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Executive Summary

This proposal documents the solution that addresses the Sustainable Transport theme. It introduces a convenient system, named “Hop-On”, for users to share bicycles. It is based on Internet of Things (IoT) concept and can be implemented with readily available technologies. Through the system, users can easily locate, book, lock and return bicycles through their mobile phone. It can be the solution for the “last mile” transportation at HDB towns or industrial parks. The tagline is “No one owns a bicycle, everyone enjoys bicycle rides”. The proposal also includes extensive study to assess the feasibility of the proposed solution.

1 Background

The Sustainable Singapore Blueprint 2015 outlines our national vision and plans for a more liveable and sustainable Singapore, to support the diverse needs and growing aspirations of Singaporeans. This blueprint is a plan for action and provides all of us a unique opportunity to work together to create a better home, a better environment and a better future that we can all be proud of. In terms of mobility, the goals include 700 km of cycling paths, 80% of households within 10-min walk of a train station, and so on. This is so to encourage higher ridership on public transport and achieve a car-lite city.

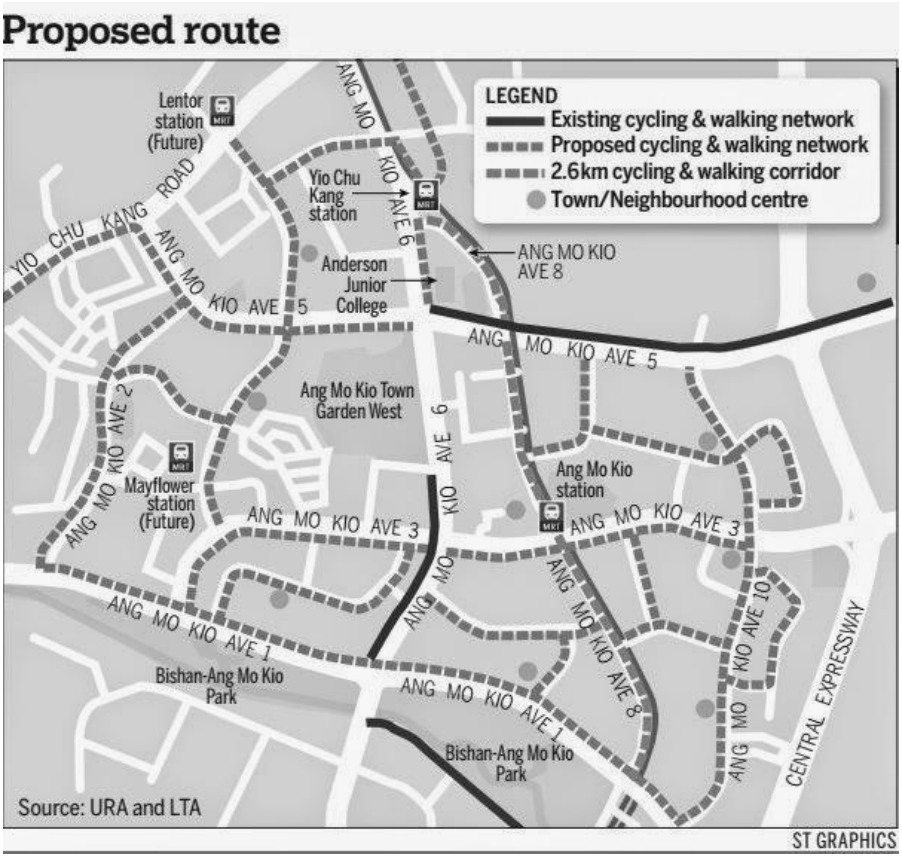

Figure 1: Proposed Cycling and Walking Network at Ang Mo Kio Town

Regrettably, it was noted that the bicycle theft in Singapore has remained high in the past few years. There was an average of 100 bicycles stolen each month between 2011 to 2014, according to the Singapore Police Force [1]. To avoid falling victim to such theft, bicycle owners have to keep their bicycles at home, ensure all removable bicycle parts are locked or secured, affix the Bicycle Security Label on the body of bicycle, etc. However, such measures cause inconvenience to the owners and their neighbours.

