ARC White Paper

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Additive Manufacturing for Excellence in New Product Development

ARC Advisory Group

Executive Overview

The relentless pressure for companies to create new products, enter new markets, and achieve greater market share while satisfying existing customers, is exacerbated by the onslaught of new technologies and industry trends that threaten disruption. Often, discussions of disruptive concepts such as the Industrial Internet of Things or digital transformation focus on broad, long-term visions and neglect the very real need for short- and mid-term business impact. Over the past decade, advances in additive manufacturing systems and materials have addressed the industrial prerequisites of part fidelity and robustness and the technology is now in a state to deliver immediate impact for industrial users. Recognizing this, organizations have begun employing additive manufacturing as a best practice within their new product development (NPD) groups. Even more companies have identified the technology's potential for business transformation, but many struggle to develop a clear vision and business case around adoption.

To determine how additive manufacturing can disrupt current processes and transform broader business strategy, companies must first understand the foundational role new product development (NPD) fills within their organization. At a more detailed level, understanding the relationship between decision making and knowledge capture within an NPD project and the effect of that relationship on the project's success, can illuminate the value of an effective additive manufacturing strategy.

To determine how additive manufacturing can disrupt current processes and transform broader business strategy, companies must first understand the foundational role NPD fills within their organization. At a more detailed level, understanding the relationship between decision making and knowledge capture within an NPD project and how that relationship will affect the project's success, can illuminate the value of an effective additive manufacturing strategy.

ARC Advisory Group has identified four essential NPD objectives that can be achieved using additive manufacturing for rapid prototyping and tool fabrication in manufacturing:

- Increasing product fitness by informing early critical design decisions
- Avoiding budget and schedule overruns by reducing the occurrence and effect of late-stage design changes
- Identifying and addressing failures early by reducing downtime between design selection and initial testing
- Compressing project timelines by enabling parallel design engineering, manufacturing engineering, and validation efforts

Significance of Excellence in NPD

For companies within the discrete manufacturing industries, NPD is the epicenter for innovation. From an operations perspective, NPD provides an opportunity to address product quality, cost, and supplier selection without introducing risk to ongoing programs. From a marketing perspective, new products fuel business growth in core markets and expansion into new territories.

As products become increasingly complex, so too does the development process. This requires coordination of larger cross-functional teams and suppliers, as well as more extensive testing. Despite the increased cost of complexity, customers will continue to demand smarter, cheaper, and higher quality products.

When executed effectively, NPD provides a foundation for success. Products designed for lean or modular manufacturing can improve operations performance, while greater functionality and quality promotes growth. As a supplier, successful NPD programs strengthen customer relationships. On the other hand, poorly executed NPD programs have the opposite effect, generating chronic quality issues and disaffecting customers.

Maintaining the Balancing Act Throughout All Phases

While there are many possible approaches for implementing NPD, they all involve four essential project phases:

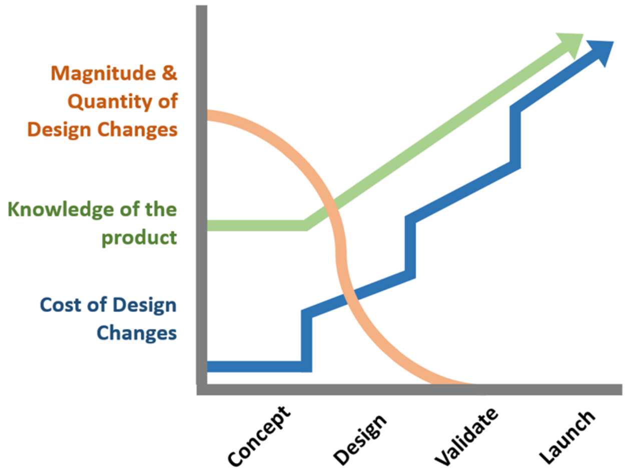
- **Concept:** Begins with ideation and research followed by rapid design iteration based on prior knowledge and application requirements. Ends when a primary design is selected.

- **Design/Development:** Detailed engineering and design modifications are performed, along with supplier selection, initial testing of the design, and investment in manufacturing equipment.

- **Validation:** Involves testing and analysis of production-representative products and manufacturing process.

- **Launch:** Once the product has passed testing, manufacturing lines ramp up production, and first products are distributed to customers.

As a project moves through these phases, the product design crystallizes, the program's body of knowledge grows, and the value invested in the program increases. In an ideal world, this order of operations is preserved. In practice, however, decisions to invest must be made without perfect knowledge and design changes will occur after investments are made. Companies that struggle with NPD often make poor decisions with insufficient information, or delay making decisions until the correct path is assured.



