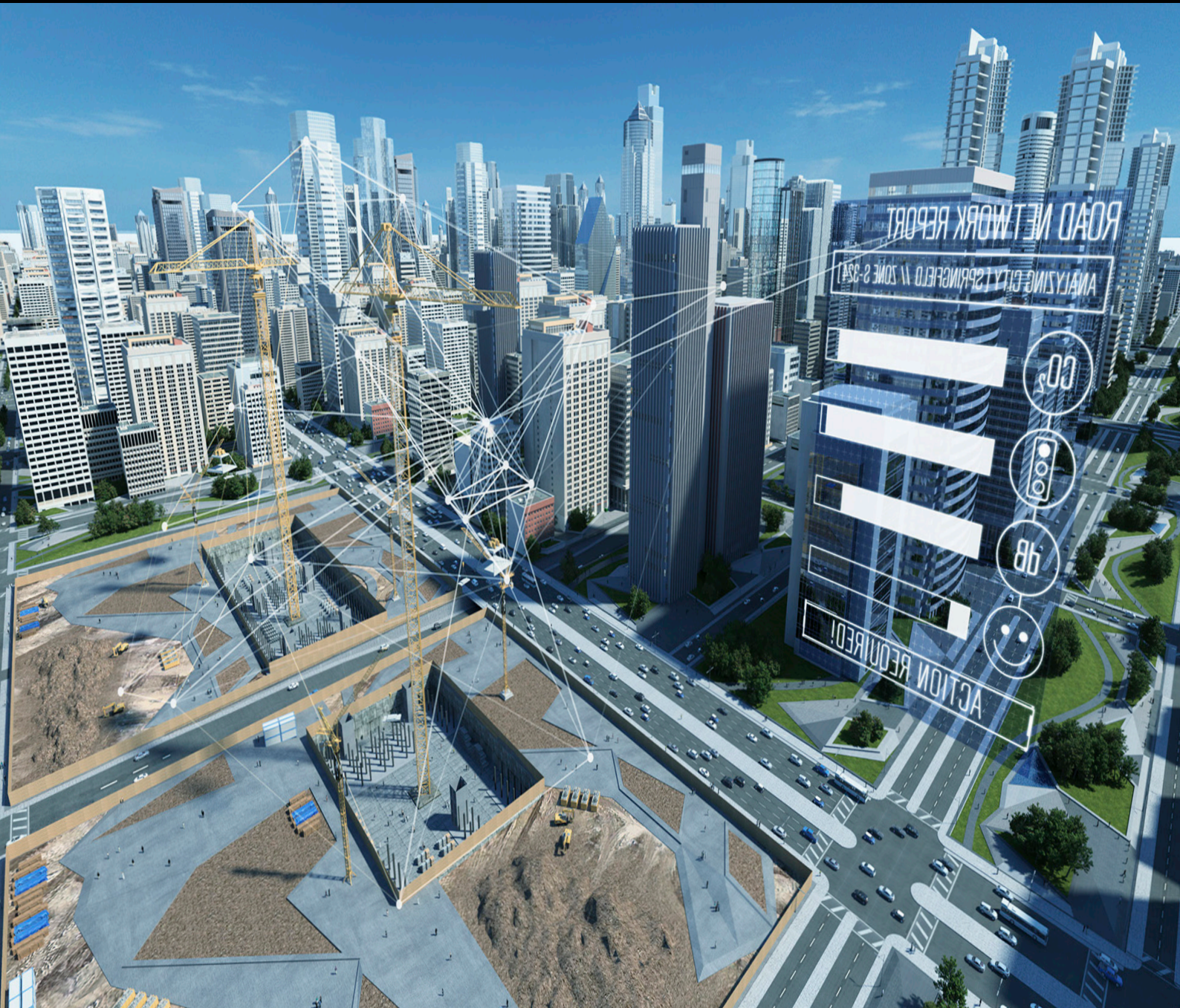


WHITE PAPER

Extended Design Validation



Extended Design Validation

Introduction

The future of making is here, whether we choose to believe it or not; bringing with it radical changes in the way things are designed, made and used. It is disrupting every industry: architecture, engineering, construction, manufacturing, and media/entertainment. With the right knowledge and tools, this disruption can be used as an opportunity.



DESIGN



MAKE



USE

Industries are converging, and they are innovating more quickly. For example, modern micro factories that mass-customise products for demanding consumers, or construction companies manufacturing their own prefabricated walls and ductwork. Or the media firms that take cues from the automotive industry and previsualise their entertainment properties.

