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Making the Walvis Bay Corridors Safer for Truck Drivers through a Dedicated Smartphone Application

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ABSTRACT

This project culminated in an interactive prototype of a smartphone application for the Walvis Bay Corridor Group, who wants to use mobile communication technology to assist truck drivers on the Walvis Bay Corridors. We conducted interviews to understand the needs of the end users and proposed functionalities that best address those needs. We then produced an interactive prototype of a user interface that captures these functionalities in an intuitive and user-friendly way. In addition, the team also performed extensive data collection to support the proposed functionalities and recommended future steps for the development of a full-fledged application.

EXECUTIVE SUMMARY

Namibia's strategically located deep water port in Walvis Bay and extensive network of well paved roads make it an ideal candidate to be a regional logistics leader within the Southern African Development Community (SADC). Although Namibia's infrastructure is among the best in the region, transportation on Namibia's vast road networks, known as the Walvis Bay Corridors, remains a challenging endeavor. The Walvis Bay Corridor Group, whose mission is to promote the usage of the port and corridors in Namibia, recognizes that information and communication technologies offer opportunities to increase efficiency and safety in the transport industry. This project was established with the objective to explore the possibility of using mobile communication technology to help truck drivers manage the challenges they face.

Figure 1 The port of Walvis Bay and the Walvis Bay Corridors

We designed a prototype smartphone application that would assist truck drivers traversing the Walvis Bay Corridors. This application features an intuitive and user-friendly interface, providing information on resources and dangers along the roads. It also aims to help drivers in other aspects of their worklife such as health and communication.

The functionalities proposed in our application prototype were based on the user needs, which were established from 50 interviews with truck drivers and trucking company officials. The interviewees expressed difficulties in locating resources, staying safe, maintaining good health, and driving across borders.

Roadside facilities are scarce and scattered along the vast expanse of the corridors. Drivers reported difficulty finding **gas stations**, **repair shops**, **police stations**, **toilets**, **showers**, **hospitals** and **clinics** along the road, especially when they drive outside of their home country. The application should contain a database of important roadside amenities, which the user can visualize in both a **map view** and a **list view**, shown on the left and middle of Figure 2. A **filter options** menu, shown on the right side of the figure, accessible via the button in the bottom right allows the users to specify which resources they want to see.

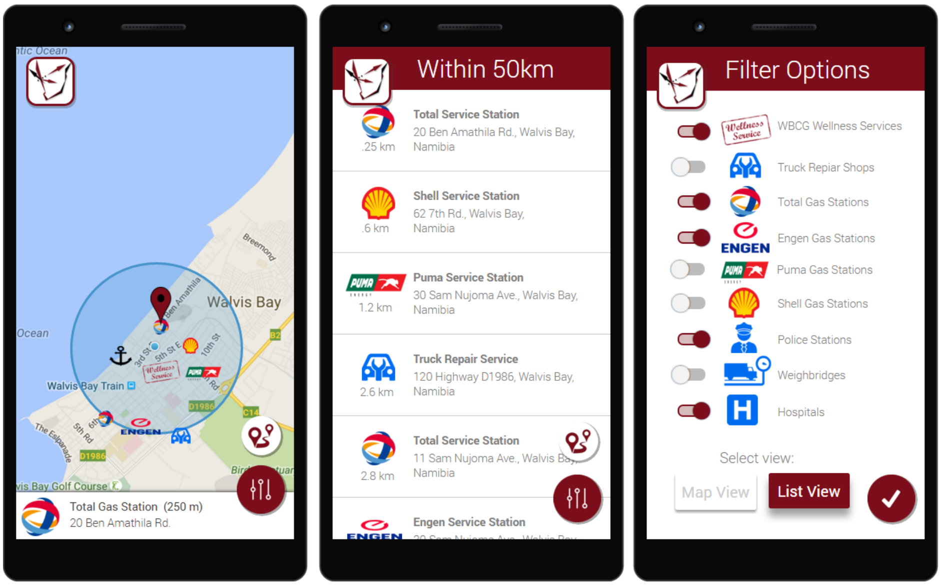

Figure 2 Map view, list view, and filter options

The application also features an **itinerary mode**, which the drivers can use for planning purposes. Figure 3 shows the modified map view and list view when itinerary mode is in effect. The map view will present the suggested route highlighted in blue and resources along the way, and the list view will be augmented by a scroll bar that allows the users to see what services are available in each town along the way.

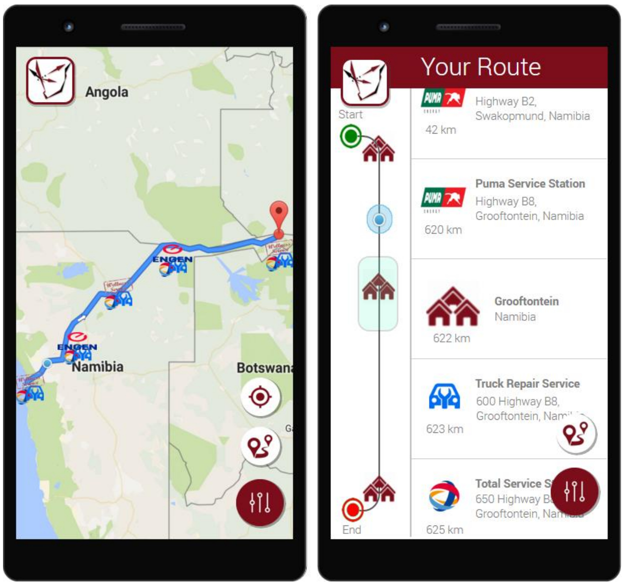

Figure 3 Map view and list view in itinerary mode

Drivers reported **cargo, tire, and fuel theft** and even cases of **hijacking**. Those who were used to driving the same route had learned where it was safe to park, but less experienced drivers often rely on their managers or resort to asking people along the road, putting them at risk of being misguided. **Accidents involving animals** were also frequent, especially at night, costing companies both time, in terms of delays, and money, as trucks and goods get damaged. To combat these issues, the application should feature location specific notifications alerting the user of danger. The screenshot on the left and right of Figure 4 below shows two types of alerts regarding increased risk of criminal activity and accidents involving animals respectively. These notifications will also be accompanied by a voice readout of the alert so as not to distract drivers from the road.

