Project Silver Steps

"The beginning of a Golden Society"

Feng Yi, Ong Zhi Kai Alan, Mathiazhagan Vasanth,

Wong Wee Yeow Francis, Nur Athirah Binte Mohammed Hussaini

Content

Steps towards inclusivity Page No.

CHAPTER 1: Introduction

1.1 Project Overview and Aim

There is a phenomenon of a rapidly ageing population in Singapore. Those aged 65 and above formed 12.4% of the resident population in 2019. This is expected to rise to 33.3% by 2050 (Statista, 2021). In 2014, the last projected number of wheelchair-users was 100,000 in Singapore. (Today, 2014). The Incidence of mobility disabilities is found to be significantly associated with age (Singapore Medical Journal, 2001). As people face more mobility disabilities as they age, there will be an increase in the elderly wheelchair population. Hence, there is an increasingly urgent need to address their challenges to help integrate and better include this vulnerable and rapidly growing community. While wheelchair-bound elderly face many challenges, one phenomenon that demands the most attention is their lack of independent mobility. Mobility limitations were associated with restricted participation in diverse activities outside the home (American Geriatrics Society Journal, 2003). Hence, the lack of independent mobility limits their opportunities in life, thereby alienating them in society by preventing them from engaging in many activities. Bearing this in mind, our group has embarked on Project Silver Steps to increase inclusivity for elderly wheelchair-bound elderly through increasing their independent mobility.

1.2 – Target Group: Wheelchair-bound elderly and their caregivers.

Elderly experience disruptions to their daily lives due to differing needs from the rest of society. However, the impact on wheelchair-bound elderly with mobility disabilities is more acute as they travel primarily in wheelchairs. (**Narayan Seva Sansthan, 2020**) Caregivers significantly enhance the wheelchair capabilities and confidence of wheelchair users (ACRM, 2018). Their lack of mobility impacts their visibility in society and affects their normalization in society. Improving their independent mobility will allow them to better integrate into modern society. Therefore, our solutions must target wheelchair-bound elderly to ensure their independent mobility and address the needs and concerns of caregivers.

1.3 Issue Identification and Significance

1.3.1 - Limited accessible pathways

Many footpaths in Singapore are inaccessible to wheelchair-bound elderly. (The Nanyang Chronicle, 2018). Out of the 23 wheelchair-bound elderly we surveyed, 81.8% found it difficult for them to access public places. (Figure 1). This means that wheelchair-bound elderly face restrictions on which routes they can use.

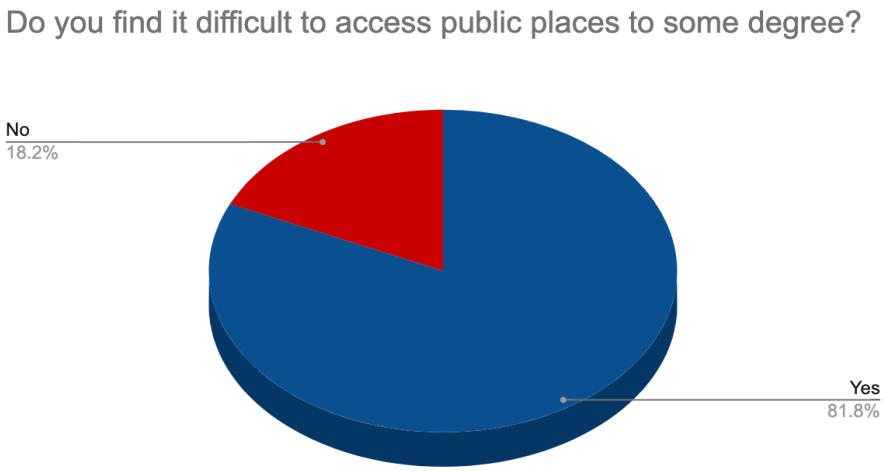


Figure 1: Do you find it difficult to access public places to some degree?

Our research has shown that there are powered all-terrain wheelchairs, therefore increasing their independent mobility. For example, the Scewo BRO uses rubber tracks to climb staircases (Scewo, 2021). However, these wheelchairs are very costly, with each unit costing at least SGD$14,957.59 (9,500 Euro) (Caterwil, 2019). Moreover, since the average monthly salary of Singapore residents in 2020 is S$4,534 (MOM,2021), these

wheelchairs are unaffordable for many wheelchair-bound elderly and are therefore inaccessible to them. Consequently, we aim to design a solution that increases the accessibility of all-terrain wheelchairs.

1.3.2 - Lack of awareness of accessible paths

Our survey of 23 wheelchair-bound elderly supports this as 72.7% report that they are not familiar with wheelchair-accessible paths. (Figure 2)

Wheelchair-bound elderly lack awareness of wheelchair accessible paths because of the difficulties faced when using current mainstream map applications such as Google maps to find wheelchair-friendly paths.

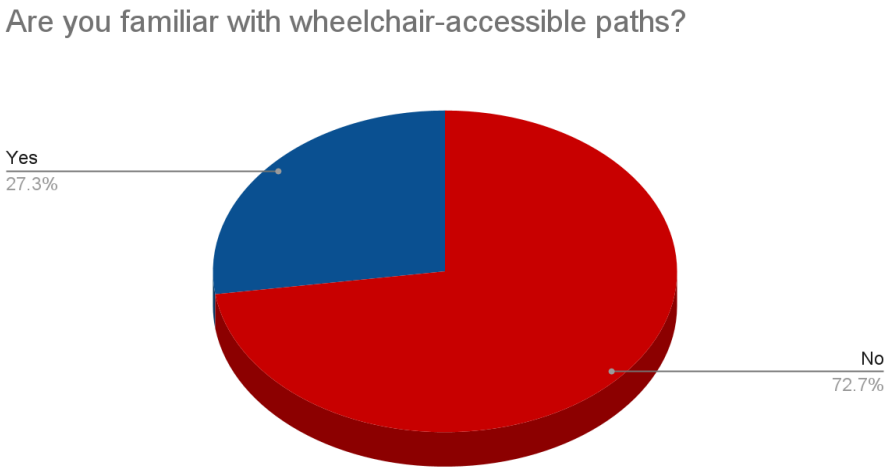


Figure 2: Are you familiar with wheelchair-accessible paths?

This is concerning as 59.1% of wheelchair-bound elderly reported encountering terrain untraversable by conventional wheelchairs (Figure 3).

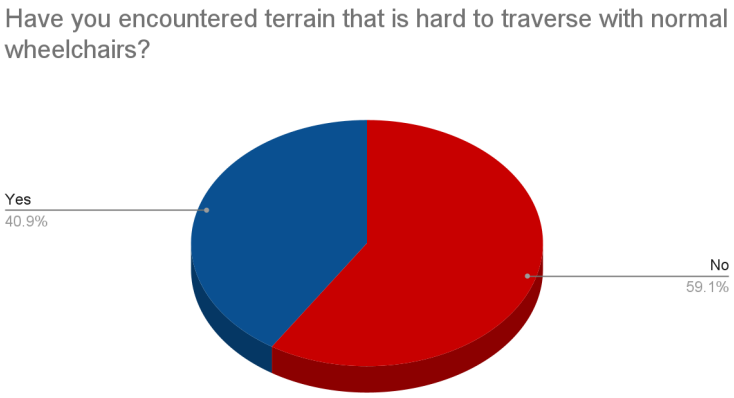


Figure 3: Have you encountered terrain that is hard to traverse with normal wheelchairs?

Consequently, wheelchair-bound elderly might find it challenging to find wheelchair-accessible paths. (Figure 4: Non-wheelchair-accessible paths) This might discourage wheelchair-bound elderly from going out alone.

Figure 4: Non-wheelchair-accessible paths

These limitations and mobility also add to the fears of caregivers. 90.9% of caregivers we interviewed are concerned about the safety of wheelchair-bound elderly when they are alone. (Figure 5)

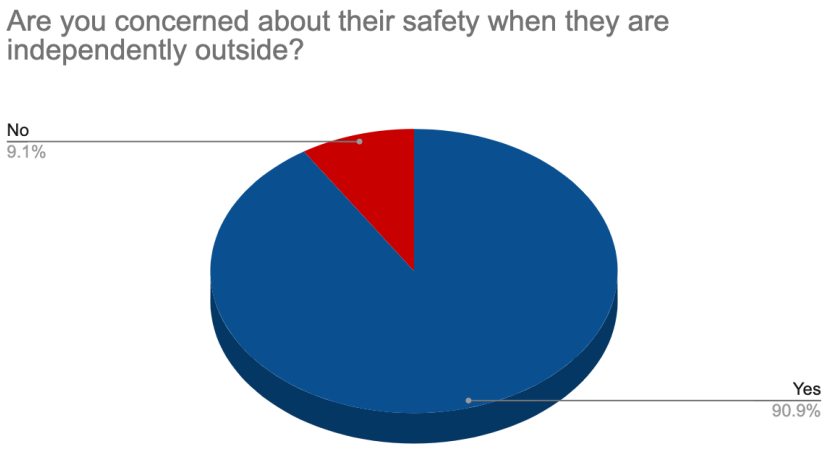


Figure 5: Are you concerned about their safety when they are independently outside

Therefore, we aim to design an app that provides wheelchair-bound elderly with the necessary information to make informed decisions on what paths they should take and provide their caregivers with the capability to monitor the status of their loved ones passively.