In the future, successful businesses will approach the ideas/practices of Design, Make and Use in a new and dynamic way. The process of creation has evolved beyond a simple linear path into integrated cycles of input and feedback.

Design sees greater collaboration, now more than ever, with ever wider virtual teams with global expertise and skills, replacing more traditional local teams. Along with democratised funding and levelling the playing field for marketable ideas. Vast amounts of data and computing power are available anytime, anywhere thanks to the cloud.

Make is providing production with ever more advancing manufacturing methods, and prefabrication developments are hastening speed to market. Wider spread micro factories are replacing traditional production facilities, enabling start-ups to compete with large corporations. Whilst today's buyers demand more personal and customised products in the same or quicker timelines.

Lastly, Use is requiring digital systems to be better integrated with physical objects, making them connected and intelligent. With places, things, and media collecting and communicating data points by the billions. These connected structures and products can respond to user data and provide insights for future developments and improvements.

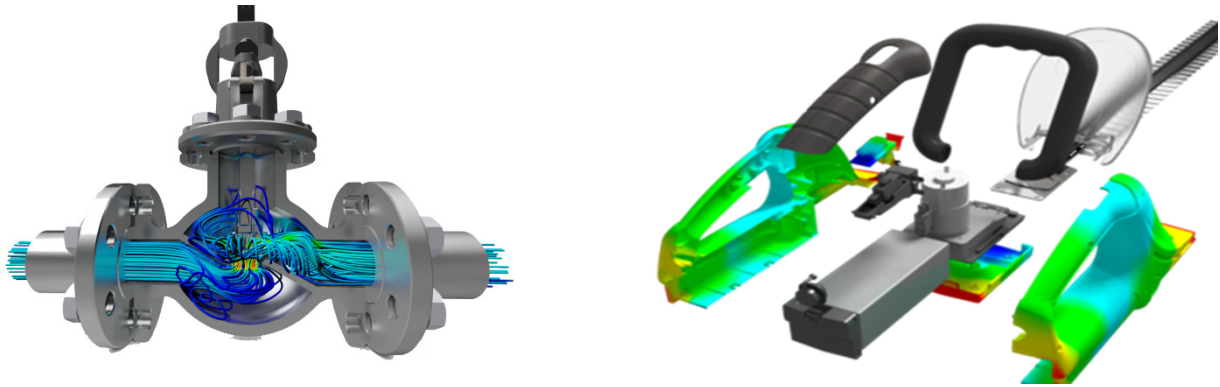
So, you can quickly see that manufacturers are under more pressure than ever to deliver better products faster, at lower costs and with less waste. The reality is that whether you are manufacturing conveyor equipment, dentist chairs or the next smart phone, the challenges each manufacturing company faces in bringing products to market have more similarities than differences. The common challenges we hear from our customers can include the following, some of which may resonate with your organisation.

- Global competition
- Increasing product complexity
- Regulation requirements
- Shortened development time
- Customer quality and satisfaction expectations

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- Securing competitive differentiation

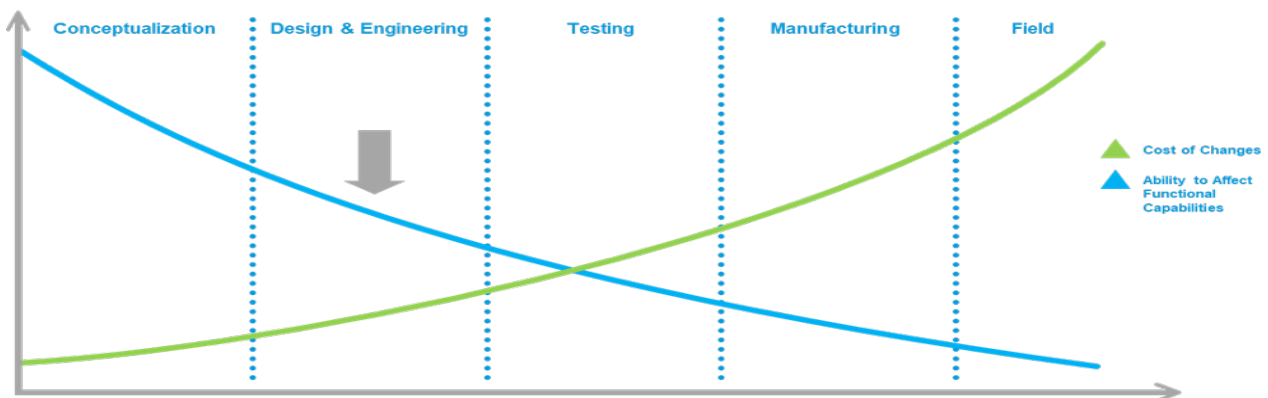
With all of this in mind, let us look at how the power of simulation can help you make better decisions sooner in your processes. Autodesk's simulation portfolio helps you to predict, validate and optimise your products using accurate analyses that you can trust. Along with a comprehensive simulation portfolio, which offers applications for mechanical simulation, computational fluid dynamics (CFD), plastic injection moulding, composite materials, structural and manufacturing simulations.