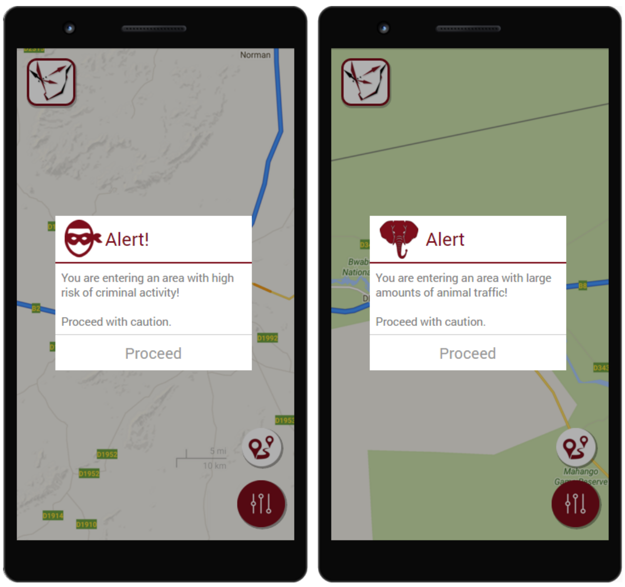

Figure 4 Alerts for criminal activities and animal traffic

Due to irregular working hours, possibly through the night, and minimal physical activity, truck driving is not considered a healthy profession. Very little information is provided to truck drivers with regards to their personal health and often truck drivers make **poor decisions regarding sleeping schedules**, **eating healthy**, **and receiving frequent medical checkups**. By providing **resources on healthy living** such as tips for eating healthy on a budget, methods for fatigue management, and educational material on sexual health in the app, the drivers have easy access to help on maintaining their health.

Rules and regulations such as **driving hours**, **speed limits**, and **maximum axle load** differ by country and drivers who are unaware of such information risk being fined. In addition, when French speaking drivers of the Democratic Republic of Congo (DRC) travel to English speaking Namibia and Zambia or vice versa, the **language barrier** causes communication issues and complicates the process of getting help during an emergency. Therefore, the application should contain **references to driving rules and regulations** (left screenshot of Figure 4 below) in countries along the corridors, as well as a **translation tool** (right screenshot below) between English and French.

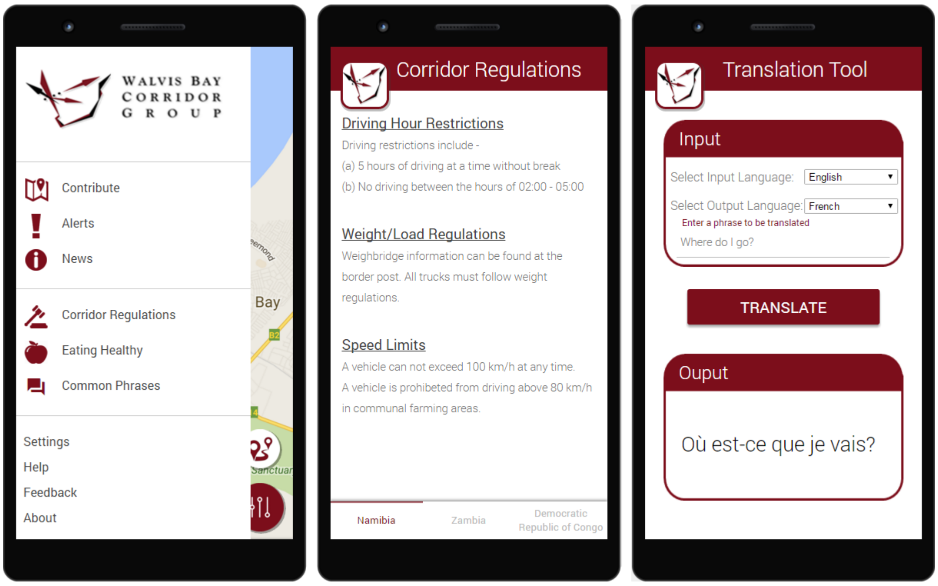

Figure 5 Navigation drawer, references on rules and regulations, and a translation tool

In order for this application to become a reality, the WBCG will need to perform **data collection** and **hire a development agency**. The application requires geolocation data in order to support the listing and mapping of all roadside resources in Namibia and beyond. The team piloted the data collection process needed on a trip up the Walvis Bay-Ndola-Lubumbashi Development Corridor, geolocating every gas station, repair shop, police station, weighbridge, hospital, and WBCG Wellness Clinic. The results of our trip can be seen in Figure 6.