1.3.3 - Lack of caregivers for wheelchair-bound elderly

Being a caregiver for the wheelchair-bound elderly is extremely demanding. Caregivers have to compromise their careers, finances and even their health (Today, 2021). Nearly 60% of people using manual wheelchairs experience falls, and this worries their caregivers. (Desirée Sutton and Suzanne McCormack, 2019) Hence some family members are incapable of providing the necessary care for their elderly wheelchair-bound family, as caregiving is too time-consuming, with monitoring their safety being a significant concern that takes up their time. This may lead to some elderly living alone without caregivers, reducing their mobility further as they can only rely on themselves. Hence, we aim to develop a solution that will make caregiving for wheelchair-bound elderly less demanding by making it less time-consuming.

1.4 Current Measures

SmartBFA is a smartphone application developed by SMU to identify barrier-free access routes in Singapore through crowdsourced sensor data" (SmartBFA website)

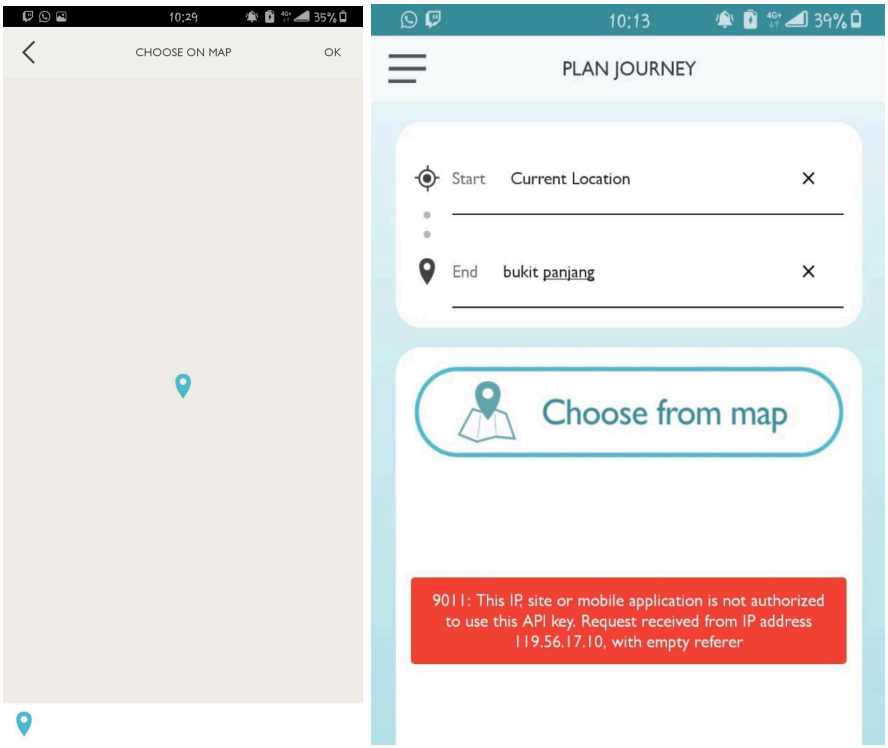


Figure 6: Screenshots of SmartBFA from the app store

However, this app is virtually unknown by the elderly wheelchair community despite media coverage by CNA in Dec 2020, considering it only has about 10 downloads on the play store. Furthermore, this application is simply dysfunctional as its map does not display any paths. (Figure 6). Therefore, this application is not able to effectively provide the services it claims to provide.

Thus, it seems this application is limited by the various glitches and bugs it contains and its lack of outreach. Therefore, we seek a tool that is more effective and accessible to wheelchair-bound elderly.

CHAPTER 2: Approach to Solution

2.1 – Solution Overview

As distilled from our cause analysis, our project aims to increase inclusivity by increasing the independent mobility of wheelchair-bound elderly through 3 strategies in our ***Project silver steps.***

Firstly, we will design a new and affordable Wheelchair that can traverse stairs, WheelSurf, to improve the accessibility of wheelchairs that can traverse stairs. Secondly, we will develop an online application, WheelWays, to allow Wheelchair-bound elderly to navigate the fastest and easiest path *(and all other accessible paths)* to their desired destination. Thirdly, WheelWays will also update caregivers of the users' status and location. Thus, caregiving will not require as much time, making caregiving less demanding for more people. (Figure 7)

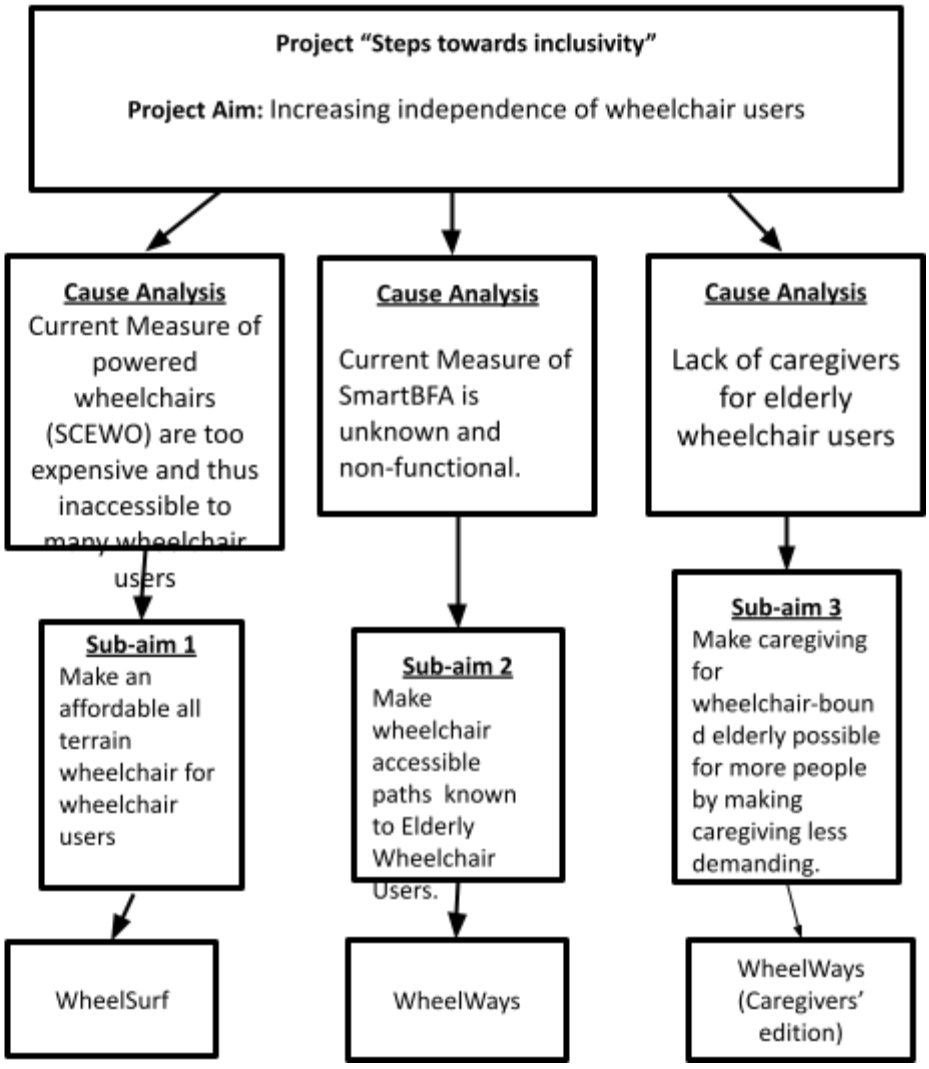


Figure 7: Solution Overview Flowchart

CHAPTER 3: WheelSurf

3.1 – Objective and Concept

Wheelsurf can achieve our first sub-aim of designing a more accessible wheelchair that can traverse most urban pathways.

