ISE 195B

Pod Car LifeCycle Cost

SAN JOSÉ STATE
UNIVERSITY

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Table Of Content

Table Of Figures

Table Of Tables

1.0 Abstract

Spartan Superway is working to develop a cost system for its personal rapid transit (PRT) system. In this project, the team benchmarked the costs by looking onto different similar automated vehicles projects. The team then gathered the data and started estimating the cost of construction by estimating the cost per pod car. The team concluded that it will cost $1,648,200 annually for Spartan Superway to construct a pod car.

2.0 Executive Summary: Findings

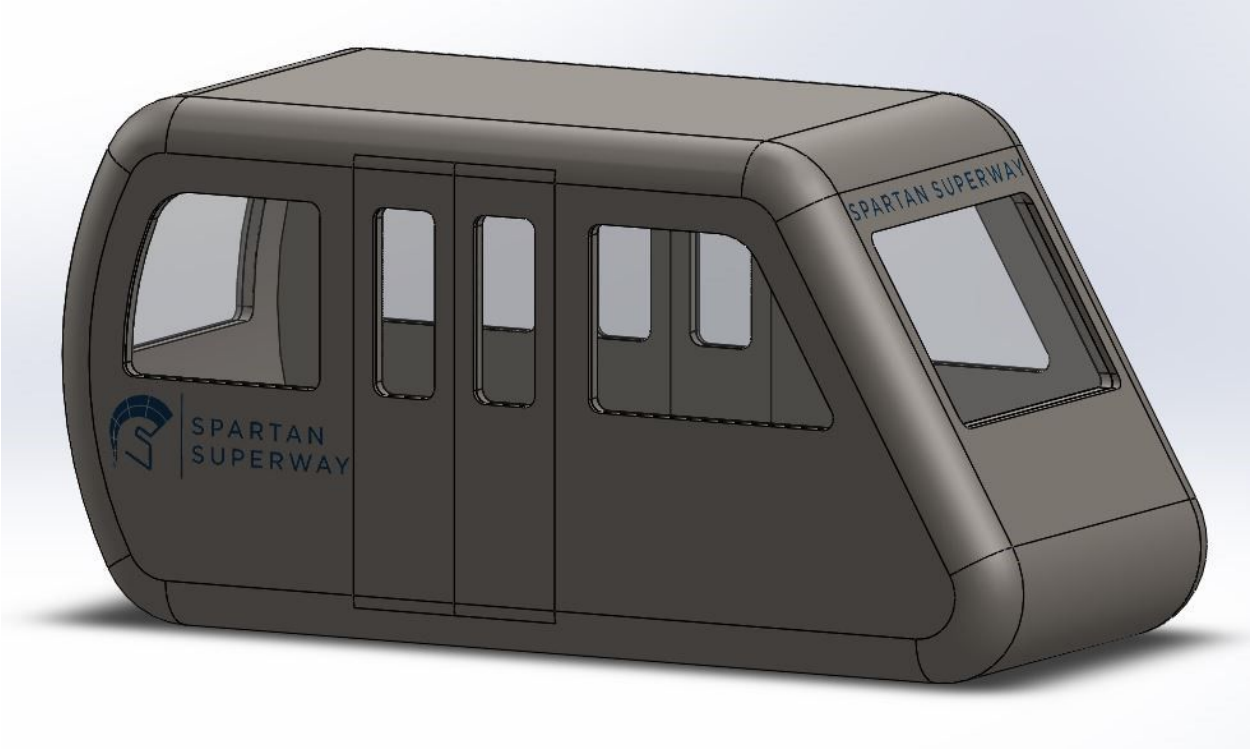

Figure 1: Full-scale cabin for PRT system Retrieved from:
http://www.sjsu.edu/smssv/projectinfo/intermediatescale/index.html

2.0.1 Introduction

Nowadays public transportation plays a critical role in our daily life, especially in developed cities such as San Jose. Spartan Superway took public transportation into a new level of technology, they invented an automated method of public transportation in which is a Pod-Car that will be traveling in the distance. This method of technology is going to be fully automated and eco-friendly, all the energy that will be used into this method is through solar energy. In order to analyze the life-cycle of a pod car, we will need to include all the stages and processes throughout the life-cycle. These critical processes contribute to most of the cost involved in the project. The team decided to deliver a generic flowchart of the pod car life-cycle in order to give the team the flexibility to propose an optimal production plan to minimize the manufacturing

cost. Spartan Superway has been working with a senior student team from San Jose State University's Department of Industrial & System engineers (ISE), and much information has been gathered. However, this project is going to be about the pod car lifecycle cost. The spartan Superway required a considerable amount of effort to deliver something unique in the public transportation industry. Namely, they designed a PRT system in which pod cars will be traveling in the distance above the streets. Figure 1 above shows the proposed design of the pod car cabin that will be traveling in the system. The point behind developing such a system is to allow the public to travel safely to their locations without having to worry about traffic congestions.

2.0.2 Problem

Estimating the financial cost for the life cycle of a Pod Car is going to be difficult since we neither have a physical full-scale prototype of the Pod Car nor the project has been developed yet. It is still in the design phase. In addition to that, we got to avoid high maintenance cost since it is going to be one of the highest costs if we do not measure it accurately.

2.0.3 Scope

Estimating life-cycle cost of a pod car will go through many estimations and comparisons to other transportation projects. The pod car will depend on solar energy to avoid high fuel and maintenance costs associated with the internal combustion engine while supporting carbon reduction goals in environmentally green initiatives. The life-cycle cost analysis will include material extraction, material processing, manufacturing, use, and waste management.

2.0.4 Limitations

The undertaken project has some study limitations to consider. These limitations may be an obstruction or decrease the permanent of the study. These limitations include:

- The availability of costs as some will be estimates.
- Implementing and adapting to a new mode of public transport will likely present unforeseen challenges and costs.

2.0.5 Summary of findings

Many projects were similar to Spartan Superway that require a lot of researches and benchmarking which will move through a lot of development to deliver the project to its success. The team was able to figure out resources that help during our researchers such as, Portland Aerial Tram, ULTra Heathrow airport, and West Virginia University PRT system. Based on theses researches the team came up with three fundamental costs of designs for Spartan Superway, these designs will help Spartan Superway to have a bigger picture of the cost that they could face in the upcoming years.

