eBook

In-House vs. Commercial System Simulation Tools

Trade-offs and Opportunities

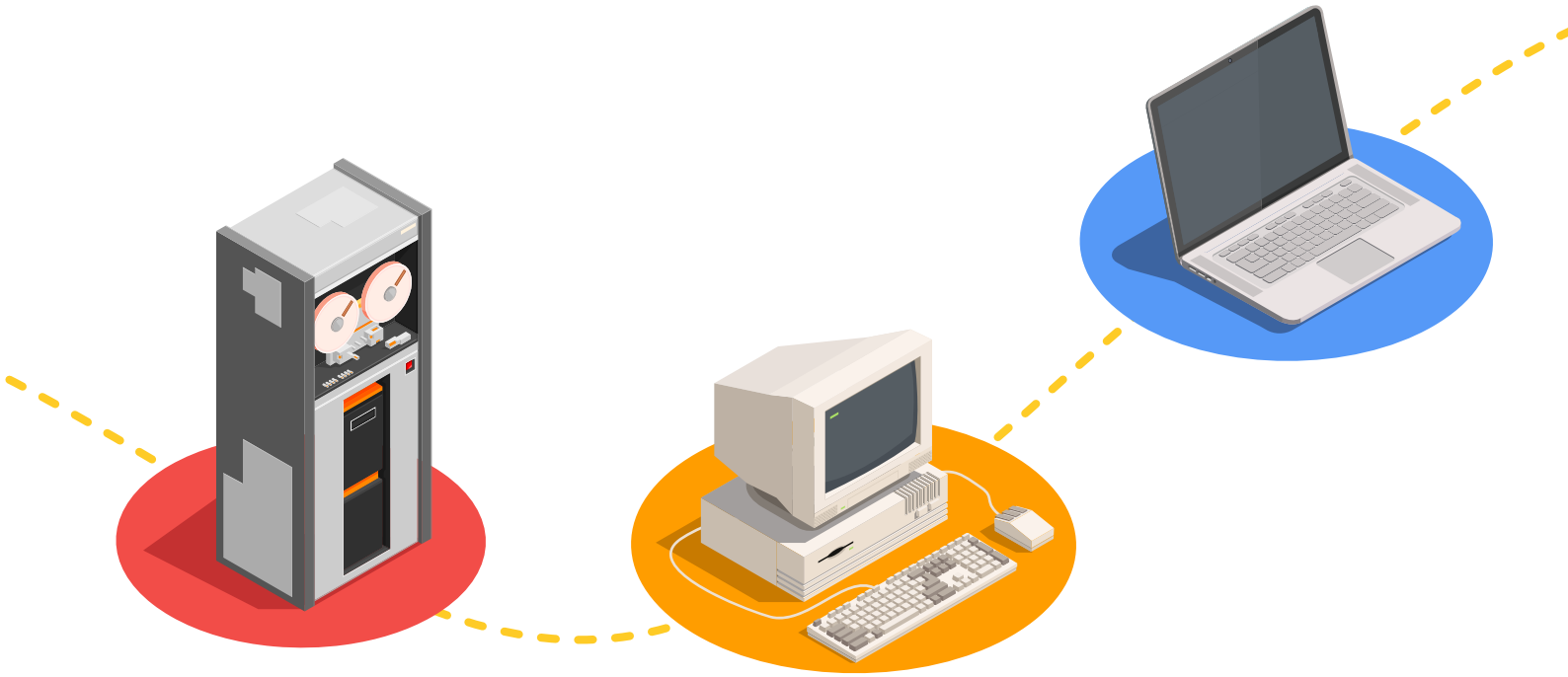
Modelon

Defining In-House Tools

For more than 50 years, ambitious teams have developed system simulation tools commonly referred to as “in-house tools.”

In-house physical system simulation tools are bespoke software applications developed by a company to model and analyze the behavior of complex physical systems. These tools leverage mathematical models and computational algorithms to simulate the dynamics, interactions, and responses of components within a system.

In the 1970s, the computational power of hardware systems began increasing significantly. While compute power was prohibitively expensive, well-funded teams, PhDs, and leaders in their industries built the foundation for today’s simulation tools.



