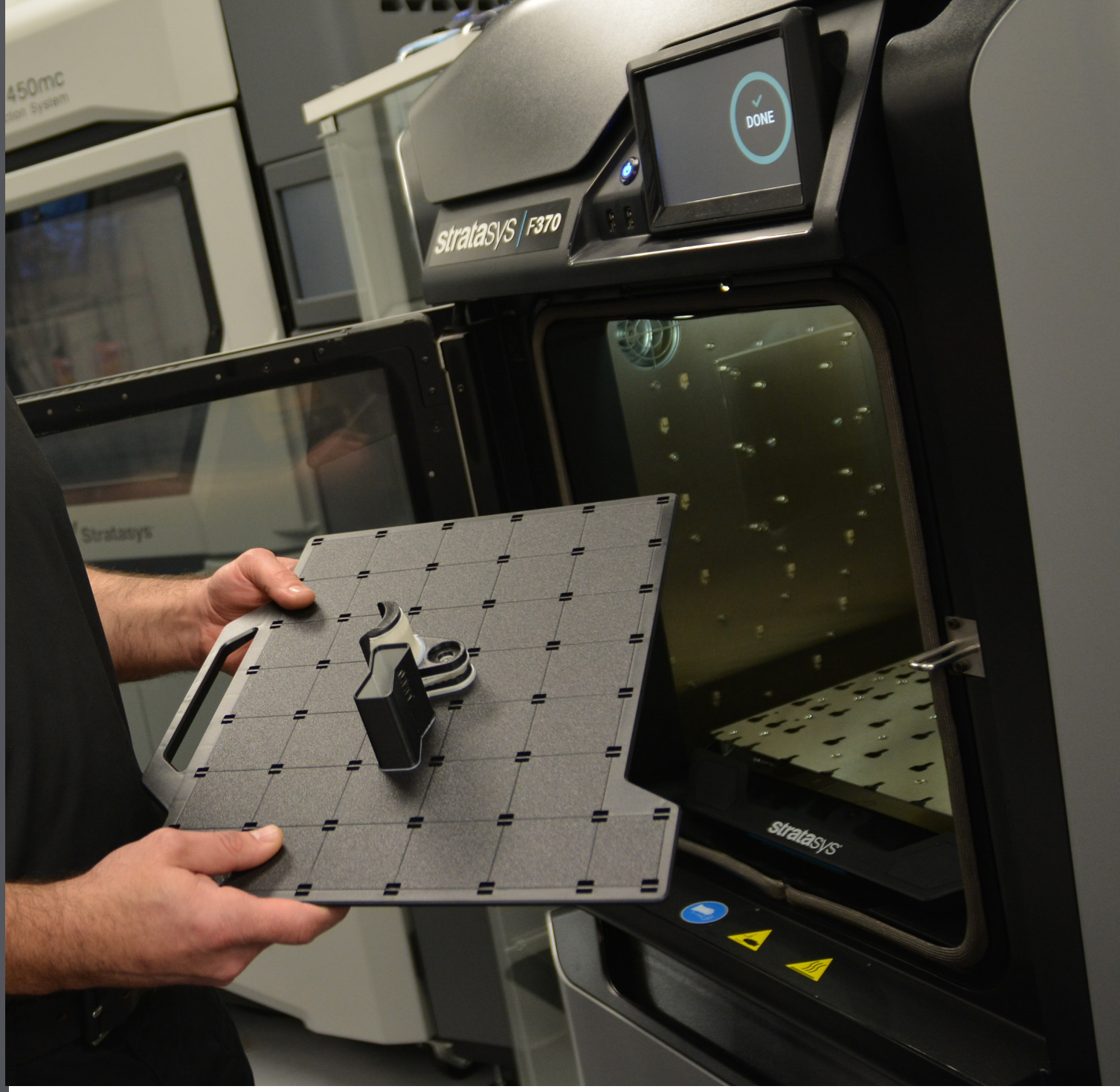



# Justifying a 3D Printer Investment

White Paper

stratasys

# The Justification Challenge

For designers, engineers and product managers, the value of 3D printers for reducing cost and accelerating product development is unquestionable. Yet despite the obvious value, it may be unclear how to convince management teams and accounting departments that the benefits justify the investment.

