The Engineering Leader's Guide to PDM & Data Management

An introduction to managing your product development team's most valuable design assets and preventing costly manufacturing errors

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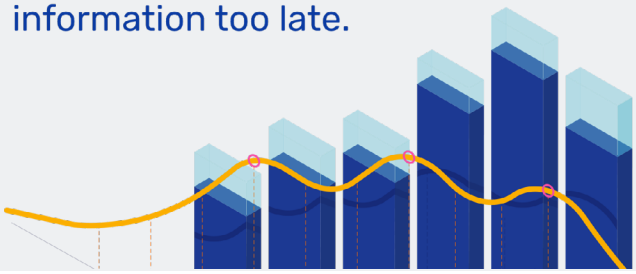


Introduction.

When people decide to pursue a career in mechanical engineering or industrial design, they're thinking mostly about creating cool and innovative products – not spending endless hours managing their design files. So it's not surprising that CAD tools get most of the glory when companies are evaluating software platforms for their product development teams. Data management solutions are usually treated as an afterthought.

In The State of Product Development & Hardware Design 2019, an independent research report on the design and manufacturing industry, 86% of companies said they need to reduce errors resulting from working on the **wrong version of a design** or receiving important project information **too late**.

It doesn't matter how smart, talented or innovative your employees are if their productivity tools are (ironically) slowing them down. In the best case scenario, mistakenly manufacturing the wrong part can lead to hours of wasted time and needlessly wasted money. In the worst case scenario, version control problems can lead to product recalls and possible harm to the public.

The good news is that most data management problems can be proactively minimized or prevented altogether.

In this comprehensive guide, you'll learn the critical role that data management plays at every stage of the product design and manufacturing process – and you'll review all the key factors to consider when choosing the best solution for your company. The book also covers the benefits and pitfalls of Product Data Management (PDM) systems, and compares them to alternative cloud and mobile technologies that are relatively new to the market.

Section 1

The Importance of Data Management

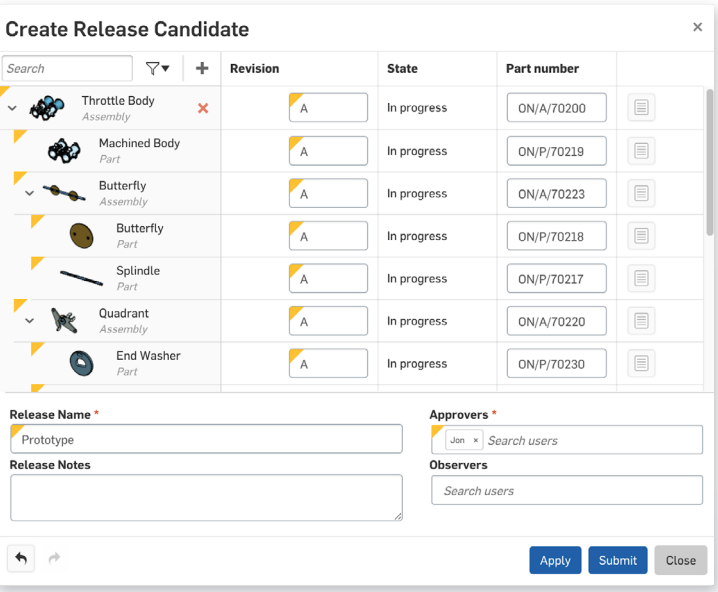
Managing Your Most Valuable Assets

Whatever types of products you manufacture or industries you serve, your design data is almost certainly created in digital form using 3D Computer-Aided Design (CAD) software. Originally invented to help draftspeople draw lines more efficiently, CAD has evolved to become the cornerstone of almost all design data produced for manufacturing.

The benefits of CAD and digital design automation tools are well documented – CAD helps you design better products faster, with fewer errors, scrap and rework. 3D design data is easier to understand, easier to modify, and easier to verify for fit and function. For non-technical users such as sales and marketing, and for decision-makers such as executives and customers, 3D design data removes ambiguity and visually explains how a product will look and how it will work.

If a picture paints a thousand words, 3D CAD paints millions.

However, the less glamorous side of 3D CAD is not often discussed – the enormous volume of data that it produces. Remarkably, in most cases, it's not even mentioned at all (especially by the CAD vendors). Companies with hundreds of products may have thousands, sometimes millions of parts, assemblies and drawings. Some of those companies have been using 3D CAD for decades without any formal or automated method of managing all those data files, relying on manual methods, standard folder structures on shared network drives, historical procedures and tribal knowledge.



Managing drawings this way, of course, is how it was done in the past. Before CAD, drawings were approved by a physical signature on a print and stored in a drawing cabinet under lock and key. If you needed a copy of a drawing, you had to ask for the cabinet keys and create a blueprint of the master copy under the watchful gaze of the drawing office manager. This uncontrolled copy of the master drawing could then be walked down to the shop floor or mailed to external job shops, where further copies were made for whoever needed them.

MANAGING YOUR MOST VALUABLE ASSETS

CAD technology has significantly advanced product development, but in many companies, the same process that was used to manage paper drawings has simply been replicated, albeit digitally using files. There now might be less physical clutter, but the organizational chaos hasn't gone away.

The risks of managing data by manual means are great and it only takes a few costly mistakes, project overruns, or product recalls to ruin your company's reputation.

The proliferation of different 3D design tools across companies, both large and small, has resulted in a veritable explosion of data. For every project, a design team may generate thousands of files for each part, assembly and drawing, not to mention all the other project-related documents. As designs go from concept to production, they naturally become more complex. Ideas that were developed quickly for a product concept are not detailed enough or don't consider all possible manufacturing requirements, so they must be modified or redesigned. More iterations and variations are produced, more disciplines are involved and numerous interdependencies are created.

Keeping track of the mountains of data produced by your design teams and your CAD system can soon become overwhelming. A simple project containing just 10 assemblies, 40 parts and a drawing for each, produces 100 individual files on your hard drive for every version and revision of the design. Before you know it, those 100 files become thousands. The margin for error increases exponentially at an alarming rate.

Because CAD files are saved on some form of digital storage media – either a local hard drive, a shared network drive or (if transferring data) an email server or USB drive – the odds of files being overwritten, lost, stolen or corrupted are stacked against you. Engineers and other project stakeholders waste countless hours searching for data, looking for the correct and most up-to-date version of a design. With more data silos spread across different media in different locations, it's too easy for teams to accidentally work on copies of the wrong version of a design without even realizing it.

MANAGING YOUR MOST VALUABLE ASSETS

Trying to manage so many copies of so many files leads to unreleased or incorrect versions of designs finding their way to sales, manufacturing, external suppliers, or your competition, with disastrous results.

Computers are good at automating mundane tasks, so it makes perfect sense that each CAD vendor would create their own software tools to help manage their proprietary data files. Unfortunately, Product Data Management (PDM) software has always been treated as an afterthought – they build the CAD system first, then worry about managing the files later.

PDM software does indeed provide many benefits – reducing the number of errors and frustrations detailed above – however it comes with a hefty price tag. There is the initial outlay, ongoing maintenance payments, training and consultancy fees to get you up and running, plus the dedicated servers and IT infrastructure requirements that are not included as part of the original quote.

Cost and time to implement are probably the main reasons why so many companies decide they would rather struggle without it. All too often, CAD is sold without PDM to keep a quote within a customer's budget. The customer then has to learn the hard way that it's impossible to run a successful business without data management.

Without question, CAD files are the life-blood of product development. So managing these files effectively and controlling who has access to them, who can modify them, how they are shared, and how data is moved from one stage of development to the next, should be a company's number one priority.

Collaborating With Internal Design Teams

Despite what most CAD vendors say in their marketing materials, CAD was never built with collaboration in mind. The fundamental issue preventing collaboration with CAD data is that only one person can edit a file at any one time. If an application does let more than one person open the same file at the same time, it usually makes a copy of the file on-the-fly so that any changes do not affect anyone else. This, however, defeats the purpose of collaboration – as each person is working on different copies of different files.

The reason why files are locked when opened by an application is to prevent:

- **File Corruption** – If you were to have more than one application trying to write to the same file at the same time, there would be data structure conflicts that could not be resolved – and the chances that the file would become corrupt are very high. Once a file becomes corrupt, both the CAD system and the operating system are unable to decipher which data is correct, and can't untangle any malformed data structures. The file is then flagged as corrupt and unusable.
- **Lost Work** – If more than one application has the same file open at the same time for editing, you are at the mercy of the "last save wins." The hours you may have spent carefully modifying a part or an assembly are wasted because somebody else, editing it at the same time, saved their work after you saved yours. The next time you open that file, everything looks completely different and all of your hard work is lost forever.
- **Conflicts** – If multiple people are working on the same file at the same time, even on a copy of the file, it is highly likely that one or more of those people could make changes that create a design conflict. Despite working on different aspects of the design or different design ideas, a conflict could have a domino effect on other areas of the project. These conflicts are difficult, if not impossible to resolve and require lots of meetings and design rework.

COLLABORATING WITH INTERNAL DESIGN TEAMS

When there is only one designer on a project, managing all the generated CAD files using a set of folder structures on a hard drive may be manageable with due diligence. However, that is not a realistic scenario. The only way to effectively keep lead times short while innovating the next great product idea is to employ teams of designers, contractors and external suppliers while keeping sales, marketing, management and customers in the loop as well. **This is when collaborating using files becomes a problem**.

To avoid any such conflicts, individual design tasks can be assigned to different engineers working on the same project in an attempt to prevent anybody from working on the same files at the same time. However, all the changes made to each file must somehow be integrated into a master top-level assembly. That means that at some point – probably several times a day – somebody must open the top-level assembly to check that all the subassemblies and parts are behaving as expected and attempt to resolve any conflicts that arise.

If a file is saved before a design change is complete – such as when a designer goes home for the evening and intends to finish it the next day – the incomplete model geometry could affect other parts of the assembly. Finding where things have gone wrong and who/what is to blame is not an easy task and it could be a complete waste of time and effort, especially if it resolves itself when the design changes are finished.

Without any formal data management software, it's impossible not to tread on each other's toes, overwrite somebody else's work, or completely break everything.

It's also impossible to know if somebody is editing a file, who that person is, or if all the files are saved and up-to-date – this means that any person who needs to access those files could be viewing incorrect data and all sorts of problems could ensue.