Invested Program Value Increases as Project Progresses Across Four Essential Phases

A successful NPD program achieves a balance between seeking adequate information and making the required decisions on the one hand and reducing costly design changes and maintaining project timelines on the other. When evaluating the potential impact of a new technology or process to your NPD strategy, it's important to consider it in that context. How will it improve early decision making and how will it reduce the financial and scheduling impact of unanticipated design changes?

Additive Manufacturing Accelerates NPD and Improves Outcomes

Advanced part fidelity and material options for additive manufacturing have redefined the technology's role in prototyping and, to a broader extent, NPD. With industrial additive manufacturing systems, companies must view rapid prototyping as an opportunity to quickly drive out inefficiencies in product design and manufacturing. Indeed, companies are already utilizing modern additive manufacturing systems to accelerate product development, reduce program cost, and improve the final product design.

Rapid Prototyping of Product Concepts and Designs

Thanks to their increased fidelity and durability, 3D printed parts are now being used to confirm engineering assumptions related to fit, form, and function during early stages of NPD programs. The relative ease of generating additively manufactured prototypes enables early evaluation of a greater number of designs and a deeper understanding of their strengths and weaknesses before critical decisions and investments are made.

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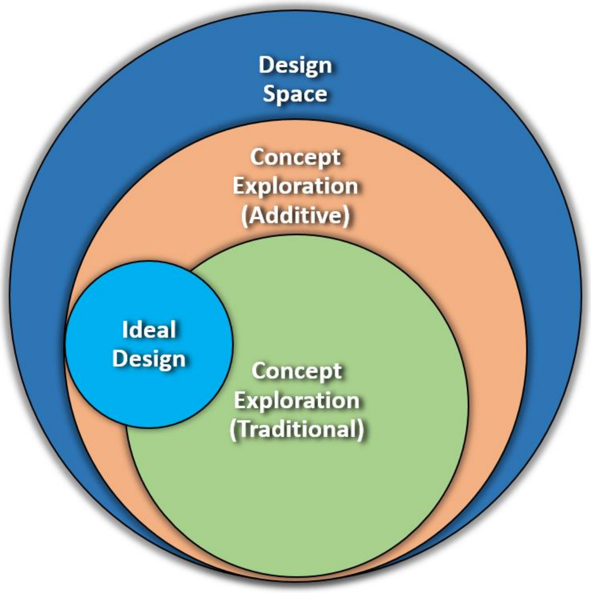
Tangible parts can be used to test mating characteristics, tolerance stack-ups, ergonomic requirements, and other aspects of a design's fit and form. Although differences in material properties between prototypes and final products may prohibit complete evaluation of function, high-quality prototypes can be used during functional testing of larger assemblies.

Minimizer, a company that specializes in polyethylene fender design and manufacturing for semi-trucks, has taken this approach for prototyping its new products. Due to the exorbitant cost of the large tools required to make truck fenders in production, Minimizer must be sure of its designs before investing in manufacturing equipment. Even soft tools meant for low-volume runs and prototyping can be expensive, often require long lead times, and do nothing to facilitate design flexibility. With additive manufacturing, however, Minimizer can fabricate durable, functional prototypes of its fenders and bracket assemblies within hours or days. For Minimizer, this means a CAD model can be updated, printed, and bolted to a test truck for evaluation within a week, with production tooling kicking off shortly after.

Inform Early Critical Design Decisions

Selecting which concept or concepts to pursue as you move from the concept to development phase has a cascading effect on the success of a product through its lifecycle. Despite the impact these early decisions may ultimately have, they are made when the least amount of information is available. To address this, companies are using additive manufacturing to increase bandwidth for concept evaluation during these early stages of a program. Physical samples can also facilitate more productive design reviews by communicating design intent and increase the opportunity to find the best design candidate.



AM Can Help Expand the Envelope for the Critical Concept Exploration Phase

The footwear industry has been one of the pioneering adopters of additive manufacturing for this very reason. For running shoes, aesthetics is essential for initiating customer engagement. If the shoes don't look appealing, then the selling points revolving around fit and function may never even come up. To quickly assess new concepts, Brooks Running, an athletic shoe company known for its technical innovation, utilizes additive manufacturing to print dozens of outsole and mid-sole combinations within a two-day timeframe during its design validation process. The speed and flexibility afforded by additive manufacturing enables Brooks Running to keep pace with the breakneck speed of the footwear industry, which often requires the company to develop two to three seasons of shoe designs at once.

Reduce Late-stage Redesign

Employing additively manufactured prototypes to physically verify engineering assumptions early in a program mitigates enormous risk by reducing or eliminating the need for late-stage redesign. Discovering a design failure during validation testing, for example, will often require retooling of the preproduction or production line. To make matters worse, the ensuing redesign may invalidate previous physical testing and engineering simulations. In industries like aerospace & defense or automotive, where a full suite of design verification tests can take months to complete, this type of setback could have a disastrous impact on a project budget and timeline.

