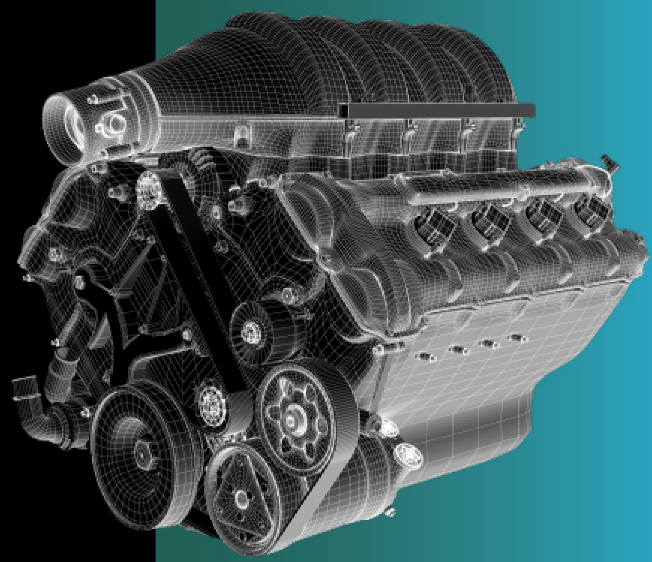
CASTOR

2021

Additive manufacturing trends report

Based on data extracted from CASTOR's part screening software after analyzing more than 30,000 parts



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INTRODUCTION

Omer Blaier, Co-Founder and CEO of CASTOR

To fully understand and exploit the potential of AM, we ask a key question that is essential to the future growth of the industry : *When does AM makes sense?*
It seems like a simple question, but is in fact more complicated that it first appears. Both experienced and less experienced users of AM already know that AM is not always the best solution for our manufacturing needs. Some of them have learned this the hard way. Using AM without a business case can be frustrating experience.
Insight and understanding from the start can shorten the path to a successful and viable deployment of AM.

CASTOR's software comes into the picture at this point and enables the manufacturer to quickly check if a part, or an assembly of parts, can be suitable for production by AM, both geometrically and economically. With two full years of experience in the use of the CASTOR software and 30,000 parts and assemblies analyzed, we realize that we stand at a unique place in the understanding of the needs of manufacturers in the area of AM. This position gives us special insight into how product developers view AM and DfAM, and we can not only provide a unique view into design trends among product developers, but feed key messages back to manufacturers on printablity and deliver key industry knowledge that will inform product developers and guide their thinking about how to design for AM when approaching their next part or product.

Our experience clearly indicates that AM is underutilized and far from fulfilling its true potential. With some effort, insight and suitable decision-support tools, AM could play a much broader role in providing innovative design and manufacturing solutions for a range of different industries. We have initiated this report as a service to the AM community so that the insights we have learned from thousands of real projects can accrue to the benefit of all, and expand understanding and knowledge about the use of AM and its potential for even greater use in the future.

AM TRENDS TOWARDS TO PRODUCTION

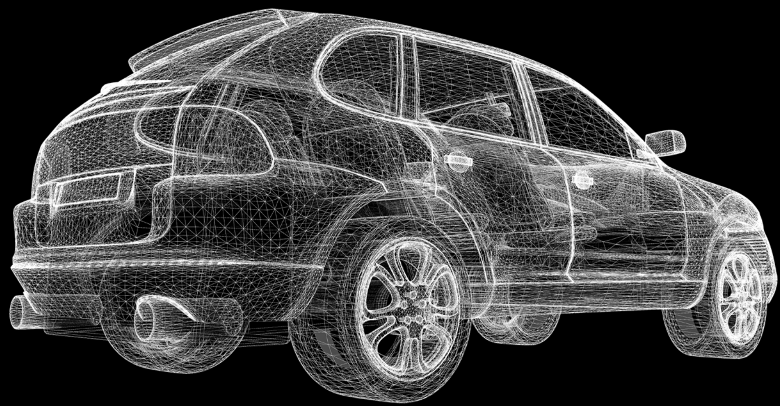
The pandemic year caused many AM companies, especially growing startups, to forego visits to potential customers, forcing many of them to spend time in the laboratory to improve their products and develop new applications.

Beyond the overall activity statistics for the industry, we have noted qualitative changes that have occurred in the industry during the second half of the last decade. A major overarching trend of the AM industry is that from year to year a greater variety, and a larger share, of AM activity is devoted to end-use manufacturing, and not the product development process.

