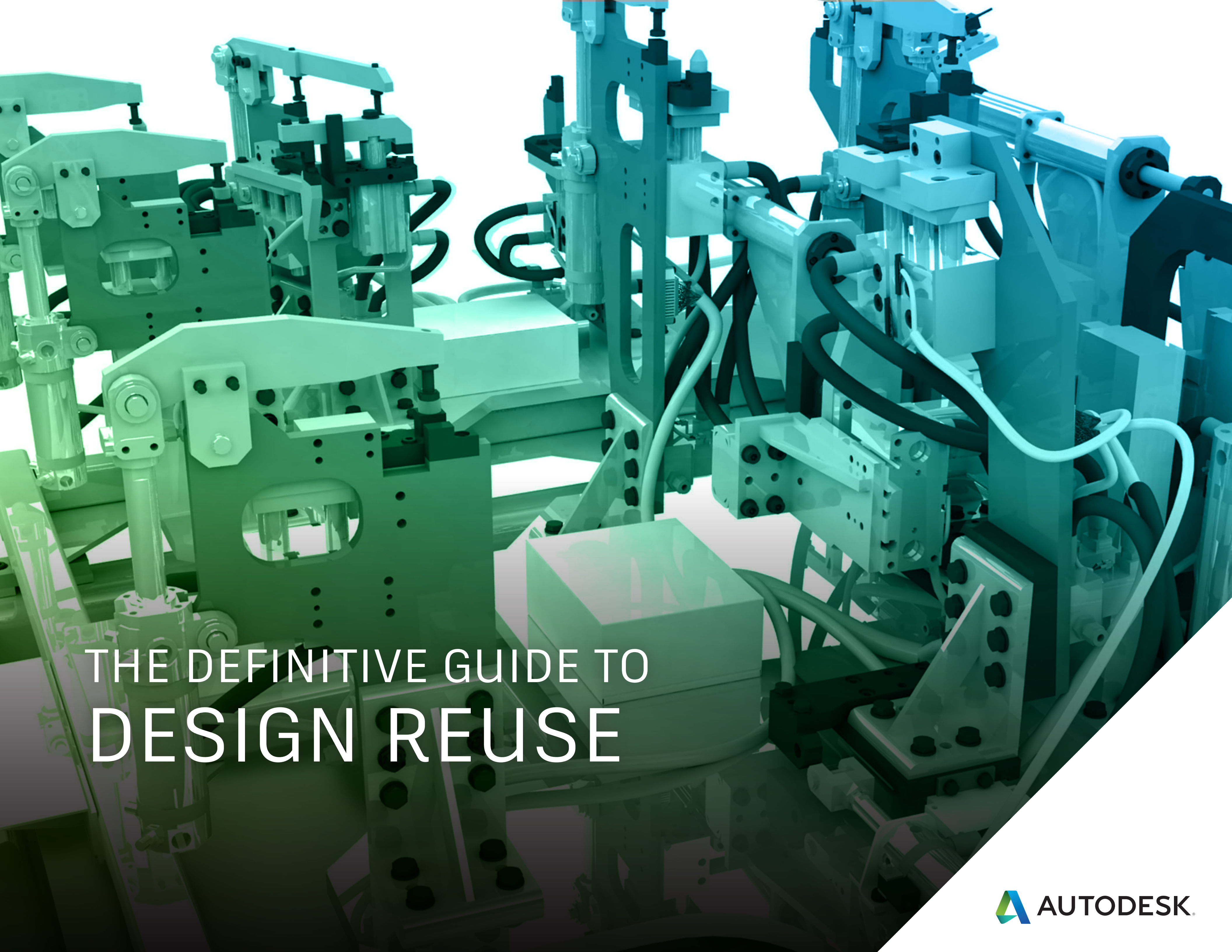

# THE DEFINITIVE GUIDE TO DESIGN REUSE

AUTODESK

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INTRODUCTION

# What is design reuse?

When it comes to mechanical engineering, we've been talking about reusing existing designs for decades. As engineers have become more and more overloaded with tasks, the appeal of using existing data when designing new products has increased even further.

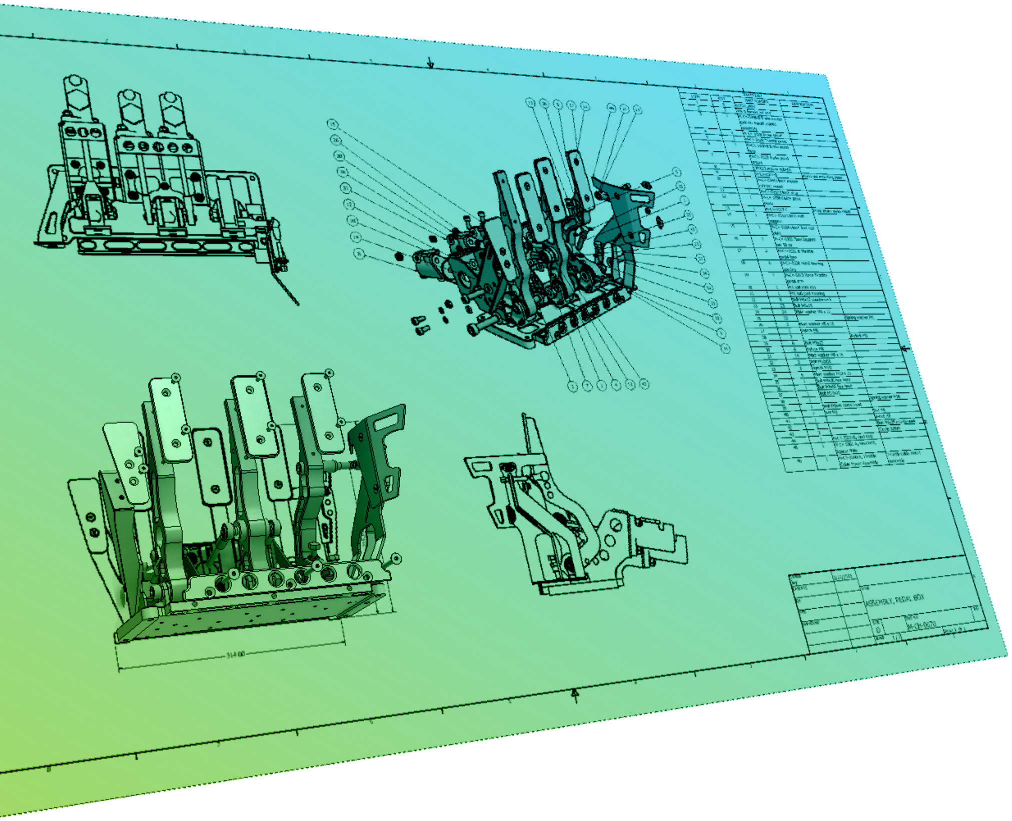


Image courtesy of Briggs Automotive Company, Ltd.

WHAT IS DESIGN REUSE?

# Sometimes simple, sometimes complex.

In its simplest form, design reuse involves finding a design and using it, unchanged, in another design.