Fabricate Tools and Decouple Manufacturing Dependencies

One of the fastest-growing industrial applications for additive manufacturing is for fabricating jigs, fixtures, manifolds, dies, and other tools. With the introduction of high-grade plastics and carbon-fiber composite printing technology, companies can rapidly manufacture tools with the strength and durability to replace their metal counterparts. So, while direct product manufacturing with additive manufacturing may be inappropriate for some projects, companies are finding that even greater benefits can be achieved by manufacturing related tools.

Fast-track Concept to Testing

The reduced tool cost and lead time afforded by additive manufacturing is essential to accelerating the early stages of new product design and testing. Utilizing additively manufactured parts for prototype manufacturing lines and test fixturing can significantly reduce the time between concept selection and design testing. For example, companies that rely on prototype mold tools to evaluate their thermoplastic part designs now use printed tools as inexpensive and quick alternatives to machined soft tools. In this context, additive manufacturing can be exercised to condense test schedules or increase test bandwidth without jeopardizing program timelines.

The same capability also allows an NPD team to respond rapidly to test failures or manufacturing concerns that would necessitate changes in design. Additionally, budget and timeline tradeoffs become less prohibitive when evaluating non-essential design changes. This empowers engineers to be opportunistic when new information is acquired.

Empower Parallel Engineering Efforts

Some manufacturing facilities use 3D printed parts as substitutes for components and production tools. Manufacturing engineers use these as surrogates for long lead time tools or components whose designs are not finalized. This allows them to work in parallel with suppliers and design engineers. In some cases, high-durability printed tools, such as fixtures, jigs, and end-effectors, can completely replace their traditional counterparts.

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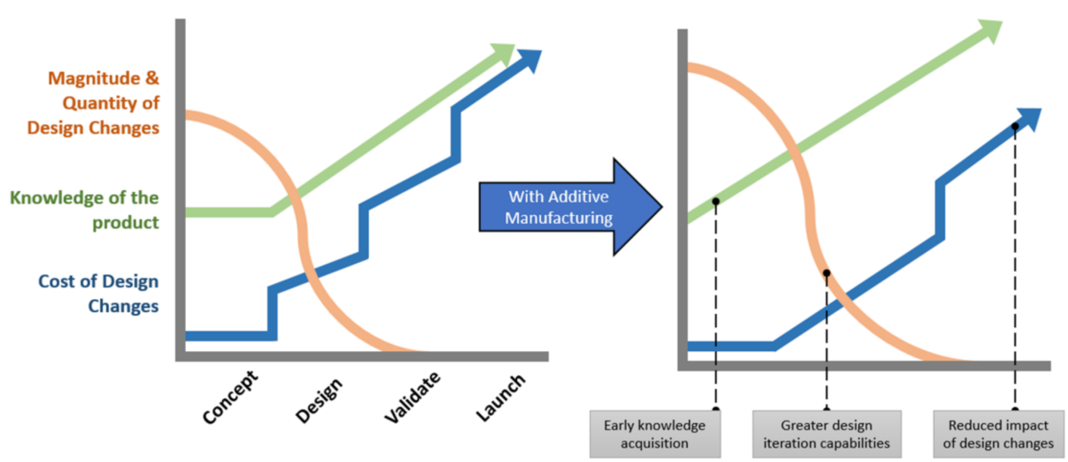
While this application is clearly well suited for discrete manufacturing, some interesting use cases are also popping up in other areas of industry where additive manufacturing is being used to parallelize what were historically sequential activities.

Syqe Medical is a startup that has developed a cannabis-based treatment for neuropathic pain relief. During the product development, two of its primary hurdles were winning investors and clinical testing. Employing additive manufacturing, Syqe Medical designed and produced its inhaler prototype within a matter of weeks to present to investors. Within two months, the company employed additive manufacturing to create working prototypes for clinical trials. This allowed Syqe Medical to quickly address the most important aspects of its product - the safety and efficacy of the treatment - while the final inhaler design and manufacturing process was still being refined.

How do Additive Manufacturing Capabilities Translate to Broader Business Strategy?

As an emerging, disruptive technology within NPD, additive manufacturing is proving to be more than an engineering tool, but rather an essential element in helping companies achieve broader business goals. Based on the established characteristics of standard NPD processes and the potential benefits additive manufacturing can provide, its larger, strategic effects become apparent beyond the scope of design engineering.



