WHITE PAPER

MAKING THE CASE:

How to Justify the Cost of a Rapid Prototyping System

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To designers, engineers and product managers, the value of additive manufacturing machines for rapid prototyping is unquestionable. Yet, in spite of the obvious value, it may not be clear how to convince the management and accounting departments that the benefits justify the capital expenditure.

The challenge is two-fold: 1) conveying the value in objective terms, 2) writing the business case in a style that executive management embraces and the finance department understands. To improve the odds of gaining approval, this white paper offers guidelines and tips for creating a compelling business case for the acquisition of additive manufacturing equipment for prototyping.

WHAT IS A BUSINESS 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 that the proposal may be one of many competing for limited funds allocated across the company. A business case is a tool that demonstrates the value of the proposed capex to management. Its goal is to validate a purchasing decision by transforming benefits into concrete, tangible returns.

A well-written business case shows that the capex proposal offers a great return with manageable risk. It becomes compelling when written with the approver in mind. Knowing the audience focuses the business case on the approver's "hot" issues, and it makes it simpler to include the "right" amount of information and detail.

Too much data can kill a capex proposal by making the business case unreadable or creating previously unconsidered objections. To make the business case with the least amount of detail possible, describe the advantages and financial gains in three parts:

1. Executive Summary
2. Situational Analysis
3. Financial Justification

EXECUTIVE SUMMARY

The executive summary holds the two most important paragraphs of the business case. If written well, half the battle has been won. The decision maker has been hooked and has begun to buy into the proposal. In some cases, the busy executive may read no further. Instead, he/she may approve the proposal with the contingency that support staff confirms the details.

If, on the other hand, the executive summary has been poorly written, the proposal may be flatly denied with no further investigation. The executive summary is that important.

A good executive summary must be succinct. Limit it to two paragraphs, each with two to three sentences. If longer, there is a risk of losing the attention of your audience.

▶ TIP

Long-term gains are advantageous but maintain focus on the more immediate results. Write the business case based on the short-term gains and reference the longer- term items as an "added value."

Use active voice and action words.

Write the business case to address the key corporate or departmental issues of the day (E.G., cost reduction, growth, globalization).

Avoid unsubstantiated claims that will put the business case in jeopardy.

If writing isn't your strong suit, consider having your draft reviewed by someone with good writing skills who can help make it more powerful and convincing.

In these two paragraphs, include a statement of the problem, the solution and the intended results. Be clear about the investment and the financial return, which will be stated in the company's preferred financial measure (such as ROI). While it may be beneficial to project the financial gains over a number of years, place more focus on the short-term gains, especially when economic conditions are poor.

Although the executive summary will be the first item that decision makers read, write it last. Because it summarizes the key points that follow in the situational analysis and financial justification, a strong executive summary can be crafted only after the business case has been fine-tuned.

SITUATIONAL ANALYSIS

The situation analysis documents four areas that influence the decision-making process:

- Current situation
- Proposed solution
- Alternatives investigated
- Risks

Like the executive summary, write the situational analysis concisely.

▶ TIP

Team up with the cost accountants to collect real, hard numbers. Rely on them for access to and an understanding of the financial data needed to make a compelling business case.

Current Situation

This is a statement of the aspects of the business that the additive manufacturing system will address once installed. In a sense, it is a "diagnosis" of a problem, and the proposed capex request is the recommended "treatment." Using concrete financial data as the foundation, state the current process and expose the associated problem or opportunity. In addition, note which departments/divisions the current situation impacts and who stands to gain from any improvement.

When describing the current situation, incorporate facts that have measurable financial components tied to them. However, do not go overboard or off on a tangent. Stick to the current challenge that is the basis for the financial justification. For example, if a reduction in prototype expense is the basis of the financial justification, omit details related to other benefits, such as sales revenue increases.

For example, do not state that sales revenue is down because of slow product introductions if the financial justification shows a reduction in overall prototype expenses.

▶ TIP

Avoid the phrase "3D printer" unless all are well-versed on the concept. Using it may trigger a review from IT.

Proposed Solution

Recommend the additive manufacturing system as the solution to the business

challenges. State the proposed solution—purchasing a system—and the measurable benefits that will result.

As long as the description of the solution remains on-topic and succinct, it is okay to reference the benefits that are difficult to quantify, such as speed. However, rather than basing the whole proposal on these benefits, use them as added-value items that the company will also realize.