Despite whatever Singapore is doing to improve accessibility, such as installing more ramps and additional lifts at 16 MRT stations (Ministry of Transport, Singapore), if the individuals do not have the right equipment, they cannot utilise it. Standard wheelchairs cannot traverse certain surfaces like rough surfaces and staircases, which are common infrastructure. These limitations intrinsic to the design of the wheelchair make it necessary to be revised and improved on.

Taking inspiration from existing all-terrain wheelchairs like Scewo Bro, we have created the WheelSurf Wheelchair. This wheelchair is capable of traversing across different terrains that are accessible to the average wheelchair-bound elderly.

Wheelsurf will help wheelchair-bound elderly by enabling them to access more urban pathways.

3.2 - Key features of Wheels-included

3.2.1 - Key Feature 1: The wheel

The non-versatility of these wheelchairs is because conventional manual wheelchairs are not designed to go on certain terrains. (Ignatio Madanhire Et al., 2020). This means that the wheels on conventional wheelchairs are not well-suited to Singapore's urban pathways.

Therefore we have designed a new type of wheel that can traverse more of Singapore's urban pathways. (Figure 8: Spokes)

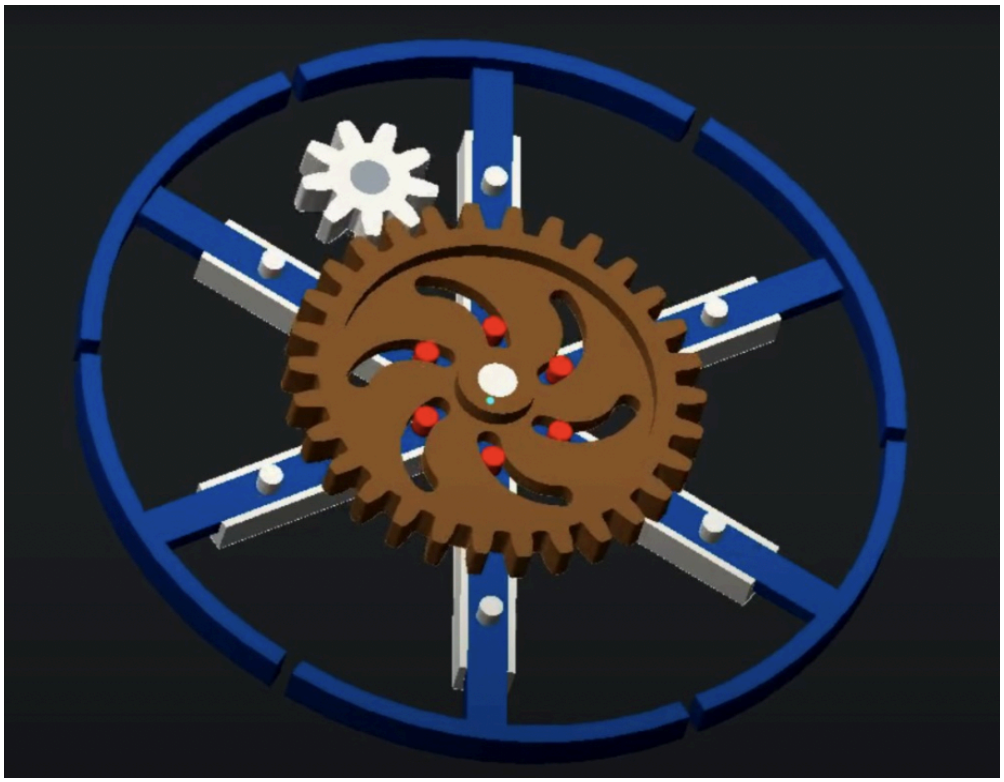


Figure 8: Spokes

The new wheel design includes spokes that can retract and extend; extruding the spokes will assist the wheelchair in traversing different terrains like stairs(Figure 9: Illustration of Spokes). The user can lock the spoke in place by using a Gear system. These gears would be used for controlling the expansion and retraction of the spokes by changing directions Chris Woodford, 2020).

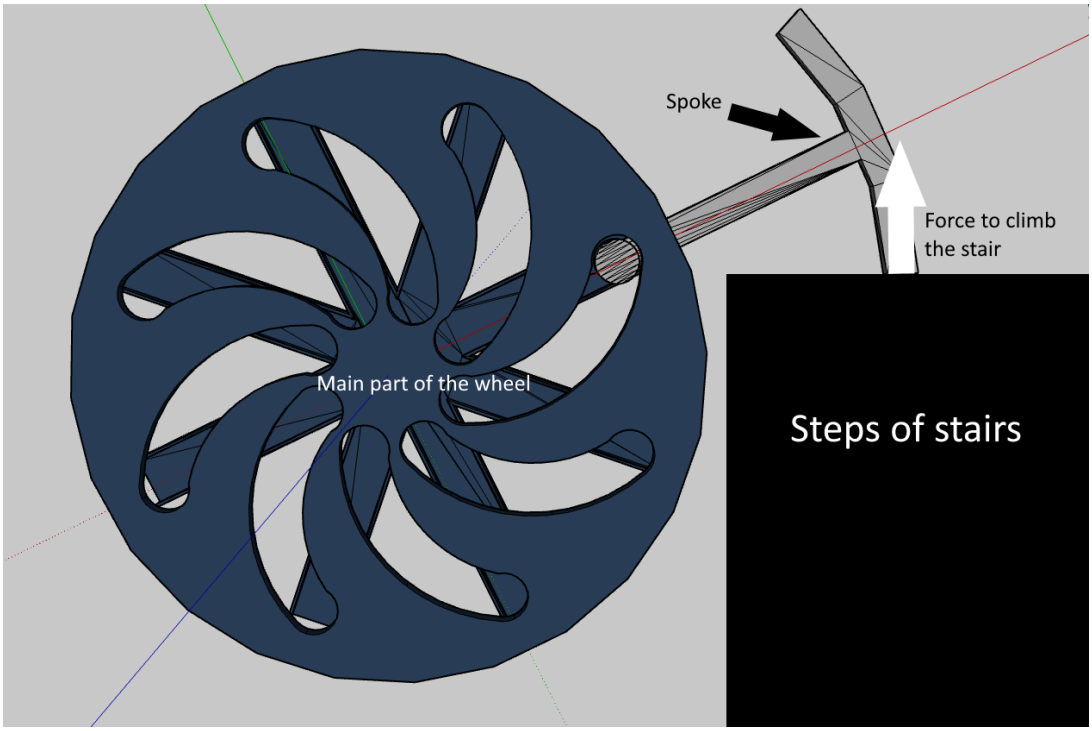


Figure 9: Illustration of Spokes

A servo motor will be used for the precise movement of the gears, which the engineering specialist we consulted with, Mr Eugene Ng, recommended. (Personal communications, 2021)(Annex A) Thus, this design would increase the mobility of wheelchair-bound elderly, allowing them to access places they would otherwise have trouble accessing.

3.2.2 - Key Feature 2: Safety features

The wheelchair will also be equipped with a Belt-in-Seat (BIS) seatbelt to ensure safety for the user by ensuring that they do not fall off even when traversing bumpy terrain. The Belt-in-Seat is selected as it is a comfortable alternative to typical car three-point belts. In addition, it is attached directly to the seat instead of the frame of the wheelchair (Ray Hasbollah, 2020). This makes it more viable for our wheelchair whose seat is more accessible . The wheelchair will also have suspensions on all 4 wheels. The suspension incorporates oil damping and a spring suspension that allows all wheels to move freely and independently for a smooth, comfortable and stable ride. (Permobil, 2019). Nearly 60% of people using manual wheelchairs experience falls (Desirée Sutton and Suzanne McCormack, 2019). Therefore this decreases the likelihood of the wheelchair-bound elderly falling when traversing uneven terrain. Furthermore, the gear system controls the retraction and expansion of the spokes to ensure proper control over their motion so that they do not fall while traversing uneven terrain.

3.2.3 - Key Feature 3: Electric Motor

Elderly have significantly decreased upper-body strength (Zoran Milanović Et al., 2013). Therefore, wheelchair-bound elderly do not have the strength to propel and control the wheelchairs manually. Therefore our wheelchair will include a powerful electric motor. This will allow for powered-steering, which allows our users to use a joystick on their armrest to adjust the direction of the front two wheels of the wheelchair to control the movement of the wheelchair, using its motor. It also has a system to switch it from forward to reverse motion so that the wheelchair does not go backwards unwantedly while climbing steep slopes or stairs. Thus, it ensures that they do not lose control of the wheelchair and potentially encounter an accident. Hence, increasing independent mobility of wheelchair-bound elderly through ensuring they can safely traverse a wider range of terrains.