Another concern on owning of a bicycle is to find a parking space. Government will have to provide much more parking space for bicycles if more people are to own bicycles.

To encourage public transport usage and reduce traffic congestion in the city area, our government introduced Park & Ride (P&R) Scheme in 1990. The P&R scheme provides a cheaper and faster way for motorists to get to the city, by offering season parking rates at selected HDB/URA carparks. However, the scheme has not been popular as most of the carparks are some distance away from the train stations and there are other constraints, such as restricted operating hours and periodic renewal of season parking.

On the other hand, our country is building the World's first Smart Nation by harnessing technology to the fullest with the aim of improving the lives of citizens, creating more opportunities and building stronger communities. In May 2005, a high-level steering committee convened to spearhead the development of Singapore's 10-year masterplan to grow the infocomm sector and to use infocomm technologies to enhance the competitiveness of key economic sectors and build a well-connected society.

On top of these, there are other programmes and initiatives that encourage healthy lifestyle, such as National Steps Challenge and Steps for Good initiated by Health Promotion Board, Healthy Living Master Plan by Ministry of Health, Steptember Making Every Step Count from Cerebral Palsy Alliance Singapore, and many others.

2 Project Description

The proposed solution, named “Hop-On”, helps users in sharing means of transport. It is meant to address the challenges under the Sustainable Transport theme. Crafted based on the Sustainable Singapore Blueprint 2015, it aims to improve short/medium distance mobility and encourage car-lite travel, especially in mature HDB estates. In this proposal, the entity has identified bicycle as the transport mode, and targeted Ang Mo Kio town, a mature HDB town, which was highlighted in Walk and Cycle Singapore [2]. The solution consists of three components, namely the “Hop-On” Module, the “Hop-On” App and the “Hop-On” Station,.

2.1 “Hop-On” Module

The “Hop-On” Module is installed on every bicycles. Powered by rechargeable battery, the module is used to provide bicycles’ location, sense any unauthorised manipulation of the bicycles, provide indicators to users and sound alarm system. Users will release the e-lock in the module through “Hop-On” App before they are able to ride the bicycle. The entity will be able to track the location and usage of all bicycles through the module. To secure the module on the bicycle, it is welded onto the body of the bicycle and positioned at a convenient location for users to see the indicators. The casing of the module is totally sealed and weather-proof, though usage of bicycle is unlikely during downpour weather.

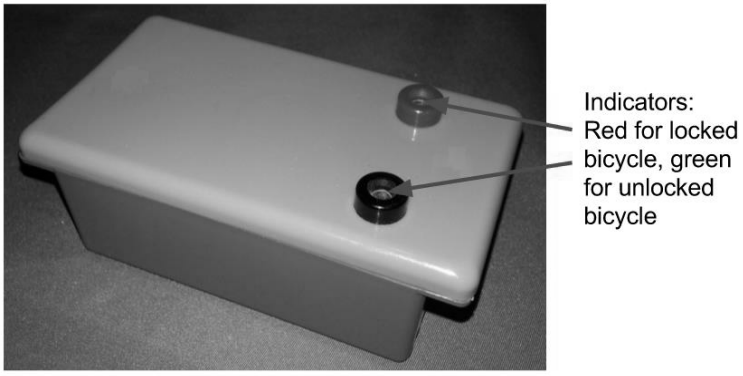

Figure 2: Proposed “Hop-On” Module

Figure 3: Proposed Bicycle with “Hop-On” Module

2.2 “Hop-On” App

The “Hop-On” App will be used by residents to register with the entity to become registered users. After activation, users will be able to use the apps to search, book and unlock available bicycles at nearby “Hop-On” Stations. After the users have finished riding the bicycles, they will bring the bicycles to nearby “Hop-On” Stations return them through “Hop-On” App. Upon returning, e-lock system on the “Hop-On” Module on the bicycle will be activated.

The apps also allow the user to check account information and report any fault, theft of the bicycle. Once the report is received, the entity will send out personnel to attend to the reported issues.

