the figure on the right, provide some factual insights.

- **2D Formats Rank as the 2nd and 3rd Most Frequently Used External Exchange Medium:** For some, the motivation is the protection of intellectual property. For others, the cause lies in the inability of suppliers to accept designs in 3D formats. The reality is that 2D formats are a widely used exchange format with external parties.
- **2D Drawings are Used More Frequently than 3D Models for Several Non-Engineering Purposes:** Those cases occur across many departments, including service, procurement, sales, quality, training and technical publications. Here, the reality is that 2D drawings are widely used by many non-engineering organizations.

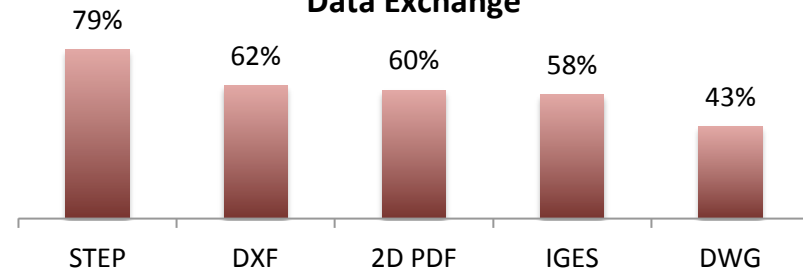
What's the point here?

Well, the point *isn't* that drawings based on 2D geometry are better than 3D modeling. There are scenarios, like concept design, where the use of 2D tools is legitimate. However, the generation of 2D drawings from 3D modeling is fast route to documenting a design.

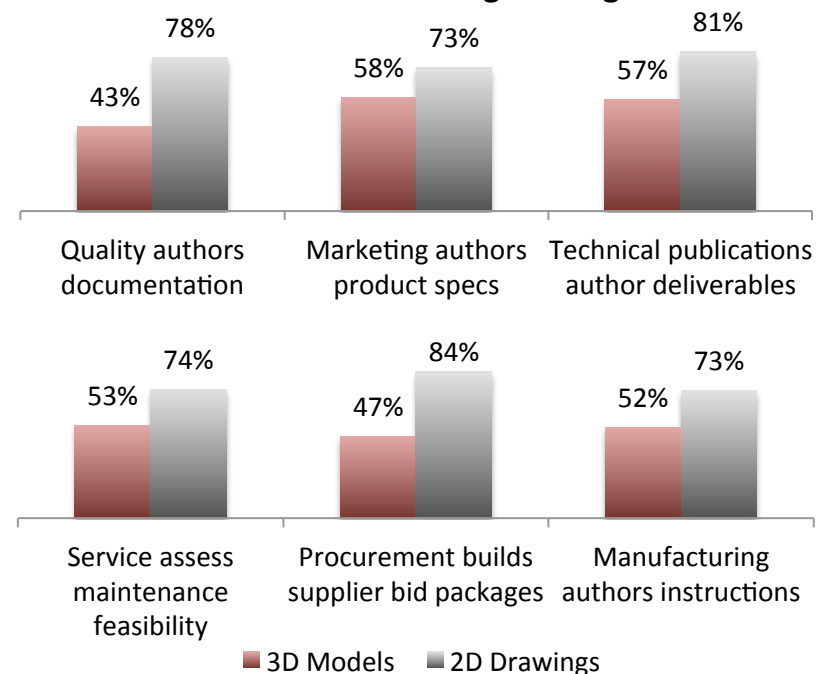
The point *is* that 2D drawings are still used in a number of circumstances for manufacturers, not in just a few exceptions that can be ignored. Each of these scenarios needs to support design change. So, the most appropriate next question is simple.

What technologies best support 2D drawing change?

Most Frequently Used Formats for External Data Exchange



Frequency of use of 2D Drawings and 3D Models outside Engineering



Finding from the 3D Collaboration and Interoperability Study, published May 2013, 848 respondents

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Generating Drawings from 3D Models

The reality today is that most engineering organizations create their drawings by laying down views of 3D models. Furthermore, as changes to a design are made, the 3D model is modified, which then propagates to the views on the drawing through associativity capabilities. Practically every modern CAD software application provides this kind of functionality.