3.3 - Solution evaluation

3.3.1 - Feasibility

Y&T Enterprise is a carbon fibre and rubber manufacturer that manufactures and supplies high-quality products at a low cost. (YTenterprise, 2021) This makes developing large quantities of the specialised carbon fibre and rubber parts needed for WheelSurf affordable. Thus, they are a strategic partner to collaborate with to produce Wheelsurf such that it is affordable. Additionally, Servo Dynamics is a servo motor manufacturer (Servo Dynamics, 2021). This means they are experienced in developing servo motors for specific purposes such as for WheelSurf. Hence they are also a strategic partner to collaborate for WheelSurf's production.

On the whole, our WheelSurf wheelchair is a technologically feasible project, according to a specialist in engineering, Mr Eugene Ng, that we consulted. It is possible for Wheelsurf to climb staircases and certain terrains. (Personal communications, 2021)(Annex A) He also recommended choosing the material and the components, such as using carbon fibre rather than steel and adding in servo motors, that would make WheelSurf much lightweight and dynamically flexible.

	Qty	Price/$
Carbon Fibre frame/kg	10	215.00
Electric motors	2	190.00
Linear actuators	4	706.00
50000mAh Lithium-ion battery	1	90.00
Other accessories (rubber, lubrication, gears, electronics, etc.)	-	~300.00
Overall Material cost/$	-	1501.00

Figure 10: Cost Calculation of a WheelSurf

The total material cost of WheelSurf is $1501.00, not including external costs. (Figure 10) Wheelsurf will not be as costly as current measures as it did not require significant research and development costs like current measures did(Personal communications, 2021)(Annex A). Therefore, even when we include the external costs, the overall market price of WheelSurf will still be significantly lower than that of the current measure of the SCEWO wheelchair, which has a market price of SGD$14,957.59 (9,500 Euro). Therefore, more wheelchair-bound elderly will have access to all-terrain wheelchairs, increasing their independent mobility, increasing inclusivity for wheelchair-bound elderly.

3.3.2 - Limitations

However, due to the design of the wheels on our wheelchair, there will be a severe load placed on the spoke. Thus there will be a heavy force acting on the spoke, causing it to retract. To counter this, we have added a linear actuator (Figure 11) to withstand the heavy loads placed on the wheelchair as a whole. The necessary components will also be made of carbon fibre. In addition, because our wheel is in 8 parts, the wheels will be made of airless rubber tires to avoid the need to pump each wheel 8 times, which would dissuade users from using the wheelchair.

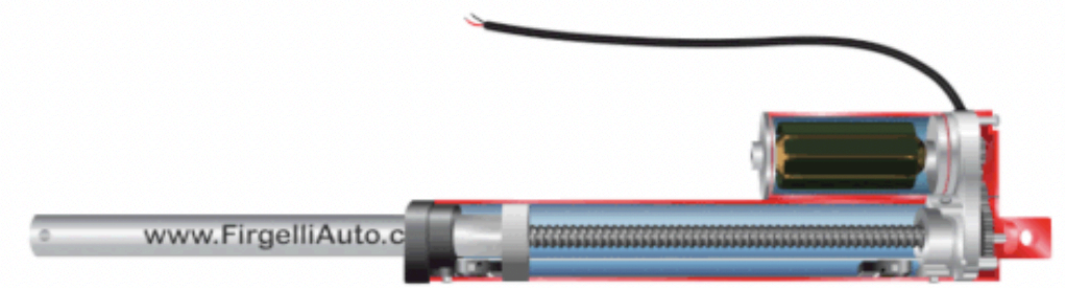


Figure 11: Linear Actuator

CHAPTER 4: WheelWays

4.1 – Objective and Concept

The WheelWays app is able to achieve both our second and third sub-aim of making wheelchair accessible paths known to wheelchair-bound elderly and making caregiving less demanding by making it less time-consuming.

Smartphone applications can provide both the user and the operator with real-time data and information to improve services immediately, such as reporting bugs and glitches. Applications are also easier to access as they can run as soon as one's phone is unlocked, making them suited for emergency situations- what our solution aims to tackle as opposed to websites.

Taking inspiration from GoogleMaps and SmartBFA, we have created the WheelWays app, which provides the users with safe and reliable wheelchair-accessible routes to their desired destination.

WheelWays will help wheelchair-bound elderly to navigate more accessible routes in their travels while assuring their caregivers of their well-being.

4.2 - Key features of Wheelsafe

4.2.1 Key feature 1: Navigation

The app would utilise the global positioning system(GPS), to locate the user's location. Similar to Google Maps, where users can navigate their desired destination through recommended routes, Wheelways would use the user's location to find them the shortest and most wheelchair-friendly routes to their desired destination, allowing them to travel easily, without encountering wheelchair inaccessible paths. Thus this would increase the independent mobility of wheelchair-bound elderly through being aware of wheelchair-friendly paths.

4.2.2 Key feature 2: Feedback

WheelWays has a feedback gathering system to gather data from users on which paths are the safest and accessible by allowing users to rate paths they have taken on a scale of 1-5(Figure 12). This would allow reliable and accurate data on the usability of the pathways for users. The application will consider the data of the paths gathered from user feedback and will recommend them based on it. Thus allowing the application to update and improve its route recommendation system continuously by the users themselves. The application will then accurately recommend routes that are suited to the needs and preferences of users, allowing users to move around independently with more ease, helping to increase the mobility of the wheelchair-bound elderly.

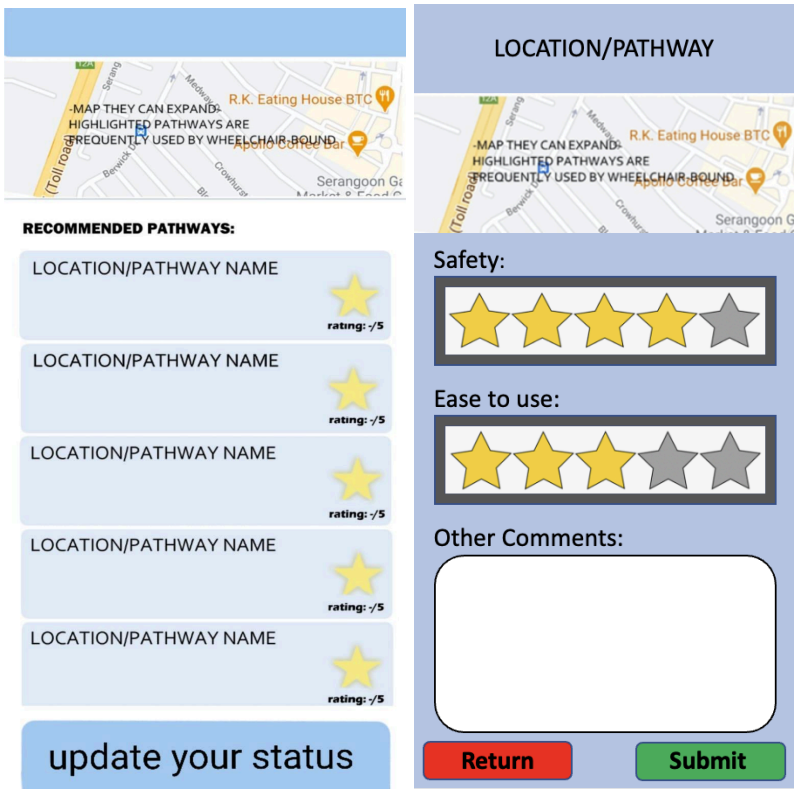


Figure 12: GPS and Feedback system

4.2.3 Key feature 3: Status updates and gyroscope

The app also includes a feature called “status”. This feature gives each user a status which is either “I’m okay”, “I’m in need of assistance”, or “I’m in distress” (Figure 13).