2.3 “Hop-On” Station

The “Hop-On” Station is basically the bicycle parking area. Bicycles provided by the entity can only be parked at the vicinity of these stations so that they are monitored and securely kept. Such stations will be setup at strategic locations, e.g. HDB blocks, MRT stations, bus interchanges, etc. At “Hop-On” Stations, one control box will be installed around the centralised location. The control box will sense the presence of “Hop-On” Modules, which are installed on each bicycle. The information will be uploaded onto the server, which can be extracted by the users through the “Hop-On” apps. The control box will also enforce the security of the bicycles through e-lock system and surveillance camera.

Figure 4: Proposed “Hop-On” Station with Control Box Installed on the Wall

2.4 Overall System

The proposed solution overall system is shown in Figure 5 below. For the control box, there are three main components, i.e. Bluetooth Low Energy (BLE), Global System for Mobile Communications (GSM) and internet protocol (IP) camera. The BLE will be used as beacon to sense and connect with BLE of nearby “Hop-On” Modules. The GSM will provide internet connection without much wiring necessary. The camera will capture image every 10 or 20 seconds. These images will be uploaded onto the web server and can be used to track any vandalism or theft of bicycles. The control box will be powered by wired AC lines.

In the “Hop-On” Module, there are seven components, i.e. BLE, e-lock, motion, battery, Global Positioning System (GPS), alarm and GSM. The BLE will be sensed by the control box and user’s handphone to confirm the presence of bicycle at the “Hop-On” Station. The e-lock can only be disabled by the “Hop-On” Apps of the user who made the booking. If the bicycle status is locked and motion is sensed, the status will be alarmed to the entity to check the condition of the bicycle. Rechargeable battery, such as lithium polymer, is used to power the module. It will be charged by the dynamo when the bicycle is paddled. The location of the bicycle when it is being used will be updated by the GPS. Any unauthorised handling of the locked bicycle will be warned by the alarm system. Similarly, GSM will connect the module to the web server for data updating.

The web server is managed by the entity and hidden from the users. It will keep track the usage of the bicycles, entries of report, accounts information and images storing. The entity can use the data to analyse the user behaviour and implement necessary improvement to the system, such as relocating of accumulated bicycles from one location to another location.

As mentioned before, the “Hop-On” Apps will be used by the users for checking availability, booking, registration, checking account status and reporting.