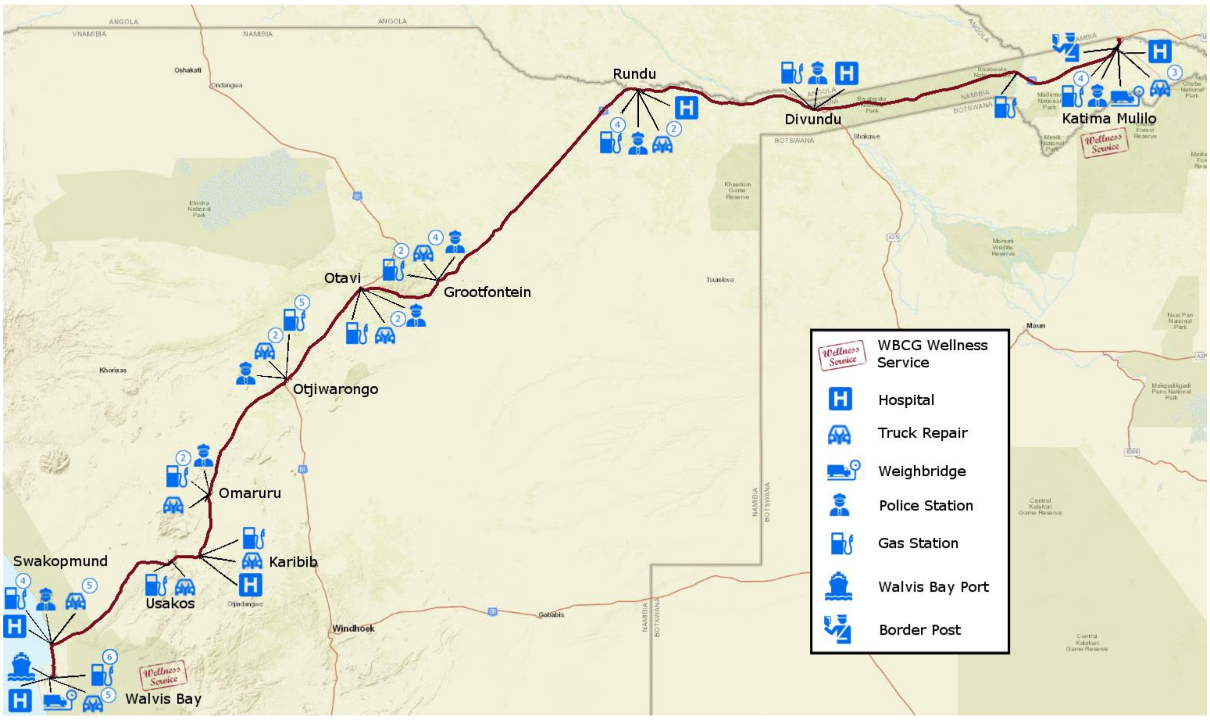

Figure 6 Map of resources along WBNLDC

We recommend that the WBCG hire a development firm to implement the application and the supporting infrastructure necessary to maintain it. We consulted with agencies in the United States, India, South Africa, and Namibia to establish the specific costs and timelines for developing an app of this scope. Using the estimates provided by these agencies, we concluded that WBCG should expect an initial cost of between US$15,000 and US$40,000 and a timeline of at least 4 months before a working version of the application can be distributed to drivers.

This design for a smartphone application is rich in features and unique in the region. We envision this application to be an assistant to truck drivers who wish to stay safe, informed, healthy, and efficient when driving on the corridors. Ultimately, this application would make the Walvis Bay Corridors more accessible and attractive, giving WBCG and its stakeholders a competitive edge to become the premier logistics hub in the SADC region.

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API	Application Programming Interface
App	Application
AWS	Amazon Web Services
CRUD	Create, read, update and delete
DRC	Dominican Republic of Congo
FAB	Floating Action Buttons
GDP	Gross Domestic Product
GIS	Geographical Information System
GPS	Global Positioning System
GSM	Global System for Mobile Communications
HIV	Human Immunodeficiency Virus
ICT	Information and Communication Technology
IRU	International Road transport Union
ISCOS	Intergovernmental Standing Committee on Shipping
ITF	International Transport Forum
LPI	Logistics Performance Index
MTC	Mobile Telecommunications Limited
NAMPORT	Namibia Port Authority
NDP_4	Fourth National Development Plan
NLA	Namibia Logistics Association
QFD	Quality Function Deployment
SADC	Southern African Development Community
SSA	Sub-Saharan Africa
STI	Sexually Transmitted Infections
TEU	Twenty-foot Equivalent Units
TKCS	Trans-Kalahari Corridor Secretariat
USD	US Dollars
WBCG	Walvis Bay Corridor Group
WBNLDC	Walvis Bay-Ndola-Lubumbashi Development Corridor
ZMW	Zambian Kwacha

AUTHORSHIP

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1. INTRODUCTION

In today's globalized world, the exchange of goods and services plays a key role in the economic growth of a country. Trade relies on logistics and transportation, which thus become important sectors in the development of a country. According to a World Bank study, the ten countries that have the most sophisticated logistic sectors are also among the richest and most developed countries in the world, suggesting a clear correlation between the success of a country's logistics sector and its economic prosperity (World Bank, 2015).

Namibia is in an ideal position to become a regional logistics leader in southern Africa. Advantageously situated on the south-western coast of Africa, Namibia has a deep water port — the port of Walvis Bay — that has the capacity for high volume maritime shipment and is closer to major markets in Europe and the Americas than competing ports in the region. Furthermore, a network of well-paved roads and rail, referred to as the Walvis Bay Corridors, connects the port of Walvis Bay to a number of countries in the southern African region. Between 2010 and 2013, Namibia invested more than N$20 billion (USD$ 1.2 billion) on infrastructure development projects to ensure that the port and transport corridors have the capacity to handle their ever increasing portion of total trade in the region. (Namakalu 2014). The Walvis Bay Corridor Group (WBCG), an organization consisting of stakeholders from both the public and private sectors of the transport industry, was established in 2000 to facilitate and promote usage of the Walvis Bay Corridors (Shipanga, 2016).

Although Namibia's logistic infrastructure is considered one of the best in the region, transportation on the Walvis Bay Corridors is still a challenging endeavor. Truck drivers are subjected to odd driving hours, navigation through unknown and possibly dangerous terrain (World Bank, 2015). Further, a mandatory transport law forces drivers to make stops every five hours (Republic of Namibia, 2001). As information on safe places to stop is not readily available, drivers are often forced to stop at unsafe locations for these mandatory breaks (Shipanga, 2016). Cases of theft, robbery, and other forms of roadside vandalism endangering truck drivers, trucks and cargo have been reported frequently throughout Namibia and neighboring countries ("Hijacker Terrorise Road", 2015). Furthermore, emergency contact information is not often readily available to drivers, delaying rescue efforts in the case of medical emergencies or vehicle breakdowns. Lack of information on amenities such as hotels, restaurants, and gas stations also adds a layer of uninformed decision-making to the trip planning process (Shipanga, 2016). The WBCG understands the limiting effects these factors have on its goal of promoting the corridors and aims to mitigate them by applying innovative mobile information and communication technologies.

This project identified the challenges facing truck drivers along the Walvis Bay Corridors, and determined how they can be addressed with a smartphone application. With guidance and support from the WBCG, we interviewed logistics company officials and truck drivers to understand their perspective on the corridors. We then determined functionalities for a mobile application that would address the needs extrapolated from the interviews and collected information needed to support these functionalities. Finally, we designed a user interface for the prototype mobile application, and researched the development cost to implement the features we proposed. A smartphone application will help truck drivers be safer and more efficient when traversing the corridors, making the corridors a more attractive option to logistics operators. Ultimately, this will provide yet another competitive advantage for the Walvis Bay Corridors and better position Namibia in the competitive logistics industry of southern Africa.