With that trend, we've noticed that the need to identify the business cases where AM parts make sense compared to traditional manufacturing methods, has become a key aspect in the decision-making process among managers of production, the supply chain, and R&D. In some areas, the break-even point between AM and traditional manufacturing continues to be extended, meaning that with each passing year the AM net is cast wider to capture products and applications that were not feasible in the same quantities just the year before.

And the widening scope of improved break-even does not consider the possibilities of manufacturing AM parts that cannot be made any other way, due to complex geometries, lightweight structures, or by combining parts in ways that reduce the cost of part assembly or secondary processes like welding or gluing.

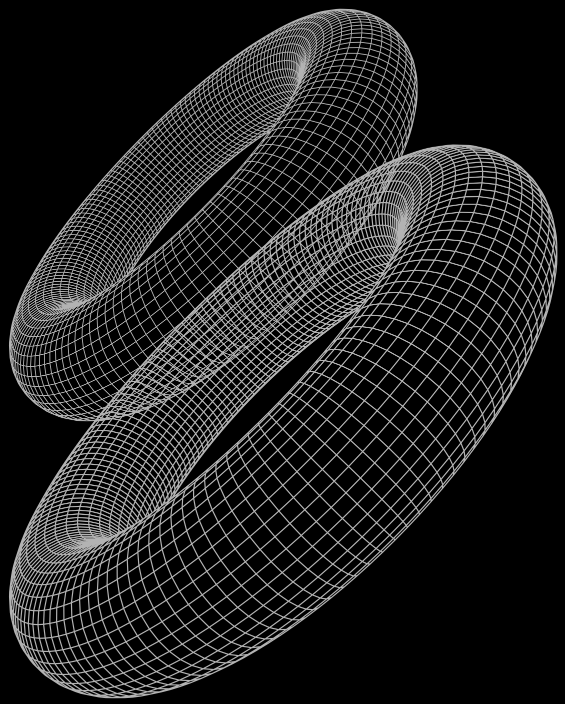
Additionally, we have experienced an unexpected dividend from global events such as the pandemic and growing concern over climate change that have drawn attention to additional benefits of AM: avoiding disruptions in supply chains through the flexibility of digital on-demand manufacturing; and reduced environmental impact through distributed manufacturing and lower material usage through sophisticated design options such as light weighting.



CURRENT AM PRACTICES INSIGHTS GAINED, LESSONS LEARNED

CASTOR is pleased to publish interesting and often unique insights from the front lines of the additive manufacturing world. Our analysis is based on data extracted from a database of 30,000 parts or assemblies uploaded to CASTOR in the period 2019 – 2021.

A key feature of the CASTOR platform is the ability to process thousands of parts in parallel, giving unprecedented depth to insights that can only be generated from part analysis at scale.



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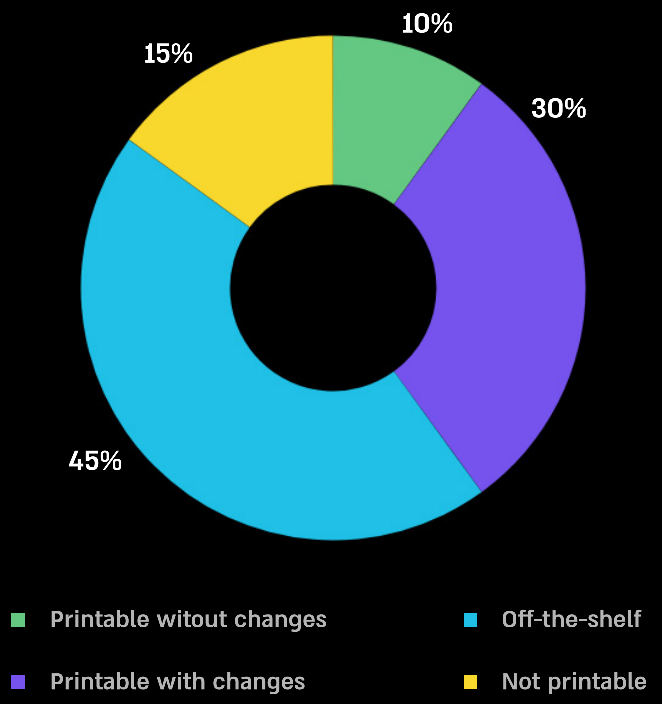
10% of parts can be technically and economically printed without design changes

