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UNIVERSITY OF BRITISH COLUMBIA (OKANAGAN)

FACULTY OF APPLIED SCIENCE, SCHOOL OF ENGINEERING

Engineering Economic Analysis – ENGR 305 202

Group 32, Section 202

"Hover Collective / UBC Brand & Marketing"

Issue: “A UBCO staff/faculty U-Pass Makes Sense”

Abstract

In this paper we investigate the benefits of providing the staff and faculty of the University of British Columbia Okanagan with a U-Pass. By focusing on successful cases and examining several aspects, such as environmental and economical, we are able to see how implementing the U-Pass would be favourable. Additionally, relating the research on how the U-Pass benefits the students, both currently and in the past, makes it clearer to anticipate how the U-Pass will benefit the staff and faculty. We also discuss the effects relating to numerous factors such as funding, current traffic patterns, congestion and pollution. Lastly we touch on future research which will aid in the implementation of making the U-Pass available to staff and faculty of UBCO.

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Introduction

A U-pass stands for “Universal Transit Pass". The Universal Transit Pass program in British Columbia is a program initially implemented in 2003 by Translink, which is a government created and funded transportation authority. The U-Pass program is offered to post secondary school students attending public institutions across British Columbia. Although not all public institutions in BC have opted to participate in the program, the majority of the major institutions have chosen to adopt the program. Students pay for the U-Pass as a part of student’s fees through university tuition. Once these fees are paid students are free to access the bus, Sea bus, and Skytrain systems in Vancouver, and also discounts on the West Coast Express. More specifically in Kelowna it provides unlimited access to the bus system.

At UBCO each student pays $63.00 per academic term, or about $15.75 per month for this program which includes the bus routes. At UBC Vancouver the U-Pass BC Program costs $41.00 per month, or $164.00 per academic term. This difference in price between the two UBC campuses is due to UBC Vancouver also getting access to the Sea bus and Skytrain, in addition to the buses. It’s also noted in both of these cases, and at other institutions, the U-pass must have a 100 percent adoption rate by all students. This means all students must pay for the U-pass as part of their tuition regardless if they need it, but some exemptions exist for special cases (ie. medical reasons) that allow you to opt out of the program.

At UBCO the U-Pass is only offered to students as of right now. We will be exploring why the U-Pass should include both students and staff/faculty at UBCO.

Problem Statement

The aim of this term project is to investigate the pros and cons of opening the U-Pass to faculty and staff at UBCO. It will outline the most significant factors as to why providing staff and faculty with a U-Pass is beneficial. The U-pass is known to be a valuable asset to students who are commuting to and from school. It is also valuable to students on campus as it provides them with a way to get off campus to explore the city or run errands. As of right now the option of this pass is not extended to staff and faculty at UBCO. Many staff members are not from Kelowna, coming from different parts of

the country or the world. When they come to UBCO they are forced to either buy/rent their own vehicle, live on campus and/or buy a bus pass themselves. Opening the U-Pass would be beneficial to both the staff and faculty at UBCO and also the university itself. The university would benefit from opening this program to staff and faculty as they would receive the money staff is currently paying the city for a bus pass. Staff and faculty would benefit because having the U-Pass would provide them with a reliable, safe, eco-friendly, and cost-efficient way to travel to and from school and into the city.

Objectives

The objective of this report is to prove the value of having a U-Pass for staff and faculty at UBCO. Different aspects such as environmental impact, economic impacts, and social impacts affect this. We will focus on how these impacts would affect UBCO, the U-Pass program/program users, and the Province of British Columbia. It will be important to note both the positive and negative impacts the U-Pass could have and will be explored more in depth in the Data and Analyses and Sensitivity and Risk Analysis sections. Once all the pro's and con's of the pass have been explored we will prove why having a U-Pass for staff and faculty at UBCO is worth having.

Team Contributions/ Division of Tasks

Ammar Riyadh (28222354) - Future Research

Youssef Mahmoud (37624970) - Conclusions and Recommendations

Shriya Agrawal (29537578) - Literature Review, Formatting

1. U-PASS: A Model Transportation Management Program That Works, by Michael E. Williams And Kathleen L. Petrait
2. Greenhouse Gas Emission Baseline: Students, Faculty And Staff Commuting To The University Of British Columbia by Jonathan Frantz
3. Developing ecological footprint scenarios on university campuses: A case study of the University of Toronto at Mississauga by Tenley M. Conway et al.

Niema Amini (53007143) - Result and Discussion, Overall report editing, formating

Pengyu Cao (13369376) - Sensitivity and Risk

Xinyan Chen (26307165) - Data and Analysis

Brendan Gairdner (22626949) - Literature Review (These are mine I will be discussing)

1. Strategic plan to increase transit by Michael Ross
2. U-Pass at UBC by Graham Senft
3. Understanding UC Riverside's U-Pass program by Ciudad-Real
4. An Econ. Analysis of the U-Pass by Hafeez

Pratiksha Desai (65842635) - Abstract and Introduction

Rory Duvall (65399321) - Methodology

Literature Review

1. Elements of Successful Universal Student Transit Pass Programs
2. U-Pass BC program survey
3. U-pass BC to save students on transit fares

Ellie Gartrell (54824065) - Introduction, Problem Statement, Objectives, Formatting

Literature Review

A Strategic Plan to Increase Transit Use through the U-Pass Program at UBC Okanagan by Michael Ross

In this report, Ross examines the benefits and possibilities of implementing the U-Pass system. Although this report was written before UBC Okanagan began using the U-Pass system, many parts of the report hold true and it is interesting to look back upon initial analysis. Ross makes many arguments conveying the message that the U-Pass implementation is a good idea. He highlights the environmental, economic, and potential partnership benefits.

It is a well-known fact that carpooling and public transit produces fewer emissions and is better for the environment than everyone driving cars individually. Ross makes the point that an increase in carpooling will ultimately reduce traffic congestion in Kelowna, which can be quite bad, especially near UBC Okanagan.

Ross spends a great deal of his report talking about the potential economic benefits that U-Pass implementation could provide. On pg. 14 he effectively uses a student profile to showcase Francis Dixon, a student at UBC Okanagan's point of view. She uses the public transit system daily and runs into problems with the low frequency of busses at night. With the implementation of the U-Pass system, there will be an increase in demand and bus frequency helping solve this problem students are facing.

Ross acknowledges the fact that not every student uses the public transit system and that there will be against the U-Pass system. He states that the U-Pass is about providing solutions for the population overall and helping the environment, which outweighs the students who will not be using the bussing system.