▶ TIP

Use the intangible benefits to embellish the proposal during the proposal review meeting. E.G. "What doesn't show in the savings table is that prototype delivery time will be slashed by 80%."

A good practice is to state end results rather than the intermediate returns. For example, if a capex proposal would increase operational efficiency, in terms of labor hours, state how the time will translate into profit. Would it be used to decrease head count? Would it be used to increase departmental output? Get to the point and tell the decision-makers the bottom-line results.

The last item in this section is a statement of what the proposed solution will cost and how long it will take to get it operational. For the cost, use the up-front investment needed to start making parts.

▶ TIP

List time and speed as part of the solution, but use as a "given" advantage without having to resort to hard dollars in the financial return.

Alternatives

The purpose of this section is to show that a sound evaluation was conducted. By stating the primary alternatives that were considered, it shows that a reasonable investigation was performed.

It is tempting to list every alternative considered, but doing so will lead to unwelcome questions and objections. Rather than being comprehensive, state the most obvious alternatives. For each, follow up with a short statement of why it is an inferior option.

Risks

All capex proposals have some risk associated with them, so don't pretend that the additive manufacturing solution is risk-free. Instead, discuss the risks to show that they are manageable and that the investigation included consideration of all contingencies.

As with the alternatives, include the most obvious risks. Dispose of each with a short statement of the countermeasure should they occur. Then be prepared to field the questions from management regarding the risks not listed in your business case.

▶ FINANCIAL JUSTIFICATION

The core of the business case is the financial justification. It presents the anticipated return on the capex investment. There are two parts to the justification: 1) the capital expenditure and related expenses 2) the financial benefit. When combined, these items produce the

financial indicators that measure the value of the investment.

When building the financial justification, seek guidance from your finance department staff. They will assist you in selecting the proper performance measures—such as return on investment (ROI) or payback period. They can also provide assistance with data collection and calculation methods and offer guidance on items such as "hurdle" rates.

▶ TIP

Keep it simple. Try to use averages and high-level calculations wherever possible, both for expediency and to avoid getting bogged down in details.

The elements included in the financial justification will depend on many factors, so it is important to understand the decision-making process and the decision makers' concerns. For example, if the decision is made at the corporate level, shifting expenses from one business unit to another does not yield any net savings.

Ideally, the justification will show a large return for a small investment. This is the winning combination, but the process of getting to this combination may not be so simple. In fact, it is often best to include only what is necessary to show a compelling return. While it is tempting to boldly state that all prototypes companywide will be produced on the new additive manufacturing machine, making this claim may threaten other department heads, set unrealistically high expectations, or make the business case unbelievable.

To achieve a balance between compelling and realistic, fine-tune the numbers through several revisions. After each pass, review the return on investment. If it is too low, add more prototyping work. If unnecessarily high, remove items that create questions, or conflict.

Strategies: Higher Revenues vs. Lower Expenses

Current business conditions and the goals of the decision makers will dictate whether you should build the justification on increasing revenues or decreasing expenses. In most cases the strongest approach is to justify the purchase in terms of cost reductions. However, if your company is pursuing a major revenue growth initiative, showing returns in terms of increased sales revenues may be a wise option.

Also consider the measurability of the proposed returns. Calculations from hard, tangible numbers are easiest to sell. Yet, in most cases, a cost reduction proposal provides more of these measurable benefits. With few exceptions, the prime source of savings will be from bringing outsourced prototype, pattern and tool production in house. These savings are the starting point for a three-tiered approach to cost justification of an additive manufacturing system.

Value (Return)

The value is the financial gain that results from the capex before the investment expense and ongoing costs are subtracted. It is the gross profit potential for the company, division or department that results from expense reductions, revenue increases, or a combination of both.

Assuming that savings will take precedence and that the financial return demands hard numbers, an effective strategy is to try to justify the purchase based on replacing current prototyping processes with in-house additive manufacturing. This is tier one. If the return is not large enough, then proceed to tier-two and tier-three benefits.

Tier One – Replacing Existing Prototype Methods

Begin by collecting historical data for any models, prototypes, patterns and tools that are representative of the parts the new additive manufacturing system 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.

There are two sources of parts for the justification: outsourced parts from suppliers and those made in-house. For both sources, include not only additive manufactured parts but also those that are machined, molded, cast, formed and hand-fabricated. Collect data for all items that could be transitioned to the proposed additive manufacturing system. Parts produced in-house must not be ignored, but they should be included only after careful consideration of corporate dynamics, process ownership, and budgetary approval level.