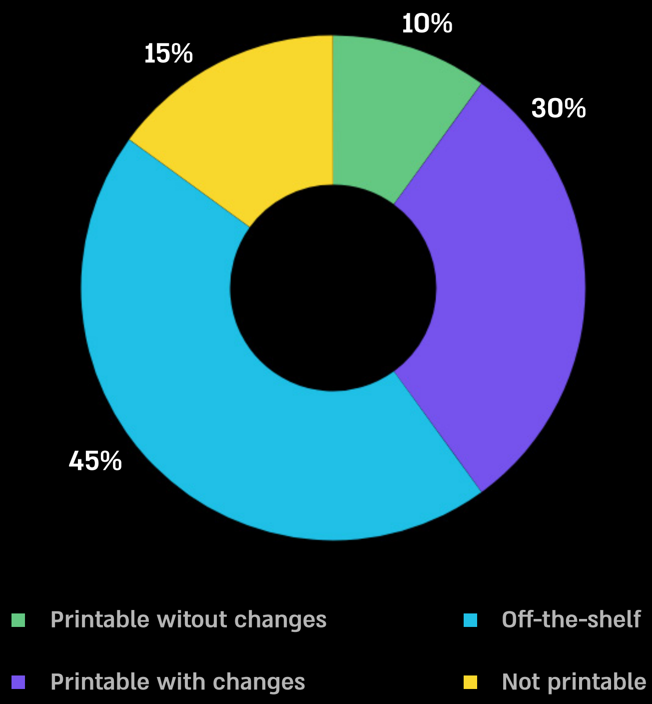
3D PRINTABILITY OF PARTS



Parts designed for traditional manufacture in general are not ideal candidates for 3D printing that makes sense. 10% of random parts can be printed without changes at all. We expect that with time, as knowledge about DfAM spreads in the engineering and design community, this figure will rise. We will track this parameter from year to year and it will serve as a measure DfAM readiness.

Of the other 90% parts, 30% can be technically and economically printed with changes, 60% are either unprintable or don't make a good business case

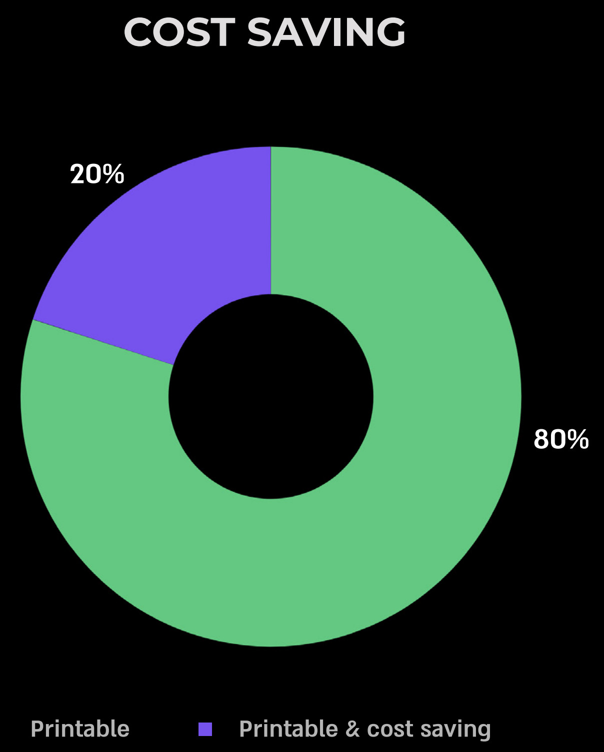
3D PRINTABILITY OF PARTS



A variety of parts initially disqualified for printing can be modified with relative ease. Design rules based upon requirements of a 3D printing technology being considered for use to build a part can in many cases be easily implemented retroactively without too much trouble. This category of modifications includes parameters such as wall thickness, holes size, or other dimensional limitations based upon the printing platform in question.

Conversely, avoiding the dimensional limitations of injection molded or die cast parts, such as draft angles, or complex undercuts, can greatly simplify the design for parts designed for shorter production runs. Around half of parts submitted as part of assemblies are off-the-shelf parts, such as screws, nuts and bolts, and these parts were never intended to be candidates for production by AM by virtue of them not being cost effective.

Among the printable parts, 20% can save costs compared to traditional manufacturing



The definition of "Cost Saving" for the purposes of this analysis is the difference per part of traditional manufacturing less the cost of AM production, for a given production quantity. Understanding the situations where AM can save the manufacturer money is an important factor in a company's AM strategy. The above figures are in percentages, but the overall savings could be significant based upon production run size and lead time to supply the parts to market.