U-Pass at the University of British Columbia: Lessons for Effective Demand Management in the Campus Context by Graham Senft

In this case study, Senft talks about how the U-Pass has affected the University of British Columbia. He shares some possible strategies on how the U-Pass can be used effectively in the university setting and provides analysis throughout his report.

Senft starts off his report displaying the fact that since the implementation of the U-Pass there has been a fifty percent increase in transit riders and a twenty percent decrease in single-car drivers (pg. 2). He shows that a reason for this increase is due in large part to one key strategy. Increasing the cost to use your car at school via parking prices etc., while providing a viable alternative for transportation via the U-Pass. Senft uses an example where the city of Victoria was strategically increasing parking prices during busy traffic times. They saw that within a year that the number of single occupant drivers had gone down and that public transportation use had gone up, increasing the efficiency of driving in Victoria. Although the school is forcing students into using the U-Pass, the university sees it as a way to support the students providing alternatives and a better system for the city of Kelowna in general.

Senft explains that as a university grows demand for parking will also grow, the problem with this is that parking space availability stays the same or can only grow to a certain level. This problem can be solved using the public transit system.

Senft acknowledges that the university is forcing students into paying for something they didn't choose to pay for won't go without dispute. The university also realizes this, but they believe it is the better system that will help everyone in the long run as Senft has shown in this case study.

Understanding UC Riverside's U-Pass Program and Student Ridership by Victoria Maria Ciudad-Real

The goal of this report was to find out how students feel about the U-Pass program, if they are likely to use it, and how the U-Pass program can be improved. Although this report is based on data from California, the U-Pass system works the same way and the report is useful to us.

After surveying students, Ciudad-Real found in general that most students liked and more importantly used the U-Pass program. She found that only fifteen percent of students said they have never used the bussing system (pg. 11). Of the fifteen percent, little to none of those inactive riders did not have a reliable transportation method. In other words, everyone who didn't ride the bus had a car or other method.

Students were asked to rate how they feel about the U-Pass system on a scale from 1-5, with 1 being very poor and 5 being very good. The average score was 3.5, with no score less than 3 which was adequate and only one score of a 5 (pg. 13). When asked about this, students gave some of the following answers to why they liked the U-Pass. They don't have to pay for parking or any other fee involved with owning a car, they liked helping the environment, and lastly many students simply rely on this service. The main problem with the U-Pass was wait times for busses, which can be solved by increasing the demand for bussing and the city increasing the bus frequency.

This report can be summed up best by what a student who relies on the bussing system to get to school said that without the U-Pass system they would not be able to attend school. The U-Pass program is great because it offers people who may not have been able to afford schooling to educate themselves.

An Economic Analysis of the Effects of the U-Pass on Transit and Single-Occupant Vehicle Ridership by Ayesha Hafeez

The purpose of this report is to answer the question if the use of the U-Pass program actually reduced the use of single occupant vehicles and increased the number of people using the public transit system. The goal of the university was to reduce single occupant vehicle use by twenty percent, Hafeez conducted a thorough analysis to see if this actually happened.

Hafeez examined popular bus routes and found that almost all of the routes had a substantial increase in ridership, with an increase of up to 135% on a certain bus route. The predicted increase of ridership on two other routes were 2.1% and 9.7%, these two routes saw an increase of 78% and 90% (pg.18). This increase far surpassed expectations and resulted in a lower number of single occupant vehicle users. Hafeez accredits this to increasing gas rates, and parking rates. She found that after studying one particular parking lot there was a decrease in use of 21% (pg. 25).

Hafeez was able to conclude that increasing certain bus route frequency would furthermore increase the use of the U-Pass and continue to reduce the amount of single occupant vehicles.

U-Pass BC Program Survey 2018

This particular survey was conducted in metro Vancouver in order to better understand usage and preference of travel as a consequence of the BC U-Pass system. It focused on 10 post-secondary institutions and had a wide range of students and graduates in order to have a fair representation of all who qualify for the U-pass BC program.

This survey reveals a lot of good information and statistics which give insight into the benefits of having the program apply to staff and faculty. Staff would most relate to the graduates where the survey indicates that three years post graduation over half of graduates take transit at least once a week. The survey also shows the main causes for taking transit such as convenience and cost. These both still apply to staff as they also have to deal with the cost of owning and maintaining a vehicle as well as dealing with rising gas and parking costs. As well it is indicated that there is a desire to use transit more once the user is more comfortable with the city and the routes and furthermore that it is more appealing due to the lower stress of not having to drive or find parking.

Overall the survey hosts a lot of interesting data which may be extrapolated off of to incur logical assumptions about how a U-Pass for staff and faculty may impact those using it as well as the school.

U-Pass BC To Save Students On Transit Fares

This news article discusses the benefits of the U-Pass for all British Columbian post secondary institutions. The main aim of the U-Pass is to save students on transit fares as many students rely on transit to get to school because owning, operating, and parking a car can be very expensive. It also states having such a huge cost gap between transit and a personal vehicle will lead to a more transit heavy culture causing less congestion and greenhouse gases. A U-Pass for faculty and staff will also give them a cheap means to contribute to being environmentally friendly as well as save money for larger priorities.

Elements of Successful Universal Student Transit Pass Programs from Planning to Implementation: A Benchmark Study

This research article aims to discuss and evaluate exactly what is in the title. This article more specifically analyses the impact of a U-Pass system with three different parties being the focus: transit agencies, university, and students. This article was put together using various sources such as online surveys, case studies, literature and online resources. This as a resource may be used to enhance existing systems or help give a perspective to expand it to staff and faculty.

The most successful implementation of a U-Pass system is stable funding, broad support, identified benefits, ongoing marketing, and formal agreements. With a U-Pass already in practice in BC and UBCO specifically that would make it much easier to attain some of these points easier when extending the pass to staff.

The main takeaway from this article is if implemented properly a U-Pass for anyone at a university will have major benefits such as how it benefits transit agencies, students/staff and institutions. These benefits come from increased use of transit during time at university as well as after, reducing costs of travelling to and from university, and reduces congestion and frees up parking space. There

is also a side effect of reduced stress from the aftershock of saving money and avoidance of congesting driving and finding parking.

U-PASS: A Model Transportation Management Program That Works, by Michael E. Williams And Kathleen L. Petrait

This article documents the implementation of a U-PASS program in The University of Washington, involving benefits for students, faculty, and staff, currently at 75% participation rate (Williams, n.d.). The paper primarily explores how after a single year of operation, the environmental impact and overall costs of all involved parties have significantly decreased.