Collaborating With External Design Teams and Partners

Exchanging product data with remote employees, contractors, suppliers, customers, or any other third party companies (i.e. overseas manufacturers), compounds these issues even further. If a company is simply manufacturing the end result, the only thing you need to do is make sure they have the correct version of the files to work with. If a contract designer or a remote employee needs to make edits to the files, all the problems listed above also apply, only they become worse.

Outsourcing reduces overheads, but increases risk. There are many stakeholders at every stage of a project who need access to the latest design data. Unless there is an alignment of processes and applications, there's a real potential for misunderstanding and loss of control. Managing the distribution of data across many different sites and making it available when needed is difficult, especially when data is siloed or there are multiple definitions of the same data stored in multiple locations and you only want certain data to travel outside of your firewall.

Any person or entity that does not have access to your company network must receive the data files by some other means. Common methods include email attachments, FTP sites and file-sharing services such as Dropbox, OneDrive or Google Drive.

Email

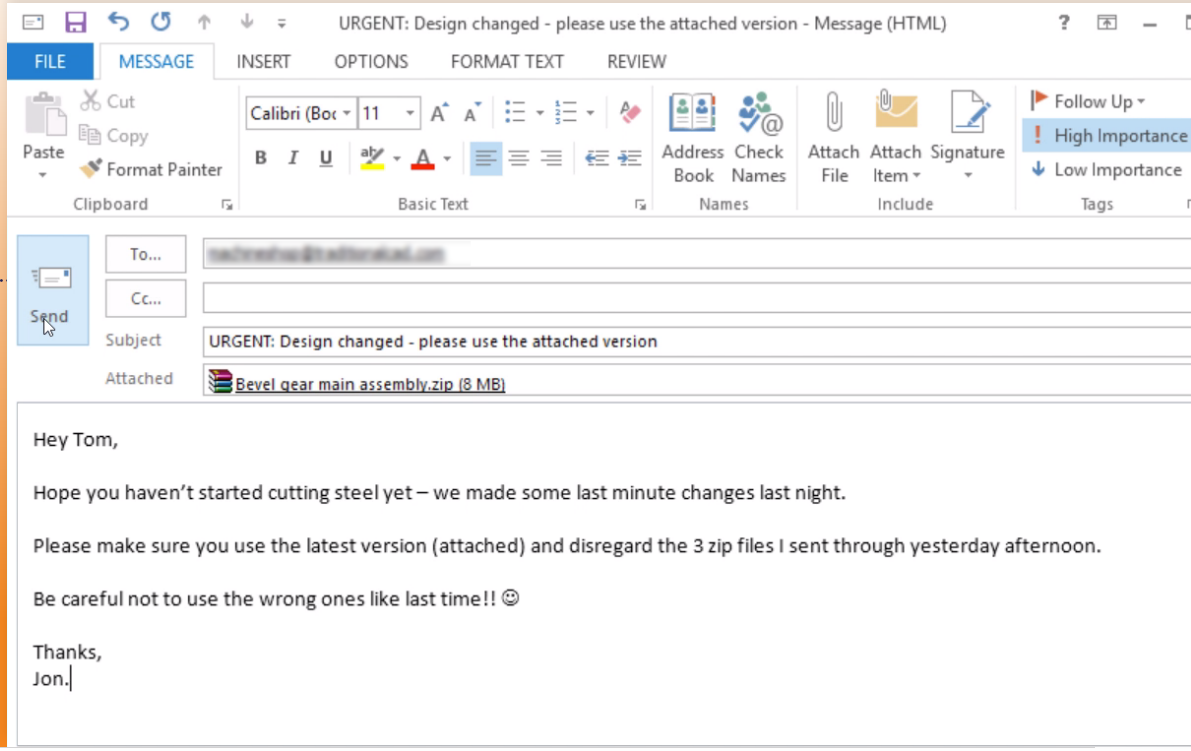
For convenience, nothing beats email. It provides a quick and easy way to document your requirements in as much detail as needed and attach as many files as you wish, creating a permanent record of every conversation.

- **Security** – Many email services now provide end-to-end encryption, so it's a lot more secure than it used to be. However, even with these improved security protocols, once an email and attachment has reached the intended recipient, the information is unencrypted. You have no idea if their security protocols match your security protocols – they may not use firewalls or even password-protect their computers, so anybody could be accessing their systems and copying their emails.

COLLABORATING WITH EXTERNAL DESIGN TEAMS AND PARTNERS

- **Multiple, Uncontrolled Copies** – Once you attach a file to an email (Copy #1) and send it, you have no idea where that file is going or how many copies are being made. When your message lands in the recipient's inbox (Copy #2), they must download the attachment to their computer's hard drive (Copy #3). They may need to forward it to a colleague (Copy #4) or send the file to the shop floor (Copy #5). They may want to work on it over the weekend, so they copy it to a USB stick (Copy #6) and then copy it to their personal PC at home (Copy #7). They may subcontract some of their work or manufacturing processes, so they attach the file to an email (Copy #8) and send it... ad infinitum. Multiplying copies not only increase your security risk, but also the chances of manufacturing the wrong parts. Once several versions of a design have been sent to the same supplier, it becomes more difficult to keep track of which file is the latest.

- **Attachment Size Limits** – This varies for each email server and company's admin settings. Some are as low as 4MB, some as high as 25MB, but when you receive an automated email back from your supplier stating that your email was rejected due to file-size limits, that's more work for you. You must either break the attachment down into smaller ZIP files or ask your supplier if there are other ways you can send the files.



CONFUSING FILE COPIES - *The more versions of your design that you send to an external partner, the more likely there will be confusion over which version is the latest and most up-to-date.*

COLLABORATING WITH EXTERNAL DESIGN TEAMS AND PARTNERS

FTP Sites

Antiquated, but still in use today, the File Transfer Protocol (FTP) is a standard network protocol usually accessed via a cryptic Internet Protocol (IP) address with a supplied username and password. Security can be improved if the FTPS or SFTP protocols are used to encrypt network traffic.

- **Security** – Each user must have their own unique username and password combination. Using a generic username and password may be convenient, but it prevents you from being able to deny access to specific people. A manual method of managing usernames, passwords, folder permissions and due diligence is required to ensure that only the right people can access the right folders.
- **Multiple, Uncontrolled Copies** – Just as bad as email. The recipient must download a copy of the file to their local hard drive and follow the same processes.
- **Difficult to Use** – A certain level of computer literacy is required.

File-Sharing Services

File-sharing services, such as Google Drive or Dropbox, are very popular and enable users with paid subscriptions to send files of any size very easily. Files can either be copied into a special folder on your hard drive that automatically syncs with the service in the cloud, or you can upload files using a web browser. The recipient only needs to click a link to download the file locally.

- **Security** – File-sharing services have extra security when data is stored on their servers and when data is being transmitted. You can also add password protection. However, how do you send that link and password? Over unencrypted email? In addition, a survey from Osterman Research found that 69% of employees regularly use their own personal file-sharing account to store and send sensitive company data. Of the respondents that had since left a business, 6% admitted to sharing that data with their new employer or others!
- **Multiple, Uncontrolled Copies** – Once the end-user has the file, they can do anything they want with it as per email and FTP.

COLLABORATING WITH EXTERNAL DESIGN TEAMS AND PARTNERS

With any method of transmitting data files, there are concerns around security, mistakes and uncontrolled copies. File type and file version can also be an issue. If the recipient is not on the same version of the same software as you, then they will not be able to open the files. You must, therefore, make sure that the files you send are compatible with whatever system they use. If they only need to view the files, they will need to download and install compatible viewing software.

Once an external party has your files and they are able to open them and work on them, you can do nothing but wait until they have made their edits and have sent the changed files back to you (using one of the same methods outlined above).

It is also impossible to know what changes are being made, if any. Since your partners are not local to you, you cannot just walk over, look over their shoulder and ask questions. This requires regularly scheduled design reviews, which often can be disruptive and time-intensive. When deadline day arrives, their final edits may not be what you were expecting. This is wasted time that is difficult to quantify.

Exchanging CAD files using manual methods is not scalable for large design teams or even modest teams with multiple locations.

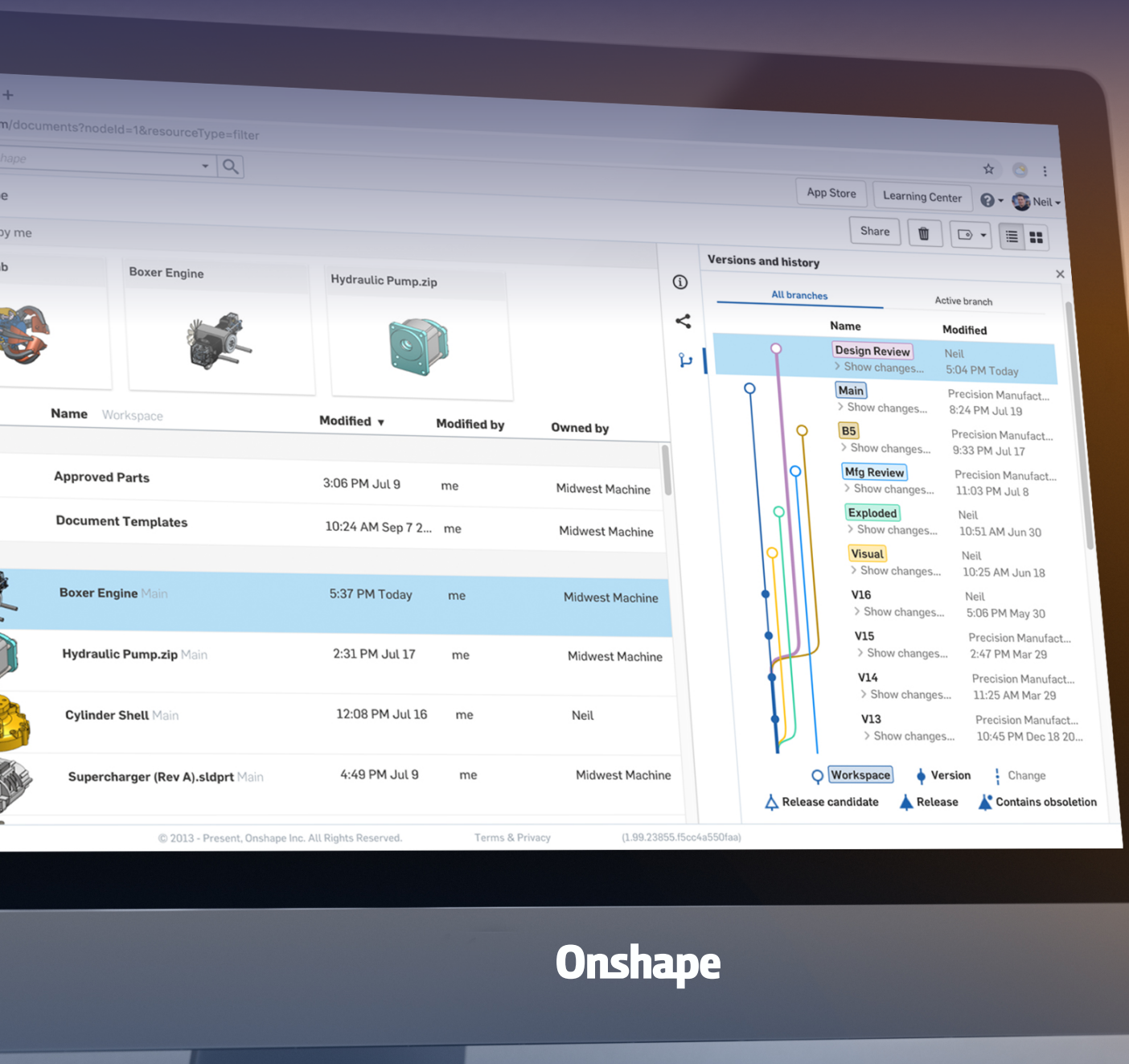
Each team has their own processes and rarely communicates with each other, leading to duplicate data, information silos and islands of automation. When several copies of the same part are spread across different systems at different locations and a change is required, it's virtually impossible to know which file is the master copy and who should be making the change. Changes are often made to one copy, but not to others. Mistakes are easily made.

