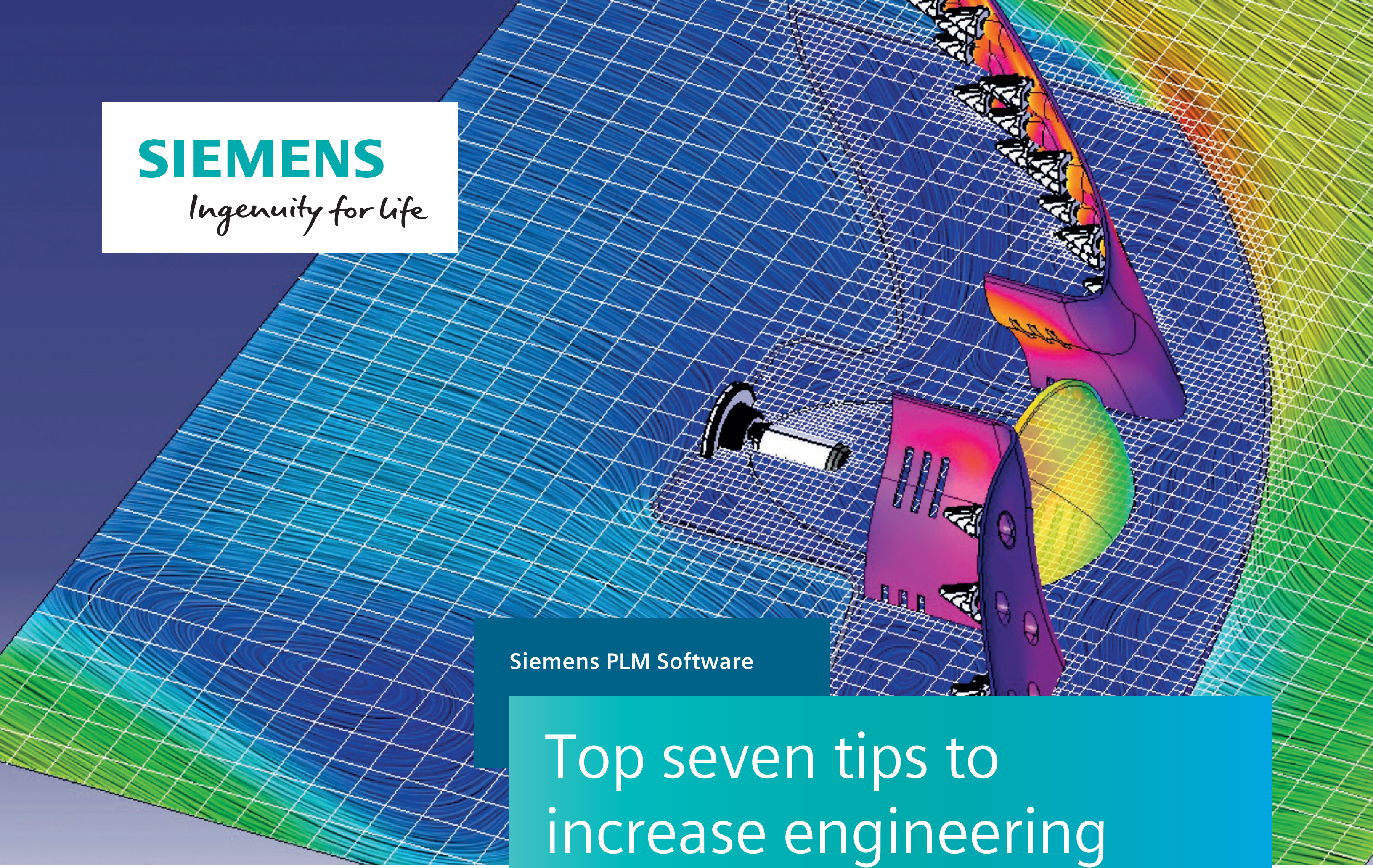


Siemens PLM Software

Top seven tips to increase engineering productivity by frontloading CFD

Executive summary

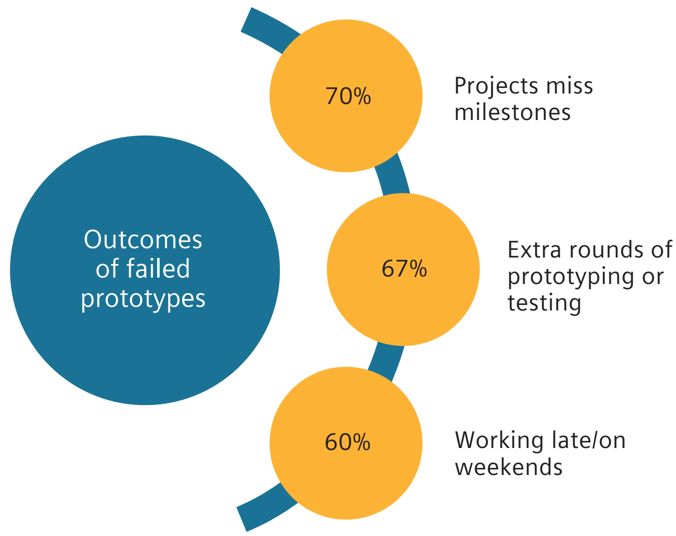
The global competitive landscape for manufacturing is squeezing everyone – from the Tier 1 automotive companies to electronics goods manufacturers. It is shortening the required time to market and with little warning. This high-pressure environment requires high productivity from its players resulting in either doing things faster and leaner without compromising quality or giving the game away to a hungrier competitor who is willing to do whatever it takes.

Introduction

How do you become more productive? Do you continue to do the same thing over and over again and expect a different outcome? Or do you examine every step in the process to make sure you have an optimal one that enables your team to work smarter and produce more?

Surveys conducted by multiple industry analysts and CAE vendors suggest that companies that have been identified as the most successful in their markets assess performance of their designs early during the design process and promote collaboration and sharing knowledge between analysis experts and design engineers.