2.0.6 Similar PRT Systems Analyzed

Table 1: PRT Systems Analyzed

	Metric	ULTra	Portland	West Virginia	Average	S.D.	Median	Range
Material Extraction	Material Cost	$60,000	$80,000	$72,000	$70,667	$10,066	$72,000	$20,000
Material Processing	Annual Machine Maintenance Cost	$30,000	$20,000	$20,000	$23,333	$5,774	$20,000	$10,000
	Annual Labor Cost per Worker	$33,280	$48,200	$38,360	$39,947	$7,585	$38,360	$14,920
	Annual Machine Operation Cost	$1,000,000	$820,000	$880,000	$900,000	$91,652	$880,000	$180,000
	Production Waste Management Cost	$37,000	$27,000	$40,000	$34,667	$6,807	$37,000	$13,000
Manufacturing	Annual Maintenance Cost	$200,000	$124,000	$90,000	$138,000	$56,321	$124,000	$110,000
	Transportaion Cost	$180,000	$210,000	$169,000	$186,333	$21,221	$180,000	$41,000
	Annual Labor Cost	$240,000	$290,000	$220,000	$250,000	$36,056	$240,000	$70,000
	Annual Operation Cost	$200,000	$230,000	$180,000	$203,333	$25,166	$200,000	$50,000
	Product Waste Management Cost	$180,000	$270,000	$175,000	$208,333	$53,463	$180,000	$95,000
	Total	**$2,576,888.00**	**$4,873,200.00**	**$2,259,660.00**				

The table above shows the life cycle costs of similar projects. The team analyzed the costs per lifecycle stage, yet the use and waste management phases have been eliminated since the project is in its early stages and these phases are out of the scope. Some of the costs had to go through estimations because it was difficult at this stage of the project to have quantifiable and reliable measures. However, the team benchmarked the data from more than one resource and concluded that these measures are the most reliable at this critical stage. Some costs are considered to be confidential to the business yet the team was able to collect data that leads to these costs being close to its intrinsic values.

2.0.7 PodCar Life-Cycle Flowchart

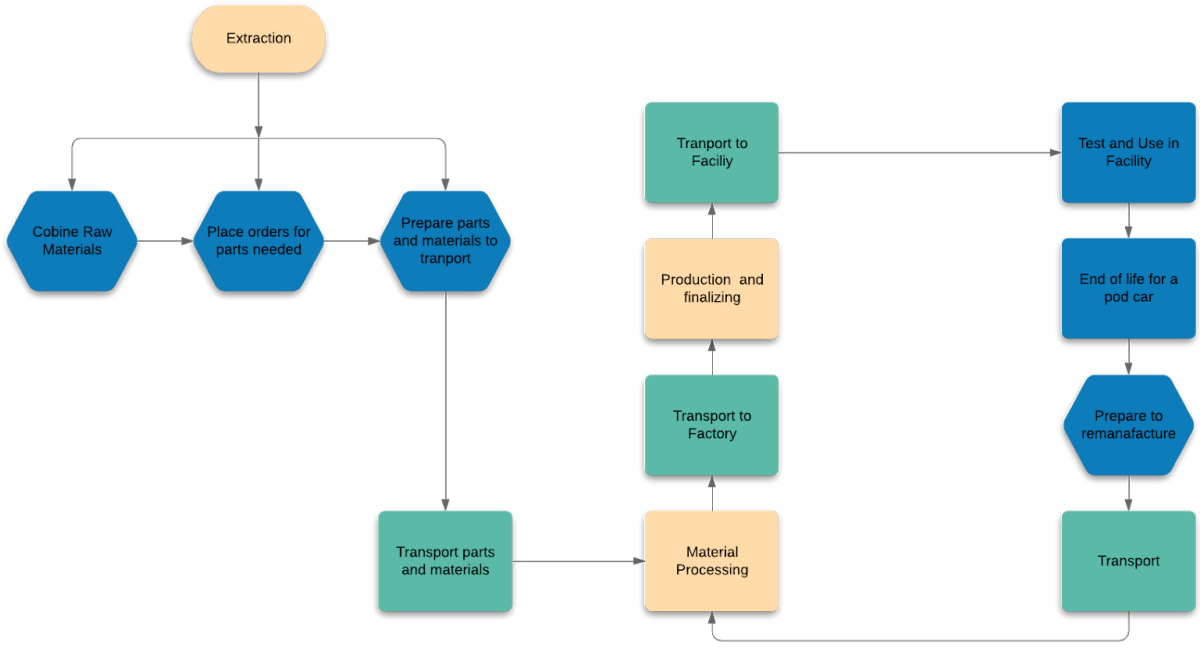

Figure 2: PodCar Life-Cycle Flowchart

2.0.8 Waste

a) Overproduction

Since the company only has one genuinely active system in Heathrow Airport, there is the issue that the cars will be made ahead of time and then not used for long periods of time, leaving the newly manufactured good to decay over time. This also leads to unnecessary spending to store cars. Producing Pod cars earlier than scheduled time could lead to earlier maintenance. We are trying to minimize cost as much as possible.

b) Transportation

Although the cars are small and minimal for what they are, on the scale of transporting it is approximately the same cost as transporting a compact car. The guidelines to drive them places aren't in a place where they can be transported to the destination, so gas, labor and time is wasted.

c) Inappropriate Processing

Because cars aren't being mass-produced, it costs a significant amount more to produce them individually. However, they also possess extremely high-grade equipment, which is a bit unnecessary given the small batches churned out.

d) Unnecessary Inventory

Shown by the photos presented on their websites, they seem to have an excess in pods than needed at times, which disrupts workflow. "Vehicle storage is distributed throughout the system. The OMF would not be designed to hold all of the vehicles. During system shutdown, vehicles are stored under canopies in stations, under canopies in adjacent-to-guideway storage just upstream of high-demand stations, as well as within the OMF"

e) Unnecessary / Excess Motion

Since the company cannot afford such large construction teams, there is an excess in energy and movement spent. Overworked machines and employees can lead to pricey malfunctions and workers comp.

f) Defects

There are always going to be defects in work, regardless of anything you try. Given that, it always directly affects the bottom line, that product is being wasted.

2.1 Bill of Materials (BOM):

Table 2: Detailed Bill of Materials

Part Name	Quantity	Description	Cost
Wheel	4	Iron	$400
Chassis bar	4	Every corner.	$400
Sensor	1	Electronic	$700.00
Sliding Doors	2	Fiber Glass. Need to be order specificly for the	$800.00
Battery	1	Supercapacitor	$1,600.00
Motor	1	EM2332T 10HP, 1180RPM, 3PH, 60HZ, 256T, 0960M, TEFC, F1	$1,750
Cabin Parts	6	Fiber Glass, and Glass (inside the cabin) Incuding floor, sides, top.	$1,600.00
Headset	kit	In order to make any announcement	$500.00
Seat	6	Plastic Type	$250.00
Boday Parts	4	Fiber Glass. Need to be order specificly for the	$5,000.00
Lights	4	Front lights back lights. (outside)	$4,000.00
Lights	kit	Inside lights (inside)	$1,000
AC	1	Air Condition	$1,200.00
Windows	8	Including doors window, windshield, side windows and back windows.	$8,000.00
Total			$27,200.00

There are various kinds of items such as parts and raw materials necessary to manufacture products in a factory. A bill of material is a list that has a relationship where raw materials are indicated. In table 2 is a bill of material (BOM) of Spartan-Superway that showing all lower level items of the specified item, and is used to analyze the product cost. In table 2 explains each part that is going to be used in order to manufacture a PodCar ride. For example, the Iron wheel has been used since it will last more than expected, and it has a low maintenances cost. However, the raw material of the whole PodCar is going to cost around $28,000 as shown in table 2.

