COLIBRIUM ADDITIVE
A GE Aerospace Company

Building the Business Case:

Identifying Criteria to Measure ROI for Additive Manufacturing

A faster return on investment (ROI) starts with a business plan.

No longer a newcomer to the industry, metal additive manufacturing (AM) is a growing technology that gives companies a competitive advantage and a positive ROI. With lower barriers to entry than ever before, including reduced costs and an increasingly skilled workforce, more industries can adopt proven processes and begin to map out a plan for how additive can improve their business.

To realize your additive advantage and ensure your investment pays off, you must first build a comprehensive business case.

"The business case isn't in a part-to-part comparison; it needs to be justified through system-wide impact."[1]
– Francois Gingras, Director of Industrial Equipment at CRIQ

For metal additive, getting to ROI is more than just assessing the cost of the part.

Manufacturers must look at how additive can impact the whole system—from part cost to product performance improvements to supply chain impact to new revenue streams. If manufacturers look only at the cost to make a part, they lose out on the larger ROI and potential new business opportunities additive can enable while competitors forge ahead.

The four steps to creating an AM business case:

Step 1

Build a Cost Model

How can additive technologies reduce the initial part cost?

Step 2

Evaluate Performance Factors

How will additive impact product life and life cycle costs?

Step 3

Identify Supply Chain Disruption

How will additive streamline my manufacturing processes and overcome existing pain points within the business?

Step 4

Determine the ROI

Based on my business goals and in-depth ROI analysis, does additive make sense for me?

Step

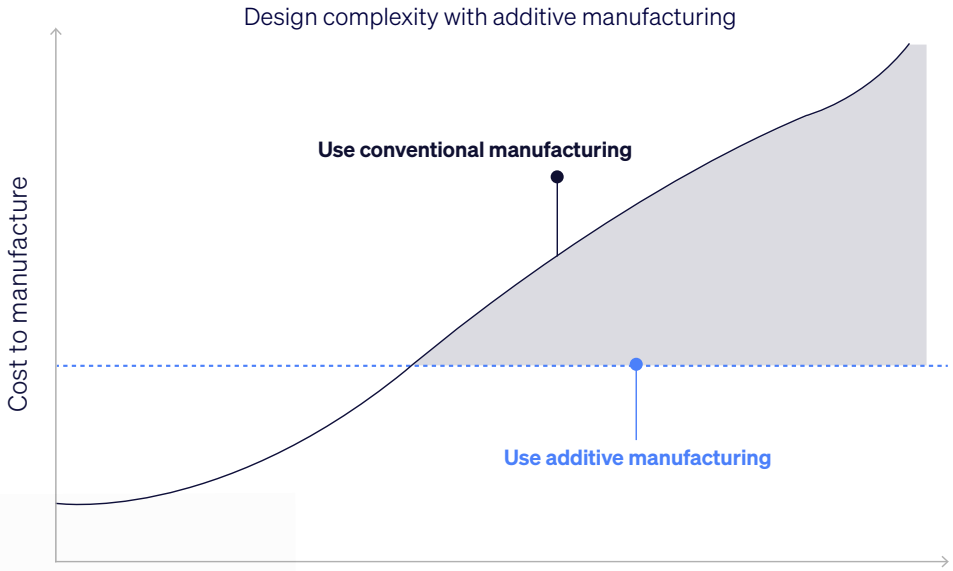
1

Build a Cost Model

A cost model can include several things, like tooling, infrastructure and the final component. These factors alone do not constitute a business case but are a key area to assess as you develop your business case.

The first major step is choosing a part for additive. The best part for the greatest or fastest ROI isn't always the costliest or most difficult to manufacture. Costs influence decisions throughout the design process, from requirements to conceptual design, process selection and designing for producibility.

How to select possible parts for additive



With conventional manufacturing, as the degree of complexity increases, the cost to manufacture also increases. Additive manufacturing eliminates this factor, so design innovation is essentially free.

When creating the list of possible parts where additive may make sense, manufacturers need to consider the design freedom additive offers. Design freedom enables you to think outside what is possible with conventional manufacturing. Evaluate multiple parts for their level of complexity (use the chart above as your guide) and assess which ones deliver the best ROI from design freedom, less labor and more efficient use of materials.