Advantages of In-House Tools

In-house tools offer a variety of advantages once they're de-bugged and deployed.

First and foremost, complete customization is appealing. Every function, interface, and feature is determined by the in-house team. While software always requires iteration to reach full utility, there's no question that what's being developed meets the organization's needs.

Security is also a perceived advantage of in-house tools. These tools are often developed and administered exclusively as on-premises solutions. Intellectual property would never be shared, and teams will likely follow IT protocol. Additionally, fixing issues may be a higher priority for an internal team in case of system downtime or system errors. Sharing the error and aligning on a potential fix should take less time.

Lastly, in-house tools offer control over the development roadmap. While building a basic system is always challenging, dictating the timing and substance of each incremental update gives confidence. There's no frustration or uncertainty in waiting for a new feature or wondering whether the team's feedback is taken seriously.

Realities of In-House Tool Development

In-house system simulation tools require diligent problem-solving and precise project management to drive successful outcomes.

Even for successful projects, in-house tools struggle to scale affordably and effectively across an organization. Lack of scalability limits the power of simulation to only a few team members, meaning significant value is left on the table. In the long term, a lack of accessible system simulation may mean lower-quality decisions impacting customers.

For teams committed to in-house tools, years or decades may pass between evaluations of commercial system simulation tools. During that time, assumptions about commercial tools can become widely accepted. It's wise to compare in-house vs. commercial tools closely.

Let's examine common assumptions about commercial system simulation tools one by one:

ASSUMPTION 1:

Commercial system simulation tools can't accurately represent our systems

Today's best commercial platforms are robust and well-integrated. The teams developing the best platforms have subject matter expertise in the industries they serve and the latest modeling approaches.

This expertise means that leading commercial tools were built to simplify routine tasks and allow flexibility to achieve more complex tasks.

For example, when Rimac, a leader in high-performing electric automobiles, sought to model their battery systems and simulate real performance conditions, they chose to work with Modelon, a leader in system simulation technology. Once Rimac started using Modelon tools, including the Electrification Library for battery pack and powertrain modeling, they identified several workflows to support their product development processes. These workflows required modification of crucial system design parameters, modular reconfiguration of the battery pack and battery level of detail, and additional interfaces for multi-physics simulation.

"Modelon's libraries are giving us more confidence in our early system designs and enable us to build and run simulations more quickly than ever before. Where we used to apply manual steady-state analysis, we can now run a full simulation and get much more insight, opening new possibilities," said Kruno Hrvatinić, Head of Control and Simulation at Rimac Technology.

ASSUMPTION 2:

In-house tools are the only way to protect Intellectual Property (IP)

Protecting IP is essential. Engineering secrets are closely held for good reason. When in-house tools rose in popularity, commercial tools couldn't promise security for sensitive information and genuine product support.

Today, teams don't have to choose between in depth product support and IP protection. Component libraries with fundamental physics are designed such that the publicly known equations are in libraries provided by the tool, and the IP-sensitive parameterization, empirical correlations, and system topologies are kept by the customer. The sensitive data are not needed for support queries.

ASSUMPTION 3:

Our industry expertise makes us uniquely suited to build this solution

Industry experts know their requirements and potential roadblocks well. However, developing software to model those requirements is challenging. Interface design, hosting, integrations, and robustness are complex to build into a single tool, even for those fluent in multiple coding languages.

Developing, maintaining, and scaling software requires a different skill set than building physical systems. Many teams switching from in-house tools to commercial tools find time savings, reduced total cost of ownership, and a renewed focus on critical activities.

ASSUMPTION 4:

In-house development is the only way to have a custom platform

The best modern commercial system simulation tools can customize their pre-built models and components and create different user interfaces for use by non-developers.

Some coding languages are better than others for physical system simulation. For example, Modelica allows for lots of customization, and with the proper UI built on top of it, the possibilities grow even further. Modern commercial teams support customization via their customer success organizations or manage development projects for the customer from start to finish.

Custom development with a commercial partner such as Modelon has two significant advantages:

1. In-house teams can reallocate time to work that drives revenue.
2. Knowledge of development techniques is shared by the partner rather than centralized to one or two employees (who are unlikely to remain at one organization indefinitely).