Interestingly, testing a design only at the prototype stage has been proven to be very costly. According to a report by *Lifecycle Insights*[1], failed prototypes lead to project milestones being missed, extra rounds of testing and having to work long hours among many other issues.



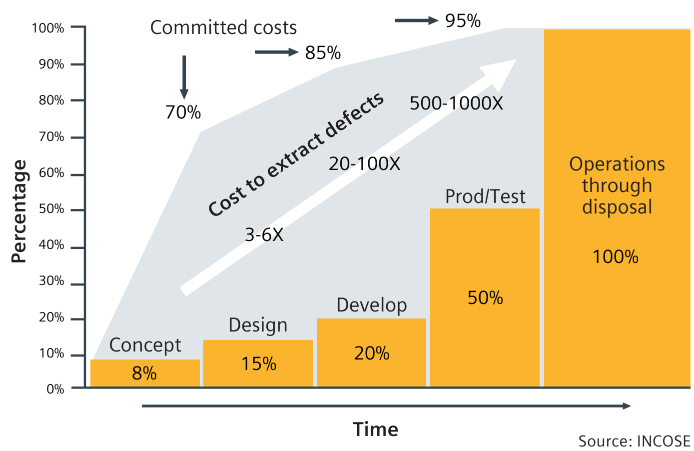
Source: *Lifecycle Insights*[1]

Simulate early, simulate often

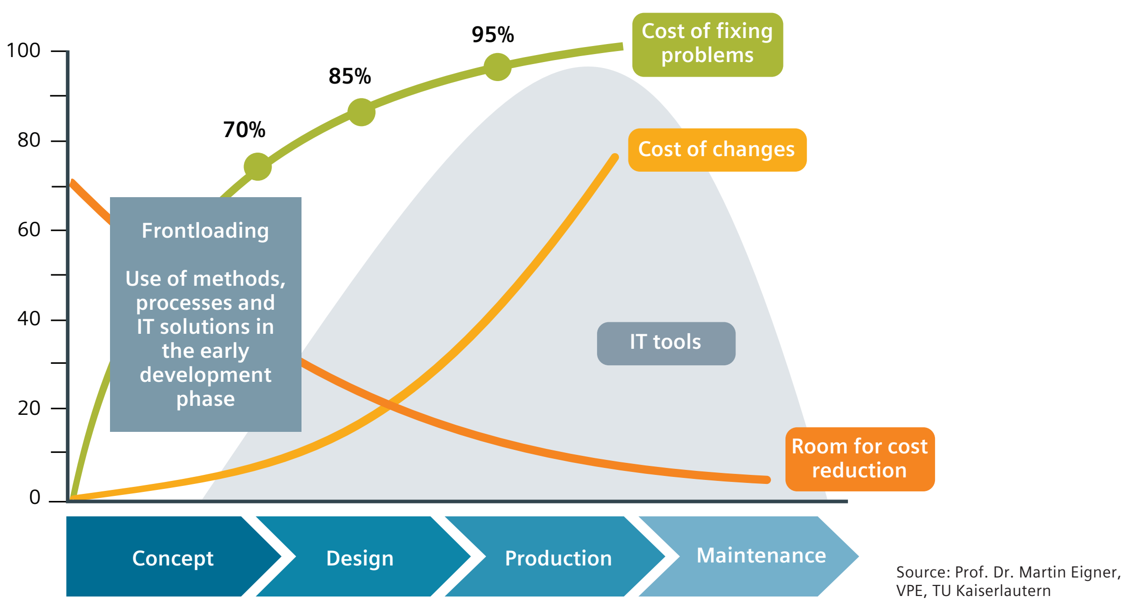
The benefits of simulating early as a part of the design process have been documented extensively. The cost of each engineering change increases with each step from concept to production. According to the U.S. Department of Defense (as reported by the Defense Acquisition University), while 20 percent of the actual cost has been accrued, 80 percent of the total lifecycle cost of U.S. defense projects were determined by the test phase[2]. In other words, the cost of the product was locked in by decisions made during the early concept stages when little is known about the design. Also, the cost to fix defects rose as you proceed further down the process.

Although this data is from the defense sector, commercial entities likely face similar lifecycle costs. For electro-mechanical designs, simulating early and often is important. The right tools need to be made available at the right time so that the information can be accessed for early evaluation. This practice is called frontloading.

Cumulative percentage lifecycle cost against time



Committed lifecycle cost as reported by the Defense Acquisition University. The arrow shows that errors are less expensive to fix the earlier they are removed in the lifecycle.



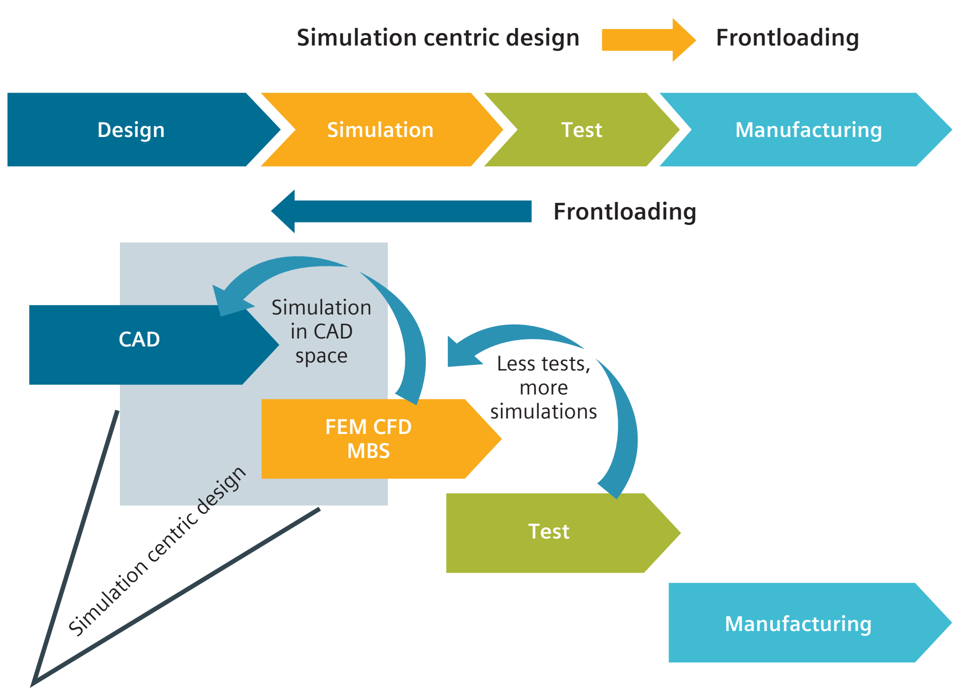
Frontloading economical value (Eigner, 2010).