The fundamental advantage of 3D printing is that it enables the cost-effective production of models, prototypes, tooling and production parts. Independent of design complexity, these items can be produced in hours or days rather than days or weeks. That advantage yields the benefits of expediting the product development process, expanding the scope of prototyping work or streamlining production with more effective tooling. However, these benefits may be undermined by the two-fold challenge they might create.

For many companies, efforts like prototyping or making new tools are viewed as an expense, not an investment, for which there is no budget. With this mindset, increasing the volume of this work means only that expenses will increase. This translates to a negative impact on the bottom line that becomes hard to rationalize. To justify 3D printing, the value of switching from conventional methods to 3D printing must be quantified in real, tangible ways.

Likewise, a justification based on speed must also be rooted in tangible gains that result from making the production process faster. Although "time is money" is an oft-stated platitude, the direct link between time and money can be difficult to establish, at least in terms that are indisputable in a financial justification. Without the time-to-money correlation, 3D printing justifications may be difficult.

These scenarios force many to justify 3D printing on the weakest value proposition, saving money by substituting it for current processes. This approach works, and many companies have successfully used it for justification. However, doing so ignores the value of enacting change within the product development cycle — changes such as completing more design iterations, prototyping early and often or making the impractical possible. Excluding these benefits weakens the justification, which makes it more difficult to make the case for an investment in 3D printing.

The following discussion provides strategies and guidelines offered by those that have been successful in justifying 3D printer purchases.

The fundamental advantage of 3D printing is that it enables the cost-effective production of models, prototypes, tooling and production parts.

**Prototyping: Synergy Design**

Synergy is a product development company that creates many of the goods we use every day. Clients rely on Synergy to transform bright ideas into real, marketable products. Industrial designers and engineers often work around the clock to perfect the grip on a medical device or the appearance of a phone charger.

Prototyping is a key component in Synergy's design process. Ideas are embraced, refined or abandoned based on a prototype's look and feel. To speed up and sharpen the decision-making process, Synergy brought a multicolor, multimaterial 3D printer in-house. It produces whole-product prototypes in full color — even with multiple materials, textures and gradients — in as little as a few hours.

So when Synergy redesigned a keypad for an emergency-response system used in the aftermarket automotive industry, their 3D printer played a key role. Previously, their prototyping manager would have tapped several vendors to create a single keypad panel prototype — using CNC machining and water printing for the body, casting for the light pipes, sanding for smoothness and then silicone engraving and additional printing for the buttons. This process would have taken anywhere from ten days to two weeks to create at a cost of $700 per unit. With their 3D printer, it took just hours and cost $200 per unit.

"Now our customers can make instant decisions about the ergonomics of a product — about the touch and feel — as well as test how it fits into its environment," said Tamar Fleisher, Synergy Art Director. "The ability to simulate light transfer on the panel meant my client could decide about every detail of the design. And if a design change was needed, I could go to my computer, make the design change and print it in a matter of hours."

By changing their prototyping process with in-house 3D printing, Synergy reduced the lead time to produce those prototypes by 90% (from up to two weeks to one day). This also included a 70% reduction in cost to produce them.

# Making the Case


When the cost of new equipment exceeds the signing authority of a manager, funding will come from a capital expenditure (CapEx) budget that upper management controls. This means the proposal will be one of many competing for limited funds allocated across the company. To show that 3D printing is the wisest investment among the other proposals, build a business case that clearly demonstrates the value of the proposed CapEx to management.

The goal is to validate a purchasing decision by transforming benefits into concrete, tangible results. When well written, it shows that the CapEx proposal offers a strong return with manageable risk. It becomes compelling when crafted with the decision makers in mind. Knowing the audience focuses the business case on the approvers' "hot" issues, and it makes it simpler to include the right information.

If the proposal is structured to justify a specific, targeted application, it becomes a use case. Although it addresses a more limited scope than the business case and is often approved at a departmental or divisional level, the use case format and content are the same as that in a business case.

Both the business case and use case contain three parts: executive summary, situational analysis and financial justification. The executive summary is a single-page (or shorter) synopsis of the situational analysis and financial justification. The situational analysis describes the current situation, proposed solution, alternative solutions and associated risks. The financial justification, which is the focus of this discussion, presents the anticipated return on the CapEx investment through an analysis of the monetary outflow and the expected financial gains. When combined, the monetary inflow and outflow produce the financial indicators that measure the value of the investment.