2.1.1 Requirements:

Table 3: Requirements

Theme	Process	Salvage Value	Technology	Inflation Rate
BOM	Benchmarking	Value at the end of its useful life	Internet access	Percentage %

2.1.2 Concept:

In this bill of material items and information was used based on past projects that been done in the past. Benchmarking and researches have the highest share of this project. However, most of the numbers of the bill of material were based on estimation, since all the project that is been done in the past has not published anything online. They only thing where published is the final price of the whole project. Based on researches, the whole material prices have been estimated.

2.1.3 Visualization:

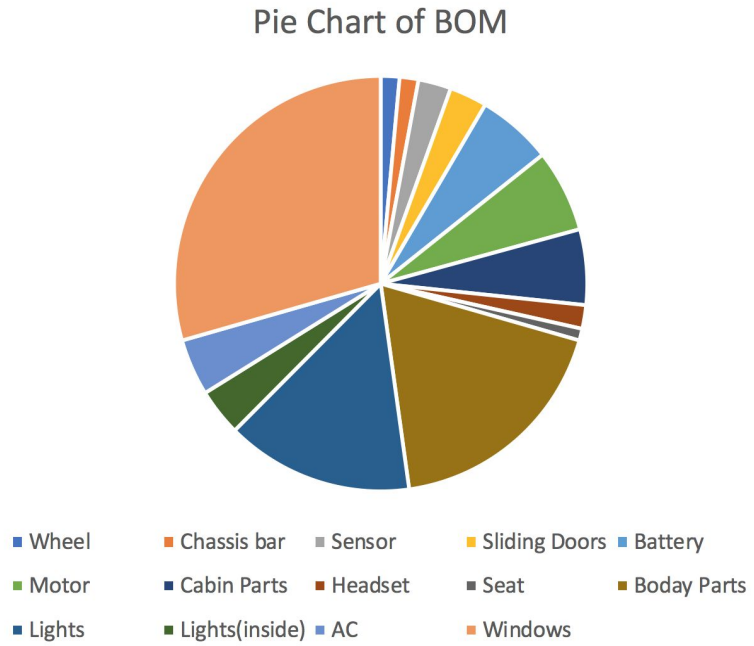

Figure 3: Pie Chart of Bill of Material

In figure 3 is a pie chart of a bill of material, it has the percentage of the materials that going to be used in order to build an automated PodCar. As shown in figure 3 windows has 29% of the whole price, since it needs specific windows that can adapt to the weather condition. Body parts are the second material that has the highest percentage of 18% since the PodCar need to be manufactured separately. Based on figure 3, windows and body parts are the most important material that needs to be used in order to manufacture a PodCar.

2.1.4 Requirements Satisfied:

Table 4: Requirement Satisfaction

Theme	Process	Salvage Value	Technology	Inflation Rate
Satisfied				
Partially satisfied				
Not satisfied				

As a requirement satisfaction, it has been chosen as a process, salvage value, technology, and inflation rate. As shown in table 4 process and technology is the only requirement was satisfied. A unique process has been used in order to get the information that is needed to build a bill of material. Technology is the process that been used to accomplish the goods of the product. However, the salvage value of the product is going to be 5% after the end of its useful life.

2.1.5 Summary:

To sum up, a bill of materials is a comprehensive list of materials such as parts, items that are required to produce a product. Bill of material, in other words, can be understood as a recipe and shopping list. The requirement that is been used to deliver this system was a process, salvage value, technology, and inflation rate. On the other hand, requirement satisfaction was too satisfied with the process that's been used in estimating and benchmarking the whole system.

2.1.6 Bill of Material Verification

This part will explain the detail design that has been approved early in the previous documents. However, in this document, it will provide an estimated cost, operational impacts, and other metrics that will help have a bigger picture in our detail designs. This document will help to verify the ability to measure and compare different prices from different metrics.

2.1.7 Operational Impacts

The operational impacts will look at the logistics of comparing each company materials price to either scale down or scale up. Based on the information that has been provided in the references, each company is different that Spartan Superway. The pod Car it has a different size based on each company and based on each location of these companies the prices are depending on each location as for example, Ultra is built in London so it is has a different price comparing to the other companies. However, table 5 shows the base case which is the current situation of the project and the design which represent the improvement that has been made by the team, and what the difference will be. All these improvements will make a huge difference in improving the current situation of Spartan Superway. By comparing two samples the P-Valve was 0.44336784, which is not significant.

Table 5: Operational Impacts

Metric	Unit	Base Case	Design	Difference	Diff. Significant?
Material Extraction	Dollar Per PodCar	No prices and no design of a cost	Having a cost and design of cost	Easier to look for a cost	YES
Material Processing	Dollar Per PodCar	No design of Cost BOM	Having a cost design	Having a bigger picture of the cost	YES
Manufacturing	Dollar Per PodCar	No design of manufacturing cost	Having a cost design	Having a bigger picture of manufacturing cost	YES

In table 6 it shows the different prices between Spartan Superway and Ultra. Ultra's Pod Car it was the same size as Spartan Superway Pod Car. However, the scale rate for these two

companies was 2.00, since Ultra was built in London and the living expensive it doubles compared to the United States.

Table 6: Spartan Superway Vs Ultra

	Metric	SpartanSuperway	Ultra	Scale Down
Material Extraction	Material Cost	$27,000	$72,000	$36,000

Spartan Superway and Portland have a huge difference in prices as shown in table 7. The scale down for these two companies is 3.0 since Portland is three times bigger than Spartan Superway. Portland built aerial tram for public transportation, which is different than Spartan Superway.

Table 7: Spartan Superway Vs Portland

	Metric	SpartanSuperway	Portland	Scale Down
Material Extraction	Material Cost	$27,000	$80,000	$25,806

In table 8 it explains that West Virginia and Spartan Superway they have some differences based on the price. The scale down for these two companies is 2.5. However, West Virginia's Pod Car it is quite similar on the size comparing to Spartan Superway, but West Virginia's Pod Car they used materials that are different than Spartan Superway and a lot more compared to the others.