Additive Manufacturing's Impact on the Design/Knowledge/Investment Relationship of an NPD Program

Facilitate Product Innovation

The agility and flexibility afforded by additive manufacturing during the concept and development phases of NPD reduces risk and promotes creativity when exploring novel designs. Instead of being locked into early design decisions, companies are investing efforts to continuously address changing customer needs throughout NPD. In highly competitive and innovation-driven markets, this ability to efficiently incorporate new requirements into ongoing programs separates the innovators from the laggards. A single successful product launch can carve out a larger share of a primary market or help a company penetrate new markets. Conversely, a delayed or underwhelming product launch can cripple growth initiatives.

The same additive manufacturing benefits can help users accelerate programs where innovation is not a priority by identifying and addressing quality and performance issues of design before they become critical problems.

Enable Aggressive New Business Development

Within today's tightly knit manufacturing supply chains, additive manufacturing can have invaluable impact on project timelines. Printing parts and tools enables suppliers to quote compressed timelines compared to their competitors. The ability for suppliers to provide early samples to customers facilitates co-development and helps identify requirement gaps, benchmark performance, and address design issues before decisions are made that could otherwise lead to costly or time-consuming delays. Furthermore, the ability to rapidly modify manufacturing lines can ensure important milestones are hit despite unanticipated design changes.

This resiliency is a critical attribute that customers look for in suppliers. For larger projects, the failure of a single supplier to meet a crucial deadline can disrupt system-level testing, impede production run at rates, and potentially push back product launch. Suppliers that show proficiency in avoiding such delays are duly recognized and have greater chances of winning new business on future projects.

Support Manufacturing Initiatives

As mentioned previously, introducing additive manufacturing capabilities to manufacturing engineering teams enables them to work in parallel with design engineering efforts. Involving manufacturing early provides an earlier opportunity to test assembly methods, identify bottlenecks, and provide input to the product designers. Moreover, companies can extend the time for manufacturing engineers to focus on quality and capacity targets without prolonging the overall NPD project. This helps ensure better operational performance at product launch.

This approach is considerably more time- and cost-efficient than attempting to fix or adjust processes after production has started, which often requires asset downtime and extensive testing. For suppliers, this issue can be exacerbated if customers require notification, participation, and signoff for process and design changes. In some cases, suppliers are simply forced to absorb the cost of high fallout, rework, or quality issues to avoid the risks associated with process or product redesign once a product has been launched.

Conclusion and Recommendations

The Minimizer, Brooks Running, and Syqe Medical use cases described in this white paper provide real-world examples of how businesses can utilize Stratasys additive systems to target unique NPD needs. While many companies could provide specific solutions to address some of these needs, Stratasys, as the global market leader in additive manufacturing, has developed a comprehensive catalog of systems and materials for meeting a very broad spectrum of the challenges that plastic-based additive manufacturing solves today.

With industrial-grade additive manufacturing solutions, such as the ones provided by Stratasys, organizations can achieve faster, better-informed decision making and accelerate NPD programs, while driving down project cost. However, equipping engineers with additive manufacturing capabilities before defining its role within the NPD process can lead to poor utilization, which could obscure benefits, delay ROI, and discourage further investment. With a methodical approach, organizations will categorize chronic breakdowns and shortcomings of their current NPD process, identify additive manufacturing technologies and applications that address those weaknesses, and develop best practices for utilization.

Based on ARC research and analysis, we recommend the following actions for discrete manufacturers interested in additive manufacturing:

- Companies must first understand the problems they are trying to solve before defining their specific additive manufacturing strategy. A failure to recognize the differences between the NPD process on paper and in action often makes it more challenging to leverage additive manufacturing effectively. Conducting a systematic evaluation of current and historical NPD programs will illuminate points of departure within your process at which budgets and milestones fail to align with goals. Identifying the causes of these issues will help to better understand additive manufacturing opportunities.

- Seek the help of additive manufacturing experts for technology education, selection, and system implementation. The additive manufacturing market is segmented into seven distinct process categories, which are further distinguished by supplier-specific technologies. Products can range from inexpensive desktop units, to production-ready industrial systems. Depending on your goals, you can expect to spend anywhere from a few thousand to several hundred thousand dollars on a single system. To help navigate this market, many leading suppliers have consulting teams that help determine what technology and what level of investment will be appropriate for your unique needs.

- Start with pilot projects. An additive manufacturing strategy for NPD should initially be deployed on a case-by-case basis. Delegate an additive manufacturing center of excellence to determine what projects are best suited for early implementation, evaluate performance, and use that information to define company-specific best practices. You may find that the benefit of additive manufacturing varies significantly by project. Developing criteria to identify which projects are best suited for additive manufacturing support will be important to maximize utilization. When the strengths and weakness of additive manufacturing within your organization are sufficiently understood, you can integrate those best practices into your standard NPD process.

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