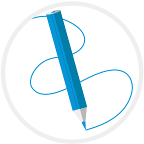
**Most cases, however, are not so simple.**

Why? Because design reuse isn't just about a single 3D model file. Most existing designs also have a multitude of other completed deliverables, ranging from simulation models to engineering drawings to manufacturing process plans. It can include jigs, fixtures, and molds as well as assembly or manufacturing instructions. It might also be photo-realistic rendering set ups and service documentation. In these cases, you don't just want to reuse the design, you want all those copies of all other deliverables updated to reflect the new design you're producing.

WHAT IS DESIGN REUSE?

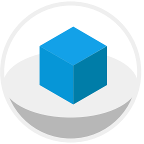
# Focusing time on value-adding activities

Most people would agree that re-creating a design that, already exists is not a good use of anyone's time. Yet, a Tech-Clarity report titled *Reducing Non-Value Added Work in Engineering*[1] indicates this is a relatively widespread issue and engineers spend a third of their time on non-value added work. Therein lies the most significant windfall from employing any kind of concerted design reuse effort. You can avoid time-intensive modeling tasks and do something else.



The objective in **Concept Design** is to conceive new product ideas and verify their feasibility. With more time, engineers can explore more concepts, leading to a higher likelihood of coming across your next great product.

In **Detailed Design**, engineers must develop and detail designs that viably fulfill requirements. Accelerating tasks associated with geometry means more time can be spent assessing other options or other tasks in the design cycle, such as simulation, prototyping, and testing.



Analysts in **Design Validation** are extremely pressed for time with deep queues of work. Reusing designs helps them to accelerate the geometry related preparation tasks required for simulation, allowing them to deliver projects faster or complete more projects overall.

For **Tooling Design and NC Preparation**, the mandate for manufacturing engineers and NC machinists is to deliver machined parts and tooling as quickly as possible. Design reuse helps them to shorten the time needed to develop tooling for those jobs, allowing them to get into production earlier.

WHAT IS DESIGN REUSE?

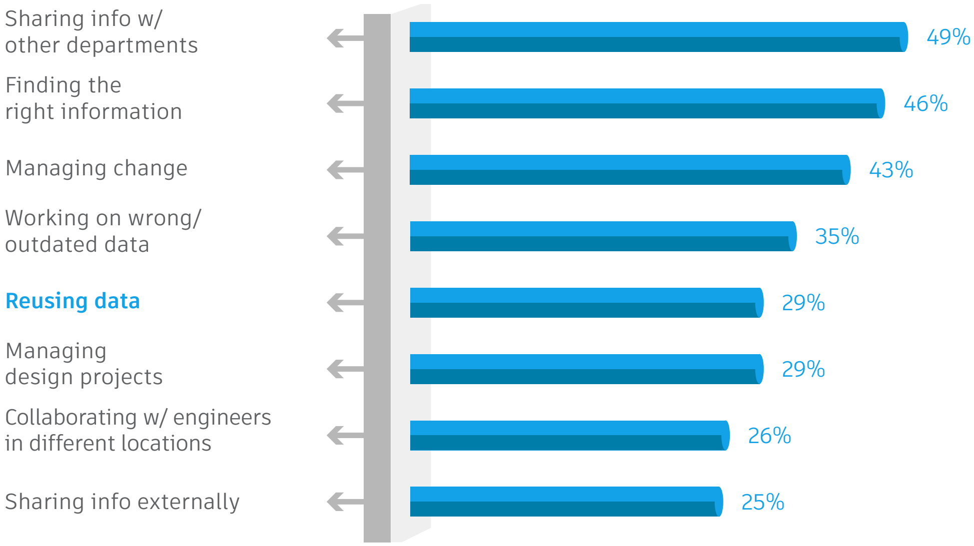
# It’s about knowledge too

Beyond saving time, design reuse offers other advantages. Because existing designs have progressed at least partially through development, if not already been released and launched, the knowledge gained from it can be applied to the new design. This might include testing characteristics to monitor, production issues to proactively address, and learned tricks to apply during assembly or service procedures.

WHAT IS DESIGN REUSE?

# Why is design reuse difficult?

Despite all the appeal of design reuse, it is significantly underutilized today. In fact, 29% of the respondents from a 2015 research report titled *The Facts About Managing Product Data*[2] cited that reusing design data is one of their top design challenges. Yet, there is little confusion about what needs to be done to reuse designs. The four major sets of activities that underpin the practice are well understood. However, the problem lies in the numerous technology induced issues that make it difficult to adopt and use broadly.




Source: The Facts About Managing Product Data, Tech-Clarity, 2015

# FINDING & USING EXISTING DESIGNS

Design reuse practices can't start without the means of finding the data you already have. This activity is directly tied to which technology is used to manage designs within the organization. Some use the operating systems of their computer hardware or shared drives. Others utilize Product Data Management (PDM) systems, either on-premise or as part of a cloud-based offering.

# Findings designs on an operating system

Computer-Aided Design (CAD), Computer-Aided Engineering (CAE), and other development tools produce a lot of files. Those files must be saved and managed somewhere. According to *The PLM Study*[3] from Lifecycle Insights, **76%** of all respondents manage their CAD data on the operating systems (OS) of their laptops, desktops, and shared drives.

There are some advantages to using an OS to manage designs as files.

- You can create any folder structure you desire to organize data. It is also possible to browse through this structure of folders to find specific design data.
- Modern operating systems index the names and basic metadata of files on their file systems. This offers the ability to search for specific files using text matches.
- There is some ability to visualize a thumbnail of the contents of files so it's possible to verify that the file is the correct one before opening it.
- Folders can be easily shared with other members of the design team or created on servers that can be controlled using standard OS permissions.
- No deployment is needed. It is a core part of the computer. There is nothing to learn. There is no additional cost.

FINDING & USING EXISTING DESIGNS

# Findings designs on an operating system

However, there are significant disadvantages to using this approach when it comes to reusing designs.

- Operating systems lack the ability to draw out the rich metadata that exists within engineering design data. That means many of the most relevant pieces of information cannot be used for searches.

- The number of files in a moderately complex model can number in the hundreds and even thousands. Browsing through so many files can be painstaking.

- Maintaining a consistent, organized folder structure and file naming convention takes significant effort and ongoing discipline by everyone participating in the project.

- Organization of files on an operating system can vary greatly from person to person. Understanding how anyone has organized their design data can be extremely time consuming.

- Designs on each individual user's computer are extremely difficult, even impossible, to find because it is not openly accessible.

FINDING & USING EXISTING DESIGNS

# Findings designs in a product data management system

Data management capabilities are used to manage all the files and associated metadata that collectively represent the complete definition of the product. These are typically offered as a standalone Product Data Management (PDM) tool or as part of a broader Product Lifecycle Management (PLM) system that also offers process execution, collaboration, and reporting functionality.

With these systems, you can check designs in and out as files. In a cloud-based, CAD+PDM integrated solution, designs are file-less with the system tracking every individual change automatically.

There are numerous advantages to using the data management capabilities of a PDM or PLM system to manage designs and enable design reuse.

