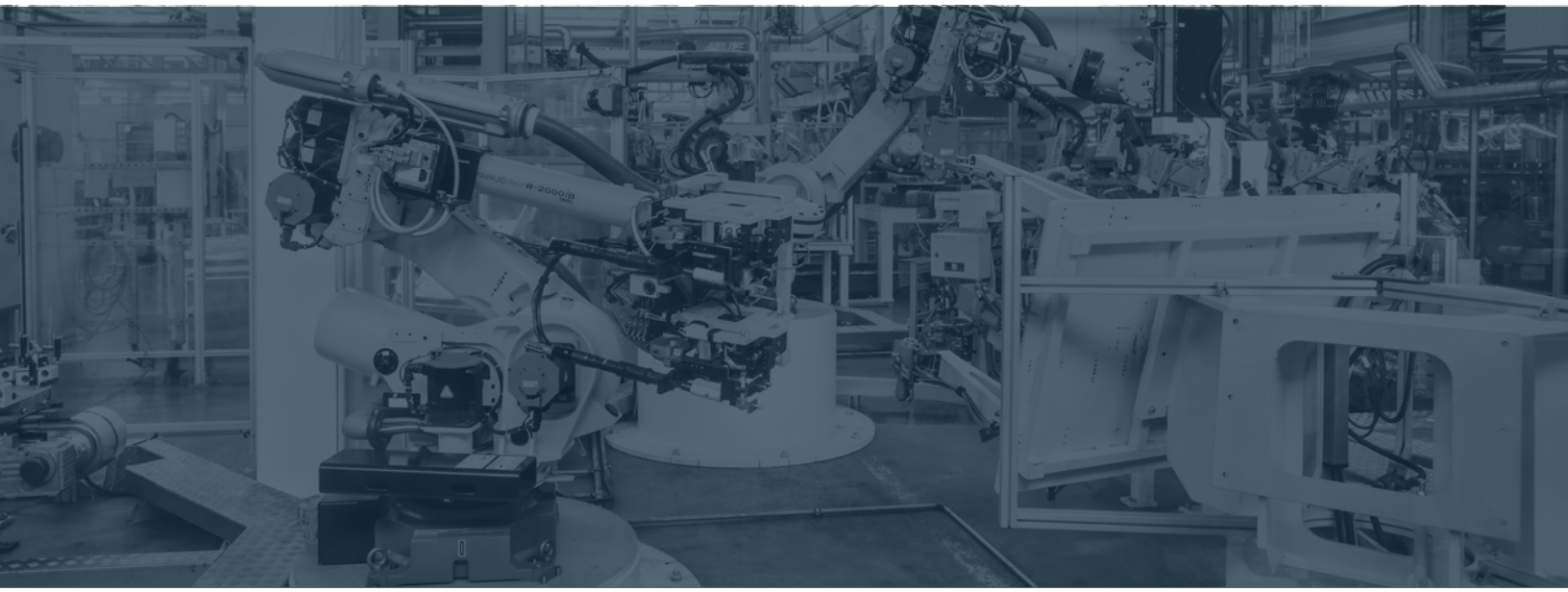
VENTION

Getting an edge in machine design



WHITE PAPER

How design software and industrial hardware integration is becoming the next competitive advantage