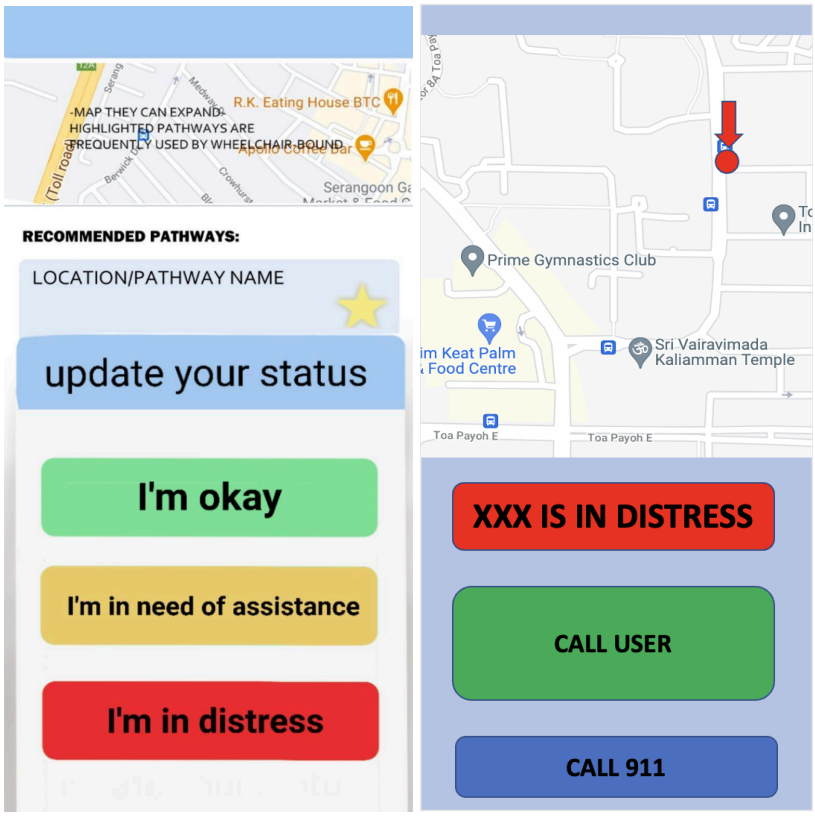


Figure 13: status update

The status updates can be changed manually or via an additional Bluetooth gyro sensor attached to the wheelchair. The Bluetooth gyro sensor will relay data on whether the wheelchair is upright to the phone via Bluetooth. If the wheelchair is not upright, it will automatically change the user's status to “I’m in distress”. Notifying the user’s caregiver and all caregivers within a 50-metre radius of the user to receive immediate help. If it is a false alarm, the user can simply change their status back manually as an indication. Of the 23 caregivers we surveyed, 63.6% commented that they would be less worried with this change. (Figure 14)

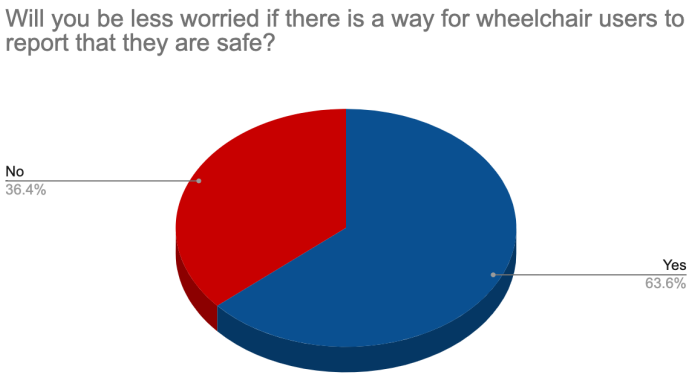


Figure 14: Will you be less worried if there is a way for wheelchair users to report that they are safe?

Hence, caregiving will be less time consuming as they do not need to actively monitor the safety of users while they are travelling.

4.3 Solution evaluation

4.3.1 Feasibility

Google is a world leader in navigation app services. This means that they can help set up a reliable GPS coordinates navigation system in WheelWays, based on Google's established navigation system. Hence they are an essential collaborator in the launching of WheelWays. Additionally, we could approach Murata Manufacturing, which is a gyroscope sensor manufacturer. (Murata Manufacturing, 2021) They can help us develop the gyro sensor for our WheelWays application, making them a crucial collaborator in developing WheelWays. Govtech would also be the best possible collaborator for this app. They have much experience creating applications that help the country and would have the most incentive to work with us and maintain the app for societal good. (Govtech, 2021)

4.3.2 Limitations

A weakness of Wheelways is that wheelchair-bound elderly may not use it frequently. Thus, we will encounter problems similar to applications like SmartBFA, as shown in chapter 1.3 (SmartBFA website, 2021). Additionally, the user community may not be large enough to provide sufficient information for Wheelsurf to determine an accurate map of wheelchair-friendly paths. To tackle this, we will conduct market research and better advertise our application to the wheelchair-bound elderly. This way, more users will provide sufficient feedback for WheelWays to accurately recommend the optimal wheelchair-friendly routes via WheelWays.

Chapter 5: Overall Evaluation

Overall Limitation

A weakness of our project is that it assumes that wheelchair-bound elderly have family caregivers as some do not. However, the proportion of elderly living alone has been increasing since 2000 (Duke-NUS, 2018). Living alone means that they have no caregivers to monitor their safety on WheelWays. Thus, WheelWays will be non-functional in monitoring their safety. However, WheelWays' status updates can be set to people other than official caregivers, such as close friends. In addition, status updates are still sent to all caregivers within the vicinity. Hence, WheelWays would still be able to achieve its aim even without family caregivers.

Another weakness of our project is that it assumes that wheelchair-bound elderly can afford WheelSurf. However, the median monthly income of the elderly is S$2,352 (Today, 2019). This means that WheelSurf will take up a large proportion of an elderly's income. Hence, while WheelSurf may be more accessible than current measures, it is still unaffordable to many wheelchair-bound elderly. However, WheelSurf can still be made accessible to wheelchair-bound elderly as it is subsidised. This is because the Seniors' Mobility and Enabling Fund provides subsidies for wheelchairs for the elderly (AIC, 2021).

Overall Strength

Singapore needs to do more than just install handrails and ramps in homes and outdoor spaces (Straits Times, 2021). Therefore, our two-pronged approach will work in line with the government's aim for Singapore to become more future-ready by allowing Singapore to harness the potential of its ageing population. Thus, they can provide and contribute to society by delaying their retirement age to their increased mobility. Moreover, our solutions will also help the non-elderly wheelchair users and other physically disabled Singaporean residents who have difficulty traversing this urban landscape. Thus, with the help of this project, Singapore can become more prepared for its future with an ageing population and become more inclusive for all wheelchair users.

Bibliography

1. Statista (27 April 2021) - Forecasted share of the population aged 65 years and above in Singapore in 2019, 2030 and 2050 https://www.statista.com/statistics/713663/singapore-forecast-aging-population/#statisticContainer
2. Today (5 May 2014) - Teams in the running to win seed funding for apps that help people with disabilities https://www.todayonline.com/singapore/teams-running-win-seed-funding-apps-help-people-disabilities
3. Singapore Medical Journal (2001) - Disability and Handicap among Elderly Singaporeans http://www.smj.org.sg/sites/default/files/4208/4208a4.pdf
4. American Geriatrics Society Journal, (15 August 2003) - Activity Restriction Among Wheelchair Users https://agsjournals.onlinelibrary.wiley.com/doi/abs/10.1046/j.1532-5415.2003.51408.x
5. Narayan Seva Sansthan (9 June 2020) - 10 Problems faced by people with disabilities https://www.narayanseva.org/blog/10-problems-faced-by-people-with-disabilities
6. ACRM, 2018 - Extent to Which Caregivers Enhance the Wheelchair Skills Capacity and Confidence of Power Wheelchair Users: A Cross-Sectional Study https://www.archives-pmr.org/article/S0003-9993(17)31462-4/fulltext
7. The Nanyang Chronicle, 2018 - Building a more inclusive Singapore for people with disabilities http://www.nanyangchronicle.ntu.edu.sg/Opinions/2504wheelchair.html
8. Scewo, 2021 - product website https://www.scewo.com/en/product/
9. Caterwil, 2019 - How to choose a power stairs climbing wheelchair that is perfect for you? https://caterwil.com/2019/10/22/how-to-choose-a-power-wheelchair-that-is-perfect-for-you/
10. MOM, 2021 - Summary Table: Income https://stats.mom.gov.sg/Pages/Income-Summary-Table.aspx
11. Today, 2021 - The Big Read: As S'pore society ages, who will care for the caregivers? https://www.todayonline.com/big-read/big-read-spore-society-ages-who-will-care-caregivers
12. Desirée Sutton and Suzanne McCormack (19 July 2019) - Fall Prevention Guidelines for Patients in Wheelchairs or Patients with Delirium: A Review of Evidence-Based Guidelines https://www.ncbi.nlm.nih.gov/books/NBK546784/
13. SmartBFA website (2021) https://smartbfa.com/