There may be some of you wondering if simulation or analysis is required in your business, could it benefit your processes or help contribute to some of the gains explored above. Well, consider if you or anyone else in your organisation has asked any of the questions below and the answer will be yes, simulation or analysis could make a huge contribution.

- Will my part fail and when?
- How light can I make this part?
- Will a part handle the required fluid pressure?
- What happens when temperature changes, will it overheat?
- What happens if I drop it?
- Will it have defects?

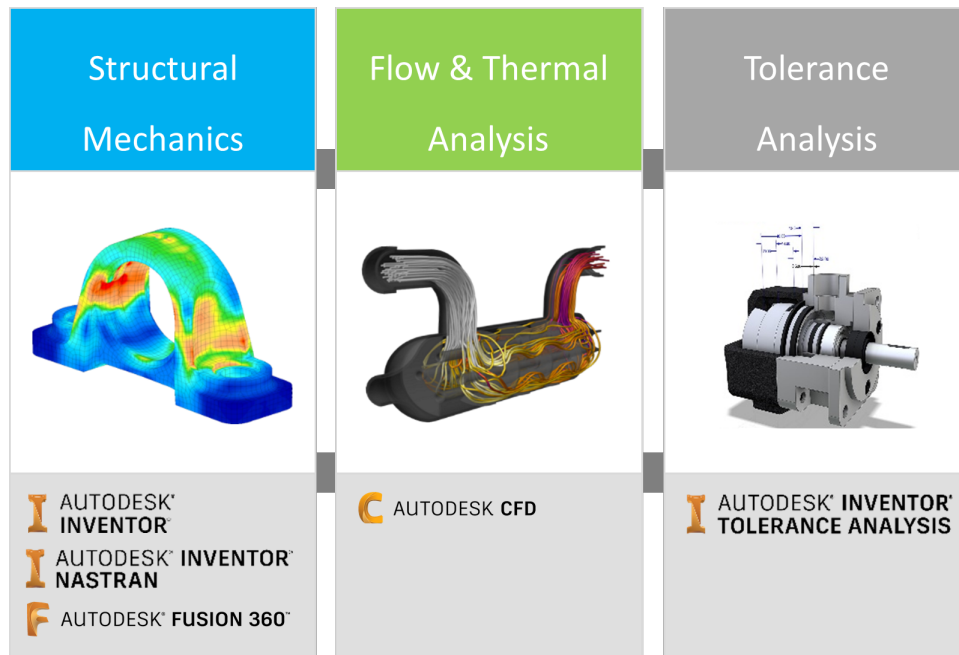
In addition to these questions, there is also the matter of when it can be more cost effective and flexible to have an impact on a design. This is typically at the point of Design and Engineering, before you get to testing, manufacturing and finally in the field. Therefore, digital toolsets to help prove a design and explore other options earlier in the process will not only lead to a more resilient design but also help contribute to greater design exploration, tighter quality control and market differentiation.



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What Simulation and Validation tools are available?

Autodesk have made a series of important acquisitions over the years, beginning in 2005, with the acquisition of Solid Dynamics. Then the acquisition of Algor in 2008, Blue Ridge Numeri's in 2011 and more recently Nastran in 2014. These additions have helped grow Autodesk's digital ability to simulate everything, from fluid flow, thermal dissipation, ultimate stress, nonlinear materials, drop testing, to frequency analysis. To more advanced and specialised studies of composite materials, plastic mould design and advanced manufacturing techniques. The focus for this document is around structural mechanics, fluid, thermal, tolerance and generative design. The below highlights where these tasks relate to the relevant Autodesk technologies, which we will explore further.