Table 8: Spartan Superway Vs West Virginia

	Metric	SpartanSuperway	West Virginia	Scale Down
Material Extraction	Material Cost	$27,000	$72,000	$28,800

2.1.8 Lifecycle Costs and Benefits

The following table list of the lifecycle cost and their perspective. Lifecycle cost has a one-time cost, recurring cost, one time benefits, and recurring benefits. Based on researchers that have been done by the team, there is many costs have been identified by the team. As an example, bill of material it is a one-time cost per pod car, but maintenance, on the other hand, is a recurring cost. As shown in table 9 bill of material it could be a recurring cost per pod car, which means that by the end of the lifecycle stage the materials need to be purchased again. As shown in table 6 the growth of one-time benefits and recurring benefits, it could be done by researches and development.

Table 9: Lifecycle Stages

Life Cycle Stages	Introduction	Growth	Maturity	Decline/ Revision
One Time Cost	Implementation of BOM	Initial reaserch and development	N/A	Finding a better alternative for the BOM
Recurring Cost	Maintance/BOM Per each cycle	Reaserch and development	N/A	Finding a better alternative for the BOM
One Time Benefits	N/A	Reaserch and development	N/A	Finding a better alternative for the BOM
Recurring Benefits	N/A	Reaserch and development	N/A	Finding a better alternative for the BOM

2.1.9 Cost & Benefit Estimation

The following table provided an estimation of the cost and benefits that are expected to be seen in the proposed detail design. Table 10 is similar to the previous table which has a slightly different than the lifecycle cost. In this table, it has the actual estimation of the growth that will need to be done in this project. However, the idea behind Cost & Benefit estimation is to deliver a bigger picture of the design cost to the client, and whether or not they choose to go for it.

Table 10: Cost & Benefit Estimation

Life Cycle Stages	Introduction	Growth	Maturity	Decline/ Revision
One Time Cost	$27,000.00	2400	N/A	N/A
Recurring Cost	$27,000.00	2400	N/A	N/A
One Time Benefits	N/A	2400	N/A	N/A
Recurring Benefits	N/A	2400	N/A	N/A

2.1.10 Cash Flow

The following cash flow shows the flow of cost required to deliver the project to its success. As shown in figure 4 there is no initial cost in many companies there is only a one-time cost per pod car. The cost material what is required for this project is as shown in figure 4, each company has a different price as mentioned previously. However, in figure 4 shows no benefit since Spartan Superway has not started the project yet.

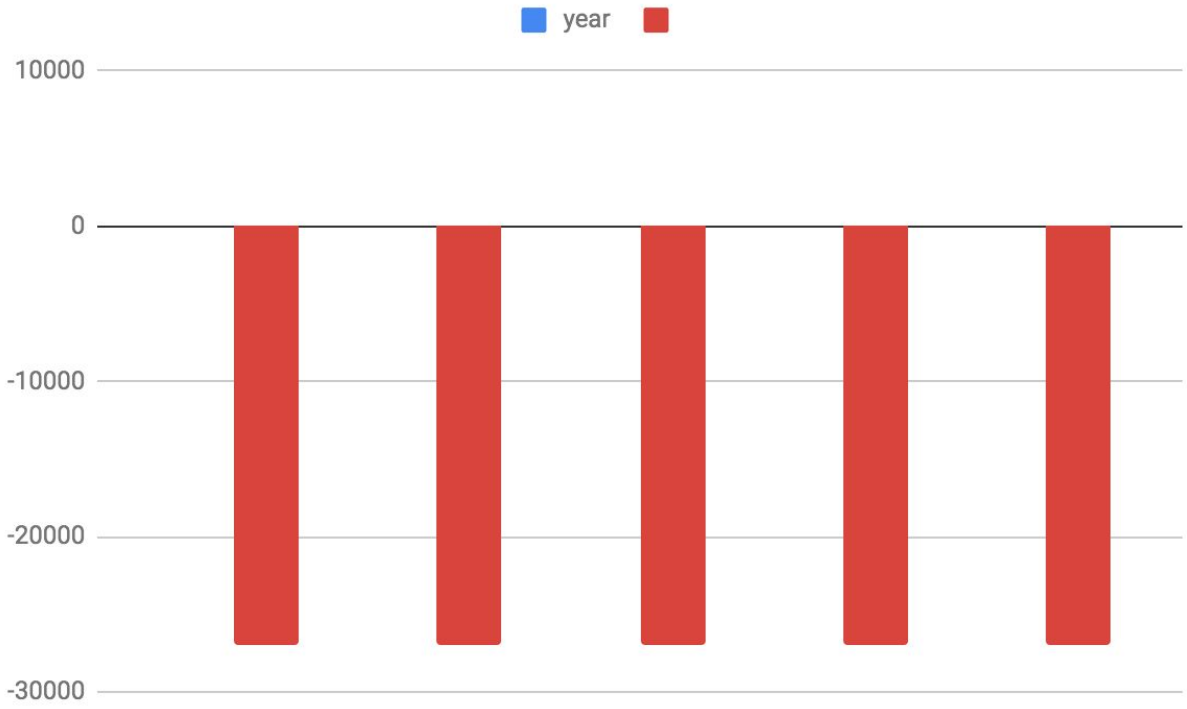

Figure 4: Bill of Material Cash Flow

2.1.11 Financial Metric

The following table shows the net present value of Spartan Superway for the upcoming 4 years. As shown in table 11 the NPV it seems slowly decreasing which means there will take a lot of years to receive revenue. However, when determining a proposal that needs to consider it or not there is a number of items need to be considered first. In Spartan Superway situation since it is a company that has been started recently, they need to consider the cost revenue and that is what our team is going to deliver.

Table 11: NPV

year	Cash Flow	NPV
1	810,000	771428.5714
2	810,000	734693.8776
3	810,000	699708.4548
4	810,000	666389.0046

2.1.12 Recommendation

The Spartan Superway they have a number of areas that need to be considered. First, having a cost design it will help a lot during this project. Spartan Superway they mentioned at the beginning of this semester that they facing a lot of struggles to have cost design. Our team will be looking at delivering a solid cost design in several ways. For instance, BOM (Bill of Material), Labor cost, and overhead, that what our will recommend to spartan super way.

2.2 Labor Cost Design

2.2.1 Labor Cost

Labor cost was one of the three proposed estimates to complete the life-cycle project of a pod car. Labor costs will include all direct, indirect, and overhead expenses. Explaining the required roles and number of workers to start the process.

2.2.2 Concept

Benchmarking was used to estimate labor salaries and total costs for producing pod cars. The data collected was from various websites. The costs are distributed between the jobs required to start the process. There are three different categories of labor cost, Direct, indirect, and manufacturing overhead labor.