Many frontloaded simulation tools are available for use by design engineers. About 20 years ago, the first wave of simulation tools, stress analysis, was introduced for use during the early design stages and it quickly became an integral step in the process. Now, all major MCAD vendors provide design-level stress simulation as a part of their portfolio. By frontloading stress simulation and conducting analysis early during the design stage, manufacturers did not stop simulation during the validation stage. Simulation simply became a method by which trends were examined and less desirable design ideas were dismissed. However, unlike the verification stage, during the design phase, speed is of the essence. Engineers need to simulate not only early but also often to keep in step with the speed of design changes. By iterating rapidly, engineers can discount the less attractive ideas and innovate more. Once a design has been explored and identified as viable, it can continue on to the verification stage.

The practice has now spread to new areas including computational fluid dynamics (CFD) analysis – long the reserve of the specialist during the validation phase. Frontloading provides the best environment for design-centric CFD. This is similar to what in the past was called "upfront" CFD, except that here we are talking about

TIP 1

Encourage performance assessment as early as possible and promote collaboration and knowledge sharing between analysis experts and design engineers during the design process to immediately improve efficiency and productivity in your organization.

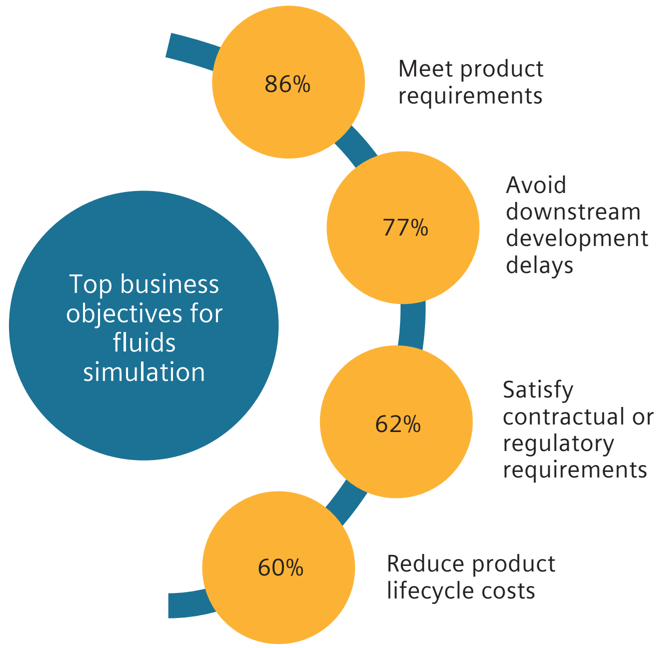


CAE centric design – CAE frontloading (Sabeur, 2015).

embedding CFD in CAD, which adds benefits throughout a product's manufacturing process. Market research data such as this from *Lifecycle Insights*[1] highlights top objectives for fluid simulation as a design tool:

- Meet product requirements (for example: lower weight, faster speed, complex behaviors etc.)
- Avoid downstream development delays and costs (for example: reduce testing and prototyping, reduce change orders, etc.)
- Satisfy customer contractual obligations or regulatory requirements
- Reduce product lifecycle costs
- Drive production costs lower

In short, design engineers can help reduce the number of prototypes and optimize cost (through use of better materials and quality), efficiency, as well as improve company profit margins.



Source: *Lifecycle Insights*[1]

TIP 2

Impact efficiency and company profit margins by reducing the number of prototypes and optimizing cost (through use of better materials and quality).

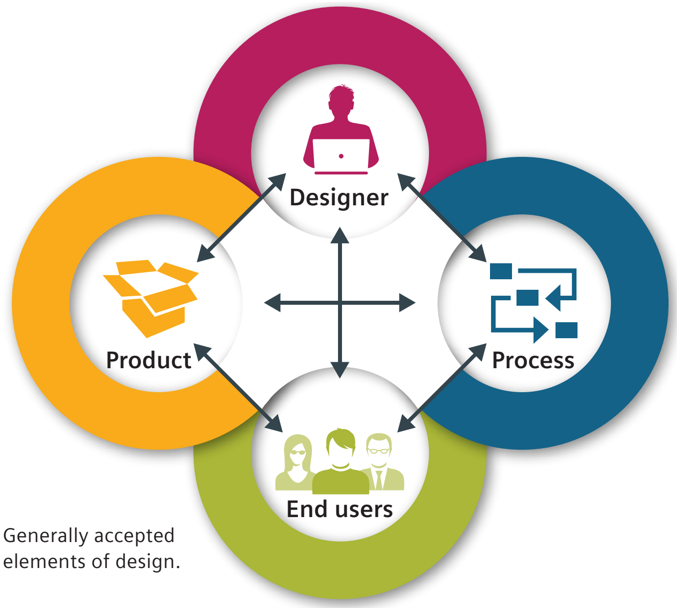
Successful implementation is key

Frontloading CFD has obvious benefits but how best to implement it?

