REINVENTING 2D CAD:

FUELING RAPID AND INTELLIGENT LAYOUT

The tools that designers and engineers have used to develop layouts from 2D geometry haven't changed much of the past couple decades. There is, however, hope on the horizon. Direct Sketching offers fast and intelligent change, fueling rapid machine layout.

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Machine design is distinctively different from product design.

And it shows. Of course, the individual parts in machine design aren't necessarily more complex than those in product design. The complexity instead lies in the function of the overall machine. The sheer number of parts is, in general, higher. Machine design often support a continuous operation or process, so the functions provided are complex as well.

A key component of machine design is the layout. With it, designers and engineers pin down the big picture of the design. They use layouts to figure out how to size key equipment like motors and pumps. They use them to define the requirements and parameters for systems and sub-systems. It's critical to the design process.

In recent years, some engineering organizations have begun to develop their layouts in 3D models. Frequently starting from scratch, their designers and engineers invest a significant amount of time into such an effort. They model each piece of equipment or download them from suppliers. They built out stock components that can then be tweaked to each design. While such endeavors are admirable, few organizations can afford the time to do so. Most organizations find it easier and faster to do what they've been doing for decades: develop the layout using 2D geometry

The tools that designers and engineers have used to develop layouts from 2D geometry haven't changed much of the past couple decades. Drafting Tools can modify lines, curves, arcs and splines individually, but does not fuel rapid modifications. Feature-based Sketchers power intelligent change, but bog down as the number of 2D geometric entities increase into the hundreds, which is frequently the case with layouts. In the end, designers and engineers are forced into an ugly compromise: employ fast but unintelligent tools or smart but performance-poor tools. Either way, they lose.

There is, however, hope on the horizon. Direct Sketching, which apply direct modeling concepts to 2D geometry, enables intelligent change without performance degradation. Ultimately, Direct Sketching can fuel rapid and intelligent layout.

In this eBook, more details on all these topics. It includes more background for layout work. It specifies how Drafting Tools and Feature-based Sketchers work in the context of layouts. It also offers more information on the critical capabilities of Direct Sketching.

Developing layouts is a critical step in the design process. The time for it to become far less taxing is overdue.

The Context of Designing with Layouts

Unfortunately, layouts based on 2D geometry rarely, if ever, start from a clean sheet. New designs either extensively borrow from previous work or use it wholesale. The specifics of how past work is reused is critical to understanding how tools can succeed or fail.

Layouts Inherently Include Lots of 2D Geometry

Layouts frequently start with an existing drawing or section of a completed design. From there, designers and engineers often deconstruct such prior work, separating out the items, components and equipment so they can be removed, moved, replaced or modified in the layout. In parallel, they also create or pull in the representations of off-the-shelf or custom built components and equipment that will be purchased into the layout.

It is important to understand that while all of these is happening in the layout, the number of 2D geometric entities is very large, numbering in the hundreds if not thousands, and only increases. These layouts tend to be very large.

The Layout's Purpose is to Iterate and Explore

In all of this activity, it is easy to forge the actual purpose of the layout. The layout is really an artifact that enables design work, not just documentation for fabrication, assembly or manufacturing.

Designers and engineers use layouts to iterate and explore different options and alternatives. This can include creating multiple layouts, often organized into different sets that lay on top of each. It is not uncommon to use colors to visually differentiate between the different options.

Here's the key though: the more they test out various design possibilities, the higher the likelihood that they will find a choice that costs less to produce, fulfills its function more completely and meets numerous other requirements. Ultimately, that is the overall purpose of any design activity. Layouts are one mechanism to accomplish that goal.

Using Drafting Tools to Create Layouts

For decades now, Drafting Tools have commonly been used to create and modify 2D geometry in layouts. In general, these tools allow designers and engineers to trim, extend, copy, delete and perform other operations to 2D geometry like lines, curves, arcs and splines. These tools are also used to develop and change engineering drawings as well.

Unintelligent Capabilities undermines Design Speed

When it comes to using Drafting Tools for layouts, a major challenge lies in the amount of time needed to do this kind of work.

As mentioned earlier, layouts regularly have a large number of entities, numbering in the hundreds or thousands. With Drafting Tools, the lines, curves, arcs and splines in the layout can be manipulated on a one-by-one basis, even if they make up one unbroken chain.