Williams and Petrait report that involving faculty in the program freed up a lot of the already limited parking spaces available on campus, allowing the university to rent the space out to more students and visitors. The carbon footprint of the university campus also significantly dropped, with “36,000 participants” out of the “50,000 people in the university community,” increasing in number as the program grows. The funds for this project were extracted from parking system revenue funds (after raising the parking fees to market rate, profiting the University further), subsidized monthly U-PASS user fees from participating students and faculty, and other various sources of funding that the university had procured (Williams, n.d.).

The program upped the use of transit systems by 35%, created a significant decrease in traffic en-route to campus, and helped users who lived close to campus feel safer travelling at night-time. The encouragement of the university towards using U-PASS as often as possible, as opposed to individual commuting via cars or bikes, led to an observed decrease in the city’s overall traffic count and pollution levels as well (Williams, n.d.).

Although Williams and Petrait document the program as being in its initial stages in 1992, it can be concluded from this article that involving as many members of the campus community as possible in the implementation of such a program is not only beneficial for the promotion and economical gain of the university campus, but also helpful to the environment and promotional towards sustainable travel.

Greenhouse Gas Emission Baseline: Students, Faculty and Staff Commuting to the University of British Columbia by Jonathan Frantz

This report calculates the Greenhouse Gas (GHG) emission rates at the Vancouver campus of UBC, and explores the factors that affect these rates. These factors take into account aspects such as commuting to and from campus, medium of commute, commuter frequencies and the university population. After rigorous calculations and estimations, Frentz concludes that the U-Pass at UBC, implemented in 2003, has significantly decreased the Greenhouse Gas Emissions of the university campus. The report thus serves as an analysis of the effectiveness of the U-Pass in reducing environmental impact.

Since “UBC is the second most travelled to destination in the City of Vancouver” (Frentz, 2003, pg. 5), the “students, faculty, and staff that commute to UBC produced about 30,544 tons of CO2e in 2002” (pg. 17). Despite this number being higher than the emission rates in 1997, Frentz discusses how “the commuting population grew by 10% between 1997 and 2002, yet GHG emissions only grew by 6.73% over that same time period, which means that the per capita GHG emission rates are decreasing” (pg. 17). Frentz also suggests further research into the matter, and more reliable data collection methods to evaluate the future trends of UBC’s emission productions and potential decreases in it. He concludes that the use of a U-Pass will in fact reduce the school’s environmental footprints by great amounts.

Therefore, it can be observed from Frentz’s in-depth analysis that although he lacks in precision of data collected at the time the article was written, providing students with the benefits of the U-Pass influenced benefits for the environment and university as a whole, bettering UBC’s image and standard and helping the City of Vancouver. As seen from the exploration of the various other articles above, there is more to gain from widening the reach of UBC’s U-Pass program and extending its benefits to the staff and faculty as well, such as financial advance, publicity, more parking space, and an even better ecological footprint, taking a step further towards global betterment.

Developing ecological footprint scenarios on university campuses: A case study of the University of Toronto at Mississauga by Tenley M. Conway et al.

This journal article explores different factors that affect the ecological footprint of the University of Toronto at Mississauga (UTM), to determine how best to decrease it. Conway et al. explain that in evaluating such a statistic, there is a certain amount of uncertainty, as it is almost impossible to have entirely accurate data collected, and that there is no given and/or approved threshold for an ecological footprint for a university campus, making it hard to evaluate how much of a decrease might need to be implemented. The study finds that “69% of the campus footprint is due to energy consumption,” and “the second largest category is transportation, at 16%” (Conway et al., 2008).

The article makes reference to UBC’s implementation of the U-Pass (Urban Systems) to minimize its impact, and assumes that “about 30-50 percent of student carpoolers and solo drivers would potentially switch to public transit” if given the option. This statistic would also apply to staff and faculty, if the U-Pass was provided as an option for them as well, further decreasing the university’s ecological footprint. The study reveals that the current footprint of the article, written in 2008, was found to be a hundred times larger than the size of the university campus. To decrease this amount, Conway et al. inform the reader that the university is exploring implementation of solar energy systems, as well as U-Passes for students.

Seen through the extensive research in this report, supported by numerous sources from different time periods and regions, it can be concluded with general consensus that having a U-Pass for UBC Okanagan staff and faculty would positively impact the ways in which the university affects its surroundings in all perspectives, including socially, financially, and ecologically. As well, this would further promote the university in its globally known pursuits of betterment, and the benefit provided to the members of UBC’s community would positively reflect upon the university’s care towards them.

Methodology

This report delves into the beneficial and negative aspects of extending the BC U-Pass to the staff and faculty at UBCO. Will the U-Pass have the same benefit and usefulness that it has already given to students or be an option mainly left unused once extended to staff. The main variables affected are costs, convenience, time, stress. A well implemented and utilized program may come out as being very beneficial overall.

This report mainly focuses on surveys and research done showing the effects the BC U-Pass has already had on many students at universities around the province as well as some other studies done analyzing the topic. Separating the research gathering to several members helps to diversify the sources and their material in order to give a thorough representation of data and ideology. Making sure the sources are well respected, peer reviewed and relevant to the topic at hand. There is little research or data pertaining to a U-Pass specifically for staff and faculty. Thankfully this is not a large issue as staff and faculty often have very similar lifestyles, timetables, and issues pertaining to transportation as students do. Therefore much of the data gathered may be used in order to have a good understanding of how it would apply before it is ever implemented. Another method of research which would have come in handy would be doing a survey of the UBCO staff and faculty to have real hard numbers pertaining to the exact group this would apply to. Unfortunately we lack the resources necessary to do this.

The majority of the analysis will be based on costs and numbers gathered through research such as survey percentages and cost figures. This is a good approach as the majority of decisions made for these kinds of projects are largely economically based. Showing an economic benefit to the institutions as well as the staff and faculty there is hardly any objection to implementation and this can be applied to many other universities across the province that are in a similar situation as UBCO.

Data and Analysis

Since the U-pass program requires a hundred percent adoption, all students must pay for the program as part of their tuition fees, but not all students activate and use the U-pass. The majority of students do however choose to activate and use the U-Pass for public transportation during their university studies. Based on research, about 54% of students have their U-Pass activated for a minimum of four years, 34% have their U-Pass activated for two to three years and only 13% students have their U-pass BC only one year or less. This demonstrates that the U-pass is utilized and overall reduces the cost of transportation for a large number of students. When these graduates are asked about why they chose to use the U-pass program they mention that it is a cheaper option than driving and parking and in addition provides a lower cost versus regular fare. The figure below shows the percentage of students that activate their U-pass for either 1 year or less, 2-3 years or 4 years and greater.