Implementing any change requires an examination of the four main elements of design and product development:

- The product being designed
- The process being used to design it
- The designer
- The end user of the finished product

Each consideration is a potential source of complexity and improvement. However, the process and the designer can be adjusted for immediate productivity gains. The product will be automatically improved as a direct result. (The end user falls outside the scope of this paper.)



Generally accepted elements of design.

The process

True to the concept of frontloading, many leading manufacturers have abandoned the old serial design system, where various functions work along a continuum, in favor of a multi-disciplinary product design process that requires successfully integrating multiple authoring systems and processes. For example, the number of electronic components in cars has grown drastically. Electronics now accounts for 35 to 40 percent of its cost. The Mercedes-Benz S-Class has 100+ ECUs and contains nearly as many ECUs as the Airbus A380 (excluding the plane's inflight entertainment system)[4]. Therefore, designers need access to multiple tools across mechanical and electric/electronic domains to ensure a timely delivery of products that meet with customer specifications.

This complex environment requires a high level of interdependencies to function effectively. Despite this complexity, organizations that have successfully implemented frontloaded CFD have not needed to reimagine or change their engineering process to benefit from it. Many engineering team managers originally thought that it would be more convenient to use existing tools, but they quickly realized that they were forcing their teams to use the wrong tools. The key success factor is selecting the right solution that offers the right combination of application-specific functionality and that fits into existing engineering processes without any disruption.

However, not just any CFD tool can be frontloaded. The CFD software that is used during the verification stage is not a good candidate for frontloading in the design process. This can be seen by reviewing the traditional CFD process where the CFD code receives geometry from a stand-alone CAD system versus a CAD-embedded one.

TIP 3

Successful implementation is the key to reaping benefits of frontloading CFD.

All CFD simulations require use of CAD models, geometry preparation including CAD clean-up and repair, meshing, solving, postprocessing and reporting. But each type of software deals with this process differently. The traditional process requires stepping inside and outside of the CAD package and repeatedly returning to the CAD tool with inherent risks of geometry approximations coming into the CFD simulation. Because design is iterative in nature, this process needs to be repeated for every single geometry change. In comparison, CAD-embedded CFD is contained within the CAD software; any and all geometry changes take place inside the CAD environment.

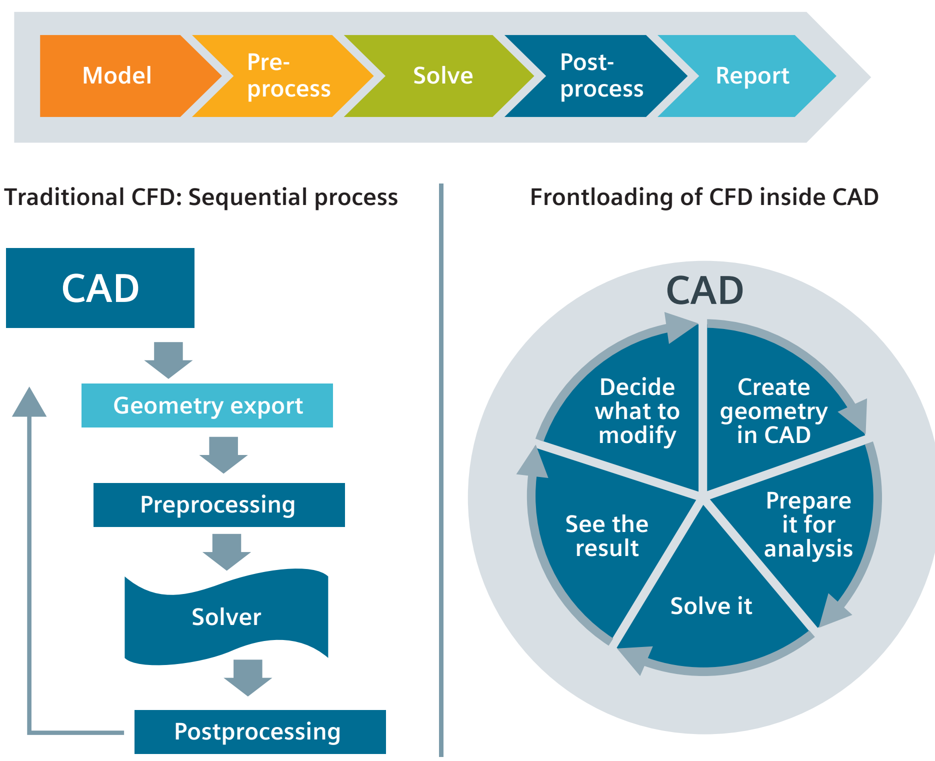
Many traditional CFD software programs consist of multiple interfaces – one for preprocessing, one for solution, and another for postprocessing. Traditional CFD software programs also tend to have their own proprietary interfaces that are not integrated with CAD. Every time a model needs to be analyzed, the data has to be prepared and exported out of CAD and imported into the CFD tool where the model can be "healed" for use.

TIP 4

Select the solution that fits into your existing processes without any disruption.

"CAD-embedded CFD makes it possible to determine simulation results nearly as fast as we can change the design. The result is that we were able to improve the flow rate of our new CO_2 valve by 15 percent while eliminating about 50 prototypes and reducing time to market by four months."