Building from the historical data, project the additive manufacturing workload for the near term, which is typically one to five years. Estimate if the same or similar parts will require prototyping and pair that with corporate projections related to changes in R&D spending, rate of new product development and changes to product mix. This review provides a baseline of all potential part candidates.

To keep the cost justification relatively simple and somewhat high level, review the part 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 the additive manufacturing process. Finally, review the parts within each category to determine the percentage that will be run on the new additive manufacturing machine. This provides a gross estimate of the number of parts, their size and their volume. This data will be used to determine the savings potential as well as the cost to construct them on the new machine.

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

▶ TIP

If tight budgets are threatening the volume of prototyping, include the value of prototyping for those items that can be retained after an additive manufacturing system is installed.

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/handling charges
- Taxes

Optionally, advantages and efficiency gains that occur when outsourced work is brought in-house may 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 in-sourcing prototype development. Include time estimates for:

- Engineering documentation and detailed drawings
- Solicitation of quotes
- Placing orders
- Accounting:
  - Purchase orders
  - Accounts payable
- Project management:
  - Phone calls, emails and meetings
- Incoming inspection
- Maintaining and protecting confidential information

If including the savings on in-house work that will be transitioned to the additive manufacturing system, 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 cost accountants in the company. They will be able to devise a cost estimation methodology.

In a cost justification worksheet (see figure 1, next page), enter the sum of all of these costs in the first year column for return (value). Note that this value does not reflect the net "true" return since it excludes the cost of making the additive manufactured parts, which will be calculated in the expenditures section of the justification. Unless there are corporate projections that would lead to year-to-year increases (or decreases) in prototype consumption, keep the justification simple by using the same financial return for years two through five.

INITIAL INVESTMENT:	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
Capital equipment	(- -)					
Operating expense	(- -)					
Total Investment	(- -)					
ON-GOING 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	275,000	350,000

Figure 1: Cost Justification Worksheet

Tier Two – Increasing Prototyping Activity

If larger financial returns are needed to obtain approval of the capex proposal, move to the next area of benefits that additive manufacturing offers. This tier places a dollar amount on the inherent value of developing concept models, prototypes and prototype tooling. Using machine capacity that remains after tier one parts are produced, the business case will show that additive manufacturing enables the production of more models, prototypes and tools.

It is readily accepted that additive manufacturing promotes the creation of more prototypes in more stages of the product development process. The speed, efficiency and capability of the process remove the barriers of time, cost and effort when making prototypes. So additive manufacturing makes it easy and practical to produce more prototypes. This is a defensible position. The challenge is calculating a measurable value that results from the prototypes.

The strategy for tier-two benefits is to leverage what corporate management has already accepted as fact. Use any acknowledged values of prototyping in the calculation of return from the additive manufacturing machine. For example, if a rule-of-thumb exists for a ratio of prototyping investment to money saved from error avoidance, use it in the justification. Another option is to build from recent situations that had direct, measurable impact in financial terms. If it is a reoccurring situation, use this data to validate the estimates. For example, if an expensive injection mold was reworked because of a problem that a prototype would have exposed, use the estimated cost, and lost time, for rework as a basis for value calculations.

Figure 2 (next page) presents common benefits of prototyping that are candidates for tier two of the justification. Use the list to start the brainstorming process to find areas of value that management can appreciate and will accept. If a dollar amount is associated, include the value in the justification. If not, exclude it from any calculations. However, if the excluded benefit has a lot of impact, consider referencing it as an additional,

TIER–TWO RETURNS: VALUE OF PROTOTYPES

EXPENSE REDUCTION

- Early error detection
- Less tooling rework
- Fewer engineering change orders (ECOs)
- Avoid product launch delays
- Avoid expediting expenses
- Eliminate/decrease prototype tooling costs
- Reduce manufacturing costs
- Improve quality
  - Decrease returns, warranty claims
- Faster problem diagnosis

INCOME (SALES INCREASE)

- Time-to-market reduction
  - Increased sales
  - Increased market share
- Improved product appeal
- Improved product quality
- More product launches
- More frequent product improvements

Figure 2

but unquantified, benefit of additive manufacturing that sweetens the deal.