ASSUMPTION 5:

Once the in-house tool is built, we can scale at zero cost per additional user forever

Software developers know the product is never "done." Features are developed, tested, and released. Updates are built and shipped. New features are planned, and the cycle continues to make the best solution possible.

Beyond the challenge of developing a minimum viable product, the system's maintenance, validation, and scalability are important considerations. For example, is the system secure after multiple updates to the computer's operating system? Can the tool be accessed securely anywhere outside of corporate headquarters?

These challenges are magnified for in-house developers because, unlike commercial platform developers, the team surrounding in-house developers spends a small portion of time supporting the software.

The cost to build a complete feature set for one in-house tool is massive. To properly support and maintain one of those tools would require 1-3 full-time employees, depending on their tenure and level of competency. Building an in-house tool requires a commitment to routine development cycles, which may contradict the organization's primary goals.

ASSUMPTION 6:

An in-house tool will yield more accurate and actionable results

Lastly, the belief that in-house tools yield more accurate results is worth questioning.

A modern commercial simulation tool can use and protect unique IP while producing repeatable and verifiable results. Validating models with data from real-world tests is standard practice. Customizing code, using fundamental physics, and building partnerships are essential to the best commercial system simulation tools.

One example of partnering with commercial software tools to achieve more accurate simulation results is Collins Aerospace. In 2012, Collins, who had a history of in-house tool use, started working with Modelon. They aimed to replicate existing system models and produce identical results in a modern modeling language.

Collins' choice to upgrade its tool set with help from a commercial partner took the significant burden of maintaining their tool and modeling physics off their internal teams. After upgrading their tool set, Collins worked with Modelon to upgrade their compiler and solver, which helped produce more robust results than their existing in-house tool would allow.

Total Cost of Ownership for In-House Tools vs. Modelon Impact

Let's consider the cost of developing a physical system simulation and modeling tool in-house vs. using a commercial tool.

In-house tools often require multiple team members to build, operate, and maintain them. Depending on industry and complexity, tool maintenance alone may cost $500,000 annually in salary alone. The technical infrastructure to support the tool and time spent in development vary by industry but can easily cross over seven figures.

While some organizations see the allocation of work hours, headcount, and capital as essential to their business, many others (Fortune 500 and emerging startups alike) recognize the value of modern commercial tools.

The graph on the next page shows generalized expense calculations over 5 years for developing a physical system simulation and modeling tool in-house compared to partnering with Modelon and paying for platform licenses, services, and add-ons.

In-House Tool Development Costs

Salary	Infrastructure Costs	Tech Stack:	Support/Maintenance
1–5 developers	Efficient computer hardware	Integration	Testing infrastructure
1–2 domain expert		Security	QA team
1 project manager		Scalability investments	Support staff
			Maintenance costs