Factors to look for when considering parts for additive:

- Complex castings and geometries
- High-labor parts
- Fabricated assemblies
- Durability improvements
- Part consolidations
- Weight reductions
- Performance improvements
- Part obsolescence
- Customization
- Low-volume parts

Save on part costs throughout the process.

For each part you consider for additive, analyze all the associated expenses that come with manufacturing that part. Look for opportunities, or challenges, for an ROI.

Material costs	Raw material costs of a single component + support structures + unused powder not consumed after the reuse limit + scrap parts	• How does this material cost compare to conventional manufacturing methods? • Determine the type of metal powder needed for that component • How much waste—solid or powder—does the process create?
Labor costs	Cost of people's touch time on a part and may include associated overhead; higher labor costs = more expensive final product	• Load build chamber with powder • Prepare the file to print • Inspect and clean optics and build chamber • Remove part from platform and platform from machine • Conduct filter maintenance • Inspect and test machines and powders • Program the machine
Capital expenses	The plant and equipment expenses allocated to each part over a period, which can be depreciated over time or leased, and may include associated overhead	• Additive, thermal processes and inspection equipment • Support equipment such as powder removal, sieving and hoists • Facilities for the machines and additive production • Power backup systems
Operating expenses	Expenses for the day-to-day maintenance and operation of the plant and equipment, as well as machine and process consumables	• Laser/scanner repair and replacement • Recoater arm inspection/replacement • Inert gas usage • Filter and tooling maintenance • Personal protective equipment (PPE) • Electricity • Build plates
Processing costs	Iterative process that is continuously refined and considered at the system, component and feature level; a data-driven approach	• Feature resolution • Surface finish • Powder removal • Build size and speed • Number of parts per build • Post-processing requirements
Test and inspection costs	Costs associated with inspecting additive parts for performance, dimensional and geometric specifications, among other qualities	• Functional testing (pressure, flow, etc.) • Non-destructive inspections (e.g., visual, X-ray and CT scans) • Destructive testing (e.g., cut-ups)

Step 2

Evaluate Performance Factors

Performance factors quantify the system-level benefits or impact of the product in terms of their life cycle costs.

With enhanced performance factors, metal additive delivers end results that traditional manufacturing cannot. Today, manufacturers are leveraging additive to optimize their parts and products, from improved cooling performance to patient-specific implant designs.

"Additive manufacturing makes it possible to produce geometries that cannot be achieved using traditional manufacturing methods. In addition, the parts have greater performance capacity or functional precision."[2]
– Alex Berry, Director and Shareholder at Sutrue Ltd.

Once again, businesses need to evaluate the ROI of potential components for additive from many perspectives—whether that's reflected in improved parts and extended product lifetimes, or costs saved with lighter, more complex and more durable parts.

Performance factors across industries

The following is a partial list of performance factors that may pertain to your overall business plan assessment.

- Freedom of design
- Enhanced bone ingrowth in orthopedics
- Reduced risk of delamination of trabecular structures
- Weight reduction
- Increased fuel economy
- Improved efficiencies
- Enhanced reliability
- Less warpage due to faster cooling time
- Improved sustainability

How companies are improving part performance with additive

Avio Aero improves sustainability of turbine engine blades.

10% lower fuel consumption and decreased emissions3

4WEB Medical leverages freedom of design for spinal implants.

75% of implants filled with graft material for maximal bone incorporation4

Gplast reduced warpage of music system part with faster cooling time.

From: 12% parts rejected To: 3% parts rejected with additive5

Step

3

Identify Supply Chain Disruption

Supply chain disruption identifies and quantifies strategies to overcome existing pain points within the business.

Supply chains add to process steps and the number of human touches a product goes through from start to finish; this complexity is becoming unnecessary and outdated for some situations. Moreover, your supply chain comes with its own set of challenges, like time and expense to create and manage purchase orders, long lead times and high-cost customization—not to mention recurring expenses, like leased equipment and indirect materials.

With additive, manufacturers can streamline the supply chain and optimize the process to make a part by solving current market challenges at a lower cost to manufacturers.