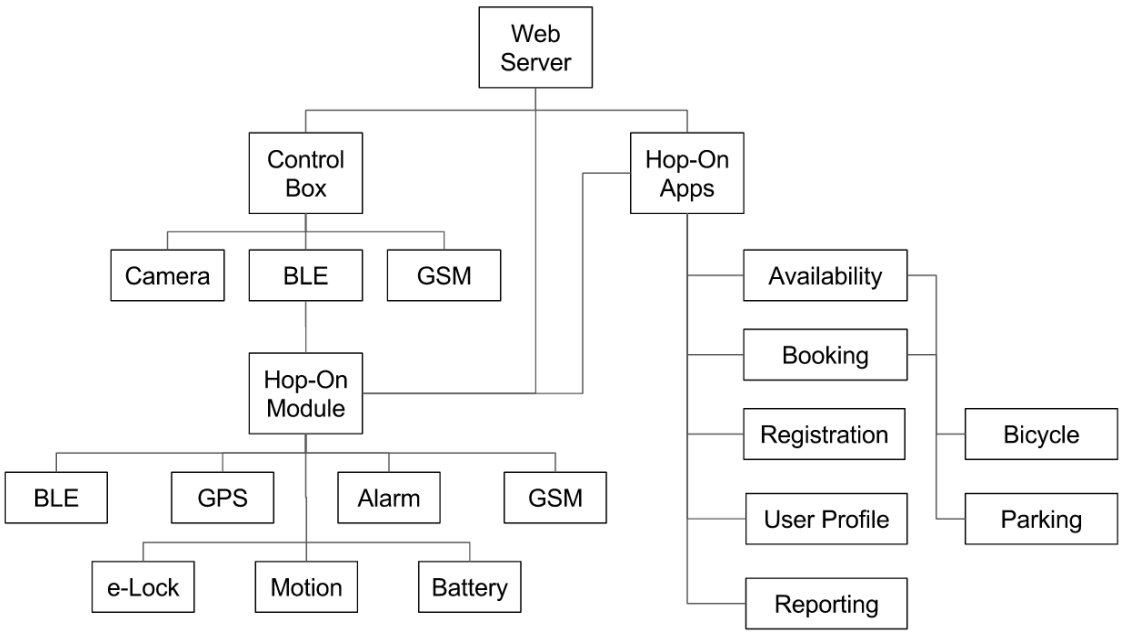

Figure 5: Proposed Solution Overall System Block Diagram

2.5 How It Works

Interested residents will first install the “Hop-On” Apps and register through the apps. Their registration will be activated within 1 - 3 working days. When the registration is received, the entity will place bicycle at the resident block of the registered user, which is likely to be the first point of usage. The registration activation procedure is necessary to accommodate sufficient bicycles at the user’s usage location, i.e. their home. If registration is activated and bicycle is used instantaneously, there might be shortage of bicycle when a group of new users ride the bicycles away at the same time. Once the account is activated, the user will receive confirmation from the entity.

At the beginning of the trip, say from home to MRT station, the user will use the “Hop-On” Apps to find nearby available bicycle, preferably void deck of the user’s HDB block. If there is a bicycle available, the user can proceed to book the bicycle through the apps. The user then will depart from home and collect the bicycle at the “Hop-On” Station of the HDB void deck. When collecting the bicycle, the user needs to unlock the e-lock of the bicycle through the apps.

After unlocking the bicycle, the timer will start counting and the usage duration will be calculated under the user’s account. Each user has certain amount of entitled usage duration, such that the bicycle is not occupied by one user for unlimited timing. The user can also check and book parking lot at the destination’s “Hop-On” Station. When the user has reached the destination, the bicycle will be returned to the “Hop-On” Station and the e-lock needs to be activated to stop the timer. The process is illustrated in Figure 6 below.

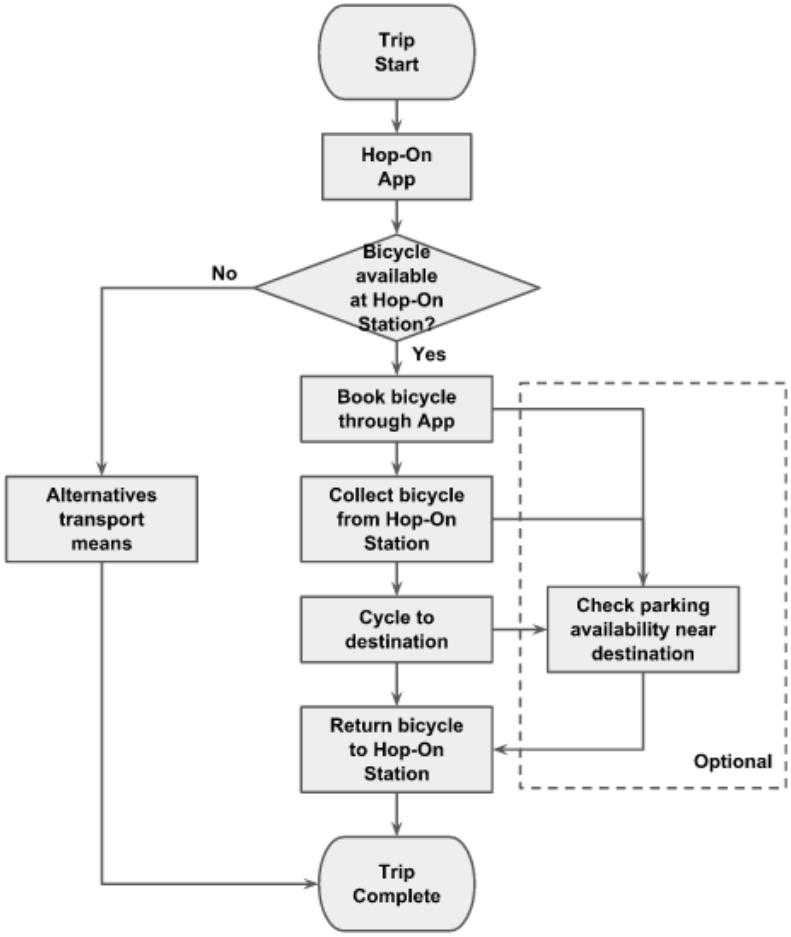

Figure 6: Flowchart of Usage Experience

3 Prototype Development

To demonstrate the workability of the proposed solution, a prototype, which comprises the control box, the “Hop-On” Module and the “Hop-On” Apps, will be constructed. Functional web server will be furnished to show the usage data updating from the control box and the “Hop-On” Module, as well as image captured from the IP camera. The “Hop-On” Apps can demonstrate extraction of data from the web server, checking and booking of available bicycle, as well as releasing e-lock of the bicycle.