14. Ignatio Madanhire, Loice Gudukeya and Roy Mushonga (18 October 2019) - Development of a Rough Terrain Wheelchair Design
https://www.intechopen.com/chapters/71202
15. Chris Woodford (8 August, 2020) - Gears
https://www.explainthatstuff.com/gears.html
16. Ray Hasbollah (6 March, 2020) - Top 10 Most Wheelchair-Accessible Vehicles
https://carpart.com.au/blog/educational/top-10-most-wheelchair-accessible-vehicles
17. Permobil wheelchair website (16 April 2019) - The Importance of Suspension in power Wheelchair Use
https://hub.permobil.com/blog/importance-of-suspension-in-power-wheelchair-use
18. Zoran Milanović, Saša Pantelić, Nebojša Trajković, Goran Sporiš, Radmila Kostić, and Nic James (21 May, 2019) - Age-related decrease in physical activity and functional fitness among elderly man and women
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3665513/
19. YTenterprise website (2021)
http://www.ytenterprise.com.sg/
20. Servo Dynamics website (2021)
https://www.servo.com.sg/
21. Isobel Hamilton (16 March 2018) - Google Maps launches a 'wheelchair accessible' option for 6 cities
https://mashable.com/article/wheelchair-accessible-google-maps
22. Murata Manufacturing website (2021)
https://www.murata.com/en-sg
23. GovTech website (2021)
https://www.tech.gov.sg/
24. Duke-NUS (April 2018) - Home Alone: Older Adults in Singapore
https://www.duke-nus.edu.sg/docs/librariesprovider3/research-policy-brief-docs/home-alone-older-adults-in-singapore.pdf?sfvrsn=6735541d_0
25. Agency for Integrated Care (2021) - Seniors' Mobility and Enabling Fund
https://www.aic.sg/financial-assistance/seniors-mobility-enabling-fund
26. Straits Times, 2021 - Reimagining Singapore: How the city might look like in the future
https://www.straitstimes.com/singapore/reimagining-singapore-how-the-city-might-look-like-in-the-future

Annex A

Personal communications 2021 with Mr Ng Zhi Wei, Eugene

(Mr Eugene Ng is a specialist in engineering from the National University of Singapore that we have contacted.)

We: Hi Mr Eugene Ng, we are going to ask you questions about the mechanism of our wheelchair, WheelSurf.

Mr Eugene Ng: Sure

We: [Shows design] This is our wheelchair design, do you think this is feasible?

Mr Eugene Ng: So how does this wheelchair work?

We: The wheel expands with protruding spokes so that it can get leverage so as to be able to climb stairs.

Mr Eugene Ng: Very interesting idea. Hmm,...

We: Yes we are also going to use steel for the making of the spokes because it is very cheap.

Mr Eugene Ng: So there are some problems I see here about this mechanism, it works but you see, it is very prone to high stress and the load on the mechanism is very high.

Mr Eugene Ng: So ideally you can use carbon fibre as a material for the spokes instead of steel. Also, the mechanism itself can be improved by using a Gear system at the top with a servo motor as there would be a heavy load above because it has to carry half the weight of a person per wheel.

Mr Eugene Ng: Put a ring on the spokes, and attach rods such that they can hold the spokes in place to prevent it from contracting. And use a linear actuator for the above. Also, Use a hand brake to move rods into place to secure spokes into place the Clutch system like in cars.

We: Oh okay, that was something that we didn't think of. By the way, can I ask what the servo motor does?

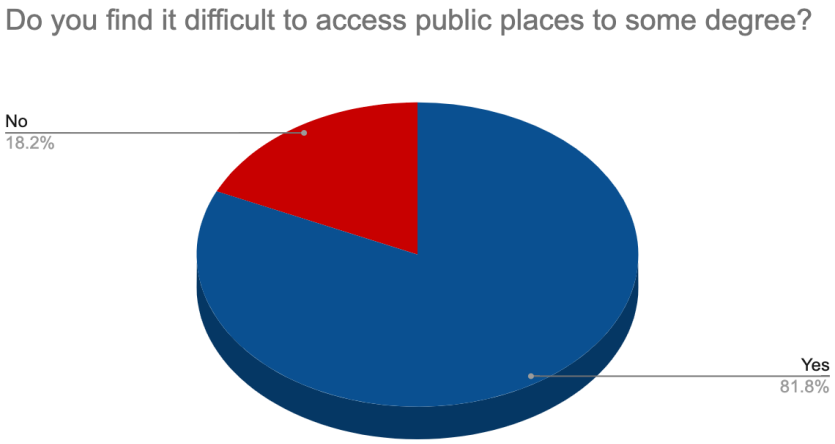
Mr Eugene Ng: It serves as a motor that rotates and can push the spokes of the wheelchair with precision, so it can adjust to the optimal height the spokes need to be, so in whole, it adds to the dynamic flexibility of the wheelchair.

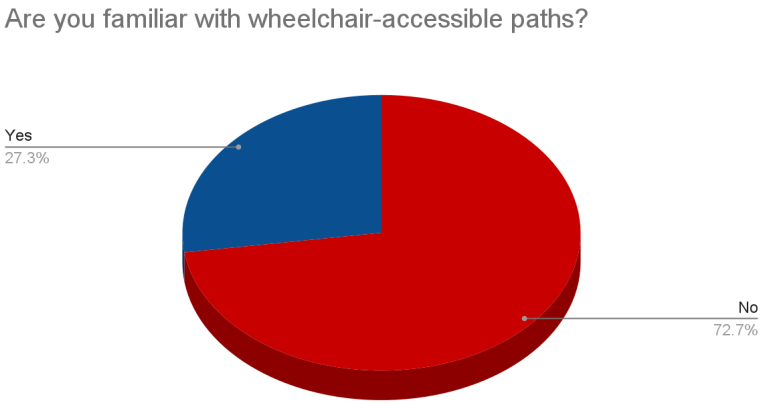
We: But with all these changes, wouldn't the price of the wheelchair be very high. Our project is supposed to be a cheap alternative to the expensive wheelchairs

Mr Eugene Ng: Not necessarily, it would be a lower cost price since you don't need high RnD (Research and Development) cost, which is where most of the cost comes from. Since you are entering a new market, you bring in the new competition, so your price may be lower, to emphasise how price may be more affordable especially compared to current measures.

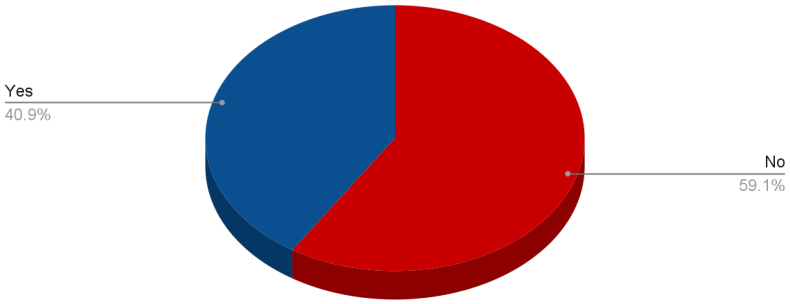
We: Thank you, Mr Eugene. We greatly appreciate your constructive and valuable feedback, they would definitely add value to our project. With that, we have come to the end of our interview. Hope you have a nice day!

Annex B: Survey Results

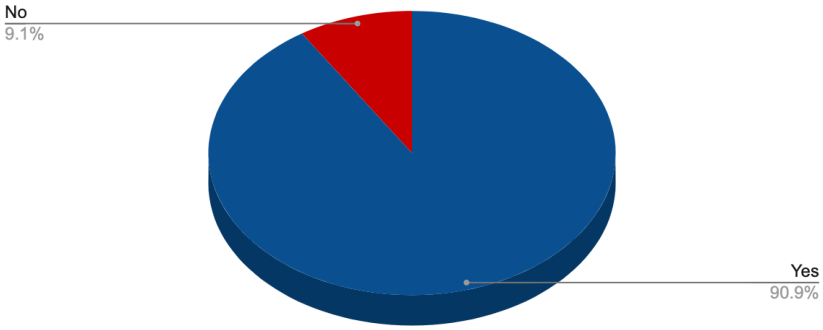


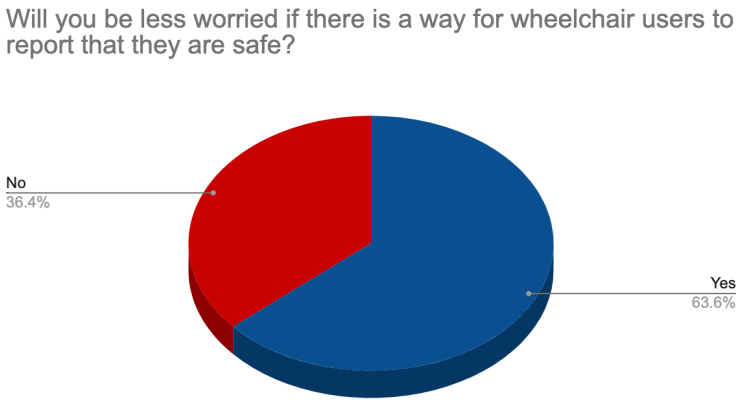


Have you encountered terrain that is hard to traverse with normal wheelchairs?