While building the financial justification, seek guidance from the finance department. It will assist you in selecting the proper performance measures, such as return on investment (ROI) or payback period. It can also aid with data collection and calculation methods, as well as guidance on items such as "hurdle" rates, which are the lowest threshold for which an investment will be considered.

# Justification Strategies

To build a winning justification that circumvents the challenges of monetizing the advantages of 3D printing, there are four strategies for success. Used alone or in combination, these approaches provide a strong foundation upon which to build the financial case for an investment in a 3D printer.

### Build on a Tiered Approach

As previously noted, the simplest and most commonly used method of justifying 3D printing is to calculate the savings when it is a Substitution for work that is currently being done with traditional manufacturing techniques or through third-party 3D printing service providers. This is the starting point and the foundation for any justification. However, it yields the lowest overall value to the company since it only considers the decrease in prototyping expense for work that is already being done.

If larger financial returns are needed to obtain approval of the CapEx proposal, move to the next tier of 3D printing benefits, Augmentation. This category is based on doing more of the same type of work that was included in the Substitution tier. The speed, efficiency and capability of 3D printing remove the barriers of time, cost and effort. So, 3D printing makes it easy and practical to produce more prototypes, tools or production parts, which delivers more value.

The benefits of augmenting prototyping work are defensible. However, the challenge is calculating a measurable and accepted value that results from the prototypes. To do so, the decision makers must believe that there is a correlation between the action and the anticipated outcome. Otherwise, the purpose for the 3D printer will be viewed as just an increase in expenses.

The third and final tier is Extension. Here the justification is built upon 3D printing offering a solution that isn't a current activity. Extension is likely to deliver the most significant value since it is changing and improving processes, but it is the hardest to quantify. Because the activity is new for the company, the impact can only be forecast, which makes its value susceptible to debate and doubt.

### Target Cost Reduction

Profit improvement is the ultimate goal of any business action, and it is achieved by either increasing sales or decreasing expenses. However, when it comes to a justification, the most powerful approach is to address the cost side of the equation.

There are many reasons to focus on cost reduction in a justification, but the most significant is that expenses are a current fact while improved sales are a forecasted possibility. Current and measurable, a reduction in expense is more tangible and defensible than a projection of increased sales. Additionally, cost containment is usually a priority for all companies, and therefore, a top-of-mind issue for management.

### Address Current Problems

Rather than laboring to create interest in a potential benefit of 3D printing, target the justification towards solving existing problems. The strategy is to leverage what corporate management has already accepted as fact. If not presented as a solution to a current problem, management may view the proposal as just another added expense or be doubtful of the return on its investment.

There are two advantages to this approach: it addresses a current "pain" that the company

seeks to eliminate, and that problem is likely to have a cost associated with it. If 3D printing can be shown to be the best option to overcome the challenge, the savings are then a part of its return on investment.

For example, if mold rework is a frequent issue that has management's attention and management has identified an associated cost, the benefit of multiple design iterations, made possible by 3D printing, shifts from a convenient advantage to a practical cost-saving measure. For the justification, the financial value of rework reduction has already been determined — it is the cost that management has associated with the problem. Since that number is management's, it is a fact that needs no further evidence.


### Leverage Shared Budgets

To sidestep the business case and executive management approval, consider tapping into established budgets from multiple departments. When the acquisition and operating expenses are split across departments, the decision making can shift from corporate management to managers and directors.

The added benefit of this approach is that these decision makers are more likely to appreciate the value of 3D printing. Managers close to the day-to-day operations inherently appreciate, understand and crave 3D printing's less-tangible advantages. Rather than needing proof of the technology's impact, the manager merely needs to decide if the budget can support the purchase.

# Building the Financial Justification

The process of building a financial justification has only three steps:

**1. Determine the financial benefit**

**2. Compile the initial and ongoing expense**

**3. Calculate the investment's performance**

Considering the strategies that have been discussed, start with the monetization of 3D printing's benefits.

## Step 1: Calculate the Value

The value is the financial gain that results from the CapEx before the investment expense and ongoing costs are subtracted. It is the profit potential for the company, division or department generated by expense reductions, revenue increases or a combination of both that result from a 3D printing investment.

Per the previously discussed justification strategies, there are three possible value categories: Substitution, Augmentation and Extension. In that order, both the value and difficulty in proving the worth move from low to high.