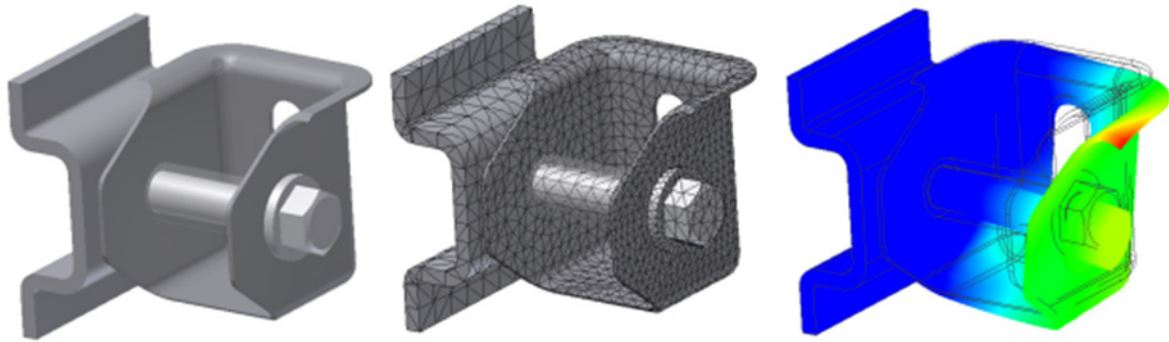


Structural Mechanics

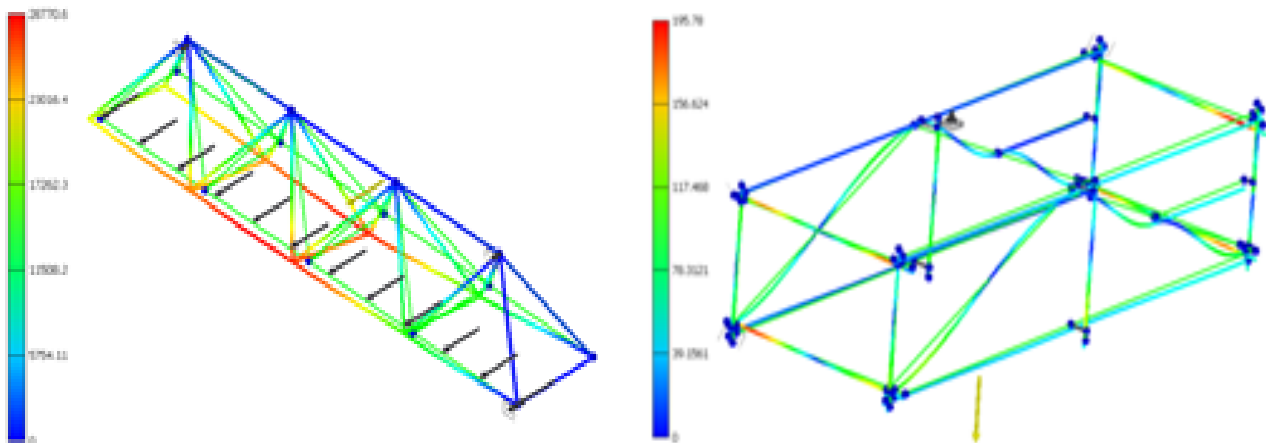
These tools typically utilise Finite Element Analysis (FEA) or Finite Element Method (FEM) to predict product performance through linear, non-linear, thermal and dynamic analyses. All these provide an opportunity to optimise designs and validate product behaviour before manufacturing. This can sound complex, however FEA or FEM is a numerical calculation method, used to find approximate solutions across a wide range of problems, creating partial differential equations. Effectively FEA or FEM divides large problems into smaller/simpler bite sized chunks, with calculations then done on each chunk individually. This creates a system of equations to represent the entire problem.

An entry level into this type of analysis can be found within Autodesk Inventor, with the built in Stress Analysis environment. Here you are provided with the ability to run single or parametric, linear static or modal analysis studies. Autodesk Inventor Parts, Assembly and Weldment file types are all supported, with the ability to use any parameter within a Parametric Dimension simulation. This environment includes a Simulation Guide to help you through the process of configuring your first simulation.