2.2.3 Visualization

Table 12: Detailed Labor Cost

Roles	Salary /year	Number of Workers	Total cost of all workers
Project Manager	$90,000	1	$90,000
HR Manager	$96,000	1	$96,000
Electrician	$67,648	3	$202,944
Mechanic	$51,997	5	$259,985
Operating machinery	$54,000	2	$108,000
Quality Conrtol Manufactoring Eng	$82,126	1	$82,126
factory workers	$38,000	9	$342,000
Health and Safety	$78,000	1	$78,000
Technician	$42,000	5	$210,000
Total Labor Cost	$1,469,055		Total Cost
Total Cost/Pod Car	$48,968.50	Manufacturing overhead labor	$462,929
		Direct labor	$820,126
		Indirect labor	$186,000

The table shows the different roles of labor to produce pod cars. In this table, there are 3 different categories for labor costs. Direct, Indirect, and Manufacturing overhead labor. The total labor cost is $1,469,055. Assuming that there will be 30 pod cars to produce and that is estimated to be $48,968.50 for each pod car. Direct labor had the highest cost amongst them at $820,126 while the lowest was Indirect labor at $186,000. Furthermore, Manufacturing overhead cost was in between $462,929.

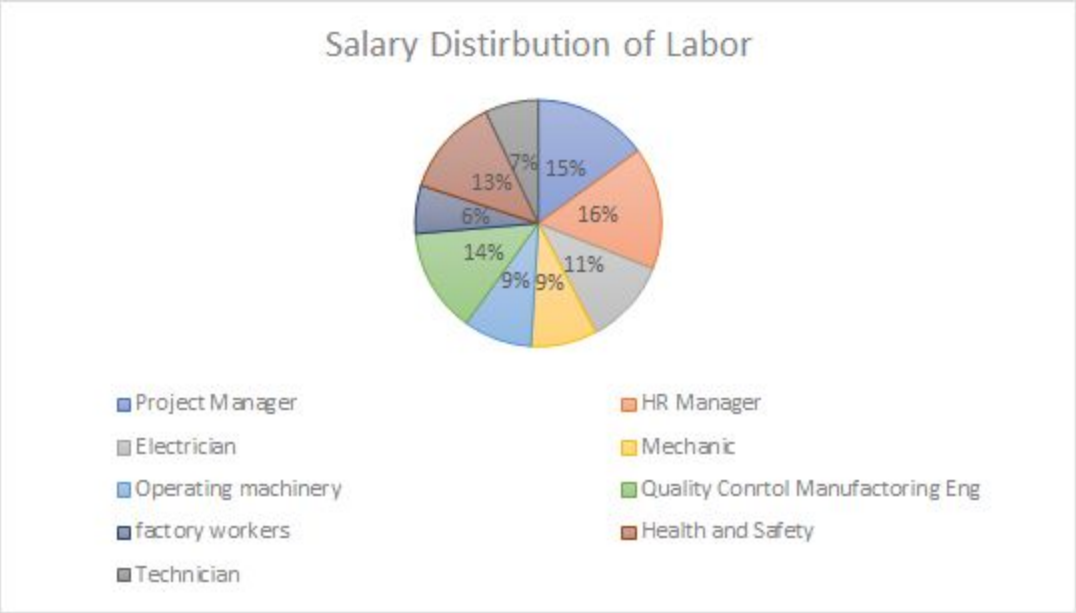

Figure 5: Detailed Labor Cost pie chart

The Pie chart shows the distribution of salaries for each role. The human resource manager is the highest paid job with 16% of the total cost and then comes the project manager with 15%. The lowest will be the factory workers and that will be 6%. The rest of the roles are ranged from 9% to 14% of the total cost.

2.2.4 Operational Impacts

This part will verify the detailed design that has been implemented for this project. It's important to compare the data collected from a different project to make the right decision. In this section of the paper, four different companies are being compared from different places in the US and one was located in the UK. The comparison with the UK project is not fair since the wages are significantly lower which made the total cost lower. Table 13 shows the annual labor cost per Podcar as a metric while the unit was calculated by dollars. The base case was chosen to be the Spartan Superway while the other designs were the other three projects. The last two parts of the table if there is a difference in the total price.

Table 13: Operational Impacts

Metric	Unit	Base Case	Design	Difference	Diff.significant?
Labor cost	Dollars per Podcar	Spartan Superway	Ultra	High	Yes
			Portland	Medium	Yes
			WVM	Medium	Yes

Table 14 shows the data collected for Ultra. This project took place in London, UK. Which is up and running currently. It's operating at London Heathrow airport. Since it's in a different country, a lot of labor cost will differ from Spartan Superway. From the data shown, the wages are significantly lower than San Jose, CA. Which explain why Ultra had the lowest labor cost amongst all the projects with a total of $34,400.

Table 14: Ultra

	Ultra		
Roles	Salary /year	Number of Workers	Total cost of all workers
Project Manager	$45,000	1	$45,000
HR Manager	$50,000	1	$50,000
Electrician	$36,000	3	$108,000
Mechanic	$38,000	5	$190,000
Operating machinery	$35,500	2	$71,000
Quality Conrtol Manufactoring Eng	$58,000	1	$58,000
factory workers	$22,000	9	$198,000
Health and Safety	$62,000	1	$62,000
Technician	$50,000	5	$250,000
			Total Cost
		Ultra	
Total Labor Cost	$1,032,000	Manufacturing overhead labor	$298,000
Total Cost/Pod Car	$34,400.00	Direct Labor	$639,000
		Indirect labor	$95,000

Table 15 will shows the data collected for Portland. The project was the second highest total labor cost. It's significantly less than Spartan Superway but a little higher than West Virginia's project. The cost per pod car was $42,100.

Table 15: Portland

	Portland		
Roles	Salary /year	Number of Workers	Total cost of all workers
Project Manager	$81,000	1	$81,000
HR Manager	$78,000	1	$78,000
Electrician	$64,000	3	$192,000
Mechanic	$60,000	5	$300,000
Operating machinery	$44,000	2	$88,000
Quality Conrtol Manufactoring Eng	$55,000	1	$55,000
factory workers	$26,000	9	$234,000
Health and Safety	$65,000	1	$65,000
Technician	$34,000	5	$170,000
			Total Cost
		Portland	
Total Labor Cost	$1,263,000	Manufacturing overhead labor	$492,000
Total Cost/Pod Car	$42,100.00	Direct labor	$612,000
		Indirect labor	$159,000

Table 16 shows the costs for West Virginia project which was the second-lowest total cost between the four. The cost per pod car was $41,066. It was surprising that it had a low total cost for producing a pod car since the project was significantly bigger than the other project and cover more miles.