VENTREX



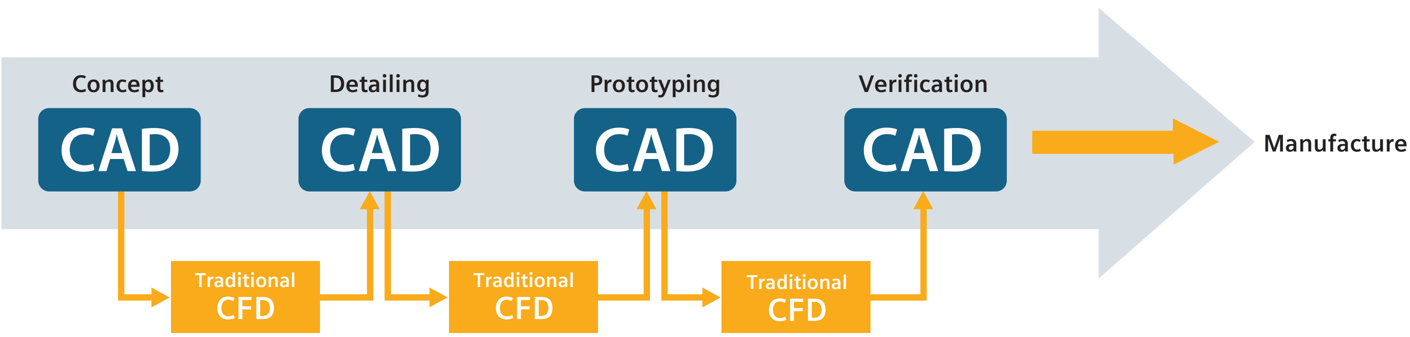
The CAE simulation process (Sabeur, 2015).

Traditional CFD tools are crammed with technology that requires advanced training and education, which is why dedicated analysts are usually assigned the task. For example, most traditional CFD tools support many types of meshing algorithms. The engineer has to know which one would be the most appropriate for the specific application. In addition, he or she will have to work on the mesh until an optimal mesh for the model and application has been achieved. In short, using traditional CFD tools can be extremely time-consuming and slower than is needed during the design stage.

"With Simcenter FLOEFD we can easily create several different simulation cases to allow the design engineer to make optimization judgments…Simcenter FLOEFD ultimately gives us predictions of the surface temperatures on the IGBT/ShowerPower system before we iterate to a final prototype and build and test it."

Danfoss Drives

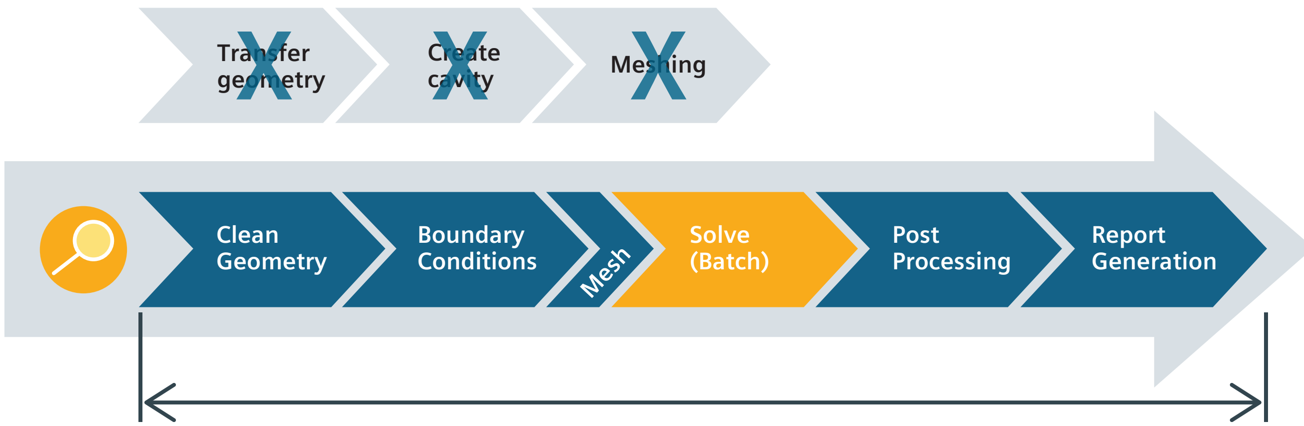
Traditional CFD



However, design-centric CFD solutions include built-in intelligent automation. They have been developed to be simply another supported feature inside the CAD system, alongside finite element method (FEM) analyses such as stress, to help frontload CFD.

Design-level frontloaded CAE

Frontloaded CFD



Frontloaded CFD solutions offer significant time savings.

Also frontloaded CFD solutions compress analysis time significantly – some organizations have reported a time compression of 75 percent. How is this possible? Frontloaded CFD solutions offer key proven technologies that greatly reduce model preparation and preprocessing, such as:

- By being fully embedded in CAD, the software uses the same native geometry for analysis. Exporting data and healing it in preparation for analysis is no longer required. In addition, the software simply slots in – it does not require you to learn a new interface nor does it require a familiarity with the interface every time the software is used. CFD analysis is simply another functionality offered by the CAD package.
- In fluid-flow and heat-transfer analysis, we are interested in understanding what is happening in the negative space, the empty space. With traditional CFD, additional geometry has to be created to represent that cavity. Frontloaded CFD solutions are intelligent enough to recognize that the empty space is the fluid domain so that no time is wasted creating geometry to accommodate software. This step is completely unnecessary.

"Simcenter FLOEFD from Siemens PLM helps us to understand and optimize headlamps. Even very complex geometries and test conditions can be investigated with a minimum of effort. New features such as Monte-Carlo radiation and the LED module are especially helpful in speeding the development of very complex products."

Automotive Lighting

- Before analysis can begin, the model has to be meshed. With traditional CFD, the engineer has to be fully conversant in which algorithm best depicts the flow phenomenon being studied. Frontloaded CFD solutions have a fully automated mesher that will automatically generate the best possible mesh for the problem being set up. The software has built-in intelligence such as SmartCells™ that make it possible to use even coarse meshes without sacrificing accuracy. To learn more about the technology, please read "SmartCells – Enabling Fast & Accurate CFD."

The National Institute for Aviation Research has verified the time savings offered by frontloading comparing it with traditional methods.