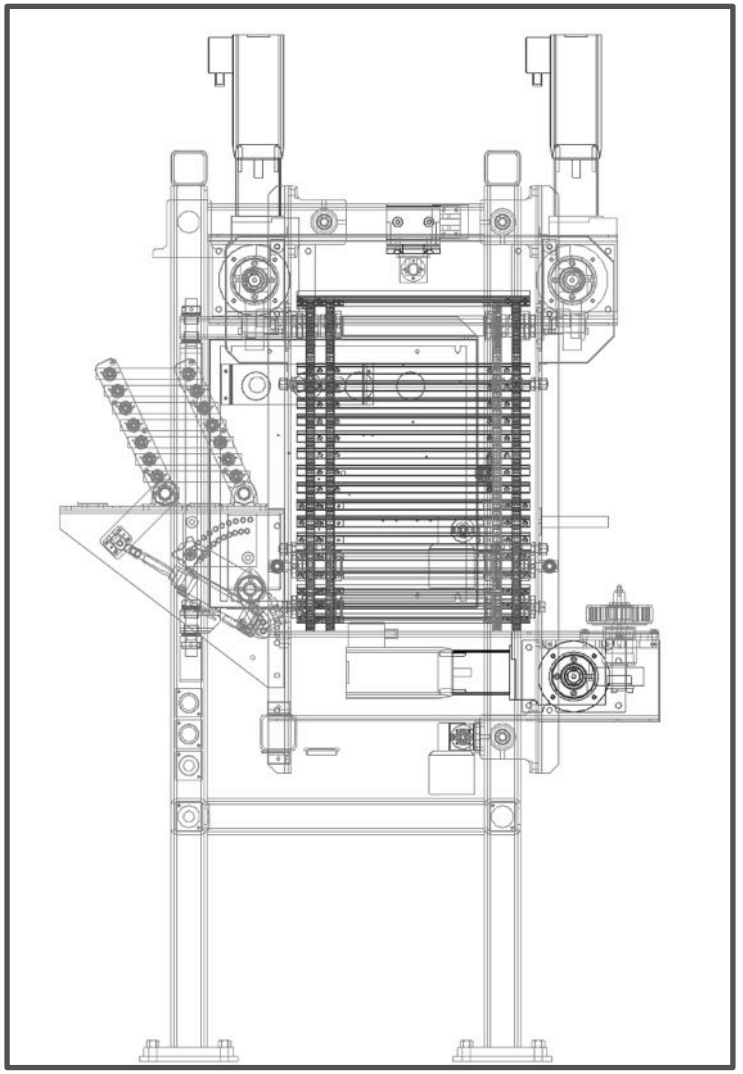
It's that simple. The failure of Drafting Tools to drive intelligent change across connected 2D geometric entities undercuts its usefulness for layouts.

Applying and Enforcing Design Intent

A different issue that undermines the effectiveness of Drafting Tools when developing layouts is the inability to create and apply rules. Designers and engineers need the power to define behaviors to 2D geometric entities, such as maintaining concentricity or staying horizontal.

The lack of this capability in Drafting Tools force designers and engineers to enforce such rules manually, hoping they don't forget one along the way.

In summary, 2D Drafting Tools lack several key capabilities needed to productively develop layouts. They were useful in the past, but the needs of designers and engineers have changed. New tools are needed.



Using Feature-based Sketchers for Layouts

When it comes to developing layouts using 2D geometry, Feature-based Sketchers distinctly stand out compared to Drafting Tools. They develop the sections that are used to extrude, revolve or sweep to create or remove solid geometry in 3D models. To decide whether or not Feature-based Sketchers are the right for developing layouts, it is important to understand how they work with 2D geometry.

Feature-based Sketchers and Fully Defined Sections

In Drafting Tools, the location of each 2D geometric entity is precisely known as it is created. When Feature-based Sketchers are used, alternatively, 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.

Designers and engineers can certainly manually create specific combinations of dimensions and constraints for sections. Though it is far more common that Feature-based Sketcher auto-dimensioning capabilities are used to do this automatically for the section. In fact, this automated capability isn't a one-time action. Modern sketchers often 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

As mentioned early in this eBook, layouts frequently start with an existing drawing or section of a completed design which include hundred and perhaps even thousands of 2D geometric entities.

Problems arise as Feature-based Sketchers enforce, reapply and adjust combinations of dimensions and constraints in this context. For sections with tens of 2D geometric entities, there are few problems. But once the numbers rise into hundreds and thousands, as they are in layouts, performance degrades rapidly. In fact, they often become unresponsive.