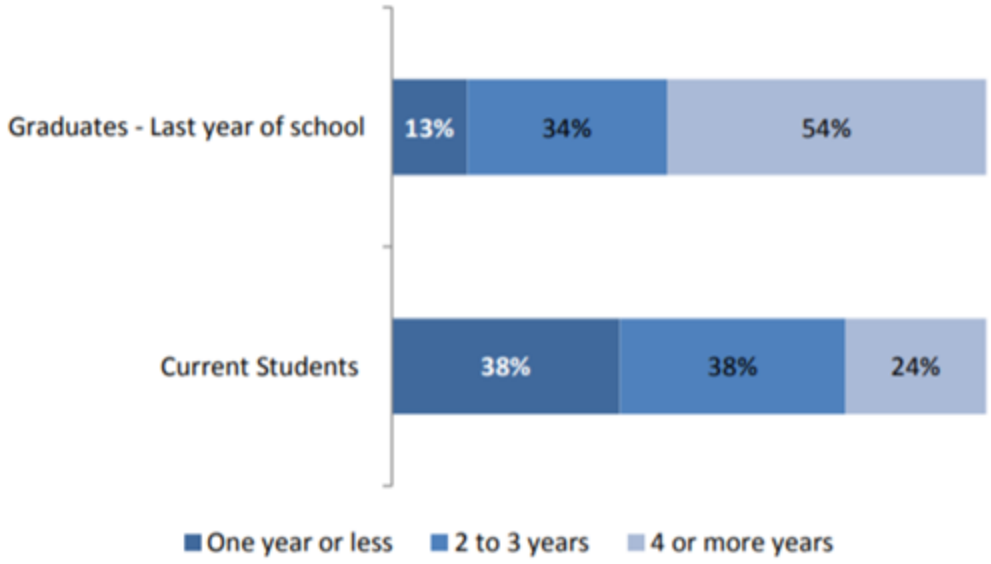

Figure 1: number of years with U-pass BC (among those who active their U-Pass)

The benefit of having a U-pass in UBC is significant. The benefits are demonstrated in the research survey, where the respondents provide three top reasons about why they choose to utilize their U-Pass. The top reason according to the respondents which were graduates and undergraduates was that the U-pass provided a transportation option for the students who do not have a car (58% list

it at their top three reasons, and 28% list it as their top reason). The second most popular benefit is that the U-pass provides a cheaper option than driving a car and finding a parking place (about 48% rank it as their top 3 and 20% students rank it as their top). The third ranked benefit is that the U-pass provides a lower than regular fare options (47% rank it as their top 3 benefits and 23% choose it as the top benefit). In BC the regular price of the bus ticket is $2.75, and if a student was to take the bus twice daily to and from campus, it will cost them a minimum of 2.75*(5*4) = $55 every month. In other provinces, the cost for public transportation fare is more expensive than BC. In addition, other than a means of transportation to campus, students also need to access grocery stores and other shops. The U-pass helps a lot in these cases, especially when students or faculty have no other means of transportation like their own vehicle. The figure below shows the percentage of students that ranked each benefit of the U-pass as their top choice or in their top three choices.

BENEFITS	GRADUATES – LAST YEAR OF SCHOOL		CURRENT STUDENTS	
	% TOP BENEFIT	% TOP 3 BENEFIT*	% TOP BENEFIT	% TOP 3 BENEFIT*
Provides a transportation option for students without access to a vehicle	28%	58%	31%	61%
Cheaper than driving and finding/paying for parking	20%	48%	16%	45%
Lower cost than regular fare options	23%	47%	20%	44%
Can travel within all zones	9%	33%	8%	30%
Promotes the use of public transportation	7%	25%	4%	17%
Reduces greenhouse gas emissions/Good for the environment	1%	17%	5%	25%
Ability to do other things while commuting (study/work, reading, sleep)	2%	14%	2%	15%
Easier/faster than purchasing a monthly passes/tickets	2%	13%	4%	17%
Decreases reliance on motor vehicle	2%	11%	3%	13%
Do not need to carry change/cash for fares	2%	10%	4%	13%
Reduces traffic congestion	1%	10%	1%	12%

Figure 2: benefit of having U-Pass BC (among those who active their U-Pass)

Based on the results from the study, it is evident from figure 2 that there are numerous benefits for students who choose to activate their U-Pass. In addition to these benefits, other benefits include environmental sustainability, traffic reduction by use of public transportation, and an efficient method of ticket purchasing. The result of why the U-Pass BC provides great benefit for students will be proved by the following calculations.

First, by using the method of MAE, let's analyze by using three different criteria which includes cost, study, environment and safety. Since the respondents are mainly graduates and undergraduates; we weigh the cost, ability to study during transportation, environmental friendliness and overall safety as 2, 3, 2 and 3 respectively. For example, based on our consideration if you are taking the bus students are able to study while they are taking the bus, giving it a score of 10 for this criteria. For cost, walking by foot clearly gives the highest score. Environmental friendliness would be the highest for by foot and bike transportation. In addition, taking the bus would yield the highest safety score. According to the MAE, the best method of transportation would be taking the bus.

Comparison of different types of transportation for students:
By using the method of MAE:

Criteria	weights	take bus	Drive	by bike	on foot
cost	2	8	1	9	10
study	3	10	1	1	5
enviornment	2	8	1	10	10
Safety	3	10	5	1	5
Total scores	10	92	22	44	70

Total Scores Calculation:

taking Bus: $2\times8 + 3\times10 + 2\times8 + 3\times10 = 92$

Driving: $2\times1 + 3\times1 + 2\times1 + 3\times5 = 22$

By bike: $2\times9 + 3\times1 + 2\times10 + 3\times1 = 44$

safety: ~~5×10~~ $2\times10 + 3\times5 + 2\times10 + 3\times5 = 70$

Figure 3: Multiple Account Attribute Table

We then draw the cash flow diagram for graduates and undergraduates who are taking the bus to campus daily and see their cost per term. The cash flow diagram for students taking the bus is an

annuity or uniform series. The savings a student makes is significant as evident from the cash flow diagram. If a student was to pay a regular concession rate twice daily, each term they would be paying a total of $682 versus the $63 per term for the U-pass.