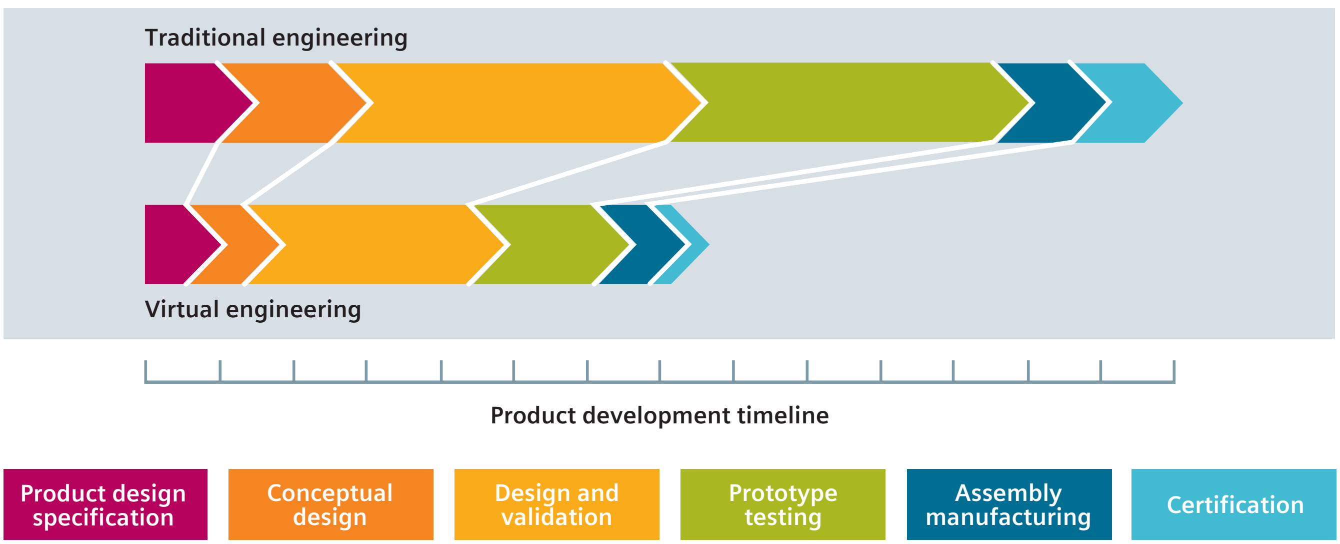
In short, by using the right tool to frontload CFD, you may be able to significantly shorten your simulation time and achieve a shorter, more competitive engineering design process.

"We can show the finished design to our customer complete with how it looks and works in just one day – that's a savings of three weeks and thousands of euros for each model."

JAZO

TIP 5

Select the right tool to frontload CFD, significantly shorten simulation time and achieve a more competitive design process.

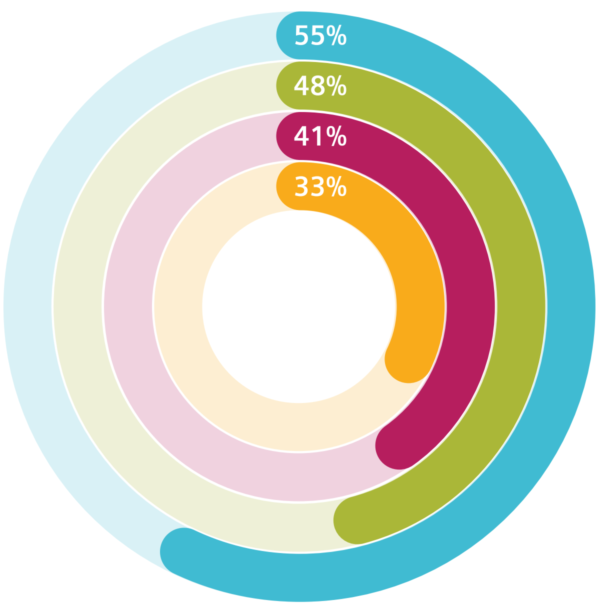


Simcenter FLOEFD and frontloading CFD can shorten development time (National Institute for Aviation Research).

The designer

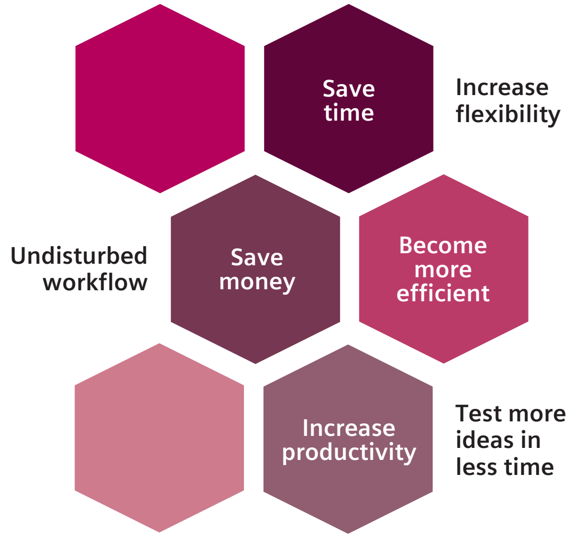
Today's typical designer is a mechanical engineer. During the course of their education most mechanical engineers have been exposed to the principles of CFD in one shape, form or another. But most importantly, an engineer working on the design of any product is fully versed in the background of what he or she is designing. For example, a design engineer working on the design of automotive lighting got the job because he had a background in electronics design and is familiar with the basic properties and behavior of automotive lighting. He understands that electronics generate heat and the effect of excessive heat on performance. He understands that squeezing electronics into an enclosure will create a thermal problem. He understands that many electronic components are at his disposal to reduce the heat, including heatsinks. Even the use of different materials may create a different operating environment that may change the effect of heat.