Hindering Design Exploration and Iteration

In addition to causing performance issues in layouts, Feature-based Sketchers' needs to fully define sections also inhibit efforts to explore and iterate design options and alternatives. Specific combinations of constraints and dimensions cause some attempted changes to fail, requiring modifications to the section definition.

The goal of any design effort is to find better designs by iteration and exploration. CAD software applications shouldn't make those efforts harder. They should make them easier, especially when developing layouts with 2D geometry.

Using Direct Sketching to Create Layouts

For developing layouts with 2D geometry, compromise has been the name of the game for designers and engineers selecting Drafting Tools or Feature-based Sketchers. A new option, in the form of Direct Sketching, offers intelligent change, doesn't inhibit design exploration and performs well even as the number of 2D geometric entities climbs. Here's an overview of the critical capabilities of Direct Sketching.

Explicitly Locating 2D Geometry

Previously, knowing how Drafting Tools and Feature-based Sketchers work with 2D geometry was important to grasping how they manipulate them. This section does the same with Direct Sketching.

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 similar to that used by Drafting Tools, where locations are already explicitly known in space.

This immediately stands as an initial difference between Feature-based Sketching and Direct Sketching. By avoiding the approach of enforcing, reapplying and adjusting combinations of dimensions and constraints to sections in real-time, the performance of Direct Sketching does not degrade.

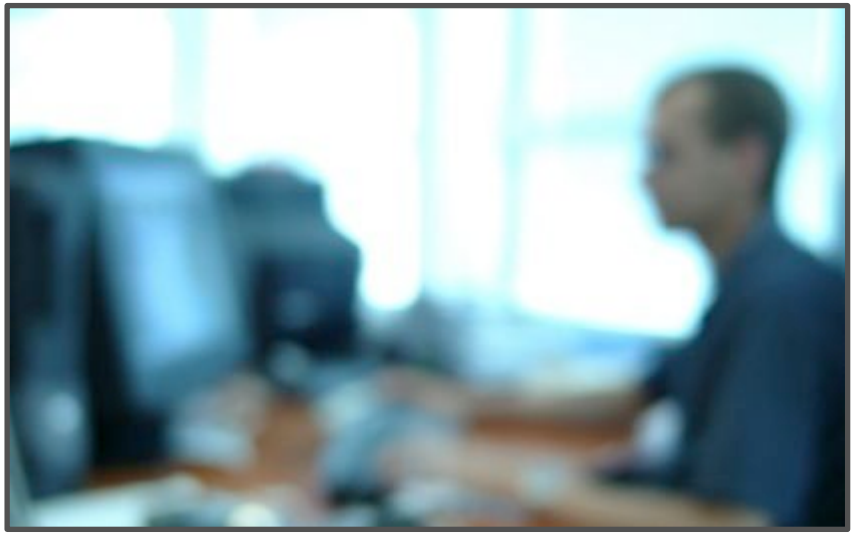
Temporary Instead of Persisted Assumptions

As developing layouts qualifies as design work, speed is naturally important to iterating and exploring many options and alternatives. Intelligent change is a critical part of that.

Direct Sketching makes assumptions about the relationships between 2D geometric entities, very similarly to how Feature-based Sketching uses dimensions and constraints to make smart changes. These assumptions, however, are only *temporary* instead of *persisted*.

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

That simple difference lies at the heart of a significant advantage between Feature-based Sketching and Direct Sketching. 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.