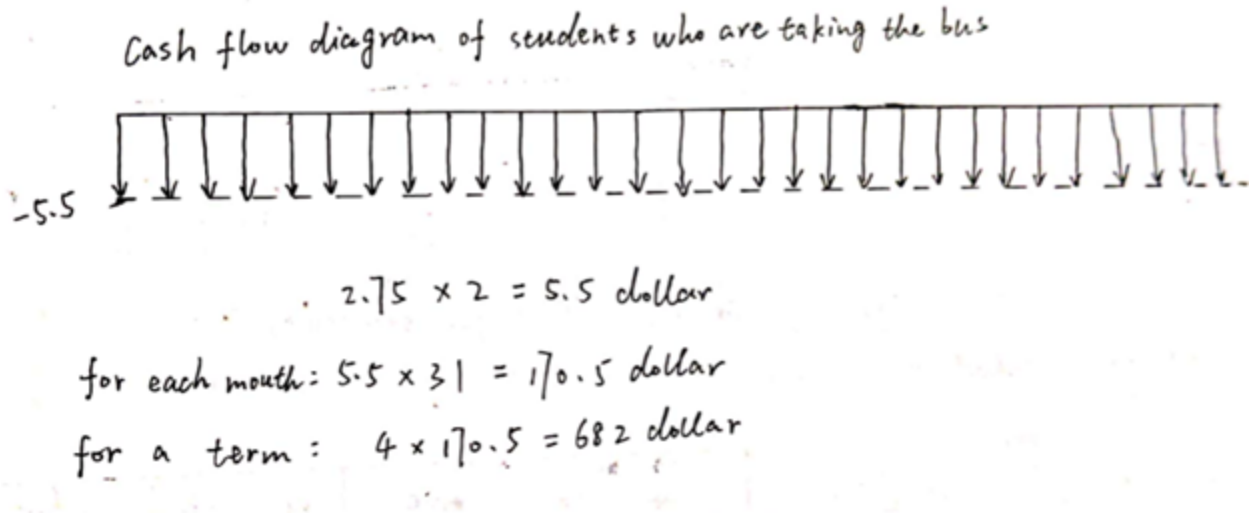

Figure 4: Cash Flow Diagram

Sensitivity and Risk Analyses

In order to effectively estimate the project's parameters; sensitivity plots, scenario analysis and a Monte Carlo simulation was performed. Through analysis the U-pass programs degree of sensitivity to changes in project parameters can be effectively observed. These parameters include; initial investment of the program, repair and maintenance related to the introduction of the program, fuel cost due to increased ridership , staff salary required, annual earning from U-pass fees and MARR.

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Cost Category	Base Case
Initial Investment	$5,000,000
Annual Repair and Maintance	$150,000
Annual Fuel Cost	$100,000
Annual Staff Salary	$200,000
Annual Earning from U-pass	$950,000
MARR	10%

Figure 5: Sensitivity Analysis Data Table- Base Case

Cost Category	-10%	-5%	Base Case	5%	10%
Initial Investment	$4,500,000	$4,750,000	$5,000,000	$5,250,000	$5,500,000
Annual Repair and Maintance	$135,000	$142,500	$150,000	$157,500	$165,000
Annual Fuel Cost	$90,000	$95,000	$100,000	$105,000	$110,000
Annual Staff Salary	$180,000	$190,000	$200,000	$210,000	$220,000
Annual Earning from U-pass	$855,000	$902,500	$950,000	$997,500	$1,045,000
MARR	9%	9.5%	10%	10.5%	11%

Figure 6: Sensitivity Analysis Data Table- Pessimistic and Optimistic Cases included

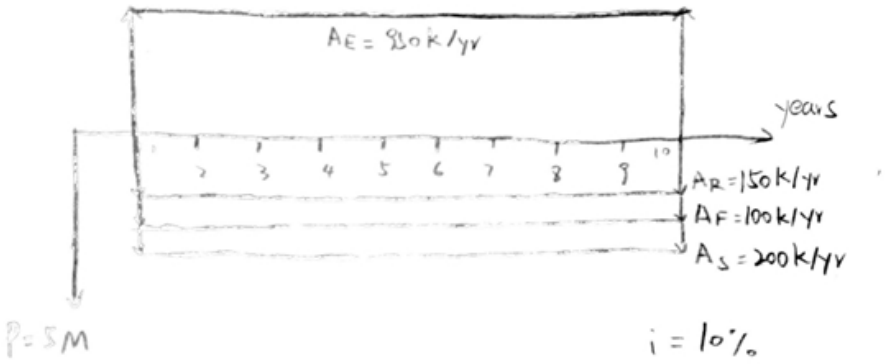

Figure 7: Cash Flow Diagram- Base case only

Economic Model:

NVP = $-P+(A_E-A_R-A_F-A_S)$ (P/A, 10%, 10)

=-5,000,000+(950,000-150,000-100,000-200,000) *(6.145)

=-1,927,500

Cost Category	-10%	-5%	Base Case	5%	10%
Initial Investment	$4,500,000	$4,750,000	$5,000,000	$5,250,000	$5,500,000
Annual Repair and Maintance	$135,000	$142,500	$150,000	$157,500	$165,000
Annual Fuel Cost	$90,000	$95,000	$100,000	$105,000	$110,000
Annual Staff Salary	$180,000	$190,000	$200,000	$210,000	$220,000
Annual Earning from U-pass	$855,000	$902,500	$950,000	$997,500	$1,045,000
MARR	9%	9.5%	10%	10.5%	11%
NVP	($1,734,750)	($1,831,125)	($1,927,500)	($2,023,875)	($2,120,250)