In short, design engineers are more than capable of assessing the problem, checking multiple design variants to see which ideas are the most effective, testing them, and generating a solid design. In fact, industry research[1] corroborates that design engineers are in fact conducting fluid simulation in great numbers:



A centralized group of dedicated simulation analysts
Design engineers distributed across development projects
Small teams of simulation analysts assigned to development projects
Simulation analysts hired from third-party companies (outsourced)

Source: *Lifecycle Insights*[1]



> *"Simcenter FLOEFD computational fluid dynamics software enables design engineers without a fluid analysis background to perform thermal simulation. The result is that we got the design right the first time, only had to make one prototype and avoided expensive design changes that typically occur in the late stages of the development process."*
>
> *Azonix*

TIP 6

Using the right tool, design engineers are more than capable of assessing a problem, checking design variants, and testing trends.

Here are some examples of successful implementations of Simcenter FLOEFD™ software, Siemens PLM's frontloaded CFD solution, by the design group:

"The most important consideration in selecting an analysis software tool was that all team members could use it regardless of their level of ability...The people who don't have much experience of analysis can use it easily...It was important that the tool integrated with Pro/ENGINEER. We didn't want to have to create another model for analysis and being CAD-embedded we could validate various analysis models repeatedly. We also wouldn't have any difficulty in switching between processes (from design to analysis).

Seiko Epson
For additional information please go to http://go.mentor.com/4PhyU.

"We have eight designers in our group and three use Simcenter FLOEFD. You can use it once every three months because you won't forget how to use it! The special thing about Simcenter FLOEFD is that you are closer to reality in this software."

Orbotech

"We like Simcenter FLOEFD because it is fast in calculation for steady analysis. Since we have no specialist CFD experts, our designers take care of simulation analysis. Simcenter FLOEFD is the best for CFD because of its simplified auto-meshing setting inside our preferred CAD package, PTC Creo. We found the cut cell CFD function to be very valuable."

Mitsubishi Materials Corporation
To learn more, please go to http://go.mentor.com/4SaAP.

In other words, all design engineers need is access to the right tools at the right stage of design to ensure productivity gains along the entire engineering process.

Why is Simcenter FLOEFD the right solution?

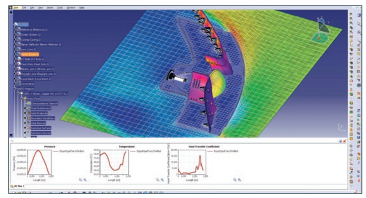
Simcenter FLOEFD technology, first introduced to the market in 1991, has been used by thousands of engineers to frontload CFD in the design process.

The award-winning Simcenter FLOEFD will not disturb or require modification of the workflow. Simcenter FLOEFD simply fits into the process without any disruption. It provides increased flexibility to test many design ideas in less time – when the R&D cost committed to the project is lower and fairly flexible. It helps the design team become more efficient at discarding suboptimal ideas sooner and lets the analyst team focus on solving more complex analysis problems and complete verification faster.

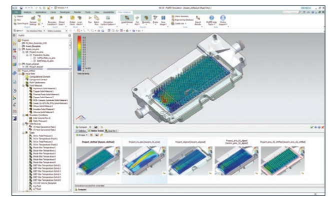
Proven productivity gains

Conducting analysis with Simcenter FLOEFD is significantly fast. The speed is a result of intelligent automation, use of the CAD environment, and ease-of-use. Simcenter FLOEFD is completely embedded in the most popular CAD programs. Despite its different interface for each CAD program, the experience remains the same. Designers have reported being able to use the software with less than eight hours of training, much less than traditional CFD programs which can require as long as 12 months training to use the software productively.

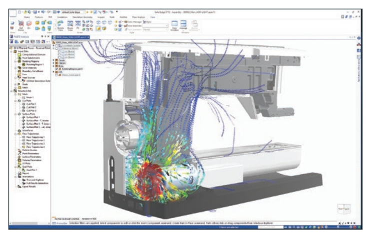
Simcenter FLOEFD has won many awards and been selected as a finalist in two categories by the NMI.



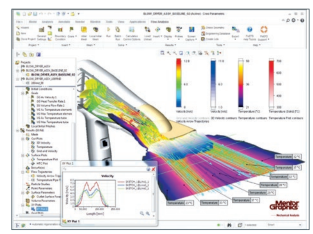
Simcenter FLOEFD for CATIA® V5 software.



Simcenter FLOEFD for Siemens NX™ software.



Simcenter FLOEFD for Siemens Solid Edge® software.



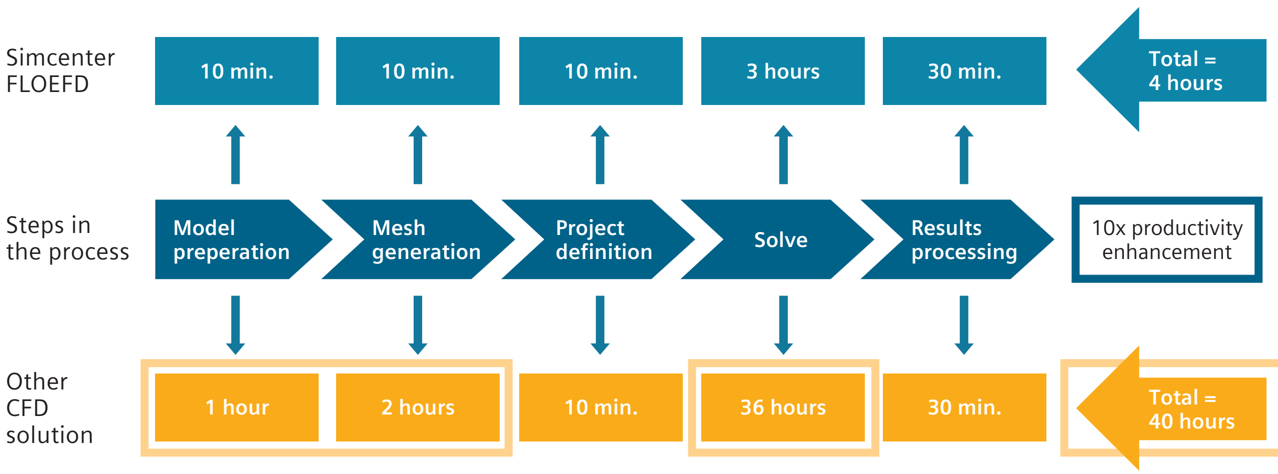
Simcenter FLOEFD for PTC Creo® software.