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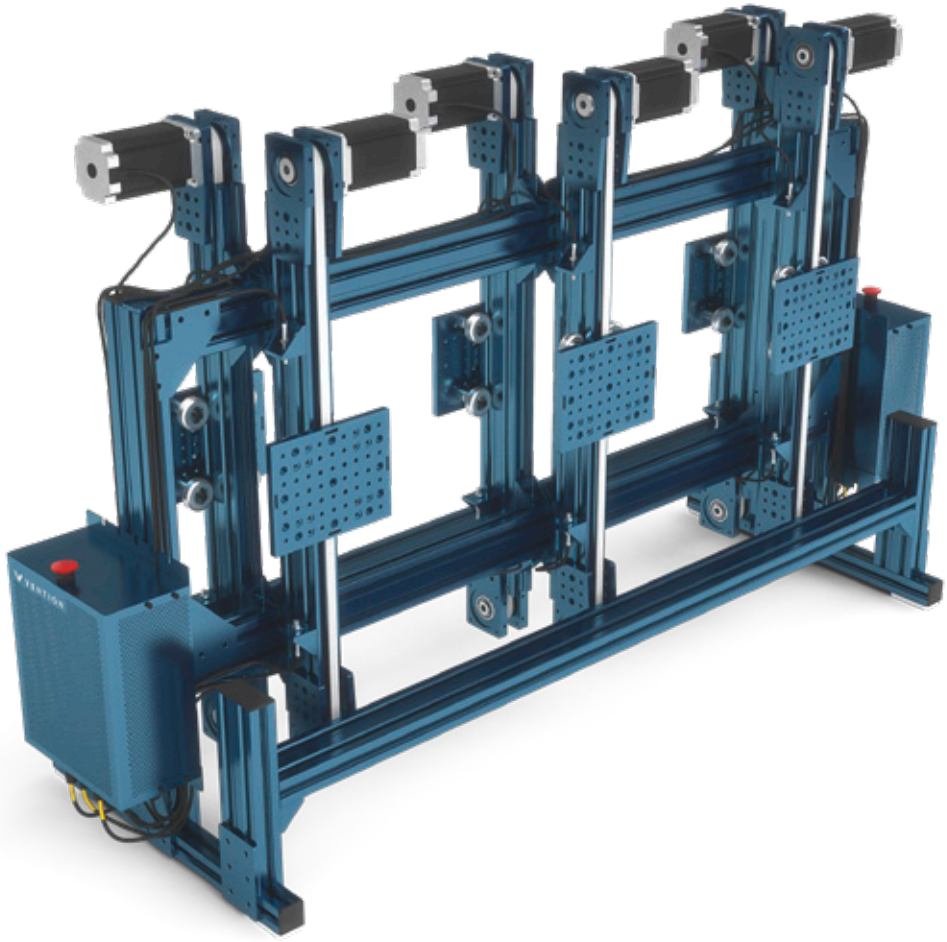
INTRODUCTION

The imperative for faster machine design

Today's engineering managers are under significant pressure to design products that can evolve as fast as the needs of the customers they aim to serve. As a result, we see car platforms with a shelf life of three years instead of five years become the norm, and we saw electronic products adopt an obsolescence schedule of one to two years instead of three years. This new reality is significantly disrupting how end-products and supporting production equipment (i.e., machines) are being designed and manufactured.

At its highest level, a shorter product lifecycle means that the window to depreciate related production equipment is also shorter, creating a need for production assets that can be readily designed, deployed and repurposed at low cost. Despite such pressure, custom industrial equipment is still being designed and manufactured the same way it was 20 years ago, relying on a highly fragmented ecosystem of regional industrial distributors, engineering integrators and local machine shops. This industry is ripe for a major change.



A shorter product lifecycles are creating a need for production assets that can be readily designed, deployed and repurposed at a at low cost.

SIX SOURCES OF WASTE IN MACHINE DESIGN

Designing and building custom industrial equipment is a complex process, and as a result, a time-intensive and costly one. Ever since the first generation of mainstream CAD software was introduced, the process by which these machines are created still remains unchanged. Even today, to create that equipment, manufacturing engineers spend most of their time translating data from one environment to the next instead of doing true mechanical design.

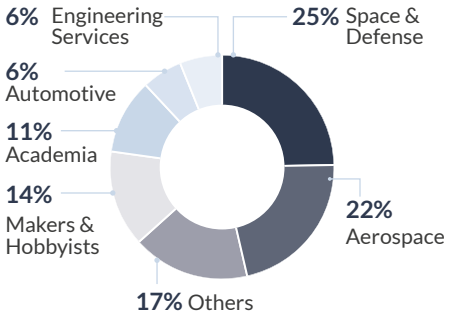
Over the last eight months, Vention has been working with a select group of ~70 engineers and designers in a variety of industries (e.g., automotive, aerospace, engineering services) to identify the primary sources of waste in the design and manufacturing of custom industrial equipment. Surprisingly, few sources of waste were related to CAD activities. The main sources of waste identified were:

- Time spent searching through an array of industrial catalogs and distributor websites for vendor parts (e.g., bearings, gears, servo-motors, controllers)
- Time spent validating the compatibility of vendor parts coming from different suppliers (e.g., interface, tolerances, communication protocol compatibility)
- Time spent searching and importing 3D models of selected vendor parts into desktop-based CAD software, acknowledging that several 3D models can't be found online and must be created from scratch
- Time spent designing custom parts required to connect other parts from different vendors (e.g., bracket, mounting plates, etc.)
- Time lost redesigning previously designed equipment because CAD files and project documents were not properly maintained
- Time spent purchasing vendor parts and custom parts from various suppliers (e.g., translating engineering requirements and data onto purchasing requirements, creation of multiple purchase orders, management of on-time delivery from fragmented pool of suppliers)