These systems act as a centralized and highly secure repository of all design data.

They deeply understand the metadata within design files, opening up that information as search criteria whenever you are trying to find designs to reuse.

PDM/PLM provides a graphical preview of the design without opening it in the CAD application.

They provide a means to classify designs according to shared qualities or characteristics into a taxonomy that makes it easier to find designs to reuse.

When cloud-based data management is offered as an integrated service alongside a CAD application, every single change is automatically saved and tracked.

Compared to using an OS to manage designs, PDM systems carry few disadvantages.

The use of PDM systems requires users to manually check-in and check-out design data, which can be a change of habit.

Sharing data with external parties can be a challenge with on-premise PDM systems that reside behind a firewall. This is not true for cloud-based solutions where designs reside on a server outside the firewall, where permissions can be granted to outside parties.

PDM and PLM systems are a separate application and not a native function of the OS. Deploying and managing them does require some degree of IT effort.

FINDING & USING EXISTING DESIGNS

# Findings designs through online source

Today, there are a multitude of resources on the web that act as design repositories. These sites allow you to search for or even configure designs and then download them. From there, they can be incorporated into your product or modified into new designs.

These sites provide a variety of advantages for finding existing designs. There are strong text-based and classification-based tools to help you find the right designs to suit your needs. You can download the designs in a wide variety of file types, including the native formats of some CAD applications. This avoids any issues with geometry that might be broken during translation or import.

Image courtesy of Asius Technologies, LLC.

There are some disadvantages to using such sites to find existing designs.

- The metadata of such designs may not comply with the internal standards that have been defined within your organization, leading to an inability to use formalized parameters for text searches the next time you want to reuse this design.
- Designs available at such sources are commonly without the parametric features that were used to originally build it. You'll need to find other methods to modify them.

To conclude, online sources are a great way to avoid unnecessary modeling. However, it is important to understand how they fit into the standards of your own organization.

# USING NON-NATIVE DESIGN DATA

It’s an inevitable reality today: different organizations use different CAD applications. Even when you want to simply reuse a 3D model, it may not be easy. Designs in non-native formats may also be undergoing change during the design process complicating matters when they need updated.

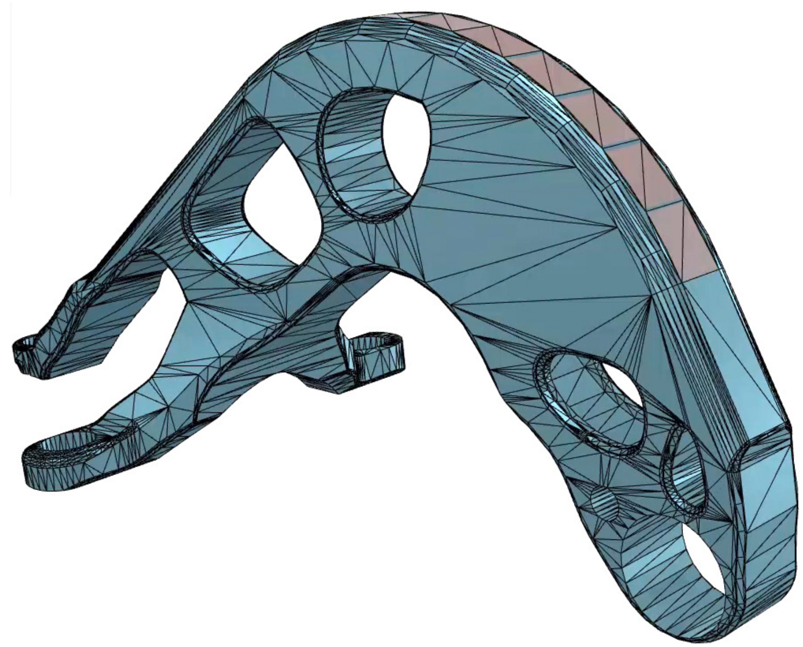
USING NON-NATIVE DESIGN DATA

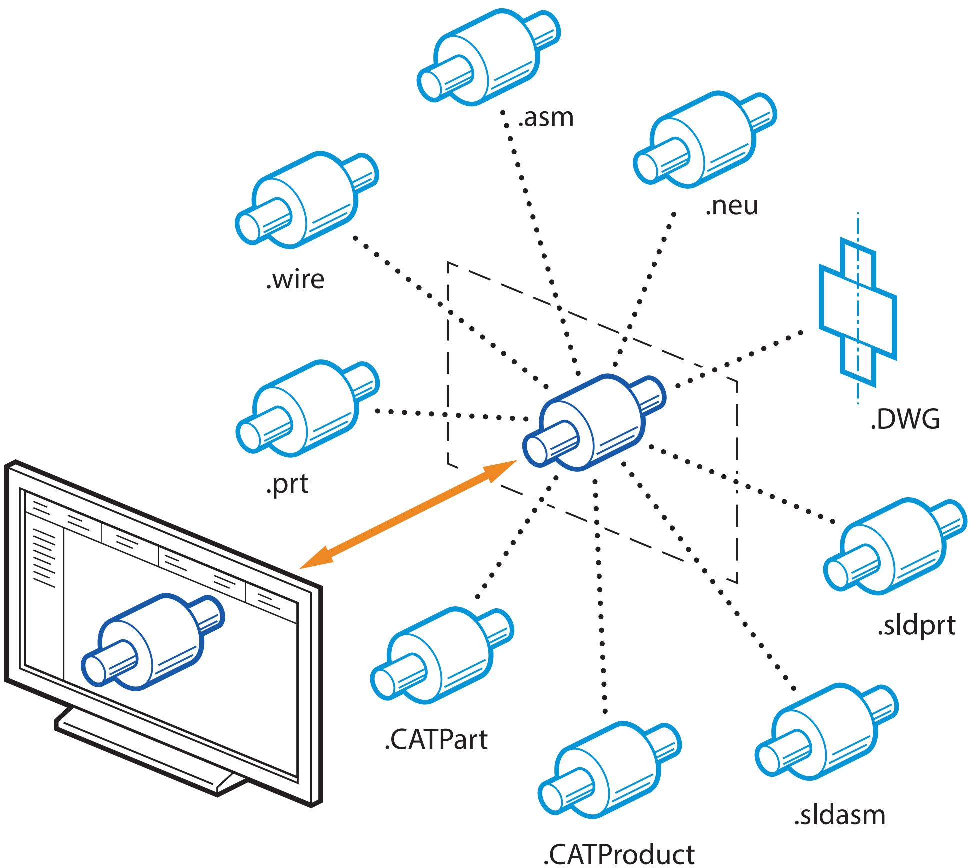
# Translating a 3D model from a non-native source

The traditional method of using designs that originate from another CAD application is to export the file into a neutral format, like STEP or IGES. Once exported, you can then import those designs into your CAD application. Most modern CAD applications are able to translate the native files of other CAD systems as well.