Table 16: West Virginia

	WVM		
Roles	Salary /year	Number of Workers	Total cost of all workers
Project Manager	$92,000	1	$92,000
HR Manager	$75,000	1	$75,000
Electrician	$56,000	3	$168,000
Mechanic	$50,000	5	$250,000
Operating machinery	$50,000	2	$100,000
Quality Conrtol Manufactoring Eng	$75,000	1	$75,000
factory workers	$28,000	9	$252,000
Health and Safety	$60,000	1	$60,000
Technician	$32,000	5	$160,000
			Total Cost
WVM			
		Manufacturing overhead labor	$418,000
Total Labor Cost	$1,232,000	Direct labor	$647,000
Total Cost/Pod Car	$41,066.67	Indirect labor	$167,000

Table 17 shows three different projects compared to Spartan Superway labor cost. There are different categories of labor cost. Manufacturing overhead, Direct, and indirect labor. With Ultra being the lowest with a total of $34,400 per Podcar and Spartan Superway as the highest.

Table 17: Comparison with Spartan Superway

	Spartan SuperWay	Ultra	Portland	WVM
Manufacturing overhead labor	$462,929	$298,000	$492,000	$418,000
Direct Labor	$820,126	$639,000	$612,000	$647,000
Indirect labor	$186,000	$95,000	$159,000	$167,000
Total Labor Cost	$1,469,055	$1,032,000	$1,263,000	$1,232,000
Total Cost/Pod Car	$48,968	$34,400	$42,100	$41,066

2.3 Overhead Costs

The proposed overhead cost estimate is one of the three proposed estimates which are essential to come up with a complete life-cycle cost system of a pod car. The overhead cost estimate should include all of the indirect expenses that support the manufacturing and assembly of a pod car.

2.3.1 Concept

For this design, benchmarking will be used in order to come up with the most accurate estimation of the overhead cost per pod car. The costs will be categorized into 7 different categories and for each category, high and low estimates will be benchmarked and an average will be calculated in order to have a good estimate of the cost. The costs will be delivered in a spreadsheet for clarity and editability.

2.3.2 Visualization

Table 18: Detailed Overhead Costs

	Low Cost Estimate	High Cost Estimate	Average	$ / Pod Car
Electricity, natural gas, water, and sewer for operating the manufacturing facilities and equipment.	$ 200,000.00	$ 270,000.00	$ 235,000.00	$ 7,833.00
Computer and communication systems for the manufacturing function.	$ 15,000.00	$ 30,000.00	$ 22,500.00	$ 750.00
Repair parts for the manufacturing equipment and facilities.	$ 25,000.00	$ 65,000.00	$ 45,000.00	$ 1,500.00
Supplies for operating the manufacturing process.	$ 7,500.00	$ 20,000.00	$ 13,750.00	$ 458.00
Depreciation on the manufacturing equipment and facilities.	$ 10,000.00	$ 70,000.00	$ 40,000.00	$ 1,333.00
Insurance and property taxes on the manufacturing equipment and facilities.	$ 100,000.00	$ 400,000.00	$ 250,000.00	$ 8,333.00
Safety and environmental costs.	$ 250,000.00	$ 400,000.00	$ 325,000.00	$ 10,833.00
Total	$ 607,500.00	$ 1,255,000.00	$ 931,250.00	$ 31,040.00

Table 18 shows the 7 categories of the overhead costs and their low and high annual estimates as well as the average. Assuming 30 pod cars a year are to be manufactured, the average has been divided by 30 in order to get the cost per pod car. The costs of all categories per pod car been summed in order to get the intrinsic total cost of overhead per pod car, which has been estimated to be on average $31,040 per pod car. Where $20,250 being the low estimate and $41,833 is the high estimate.

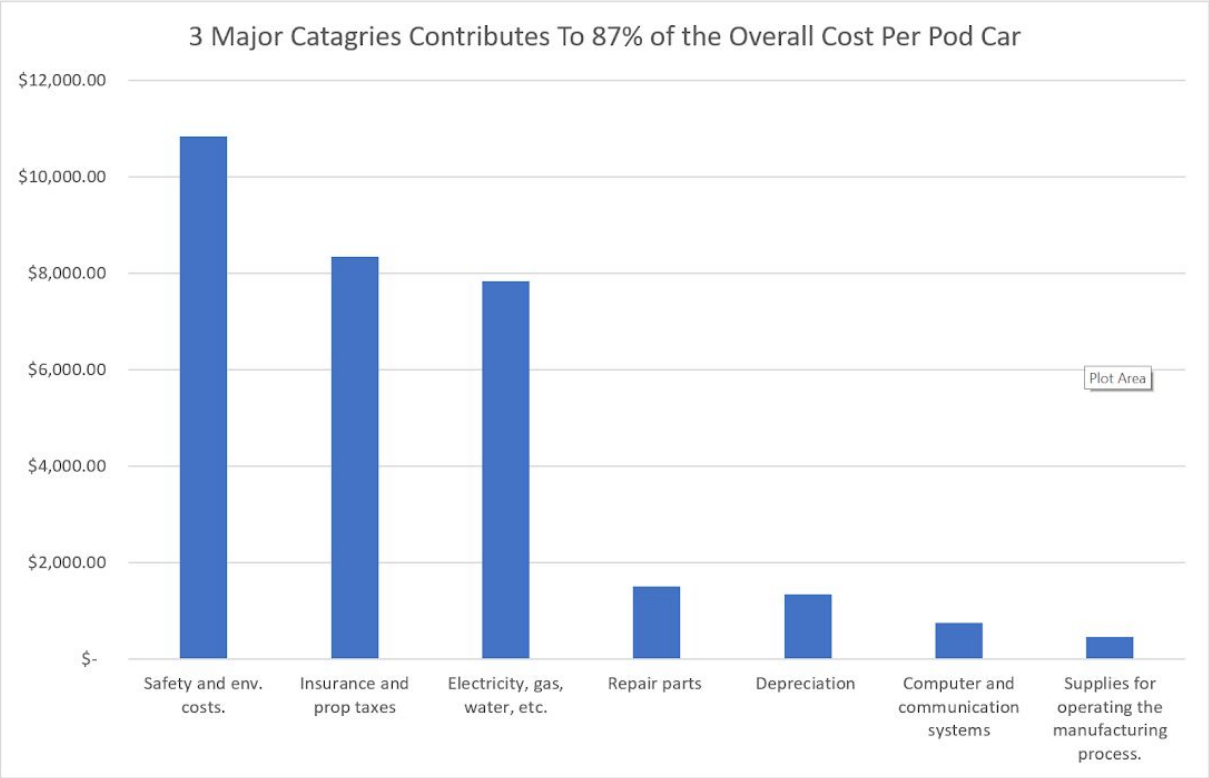

Figure 6: Overhead Costs Comparison by Category

Figure 6 shows the variation between the 7 categories of the overhead costs per pod car. It's clearly visible that the safety and environmental costs, the insurance and property taxes and utility bills for operating the manufacturing facilities contributes to the majority of the overhead cost. These 3 categories are 87% of the overall overhead cost, where the other 4 categories contribute to only 13% of the overall overhead cost.