### Substitution

There are two sources of components for the justification: outsourced parts from suppliers and those made in-house. Collect data for all insourced and outsourced items that could be transitioned to the proposed 3D printer, including the prototypes, parts or tools that are currently 3D printed and those that are machined, molded, cast, formed and hand-fabricated.

Begin by collecting historical data for any models, prototypes, patterns and tools that are representative of the parts the new 3D printer will make. Use a 12- to 36-month look-back period. For items in this time span, gather cost data, process information and part descriptions.

Building from this historical data, project the 3D printing workload for the near term, which is typically three to five years to provide a baseline of all potential part candidates.

To keep the cost justification relatively simple and somewhat high-level, review the 3D printed candidates to determine overall categories to which averages may be applied. For example, consider the number of plastic parts, simple sheet metal components, complex machined parts and bulky cast metal parts. Subdivide these categories with other qualifiers such as size. For each of the categories, determine if they are suitable candidates for 3D printing.

Finally, review the parts within each category to determine the percentage that will be run on the new 3D printer. This provides a gross estimate of the number of parts and their size. This data will be used to determine the savings potential, and later, the expense to 3D print them.

Now it is time to calculate the actual cost of all of these parts when made with conventional manufacturing processes or by third-party 3D printing companies.

For outsourced work, use invoices to determine average costs for each category of parts. Make sure to include all expenses, such as:

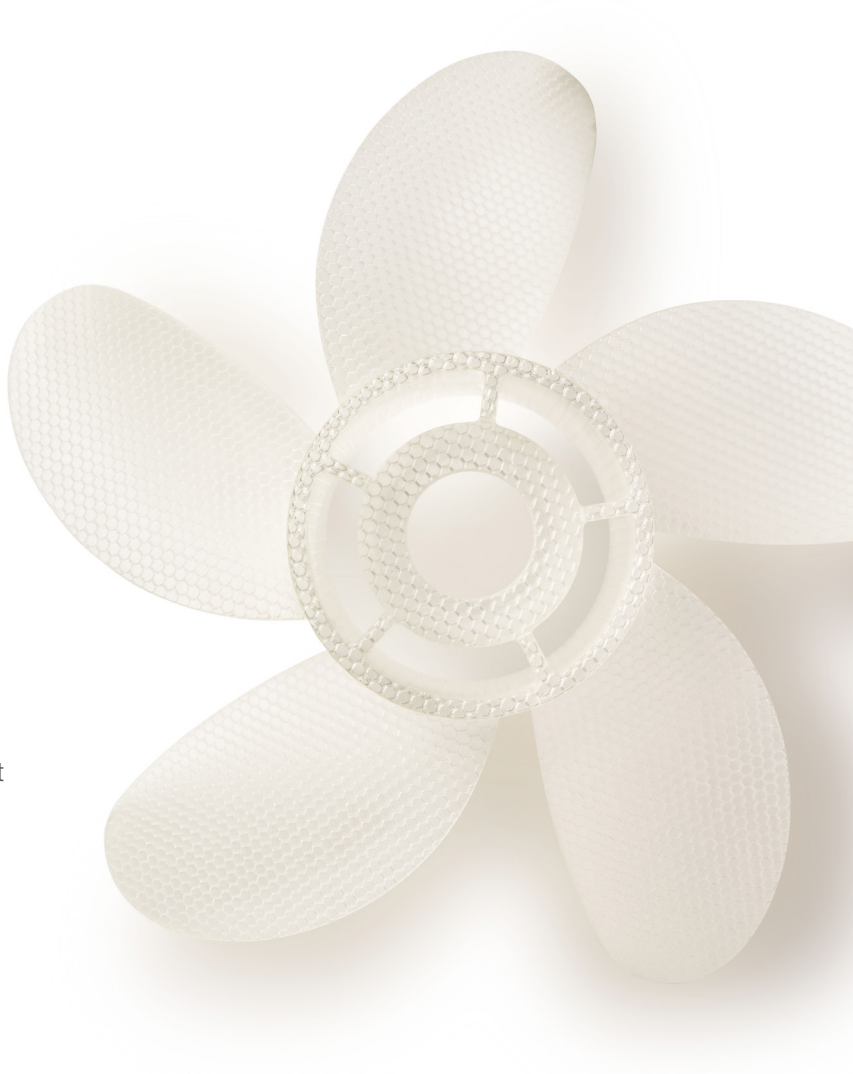
- Part cost
- Engineering charges
- Labor charges
- Expedite fees
- Shipping and handling charges
- Taxes