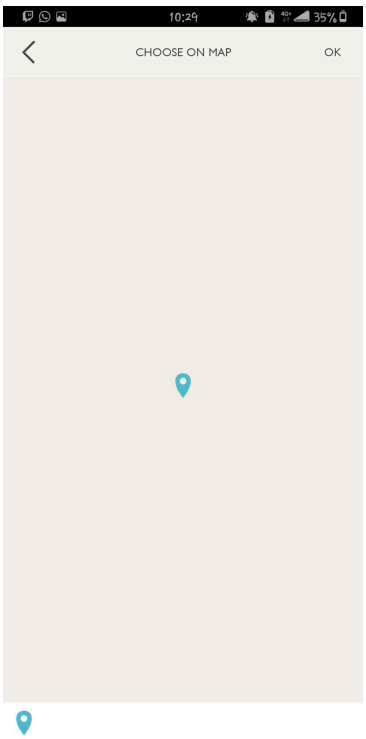


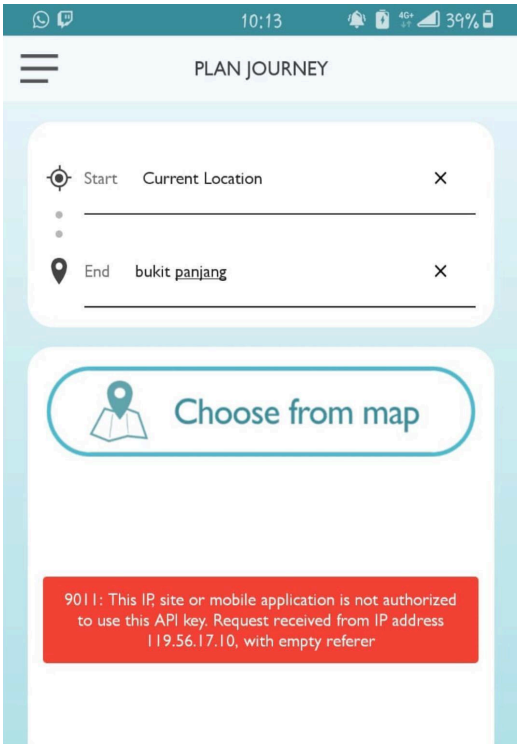
Are you concerned about their safety when they are independently outside?