Local Instead of Global Assumptions

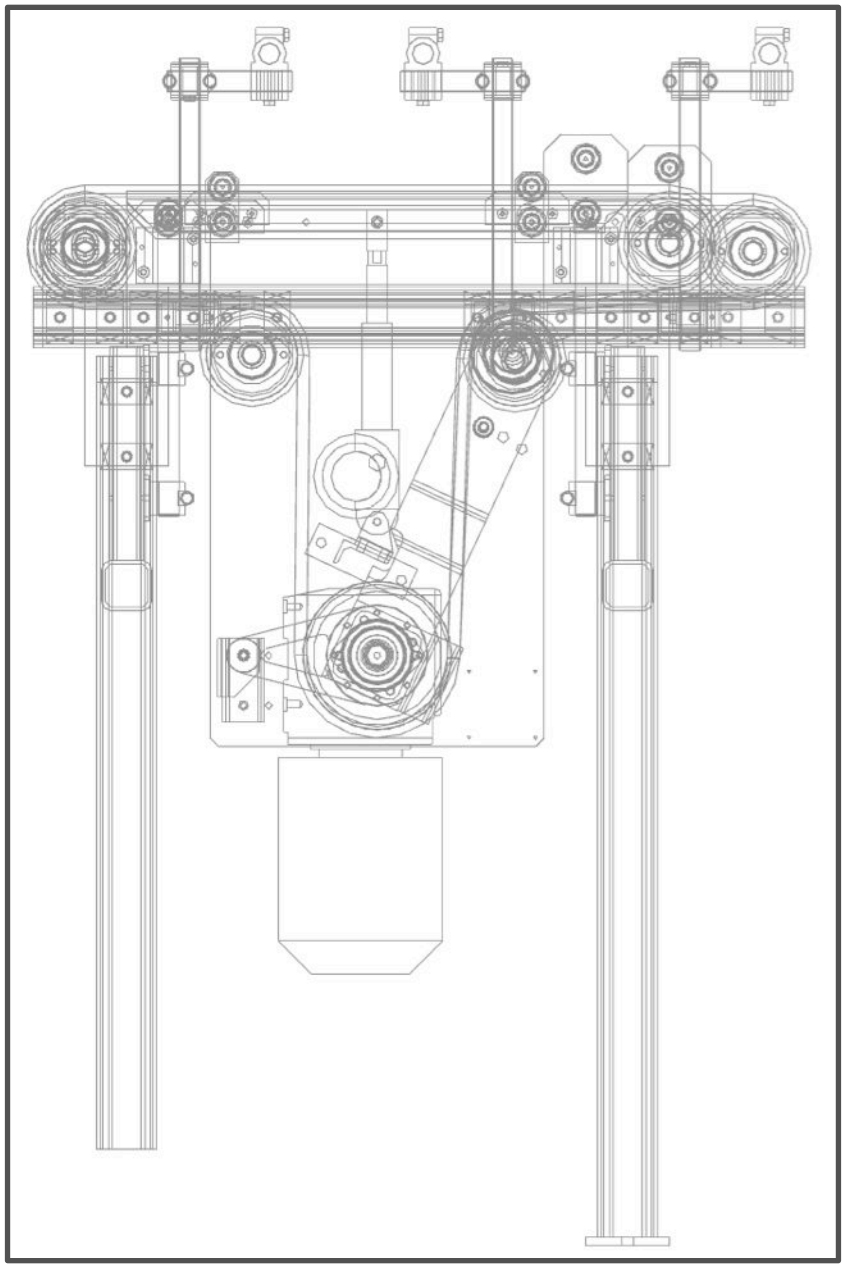
Applied the same set of 2D geometry, temporary instead of persisted assumptions offers a negligible advantage in terms of performance. In fact, the Direct Sketching approach of creating and using new assumptions for every change would further impair performance compared to the one time definition of assumptions by Feature-based Sketchers. The difference, however, lies in the scope of the assumptions.

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. That offers a performance advantage.

Defining Global Design Intent

Of course, temporary and local assumptions offer advantages in the form of swift and smart change to 2D geometry. However, it is also important to be able to apply and enforce design intent.

With Direct Sketching, designers and engineers can manually create dimensions and constraints. 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.



The Value of Rapid and Intelligent Layout

In this eBook, the context of layouts with 2D geometry has been defined, the application and issues of Drafting Tools and Feature-based Sketchers have been detailed and the critical capabilities of Direct Sketching have been described. It is also very vital to understand the impact of fueling rapid and intelligent layout, both for the company and the individual.

The Value to the Company

What is the value to a company of developing layouts more efficiently?