The importance of early collaboration with everyone in the supply chain cannot be stressed enough. Getting early feedback at every stage of the design helps you to manage and reduce product-related costs, manufacturing defects, recalls, complaints and risk.

All of the above issues underline the need for good working practices and secure data management. The level of automation, management and security that is provided by the data management solution you choose depends upon which route you take. The next section explores data management in more detail, what you should look for in a data management system, the benefits and pitfalls, and best practices to set you up for success.

Section 2

The Benefits of Data Management



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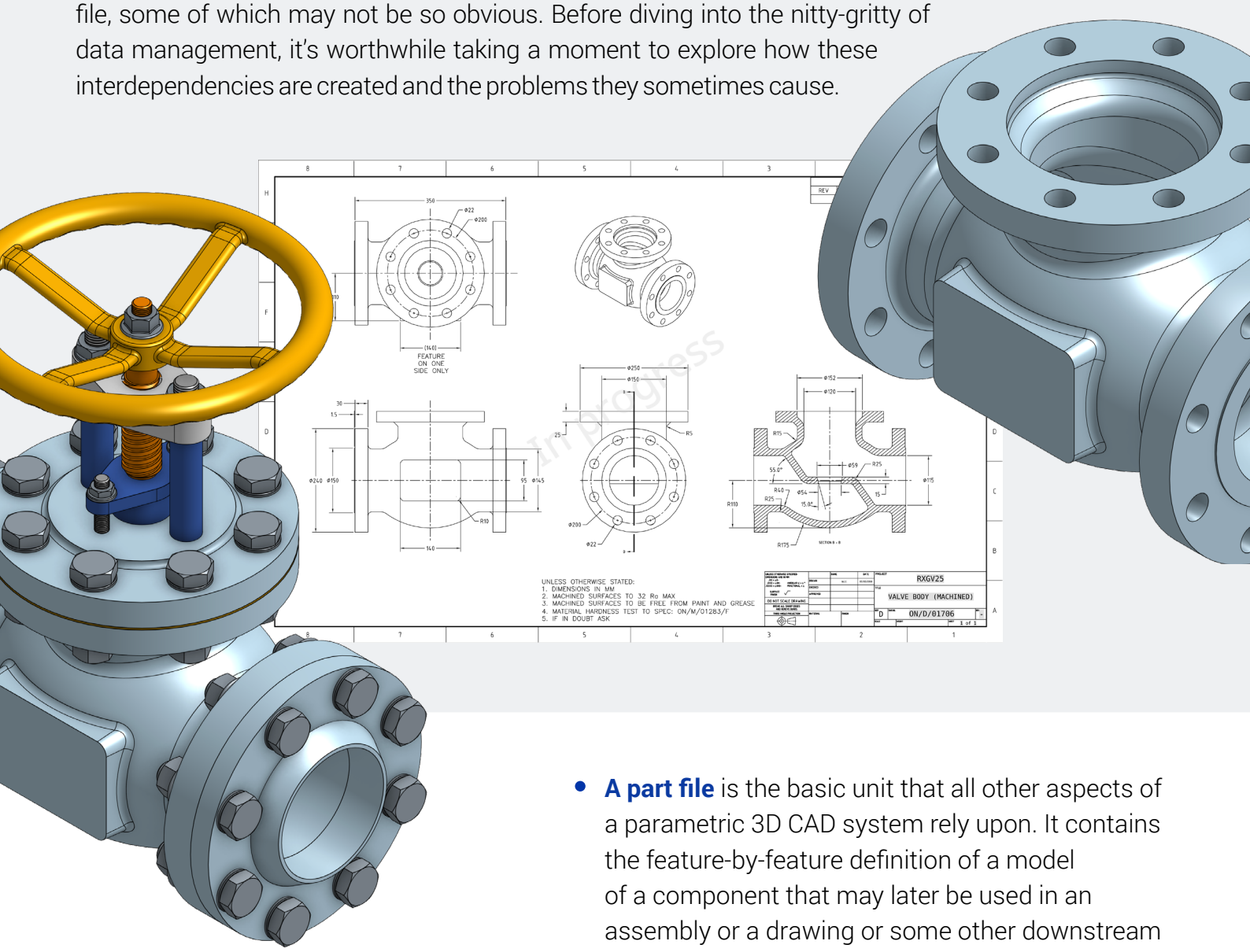
Why Does 3D CAD Need PDM?

One of the key roles of Product Data Management software is to manage and organize the complex interdependencies that 3D CAD creates between each type of file, some of which may not be so obvious. Before diving into the nitty-gritty of data management, it's worthwhile taking a moment to explore how these interdependencies are created and the problems they sometimes cause.



At a basic level, each CAD file contains either a part, an assembly or a drawing.

- **A part file** is the basic unit that all other aspects of a parametric 3D CAD system rely upon. It contains the feature-by-feature definition of a model of a component that may later be used in an assembly or a drawing or some other downstream deliverable like simulation, CAM or rendering.
- **An assembly file** relies on a part file to provide the necessary geometry so that it can position it relative to other parts in the assembly.
- **A drawing file** relies on a part file to provide the necessary geometry to create drawing views and accurate measurements for dimensions and other annotations.

WHY DOES 3D CAD NEED PDM?

Neither an assembly file nor a drawing file contain the geometry required to accurately depict correct part geometry. Some systems may cache this data as a snapshot in time in the assembly or drawing file, mainly to enable viewing software to display the geometry without having all the files present. But cached data may be out of date, so it's a risk to rely on this information. Think of a drawing with cached data like a print – it could potentially be out-of-date the moment it is created, and it's almost impossible to tell if it is or not without further investigation.

Therefore, in order to depict the latest design accurately, an assembly or a drawing cannot truly exist without access to the required up-to-date part files. If a part file goes missing, becomes corrupt, is changed without permission or is just generally interfered with, the assembly and drawing could potentially be wrong and cause untold damage to a project. Likewise, viewing a drawing containing cached data could be extremely out-of-date. Incorrectly manufactured parts cost companies millions each year taking scrap, operator time and rework into account. Unauthorized modifications to just one part in a project could have a domino effect on others, multiplying the incorrect part count and thus overall lost time and money.

Carefully crafted parametric models can propagate changes quickly and effectively to all downstream deliverables such as assemblies and drawings. Unfortunately, very few parametric models are as resilient to design changes as they should be. Engineers don't have the luxury of time to plan ahead and define robust references between features in a part and parts in an assembly. Project deadlines are always looming and design changes come thick and fast. The results, through no fault of their own, are models which fall apart at the slightest change. This flakiness causes models to fail and references to be lost. Faces that were used in an assembly go missing and edges that were dimensioned in a drawing move without warning. A simple design change can have a severe domino effect.