How much does an average purchase order (PO) cost to fulfill?[6]

$59 (low costs in some industries)
$217 (average across industries)
$741 (high costs in some industries)

PO costs increase for each additional supplier required to create one part. More suppliers equals more labor costs, manufacturing sources, inspection costs and repair sources.

Supply chain optimization across industries

The following is a partial list of performance factors that may pertain to your overall business plan assessment.

- Serial production of mixed designs and sizes
- Part consolidation
- Inventory reduction
- Waste reduction
- Freight savings
- Purchase order reduction
- Streamlined supplier base
- In-housing of tooling operations
- Reduced workflow
- Lead-time reduction
- Maintenance, repair and overhaul (MRO) improvements
- Single source

Case study: Mid Frame Super Structure

Supply chain optimization with additive

Take a look at how additive simplified the supply chain and overall process for GE Aviation's Mid Frame Super Structure.7

Conventional Manufacturing	Additive Manufacturing
Part(s): 300	1
Engineers: 60	6–8
Manufacturing source(s): 50+	1
Data system(s): 40	1
Repair source(s): 5	1

Step

4

Determine the ROI

All your research and cost assessments come together in this final step in building the business case: finding your ROI and path toward production.

Pull together:

- The analysis completed for the cost model
- Performance factors
- Supply chain optimization

Once you have everything laid out in front of you, confirm your business challenge, opportunity or industry obstacle you hope to solve with additive. The sum of the above is the ROI for each of your selected applications.

Based on the ROI for each application, provide recommendations to your management team as to which part(s) to choose for additive. Use a checklist like the one at the end of this playbook to help you build your case.

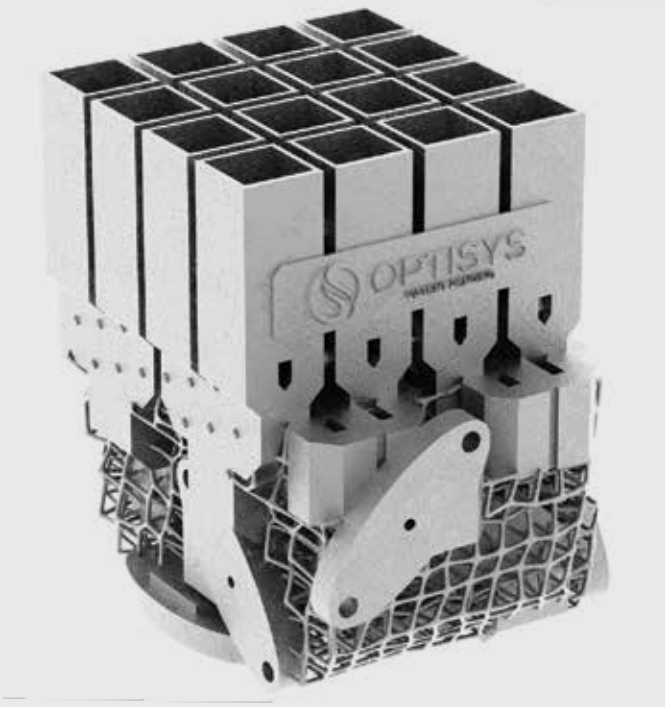
Tips for evaluating part costs

Develop an assessment spreadsheet in which you analyze 8 to 15 products for additive. Using your internal ranking system, evaluate the production modalities and costs associated with each part. Choose up to three of these as potential candidates for additive.

Case study: How much further did additive take Optisys?[8]

Business objective: Capture new revenue streams by creating a superior antenna that operates up to a 90-GHz frequency band.

Market obstacle: Traditional antenna manufacturing consists of complex systems that are large and heavy, which can lead to higher launch costs and inconsistent radio frequency (RF) performance at higher frequency bands.



Results:

Cost model:

- Optisys breaks even on machine acquisition just one year after purchasing its first metal additive machine
- 75% reduction in non-recurring costs

Performance factors:

- 95% weight reduction
- 80% size reduction

Supply chain disruption:

- 100 parts with subtractive manufacturing to 1 part with additive
- Lead-time reduction: 11 months to 2 months

Business opportunities:

- Increase in sales: 30+ signed commercial contracts with $34M in submitted proposals
- 2 patents awarded, with 10 provisional patents submitted and 20+ additional patents in preparation
- New market expansion: 5 product lines designed for AM

"Its easy to add features to an existing AM design, easier to assemble the finished components and, long-term, you have less testing, maintenance, and service when you have fewer parts."[8]
– Rob Smith, COO at Optisys

Checklist: Build Your Additive Business Case

The goal of writing your business plan is twofold: Choose parts for additive and assess if additive is going to give you a true ROI.