Break-even point in cost is often not as important at break-even point in time, especially in periods of disrupted supply chains, so a final analysis of whether to print or not needs to take into softer factors such as available lead time and other commercial considerations. In the case of spare parts, the cost of downtime could be a critical or dominant factor. Understanding the dynamics of AM is a key factor in making sensible or profitable manufacturing decisions.

Top reasons for parts' unprintability - How can manufacturers increase the number of parts that can be printed

Typical reasons for an unalterable classification of a part as unprintable are divided into two categories: design-driven part geometry which makes printing impossible, and the unavailability of AM materials with suitable material properties. Parts classified as unprintable can be reclassified by one of two reasons: easily implementable design changes; or acceptance of risks indicated by the software (such as higher costs of milling to achieve a desired surface finish), or waiving the need for a desired specification in non-critical areas of the part. Faulty STL files resulting in an unprintable classification can automatically be fixed by the CASTOR platform if requested by the customer. Off-the-shelf parts (screws, nuts, bolts, etc.) will not be cost effective for AM production.

REASONS FOR UNPRINTABILITY

Unprintable	
Size: too big for printer tray	**0.40%**
Wall thickness: Below printer threshold, design cannot support thicker walls	**1.80%**
Material properties: No AM material meets minimum properties	**2.10%**
Stability for printing: No stable orientation possible for AM	**0.70%**
Printable with design changes	
Tolerances: Too fine for AM processes	**5.30%**
Small holes: Too small for any AM process	**1.10%**
Metal supports: Expensive milling or finsishing required to remove support markings	**2.50%**
Metal surface roughness: Inaccessible for smoothing	**18.20%**
Heat: Residual stress buildup in the printer	**7.70%**
Other problems	
CAD file error: Printable after repair	**8.10%**
Never Cost Effective	
Off the shelf parts	**33%-66%**

Note: Some parts return multiple problems. Total not 100%

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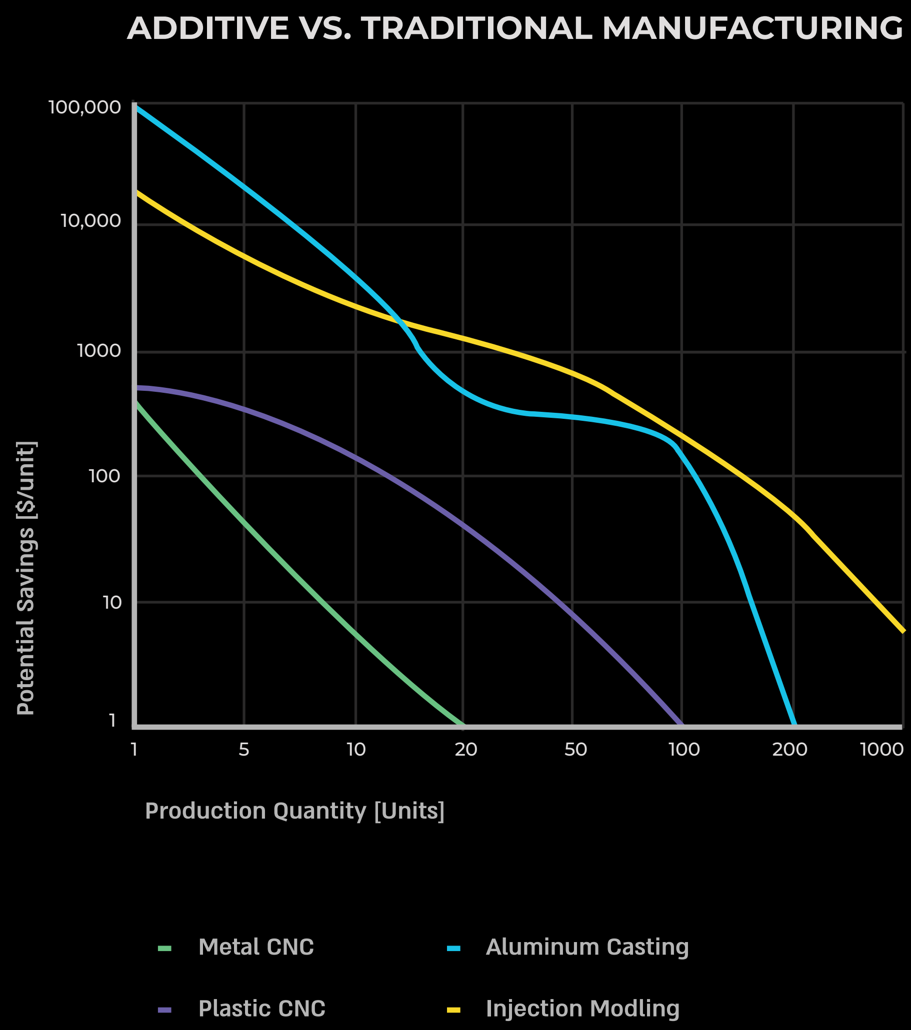
The total potential savings per production run ranges from 100s-1000s of dollars for low quantities, to 10s of dollars for higher quantities