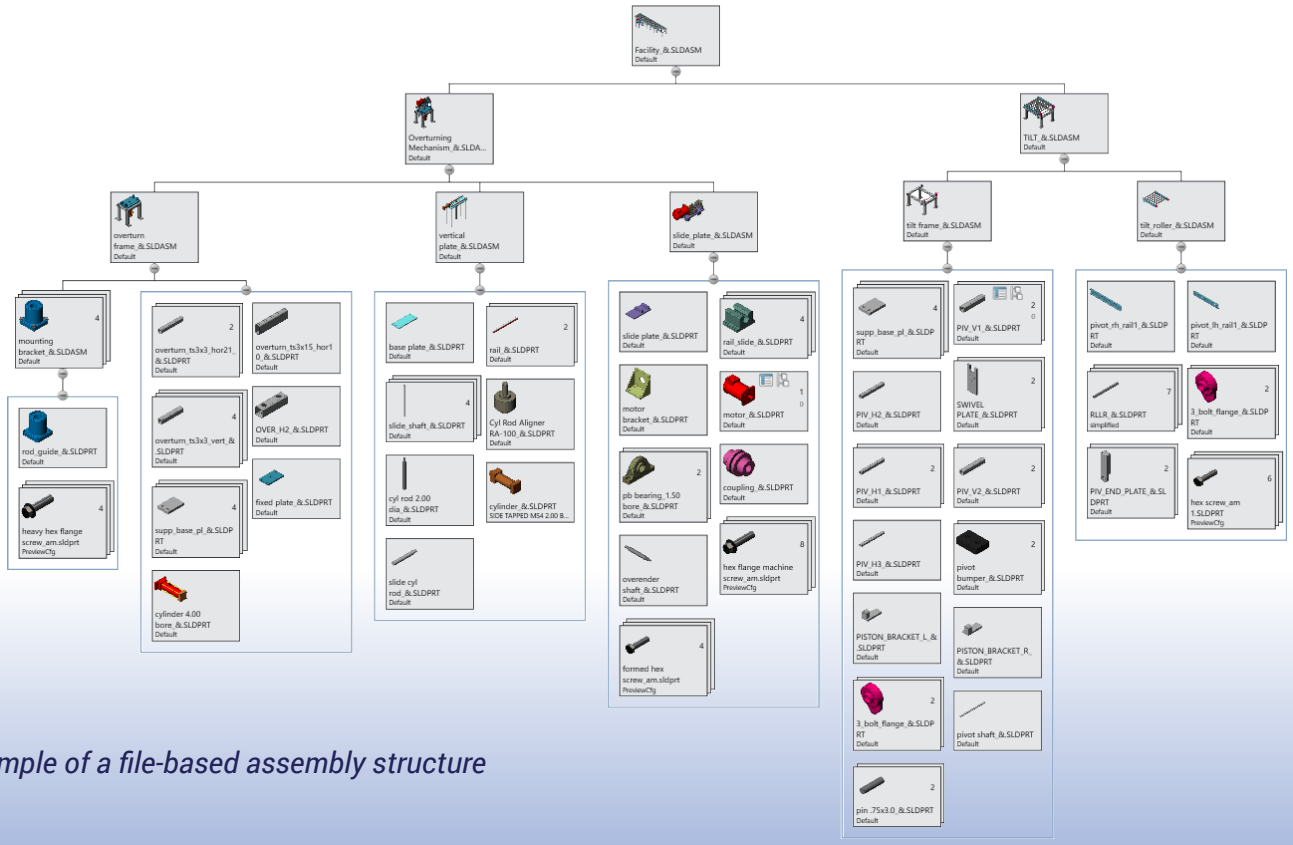
Managing these interdependencies can only effectively be achieved using data management software. Vendor-supplied PDM software understands the data structures inside each file and knows which files are dependent upon others.

How Do PDM Systems Work?

Product Data Management software comes in many varieties and from many sources – your CAD vendor, your ERP provider or some other document management system – with varying levels of usability, flexibility and capability. Some have better integrations with other business systems, but the only one that truly understands your design data (without having to reverse engineer the file formats that get encrypted with each release) is the PDM system from your CAD vendor. These systems take full advantage of the data available from the CAD system, often have thin client add-ins that enable quick access to data structures and the complex references and interdependencies between parts in an assembly, and have the best ease of use (albeit training is usually required to get the full benefits).

A CAD file can contain any type of geometry, simple or complex. It also contains references to the interdependencies between each file and data about that file (called “metadata”), which contains properties such as name, description, material, part number and project name.

When a design is checked into PDM, the highest level object, usually an assembly, is opened and the data structure is interrogated. From this file, the PDM system will extract a list of each dependent subassembly or part file. Each of those files will then be opened in turn and their dependencies, such as drawings and other parts and assemblies, will be added to the assembly structure list and an accurate Bill of Materials (BOM) is created at the same time. This process will repeat itself until no further levels of dependency exist.



An example of a file-based assembly structure

HOW DO PDM SYSTEMS WORK?

Assuming all the files can be located, they are then copied to a dedicated file server over the network and all the interdependencies and metadata are stored in tables in an SQL database. The tables in this database are configured by the PDM software during installation to exactly match the metadata created by the CAD system. This enables data to be structured and categorized so that it can be indexed, searched and easily manipulated using Structured Query Language (SQL) transactions.

For a CAD file, a table may state what type of file it is, where it is stored, list all of its custom properties and have links to the assembly or project that it belongs to. A simple SQL query is able to quickly find all the information about a file and its relational hierarchy to all the other files in your database.

Once the table structure has been defined, it is not easily changed. This causes an issue with the annual upgrade cycle of most CAD and PDM systems, in that data structure changes required to accommodate new CAD features often require changes to be made to the PDM database structure. CAD vendors, therefore, attempt to keep PDM system releases in sync with CAD releases (within maybe a week or two) to minimize the impact of the downtime that is imposed on their customers.

For large databases with many files, the data structure and file version upgrade process can take a considerable amount of time and IT resources. It is also not unusual for unknown errors and model failures to be introduced when CAD files are upgraded.

Third-party PDM systems are not able to keep up with these new encrypted data structures and often have to wait and react to changes to a CAD system's proprietary file format. New versions of third-party PDM systems are often delayed for several months after the latest release of the CAD tool, while the new file format is reverse engineered. They also have to modify their PDM solutions to be able to keep up with any new CAD capabilities. If a new feature is too difficult to implement or deemed so insignificant that it doesn't add any value, then they may not be added at all. Delaying a new PDM implementation is not a major inconvenience for many companies, because their standard practice is to wait a few months and several service pack releases in order to test the new CAD and PDM system in a sandbox environment for bugs and other defects before rolling out company-wide.

of companies using PDM/PLM systems **wish there were a better way** of preventing data management errors.

According to a recent independent product development survey, nearly three out of four companies are unsatisfied with the PDM approach to design data management.

The Pros and Cons of PDM Software

Think of a PDM database like a library card system that keeps track of where files are kept and a brief summary of what each file contains. To find a file, you consult your index card to find where the file is stored on the network and then "check out" the file which copies it to your local hard drive. Just like a library book, once a file is checked out, it is no longer available for anyone else. You can still see the metadata and a view-only representation of the file, because the library card is always available and always kept in a central location, but the file itself cannot be copied for editing.

The files on the server and the library card system are password-protected to prevent unauthorized access. A user must first sign-in to the PDM system using their unique username and password before they can access any data. For this reason, a PDM system is often referred to as a "PDM vault" because of this extra layer of security. However, once files are checked out of the PDM vault and copied locally to a user's hard drive, they are no longer secure. These files are now essentially uncontrolled and can be edited, copied or emailed, presenting a serious security loophole. Once a file is copied and sent to a supplier, there's always the possibility that it could already be out-of-date and they could manufacture the wrong version of a part. The master copy of the data is still stored in the PDM vault, so at least that is safe (assuming it is regularly backed up).

Checked-out files are locked by the PDM system to prevent others from checking them out, editing them and overwriting any changes made by other team members. Nobody can work on a file until it is checked back into the PDM system and unlocked.

THE PROS AND CONS OF PDM SOFTWARE

This mechanism ensures that those who have files checked out can be easily traced, files can be version-controlled and conflicts between design teams can theoretically be avoided In practice, this becomes more of an obstacle than a benefit as locked files prevent others from working, resigning them to wait until the files are checked back in and unlocked before they can get edit access. This forces a serial design workflow causing bottlenecks and unnecessary delays.

The bigger the team and the more agile the design process, the bigger this problem becomes. Since it is not always possible to give a PDM license to outside contractors, files must be checked-out by an employee, sent to the contractor, then checked back in by the same employee when the files are sent back.

It is typical for a checked-out file to remain so for some time as the designer continues to make changes. During this time, nobody in the company is able to see the design changes and how much progress is being made. Only once the file has been checked back in, is it made visible to others. Constantly checking files in and out of the vault is a hindrance. It requires the designer to stop what he or she is doing and run the check-in process which can take several minutes depending upon the system requirements and the size of the files being copied. This is precious time that affects a designer's train of thought, so it is generally avoided whenever possible. The designer usually waits until the job is complete or a colleague or manager has requested the file to be checked in.

Between check-ins, the file is not only uncontrolled, but it may also go through several design concepts and complex edits before the designer is satisfied that it's at a stage where it should be versioned and stored safely in the vault. If the designer decides that no changes are necessary, the lock can be removed from the file in the vault and a copy of the file will remain on the designer's local hard drive.

THE PROS AND CONS OF PDM SOFTWARE

At this stage, the product development team must be careful to ensure that further changes to the local file are not made while the file is unlocked in the vault. **Otherwise, all changes could be wasted if the file is checked out again as the local file is overwritten.**

During the design process, the designer may go through several iterations while the file is checked out. With every save, previous iterations are lost.

This can be avoided if the file is checked back into the vault on a regular basis, but that workflow is not conducive to design exploration. It takes too much time. When inspiration for a new idea or better solution strikes, it is always while trying to solve a current design problem. The designer then goes off on a tangent with ideas of how to make it better, making drastic modifications to several parts and assemblies, only to realize later that the first idea was far superior. But if the file wasn't saved or checked into the vault, the original idea and inspiration has disappeared forever.

When work is lost, there's even more wasted time trying to remember the original idea and recreate it all over again. The same applies if you adopt the "save often" technique, which is often necessary to make sure that no work is lost due to CAD crashes. However, this technique has one major flaw – you might be saving bad work over good. Once you hit "Save," you can never go back to a previous design idea.

Nearly **HALF** of product development teams using PDM/PLM systems say they **slow down the design process** and block access to design data when they need it.

While PDM systems are good at recording milestones in a project, they are of little practical use when designing in CAD – as there is no security or data recording available when a file is checked out. Managers and executives are able to see who has a file checked out, but they are not able to see how a design is progressing.

There are many more benefits to a carefully deployed data management solution. There are also many downsides that are not so obvious (and not usually brought to your attention by CAD vendors). The issues mentioned above apply to all file-based CAD and PDM systems and cannot be avoided.

What is PLM?

You may have heard of additional three-letter acronyms related to engineering data management. The most common one is "PLM," or Product Lifecycle Management. There is a key difference between PDM and PLM.

While PDM is focused on the management of engineering data and is generally used in the engineering department, PLM is seen as an evolution of PDM that branches out of the engineering department and deals with all the interactions between various stakeholders involved with the product at every stage – from initial concept through to product retirement.

Common functions of PLM might include:

- *Project Management*
- *Supplier Management*
- *Requirements Management*
- *Systems Engineering*
- *Multi-Disciplinary BOM Management*
- *Manufacturing*
- *Service and Support*
- *Product Disposal and More*

With regard to design and manufacturing data, the focus of a PLM system is the item or the part number, not necessarily the physical CAD file.