Advantages and efficiency gains that occur when outsourced work is brought in-house may also be included. Note, however, that the labor-oriented items are subject to challenge unless they result in staffing reductions or fewer new hires. If not directly included in the financial justification, reference them elsewhere in the business case since they are benefits of insourcing. Include labor estimates for:

- Engineering documentation and detailed drawings
- Solicitation of quotes
- Placing orders
- Creating purchase orders
- Managing accounts payable
- Managing the project
- Inspecting incoming parts
- Maintaining and protecting confidential information

If including the savings on in-house work that will be transitioned to the 3D printer, a cost estimate for these parts must be created. For large corporations, internal cross-charges make the calculations simple. Records of the inter-departmental charges document the expense of these parts. If cross-charges are not used, seek advice from the company's cost accountants. They will be able to devise a cost estimation methodology.

In a cost justification worksheet (Figure 1), enter the sum of these costs in the first-year column for return (value). For subsequent years, apply a multiplier to the first-year value that reflects anticipated changes to the volume of prototyping work. Note that this value does not reflect the net return since it excludes the cost of 3D printing the parts, which will be calculated in the expenditures section of the justification.



| | Year 0 | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 |
|---|---|---|---|---|---|---|
| Capital Equipment | (- -) | | | | | |
| Operating Expenses | (- -) | | | | | |
| Total Investment | (- -) | | | | | |
| Ongoing Expenses | | ($- -) | ($- -) | ($- -) | ($- -) | ($- -) |
| Return (Value) | | 75,000 | 75,000 | 75,000 | 75,000 | 75,000 |
| Total | (- -) | 75,000 | 75,000 | 75,000 | 75,000 | 75,000 |
| **Cumulative Total** | ($- -) | 75,000 | 150,000 | 225,000 | 300,000 | 375,000 |

Figure 1: Cost justification worksheet.

### Augmentation

If larger financial returns are needed to obtain approval of the CapEx proposal, move to the next tier of benefits from 3D printing. This category places a dollar amount on the inherent value of developing concept models, prototypes and tooling for the business operation. For Augmentation, the business case will show that 3D printing delivers more financial value.

For example, expanding the scope of prototyping work will include consideration of doing both more iterations of components that are currently prototyped, as identified in the previous tier, as well as enabling more components and products to be produced. The latter may be justified both by the speed or efficiency of 3D printing and the capability of making complex objects quickly.

For simplicity, use the categorization approach detailed in Substitution to document the candidates and the projected savings.

To move this added work from the expense column to a financial gain, determine the value of the work, from the decision maker's viewpoint. As noted in justification strategies, begin by attempting to link prototyping activity to an ongoing, top-of-mind problem within the organization. If unable to do so, select benefits that will resonate and can be quantified in financial terms.

Considering the volume increase of prototyping or tool production, calculate the anticipated annual return based on the identified values. Add this total to the value for Substitutions posted to the cost justification worksheet in Figure 1.

**Tooling: Volvo Trucks**

The Volvo truck is an ultra-reliable paradigm of automotive innovation that is built for the long haul. And like the truck itself, the tools used to build its engine need to be rugged, streamlined and efficient. To produce tough manufacturing and assembly tools in less time, Volvo Trucks now 3D prints many of them.

Within three months of purchasing its 3D printer, Volvo Trucks created more than 30 different production tools including a range of lightweight-yet-durable clamps, jigs and supports, and ergonomically-designed tool holders to organize their work environment.

"The fast and cost-effective nature of additive manufacturing means that we are far less restricted than we were even six months ago, allowing us to constantly improve our processes," said Jean-Marc Robin, Technical Manager at Volvo Trucks. "We now have operators approaching our 3D print team with individual requests to develop a custom clamp or support tool to assist with a specific production-line issue they might be having. From a time and cost perspective, this is unimaginable with traditional techniques.

Pierre Jenny, engine production manufacturing director estimates that the tools his plant previously machined in metal required 36 days to design and manufacture. Now in just two days, their 3D printer can make lighter tools and fixtures in production-grade ABS thermoplastic.