Given that, why are we talking about modifying drawings with tools that manipulate 2D geometry? There are two good reasons for doing so.

Breaking Associativity During External Exchanges

In most exchanges of design data with external organization, associativity between 3D models and drawings derived from them are broken. As shown by findings from the 3D Collaboration and Interoperability study, neutral formats that utilize 2D geometry are two of the top three most frequently used exchange mediums with external parties. Exporting drawings from CAD software application transforms those views of 3D models into 2D geometry that is no longer associative. Those drawings are then often used as the collaboration medium, with markups and comments. Furthermore, it can also be used as a legal specification for delivery.

Breaking Associativity During Long Term Archival

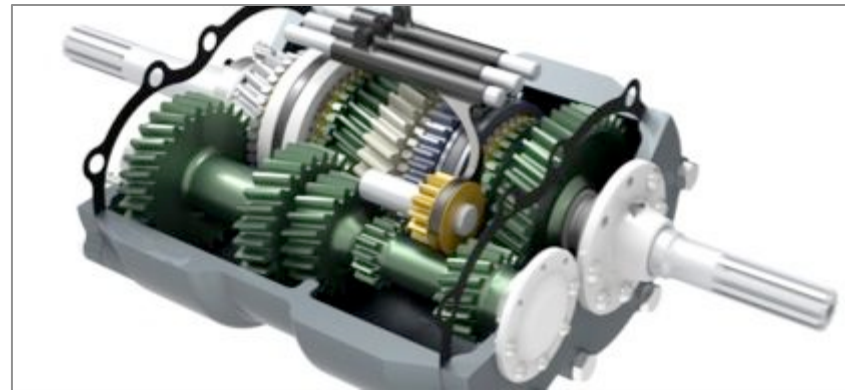
In addition to the practice of exchanging drawings with 2D geometry that are no longer associative to 3D models, many engineering organizations must develop a strategy to archive documentation for their products for the long term. As CAD software applications offer

improved capabilities release after release, they can sometimes break the ability to open drawings and 3D models built in prior releases. Engineering organizations could open up every drawing and 3D model made in the history of their company and fix every issue that occurs, but it is a significant effort that few can afford in today's tight schedules.

Instead, many export such drawings and 3D models into neutral formats. This strips the features away from 3D models and breaks the associativity that drives change to related drawings. But, it does practically guarantee that those deliverables can be opened and used in the future.

Brief Conclusion

In these two cases, the associativity between 3D models and drawings are broken. Therefore, the only means of making changes to the drawings is to modify the 2D geometry. That's the reality in today's product development environment, even with the widespread adoption of 3D model to drawing associativity. As a result, tools to manipulate the 2D geometry in drawings are still needed.



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Modifying Drawings with Drafting Tools

When designers and engineers have to manually change drawings with 2D geometry, they often revert back to Drafting Tools that were used for the job for years before 3D modeling became widespread. These tools trim, extend, copy, delete and perform other operations to 2D geometry like lines, curves, arcs and splines.