Some PLM systems blur the lines between PLM and PDM, having elements of PDM built-in. However, the best PLM systems are often not developed by the same vendor who supplied your CAD system. Therefore, the PDM element may not be as strong as it should be. Integrations between standalone PDM and PLM systems are available, but that is one more IT issue for your team to resolve.

The scope of PLM is a lot more extensive than PDM, and as such, is not covered in this book.

Section 3

What to Look For in a PDM System

Onshape

Implementing a PDM strategy is not only time-consuming for project managers, but for every other stakeholder who needs to find the necessary resources to see the project through. As everyone is overloaded with other ongoing projects, understanding how a specific PDM solution impacts your business and your processes is more important than checking off a laundry list of PDM capabilities.

One of the biggest and most costly mistakes made while implementing a PDM system is trying to map current business processes to an off-the-shelf data management solution. This approach will likely lead to disappointment or a hefty consultant's bill for a long drawn-out implementation with custom forms and macros. Just because a specific process has always been used, doesn't mean that it should continue to be used with a new tool. Many data management tools have workflows that will address most of the design processes you currently employ, and some will do things differently. It's best to regard this as an opportunity to brush off the cobwebs and re-engineer your business processes if a particular workflow makes more sense.

These are the minimum requirements you should look for in any Product Data Management system:

1 Installation, Setup and Maintenance

For companies with dedicated IT resources and CAD administrators, installation and maintenance of a PDM system is not a major issue beyond downtime and extra related costs. For smaller companies, however, it is often the CAD expert who also becomes the unofficial CAD administrator.

The PDM software itself does not take too long to install. But in most cases, the provisioning of multiple dedicated servers and installation and configuration of the SQL database (which usually comes as an extra cost) takes a certain level of patience and expertise. When the next annual release happens, it is pertinent to create multiple instances or sandbox environments that mirror your production setup. That way you can test that everything works as it should in a controlled environment before deploying new software to production. This will require extra hardware, time and IT resources, but it's a necessary and worthwhile exercise.

If you are working across multiple sites, you need to assess what capabilities are available for data replication – making exact copies of file servers – so that each site has a local copy of the data. Replication can usually be scheduled to run overnight or on-the-fly, but consider the network band width required to move large datasets and the costs of running and maintaining extra servers.

Ongoing user and project management often falls to the CAD administrator, too. When occasional users such as sales, marketing, manufacturing, and guest users (such as contractors and customers) need access to your data, explore how flexible your software and vendor are for additional licensing and remote access options. Ask what processes need to be followed in order to give people access to the data they need as quickly as possible.

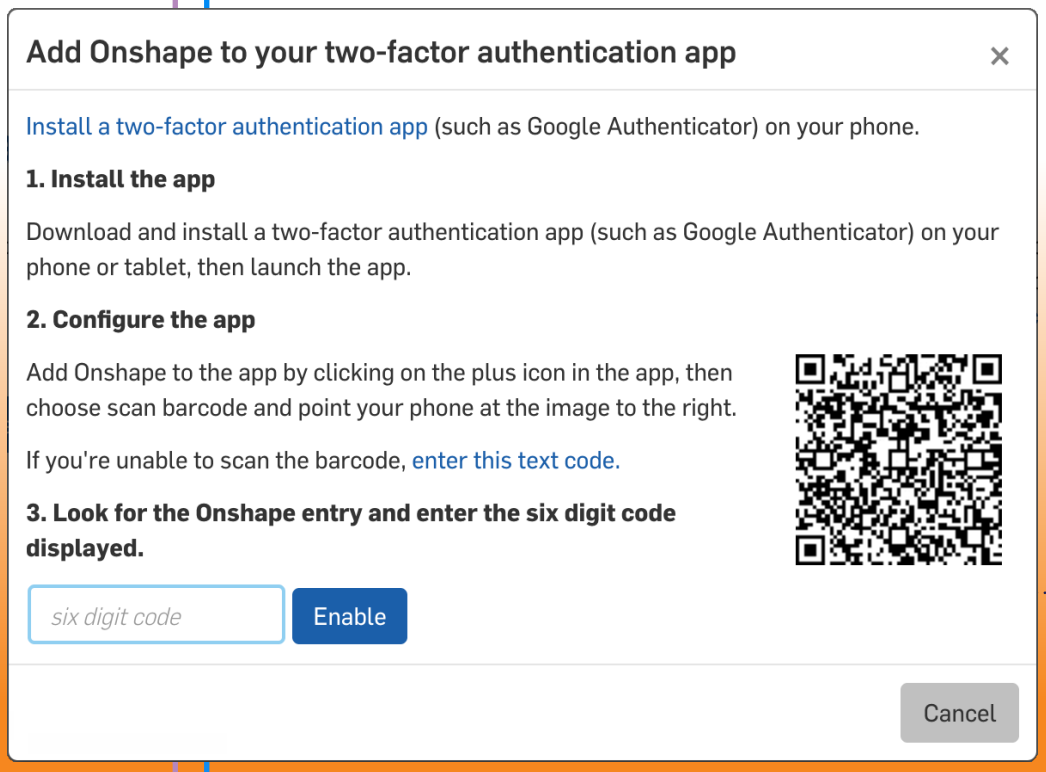
When evaluating a PDM system, discuss the options available for installation and maintenance to see how much work is involved. If it is not possible to configure the PDM system yourself, your vendor will be happy to supply a consultant for an additional cost as part of your implementation package.

2 Security

It is important for any organization adopting a PDM system to evaluate their security requirements and try to predict who will need access to their data and what type of access will be required.

A minimum security requirement is that each user should have their own unique username and password and must login to the PDM system before they can access any company data (even the temporary files on their hard drive that were part of a previous session). This is in addition to any computer accounts and passwords. For users requiring remote access, a data management system should have additional security features like 2-Factor Authentication (2FA) available as standard.

Once authenticated, each user should not be able to access all data – only the projects, folders or individual files they have been given permission to view or edit. More granular user and group management would enable access to be controlled by role (or job function), team, project, folder and individual item. These security permissions should be able to be controlled by the system administrator or by the project manager.



A data management system should have additional security features such as 2-Factor Authentication (2FA) available as standard.

It is your IT department's responsibility to ensure that no security measures can be circumvented. Your overall security plan should include password-protecting servers and shared network drives, administering firewalls, locking down USB ports to prevent file copying and physically securing server rooms.

When employees leave or move onto other projects, find out how easy it is to remove their access to your data and if it's possible to collect or delete any files (on their hard drives or other storage media) that may be left over from previous PDM sessions and file check-outs. The PDM system should have an easy-to-use interface for administration of user accounts, as well as audit trails that show who accessed what and when. It should be easy for an administrator to reassign document ownership and access control on the fly.

3 Engineering Document Control

If you are considering a data management system from a different vendor than your CAD system, test their capability to handle all the different types of files you typically create as part of a project. The check-in and check-out procedure can vary between different systems and the efficiency of this process is highly dependent on how the backend servers are setup and the local client software or CAD add-ins are configured. Moving large datasets across a network during a check in/out process can take time, especially between different sites, so this should also be considered.

Other, non-CAD files are also critical to the development and documentation of a project. These can be PDF files, images, videos, or any other file-based item including Microsoft Office documents, spreadsheets and email correspondence. A PDM system should be able to handle these items as part of the product release process and keep a detailed, documented audit trail of every item from concept through to manufacture. Standard parts, fasteners and other approved supplier parts should be managed from a central repository to make them easy to find and easy to share between multiple projects, design teams or locations to prevent duplication.

4 Search

PDM's ability to index large amounts of data, including metadata, make it ideal for finding the right part or document quickly. Unless the search tools are granular enough, you may end up with long lists of similar parts or duplicates. Check what options are available, and how specific you can be with your search criteria. Can you search based on any metadata and can you combine multiple criteria? Can you search files that have been checked-out or new files that have not been checked in yet? Other search types that are common to PDM systems are reverse links (also known as "where used" reports) that display all of the drawings linked to an assembly that meet specified criteria or all of the assemblies where a revision of a specific part is consumed.

5 Version Control

As products go through each stage of a design process, certain milestones or recognized development stages are versioned in order to document progress or to inform others that a product is ready for review. A designer working on a project may make many modifications and design iterations in the course of determining the most efficient and cost-effective design. Once the designer is happy with the current state, checking-in the design should automatically create a version.

A version draws a line in the sand and stores the design at that moment-in-time in the database. This provides a permanent record of a version of the design that can be retrieved, reviewed and used as the baseline for further design edits or new product lines. For example, a product containing a complex linkage or mechanism may have been developed through any number of conceptual design ideas. Each idea is then considered based on its individual merits and the design that gets the consensus of approval will become the basis of the product moving forward. In order to document each of the ideas and to ensure that everyone is looking at the version that was put forward by the designer, version control is very important.

Make sure that a version stored in the PDM database can be easily searched, retrieved and is immutable, or in other words, cannot be changed or deleted by the user or the CAD administrator. Removing or altering an existing version could have a severe impact if it is used in other projects. Between each version, or check-out/check-in, a designer may make multiple changes to a design or create new parts. How easy is it to track those changes?

6 Revision Control and Approval Workflows

Revisions are used to denote designs that have been reviewed and approved through a formal release procedure and may be candidates for production – depending upon the state at which that revision is in. Revision control relies upon preconfigured approval workflows and revision schemes in order to route documents to the right people for sign-off and to apply the correct revision number.

When evaluating this important part of any data management solution, assess whether it can replicate your revision schemes and approval workflows. In many cases, an exact match may not be possible and your processes may need to be adjusted to suit. Redesigning and optimizing your engineering business processes is often key to a successful deployment of any PDM system – especially those processes that existed before PDM or before CAD.