2. BACKGROUND

In this chapter, we present a study of the current state of the logistics sector in Namibia and discuss how a mobile application can increase safety and efficiency in the transportation industry. We begin with an overview of logistics in southern Africa, followed by an analysis of the current state of the transportation sector in Namibia and the challenges it faces. Finally, we discuss the impact of information and communication technologies in Africa, and case studies of how mobile applications can help address problems in the logistics sector.

2.1 LOGISTICS IN SOUTHERN AFRICA

The logistics industry in Southern Africa relies on nine major ports and ten corridors, which are major highways and railways leading to and from the ports situated on the coast, for movement and distribution of products throughout the region. The major ports for container shipment are: Lobito in Angola; Beira, and Maputo in Mozambique; Walvis Bay and Lüderitz in Namibia; Durban and Cape Town in South Africa; and Dar es Salaam in Tanzania (World Port Source, 2016). Figure 7 shows a map of these ports and corridors in the South African region.

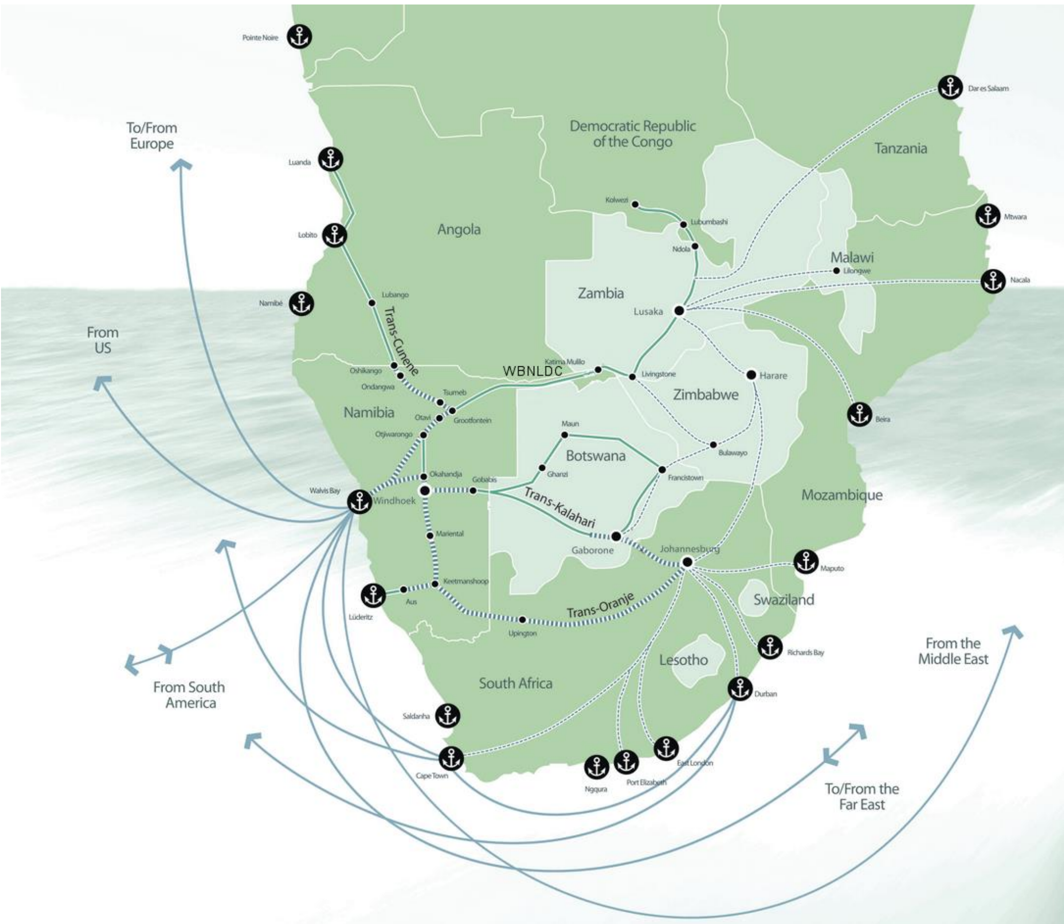

Figure 7 Map of corridors in the SADC

The fast growing economies of countries in southern Africa depend on a strong logistics and transportation industry. Over the past ten years, the collective Gross Domestic Product (GDP) in the 15 countries of the Southern African Development Community (SADC) has increased by 183% (AFDB Socio Economic Database). This growth has been driven by the high demand of various natural resources and manufactured products, such as petroleum oil, agricultural products, clothing items, and textiles available in the region (Southern African Development Community, 2012). The export oriented nature of economies in the SADC suggests that the logistics sector plays a significant role in their overall economic development.

2.2 LOGISTICS IN NAMIBIA

The logistics infrastructure in Namibia consists of two ports, the port of Walvis Bay and the port of Lüderitz, and four corridors, the Trans-Kalahari, Trans-Caprivi, Trans-Oranje, and Trans-Cunene. Namibia's geographical location puts the country in an advantageous position to serve the logistic needs of its neighboring countries. Situated on the west coast of Africa, Namibia's ports are closer to major markets in Europe and the Americas than other ports in the region, such as the port of Durban or Dar es Salaam. The Walvis Bay Corridors consist of a network of roads and railway that connect Namibia's ports to regional economic powerhouses such as Angola and South Africa, as well as several landlocked SADC countries that are dependent on foreign ports for import and export (Savage, Fransman & Jenkins, 2013). Figure 8 maps the locations of Namibia's ports and corridors, and identifies the principal shipping routes used for international trade.