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In addition to the above Stress Analysis environment, Autodesk Inventor also provides a second environment for Frame Analysis which offers both linear static analysis and modal analysis. This requires the model data to have used Content Centre (structural profiles) components individually or via the Frame Generator toolset. Following this you can then utilise Frame Analysis to understand the structural integrity of a given frame regarding deformations and stresses, when subjected to the required loading and constraint conditions. The main advantage with this environment is the fact that beam elements are used, which are simple linear elements (curved beams are not supported). Meaning that calculations and simulations are extremely quick, since complex meshing is not required, allowing you to quickly identify performance issues and find better design alternatives.



The most recent Autodesk addition to this area of simulation, is Nastran. This was an acquisition made by Autodesk in 2014. Since then, the toolset has developed further and is now fully integrated into both Autodesk Inventor and Autodesk Fusion 360. Autodesk Inventor Nastran is only available through the Product Design and Manufacturing Collection, therefore not available to purchase separately but once installed, this toolset becomes available within Inventor as another extended environment. In Autodesk Fusion 360, Nastran tools are included within the Simulation workspace, meaning another point of access for Product Design and Manufacturing Collection users, as Autodesk Fusion 360 is also included here.

So, what does Nastran bring to the line-up? Nastran provides an FEA or FEM pre and post processor embedded directly within a CAD environment. It is specifically tailored for designers and analysts as a tool for predicting the physical behaviour of practically any part or assembly under various boundary conditions. This easy to learn program allows designers to refine designs without ever leaving its Windows environment by enabling them to analyse the response of parts/assemblies from within their CAD environment for given boundary conditions.

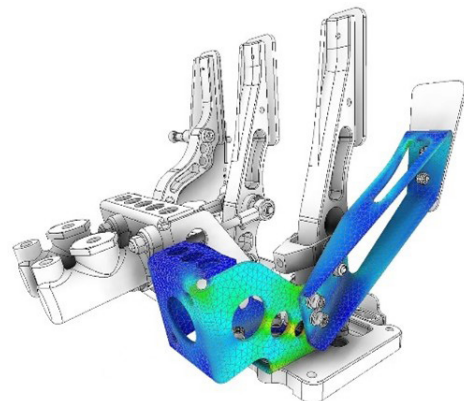
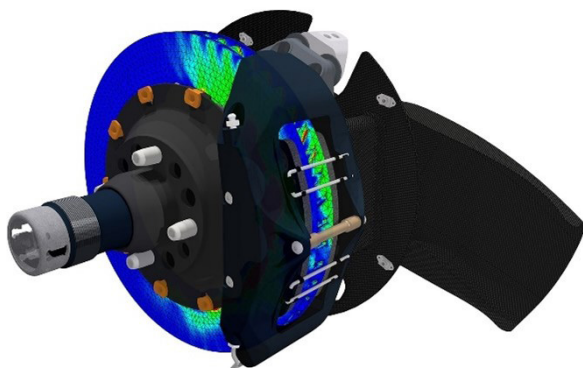
Autodesk Inventor Nastran offers designers and analysts access to a large range of solution capabilities:

- Linear, Prestress and Nonlinear Static
- Normal and Prestress Modes

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- Linear and Nonlinear Buckling
- Direct, Modal and Nonlinear Transient Response
- Impact Analysis
- Direct, Modal Frequency Response
- Random Response
- Shock/Response Spectrum
- Multi-Axial and Vibration Fatigue
- Linear and Nonlinear Steady State Heat Transfer
- Nonlinear Transient Heat Transfer
- Explicit Dynamics
- Explicit Quasi-Static

Along with the above comprehensive list of studies that Autodesk Inventor Nastran can deliver, there is also the opportunity to import/export results from/to other Autodesk applications. This includes Autodesk CFD pressure or thermal results used in the initial setup for a Nastran simulation. Or using Autodesk Moldflow results to generate an accurate plastic part mechanical simulation. Or using the resultant mesh from Autodesk Inventor Nastran within Autodesk Netfabb for advanced manufacturing.



When it comes to Autodesk Inventor Stress Analysis or Autodesk Inventor Nastran both come in the Product Design and Manufacturing Collection, so cost is not a factor when deciding which application is most appropriate. Using Autodesk Inventor Nastran for the study types included within Autodesk Inventor Stress Analysis will not necessarily provide a superior result. However, Autodesk Inventor Nastran will provide a greater range of verification tools. For example, you could use both applications to see if a component is likely to fail under a linear static load. The result might show no component failure, but buckling may have occurred before the failure point and this is where Autodesk Inventor Nastran could be used for further understanding of how a design will behave under different conditions. Overall workflows in each application are very similar, which allows for users to pick the right tool for the right job at the right time.