While most companies look upon their current production tooling as "good enough" Volvo decided to invest in 3D printing and produce more effective tools in 94% less time.

## Extension

The third tier, **Extension**, encompasses changes within existing processes. It is similar in concept to **Augmentation**, but it applies to the activities that are not being performed. With a change to the process, the financial benefits can be quite significant. However, it may also be more difficult to establish the financial value since there is no precedence.

When including Extension applications in a justification, look for opportunities enabled by the speed, cost, efficiency and flexibility of 3D printing. Essentially, these opportunities will be the applications that are impractical, or simply ignored, when limited to conventional manufacturing processes. In other words, seek the applications that can't be justified — due to time, cost or effort — if using machining or molding.

The opportunities to apply **Extension** span all activities where 3D printing offers a solution for existing problems. With this in mind, there are far too many examples to list.

However, they can be categorized in three buckets:

- Different phases of product development
  - For example, early concept models or late-stage manufacturing review prototypes.
- Different product or component types
  - For example, highly complex components or multi-piece assemblies that that are too costly when used as early form and fit prototypes.
- Different applications
  - For example, numerous tools that expedite production or more ergonomic,lightweight tools that reduce on-the-job injuries.

As with **Augmentation**, use the simplification approach of part-type categorization discussed in the **Substitution** tier and link the activity to problems that management seeks to overcome.

### Production Parts: China Eastern Airlines

China Eastern Airlines (CEA) operates a modernized fleet of over 600 aircraft. But there are times when replacement parts are needed sooner than the airline can get them from suppliers. To solve that problem engineers from the airline's maintenance division, Eastern Airlines Technic, set up a 3D printing lab to make the part instead of relying on the standard, slower and costlier supply chain.

Since its inception, the lab has successively produced and installed more than 300 finished parts, making CEA the first domestic airline to have 3D-printed interior parts in commercial planes. By 3D printing small batches, the company cuts lead times and cost of purchasing spare parts, while still ensuring safe, comfortable flights for passengers.

For example, newspaper holders on the back of cabin seats are easily damaged from frequent collisions with dining carts and broken parts can injure passengers. Since new part lead times are too long, the lab can design, 3D print and install new ones quickly while still meeting strict approval guidelines. By creating replacement parts in house, Eastern Airlines Technic can efficiently bridge the gap in the current supply chain system.

"In the past, if any cabin parts were broken, we had to buy new ones from designated suppliers — which could take up to three months. Sometimes there were no available parts at all," said Chen Zhiyi, Additive Manufacturing Lab R&D Engineer. The long lead times meant broken parts couldn't be fixed quickly, which downgraded passengers' flying experiences. "That's why we use 3D printing, it solves this problem in an efficient and innovative way,"said Zhiyi.

For just this one example, CEA reduced procurement time by 91% and cost by 48%.

## Step 2: Calculate the Total Expense

The investment component of a financial justification includes all expenses to acquire the equipment, get it up and running and get it operational. There are two expenditure categories: initial investment and ongoing expense.

For 3D printing, the initial investment is a straightforward calculation with easily defined expenses. The ongoing, annual expenses are a bit more difficult to calculate since they are dependent on how many parts and what type of parts are made.

For the initial investment, items to include are:

- System price
- Ancillary equipment and software costs
- Installation and training costs
- IT expenditures:
  - Networks, data storage and computers
- Facility modifications, if any:
  - Utilities, build-outs (for isolation), floor stabilization and door widening
- Shipping expense

Ongoing expenses may include:

- Maintenance contracts
- Routine maintenance costs
- Materials
- Other consumables:
  - Cleaning solutions, build platforms and sandpaper
- Labor:
  - Direct labor for machine operation, maintenance and part finishing
- Facility charges

In both categories of expenditures, include only the incremental costs for items such as labor, IT expenditures and facility charges. This is the difference between current expenses and those incurred after system acquisition. For example, if no employees will be added to support the 3D printing operation, there will be no labor costs listed even if direct labor will be needed.

To present an accurate assessment of the expenditures, the 3D printer vendor will supply much of the data, so a trusting business relationship is crucial. This is especially true for ongoing expenses. Without hands-on experience, it may not be possible to estimate build time, throughput, capacity utilization and material consumption to determine the operational expense.