Armed with the justifiable benefits, review current and proposed product development programs for candidate parts. As with tier one, keep the information at a high level and use gross averages for each category of parts. Apply the value of prototyping to the additive manufactured parts and add it to the tier-one savings in the return row of the cost justification worksheet.

Tier Three – Prototyping Rapidly

Additive manufacturing's greatest benefit is making things fast. Instead of waiting days for a CNC-machined prototype, an additive manufacturing system 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 cost justification.

While it is advisable to stress the time advantage, exclude it from the financial justification and include it in the situational analysis. Use the speed advantage as the item that puts a financially justified proposal over the top. Show a significant financial return that concludes with a statement that the company will achieve the stated savings while decreasing cycle time for prototypes, product development and product launch.

Another strategy, if tiers one and two do not provide enough value, is to locate operations that are the final stages of a process and are subject to frequent delays. These final operations often have to absorb the delays of previous operations, and therefore, may be held accountable for delays in moving to beta testing, pilot operations or product launch. If additive manufacturing can prevent the delay in this operation, there will be an link between it and a timely launch of the next manufacturing phase. Usually, the delay

has a measurable financial component that can then be used in the cost justification.

Initial Investment and Ongoing Expenses

The investment component of a financial justification includes all of the expenses to acquire the equipment, get it up and running, and to operate it. There are two expenditure categories: initial investment and ongoing expense. For additive manufacturing, the initial investment is a straightforward calculation with easily defined expenses. The ongoing, or annual expenses, are a bit more difficult to calculate since they are dependent on how many parts are made.

For the initial investment, items to include are:

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

Ongoing expenses may include:

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

▶ TIP

Do the homework. Some of the necessary equipment to build and post process parts may not be apparent.

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, there will be no labor costs listed even if direct labor will be needed.

To present an accurate assessment of the expenditures, the additive manufacturing 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 is impossible 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 parts used in the justification do not exceed the additive manufacturing machine'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 noted, include direct labor only if it is incremental. So, if the current staff can absorb the vendor-estimated increase in labor hours, exclude them from the cost justification.

Combine all elements of ongoing expense and enter them in the year one column in the cost justification worksheet's on-going expenses section (figure 3, next page). Do the same for years two through five, using the same, if any, 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 to keep it concise. 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.

Return on Investment (ROI)

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. Simply enter the financial data in the equations for return on investment (ROI), payback period, net present value (NPV) or internal rate of return (IRR). Calculate the results for the appropriate measures, note them on the financial worksheet, reference them in the situational analysis and stress them on the executive summary (figure 4, next page).

▶ TIP

The goal is a short payback period or a high return. While each company is different, an annualized ROI greater than 12% and a payback period of less than 18 months are often desirable.

With this approach, additive manufacturing's value is connected to financial gain, which gives management objective data in the favored language of profit and loss.

▶ TIP

Capex budgets are limited. Some approval processes simply sort all capex proposals by descending rate of return. The proposals are then funded, highest return to lowest, until the budget is exhausted.

Try to keep the information at as high a level as possible.

CONCLUSION

A high return on investment and a solid executive summary can lead to the approval of a capex proposal for an additive manufacturing system. That is the power of crafting a business case that uses the information, methods, issues and language that is relevant to the decision makers.

While the benefits of additive manufacturing are obvious to the team

INITIAL INVESTMENT:	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
Capital equipment	($90,000)					
Operating expense	($15,000)					
Total Investment	($105,000)					
ON-GOING EXPENSES		($34,000)	($34,000)	($34,000)	($34,000)	($34,000)
RETURN (VALUE)		$75,000	$75,000	$75,000	$75,000	$75,000
TOTAL	($105,000)	$41,000	$41,000	$41,000	$41,000	$41,000
CUMULATIVE TOTAL	($105,000)	($64,000)	($23,000)	$18,000	$59,000	$100,000

Figure 3: Cost Justification Worksheet

that is making the proposal, it is their responsibility to express that advantage in terms that are understood, appreciated and welcomed by those who control the distribution of funds from the capital expenditures budget. Compiling a defensible, clear and concise justification gives the business case the edge needed to get an agreement to invest in an additive manufacturing system.

ANALYSIS SUMMARY

INTERNAL RATE OF RETURN (IRR)	27%
RETURN ON INVESTMENT (ROI) (5 year)	95%
Simple annual ROI	19%
NET PRESENT VALUE	
Assumed Cost of Capital	15%
Present Value of Cash Flows	$32,400
PAYBACK PERIOD	31 months

Figure 4

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