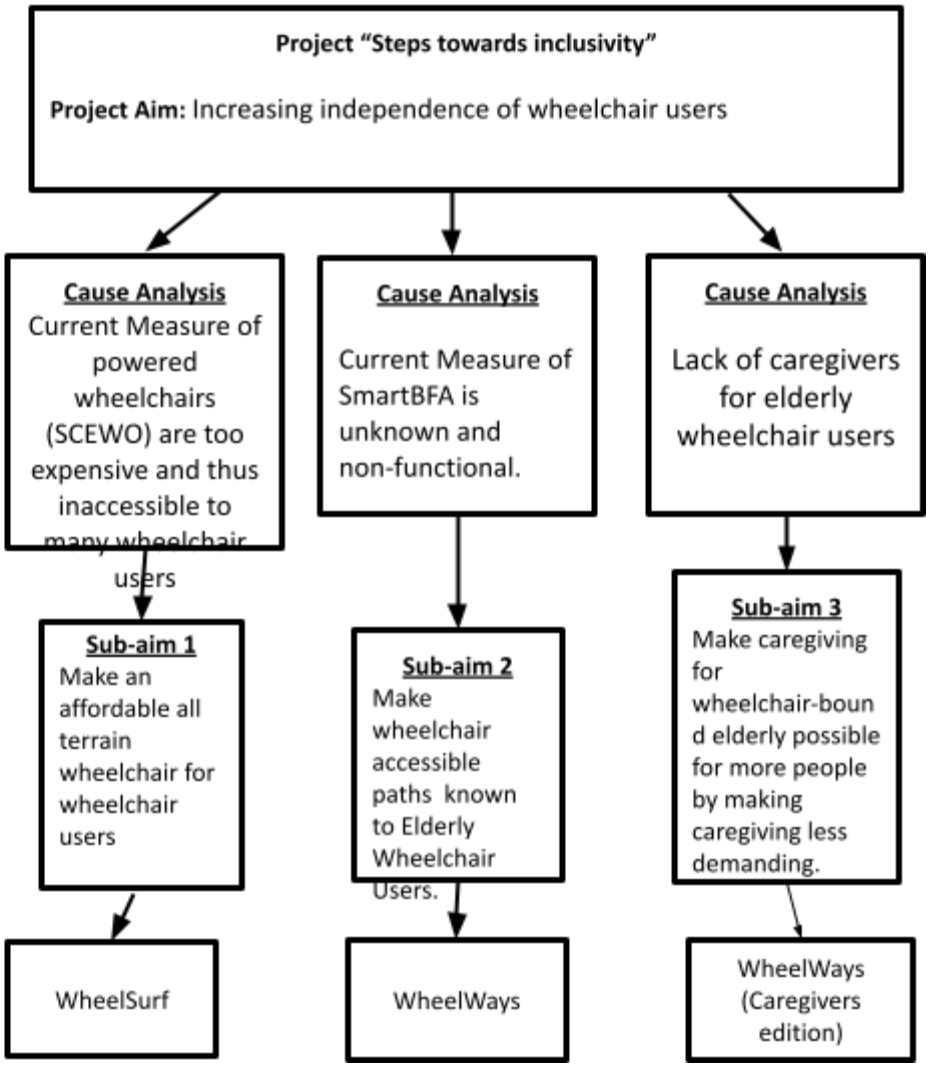


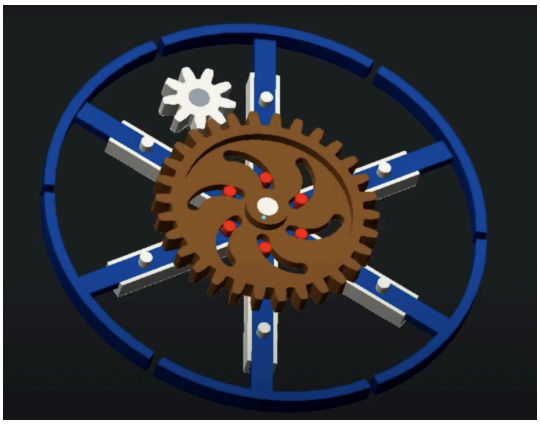


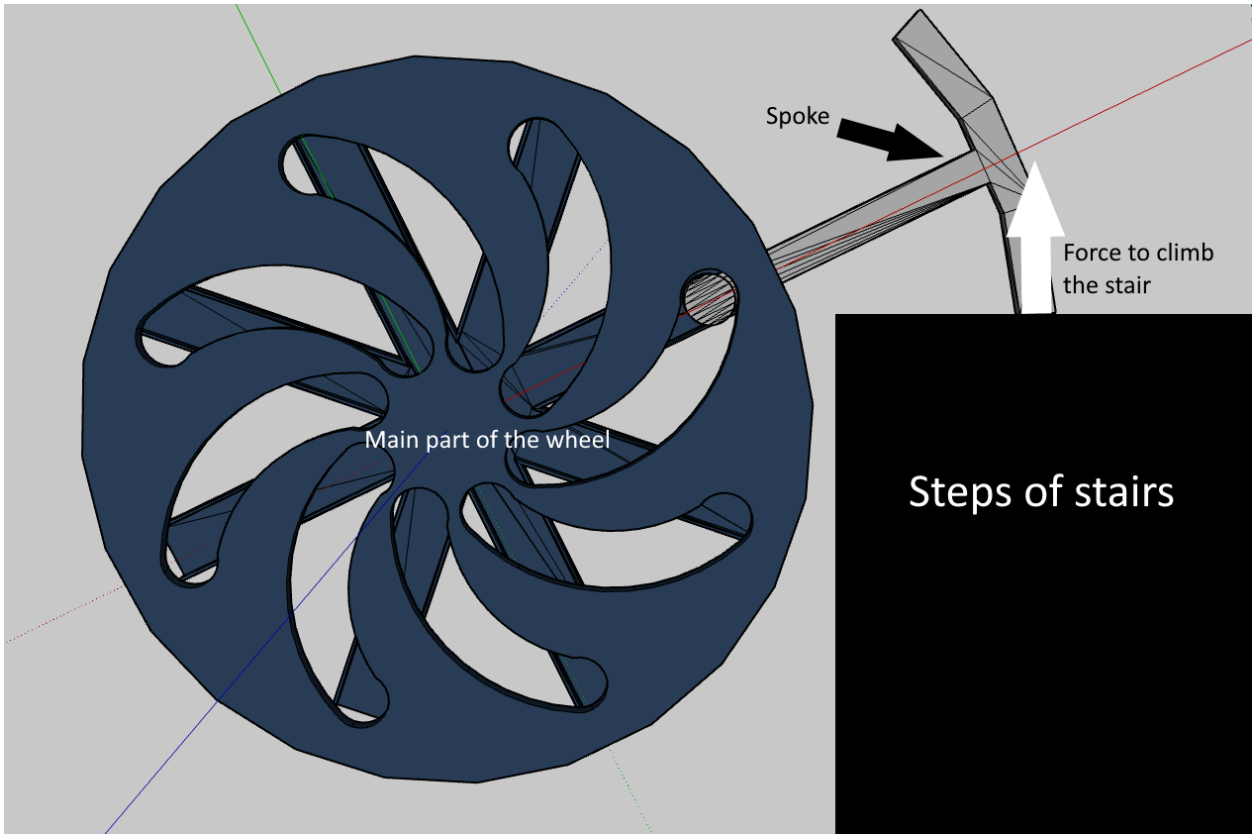
Annex C: Illustrations


10:29
35%
CHOOSE ON MAP
OK

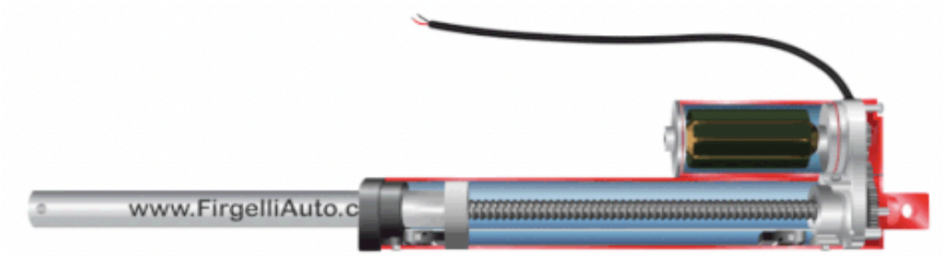

10:13
39%
PLAN JOURNEY
Start
Current Location
End
bukit panjang
Choose from map
9011: This IP, site or mobile application is not authorized to use this API key. Request received from IP address 119.56.17.10, with empty referer

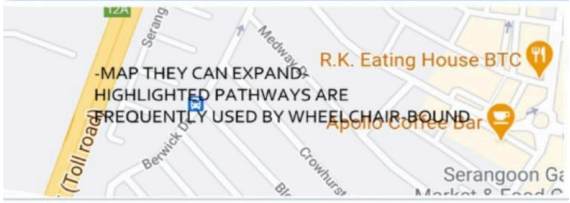

Project "Steps towards inclusivity"
Project Aim: Increasing independence of wheelchair users
Cause Analysis
Current Measure of powered wheelchairs (SCEWO) are too expensive and thus inaccessible to many wheelchair users
Cause Analysis
Current Measure of SmartBFA is unknown and non-functional.
Cause Analysis
Lack of caregivers for elderly wheelchair users
Sub-aim 1
Make an affordable all terrain wheelchair for wheelchair users
Sub-aim 2
Make wheelchair accessible paths known to Elderly Wheelchair Users.
Sub-aim 3
Make caregiving for wheelchair-boun d elderly possible for more people by making caregiving less demanding.
WheelSurf
WheelWays
WheelWays (Caregivers edition)





	Qty	Price/$
Carbon Fibre frame/kg	10	215.00
Electric motors	2	190.00
Linear actuators	4	706.00
50000mAh Lithium ion battery	1	90.00
Other accessories (rubber, lubrication, gears, electronics,etc)	-	~300.00
Overall Material cost/$	-	1501.00





RECOMMENDED PATHWAYS:

LOCATION/PATHWAY NAME
rating: -/5

LOCATION/PATHWAY NAME
rating: -/5

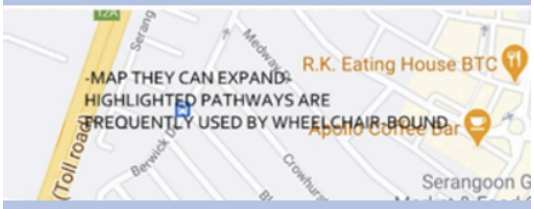
LOCATION/PATHWAY NAME
rating: -/5

LOCATION/PATHWAY NAME
rating: -/5

LOCATION/PATHWAY NAME
rating: -/5

update your status

LOCATION/PATHWAY



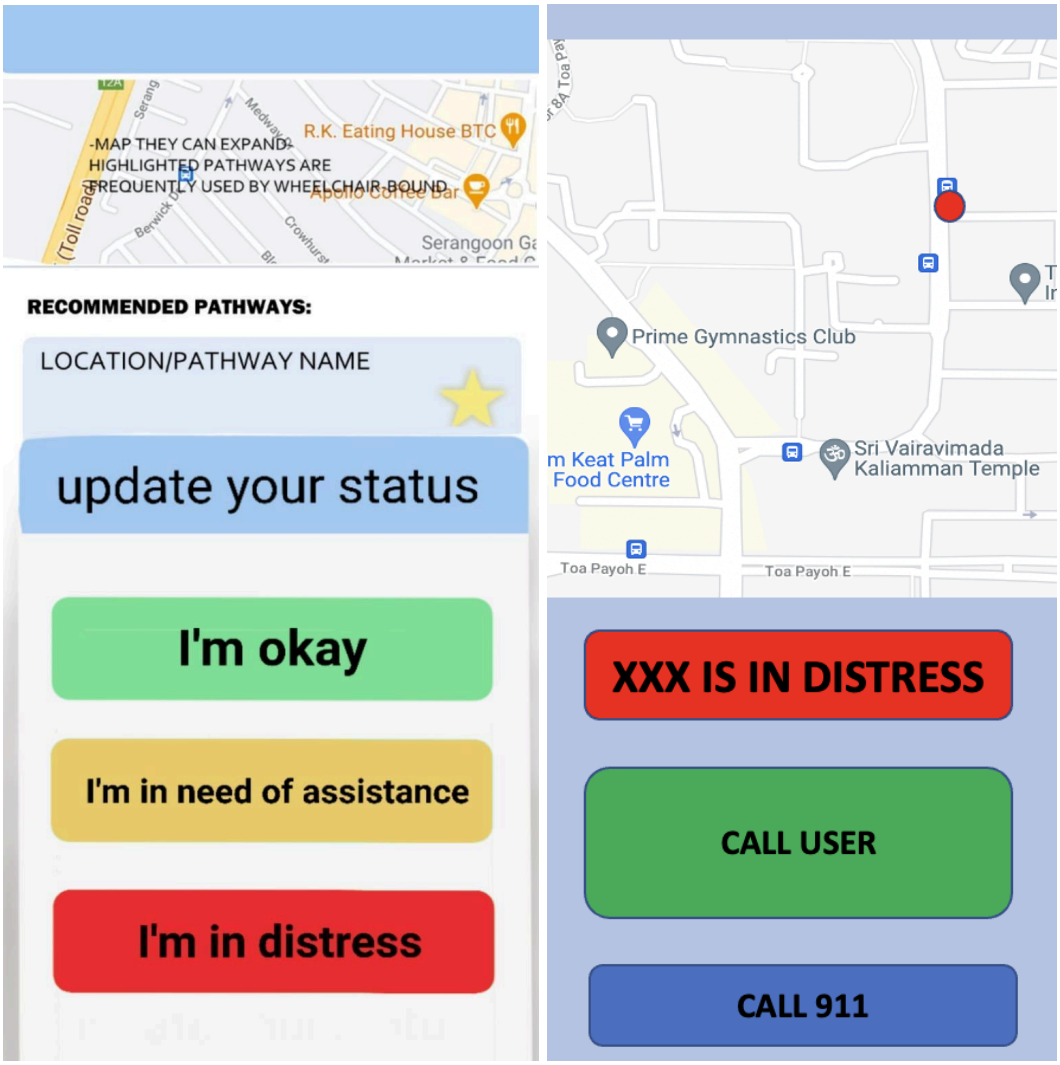
Safety:

Ease to use:

Other Comments:

Return

Submit


-MAP THEY CAN EXPAND-
HIGHLIGHTED PATHWAYS ARE
FREQUENTLY USED BY WHEELCHAIR-BOUND
R.K. Eating House BTC
Apollo Coffee Bar
RECOMMENDED PATHWAYS:
LOCATION/PATHWAY NAME
update your status
I'm okay
I'm in need of assistance
I'm in distress
Prime Gymnastics Club
Sri Vairavimada Kaliamman Temple
Toa Payoh E
XXX IS IN DISTRESS
CALL USER
CALL 911