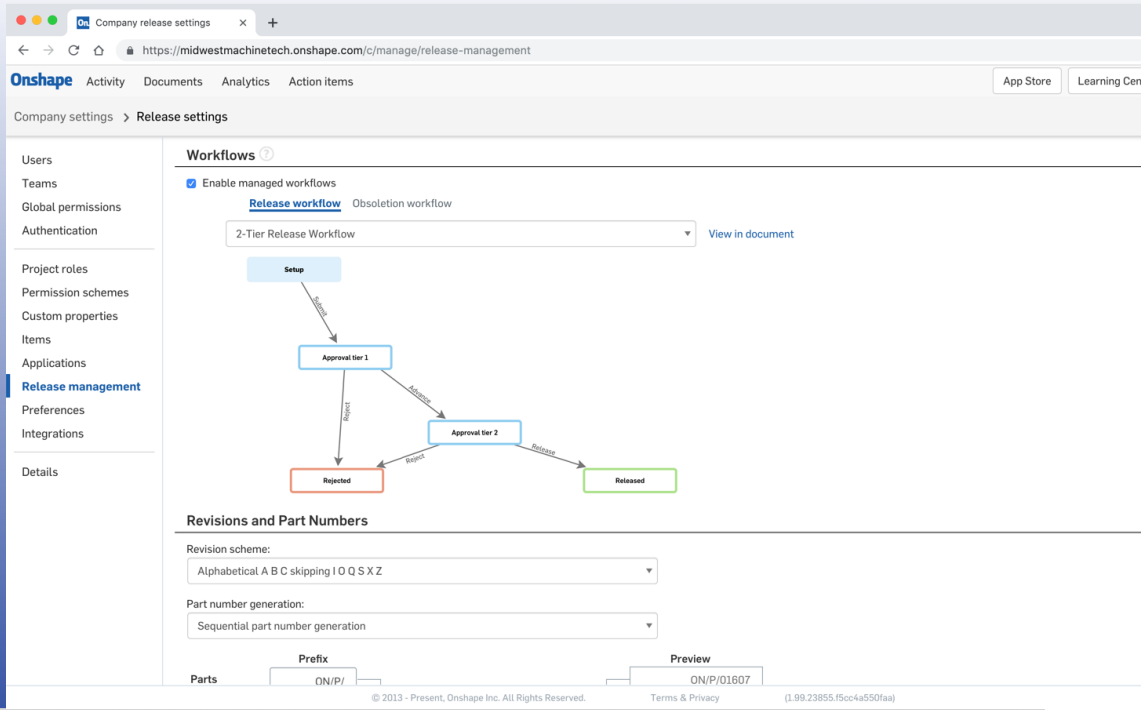
To enable this redesign and optimization, most PDM systems provide workflow design tools. With workflows, almost any business process can be modeled visually and automated to follow strict rules and various paths of approval depending on different criteria. A set of documents can be routed through different people, groups and departments (either in parallel or in serial) in order to receive all the signatures required for release.

Exceptions, such as the rejection of a document change, should be dealt with through custom paths or even sub-workflow processes. Automation is key to workflows – for example, the ability to automate the definition of an attribute (such as release state) as the workflow reaches a specific stage.

Most PDM systems will provide a visual, easy-to-use interface that enables an administrator to design the required workflows. An API (Application Programing Interface) should be available to enable some level of customization above and beyond the out-of-the-box functionality provided by the workflow designer.

To initiate a workflow, a user should submit an object for approval. If the object is an assembly, the system should be able to up-issue any subassembly or part that requires it. It should also be able to revision control individual part or assembly configurations (variations of a standard item) and add items from other documents or projects as part of the approval process.

Notifications of pending approvals should be sent to managers via email with embedded links to find approval submissions easily. Before signing-off a design, a manager must be able to easily interrogate the design in detail without having to go looking for data. Access to this information on a mobile device should also be considered for managers and executives on the go. A project manager or CAD administrator should be able to see which documents are pending approval, how long they have been in that state, and who the approvers are. This is vital to keep projects on track and to prevent any bottlenecks caused by approvers being absent from the business.



7 Automatic Part Numbering

Part numbers should be unique across the company for inventory and other purposes. If the PDM system has the option of generating automatic part numbers, it should be customizable out-of-the-box to suit most companies' needs and be able to check that numbers don't already exist to prevent duplication in the database.

If your Enterprise Resource Planning (ERP) system generates the master part codes, there must be a mechanism (through an API or other method) to extract that data and apply it to any new parts at check-in.

8 "Where Used" Reports

Standardizing and reusing common parts across multiple product lines is a great way to reduce inventory, design time and overall costs. If a part needs replacing or updating due to a failure in service or change of supplier, a "where used" report should be able to detail the exact use of any part or assembly. The report should include your current products, products you no longer sell but still support and all your in-process designs. This is critical for analyzing the impact of any proposed change and the traceability of each design.

In combination with an advanced search tool, a "where used" report can help companies to rationalize inventory and reuse existing parts as much as possible. If a part can be reused in a new design, a detailed "where used" report can inform the designer that it is a common part. The company can save costs by not having to issue new part numbers, source suppliers and allocate new inventory space.

9 Effective Collaboration

Collaboration with internal and external teams has been covered in detail elsewhere in this book. However, a good data management system should be able to aid in this process and make it as painless as possible.

When multiple designers are working on the same project, their CAD system may prevent them from being able to edit the same files at the same time, but they can still reference the last checked-in version. A suitable CAD add-in should therefore be able to alert a user who has referenced a part that is being edited by somebody else, that the design has changed and needs updating. Ideally, each user should have complete visibility into the changes that are being made so that there are no surprises when a new version appears. They should also have the option to update or freeze the design.

Sharing data to the right people at the right time should be straightforward and either controlled by the designer, project manager or CAD administrator. A unique identifier for each participant in the project, usually an email address, should be enough to assign permissions to another person who can then access the data without any further hurdles. A system should also allow companies to just as easily revoke access to data in the case of employees leaving the company or contractors moving on to another project.

10 Engineering Change Orders (ECOs)

Engineering Change Orders (ECOs) should not come as a big surprise to engineers – they're inevitable. No design is perfect the first time and improvements are always required, whether they be design improvements or changes required for manufacturing. Issues found during the initial design are corrected as part of the natural design process, while ECOs are generally requested after a product has been released for manufacturing. At this time, all ECOs are carefully vetted in design reviews to ensure that it makes sense to implement them.

An ECO is effectively rework. When changes are made to one area of a product, invariably other areas are affected too. While PDM systems can help manage all the data, the work required to implement an ECO may multiply tenfold as you chase interdependencies and tolerance stackups around a design. Workflows generally manage the ECO process, assigning permissions and notifying users who will then check-out the files to make the changes.

File locking prevents others from working on design data while an ECO is completed, so if multiple ECOs need to be carried out, the PDM system may force a serial workflow and create a design bottleneck. Check if and how the PDM system permits multiple ECOs to be affected at the same time. Once complete, changes should be able to be compared, reviewed, approved and seamlessly integrated into the main design.

11 Bill of Materials

A Bill of Materials is one of the most important pieces of information required for product design. When CAD files are checked into a PDM system and all metadata is extracted, a BOM becomes available for all users with permissions. Because the BOM is a vital source of data, it should be accessible and viewable by all project stakeholders without requiring a PDM license or special software. Users with edit permissions should be able to modify a BOM, edit part metadata and add bulk items such as such as paint, grease and sealants to the parts list.

A Bill of Materials should always reflect the currently selected configuration (if the PDM system supports configurations). This means that as an assembly configuration is selected, the BOM is updated to reflect that configuration.

12 Integration With Enterprise Resource Planning (ERP)

Enterprise Resource Planning (ERP) software automates data transmission within a company, covering procurement, production, sales, human resources, accounting and other critical business information. Integrating PDM with ERP enables users to create production BOMs in an automated and process-safe way without having to copy numbers from their CAD system and manually enter them into their master ERP system. Part properties such as material, weight and volume should transfer seamlessly to the ERP system – giving the designer a comprehensive overview of all important product information, such as stock levels, suppliers, prices, etc.

13 Real-Time Analytics

Every company wants to identify inefficiencies and reduce costs. To achieve this, you need a data management system that is able to offer complete transparency across the entire product development process. Design is one area of a business that has very little in the way of hard facts, making it difficult to uncover issues and find ways to address them.

A good data management solution should be able to generate reports that enable you to analyze key performance indicators related to your entire design process. Reports that detail how much time and resources were used on a project, how much time a user spent on each project, who has access to a design and when did they last review it, are just some of the details that will help you to evaluate and re-engineer your business processes.

Role-based custom dashboards displaying analytics related to the progress of the product development process should be easy to define in the PDM system.

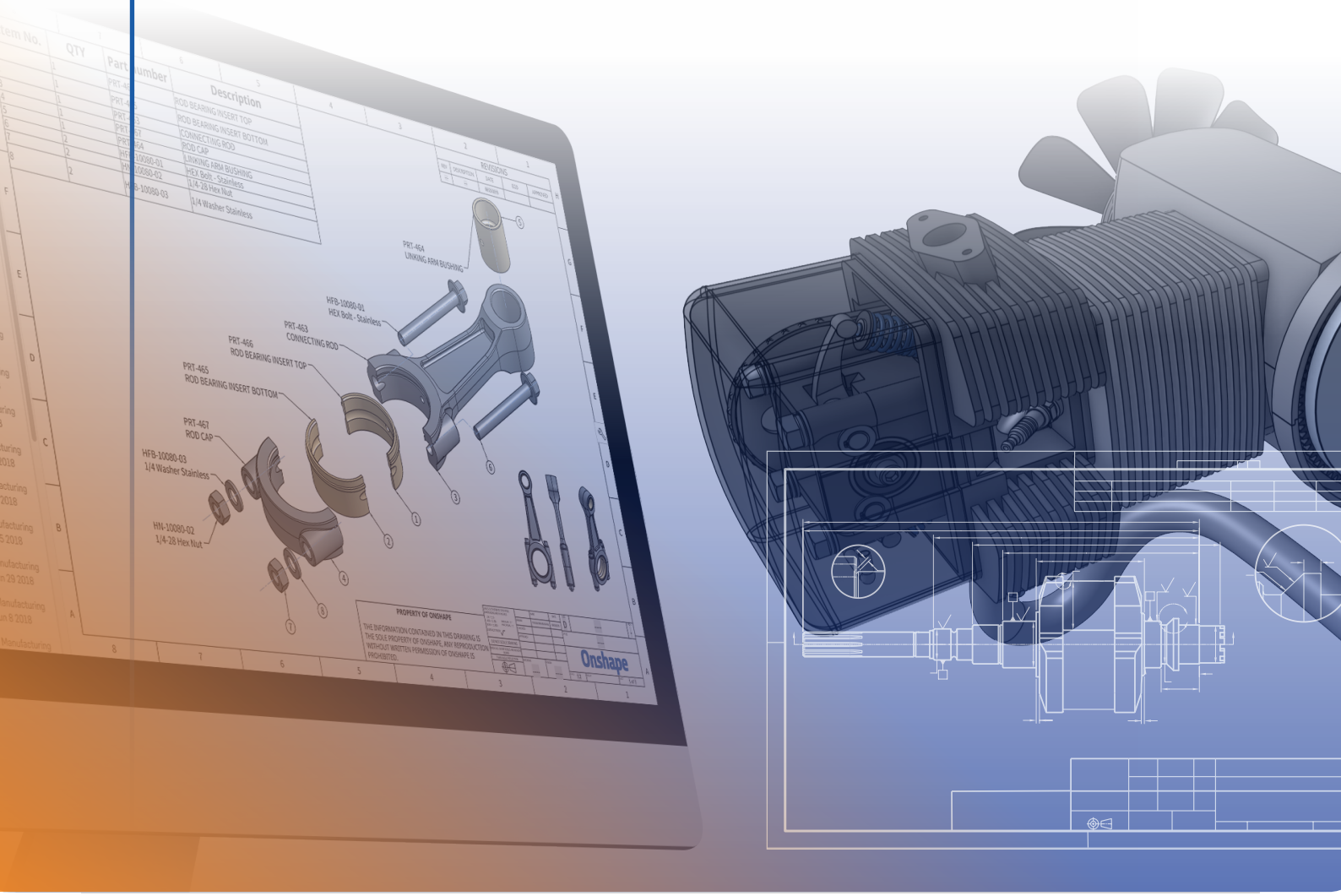
14 Automated Backups and Disaster Recovery