Unfortunately, the outcome of such an activity is not always clean. Different CAD applications use different kernels that calculate the location of geometry in 3D models to varying degrees of accuracy. That means that exports, translations, and imports often result in broken geometry. Rather than coming in as a solid object, surfaces and lines might be missing or misaligned. Such issues must be manually fixed before proceeding in the design process. In some cases, you might even determine that it is easier to completely rebuild the model instead of fixing all the translation issues.

For non-native 3D models that are also undergoing change, this process must be repeated to show any intermittent changes that have occurred since its import or translation. Even if they do happen to come in clean, all the assembly constraints and referenced geometry must be rebuilt. As a result, engineers often wait to bring in such 3D models until the last moment, after it has been completed.






USING NON-NATIVE DESIGN DATA

# Referencing a 3D model natively from a non-native source

In recent years, a new option to bring a 3D model from a non-native source into a CAD application has emerged. This new option allows you to read or open a design in its native format without translation, even if it comes from another CAD application. This technology advance brings models over far more cleanly, often eliminating the need to fix any broken geometry.

This capability enables associative changes as well. Any file that has been referenced into your design that is subsequently changed in its original CAD application will automatically update. This ensures that changes are not missed during the design process and eliminates the rework involved in applying assembly constraints or references so you can use these designs earlier, providing proper context for engineering decisions.

# COPYING COMPLEX SETS OF EXISTING DELIVERABLES

Getting the most out of design reuse often means more than simply copying an existing design as a new one. It's reusing the complete set of deliverables associated with that existing design, so they do not have to be recreated for the new one. But doing so requires careful management of the relationships that exist with the CAD files.

COPYING COMPLEX SETS OF EXISTING DELIVERABLES

# Repurposing an existing assembly into a new one

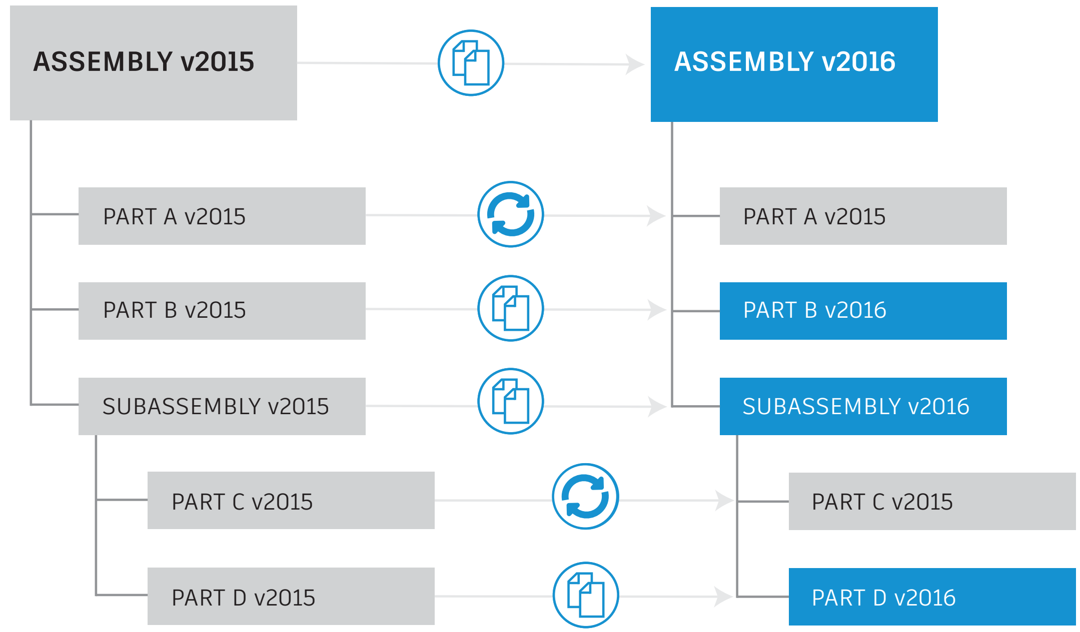
Let's look at the process for copying an assembly of four components, one of which must be repurposed into a new design.

## OPERATING SYSTEMS

On an OS, you can easily copy the assembly file and the component file and rename them. In the assembly file, however, the metadata containing the list of components to bring together has not changed so it still references the original four files. To make this change, you have to open the assembly up and manually replace any new components one-by-one. For small examples, such as this, it's only a few minutes of wasted effort. For assemblies with hundreds or thousands of components it becomes quite an exercise.

## PDM SYSTEMS

When a PDM system makes copies of designs, it also understands and can manipulate the metadata within each file. The PDM system changes the structure in the assembly file to include the new component and exclude the original one. So you can simply make the copy, open the assembly in the CAD application, and start making changes to the new component without worrying if you're working on the correct files..




1. The component that will be modified must be copied as a new design.
2. The assembly must be copied as a new one.
3. In the assembly structure, the existing component must be replaced by the new one.

COPYING COMPLEX SETS OF EXISTING DELIVERABLES

# Repurposing an existing model and associated deliverables as a new one

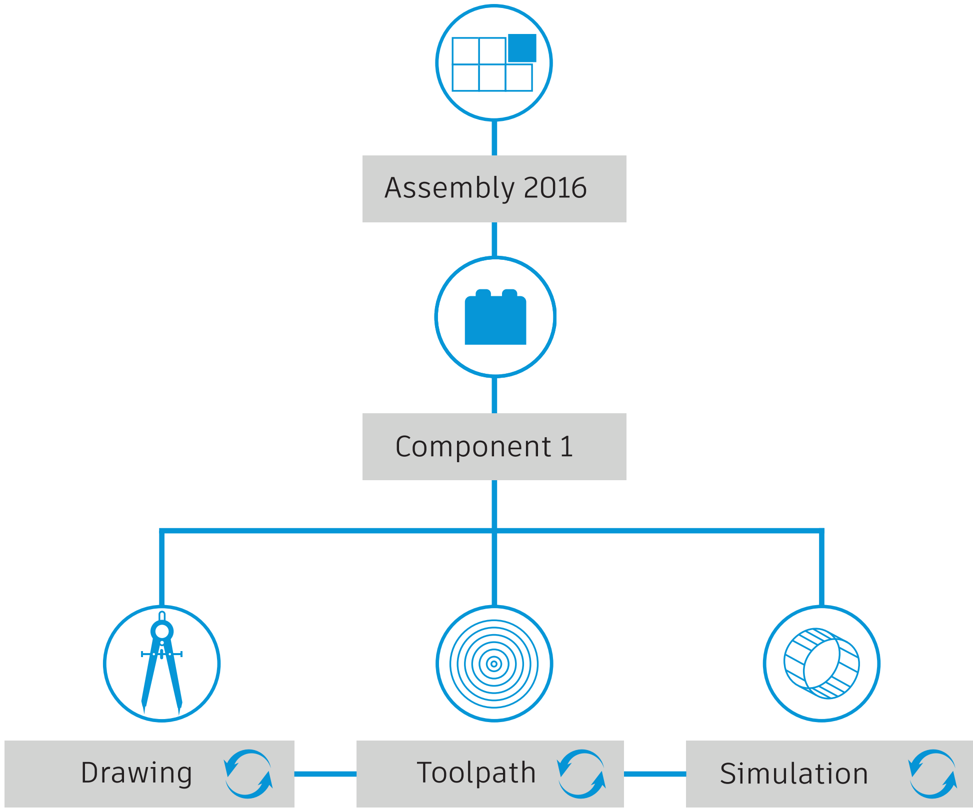
Let's consider the case where you want to not only copy an existing component as a new one, but to also bring along all referenced deliverables, including a drawing, a simulation, and a generated toolpath. Each of the derived objects contains metadata that tells it what component to reference. This must be changed to cite the new component.