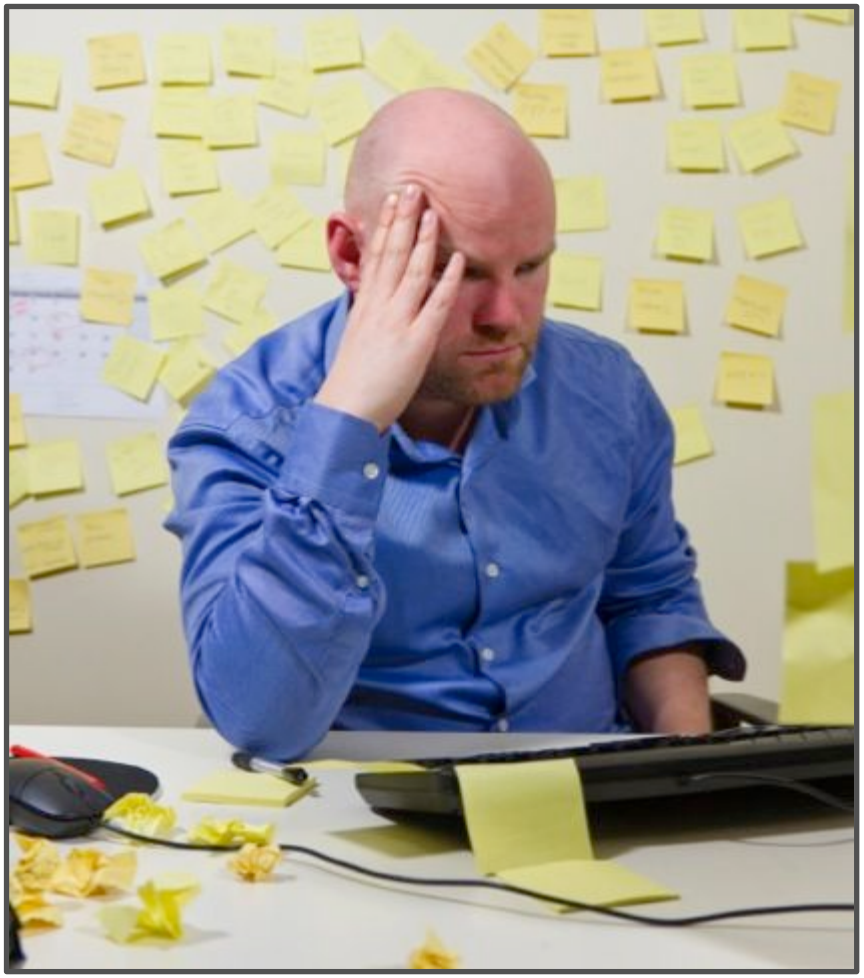
The answer to that question lies in the value that design and engineering provides. Layouts enable the iteration and exploration of different options and alternatives. The more that designers and engineers can do that, the more likely they can find a better design.

In turn, better design can equate to more completely fulfilling a customer's requirements, lowering the cost of goods or even winning customer contracts. While the answer to this question will vary dramatically from company to company, it's fairly safe to say that the outcomes are almost all positive and meaningful in one way or another.

The Value to the Individual

Developing layouts more rapidly and intelligently isn't all about the company. There are also important advantages for the individual designer and engineer.

Today's designers and engineers often have to meet tight deadlines in project schedules by working late and on the weekends. For them, exploring layouts and assessing them swiftly can reduce the amount of extra hours spent at the office.



Summary and Conclusion

For most, the development of layouts using 2D geometry isn't going away anytime soon. Let's recap the most critical issues covered in this eBook.

The Context of Designing with Layouts

New layouts often start with an existing engineering drawing, including hundreds if not thousands of 2D entities, as the background context. The goal for designers and engineers is to iterate and explore new options and alternatives, ultimately using the layout to find a better design.

Developing Layouts with Drafting Tools

Drafting Tools are often used to create and modify layouts with 2D geometry. Issues arise, however, because Drafting Tools allow the modification of entities on a one-by-one basis, undermining efforts to quickly iterate and explore alternatives and options.

Developing Layouts with Feature-based Sketchers

Feature-based Sketchers enable intelligent change, however, their performance degrades as the number of entities climb into the hundreds. Furthermore, a sketcher's need to fully define a section with dimensions and constraints hinders efforts to quickly iterate and explore alternatives and options.

Developing Layouts with Direct Sketching

Direct Sketching uses local temporary assumptions to power smart changes to 2D geometry without performance degradation, yet offer the means to embed global design intent as necessary.

The Value of Rapid Machine Layout

The main advantage of rapid and intelligent layout for companies lies in getting to a better overall design. Of course, each company will realize different benefits, but by and large, outcomes related to better designs are positive. For individuals, it stands a means to cut back on working late and on the weekends because it offers a shorter path to design completion.

Too many of today's designers and engineers have to compromise between Drafting Tools and Feature-based Sketchers for layout with 2D geometry. However, Direct Sketching overcomes the detriments associated with Drafting Tools and Feature-based Sketchers, there is a very real opportunity to find better designs and realize the associated benefits.

Underwritten in part by Siemens PLM, all concepts and ideas developed independently,

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