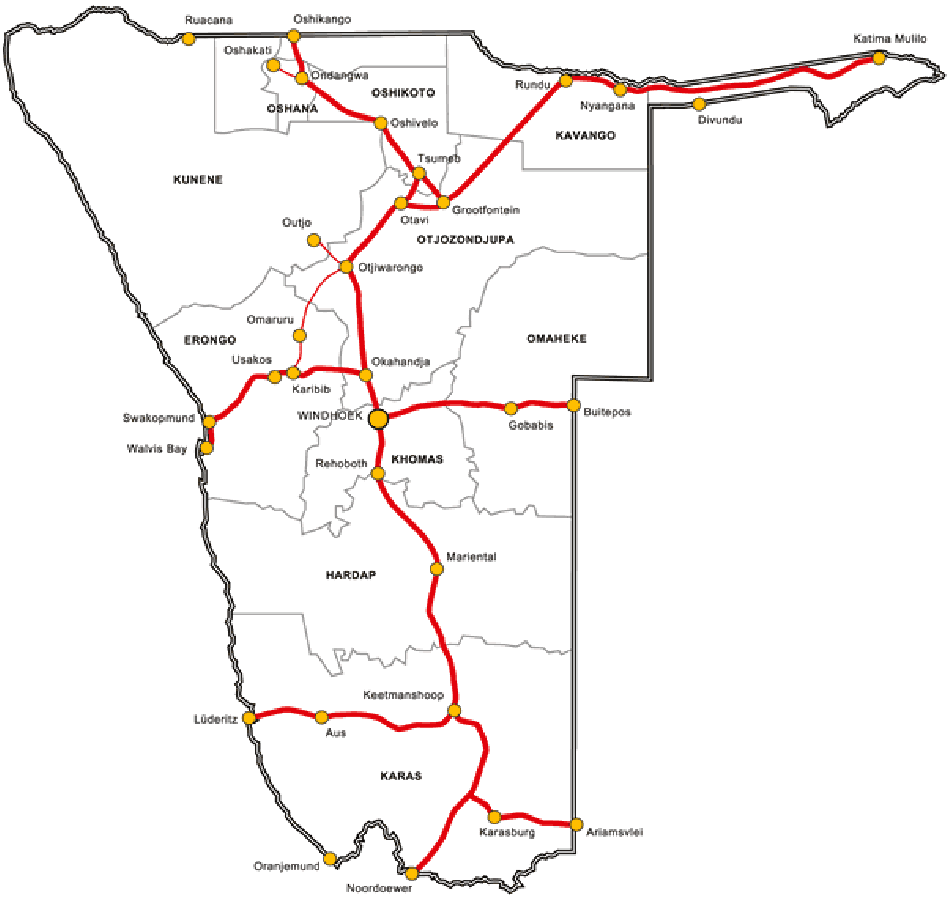

Figure 8 Transport corridors in Namibia

Political leaders and decision makers in Namibia have recognized the country's potential as a regional leader in logistics. In 1998, President Nujoma introduced Namibia's Vision 2030, a document which identifies objectives and goals for the future of Namibia in relation to its social, economic, and overall well-being. The document also called for development plans to be constructed every five years in order to keep track of growth and realign the objectives of the country if necessary. A section of the Namibia Vision 2030 describes the transport sector as being "critical to the development of all sectors of the economy" (Office of the President, 1998). The fourth and most recent national development plan for Namibia, created in 2012, states that a desired outcome of the next five years is to enable Namibia to become the regional leader in transport and distribution, essentially establishing Namibia as a regional logistics hub. It reiterates the importance of transport and logistics to an even greater extent, labeling "Public infrastructure" and "Logistics" as two national priority areas for economic development (Office of the President, 2014). The following sections will present the current performance of the major ports and corridors and discuss strategies for securing Namibia's position as a logistics hub in the region.

2.2.1 The ports of Namibia

Namibia's two ports are operated by NAMPORT, which is the national port authority in Namibia founded in 1994. It is a state owned enterprise and has, since its inception, worked to develop the ports to meet increasing demands. In 2005, 72,219 twenty-foot equivalent units (TEUs) worth of cargo traffic was recorded at its two container ship ports, the Port of Walvis Bay and Port of Lüderitz. In 2014, the two ports handled 253,952 TEUs, a 352% increase compared with the 2005 statistics. As presented in Figure 9, Namibia's ports accounted for 4.11% of all maritime container traffic among all SADC countries (African Development Bank Group, 2013; NAMPORT, 2014). The rapid growth in volume of trade in Namibia is being accelerated even further by an ongoing expansion project at the Port of Walvis Bay, which is expected to increase the port's capacity to one million TEUs in the near future (Savage, Fransman & Jenkins, 2013).