Modification Capabilities that Don't Scale

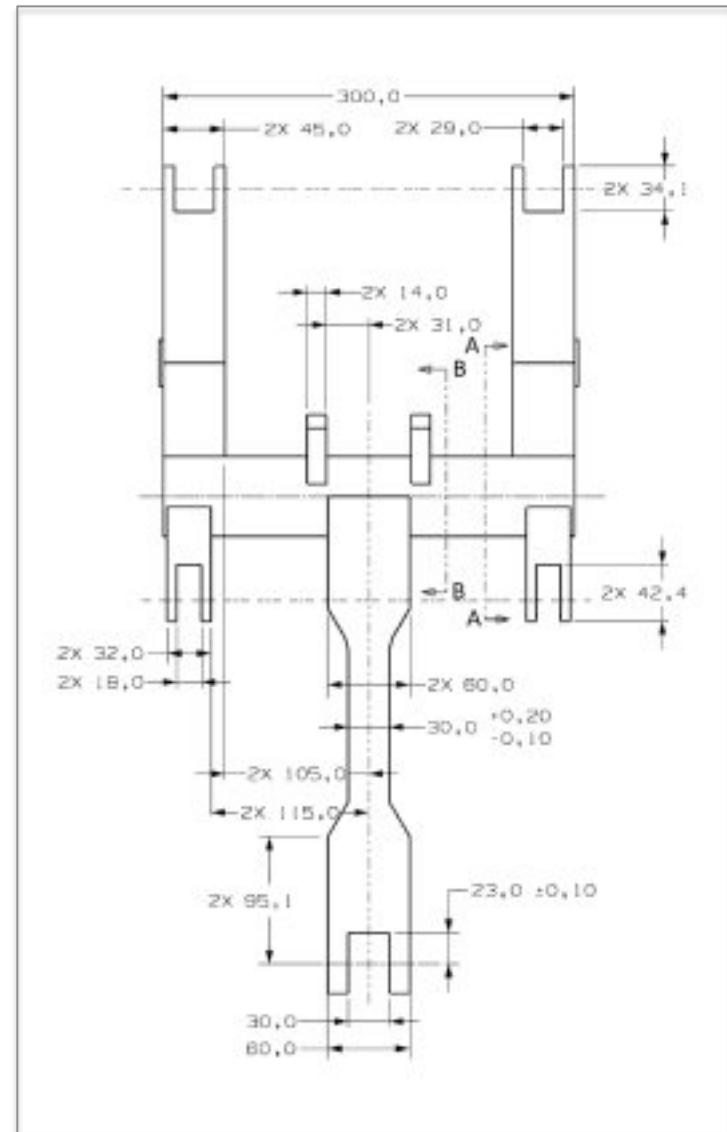
Drafting Tools can handle simple changes that require modifications to individual 2D geometric entities. Many such changes, unfortunately, involve the manipulation of chains of lines, curves, arcs and splines that need to be moved or scaled as one group. As a result, changes that are not simplistic take inordinate amounts of time.

Capturing and Enforcing Design Intent

Drafting Tools also run into problems when the designs represented in drawings carry design intent. This occurs when designers and engineers want to apply user-defined rules to the 2D geometry such as parallelism, concentricity and more. Drafting Tools offer little to no ability apply and then enforce such rules. With every modification, designers and engineers have to remember what design intent to consistently enforce, hoping they don't forget one along the way.

Brief Conclusion

In summary, modifying 2D geometry in drawings with Drafting Tools is a cumbersome and slow affair. They don't enable smart change. They don't support design intent.



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Modifying Drawings with Feature-based Sketchers

Instead of employing Drafting Tools for the modification of drawings composed of 2D geometry, designers and engineers can use Feature-based Sketchers as an alternative. These tools create sections made out of 2D geometry that are used to extrude, revolve or sweep to create or remove solid geometry in 3D models. As a first step, it's important to understand how these tools are different from Drafting Tools.

Feature-based Sketchers Require Full Definitions

The location of each 2D geometric entity is precisely known as it is created in Drafting Tools. However, when Feature-based Sketchers are used, the location of each 2D geometric entity is abstracted. This is done in order to provide parametric control of modifications to the section. As such, principles long used to detail engineering drawings are applied. The location of each 2D geometric entity must be fully defined through some combination of dimensions and constraints.

Feature-based Sketchers allow specific combinations of dimensions and constraints to be created. But, it is far more common that Feature-based Sketchers auto-dimensioning capabilities are used to do this automatically for the section. This is done over and over again as Feature-based Sketchers enforce, reapply and adjust those definitions schemes to sections in real-time, even during modifications.

These capabilities are powerful for sections that are used in features to build 3D models. But are they right for developing layouts with 2D geometry?