Autodesk Fusion 360 also includes the Nastran FEA or FEM pre and post processor embedded directly within a CAD environment. However, this is more simplified and streamlined, with an aim to make these toolsets more approachable for designers, rather than analysts. One benefit of these toolsets within Autodesk Fusion 360 is the ability to extend your computation overheads, providing quicker insights. This is delivered using integrated cloud connectivity, allowing datasets to be offloaded to the cloud to calculate the chosen scenarios. Meaning users can progress with additional tasks and await the results

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once complete, maximising productivity and gaining meaningful insights.



In addition to these more traditional tools, Autodesk Fusion 360 has an additional workspace for Generative Design. Generative Design is a design exploration process. Designers and Engineers input design goals into the generative design software, along with parameters such as performance or spatial requirements, materials, manufacturing methods and cost constraints. The software explores all the possible permutations of a solution, quickly generating design alternatives. It tests and learns from each iteration, what works and what does not. This new way of designing brings several key benefits:

- Light weighting - quickly identify solutions to minimise mass and material use while maintaining performance standards, meeting design goals, and respecting engineering constraints.
- Performance impact - evaluate multiple manufacturing methods using generative design and discover solutions to improve and optimise product durability and eliminate areas of weakness.
- Parts consolidation - Explore a range of design solutions that allow you to consolidate multiple components into solid parts, reducing assembly costs and simplifying your supply chain.
- Sustainability - Meet your sustainability goals by using generative design to lightweight your products, creating less production waste, and helping you select more sustainable materials.

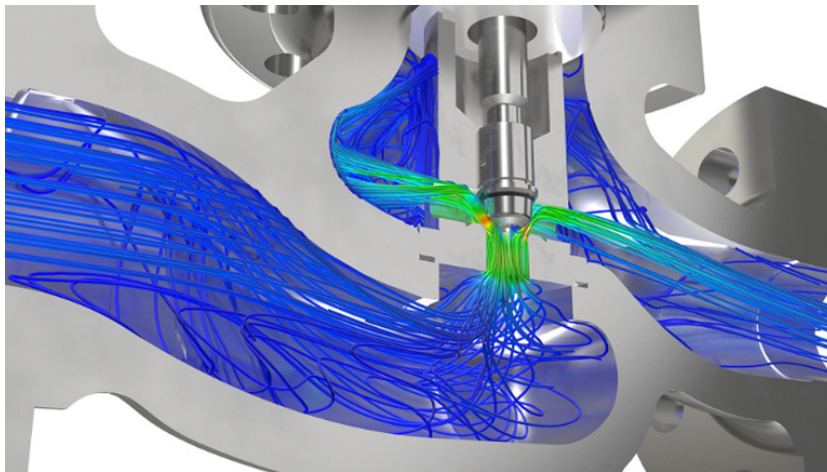
The generative design process explores manufacturing-ready outcomes earlier in your production process, optimised for cost, material, and different manufacturing techniques, so you can get to market faster.



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Flow & Thermal Analysis

When it comes to computing fluid/gas flow and thermal analysis, you are moving into the domain of Autodesk CFD. This is a Computational Fluid Dynamics (CFD) simulation package, which Engineers and Analysts can use to intelligently predict how liquids and gases will perform before venturing too far along the development cycle. Autodesk CFD helps businesses to minimise the need for physical prototypes while providing deeper insight into fluid flow design performance. Designers and Engineers are provided with a range of powerful tools for system design optimisation including fluid flow and free surface movement, thermal management for electronics cooling and BIM integration for occupant comfort of HVAC in AEC and MEP. This application is not included within the Product Design and Manufacturing Collection due to its more specific and specialised requirements, therefore would require purchasing separately.



Autodesk CFD provides fast, accurate and flexible fluid flow and thermal simulation tools to help you make better design decisions earlier in the product development process. Visualise fluid flow (liquid and gas) through 3D CAD models to aid in designing fluid control devices. Use Autodesk CFD to test the thermal performance of your electronics designs, tackle challenges such as optimum locations of heat sinks and heat pipes, thermal management, and transient effects. You can also automate the creation of design studies, compare critical values, and review results across multiple designs using the Design Study Environment. Including flexible solving, both locally, on personal servers and on secure AWS cloud servers. Finally, you can generate photo realistic renderings through the export of analysis results using interoperability with Autodesk VRED, Autodesk 3ds Max or Autodesk Maya.