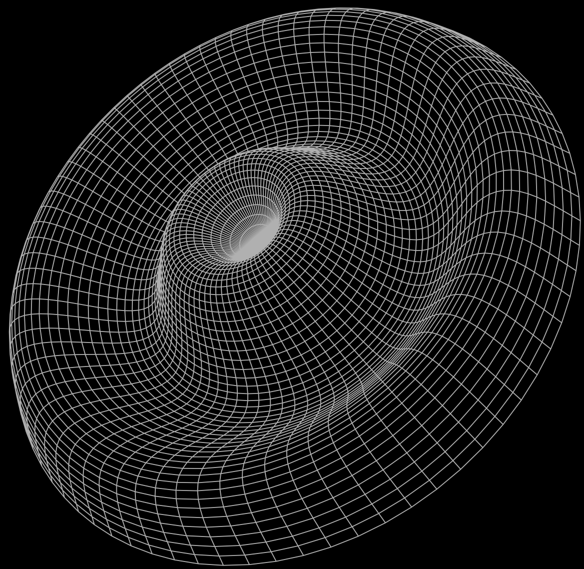
*Results differ by process

Overall potential cost savings per part in each manufacturing project will vary according to the manufacturing technology against which AM is compared, and as a function of the quantity of parts being produced. The aggregated real-case data enables AM users to ascertain the break-even point in depth, and in total savings, allowing them to make calculated decisions, dynamically and on the fly. Data revealed by CASTOR over hundreds of cases provides dimensions of insight that typical break-even analysis had difficulty in demonstrating.



GROWING THE AM PIE – DFAM TOOLS START TO BECOME MORE AUTOMATED

Design for Additive Manufacturing (DfAM) are a set of rules that assist engineers in altering their designs to take advantage of the benefits of AM. As engineers become increasingly exposed to AM, their knowledge of DfAM will increase as well. Knowing the rules is one thing, and analyzing when to apply them is another. CASTOR currently deploys two tools that assist engineers in determining where AM can save them money: light weighting of parts, and parts consolidation.



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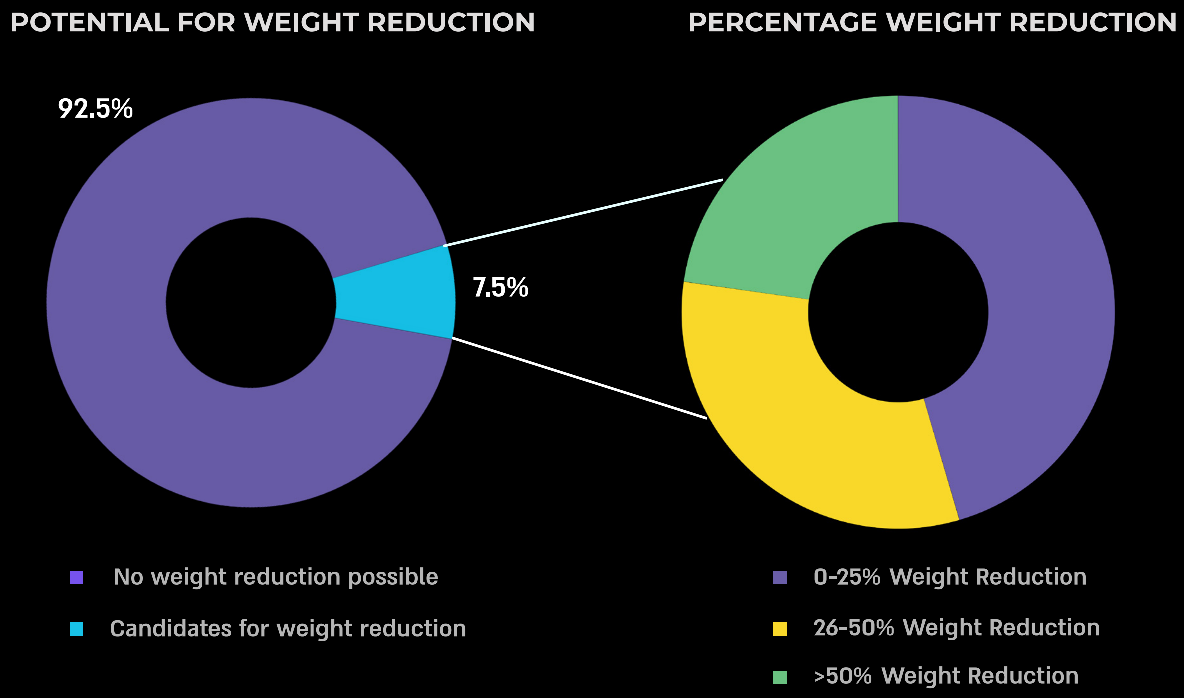
7.5% of parts can be reduced in weight without compromising structural integrity of the part