## OPERATING SYSTEMS

From an OS perspective, you might think this task easy. Simply copy the original component, all three deliverables, and then rename them. Unfortunately, the metadata in all of the derived deliverables is still the same, referencing the original files. This means that even though you might start modifying the new component, the derived deliverables would not change because they still reference the original.

## PDM SYSTEMS

Using a PDM system offers a distinct advantage in this scenario. When copying the existing component and its three deliverables the PDM system also changes the metadata references to point to the new file, not the original one. As the user opens the new design in the CAD application and makes changes, the derived deliverables are automatically updated via associativity.



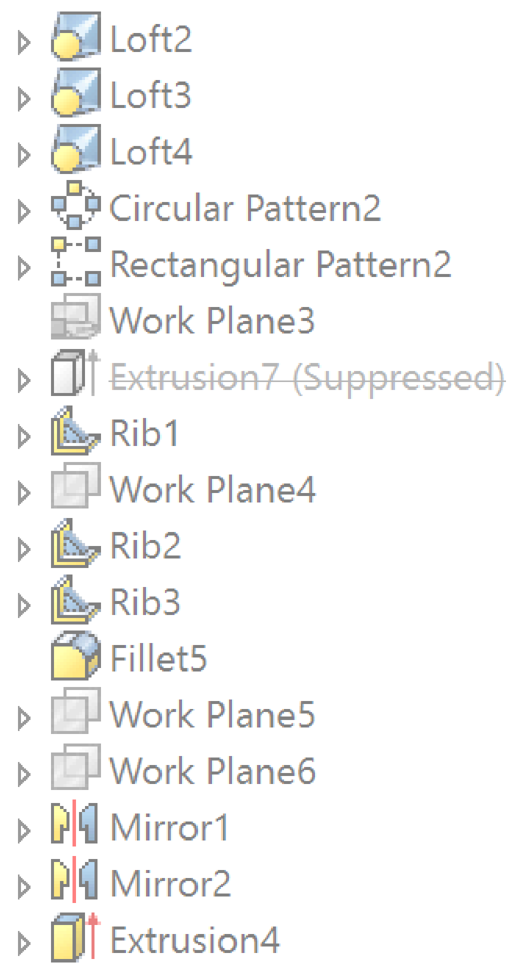
# MODIFYING NATIVE 3D MODELS

One of the most common scenarios for design reuse is to modify existing geometry to represent a new design. While working with native parametric models is the simplest scenario, there are some challenges if modeling best practices are not followed.

# Modifying existing 3D models with parametric feature-based modeling

To understand the pros and cons of this approach, it is important to know how such models are built. The building blocks of a 3D model are geometry features that are parametrically controlled, such as sketch-based extrusions and rounds. These models are built progressively out of features, creating a history based sequential order. Successive features often use geometry of prior features as references, generating a network of parent-child relationships. Features can be changed by modifying parametric dimensions or variables. Modifications are, however, limited to the initial feature definitions used to create the geometry. For example, extrusions cannot be changed into rounds.

This approach offers significant power in its ability to capture design intent. You can embed relationships, such as making one dimension always equal to half of another, that are always enforced as design changes are made. As more and more intent is embedded in the 3D model, it can react more and more intelligently to modifications. Leveraging this functionality, you can repurpose an existing 3D model into a new one per the intent of the original builder, using knowledge that's built up over time.

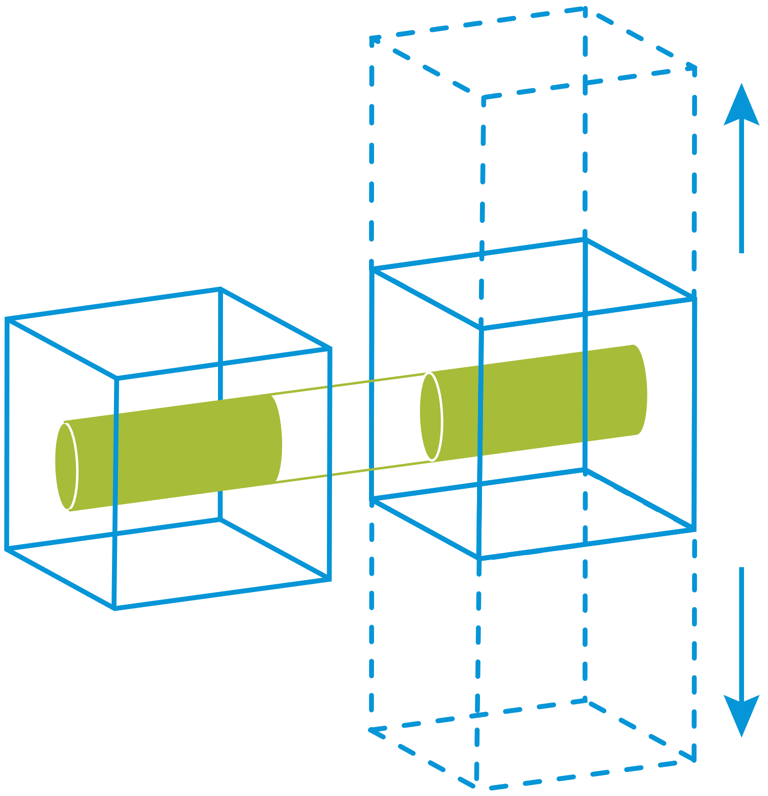


MODIFYING NATIVE 3D MODELS

# Modifying existing 3D models with parametric feature-based modeling

Of course, building up a network of interrelated features, each with their own definition, and embedding equation-like design intent does make the modeling effort more complex. Users are advised to follow many best practices that have been established over years of experience. It is important to give features, especially critical ones, specific names so they can be easily identified. For reuse of a 3D model, it is critical to understand and even plan out the parent-child relationships between features, so they are kept clean and robust. You can employ new capabilities of CAD applications that help in this regard, such as highlighting features in the history tree when geometry is selected and identifying the parent and child relationships for each feature created.

