Economic Analysis

Team Downey

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1. **Introduction**:

Economic analyses are necessary for projects that will be used for both profit and non-profit purposes. The nature of this project is primarily research-based with almost no startup cost and a heavy emphasis on being available to the general public at no cost. Because of this unique situation, a hypothetical economic analysis will be performed with the revenue and lifespan of the product as if it would be used for profit. The estimations that are being used for this analysis have been either researched using similar products or discussed with the project sponsor. This economic analysis will consider the initial start-up costs, the labor from the technician operating the system, the cost for maintenance, and the demand and revenue of the project if being sold for profit.

**2. Costs, Savings, and Revenues:**

*2.1 Summary of costs, both up-front and recurring*

1. All materials that will be needed to run the product are listed below [Table 1]. This does not include the SLM printer or sliding aluminum cover since both are outside the scope of this project. These materials make up the majority of the cost to build a unit.

Table 1:Bill of Materials

|  |  |  |
| --- | --- | --- |
| Part | Qty | Price ($) |
| ThinkPad X1 Extreme | 1 | 4,077.98 |
| Ender 3 3D printer | 1 | 251.99 |
| PLA | 1 spool | 22.99 |
| Simulink software license | 1 year | 1,300.00 |
| MATLAB software license | 1 year | 880.00 |
| Camera FLIR blacklfy USB | 1 | 1,887.00 |
| Bandpass filter | 1 | 67.50 |
| O-ring silicone | 1 | 7.92 |
| Speed goat controller | 1 | 9000.00 |
| Machine screws | 4 | 8.00 |
| Total |  | $17,503.40 |

1. Client time:
   1. Sponsor -1.5 hrs per week x 30 weeks at $83.00 per hr [1]
   2. Consulting Engineer/Technician - 1.5 hrs per week x 30 weeks at $50.00 per hr. [2]
2. Recurring costs:
   1. Maintenance:
      1. MATLAB yearly license renewal fees - $880.00 [3]
      2. Simulink yearly license renewal fees - $1,300.00 [3]
   2. Utilities or non-reusable materials- No use of power that was previously done manually or expendable materials that weren’t previously needed. Total cost is listed in Table 2.

Table 2: Upfront and Repeating Costs

|  |  |  |  |
| --- | --- | --- | --- |
|  | Cost | Time | Total |
| Sponsor | $83.00 | x 1.5 hrs x 30 wks | $3,735.00 |
| CE/Technician | $50.00 | x 1.5 hrs x 30 wks | $2,250.00 |
| MATLAB | $880.00 | x 5 yrs | $4,400.00 |
| Simulink | $1,300 | x 5 yrs | $6,500.00 |
| Total |  |  | $16,885.00 |

*2.2 Summary of savings*

1. Savings on labor:
   1. Technician manually track melting splatter- $66,000 per yr [4]
   2. Technician manually measure and document melting splatter dimensions and brightness frame by frame- $66,000 per yr [4]
2. Output increase:
   1. Increased output due to accelerated fault detection capability- It would be impossible to determine how much the output would increase because the size and complexity of the part being printed could vary significantly.
3. Maintenance cost savings:
   1. Since the vision system would have no effect on the SLM printer directly, there would not be any maintenance cost savings.
4. Production cost savings:
   1. Although there would be production cost saving, it is impossible to determine due to the variety of parts that could be printed. Total savings are listed in Table3.

Table 3: Product benefits

|  |  |  |  |
| --- | --- | --- | --- |
|  | Savings | Time | Total |
| Melting splatter tracker | $66,000.00 | x 5 yrs | $330,000.00 |
| Melting splatter measurer | $66,000.00 | x 5 yrs | $330,000.00 |
| Total Savings |  |  | $660,00.00 |

**3. Analysis:**

*3.1* Cash Flow Diagram:

A cash flow diagram can be used to visualize the incoming and outgoing cash throughout the project’s life. Below in Figure 1 it is shown how this project will have an incoming flow of cash after its first year on the market. In order to analyze the products cash flow further the net product can be found by establishing the revenue, operating costs, gross margin, annual depreciation charge, taxable income, income tax, and net income after taxes [Table 4.]. The depreciation charge can be calculated using the equation 1.

Equation 1

Calendar

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Figure 1: Cash flow diagram

Table 4: Annual cash flow with taxes

|  |  |
| --- | --- |
| Revenue (1 year) | $200,000.00 |
| Operating costs | $44,006 |
| Gross Margin | $155,994 |
| Annual Depreciation charge | $4,382.00 |
| Taxable income | $151,612 |
| Income tax (39%) | $59,129 |
| Net income after taxes | $92,483 |
| Net cash flow (after taxes) | $96,865 |

*3.2 Break-even analysis:*

In order know the point at which the product will start being profitable, a break-even analysis is performed [Table 5]. This project will break even after its first unit is sold which is ideal for a solid business plan. The formula to find the break-even point is below in equation 2.