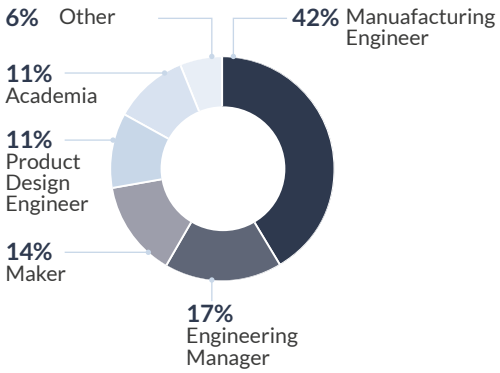
Most of these sources of waste take place at the intersection of CAD software activities and hardware-related activities; facilitating integration between the two could yield significant benefits. In the context of custom industrial equipment, where on average 50% of the total cost is related to engineering hours, eliminating these inefficiencies would not only save weeks of time, but would also significantly impact the economic business case of the end product.

Exhibit 1.
Research demographics (n=67)

Industry affiliations



Roles and responsibilities



Research conducted between March 2016 and October 2016. Data gathered through focus groups, structured interviews, and project de-construction exercises

Source: Vention.io

Manufacturing engineers spend most of their time translating data from one environment to the next as opposed to doing true mechanical design

WASTE ELIMINATION THROUGH DESIGN SOFTWARE AND INDUSTRIAL HARDWARE INTEGRATION

Recent developments in web technology such as WebGL, have enabled the development of integrated hardware[1] and design software platforms, where users can realize the entire design and build process in one single environment. Such environments allow users to:

- Select vendor parts and confirm compatibility
- Design industrial equipment from end to end
- Order the entire bill of materials from that environment
- Publish their design privately or publicly, fostering collaboration and reusability

This level of integration is about to fundamentally change the speed at which industrial equipment is designed and built. Three innovations are required in order for this integrated environment to emerge:

Tailoring CAD architecture to industrial hardware

The democratization of industrial hardware, including controllers and sensors, now makes it possible to create a LEGO-like hardware platform suited for modular machine design. When based on sound architecture that encompasses structural, motion and control components, such hardware platforms can significantly reduce the time spent on compatibility assessment and the creation of custom parts.

But those benefits pale in comparison to the cycle-time gains from integrating a hardware platform into a CAD software that operates at a much higher level of abstraction than traditional CAD. In contrast to the low-level CAD that currently dominates the market, high-level CAD is better suited to take full advantage of modular interfaces and metadata-rich 3D models representing each part of the hardware platform. Such profound differences in CAD architecture enable "intelligent features" that cannot typically be implemented. Some examples include:

- Context-based and automatic assembly constraints, significantly speeding up the CAD assembly process
- Context-based suggestion of next best parts, also positively impacting cycle-time and ensuring part reusability within an assembly
- Automation of design validation routines, based on codified technical specification of the parts
- Real-time cost and weight calculation throughout the design process

[1] An industrial hardware platform can be described as a coherent library of parts where compatibility is certified. An exhaustive hardware platform should include structural, motion and control parts, enabling the design of complete and functional machines

Exhibit 2.
Feature comparison between high-level and low-level CAD

	Features	Low-level CAD	High-level CAD
Part module	Creation of new parts	■	
	Creation of new assembly	■	■
	Embedded and curated part library	■	■
	Automatization of part compatibility assessment		■
	Context-based and automatic assembly constraints		■
Assembly module	Context-based suggestion of next best parts		■
	Automatization of design validation routines	■	■
	Real-time cost and weight through the design process		■
	Assembly purchasing from CAD interface		■
File management	Advanced search based on part semantic	■	■

Source: Vention.io

Web-based CAD as a purchasing platform

The need for design collaboration is pushing CAD software to become cloud-based. Cloud-based architecture not only enables simultaneous design, but also makes it much easier to share and reuse CAD models publicly or within private groups.