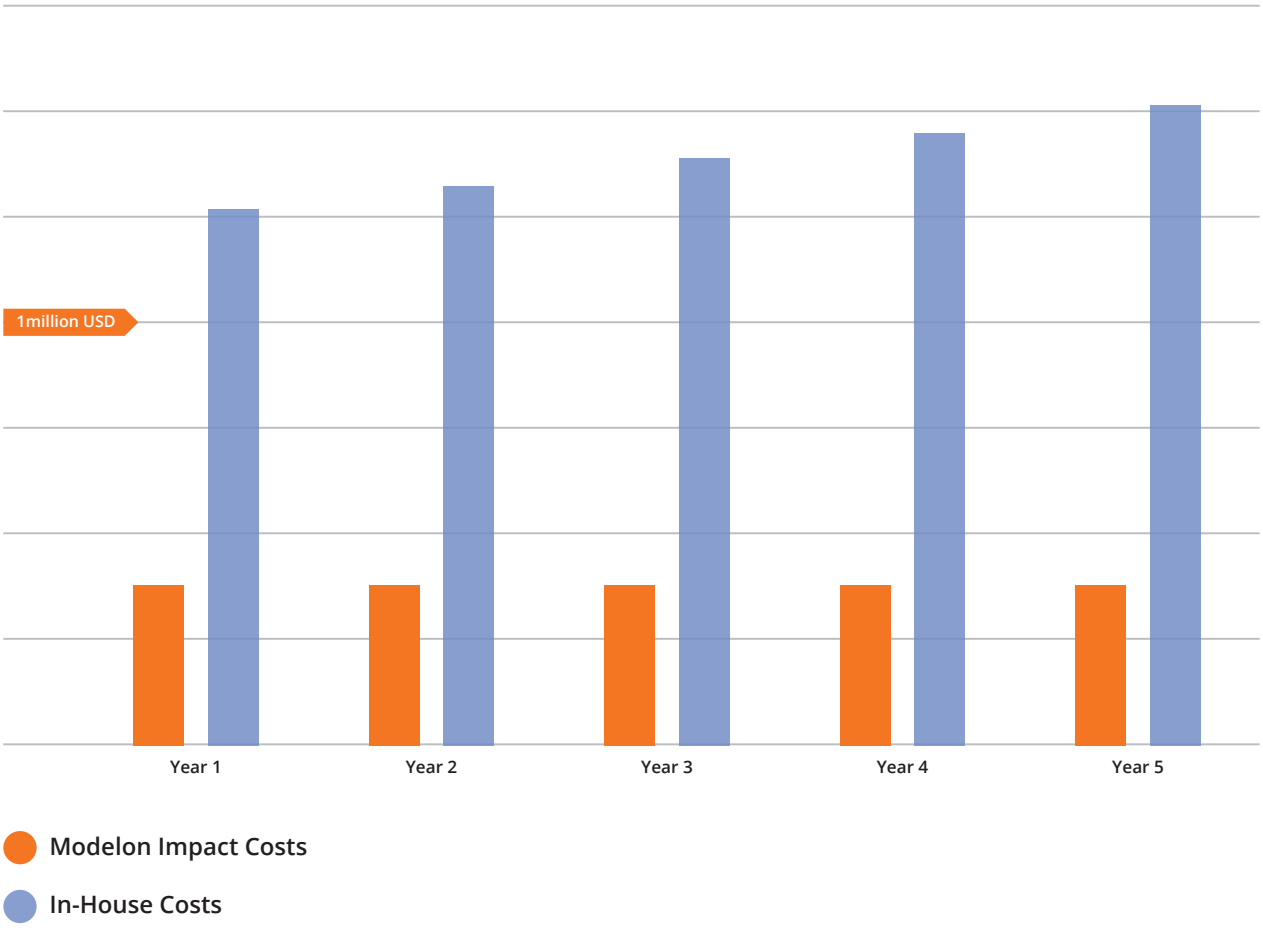
The total cost of in-house tool development over five years can easily exceed $5,000,000.

Cost of Modelon Impact and Custom Services

The total cost of working with Modelon (includes custom development projects, 24/7 cloud-based simulation and modeling platform access, trainings, licenses, and add-ons) over five years can exceed $1,000,000, but scales to the needs of your organization's team and modeling goals.

Services	Modelon Impact Licenses	Training	Add-Ons
Custom development and service projects accelerate modeling efficiency	Licenses for your users, scaling quickly depending on need	Available at any time of year to increase the team's knowledge	Productivity: Increased compute capability for power users Deploy: Run Modelon Impact through web applications and external tools.

Modelon vs. In-House Tool Development Cost



The State of Commercial Tools – Examining Modelon Impact

Various commercial tools exist for physical system design and simulation, but they don't all fit your organization. After closely reviewing the assumptions that lead teams to choose in-house tool development, let's examine why organizations choose to partner with Modelon:

Industry and Application Expertise

Modelon works closely with automotive, aerospace, energy, and HVAC-R leaders. Our industry teams have devoted their careers to understanding the industries we serve and delivering cutting-edge system simulation technology. Their knowledge is on display inside Modelon Impact, our cloud-based simulation platform, which includes libraries of models and components validated with real-world data.

Building in-house tools often requires additional headcount. Hiring team members who can have both development and domain expertise is challenging. Rather than creating a new team and a software tool, Modelon customers have access to a platform built by industry experts and one-on-one time with the experts themselves.