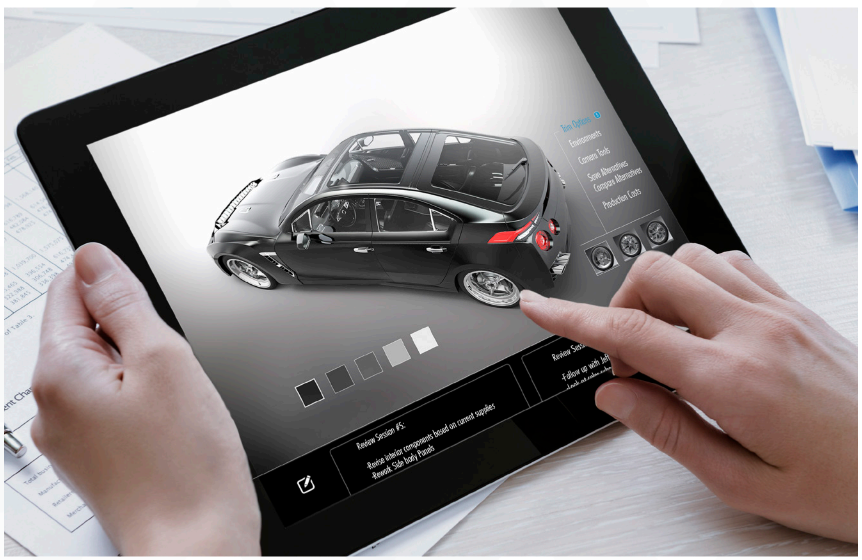
In all, parametric feature-based modeling offers powerful tools to drive intelligent and design intent oriented changes, allowing you to transform existing designs into new ones.



MODIFYING NATIVE 3D MODELS

# Configuring existing 3D models with parametric feature-based modeling

While parametric approaches can be a bit challenging when making manual modifications, they can offer real power when it comes to configuring a 3D model. You can not only embed design intent—ensuring that important engineering rules are followed for this particular design—but also prepare the model to intelligently react to changes. By employing good modeling practices and standards, you can develop a configurable model that is stable across a wide range of potential changes.



In this case, parametric modeling offers some significant advantages when it comes to automating modifications and configuring designs, including:

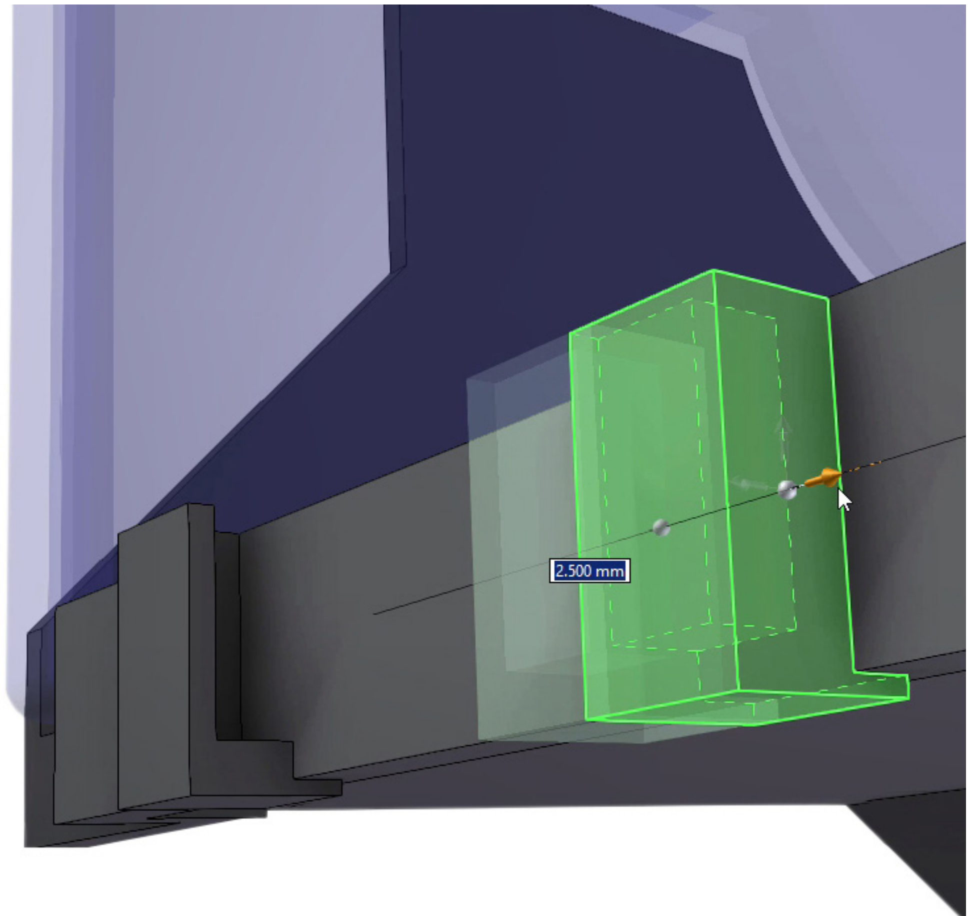
- Parametric control and interdependency enables very intelligent reactions to changes as well as powerful design automation.
- Models can morph in an automated way to represent various product configurations. In turn, you can quickly configure a model to represent a wide range of designs, enabling the exploration of many potential options.
- The intelligence and automation within a model can allow engineers to embed their intent and enforce it even when non-technical users are making changes. This approach can be used to power 3D model changes required for design automation or online sales configurators.

# Modifying existing 3D models with direct modeling

Utilizing a parametric modeling approach may not always be feasible due to its complexities, especially when best modeling practices and standards are not used.

As more features are added to a model, more interdependencies are built between them. When not properly planned and managed with best modeling practices, this network of relationships can become incredibly complicated and fragile. A design change can start a chain reaction of failures in the network of interdependent features. Significant and specific knowledge, expertise, and skills is often required to untangle such models. So much so that in some cases, it can be easier to build a new model from a blank screen than fix a hopelessly failing existing file.

Fortunately, there is an easy and viable alternative to rebuilding or fixing an existing model that has failed: direct modeling. Using the original features to change well-built models is far more preferable. However, in the case where models are hung up in failure after failure, direct modeling offers a quick and easy alternative.