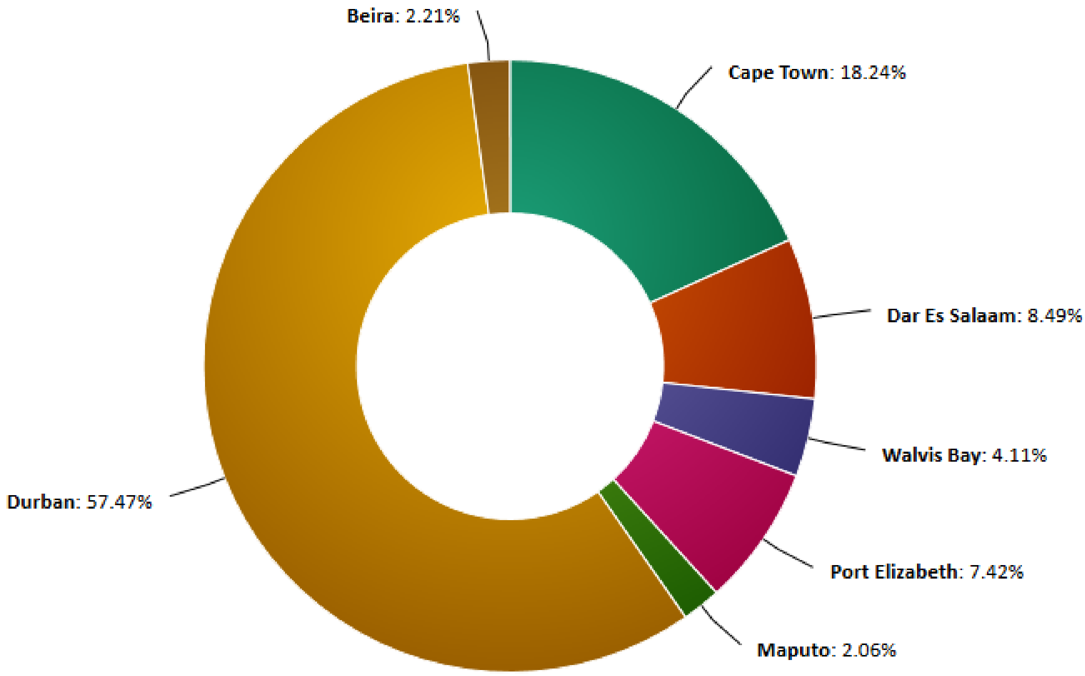

Figure 9 2014 container traffic in SADC ports by percentage

The Port of Walvis Bay is of particular importance to the sustained growth of the logistics sector. Currently, the port handles the majority of goods being transported through Namibia. In 2014, it was responsible for 77% of total cargo volumes shipped through Namibia, while the Port of Lüderitz accounted for the remaining 23% (NAMPORT, 2014). As it relies heavily on nearby zinc mines to generate cargo volume, the Port of Lüderitz is relatively isolated from the rest of the economy, and growth has been stagnant over the past ten years. The Port of Walvis Bay, on the other hand, has been the driving force behind Namibia's soaring volume of trade. The port of Walvis Bay transports a wide variety of goods, and is much more connected to the region's economy and Namibia's corridor transit network compared with the Port of Lüderitz. (World Bank, 2012). The port's harbor depth and mild weather all year round allow ships of all sizes to dock smoothly. For this reason, the Port of Walvis Bay is one of the only ports in southern and western Africa that can claim to have no delay in ship schedule and container handling (Japan International Cooperation Agency & GRN National Planning

Commission, 2015). Therefore, the port of Walvis Bay will likely remain the main driving force of growth in Namibia's logistics sector.

Cargo shipments to the Port of Walvis Bay can be grouped into three categories: landed, shipped, and transshipped. Landed cargo refers to maritime shipments to the Port of Walvis Bay which are unloaded and then transported by truck or rail to their final destination. Shipped cargo is the opposite of landed cargo - it arrives at the port by land and is transported out by ships. Transshipped cargo is temporarily staged in the port's storage area, waiting to be carried elsewhere by ship. Currently, transshipment makes up 60% of all containers handled at the port of Walvis Bay (NAMPORT, 2014). Although it is a significant source of revenue for the port, transshipment can be quite volatile and is often affected by factors outside of Namibia's control, such as geopolitical instabilities in other regions of the world and temporary changes in handling charges in other ports (World Bank, 2012). On the other hand, shipped and landed goods are less likely to be affected by unpredictable changes in cost and politics since they are driven by long term relationships and cooperation rather than the short term profit that transshipment brings. As such, increasing the volume of shipped and landed cargo are more important to the continuation of growth in Namibia's logistic sector.

2.2.2 The corridors of Namibia

Due to the limited capacity and reach of Namibia's railway system, landed and shipped goods are primarily transported in and out of the Port of Walvis Bay by means of trucks, and therefore the rest of the discussion of the corridors in this report will refer to road transport. Road cargo volume has seen an average annual growth of 33% from 2005 to 2009 (Savage & Fransman, 2014). Such high growth can be attributed to the stable political environment in Namibia, well-paved roads and low tariffs, all of which contribute to shorter transit times (Savage, Fransman & Jenkins, 2013).

However, data provided by the WBCG shows a large disparity between inbound and outbound traffic (World Bank, 2012). Although countries like Zambia, Malawi and Zimbabwe are sending an increasing amount of their exports through the Walvis Bay Corridors, the outbound shipment of goods on the corridors is still significantly less than inbound shipments. In 2011, outbound and inbound cargo totaled 462,433 and 43,460 metric tons respectively, which means that the former is ten times larger than the latter (World Bank, 2012). As a direct consequence, truck companies operating out of Walvis Bay are less likely to secure return loads, which are shipments picked up by trucks on the way back to their origination. As truck companies' profitability depends heavily on their ability to secure these return loads, the traffic imbalance at the port of Walvis Bay forces logistics operators to charge higher prices for shipping assignments leaving the port of Walvis Bay (Nathan Associates, 2011; World Bank, 2012). This higher price cost undermines Walvis Bay's attractiveness as a shipping destination.

2.2.3 Strategy for growth

As the trade imbalance is unlikely to change in the short term, Walvis Bay will continue to be a high cost competitor in the foreseeable future. Therefore, in order for WBCG to advance its missions of promoting the usage of Walvis Bay Corridors, it should ensure that top quality service is provided to the users of the corridor, so as to justify the premium cost. Today, there are a number of issues that, when addressed, will further the competitiveness of the ports and corridors in Namibia.

The unavailability of essential travel information, such as safe parking spaces and gas stations, is making corridor travel difficult for drivers, especially for those transporting cargo outside of their home country. Such amenities are relatively few in numbers along the vast expanse of highways. If a truck driver misses a stop, they might be forced to drive long distances until the next stop or pull-over at an unsafe location for breaks, increasing the risk of theft, robbery, and other forms of roadside vandalism. Such criminal activity is abundant in South Africa, South Africa, Zambia, DRC and parts of Namibia (Interviews with truck drivers, 2016). Although larger transportation companies are able to maintain a list of roadside amenities which they supply to their drivers, smaller companies do not or are not able to provide their drivers with this information and thus experience increased risk when transporting goods along the corridors (Hasheela, 2016). The lack of readily available emergency contact information is also likely to delay the arrival of help in case of medical emergencies or vehicle breakdowns.

Moreover, drivers from the Democratic Republic of Congo, a country with an increasing dependence on the port of Walvis Bay for shipment, mostly speak French. The language barrier makes it difficult for them to ask for directions or help in English-speaking Namibia and Zambia.

Occupational health issues among truck drivers is another challenge to Namibia’s logistics industry. Due to long working hours, truck drivers are prone to chronic health issues such as hypertension, diabetes and sleep disorders (Mundutéguy, 2014). Specific to the southern African region, Human Immunodeficiency Virus (HIV) and other sexually transmitted infections (STI) are prevalent especially among truck drivers (Delany-Moretlwe, 2014). Such health issues affect the productivity of the industry and increase labor cost to transportation companies (International Organization of Migration, 2003). The WBCG has a wellness program that provides HIV screenings, disease prevention brochures, and general health checkups for truck drivers. It operates free roadside clinics and mobile wellness service vans across the nation, but many truck drivers are unaware of such services (WBCG, 2016). More effective outreach is needed for WBCG to better address health issues among truck drivers.

These issues can have a direct influence on the Walvis Bay Corridors, potentially inhibiting the capacity for further growth. If Namibia wishes to continue pursuing efficiency and safety along the corridors, these issues should be addressed. An effective method for providing truck drivers with information on roadside services could help them make better decisions, communicate better during an emergency, and stay healthy on the road. Such a tool would improve the quality of service that Namibia provides to the users of its logistics infrastructure and further increase Namibia's competitiveness in the regional logistics sector.