The important dates lead to prototype submission are listed in Table 1 below.

Events	Target Start Date	Target End Date
1. Sourcing and purchasing of components	4 April 2016	29 April 2016
2. Web server configuration and setting up	4 April 2016	13 May 2016
3. Circuit design, connecting and troubleshooting	16 May 2016	1 Jul 2016
4. Mobile apps development	4 April 2016	22 July 2016
5. System integration and testing	4 July 2016	12 August 2016
6. Prototype explanatory write-up	25 July 2016	31 August 2016
7. Prototype and explanatory write-up submission	-	31 August 2016

Table 1: Schedule for Prototype Submission

The detail target completion schedule can be found in the Appendices.

4 Feasibility Study

To assess the proposed solution, three analyses, i.e. cost-benefit analysis, PESTEL analysis and SWOT analysis, were performed and explained in detail.

4.1 Cost-Benefit Analysis

A cost-benefit analysis was done for the proposed solution in quantitative approach. In Ang Mo Kio town, there are about 150,000 residents of all ages. Among the residents, about 43%, or 64,500 residents, aged between 15 to 45 years old [3], which are the targeted potential users. There are about 500 targeted "Hop-On" Stations, in considering 450 HDB blocks and 50 building of interest, such as MRT stations, community centres, hawker centres, shopping malls, parks, etc.

Assuming there are 20% registered users in the first year, which is 12,900 pax, and "Hop-On" Stations setup at 80% of the buildings. Users enjoy lower membership fees of $2 per month in the first year of registration, subsequently normal rate of $5 per month renewal fees. Every year, estimated cost rise of 10% and user pool increase of 10%. Total number of available bicycles exceeds registered users by 10%. From the entity's perspective:

Financial Year	Costs	Benefits
First Year	1. "Hop-On" components - $1.87mil 2. Monthly expenses - $0.36mil Total - $2.22mil	1. Capital investment - $1.00mil 2. Government grants - $1.05mil 3. Monthly incomes - $0.31mil Total - $2.36mil
Second Year	1. "Hop-On" components - $0.17mil 2. Monthly expenses - $0.40mil Total - $0.57mil	1. Monthly incomes - $0.81mil Total - $0.81mil
Third Year	1. "Hop-On" components - $0.19mil 2. Monthly expenses - $0.44mil Total - $0.63mil	1. Monthly incomes - $0.89mil Total - $0.89mil

Table 2: Cost-Benefit Analysis for First Three Years' Operations

From Table 2, it was estimated that the entity will be able to make marginal profits and recover invested capital within five years of operation. The detail breakdown of the items can be found in the Appendices.

From the user's perspective, the monthly fees of $2 or $5 is affordable and significantly lower than the monthly bus concession passes of $22.50 - $80, or average monthly bus fares of $15.20 - $30.80 (range from students to adults).

From government's perspective, building of cycling path is already within the master plan and budgeted for. Still, sufficient parking space needs to be allocated, especially at MRT

stations and shopping malls. Space-saving parking option can be considered, such as mechanised underground parking system. The entity can be tasked to resolve this concern.

4.2 PESTEL Analysis

Besides considering tangible aspects, macro environment study in terms of political, economical, social, technological, environmental and legal (PESTEL) was carried out and summarised in Table 3 below.