Equation 2

Table 5: Break even analysis

|  |  |
| --- | --- |
| Break Even Analysis | |
| Startup Costs | $24,253.40 |
| Sale Price Per Unit | $100,000 |
| Units/Year | 2 |
| Profit/Unit | $77,997 |
| Profit Margin | 78% |
| Units to break even | 1 |
| Days to break even | 180 |
| Profit/Year (before taxes) | $155,994 |

A more visual representation can be seen in graph form [Figure 2] where the grey line represents the total cost over 5 years, the orange line represents cash inflow, and the vertical blue line represents the break-even point which is where the total cost and revenue intersect.

Figure 2: Break-even point graph

*3.3 Profitability analysis*

To gauge the profitability of a project and the potential return expected, it’s important to find the net present value (NPV) or the internal rate of return (IRR). This project’s NPV was analyzed using equation 3 below.

Equation 3

Rt is the net cash flow, *t* is time of cash flow and *i* is the discount rate. For this analysis the discount rate is assumed to be 10%. This gave a total NPV of $342,942 [Table 6]. The IRR can be found using equation 4.

Equation 4

Here the NPV is set to zero and the IRR is calculated. This can be difficult to do manually and is simplified by using the IRR Excel function which is what was done to find the IRR in Table 7. However, it is noted that value given from Excel, 199%, is quite large and this could be due to the large profit margin.

Table 6: Net present value analysis

|  |  |  |
| --- | --- | --- |
| Net Present Value |  |  |
|  | Project Time (years) | 5 |
|  | Discount Rate: | 10% |
| Year | Present Value |  |
| 0 | $-24,253 |  |
| 1 | $88,059 |  |
| 2 | $80,054 |  |
| 3 | $72,776 |  |
| 4 | $66,160 |  |
| 5 | $60,146 |  |
| Total Net Present Value (NPW): | $342,942 |  |

Table 7: Internal rate of return

|  |  |
| --- | --- |
| Project Time (years) | 5 |
| Internal Rate of Return | 199% |

**4. Summary:**

*4.1 Cost and Profitability*

With an estimated revenue of $100,000 per unit sold and two units sold per year by Dr. Downey, the cost of our product, $24,253.40, will be covered fully within the first purchase and be profitable ever year afterwards. It is marketable with projected savings of customers being over half a million dollars per year in labor alone and is one of the first systems available for monitoring metal 3D printing. Every year, there is an estimated profit of around $155,994 for our project sponsor. In the span of five years, the net present worth of the project will be $342,942.

*4.2 Additional Benefits*

In terms of impact on the market, this is one of the first computer vision systems for metal 3D printing. It will improve the output of metal additive manufacturing by allowing operators to view and stop a print if defects are detected before wasting more time and material continuing a defective print. Eventually, it will be used for real time control of the metal 3D printing process to prevent and avoid defects via a digital twin setup which will make the process more robust, making it a better option for manufacturers. This will allow for new geometries to be implemented that subtractive manufacturing is unable to handle with a similar quality and reliability. Furthermore, with a more robust process, ASME can recognize it and implement standards for those seeking to use it. An example of this would be for heat exchangers in pressure vessels like boiler systems. By having new geometry options, new advances can be made to transfer the heat. This also would apply to computer chips as well. Include discussion of any intangible or less-quantifiable benefits

Computer vision as a means of real time correction will be a major industry overhaul during Industry 4.0. Reducing waste, increasing consistency or quality, and adapting to the manufacturing process are all important to making the best product. 3D printing, in particular metal 3D printing, is plagued with minor inconsistencies which can range from minor visual blobs to internal void defects that severely weaken the materials compared to a wrought metal. The benefit of our project is many folds. First, it will be used in a digital twin setup for U of SC for a PhD Student enhancing his education with an innovative concept that is in its infancy in now. Additionally, it will spawn multiple papers regarding machine learning and additive manufacturing bolstering the reputation of U of SC. It will also be made as an open-source solution allowing us, Team Downey, to carry and show our challenging work going into industry to set us apart from our peers in job interview.

**5. References:**

1. <https://www.glassdoor.com/Salaries/professor-salary-SRCH_KO0,9.htm>
2. <https://www.glassdoor.com/Salaries/engineering-consultant-salary-SRCH_KO0,22.htm>
3. <https://www.mathworks.com/pricing-licensing.html>
4. <https://www.glassdoor.com/Salaries/laboratory-technician-salary-SRCH_KO0,21.htm>

**6. Appendix**

1. Calculations of break-even analysis:

Table

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1. Calculations for depreciation:

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