2.3.3 Requirements Satisfied

Table 19: Satisfaction of Requirements of the Detailed Design

	Process	Technology	Accuracy	Clarity	Editablity
Overhead Cost	Benchmarking	Computers	Acurate calculations	Clear tables and calculations	Editable spread sheets
Staisfied					
Prtially Staisfied					
Not Satisfied					

In this proposed design, benchmarking was used to estimate the overhead cost, and this method had partially satisfied the requirements since there been many estimates involved. For the requirement to be satisfied an accurate result has to be found, and that was not the case in this design. For technology, only computers were involved to compute the costs of different categories of the overhead cost and to average the low and high estimate of each category. This

requirement is satisfied since using computers in general and excels in specific gives highly accurate results when calculating the averages and computing different costs. Also, since the accuracy of benchmarking was not optimal, the accuracy requirement was also partially satisfied for the same reason. The tables and calculations are clear and editable since it has been computed using an excel spreadsheet which makes it simple and clear to read as well as editable for future modifications and changes.

2.3.4 Verification of the Overhead Cost

It is very important to verify the detailed design that has been proposed in order to propose it to the client to come up with a decision on whether the proposed design should be implemented. In this deliverable, the operational and financial impacts of the detailed design will be estimated and its operational impacts will be verified.

2.3.5 Operational Impacts

Table 20: Price Comparison of Current Proposed Design and Existing Prices

	Spartan Superway	ULTRA	Portland	West Virginia	ULTRA Shrinked	Portland Shrinked	West Virginia Shrinked
Electricity, natural gas, water, and sewer for operating the manufacturing facilities and equipment.	$ 235,000	$ 461,042	$ 429,246	$ 392,150	$ 230,520.81	$ 238,470	$ 217,861
Computer and communication systems for the manufacturing function.	$ 22,500	$ 44,142	$ 41,098	$ 37,546	$ 22,071.14	$ 22,832	$ 20,859
Repair parts for the manufacturing equipment and facilities.	$ 45,000	$ 88,285	$ 82,196	$ 75,093	$ 44,142.28	$ 45,664	$ 41,718
Supplies for operating the manufacturing process.	$ 13,750	$ 26,976	$ 25,115	$ 22,945	$ 13,487.92	$ 13,953	$ 12,747
Depreciation on the manufacturing equipment and facilities.	$ 40,000	$ 78,475	$ 73,063	$ 66,749	$ 39,237.58	$ 40,591	$ 37,083
Insurance and property taxes on the manufacturing equipment and facilities.	$ 250,000	$ 490,470	$ 456,644	$ 417,181	$ 245,234.90	$ 253,691	$ 231,767
Safety and environmental costs.	$ 325,000	$ 637,611	$ 593,638	$ 542,336	$ 318,805.37	$ 329,799	$ 301,298
Total	$ 931,250	$ 1,827,000	$ 1,701,000	$ 1,554,000	$ 913,500	$ 945,000	$ 863,333

Table 20 shows the proposed design of the overhead cost compared with existing projects. ULTra, Portland aerial tram, and West Virginia PRT system has been initially calculated using the data from the measure phase. The overhead cost of ULTra has been divided by a factor of 2 to get the intrinsic values to compare it and validate it with the Spartan Superway overhead costs. Portland and West Virginia's overhead costs have been divided by a factor of 1.8 to also get an intrinsic value for comparison. These values have been obtained by comparing the size of the vehicle being manufactured and the size of the manufacturing facility. With ULTra having semi-large vehicles and very large production facility it has been estimated that their overhead cost would be 2x greater than Spartan Superway. Using the same strategy the rate has been calculated for Portland aerial tram and West Virginia's PRT system. Portland aerial tram has very large vehicles and large facility. Therefore, the rate estimated to be 1.8x the cost of Spartan Superway. Comparing the proposed design a p-value of 0.347 was obtained which

shows significant difference which means that the proposed design is relatively similar to the existing costs of similar projects.

3.0 Team and Support

The team consists of three Industrial and System Engineering undergraduate students: Abdullah Aloudah, Ibrahim Alrumaihi, and Naif Almobarak. The team would like to thank Spartan Superway for their support during this semester and for sponsoring our senior project. Special thanks to Dr. Burford Furman, Ron Swenson for their support throughout this entirety of this project.

4.0 Problem & Opportunities

First major issue run into, detailed prices aren't available to the public. As shown in the ULTra's infrastructure report, "System costing is provided in the separate, confidential business model spreadsheet. For costing, two estimates were received from major local firms." Public cost estimates that were released on Advanced Tooling Systems Ltd's website said that the costs were between 3 million GBP and 5 million GBP. Provided by the same ULTra Infrastructure report, we find out all the products and materials used to construct the pod cars and the rail systems.

5.0 Conclusion: Causes

Spartan Superway is still in its first stages and needed to have a cost system in order to make some important financial decisions for its existing project. And for Spartan Superway to have reliable projects, quantifiable costs has to be measured and verified. These costs may include the labor cost, the bill of materials and the overhead costs. Currently, Spartan Superway has some mechanical engineering teams working on a variety of projects which covers different aspects of the project. Economical evaluation has been proposed by some teams to evaluate the feasibility of their specific projects. However, not all constructional costs has been evaluated. Therefore, the team found the opportunity to propose a validated cost system.

6.0 Conclusion: Recommendations

6.1 Bill of Materials

The Spartan Superway they have a number of areas that need to be considered. First, having a cost design system will help a lot during this project. However, Spartan Superway they mentioned at the beginning of this semester that they facing a lot of struggles to have cost design. Our team will be looking at delivering a solid cost design in several ways. For instance, BOM (Bill of Material), Labor cost, and overhead, that what our recommendations will be for spartan super way. Secondly, having a cost system in three different way will help Spartan Superway to deliver their project to its success. The bill of material that been delivered by the team, it has all the information and the price specifically for Spartan Superway which will be about $30,000 to build one Pod Car.

6.2 Labor Cost

The design has been compared with three different projects to get the most fit total cost to start. After comparison, Spartan Superway total labor cost was summed to be $1,469,055 for manufacturing 30 Podcar which will equal $48,968 per Podcar. This was estimated based on the different roles and their wages in San Jose, CA. This is the minimum number of workers that could be started with to start on the project. The labor cost was split into three different categories with Direct cost being the highest then Manufacturing overhead cost and last but not least indirect labor cost.