Sizeable Development Team for Custom Projects

In addition to our industry expertise, Modelon has a large development team capable of working on custom projects. Updates and new features for Modelon Impact are available multiple times per year, but Modelon Industry Services and Solutions teams can lead development projects to meet your organization's needs.

Custom Simulation Approaches Empower Design Decision-Making

Modelon has the practical system simulation knowledge to build complex models that enable complex decision-making. We can also determine how simulations should be performed and what type of computational approach best enables your team.

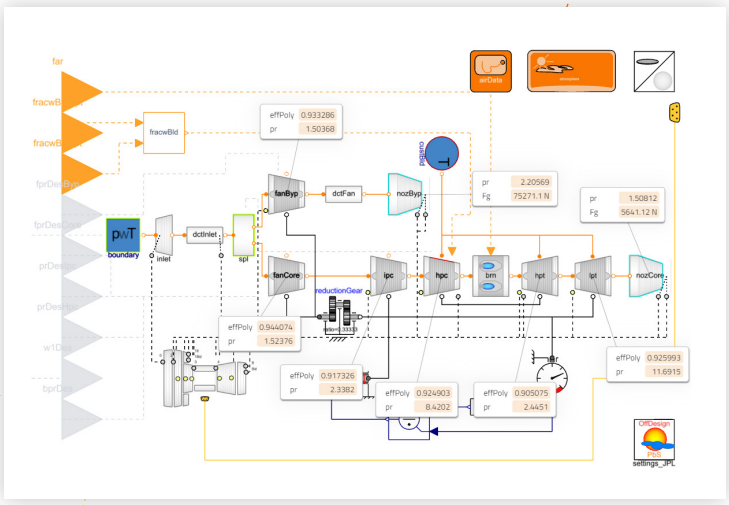
With Modelica as the coding language for Modelon technology, teams can choose how to approach their simulations. Although a computer's ability to perform complex calculations has increased exponentially in recent decades, only some simulations must leverage all the computing power to deliver an accurate result.

One of the first customers we applied this approach with was a leader in the energy industry. Rather than waiting hours or days for simulations to complete, the customer needed a computational approach that struck a balanced robustness and speed. Their engineering team began using this Modelon technology in 2014, and some of the same models and equations are still in use today, even an entire decade later.

Since then, this customer and Modelon have worked on additional service projects and built strong connections to accelerate the decarbonization of energy systems.

Pre-Built Workflows to Offload Repetitive Work

Modelon libraries include workflows common to the industries we serve, and our team adds to these workflows based on feedback from our customer base. While these workflows might be low on an in-house development team's list of feature requests, Modelon's size and experience allow us to support users fully.



This figure shows a sub-model from the Jet Propulsion library that can be included in a multi-point set up.

For example, Modelon Impact's Jet Propulsion Library, which is commonly used to model integrated aircraft propulsion systems, includes an Enhanced Multi-Point Design workflow. Classic cycle design relies on a process of defining parameters, computing performance, and changing design parameters until all goals are met is often tedious. For complex cycles, it is also not always obvious how to change design parameters to satisfy goals.

Modelon Impact's Enhanced Multi-Point Design workflow allows a user to concurrently include an on-design model and several off-design models in a single experiment. The models are interconnected to use consistent sizing information, and design rules as well as control laws can be used to couple them. This workflow replaces many manual iterations and empowers users to make better design decisions.

In-House Tool Replication

From the beginning, Modelon has replicated results from in-house tools to replace older systems.

One of our long-lasting partnerships started with the desire to replace a steady-state in-house simulation tool. This was a significant undertaking, as Collins Aerospace used this tool for air management systems onboard many aircraft.

As part of this project, Modelon developed robust large-scale steady-state solutions, which are the foundation of our cloud-based simulation platform, Modelon Impact. Interestingly, hundreds of in-house tools used today are built to run these large-scale steady-state simulations, even decades after they've been incorporated into commercial solutions.

Modelon exactly reproduced the results of their previous in-house tools. Replicating these results required collaboration and built trust between Modelon and Collins.