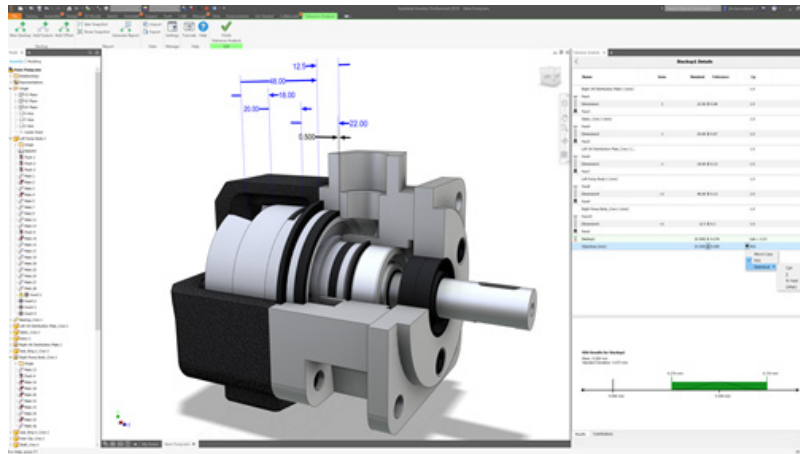
Tolerance Analysis

The Product Design and Manufacturing Collection contains integrated solutions for stress, deflection, temperature distribution and thermal expansion due to applied loading conditions, collaboration between mechanical and electrical engineering and integrated 2.5 to 5-axis CAM. In addition, it includes tools to help eliminate bottlenecks and optimise processes using factory design tools which are all great solutions for addressing common manufacturing business critical issues. However, one area that needed some focus to address today's engineering and manufacturing challenges was tolerance analysis.

Why do we need to consider tolerance stack-up? There are several causes for dimensional variation that have a significant impact on the accuracy of products. Tool wear not only leads to quality issues but can also affect size and fit for the end delivery. In addition, thermal expansion can happen when temperature changes due to manufacturing or product use, meaning that parts are going to move and deflect. Precision goals can be accomplished several ways in manufacturing, but that leads us to increased cost. Ultimately, the goal with optimising tolerances, is to create a cost-effective design for manufacturing.

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There are machining processes that will narrow tolerance ranges, but they are going to drastically increase the cost of the product and take more time to make. Understanding product tolerance and stack-up will lead to increased understanding of part function earlier in the process, help discover and resolve problems before producing to a physical prototype, make informed decisions that are going to save on costs, increase product performance, reduce warranty issues and make your product more profitable.

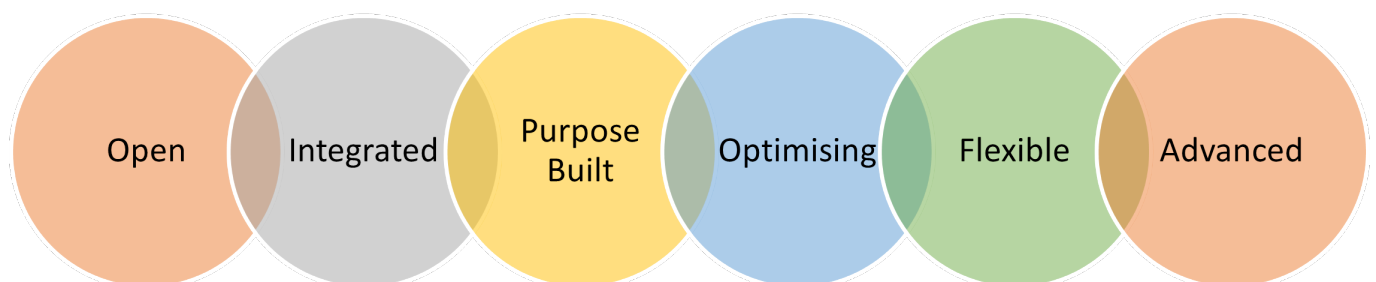


All the above hopefully explains why Autodesk Inventor Tolerance Analysis was added to the Product Design and Manufacturing Collection. This toolset is fully integrated directly within Autodesk Inventor, providing a familiar interface to run the entire workflow, from setup to viewing results. It is everything you need to calculate multiple tolerance stack-ups in your assemblies, whether they are created natively in Inventor or opened from another CAD system. You will find advanced statistical results to help make informed decisions for manufacturing and generate detailed reports to share with manufacturing and quality engineers.