To calculate these items, supply the vendor with information on the parts included in the value section of the justification. With a moderately detailed description of the parts — size, configuration and quantity — the vendor will be able to estimate the cost of materials and related operating expenses. Also, ask the vendor to estimate the total run time in order to confirm that the quantity of parts used in the justification does not exceed the 3D printer's capacity.

For the projected machine utilization, the vendor can also estimate the direct labor needed to prepare builds, operate the machine and post-process parts. As previously noted, include direct labor only if it is incremental increase. If the current staff can absorb the vendor-estimated increase in labor hours, exclude them from the cost justification.

Combine all elements of the initial investment and ongoing expense and enter them in the year one column in the cost justification worksheet (Figure 2). Do the same for years two through five, using the same multiplier that was applied to the annual returns for those years.

Beyond a breakdown by expense category, no other detail should be presented in the business case. However, it is vital to document all calculations, assumptions and detailed expenses for reference. There will be questions, so be prepared to answer them with supporting, well-documented data.

| | Year 0 | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 |
|---|---|---|---|---|---|---|
| Capital Equipment | 50,000 | | | | | |
| Operating Expenses | 5,000 | | | | | |
| Total Investment | 55,000 | | | | | |
| Ongoing Expenses | | $34,000 | $34,000 | $34,000 | $34,000 | $34,000 |
| Return (Value) | | $75,000 | $75,000 | $75,000 | $75,000 | $75,000 |
| Total | 55,000 | $41,000 | $41,000 | $41,000 | $41,000 | $41,000 |
| **Cumulative Total** | 55,000 | $14,000 | $27,000 | $68,000 | $109,000 | $150,000 |

Figure 2: Cost justification worksheet with investment, costs and returns.

## Step 3: Calculate the Return on Investment

The hard work is complete. The financial data that you have put together can be used to generate any company-desired metric that proves the value of the CapEx such as return on investment (ROI), payback period, net present value (NPV) or internal rate of return (IRR). Consult with your organization's finance department for the appropriate means to accomplish this.

# Time is Money

3D printing's greatest benefit is making individual parts fast, independent of design complexity. That speed enables the ability to quickly change the design and re-make the part if any revisions are necessary. Instead of waiting days or weeks for a CNC-machined part or tool, a 3D printer can make the part overnight. In a fast-paced, pressure-filled business environment, it is obvious that reducing delivery by days is extremely beneficial. This potential is what draws many to the technology, but time can be very hard to quantify in a financial justification.

One strategy to make the time-and-money connection is to consider past occurrences where missed deadlines resulted in added expense. For example, tabulate the expedite fees that have been paid when projects are at risk of being late or deadlines are accelerated. While the sum of these fees may not represent a significant portion of the 3D printer's purchase price, they will still serve as evidence that time has a very real monetary value.

Considering missed deadlines, what may be significant in terms of actual cost is the total expense of a late delivery caused by delays in product development. For example, if prototypes for a focus group are late, the company will have expenses for a session that never takes place.

Considering the investment in labor to organize the event, facilitator agreements, cancellation fees for the venue and all other commitments, the penalty can be quite large.

Extend missed deadlines out to product launches and the penalty can be enormous. If these types of events have happened in the recent past and have the possibility of reoccurring, they are painful reminders of the value of time, if not tangible measures for a financial justification.

The flipside of missed deadlines is accelerated processes, which may lead to productivity gains in product development or overall time-to-market reductions. The benefit of delivering faster can be the most difficult to quantify in a tangible way that is indisputable. If needed for the justification, the monetary value of a day saved must be determined and the decision makers must believe in the connection between 3D printing and the time saved.

If time cannot be translated to a monetary value, consider noting it in the business case as an added benefit on top of the financial rewards. Even if it cannot be monetized, it is a significant and unique advantage.


3D printing's greatest benefit is making individual parts fast, independent of design complexity.

# Conclusion

Justifying a 3D printer has been, and continues to be, a topic of high interest because of the struggle to prove its worth in terms of dollars and cents. There will be a time, in the not-so-distant future, when there is no longer a need to prove its value. A time when the question is no longer "does a purchase makes sense" but instead, "how many do we need." For now, the onus is to prove that the investment is worthwhile to those who make the financial decisions.

Each company's situation is different and that there isn't a single approach that works for all. In lieu of a formulaic approach, the strategies and guidelines that have worked for others will help to get an approval for purchase. The value of 3D printing is unquestionable. Use these insights to prove it.

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