6.3 Overhead Costs

The proposed design has been also verified through comparison with other similar existing projects and comparing the size of facilities and other different factors to get the intrinsic value of the overhead annual cost of Spartan Superway. This proposed design estimates that the annual overhead cost would add up to $931,250 per year which is a reasonable price taking into consideration the size of the facility that will be used by Spartan Superway and the size of their PRT systems' vehicle. After the cost system has been validated it is advised to start implementing the system as soon as possible.

6.4 Aggregated Recommendation

After the team have collected more accurate data on the 4 different designs, some of the designs had to be scaled up or down based on Spartan Superway to be fairly compared. Spartan Superway had the lowest total of material extraction, material processing, and manufacturing. Based on the given information in table 21 Spartan Superway they looking at a price of around $1,650,00 to build on Pod Car, these number has been gathered accurately by the team to deliver a solid cost of design to Spartan Superway.

Table 21: Aggregated Recommendation

	Metric	Spartan Superway	ULTra	Portland	West Virginia	Average	S.D.	Median	Range
Material Extraction	Material Cost	$27,200	$60,000	$80,000	$72,000	$70,667	$10,066	$72,000	$20,000
Material Processing	Annual Machine Maintenance Cost	$20,000	$30,000	$20,000	$20,000	$23,333	$5,774	$20,000	$10,000
	Annual Labor Cost per Worker	$31,000	$33,280	$48,200	$38,360	$39,947	$7,585	$38,360	$14,920
	Annual Machine Operation Cost	$660,000	$1,000,000	$820,000	$880,000	$900,000	$91,652	$880,000	$180,000
	Production Waste Management Cost	$30,000	$37,000	$27,000	$40,000	$34,667	$6,807	$37,000	$13,000
Manufacturing	Annual Maintenance Cost	$100,000	$200,000	$124,000	$90,000	$138,000	$56,321	$124,000	$110,000
	Transportaion Cost	$170,000	$180,000	$210,000	$169,000	$186,333	$21,221	$180,000	$41,000
	Annual Labor Cost	$200,000	$240,000	$290,000	$220,000	$250,000	$36,056	$240,000	$70,000
	Annual Operation Cost	$210,000	$200,000	$230,000	$180,000	$203,333	$25,166	$200,000	$50,000
	Product Waste Management Cost	$200,000	$180,000	$270,000	$175,000	$208,333	$53,463	$180,000	$95,000
	Total	**$1,648,200.00**	**$2,576,888.00**	**$4,873,200.00**	**$2,259,660.00**				

7.0 Conclusion: Impacts

7.1 Operational Impacts Bill of Materials

The operational impacts will look at the logistics of comparing each company materials price to either scale down or scale up. Based on the information that has been provided in the references, each company is different that Spartan Superway. The pod Car it has a different size based on each company and based on each location of these companies the prices are depending on each location as for example, Ultra is built in London so it is has a different price comparing to the other companies. However, table 2 shows the base case which is the current situation of the project and the design which represent the improvement that has been made by the team, and what the difference will be. All these improvements will make a huge difference in improving the current situation of Spartan Superway. By comparing two samples the P-Valve was 0.44336784, which

Table 22: Operational Impacts

Metric	Unit	Base Case	Design	Difference	Diff. Significant?
Material Extraction	Dollar Per PodCar	No prices and no design of a cost	Having a cost and design of cost	Easier to look for a cost	YES
Material Processing	Dollar Per PodCar	No design of Cost BOM	Having a cost design	Having a bigger picture of the cost	YES
Manufacturing	Dollar Per PodCar	No design of manufacturing cost	Having a cost design	Having a bigger picture of manufacturing cost	YES

7.2 Bill of Materials Financial Metrics

The following table shows the net present value of Spartan Superway for the upcoming 4 years. As shown in table 8 the NPV it seems slowly decreasing which means there will take a lot of years to receive revenue. However, when determining a proposal that needs to consider it or not there is a number of items need to be considered first. In Spartan Superway situation since it is a company that has been started recently, they need to consider the cost revenue and that is what our team is going to deliver.

Table 23: NPV Bill of Material

year	Cash Flow	NPV
1	810,000	771428.5714
2	810,000	734693.8776
3	810,000	699708.4548
4	810,000	666389.0046

7.3 Overhead Cash Flow

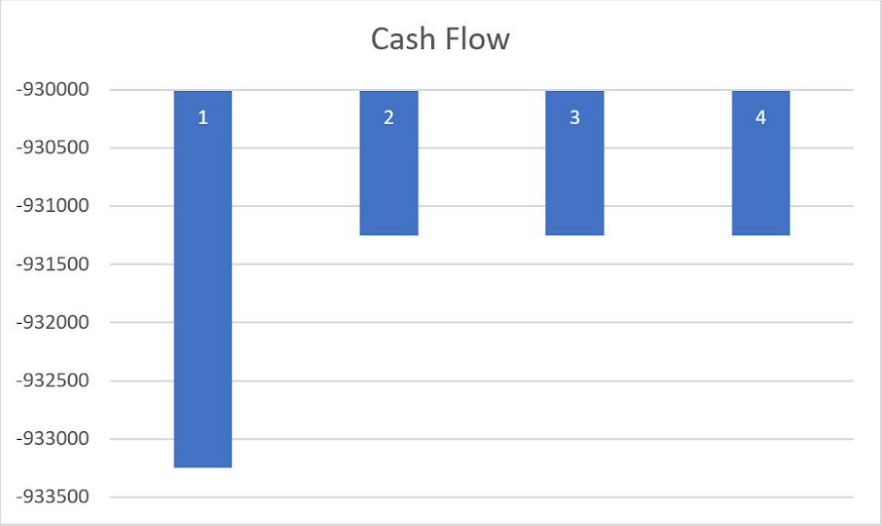

Figure 7: Cash Flow Diagram Overhead

Looking at figure 7 above, it is obvious that the proposed design would have only annual costs and no benefits. The first year would have $2000 more in costs because it would cost more to initiate and implement the proposed design. Since the design is focusing on delivering a cost system, the cash flow chart has only the costs of implementing the overhead cost system.

7.4 Overhead Financial Metrics

Table 24: Net Present Value

Year	Cash Flow	NPV
1	-933250	-888810
2	-931250	-844671
3	-931250	-804449
4	-931250	-766142

By calculating a discount rate of 5%, the net present value of the cash flow is shown in the table above, which indicates that the net present value of the cash flow is continuously decreasing since all values are negative and it only costs with zero benefits at the time. The net present value is calculated to be $3,304,071 in costs for the first four years of implementation.

8.0 Appendix

Figure 8 : Alternative Pod Car Design

Figure 9 : Exploded View of the Alternative Pod Car Design

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