Favourable	Unfavourable
1. In line with government's master plan, policies (P) 2. Low cost implementation (Ec) 3. No additional significant infrastructure necessary (Ec) 4. Public satisfaction improvement (S) 5. Necessary technology is invented and affordable (T) 6. Environmental friendly (En)	1. Riders may ride on walking path and irk the pedestrians (S) 2. Motorised bicycle may be preferred (T) 3. Privacy concern with location tracker (L) 4. Cycling path becomes crowded and regulation is necessary (L)

Table 3: Proposed Solution PESTEL Analysis

As seen in Table 3, there are more favorable factors than unfavorable factors. However, overcrowded cycling path and large number of bicycles on the move might incur serious issues when the solution is fully implemented.

4.3 SWOT Analysis

To further reinforce the proposed solution, analysis in terms of strengths, weaknesses, opportunities and threats (SWOT) was completed and summarised in Table 4 below.

Strengths	Weaknesses
1. Low cost, simple implementation 2. Rugged bicycle, low maintenance 3. User friendly 4. Keep healthy lifestyle 5. Shared accountability 6. Save time and money 7. Freedom of usage 8. Enjoy comfortability	1. Wear and tear of "Hop-On" Module 2. Low operating profit 3. Need ample area at "Hop-On" Station
Opportunities	**Threats**
1. In line with government's master plan, policies	1. Usage is subject to weather conditions 2. One directional flow of bicycles during

2. Can be replicated on other transport means, e.g. scooters 3. Can be replicated at other towns, e.g. Bishan, Tampines, etc. 4. Ease bus congestion during peak hour	peak hour 3. Reluctant change of user's commuting behaviour 4. High skill security breach and theft

Table 4: SWOT Analysis of the Proposed Solution

For strengths, the solution is low cost, with about $120 for every registered users. It is simple implementation, only requires manufacturing and mounting of "Hop-On" Module on a procured bicycle. The transport means chosen, a bicycle, is rugged and requires little maintenance, such as pumping air, tyres replacement, chain realignment, etc. It is user friendly, users only need to use their smartphones, and no additional authentication device is involved. It enables healthy lifestyle, with chances to cycle every day. It allows shared accountability, users take care of the bicycles they booked, yet they no need to worry on the liability of the bicycle, such as faulty or theft. It helps save time and money, whereby each trip done with proposed solution would be two to three times faster than taking bus. It has freedom of usage, users can hop-on available bicycles at anywhere and anytime, and without need to return to the original location. It allows users to relax and enjoy breeze of wind in early morning or evening, instead of squeezing on a packed bus during peak hour.

For weaknesses, the life expectancy of the "Hop-On" Module is about three years, which needs to be serviced or replaced. To encourage more take-up rate, the cost of using the solution should be attractive, which also presses down the operating profit. The solution also requires ample parking area for users to park their bicycles at the "Hop-On" Stations.

For opportunities, the proposed solution fits perfectly on government's master plan and policies, e.g. Sustainable Singapore Blueprint 2015, car-lite city, etc. It can be implemented on other means of transport with little or no modification, such as a non-electric scooter. It can be replicated at other towns, e.g. Bishan and Tampines, which also enable inter-town and long distance cycling. Although the government has invested billions of dollars to increase the bus fleet and bus frequencies during peak hour, bus congestion is still common and commuters have to bear with the inconvenience and longer waiting time for not able to board the bus. Commuters can choose the cheaper and better alternative, in a way also ease congestion on the buses during peak hour.

For threats, it was noted that usage of bicycle is subject to weather conditions, especially in Singapore, whereby rainy days can be observed in any period of the year. One directional transport flow is normal, e.g. heavier traffic from HDB estates to CBD in the morning. Similar situation would be expected for the solution, whereby most bicycles will be deployed from HDB blocks and parked at MRT stations in the morning. It might not be easy to change commuting habit among the residents, who are used to taking buses as the main transport mean. There could be stealing and vandalism of the installed modules and bicycle parts.

5 Conclusion

The proposed “Hop-On” system is a convenient solution for sharing of bicycles. It is based on Internet of Things (IoT) concept and can be implemented with readily available technologies.

Through the system, users can easily locate, book, lock and return bicycles through their mobile phone. It was believed to offer a better choice for the users, whereby they could travel at ease, saving time and money at the same time. Users do not need to own a bicycle, but still able to enjoy the advantages of riding a bicycle.