That being said, the benefits of cloud-CAD architecture extend far beyond improved user collaboration. The integration of a hardware platform using high-level CAD allows for a "ready-to-order" bill of materials, enabling users to design and order their machines directly from the CAD interface. Research in collaboration with industry partners has proven that weeks of schedule time are typically lost when an engineer transfers a project to purchasing. The suboptimal definition of intangible requirements, management of approved vendors and part equivalence, and the sheer time needed to transfer CAD data into purchasing software (e.g., creation of purchase orders) are the primary drivers of such waste.

Crowd-sourced marketplace fueled by a powerful search algorithm

According to Vention's research, industrial equipment is often designed under tight schedules, as upstream functions (i.e., product design) have already consumed most of the project time. For manufacturing engineers, this means that they have to prioritize schedule recovery over CAD file management. The adverse consequences of this reality are badly defined part metadata, poorly populated PLM and missing CAD files, leading to decreased relevancy of search results in PLM, and significantly reduced reusability of CAD models for future projects.

Here again, hardware and software integration leads to benefits that could not otherwise be realized. On one hand, cloud-based architecture inherently ensures that CAD files are properly maintained and remain accessible to authorized users. On the other hand, metadata-rich 3D models of the hardware platform allow for powerful, semantic-based search algorithms. This guarantees that assemblies, as well as sub-assemblies hidden within larger assemblies, are recognizable, indexable and fully searchable.

Vention's foundational "search" feature enables other features, such as a crowd-sourced marketplace. Soon, new machine designs will not be started from scratch, but rather from someone else's shared design that can be easily found amongst thousands of public contributions. The power of sharing and reusability has been demonstrated in software development, with GitHub being the most well-known example. Machine design could follow a similar path as soon as proper search technology has been implemented at scale.

Soon, new machine designs will not be started from scratch, but rather from someone else's shared design that can be easily found among thousands of public contributions.

THE BUSINESS CASE FOR DESIGN SOFTWARE AND INDUSTRIAL HARDWARE INTEGRATION

Despite the latest innovations in engineering software, the design and manufacturing of custom industrial equipment remains a highly manual--and therefore time-consuming and costly--process. Our research demonstrated that on average, 50% of the total cost is related to engineering hours, while the remaining 50% is related to the time needed to purchase hardware, such as vendor parts and custom-manufactured parts.

Fortunately, the integration of design software and industrial hardware can significantly eliminate waste and inefficiencies in scheduling and equipment costs. Working with its partners, Vention led five different "project deconstruction" exercises in order to quantify work content, schedule and costs associated with each step of the design and build process (i.e., from specifications definition to commissioned equipment). Those custom equipment projects were then reconstructed under the assumptions of design software and industrial hardware integration.

The results of our study were quite impressive. Total project cycle-time gain ranged from 1.8X to 6.6X, and total cost savings ranged from 4% to 80%. The key variables influencing various levels of gains were an engineering team's familiarity with modular hardware, having distinct designers and buyers, and the complexity of the project at hand. Exhibit 3 summarizes the results.

Exhibit 3. Results from project de-construction and reconstruction exercises (n=5)

Company classification	Large aerospace company	Large automotive manufacturer	Mid-size robotic company	Mid-size robotic company	Small printing company
Project description	Kitting station	Support for inspection fixture	Base for robot arm	Assembly station	Vertical-axis scanning rack
Project complexity	Very low	Medium	Low	Low	Medium
Design vs. buyer	Distinct individuals	Same individual	Same individual	Same individual	Same individual
Familiarity with modular hardware	Low	Medium to low	High	High	Medium to low
Design time on vention.io	75min	46min	40min	64min	34min
Vention assembly time	5h06min	7h09min	3h39min	3h17min	2h45min
Vention hardware cost	$1,940	$3,304	$1,730	$1,826	$2,059
Vention cycle-tlme benefits	6.6× faster	2.7× faster	4.7× faster	1.8× faster	3.3× faster
Vention total cost benefits	7% savings	52% savings	4% savings	N/A	80% savings

CONCLUSION

Shorter product lifecycles are creating pressure for custom industrial equipment to be rapidly designed, deployed and repurposed at low cost. Fortunately, recent developments in design software and industrial hardware technologies have paved the way for integration between the two, enabling an array of “intelligent features” that wouldn’t have been possible just a few years ago. The resulting benefits will create a step-change reduction in machine design and cost.

ABOUT VENTION

Vention enables engineers to significantly reduce the development and manufacturing time of custom industrial equipment. Vention provides a fully-integrated 3D machine builder and modular hardware platform that let users design, order and share their custom machine directly from their web browser.

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