Figure 8: Sensitivity Analysis Data Table

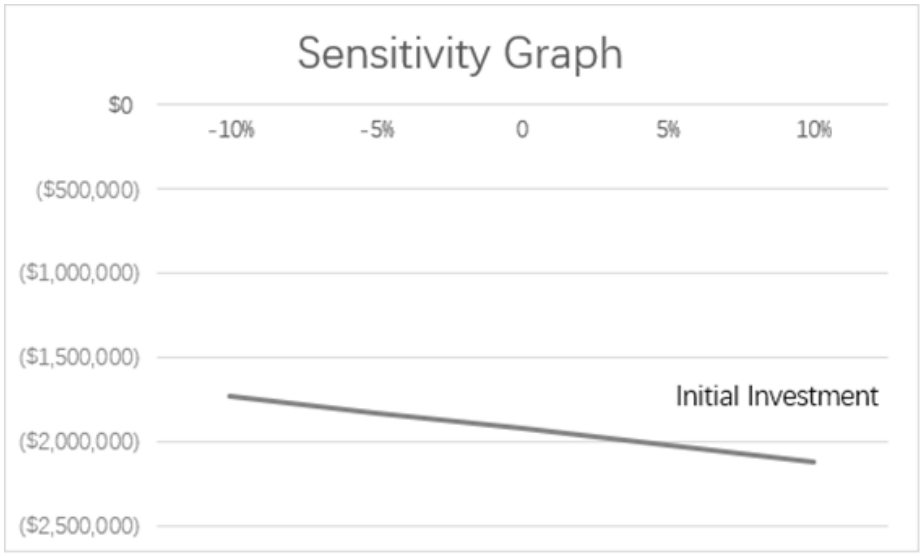

Figure 9: Sensitivity Graph

Present Worth of Variations from Base Case

Cost Category	-10%	-5%	0	5%	10%
Initial Investment	-1734750	-1831125	-1927500	-2023875	-2120250
Annual Repair and Maintance	-1,721,250	-1,824,000	-1,927,500	-2,031,750	-2,136,750
Annual Fuel Cost	-1,743,750	-1,835,875	-1,927,500	-2,018,625	-2,109,250
Annual Staff Salary	-1,788,750	-1,859,625	-1,927,500	-1,992,375	-2,054,250
Annual Earning from U-pass	-2,589,750	-2,282,375	-1,927,500	-1,525,125	-1,075,250
MARR	-3,017,250	-2,508,000	-1,927,500	-1,275,750	-552,750

Figure 10: Sensitivity Analysis data table: Present worth of ariations from base case

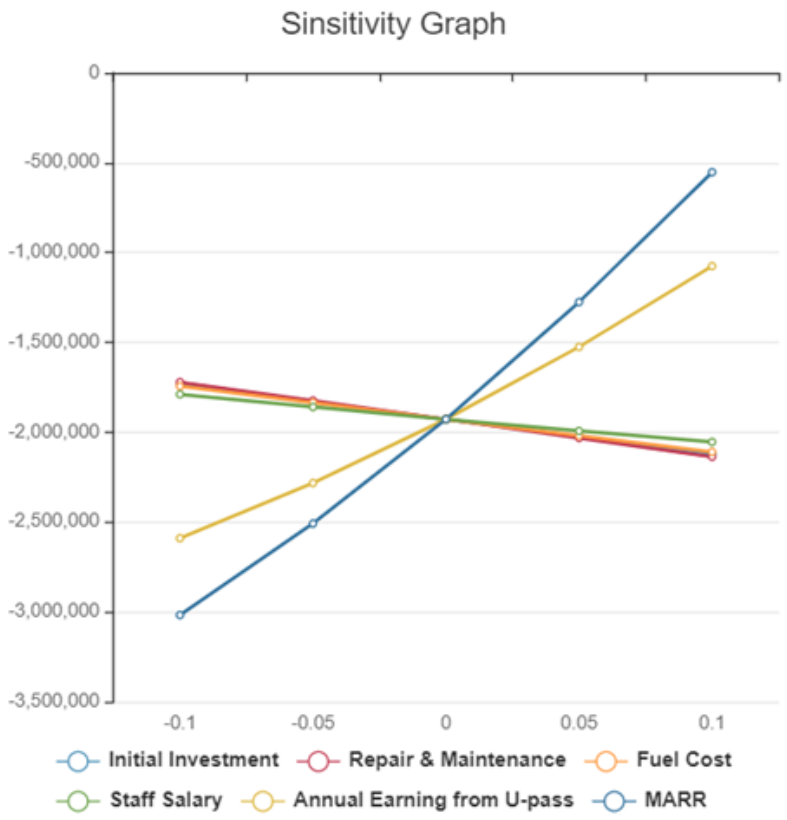

Figure 11: Resulting Sensitivity graph: Present Worth of variations from Base case

Monte Carlo Simulation

A Monte Carlo simulation was performed in order to account for risk related to the U-pass programs extension to faculty. Utilizing the randomization of variables, the cash flow elements within the economic model are randomized. This randomization effectively addresses the uncertainty when considering multiple possible outcomes. As the number of simulations is increased, the confidence of the developed probabilistic distribution also increases. When performing the simulation, the process is subsequent to the following steps; develop an economic model, establish an appropriate cumulative distribution function for each input variable, perform and repeat random sampling for each variable and its CFD, and categorize each result for effective interpretation.

CFD

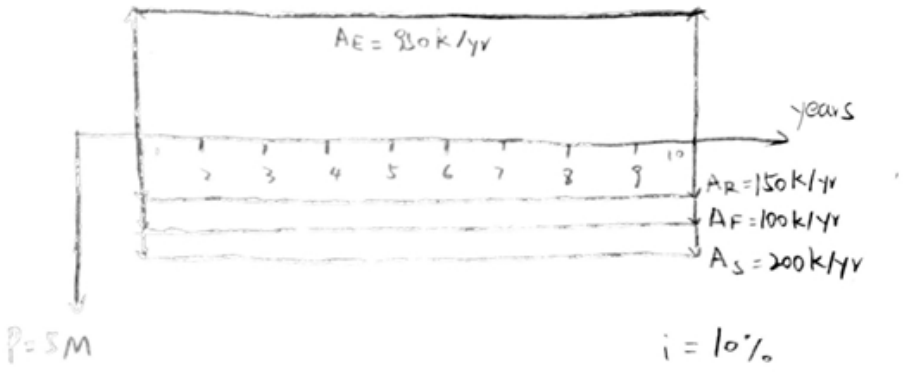

Figure 12: Cash Flow Diagram

$PW=P-(A_E-A_R-A_F-A_S)\ (P/A, 10\%, 10)$

First Cost	Probability	Annual Benefit	Probability
$4,500,000	0.2	$450,000	0.2
4750000	0.2	$475,000	0.2
5000000	0.2	500000	0.2
5250000	0.2	525000	0.2
5500000	0.2	550000	0.2