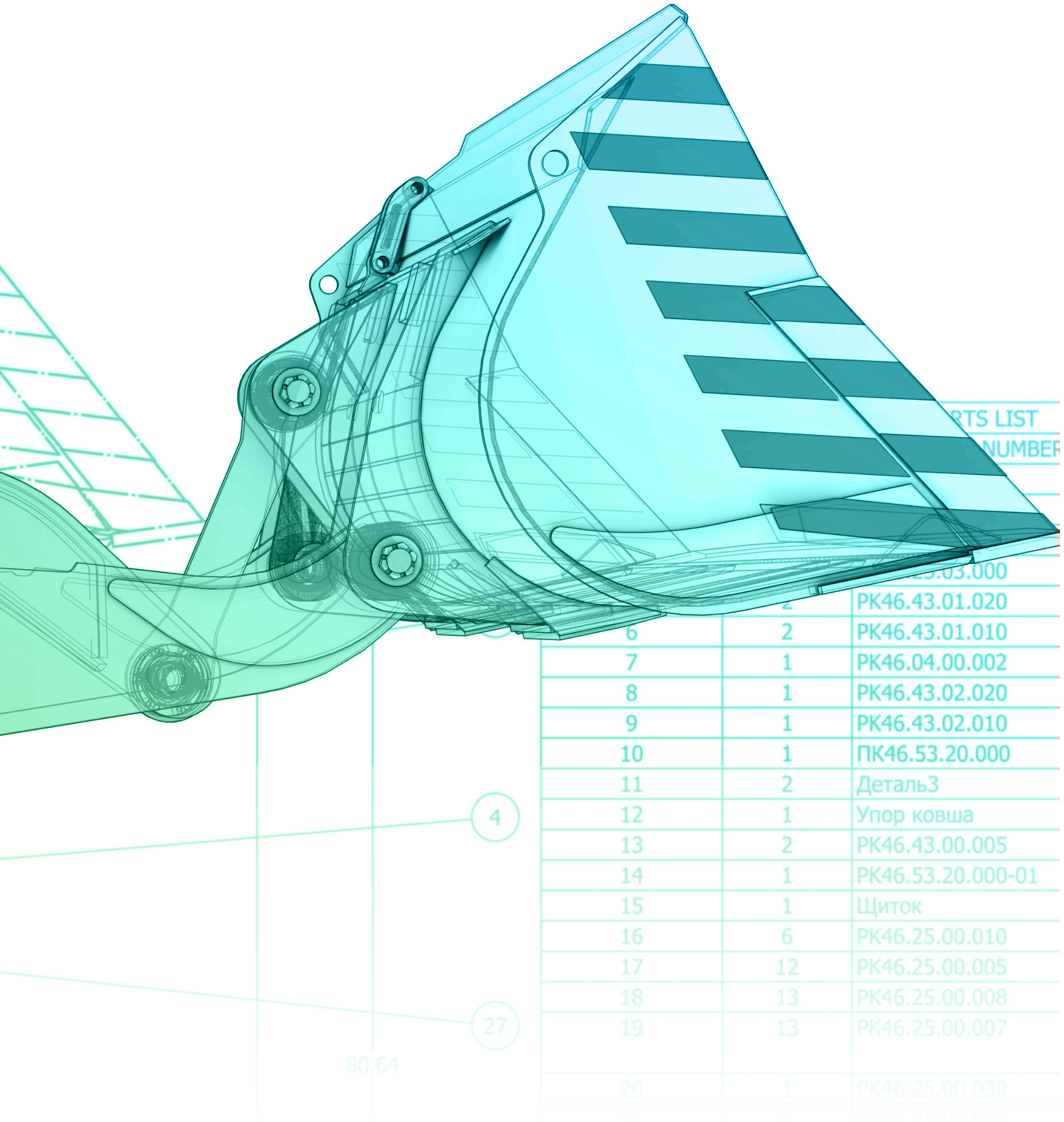


# MODIFYING NON-NATIVE 3D MODELS

Another situation common to design reuse is the attempt to modify models that have been imported from neutral or other CAD formats. In these cases, the geometry of the designs lack any parametric or feature controls by which changes can be initiated.  Commonly called 'dumb solids,' they live up to their name.

MODIFYING NON-NATIVE 3D MODELS

# Modifying non-native models with parametric modeling




Technically, parametric modeling can be used to modify non-native designs. However, there are some serious caveats to consider.

Using this approach is a good fit if the geometry that is added represent the only elements of the design that might be changed in future. As was the case with modifying existing models into new ones using a parametric approach, the design should be planned and managed using best practices.

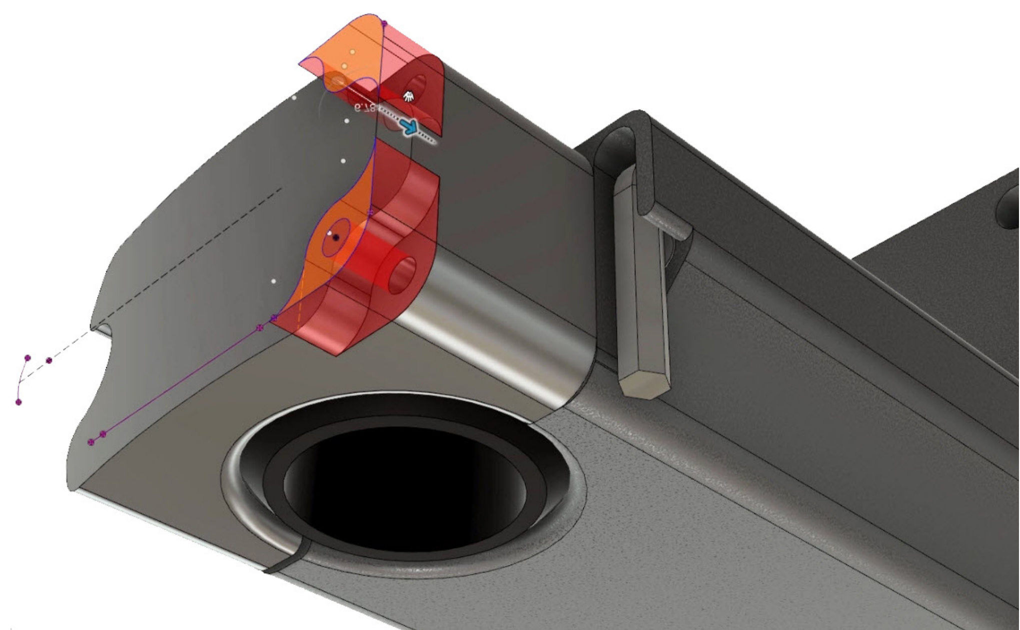
Parametric modeling is a viable option, but should only be employed when the newly created elements of the design will be specifically configurable for future reuse.

# Modifying non-native models with direct modeling

The alternative is to use direct modeling. With this approach, manipulation of existing geometry is a two-step process. First, you select the geometry you want to change. This is augmented with geometry inference; a capability that intelligently determines what else should also be modified. You can then push, pull, or drag to interact and manipulate the design.

Using the direct modeling approach provides a number of advantages when working with models without any features. Of note is that the origin of the geometry does not matter when making modifications. It could be natively created in that same CAD application or translated 10 times. All that matters is selecting geometry and manipulating it directly.

Direct modeling is built on intelligent manual modification. Its methods are smart enough to recognize inherent or implied relationships that a selected feature has with neighboring geometry. When the selected geometry is moved, the adjoining entities are modified as well. Also, because direct modeling capabilities do not use dimensions or features to make changes, the only model failures you'll encounter are the ones when the geometry you're trying to make is infeasible.



# Modifying non-native models with direct modeling

This translates into some significant benefits if you're trying to modify models without any underlying features.

- The rate at which you encounter failures is far lower than that of parametric approaches. This helps you to work with less fear of catastrophic failures from which you cannot recover.
- Direct modeling can be used to modify legacy models and reuse other's models without needing to recreate it or invest lots of time fixing it.
- This approach, without limitations of features and interrelationships, allows you to iterate and explore with little constraint.
- Since less-technical users can use the direct modeling approach, the expert users will spend less of their time assisting others and, instead, work on the truly difficult modeling tasks.

Of course, this modeling approach is not perfect. Without a network of interdependent features, there is no basis for design automation or intelligent reaction to change. These models cannot be morphed in an automated way. As a result, direct modeling cannot be used to power intelligent and automated 3D model changes needed for design automation.