The PDM database and all the files on the file server must be backed up on a regular basis, no matter how safe you think your IT and PDM systems are. Backups should be done at least once a day, if not more often. Backups are there for the sole purpose of disaster recovery. You need to be ready to deal with missing or corrupt files, hardware failures, computer viruses, ransomware, or even a fire in the server room. Performing regular backups is not a luxury; it's a necessity.

It is estimated that up to 30% of a company's CAD files become corrupt or go missing over their lifetime, so when data is lost and you need to revert to a backup, that is when you discover how good your disaster recovery strategy really is. Automated backup procedures are not part of a PDM system, so it is up to your IT department. Backing up a file-based PDM vault can be quite complex, labor intensive and expensive. Not only do you have to backup the disks used to store the actual CAD files, but also the SQL database that keeps track of those files.

To make sure the two stay in sync, backups must be run at the same time, usually during off-hours when nobody is accessing or making changes to the PDM data or the CAD files. Otherwise, the backup may be incomplete or become corrupted. This becomes trickier if your CAD data is replicated across multiple sites worldwide.

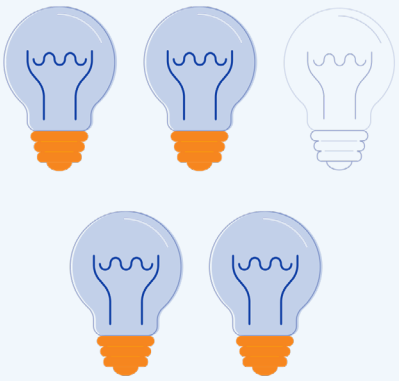
Remember that backups are only worthwhile if they are made regularly, each backup is replicated and every copy is integrity-tested and stored in a safe place (preferably off-site). If a backup procedure is scheduled to run once a day during the evening and you lose some files, at least you can restore them from the most recent backup – losing "only" one day's worth of work. That could be one day's worth of work for the entire team, not to mention the time it would take to get the systems back up and running and restoring the data from the backup. In reality, your disaster recovery plan could easily cost you several days.



Section 4

Data Management in the Cloud

Onshape



4 out of 5

companies that rate themselves as "excellent" for innovation have embraced cloud-based productivity tools.

Many companies already use cloud-based software for business-critical areas such as accounting, sales, cybersecurity and human resources. Product development teams are now finding the same efficiency and productivity benefits when managing their designs in the cloud as well.

The best data management tools are the ones you never see – they quietly go about their important tasks in the background without getting in the way of the designer, the design project or the IT team. Cloud-based data management tools go a long way towards fulfilling this promise by eliminating long drawn-out installations, configurations and day-to-day maintenance activities.

As you might expect, there are several methodologies available today that make use of the cloud. The cloud is, after all, just banks of computers hosted in a remote facility and maintained by a third party. So whatever can be achieved by locally installed software can be replicated in the cloud, right? This statement is not entirely true because there is one vital element missing: **How does a remote computer in the cloud access the files on your hard drive while maintaining strict security protocols to protect your intellectual property?**

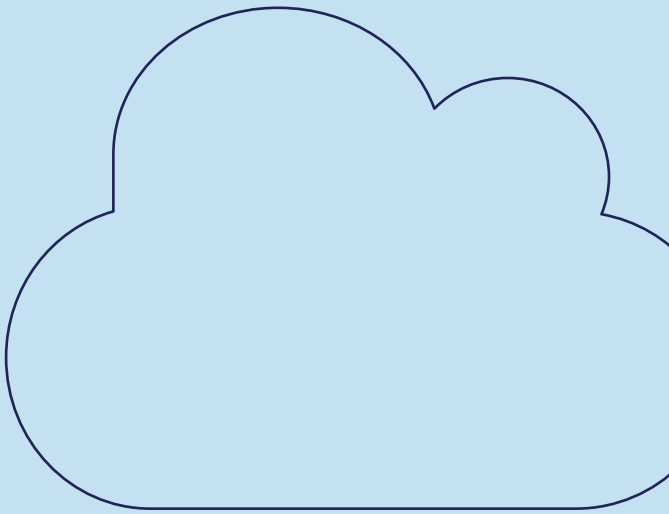
The answer is: It can't.

There has to be some mechanism to upload and download data to and from the cloud.

Popular cloud storage and file-sharing services such as Google Drive and Dropbox enable you to automate the task of data transmission by installing some proprietary software components on your computer. These services will designate certain folders on your hard drive to be a replica of some or all of the data you have stored in the cloud. Whenever a file is changed and saved to one of these folders, it is automatically uploaded to the cloud, versioned, and propagated to every user with whom the file has been shared. Everybody always has access to the latest version of the file.

However, cloud file-sharing services do not work so well when teams of designers need to work on the same projects – there's no way of knowing if somebody else is editing *their* locally synced copy of the master CAD file. Two or more people could be editing the same CAD file and now the "last save wins." The hours you may have spent editing an assembly are lost forever because somebody else, editing it at the same time, saved after you. The next time you open the assembly, everything looks completely different. This way of working ultimately causes the same duplicate file problems and manufacturing errors as sending files by email.

There are several dedicated cloud PDM solutions that use a similar mechanism of data transmission, but which also enable file-locking in their local clients. This works in a similar way to locally installed PDM – data is checked out, in this case from a web browser, and downloaded to your local hard drive. The files can then be locked if they are being edited to let the rest of the team know that the files are being worked on. Some systems obfuscate the file name and place them in an obscure location on your hard drive, but most do not. Either way, there are hundreds of files strewn across dozens of computers that can be copied at will. This not only represents a huge security threat, but also risks files being taken outside of the PDM ecosystem, which can lead to important decisions being made based on out-of-date design data.



HOW ONSHAPE HANDLES DATA MANAGEMENT

Onshape is uniquely placed in the product design space due to its inherent architecture. It's a cloud-based product design platform with a difference. The main difference being that it was built from the ground up as a data management solution first and then the design tools were added on top, not the other way around as is common with many data management systems.

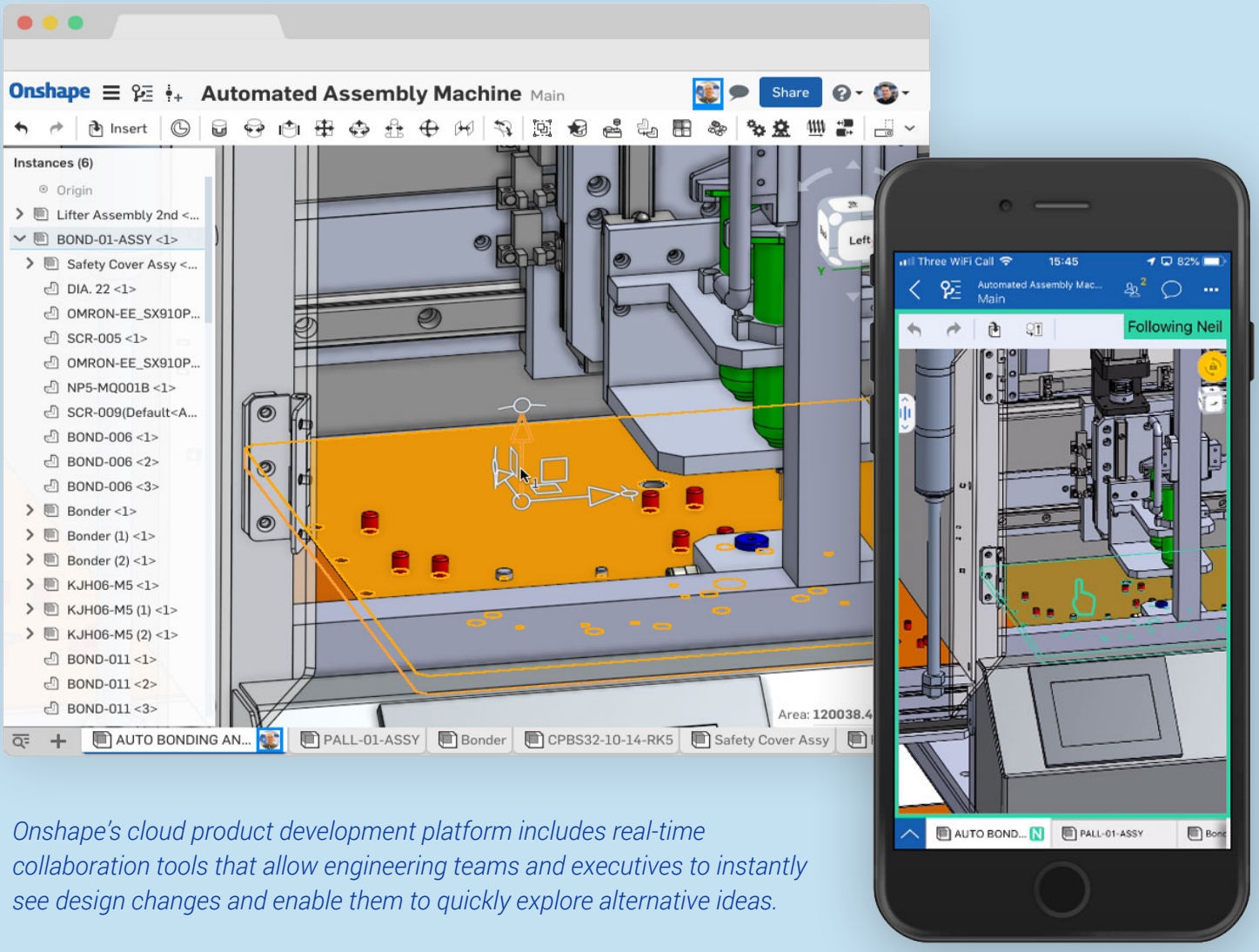
Another big difference is that Onshape does not use files, which immediately negates the most frustrating issues associated with CAD and PDM. It also does not use a relational database to store design data as other PDM systems do. A relational database (sometimes called an SQL database because of the transaction language used to add, edit, delete and find data) stores metadata in fixed tables with rigid schemas and pointers linking multiple tables together. This limits what the database is able to do, but also the type of data that it can store.