Figure 13: Probability Distributive Function for Input variables

Use Random Numbers to select input variables

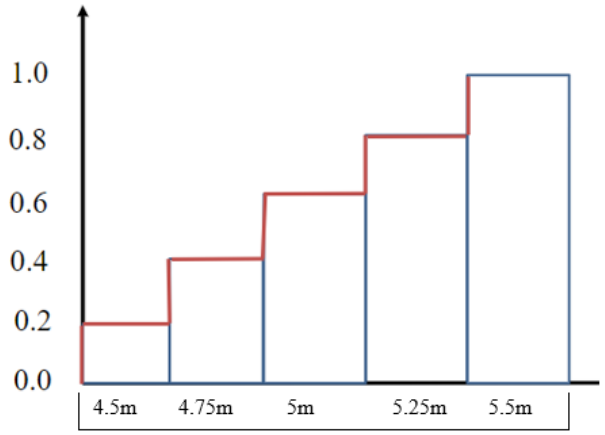

Figure 14: Cumulative Distribution function for First Cost

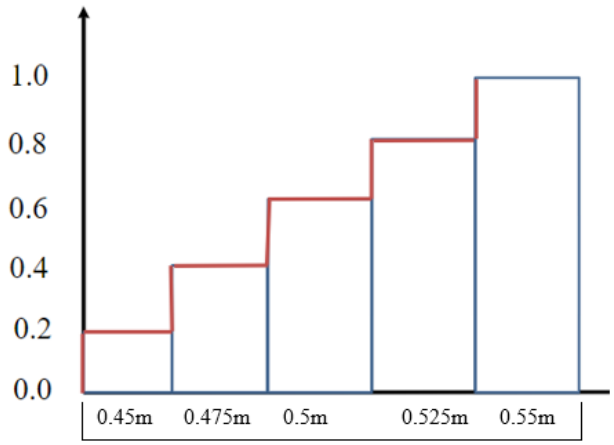

Figure 15: Cumulative Distribution function for Annual Revenue

Sample	Z1	Cost	Z2	Revenue	PW
1	0.93025	5500000	0.13213	450000	8265250
2	0.29637	4750000	0.85212	550000	8129750
3	0.65443	5250000	0.76511	525000	8476125
4	0.98626	5500000	0.36265	475000	8418875
5	0.87463	5500000	0.23461	475000	8418875

Figure 16: Repeated Cumulative Distribution Function Random sampling (only first 5 of 200 samples shown)

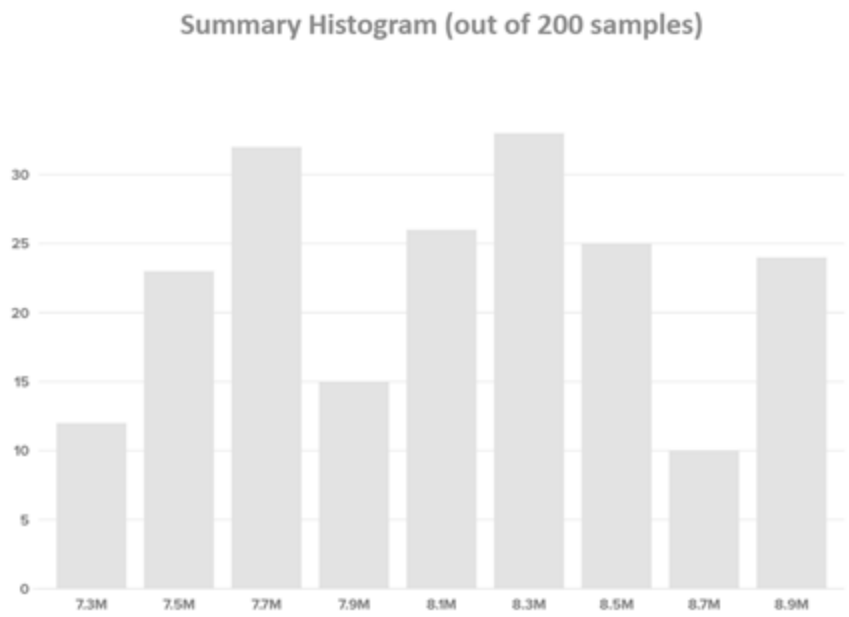

Figure 17: Frequency graph of categorized results rounded to the nearest odd decimal million(ie.1.1-1.3-1.5 million)

Expected Value:

$EV(PV)=(7.3*12+7.5*23+….+8..7*10+8.9*24)/200$

$=8.113M$

Variance:

$Var(PV)=((12/200)*(7.3-8.113)^2+((23/200)*(7.5-8.113)^2+…+((24/200)*(8.9-8.113)^2)$

$=0.2296$

Standard Deviation:

$=(0.2296)^{0.5}=0.4792$

Maximum PW:

PW=8.9M

Minimum PW:

PW=7.3M

Probability PW is less than 8M:

Pr(PW>8M)=59%

Results and Discussions

Through literature reviews, data analysis, sensitivity analysis and various research sources the interpretation can be made that the extension of the U-pass program does in fact make sense and would be beneficial. UBC is well known for its diversity amongst its student and faculty members. Much of the staff and faculty come from various countries around the world, meaning an immediate method of transportation using the U-pass without the need to have access to a personal vehicle would be beneficial. In addition, while providing faculty with a reliable, safe, eco-friendly, cost-effective community to campus, this also reduces the overall traffic congestion within the city and amongst communities which reside around the campus.

Through various sources of research, it was observed that the majority of students who attend university that implement the U-pass program activate and utilize the U-pass. Many graduates and undergraduates are in positions in which they don't own a personal vehicle, meaning having access to a cheap fare for public transportation would be beneficial. Further studies have proven majority of graduates and undergraduates who use the U-pass feel that public transportation; provides them with a means to transportation and provides a cheaper option then driving and parking Through evaluating the success of the program amongst graduate students it can be also inferred that the effectiveness of the program would apply to the extension of the program to faculty members

But it can also be noted that there are also cons to the introduction of the U-pass to faculty members. The main issue that exists is the 100 percent adoption rate that exists with the U-pass

program. Meaning some faculty that are not in the position to take public transit due to various reasons (which could include research positions or those enrolled thesis study programs) are forced to pay for the U-pass when they would not be using it. Another challenge of implementing this in the university would be the initial funding and governmental support (from the City Council) that would have to be filed for by the university. The work and processing time that would go into that may seem disadvantageous, but would be beneficial in the long run, if such a plan were to be implemented.

Sensitivity analysis has shown that net present values follow a negative trend as initial investment or first cost is varied and increased. In addition, through sensitivity analysis it was shown that the most sensitive parameters which cause net present value to vary are initial cost and the annual earning from the U-pass. These factors require close attention when extending the U-pass program to faculty. It was also observed that our net present value is negative in all optimistic cases, base cases and pessimistic cases. Although the NPV of the program is negative, the various benefits (socially, economically, environmentally) which it would bring to faculty members, students (graduates and undergraduates) and the surrounding communities would outweigh the economic viability.