Because the engineer operates Simcenter FLOEFD in a native CAD environment and uses native geometry, data does not need to be transferred out of CAD and into Simcenter FLOEFD. The model is immediately available for analysis, thus saving time and effort. Wizards, plain engineering language, and extensive libraries further enhance the experience and allow the designer to setup models quickly and effortlessly. Its automatic mesher lets the designer mesh the model with minimal intervention. In addition, the software automatically recognizes the fluid region.

Simcenter FLOEFD also makes it easy to analyze multiple variants of the design. The designer simply modifies the model in CAD, and Simcenter FLOEFD automatically attaches the previously set analysis information including boundary conditions and material properties to the new variant. Upon remeshing, the model can again be analyzed.

Speed is of the essence for enabling the engineer conduct analysis in a timely manner to keep up with the fast-moving world of design. Simcenter FLOEFD significantly saves time.

During a recent benchmark, design engineers at an aerospace company realized a 10x productivity enhancement with Simcenter FLOEFD compared to a traditional CFD package when simulating pressure loss in a complex shape channel. Because of the confidential nature of their project, more details cannot be shared here but the following is a summary of their results:



The traditional CFD tool required more time investment during the preprocessing stage, especially for model preparation, which included time for transferring the model out from the CAD package and then healing it. It also required significantly more time for mesh generation. During the solution phase, the traditional CFD tool needed significantly longer to solve the problem given the size of the mesh. Arguably, the solution time can be handled with brute force by throwing as many processors as possible at the problem. However, when comparing apples to apples (using the same hardware), Simcenter FLOEFD required less time to solve the same problem. When looking at the entire process, Simcenter FLOEFD required only 4 hours versus 40 hours to complete the same task, with the same accuracy. Needless to say, the design team is now using Simcenter FLOEFD.

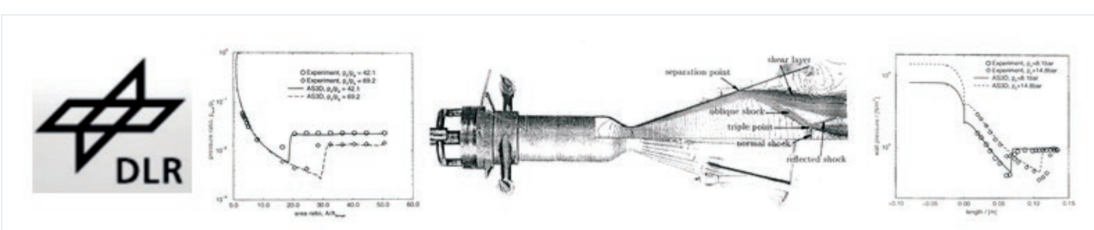
Proven accuracy

Being fast is good but being fast and accurate is better.

Simcenter FLOEFD technology has its roots in the Russian aerospace industry and has been in use since 1991. Its first validation was made in collaboration with the German Aerospace Centrum (DLR). It focused on the separation in a rocket nozzle and compared simulation results versus experiment, and the results proved that the technology was solid.

"The entire design, simulation, and physical testing process took half the length of time it would have taken using traditional design processes."

Marenco AG



Separation in rocket nozzle: The first validation of code made in collaboration with DLR (German Aerospace Centrum).

Since those early days, Simcenter FLOEFD technology has undergone a fair amount of scrutiny by leading aerospace and automotive organizations. Most recently the Society of Automotive Engineers of Japan (JSAE) published a blind benchmark of seven, leading, commercial-CFD, simulation-software programs to demonstrate the accuracy of each tool against validated test results from a wind tunnel. Simcenter FLOEFD again proved its accuracy in this nonpartisan benchmark. To read a copy of the paper, please follow this link http://go.mentor.com/4Phzl.

Accurate and fast – Simcenter FLOEFD is the only right solution for frontloading CFD.

CFD simulation as an integral step during the design stage is no longer a luxury, it is a must. Companies that embrace that change prosper. Those who do not will continue to waste precious resources. Can your company afford to be in the latter group? Contact us today for a free, no obligation and in-depth analysis of how we can help you improve your team's productivity and contribution to profit immediately.

TIP 7

Contact Siemens PLM for a free, no obligation and in-depth analysis of how we can help you improve your team's productivity.

"The biggest benefit I got from Simcenter FLOEFD was that it was embedded, I could work within a CAD system and use parametric CAD models. This made it easier to change any geometry and therefore run several variants very easily...The accuracy of Simcenter FLOEFD was always good... Simcenter FLOEFD helped me to work on contracts that involved very complex geometries, such as a stator coil end turn support system, which I wouldn't have been able to"

E-Cooling GmbH

"When I use a traditional CFD approach to do aerodynamic simulations, it can take weeks to get results back but now I can use engineering feedback within hours. An iterative approach is taken with new projects progressing from design to design... Simcenter FLOEFD enables me to quickly analyze these ideas to make an initial assessment before further detailed analysis is performed later in the program. It's an extremely efficient way to work in very unforgiving timescales."

Bromley Technologies Ltd.

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Siemens PLM Software, a business unit of the Siemens Digital Factory Division, is a leading global provider of software solutions to drive the digital transformation of industry, creating new opportunities for manufacturers to realize innovation. With headquarters in Plano, Texas, and over 140,000 customers worldwide, Siemens PLM Software works with companies of all sizes to transform the way ideas come to life, the way products are realized, and the way products and assets in operation are used and understood. For more information on Siemens PLM Software products and services, visit www.siemens.com/plm.

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