A surprising number of parts can be reduced in weight, an important factor as more companies embrace the need for more sustainable products. We can expect that this number will increase as more knowledge is accumulated and machine learning begins to play a role in automatically proposing weight reduction. Automatic tools such as bulky area identification and hollowing tools can ease the weight-reduction process of AM parts without compromising part integrity or strength requirements.

Weight reductions of more than 50% are possible - a significant value

Half of all candidate parts for weight reduction can be reduced by 25% or more, which is not an insignificant number. Pressures for reducing carbon footprint on the manufacturing of parts are growing, and we can expect weight reduction to become more significant and desirable, even for reductions of under 25%.

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Part consolidation might only be available in a relatively small number of cases, but once identified can deliver high levels of cost savings

Automation using software tools in the identification process of candidates for part consolidation can uncover cost saving opportunities that might be left unrealized if left to a manual process.

In cases where the software identified opportunities for part consolidation, cost savings increased to thousands of dollars (per project), due to the savings in labor costs, connecting screws, inventory, etc.

OUTLOOK AND CONCLUSION

As the results of this survey of real-life engineering projects show, tools now exist that make the process of decision making for production and design engineers easier than ever before.

One of the biggest hurdles to the development of AM for production applications, which is where the larger potential for AM lies, is the lack of broad appreciation and understanding of the advantages that AM can already offer. Speed to market, flexibility for short run manufacturing, and the possibility of innovative design are already there for the taking, and can be unlocked through greater awareness of principles and rules of DfAM. As with many trends that herald change, there is a learning process that engineers will have to go through. As the industry develops, DfAM knowledge will play a bigger role in delivering savings to manufacturers by expanding use-cases where AM makes sense.

DfAM analysis can today be augmented by interactive tools that provide an interactive way in which the analysis can be conducted, and trade-offs evaluated. Among them is the CASTOR platform, which offers unique and innovative functions providing a full picture of where changes in design or material properties can be afforded, technically or economically, without sacrificing product specifications. Complex questions can now more easily evaluated, such as:

- Will a change in materials deliver sufficient economic benefit to justify the change?
- Will a change in geometry to facilitate AM processes, resulting in cost savings, be critical?
- How would a geometrical change impact a part or product break-even point that may not be readily apparent?

Advanced software analysis tools of the kind we have described that are starting to make their way to market, will continue to improve, grow and become more intelligent. The outcome can only mean one thing for an expanding industry: more viable parts made by AM with less material, more quickly and where possible at lower cost, representing a winning formula for the AM ecosystem seeking innovative ways to grow.

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HOW CASTOR'S SOFTWARE WORKS

Parts or assemblies of parts in all major 3D CAD file formats are uploaded to CASTOR's cloud or on-premise software. Users specify the number of parts needed and the material planned for traditional manufacturing. The company's proprietary algorithms disassemble the assembly, process the CAD data for each part in the assembly, and within a short time return answers to the following questions:

- Which parts in the assembly can be printed without modification?
- Which AM technology offers an economically viable AM option, and in what quantities?
- What design change, if any, can be made to transform an unprintable part into printable ones?
- Where can material properties be saved without compromising the strength of a design?

ABOUT CASTOR

CASTOR is an Israeli-based software company enabling manufacturers to increase profitability by using industrial 3D printing. CASTOR solves the challenge of identifying where, when, and how to use 3D printing to reduce costs.

CONTACT US:

www.3dcastor.com

info@3dcastor.com