As 2D Geometry Totals Rise, Performance Degrades

In reality, drawings can have hundreds if not thousands of 2D geometric entities in them. As Feature-based Sketchers enforce, reapply and adjust combinations of dimensions and constraints for sections in real-time, performance degrades rapidly: even become completely unresponsive.

Brief Conclusion

The requirement for Feature-based Sketchers to completely define sections works well with features, where it can drive intelligent change across 2D entities. In drawings, however, all that powerful capability is rendered useless in the face of hundreds, if not thousands, of 2D geometric entities.



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Modifying Drawings with Direct Sketching

Manually modifying the 2D geometry in drawings is a daunting task. Drafting Tools and Feature-based Sketchers both have their drawbacks. In the past couple of years, Direct Sketching have emerged as a means to power intelligent change to drawings that performs even when working with thousands of 2D geometric entities. Here's how these tools do it.

Explicitly Locating 2D Geometry

Unlike Feature-based Sketchers, Direct Sketching does not abstract and then locate 2D geometric entities with combinations of dimensions and constraints. Instead, they use a method more similar to Drafting Tools, where locations are already explicitly known in space.

By avoiding the Feature-based Sketching approach of enforcing, reapplying and adjusting those definitions schemes to sections in real-time, the performance of Direct Sketching does not degrade.

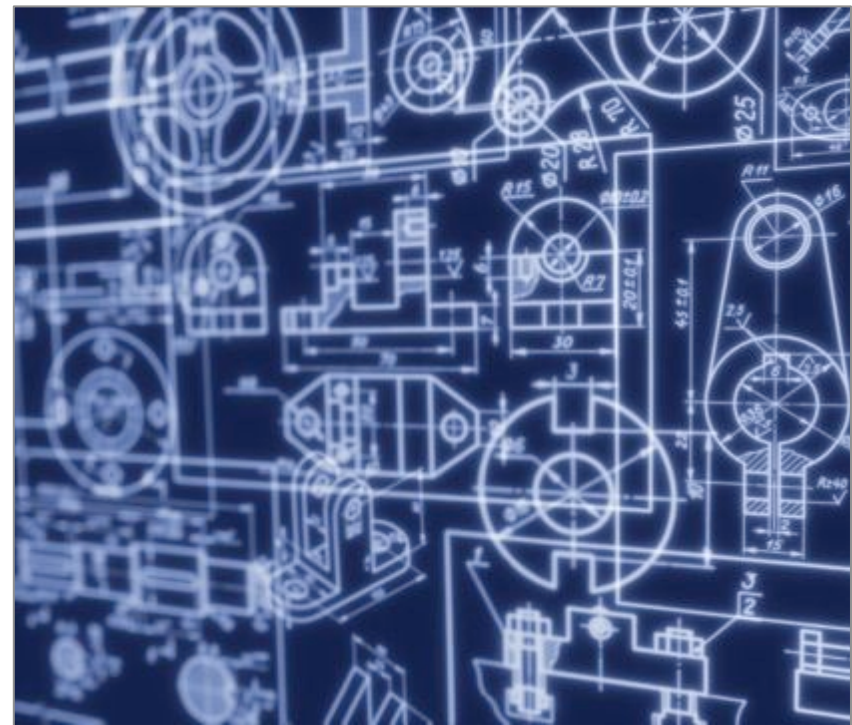
Temporary Instead of Persisted Assumptions

When designing with 2D geometry, an important objective is to drive smart change instead of modifying individual lines, curves, arcs and splines. Without some combination of dimensions and constraints that locates every 2D geometric entity, how does Direct Sketching drive smart change?

The answer is that Direct Sketching does in fact make assumptions, much like dimensions and constraints used by Feature-based Sketchers, about the relationships between 2D geometric entities. These assumptions, however, are only *temporary* instead of *persisted*.

More specifically, during the modification of 2D geometry, Direct Sketching applies and enforces assumptions to enable smart change. Once the modification is complete, however, those assumptions are removed. Initiating a different modification creates a new set of assumptions that enable that change.