It can be the solution for the “last mile” transportation at HDB towns or industrial parks. It supports government’s initiative on car-lite transportation system in the country, especially in mature towns. When the city state is covered with more extensive cycling path networks, bicycle riding can be extended to longer distance and everyone can be benefited from the solution implementation.

The proposal also includes extensive study which shows the feasibility of the proposed solution.

6 References

[1]. Average of 100 Bicycles Stolen Each Month
http://www.straitstimes.com/singapore/average-of-100-bicycles-stolen-each-month

[2]. Walk and Cycle Singapore
http://www.walkandcycle.sg/MS/walkandcycle/whats-next/amk-plan.aspx

[3]. Department of Statistics Singapore: Population Trends 2015
http://www.singstat.gov.sg/publications/publications-and-papers/population-and-population-structure/population-trends

7 Appendices

LTA Engineering Challenge - Project Completion Timeline

S/N	Topics / Tasks	Week0	Week1	Week2	Week3	Week4	Week5	Week6	Week7	Week8	Week9	Week 10	Week 11	Week 12	Week 13	Week 14	Week 15	Week 16	Week 17	Week 18	Week 19	Week 20	Week 21	Week 22	Week 23	Week 24	Week 25	Week 26	Week 27	Week 28	Week 29	Remarks
		28-Mar	04-Apr	11-Apr	18-Apr	25-Apr	02-May	09-May	16-May	23-May	30-May	06-Jun	13-Jun	20-Jun	27-Jun	04-Jul	11-Jul	18-Jul	25-Jul	01-Aug	08-Aug	15-Aug	22-Aug	29-Aug	05-Sep	12-Sep	19-Sep	26-Sep	03-Oct	10-Oct	17-Oct	
1	Proposal write-up and submission																															Proposal submission by 31 Mar 2016
2	Sourcing and purchasing of components																															Shortlisted teams will be notified by 30 Apr 2016
3	Web server configuration and setting up																															
4	Circuit design, connecting and troubleshooting																															
5	Mobile apps development																															
6	System integration and testing																															
7	Prototype explanatory write up																															
8	Prototype and explanatory write-up submission																															Prototype submission by 31 Aug 2016
9	Pre-final judging oral presentation and Q&A																															Pre-final judging in Sep 2016
10	Final judging and award presentation																															Final judging and award presentation at SITEC 19 - 21 Oct 2016

Appendix I: Prototype Completion Schedule

Appendix II: Cost-Benefit Analysis

LTA Engineering Challenge - Cost-Benefit Analysis

Financial Year	S/N	Costs Items	Unit Price	Quantity	Sub-Total	S/N	Benefits Items	Unit Price	Quantity	Sub-Total	Balance
First year	1	"Hop-On" Station	$400	400	$160,000	1	Capital investment	$1,000,000	1	$1,000,000	
	2	"Hop-On" Module	$50	14190	$709,500	2	Membership fees	$24	12900	$309,600	
	3	Bicycle	$70	14190	$993,300	3	Advertisement Income	$5,000	1	$5,000	
	4	Overhead expenses	$10,000	12	$120,000	4	SPRING SEEDS	$1,000,000	1	$1,000,000	
	5	Labour cost	$20,000	12	$240,000	5	ACE Startups Grant	$50,000	1	$50,000	
				Total	$2,222,800				Total	$2,364,600	$141,800
Second year	1	"Hop-On" Module	$50	1419	$70,950	1	Membership fees	$24	1290	$30,960	
	2	Bicycle	$70	1419	$99,330	2	Renewal fees	$60	12900	$774,000	
	2	Overhead expenses	$11,000	12	$132,000	3	Advertisement Income	$7,000	1	$7,000	
	3	Labour cost	$22,000	12	$264,000						
				Total	$566,280					$811,960	$245,680
Third year	1	"Hop-On" Module	$50	1561	$78,050	1	Membership fees	$24	1419	$34,056	
	2	Bicycle	$70	1561	$109,270	2	Renewal fees	$60	14190	$851,400	
	2	Overhead expenses	$12,100	12	$145,200	3	Advertisement Income	$9,000	1	$9,000	
	3	Labour cost	$24,200	12	$290,400						
				Total	$622,920				Total	$894,456	$271,536