2.3 Information and Communication Technology in Africa

Having identified the need to provide information to truck drivers who are using the Walvis Bay Corridors, the following sections examine the possibility of using mobile technologies to provide a solution. We discuss the current state and usage of information and communication technology (ICT) in Africa, highlighting the prevalence of mobile devices and the role they have played in various sectors across the region.

2.3.1 Mobile infrastructure in southern Africa

Africa has seen an explosive growth in mobile connectivity over the past decade. In its latest report, the GSM Association, a collaboration of more than 800 mobile operators worldwide, stated that as of the second quarter of 2015, there were 367 million unique mobile subscribers in Sub-Saharan Africa (SSA). This number has seen a 13% compound annual growth the since 2010, and is expected to keep growing. The report notes that SADC countries have the highest smartphone adoption rate in the SSA region. It also states that 25% of all mobile subscribers in the SADC use smartphones, and that this percentage is forecasted to reach nearly 60% by 2020 (GSM Association [GSMA], 2015).

The smartphone adoption rate is driven by continuously falling device prices and increased network coverage. The relatively high price of smartphones for users in the region made them unaffordable for a long time; however, competition and technological developments have now led to the introduction of low-cost smartphone handsets such as Google's Android One. These phones typically cost less than $100 USD and are affordable even among the less wealthy. Smartphones have been key to enabling internet use among people in the region (Ericsson Consumerlab, 2013; Informa, 2013). In addition to falling prices, the increased availability of high speed mobile networks has also provided incentive for smartphone adoption. Large capital expenditures are now being made by competing GSM providers across the region to provide high speed mobile internet access which will allow for full utilization of a smartphone's content-rich features. Additionally, more affordable mobile broadband packages are now becoming available (Klasa, 2014).

Smartphone usage in the SSA region is primarily driven by young consumers under 30 years of age. These consumers generally work full time or are in school, and own a smartphone typically costing less than USD 150 (Ericsson, 2013). A report by Opera Mediaworks noted that while feature phones, which are phones that have Internet capability but lacks the full range of functions of a smartphone, are the most common devices used for Internet access, smartphones such as Android devices are driving interaction with the mobile web at twice the rate of feature-phones in Africa (Opera Mediaworks, 2015).

Namibia was one of the last countries in Africa to introduce competition in the mobile communications sector but now has a market penetration rate well above the regional average. Two GSM operators, Mobile Telecommunications Limited (MTC) and Namibia Telecom, compete for customers. Both offer 3G mobile broadband and, in 2012, MTC launched a 4G LTE network in Windhoek, making Namibia the second country in Africa with this technology. Since then, the network has expanded and both operators now offer 4G in major cities, in addition to the 3G network in many smaller cities, and 2G along almost most of the Walvis Bay Corridors (MTC, 2014; Namibia Telecom, 2014). Figure 10 and Figure 11 are coverage maps of the two companies.