Conclusion

As you can see there are several different topics, when it comes to validating your designs, all with their own unique requirements and toolsets. Depending on the industry you operate in, whether it is Automotive, Aerospace, Consumer Products or Industrial Equipment, your requirements may also differ.

This is where Autodesk have a compelling number of solutions to suit your specific needs and more. Each bringing unique benefits to your organisation, aligned with Autodesk's Simulation Solution Strategy:



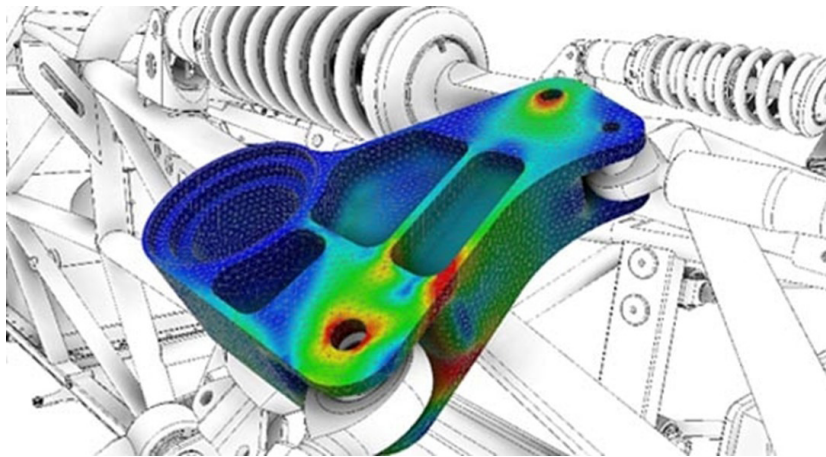
The first point on the list is Open, this is an important consideration with any simulation solution. How open is the solution to different applications and file formats? All the solutions explored in this document provide multi Computer Aided Design (CAD) and multi Computer Aided Engineering (CAE) connectivity, either via direct add-in or through import of external native file formats. Another important consideration in this openness is the ability that most of these applications have customisation or scripting ability, providing an opportunity to further tailor or enhance the outcomes for your business.

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Integrated is about having strong connections between applications and having the ability to work in a true Multiphysics workflow by simply exporting or importing the relevant information or results required at each step of the process. Alongside robust integration with our Data Management and Process Management platforms, for secure storage, collaboration, and visibility of data to the right people. Where required, the ability to visualise results in a connected pipeline to share technical detail to all levels in an appropriate manner.

Each of the solutions explained within this document is Purpose Built, not only for the task at hand. But also tailored for each end user scenario, for example, Designers, Engineers or Analysts. Providing each with an appropriate interface, tools, and results to meet their needs. Within Simulation and Validation, Autodesk have a broad solution coverage, meaning there is always likely to be a solution for your specific requirements. All culminating in deeper understanding of your products through greater use of upfront analysis driven design.

Optimisation is a big reason for many businesses to adopt simulation and validation tools. Allowing users to experiment with multiple scenarios during earlier parts of the design process, to achieve the most optimal design. This in many cases takes the form of parametric optimisation, offering a streamlined and systematic way of developing different scenarios to test different conditions in rapid succession. Generative Design, Lattice and Topological development are more modern techniques within simulation and validation but all very much at the heart of Autodesk's simulation strategy now and into the future.



Providing businesses with Flexible access and licensing to these types of applications helps put the right technology in users' hands when they need it. Taking away the large cost burden that simulation and validation solutions used to carry. Not only this, but with integration with Cloud Computing, which some of these tools have, it allows organisations to have a more elastic approach to the computing overhead that these solutions can demand.

Autodesk are always striving forward in all areas of Design, Engineering and Manufacturing. Simulation and validation are no different, with exploration into new and advanced material analysis. Allowing businesses to consider new and beneficial material choices, along with improved sustainability. Alongside this, the ability to include real world and as manufactured properties to ensure outcomes are as representative as possible. Whilst providing continued trusted and validated accuracy to businesses around the globe.

So, if you are not maximising the tools you might already have access to or perhaps you have a more specialised requirement to help simulate and validate sooner in your processes, then it might be time you consider and explore what Extended Design Validation could bring to you and your organisation.

Get in touch with us today, together we can help you digitise and streamline your product development lifecycle with greater visibility and collaboration throughout the process.