As you move forward, you can use the following checklist to ensure you factor in all the key criteria of your analysis.

Step 1

Build a Cost Model

Identify possible parts for additive consideration and gather information for each part based on the following:

Material costs	• How does this material cost compare to conventional manufacturing methods? • Determine the type of metal powder needed for a specific component • How much waste—solid or powder—does the process create? • Consider costs savings for reusing unsintered powder
Labor costs	• Prepare the file to print • Inspect and clean optics and build chamber • Remove part from platform • Remove platform from machine • Conduct filter maintenance • Inspect and test machines and powders • Program the machine
Capital expenses	• Additive, thermal processes and inspection equipment • Support equipment, like powder removal, sieving and hoists • Facilities for the machines and additive production • Power backup systems
Operating expenses	• Laser/scanner repair and replacement • Recoater arm inspection/replacement • Inert gas usage • Filter and tooling maintenance • Personal protective equipment (PPE) • Electricity • Build plates
Processing costs	• Feature resolution • Surface finish • Powder removal • Build size and speed • Number of parts per build • Post-processing requirements
Test and inspection costs	• Tensile and functional testing (pressure, flow, etc.) • Non-destructive inspections (e.g., visual, X-ray and CT scans) • Destructive testing (e.g., cut-ups)

Step 2

Evaluate Performance Factors

How will additive impact product life and life cycle costs? Use the factors that apply to your business. Add others if needed.

- Freedom of design
- Weight reduction
- Improved fuel economy
- Improved efficiencies
- Enhanced reliability
- Less warpage due to faster cooling time
- Enhanced part performance
- Improved sustainability
- Supportive of body mechanics in orthopedics
- Serial production and mixed designs and sizes
- Reduced risk of delamination of trabecular structures

Step 3

Identify Supply Chain Disruption

How will additive streamline your manufacturing processes and overcome existing pain points within the business? Use the factors that apply to your business. Add others if needed.

- Part consolidation
- Inventory reduction
- Streamlined supply chain
- Waste reduction
- Freight savings
- Purchase order reduction
- Streamlined supply base
- In-housing of tooling operations
- Reduced workflow
- Lead-time reduction
- Maintenance, repair and overhaul (MRO) improvements

Step 4

Determine the ROI

Based on your business goals and in-depth cost, performance and supply chain data you gathered, run a final ROI analysis using a spreadsheet and data for your company. Does additive make sense for this business case?