Perhaps most impressively, throughout the multi-year project, Collins' IP was securely used inside Modelon systems without Modelon employees needing or having access to it. Collins users expressed their legacy IP in Modelica code and executed it with Modelon software.

Despite their IP never being accessible to Modelon teams, the new tool, built specifically for Collins, replaced their in-house tool.

Collaborate Across Departments and Technical Competencies

Modelon Impact offers collaboration that is nearly impossible to replicate with in-house tools. Cloud functionality like link-sharing allows users in an organization to view and create a copy of an existing model. Workspace sharing enables users to share a configured workspace with team members. Collaboration between teams in different domains becomes seamless with link-sharing, and with integrated version control, there is always a "single source of truth."

Custom Interface, Workflow, and Component Development

Modelon's track record for customizing our technology goes beyond components and models to include user interfaces.

Modelon Impact supports the Functional Mock-up Interface standard. Individual elements or full models created in Modelon Impact can be exported as a Functional Mock-up Unit (FMU) and used in other platforms built on the FMI standard. In addition to FMUs, Modelon can create custom user interfaces.

Custom development for a US multinational leader in HVAC-R systems is a prime example of this development. This collaboration with a Fortune 500 company was the first time Modelon developed a user interface for a specific customer. Projects like these helped shape the current Modelon Impact interface, which is used by leading teams worldwide.

Modelon also offers App-Mode, which enables users to turn complete Modelon Impact models into valuable tools for less technical team members. An app-mode model can be customized and locked down for use across the organization. For executives and product support teams alike, App-Mode makes critical results and insights from system simulation accessible via the web.

Modelon Impact Feature Table

		Basic	Pro
Platform Features	App Mode	✓	✓
	Data visualization widgets	✓	✓
	Version control	✓	✓
	FMU import and export	✓	✓
	Shareable workspaces	✓	✓
Modeling Libraries	Air Conditioning Library		✓
	Aircraft Dynamics Library		✓
	Electrification Library		✓
	Energy Systems Library		✓
	Engine Dynamics Library		✓
	Environmental Control Library		✓
	Fuel Cell Library		✓
	Fuel System Library		✓
	Heat Exchanger Library		✓
	Hydraulics Library		✓
	Hydro Power Library		✓
	Jet Propulsion Library		✓
	Liquid Cooling Library		✓
	Pneumatics Library		✓
	Thermal Power Library		✓
	Vapor Cycle Library		✓
	Vehicle Dynamics Library		✓
	3rd party Modelica library support	✓	✓
	Modelica Standard Library	✓	✓
Solver & Performance	Steady-state simulation	✓	✓
	Dynamic simulation	✓	✓
	Real-time simulation	✓	✓
	Python custom functions	✓	✓
	Optimization	✓	✓
	Single-core simulation	✓	✓
	Multi-core simulation	* Available with add-on	* Available with add-on
Deployment Features	Documented REST API	✓	✓
	JupyterHub support	✓	✓
	Single web application run	* Available with add-on	* Available with add-on
	Multiple web application runs	* Available with add-on	* Available with add-on
Hosting	Cloud	✓	✓
	On-Premise	✓	✓
Help & Support	Help Center access	✓	✓
	Localized email and phone support	✓	✓

Modelon Impact vs. In-House Development:

Trade-Offs and Opportunities

It's essential to consider the trade-offs before continuing to invest time, money, and headcount for in-house tool development and maintenance.

Modelon Impact provides the customization and flexibility of in-house tools with the accessibility and pricing of off-the-shelf software. As a partner, Modelon is committed to helping organizations replicate the results of their in-house tools while holistically supporting complex system modeling projects.

Reach out to learn how Modelon's platform, industry experts, and validated component libraries can save you hundreds of thousands of dollars compared to in-house tools.

Rely on Modelon technology for accurate simulations that enable better system design and operations decisions.

Join us on this transformative path to engineering greatness, where every decision is backed by data-driven insights and precision.

Experience the unparalleled capabilities of Modelon Impact and unlock the future of model-based systems design with us.

Together, let's create a greener, more efficient world, one system at a time.

Modelon

Accurate Simulations. Better Decisions.