Therein lies one critical difference between these tools. Feature-based Sketchers remembers the combination of dimensions and constraints for a *section*, constantly trying to enforce, reapply and adjust in real-time. Direct Sketching only creates and uses assumptions during the change, and not otherwise.



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Local Instead of Global Assumptions

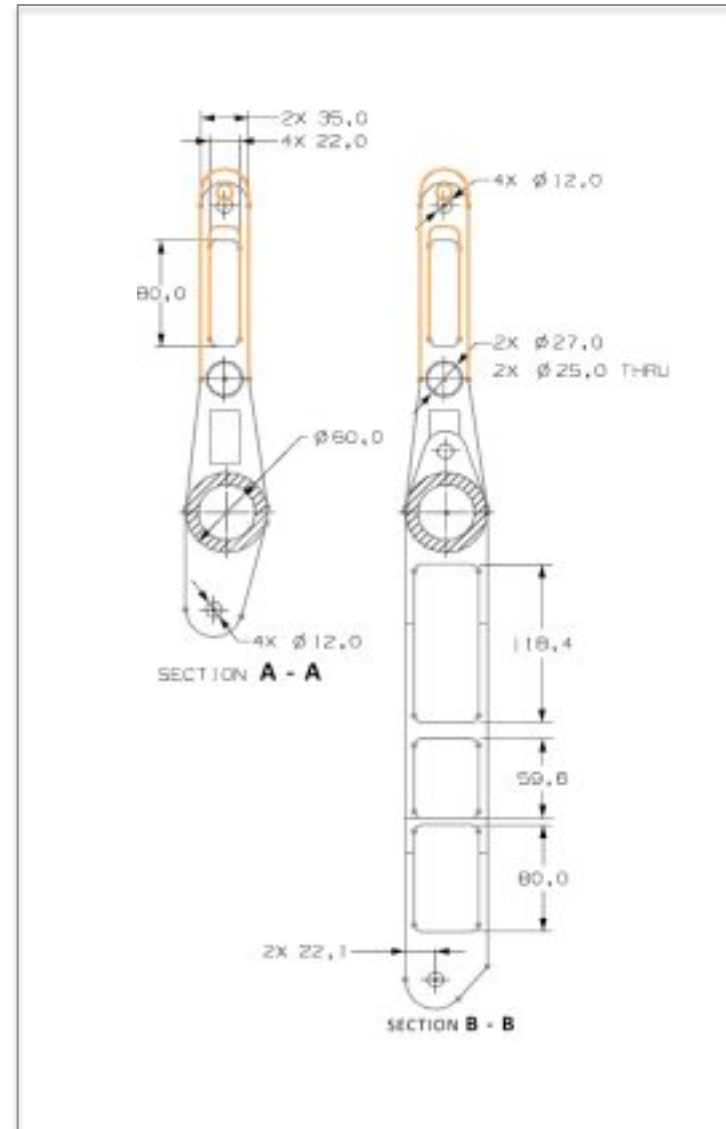
Another critically important difference between Direct Sketching and Feature-based Sketching is the scope in which these assumptions are applied. Instead of developing *global* combinations of dimensions and constraints as Feature-based Sketchers do, Direct Sketching instead only develops assumptions *local* to the 2D geometry selected for modification. That, in turn, means that Direct Sketching analyzes far fewer 2D geometric entities for assumptions than Feature-based Sketchers analyze for dimensions and constraints.

While the difference is subtle, the difference it makes in performance is not. Where Feature-based Sketchers can become unresponsive for long amounts of time, Direct Sketching has no issue making dynamic modifications.

Defining Global Design Intent

As discussed earlier, designers and engineers need to be able to apply and enforce certain design intent on the 2D geometry in drawings. Drafting Tools offer no capability in that regard. Feature-based Sketchers automatically enforce far too many.

In contrast, Direct Sketching enables designers and engineers to manually create dimensions and constraints alongside the assumptions they use to govern modifications. Even if they apply to 2D geometry that is not local to each other, Direct Sketching enforces them. This offers a means of embedding design intent in 2D geometry alongside the advantages already described for Direct Sketching.