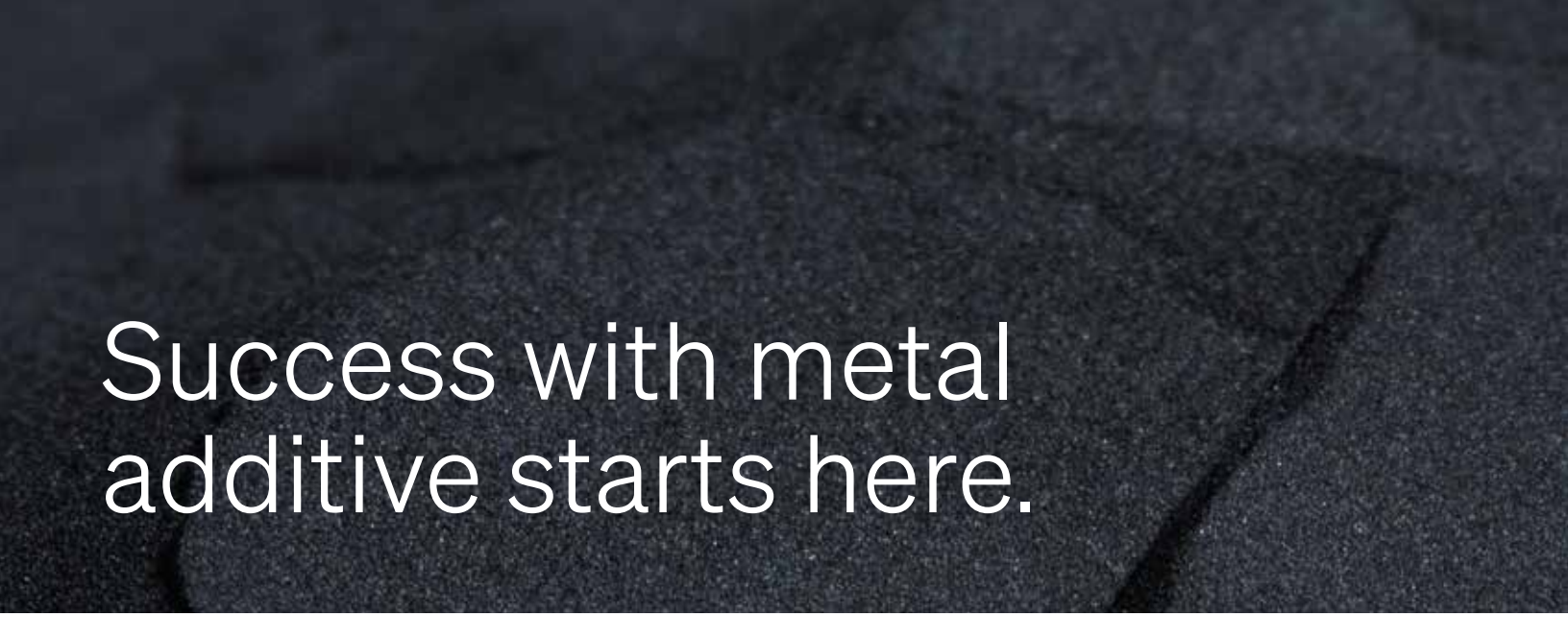
- Freedom of design
- Pull together the analysis completed for steps 1–3
- Conduct an ROI analysis to include these elements: part cost, process cost and supply chain impact
- System redesign/AM adoption factors
- Rank the parts for additive based on ROI

After the Business Case Development

Once you draft the business plan, you need to create a presentation and sell your plan to senior management. A typical plan includes the following areas:

- Business objectives
- Market obstacles
- Cost analysis (part, process, performance factors and supply chain)
- Recommendation*

*In some cases, you might not find a business case for additive, which is a good reason to write a business case before starting down the additive path.



Success with metal additive starts here.

Writing an additive business case helps ensure that the investments you want to make are positioned to result in a business advantage and a higher return on investment. However, for a business plan to succeed, a strong representative cost analysis is critical.

Today, the ready are conducting a cost analysis, evaluating performance factors, identifying supply chain disruptions and calculating the ROI of additive. They are charging forward with additive technology, disrupting the market and shaping the future of manufacturing.

The additive technology is ready. Are you?
To streamline your path to additive success even further, we've included a checklist on pages 9-10 for building your business case.

When you're ready to realize your additive advantage, we'll be there to help.
As market leaders in additive technology, Colibrium Additive is here to help you discover your ROI potential. We've walked this path and have helped other manufacturers build their business cases so they could move to production—faster.

Build a successful business case with us.
colibriumadditive.com

1 Quebec's CRIQ selects Colibrium Additive Arcam EBM, https://www.ge.com/additive/stories/quebecs-criq-selects-ge-additive-arcam-ebm (accessed June 3, 2020).
2 The additive journey: The Time Is Now, Industry in 3D (accessed June 1, 2020).
3 Colibrium Additive Production Playbook, November 2019 (accessed June 11, 2020).
4 Colibrium Additive, "Orthopedic_Precision_Targeting_GE_Additive_External," (accessed June 11, 2020).
5 Gplast, 3D Cooling/Additive Manufacturing, http://www.gplast.com/3d-cooling-or-additive-manufacturing.php (accessed June 11, 2020).
6 Inside Supply Management Weekly, The Monthly Metric: Average Purchase Order Processing Cost, http://ismmagazine.org/the-monthly-metric-average-purchase-order-processing-cost/ (accessed June 11, 2020).
7 Colibrium Additive, "Aerospace_v19," (accessed June 9, 2020).
8 The additive journey: The Time Is Now, Industry in 3D (accessed June 11, 2020).