Onshape uses a document-oriented (NoSQL) database model which supports any type of data in any format with completely flexible schemas. It is a highly performant and distributed non-relational database, the type that is used in big data applications and other processing jobs involving data that doesn't fit well in a rigid relational model. Instead of using tables and rows like relational databases, a non-relational database architecture is made up of collections and documents.

A “Document” in Onshape is an arbitrary collection of parts, assemblies and drawings, plus any other project-related data (such as images, videos, PDFs, etc.). Since design data cannot exist outside of the database, things like security, version control, lost references, crashes and corrupted data are never an issue.

This fundamental architectural difference is what enables real-time collaboration, simultaneous editing, instant and secure sharing, version control and release management. No other product development platform has this level of capability with this level of flexibility.

In real terms, this means that an entire design team can simultaneously work on the same project, same assembly, same part and even the same sketch if need be. Whenever one person on the team makes a design change, everyone else instantly sees it.



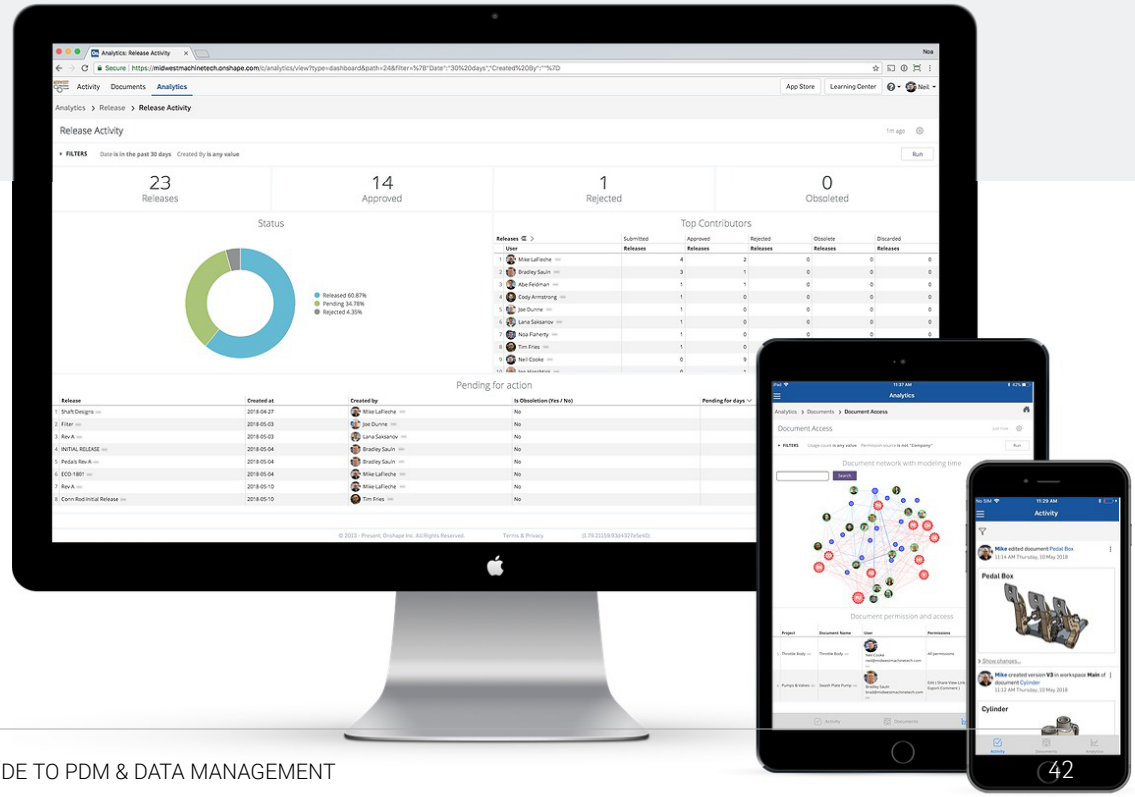
Onshape’s cloud product development platform includes real-time collaboration tools that allow engineering teams and executives to instantly see design changes and enable them to quickly explore alternative ideas.

Nothing is ever locked. All design activities are carried out in parallel – as changes are made, every action is recorded in the database and instantly updated wherever it's used. There's no "Save" button, no check-in / check-out, no accidental overwrites, and no waiting around for someone else to finish their work before you can start yours.

In the cloud, teams can co-design complex parts and assemblies without having to be physically in the same location. Since every design change is recorded, Onshape offers unlimited undo/redo and a complete audit trail of who did what and when, making it much easier to resolve conflicts.

Onshape enables multiple ECOs to be worked on simultaneously. Any number of sandbox environments, called branches, can be created to carry out ECOs, design explorations, or any activity where the main design should not be affected. A branch can be created from the same revision of the design that the ECO was raised against, so you can be sure you're editing the right data. Each branch can then be compared (to check for conflicts) and, once approved, merged back into the main design and up-issued.

Built-in release management and approval workflows can be customized to address most companies' business processes. Parts, assemblies, drawings, individual configurations and any other project-related data can be independently revision controlled following a predefined release schema. Multi-tier and multi-approver workflows provide notifications to designated individuals who are able to review and sign-off designs from any computer or mobile device without having to install any software.



Onshape's Enterprise product development platform lets companies make informed, data-driven business decisions from anywhere on any device.

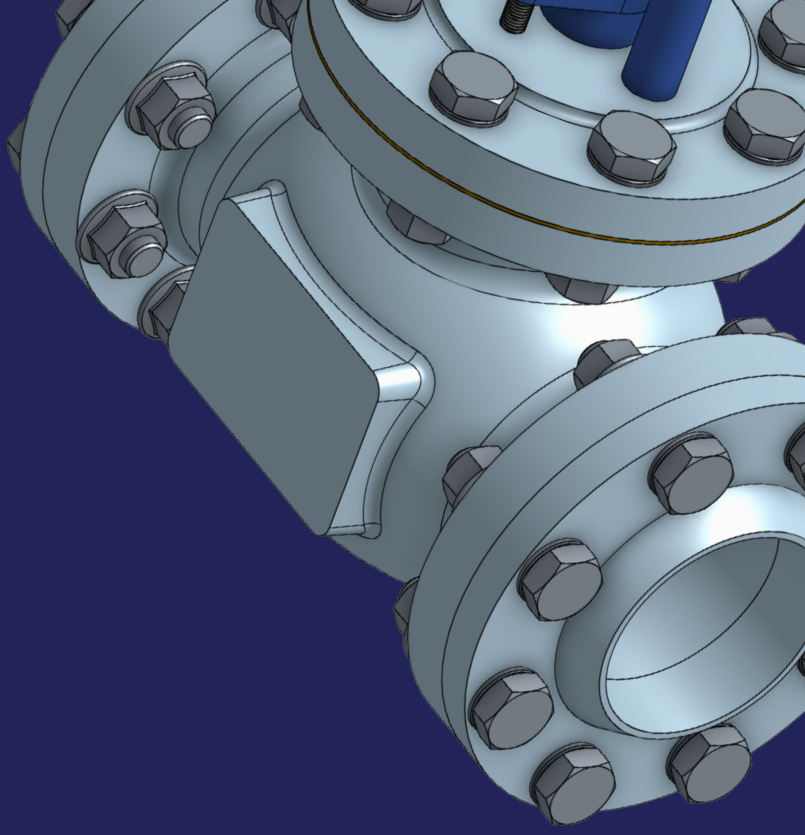
In addition to the complete design history captured in each Onshape Document (detailing who made what changes and when), Onshape's Enterprise platform records project details, duration, release status, team activity, supplier access, and more. In short, any activity that touches your data is logged and presented in easy-to-read graphs, tables and charts. This gives you complete visibility into who did what and when, how engineering efforts are trending over time, and who is contributing in what ways, enabling you to allocate more resources to get a project finished on time if needed.

89% of **executives and engineering managers** say they **need more visibility** Into their company's product design process. They want the ability to monitor their design team's progress 24/7 without meetings, emails, or phone calls.

Sharing data with colleagues, suppliers and customers is simple and secure. No design data ever leaves Onshape's servers. Just like Google Docs, all you need to do is to enter a person's email address, set view or edit permissions and press "Share." Clicking on the email link will open your design in a web browser or a mobile device. No software or downloads are required. This enables design teams to work together from anywhere and design reviews to be carried out in real time on any device. Everybody works on the exact same Document, not different copies of the data. Access to design data is just as easily revoked.

Finally, all data is backed up automatically every three hours and subjected to integrity tests at least every three weeks. Every edit made to an Onshape Document is replicated across multiple, geographically separated data centers in a matter of milliseconds. If something were to happen to one of the data centers, another one would take over immediately without you even noticing. In addition, Onshape's security and data protection measures are far superior to anything that any one company could implement (or afford) on its own.

Onshape



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If you'd like to STOP thinking about data management, get a live Onshape demo by clicking the button below.

GET A DEMO

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