REINVENTING 2D CAD: EMPOWERING TROUBLE-FREE 2D DRAWING CHANGE

What's the Value of Fast 2D Drawing Changes?

So far, this eBook has touched upon a wide range of topics related to drawings based on 2D geometry. Such drawings are still widely used in product development. Drafting Tools lack the capabilities to make fast and smart change. Feature-based Sketchers bog down as they run into the hundreds if not thousands of 2D geometric entities in drawings. Direct Sketching, with a capacity to power intelligent change quickly, has emerged. Next, the value in making modifications to these drawings in a fast and smart manner will be explored.

The Value of Faster Change for the Company

Let's look at it from an organizational perspective. Modifying drawings based on 2D geometry has two impacts on the organization, both of which are related to time.

First and foremost, spending inordinate amounts of time to complete such modifications, especially when it is unexpected, cause delays in the development schedule. Timeframes for development projects are always getting shorter. Any delay can have a serious impact.

Second, time spent painstakingly changing 2D geometric entities on drawings is time taken away from design activities. Fundamentally, modifying 2D drawings is all about documenting design decisions you have *already made*. The more time you spend on that, the less time you have exploring new alternatives and assessing designs for decisions you have *yet to make*.

As an organization, the objective with respect to modify drawings with 2D geometry is to minimize the amount of time it takes. Put simply, it is a non-value added activity in the design cycle.

The Value of Better Designs for the Individual

This issue, however, isn't all about the company. There are implications for individuals as well.

Let's be honest; modifying 2D geometry on drawings can be a mind-numbing task. Few engineers get their degree because they wanted to move lines, curves, arcs and splines around. Instead, most go into engineering to design great products and to find innovative solutions to challenging problems.

Given that perspective, this issue is about fulfillment as well. And just like the organization, the goals are to minimize time spent modifying 2D drawings and maximize time spent on design.



REINVENTING 2D CAD: EMPOWERING TROUBLE-FREE 2D DRAWING CHANGE

Summary and Conclusion

Despite a monumental push over the past twenty years, many product development processes are still highly dependent on 2D geometry based drawings. Let's recap the most relevant topics from this eBook on this issue.

The Prevalence of 2D Drawings

Findings from the 3D Collaboration and Interoperability study reveal that the 2nd and 3rd most frequently used formats for exchange with external parties are based on 2D geometry. Furthermore, many departments, including service, procurement, sales, quality, training and technical publications still use drawings to create their own deliverables. Today, drawings with 2D geometry are still widely prevalent in product development. As such, modifications to such deliverables need to be supported.

Modifying Drawings with Drafting Tools

One approach of modifying 2D geometry in drawings is to leverage Drafting Tools. However, manipulating individual 2D geometry entities undermines the possibility of intelligent change. As a result, even simple changes can take inordinate amounts of time.

Modifying Drawings with Feature-based Sketchers

Another way of changing 2D geometry in drawings is to use Feature-based Sketchers that build sections for features. While these tools can drive intelligent change, they bog down as the number of entities rise into the hundreds. Consequently, users often waste time as CAD software applications become unresponsive.

Modifying Drawings with Direct Sketching

Fortunately, a new option is available in the form of Direct Sketching, which address many of the shortcomings of Drafting Tools and Feature-based Sketchers. They use local temporary assumptions to power smart changes to 2D geometry without performance degradation as well as offer the means to embed global design intent as necessary.

The Value of Fast 2D Drawing Change

There are advantages to driving faster and smarter change to 2D geometry in drawings both for the company and the individual. For the organization, it translates into staying on schedule and spending more time on design. For individuals, it means less time spent on mind-numbing 2D drawing change and more fulfillment from actual design work.

Currently, many organizations look at modification of 2D geometry in drawings as a time intensive cost of doing business. With Direct Sketching, there is a opportunity to recoup precious time in the development schedule.

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