Through Monte Carlo simulations, the probability of various events occurring can be quantified. It was observed that there is no probability that the present worth will be negative or equal to zero. This would mean the probability that the present worth is positive is 100 percent and in addition the probability of the present worth exceeding 8M is 59%. This implies that the project is viable since the chance of making money (above 8M) is 59% and the probability of a positive present worth is 100%.

Conclusions and Recommendations

In conclusion, the U-Pass system was made to provide a cheaper and more environmentally friendly option for students attending the university. Through our research and analysis, we have discovered that it significantly causes a positive effect on students, and they are inclined to use the buses over other methods of transportation throughout their university career instead of getting their own vehicles and searching for parking spots on campus, which are very competitive and costly to get generally.

Faculty should be added to the U-Pass program as they share similar lifestyles and transportation destinations to the students; this can help reduce single-occupant vehicle riders which will consequently lead to a decrease in daily traffic and congestion on campus and throughout the city.

However, the U-Pass option should not have a 100 percent adoption rate and be forced upon students and faculty. In some cases it will just increase expenses on people that have their own vehicles and prefer to commute using them.

Future Research

The future of the U-Pass program has been a topic of discussion for many universities spanning across North America. The U-pass is considered as a relatively new program, and as with any new program, there is always room for improvement. Problems that should be improved upon consist primarily of the costs associated with the U-Pass and the increased demand for public transportation affecting the loading capacity of the buses. Further research upon these concerns will increase the effectiveness of this program in the long-term.

The goal of the U-Pass is to increase ridership of public transport as opposed to driving, aiming to cut costs for students and decrease fuel emissions. (“U-Pass Review Final Report”, 2005). In a report conducted by UBC, it mentions that with the implementation of the U-Pass program, transit ridership has significantly increased, resulting in service reliability issues (“U-Pass Review Final Report”, 2005). The future of the U-Pass relies heavily on the adaptability of transit systems in becoming more efficient in incorporating larger masses of people. A possible solution to further improve the transit system is the implementation of all-door boarding as it reduces crowding and loading times (“U-Pass Review Final Report”, 2005). All-door boarding requires that passenger waiting areas be controlled by supervisors or physical barriers, which can be costly in the short run. However, further research upon incorporating all-door boarding with minimal to no supervision required could eliminate the costs associated with controlled waiting areas. All-door boarding can be a cost-effective and beneficial long term solution to improving transit which will, in turn, benefit all members involved. Students will be able to get to campus in a shorter time and bus drivers will deal with fewer crowds and faster loading times.

If the connectivity of the Transit route was improved, student drivers could be convinced to make the switch to using their U-Pass and stop bringing their cars to school, enabling them to save on parking and fuel while simultaneously reducing their negative impact on the environment. Nonetheless, there continues to be a large number of non-users who rely on their cars to get to campus. In regards to UBC, they incur costs of 1.3 million per year for the U-pass and 1.15 million of that cost reflects the

subsidies (“U-Pass Review Final Report”, 2005). A portion of this subsidy comes at the expense of car owners, as the prices of parking permits at universities are inflated (“U-Pass Review Final Report”, 2005). Although students have increased their use of transit, there are still a large number of car users who disagree with the mandatory nature of the U-Pass program. More research in finding corporate sponsorship for further funding will allow for decreased dependency on the subsidies incurred from car owners.

Furthermore, U-Pass advertising should be promoted, especially for car owners who indirectly benefit from the program. With an increased amount of students using transit, there is less congestion on the road, therefore a decrease in commuting time which in turn conserves gas ("The U-Pass: An Economics Perspective ", 2015). Car users can save money on the services they do use by paying for a service they might one day use. Advertising the eco-friendly program along with the benefits for car users will increase compliance from both non-users and users.

The future of the U-Pass is optimistic due to its cost-efficiency for all members involved. The program has been effective in increasing ridership and decreasing fuel emissions in the cities that have incorporated the U-Pass. Research on all-door boarding can further improve the overall efficiency of public transit by reducing crowding and loading times. Additionally, the dependency on subsidy obtained from car owners can be decreased by finding corporate sponsorships to aid the funding of the program. Finally, increasing U-Pass advertising as an eco-friendly program and expressing the benefits to all members will increase acceptance from both non-users and users.

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Appendices: Appendix A

TERM PROJECT DELIVERABLES:
Each team shall submit a written report, as follows:

1. REPORT: Due by midnight on Wednesday April 8th – submit ALL materials (see items a. to d. below for the list) by CANVAS ASSIGNMENT to your instructor (Please do NOT e-mail large files), as follows:
    a. Term Project REPORT (maximum 10,000 words), submitted electronically in MS Word (.docx) format to your instructor by midnight on Wednesday April 8th. Its content should reflect: 1) good research on your assigned topic; 2) both pro/con perspectives of the issue; and, 3) arguments used/rebutted in your assigned position/bias (pro or con). Its format shall follow standard engineering report format, including sections titled:

        Abstract
        Introduction
        Problem Statement
        Objectives
        Team ((including list of team members and their respective efforts on each part of this project report)
        Literature Review
        Methodology
        Data & Analysis
        Sensitivity & Risk Analyses
        Results & Discussion
        Conclusions & Recommendations
        Future Research
        References (a minimum of 10 peer reviewed journal articles)
        Appendices (including sample calculations, data, and other supporting materials).

    b. The Final Report will demonstrate your ability to assimilate and apply ENGR 305 theory to real-world problems; your depth of understanding of how economics plays a key role in decision-making.
    c. Supporting ANALYSES – Electronic files in their original MS Excel, At Risk, and other formats necessary for the instructor to review and confirm your raw data collected, your analyses conducted, sensitivity and Monte Carlo analyses, your results, and software used.
    d. Turnitin report for your Term Project REPORT; Instructor to confirm logistics; ZERO mark without this.
    e. Instructor will assess your Term Project REPORT (worth 100% of your Term Project mark) based on the following marking rubric:
        i. Completeness of submissions (ALL of parts a, b, and c above) (10%)
        ii. Literature Review - scientific rigor, scope of search, minimum 10 peer reviewed journal papers or other widely respected sources (20%)
        iii. Data & Analysis - correctly applied economic principles and tools; a demonstrated application of MAE or AHP and a detailed cash flow diagram are required (20%)
        iv. Sensitivity & Risk Analyses – sensitivity plot, scenario analysis, and Monte Carlo Simulations required (20%)
        v. Discussions & Conclusions – based on your results and analyses (20%)
        vi. Professionalism – word choice, spelling, grammar, formatting, quality & clarity of graphics (10%)
    f. Be sure to include a page in your report describing what role(s) each member played in your term project.