In all, direct modeling is the best technology to quickly and easily modify non-native models. However, if you want to make newly created aspects of a design reuseable, parametric feature-based modeling is a better fit.

# REUSING 2D DATA

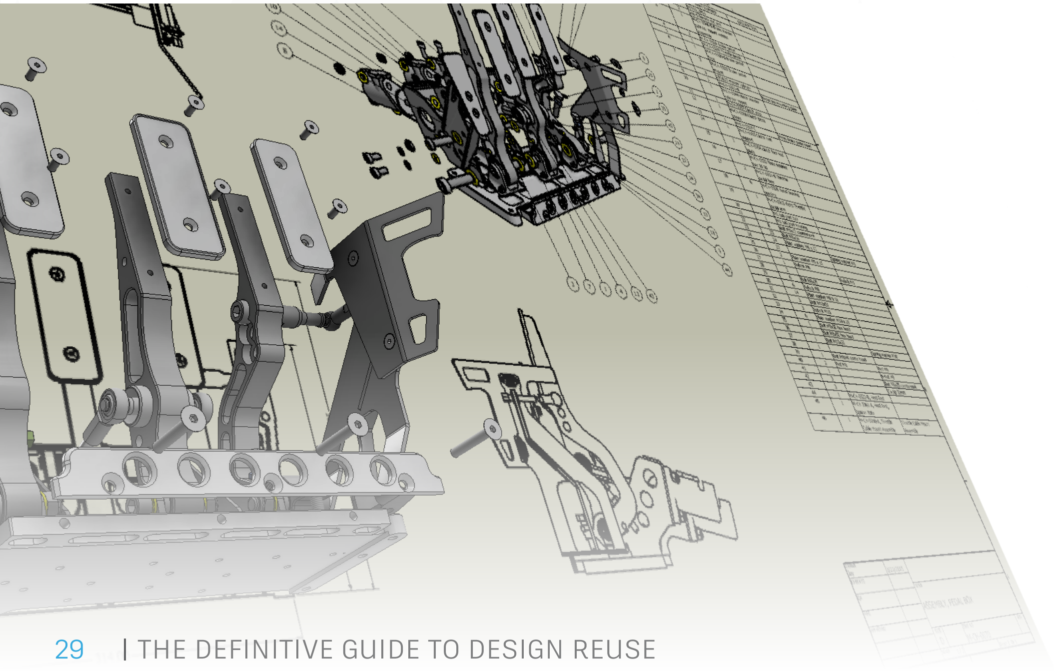
While most of the focus for design efforts tends to focus on 3D models, there is still a lot of 2D data out there, leading to a different type of design reuse scenario. Copying and modifying such designs is simple: just copy and paste the file or the entire drawing within the same file. However, using 2D data alongside or to build 3D models presents more of a challenge.

REUSING 2D DATA

# Building 3D designs from 2D data

## BUILDING A 3D MODEL FROM 2D DATA

While existing 2D data might not be as advantageous as a 3D model, it can certainly provide many benefits in building one. You can use existing 2D data to accelerate the definition of sketches that are the basis of features of a 3D model. The entities in the 2D data already accurately represent a design, so you don't have to worry about misinterpreting an engineering drawing. In the end, you have a new 3D model that can be controlled through parameters and features.



## DRIVING A 3D MODEL FROM ASSOCIATIVE 2D DATA

A variation on the approach of building a 3D model from 2D data is the ability to associatively drive changes. While building out the fully detailed design, you can make a sketch dependent on the 2D entities. So when the data is changed in the 2D application, those changes are propagated to the sketches that drive the features of the 3D model.

While it may not always make sense to use this approach, it does have some powerful applications. You can use a single set of 2D data in many different 3D models, some of which may never exist in the same assembly, as is the case with a family of components. The 2D data can then be used to make a single change that is reflected in many different 3D models. Such a top down approach offers a means of global control.

Image courtesy of Briggs Automotive Company, Ltd.

# SUMMARY

Design reuse not only has applications in Detailed Design, but also Concept Design, Design Validation, and Tooling Design and NC Preparation. It's not just about reusing a design, but also all of its associated deliverables such as simulation models, engineering drawings, manufacturing models, tooling, assembly or manufacturing instructions, photo-realistic rendering set ups and service documentation.

SUMMARY

# Finding & using existing designs

### SEARCHING FOR DESIGN DATA

Engineers must find designs before they can be reused. Operating Systems do not understand such data, severely limiting the ability to textually search or browse for designs. Product Data Management systems, however, deeply understand design data, enabling effective searches and means of browsing to find the right data.

### REUSING NON-NATIVE DESIGN DATA

From time to time, you must use or repurpose non-native designs. Translating or importing such data results in feature-less models, leaving no mechanism to drive change, and frequently broken geometry that must be fixed or rebuilt. Changes to the original design means users have to duplicate these efforts. New capabilities to read models in their native format from other CAD applications have emerged, providing a means to more cleanly bring in whole geometry and even associatively keep up to date with modifications from the original CAD application.

### REUSING COMPLEX SETS OF DESIGN DATA

Designs often have some combination of 3D models, engineering drawings, and more that acts as an interrelated set. To get the most out of design reuse, you need to repurpose all of this content. Simply copying and pasting this set of files on an Operating System, however, is inadequate. It cannot change the underlying metadata that govern the relationships between these files. Product Data Management systems not only understand this metadata, but can also change it while copying files.

SUMMARY

# Modifying native 3D models

## MODIFYING NATIVE 3D MODELS

Using parametric feature-based approaches, you can embed design intent and intelligence into 3D models. By employing good modeling practices and following standards, you can produce flexible and robust models. Repurposing such models into new designs is relatively easy. In fact, such designs can be programmed to accept standard inputs before transforming. This configuration approach can dramatically increase reusability. Unfortunately, not all models have been built so carefully. In extreme cases, the resulting models are inflexible and hard to modify. This is when direct modeling is best applied.

## MODIFYING NON-NATIVE 3D MODELS

Modifying non-native models is very challenging because they lack any features by which to instigate change. Parametric modeling can be applied with planning and use of good modeling practices and standards. However, this is only advisable if you will need to repurpose the design again in the future. Direct modeling can be used to more quickly adjust the design as required.

## REUSING 2D DATA

Utilizing 2D data alongside 3D models is difficult. You can insert such designs into assemblies, allowing them to visually check form and fit through front, top, and side views. And the 2D entities from such data can be used to quickly and accurately build out sketches in features to accelerate 3D modeling efforts. The resulting 3D models can then be independent of that 2D data or associatively tied to it, allowing you to drive changes in 3D models from the original design.

In conclusion, reusing designs has not been easy. It has been difficult due to a variety of technology-induced problems. Yet, in the last few years, many new technologies and capabilities have emerged to vastly improve design reuse.

1 Reducing Non-Value Added Work in Engineering, Tech-Clarity, 2014.
2 The Facts About Managing Product Data, Tech-Clarity, 2015.
3 The PLM Study, Lifecycle Insights, 2016.