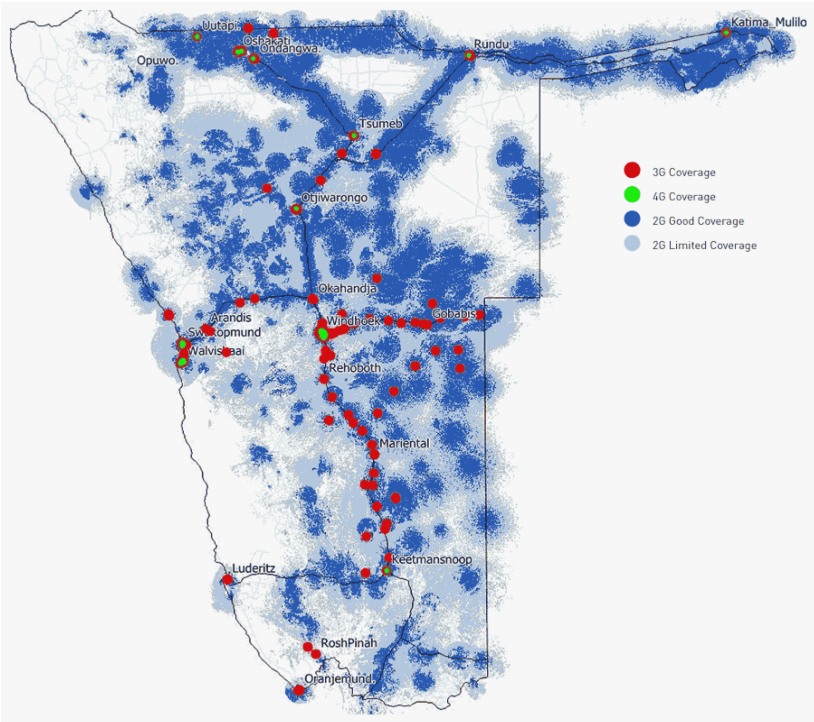

Figure 10 Network coverage of MTC 2014

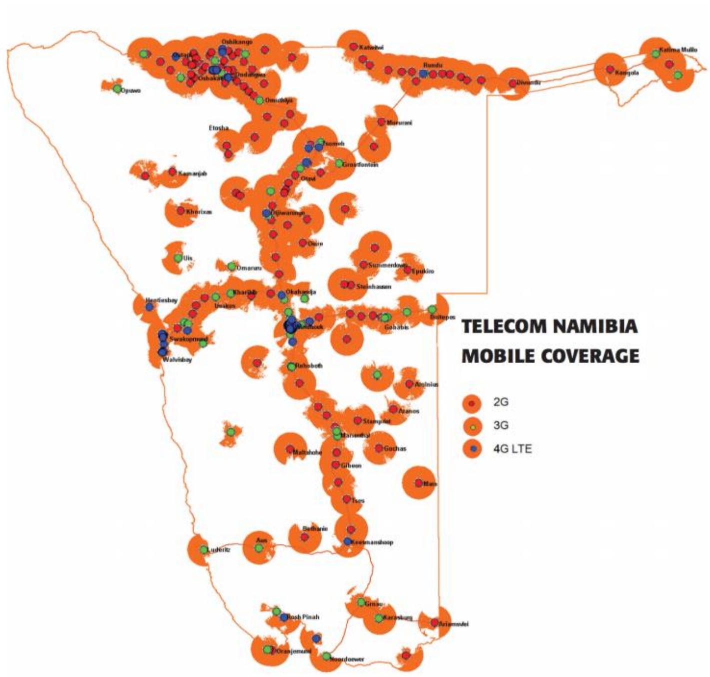

Figure 11 Network coverage of Telecom Namibia 2013

2.3.2 Impact of mobile information technology in Africa

Mobile technology is playing a central role in addressing a range of socio-economic developmental challenges in Africa. In 2007, the mobile money transfer service *M-Pesa* was introduced in Kenya. Today, 17 million Kenyans use *M-Pesa* to pay bills, buy groceries, and pay for their children's school fees. The service now handles approximately 25% of Kenya's gross national product (Bleach, 2014). In the agriculture industry, *M-Farm* is a service that allows low-volume farmers to access up-to-date market prices and agricultural trends via their mobile phone. The increased transparency along with an ability to collaborate with other farmers has drastically improved the life of rural farmers in the country. (Solon, 2013). Many services of this nature began as a text messaging interface, but as smartphones become more prevalent, mobile apps are gaining popularity as a more content-rich way of interacting with users (Ericsson, 2013).

Organizations are finding ways to utilize the growing mobile technology infrastructure in all sectors, and logistics and transportation are no exceptions. Here, we examine two examples of how mobile applications are being used to improve existing transportation infrastructures and aid those utilizing them.

M-ship is a mobile application developed by the Intergovernmental Standing Committee on Shipping (ISCOS), an initiative by Kenya, Uganda, Tanzania and Zambia. Residents of the East African Community can use the application to report delays and incidents of corruption along major transport corridors and sea ports in the region. This allows the ISCOS to gather feedback on the effectiveness of specific transport operations, and quickly determine bottlenecks and areas that need improvement. (Heavy Industry Logistics, 2015).

Similarly, *TRANSPark* is a web-based application developed and maintained by the International Road Transport Union (IRU). The application, which is available on iOS, Android, and as a web app, provides detailed information on more than 4000 truck parking areas in over 40 countries around the world. Figure 12 is a screenshot of the app's user interface. Users are able search for truck parking along their routes or within a radius around a target location. For each parking area, the availability of various facilities (security features, truck repair, vehicle wash, hotel, restaurant, and medical services) are listed. Users can also add the locations of additional parking areas not recorded in *TRANSPark*'s database and rate the security and comfort levels they offer. Furthermore, the app has additional information such as border waiting times, fuel price comparisons and instant news. Currently, *TRANSPark* provides this kind of information for truck drivers on the North-South transport corridor leaving from the Port of Durban (International Road Transport Union, 2012). For a more detailed description of *TRANSPark*, refer to Appendix A.

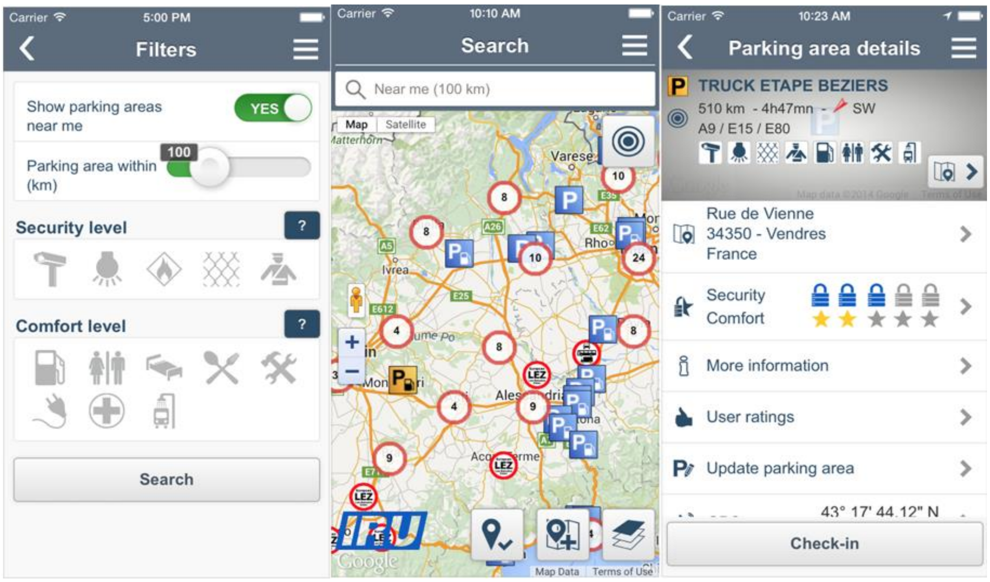

Figure 12 Screenshots of TRANSPark

Collection and distribution of information will be key in positioning Namibia as a trade leader in southern Africa. In order to attract new users and continue to growing its logistics industry, truck drivers in Namibia must be able to use the corridors safely and effectively. Information on road-side services and safe parking areas are not easily accessible for drivers along the Walvis Bay Corridors today. A smartphone application is a proven way of making this type of information available. Mobile applications are already being used to address similar issues in logistics and transportation elsewhere in the world and in the region, as shown by services such as *m-ship* and *TRANSPark*. The current mobile infrastructure and smartphone prevalence in Namibia makes a mobile app the ideal candidate for similar innovations in the logistics sector.

3. General Methodology

The goal of this project was to help better position the Walvis Bay Corridor Group and its stakeholders in the competitive logistics industry of Southern Africa by designing a smartphone application that assists the truck drivers who are using its corridors. To reach this goal, our project was broken down into the following objectives:

1. Determine users' needs
2. Propose application functionalities
3. Design application interface
4. Plan the future application development

Determining **user needs** involved **qualitatively interviewing** truck drivers, transport company officials**,** and organizations in the logistics industry within Windhoek and Walvis Bay. We examined the interview results to **identify issues** that drivers and companies are facing along the corridors today.

We then **proposed functionalities** that the application should have to address the user needs. To determine the importance of each functionality, the team used a process called **Quality Function Deployment (QFD),** which combined inputs from team members and truck drivers who were surveyed during an excursion to the Namibia-Zambia border post at Katima Mulilo.

Using the prioritized functionalities, the team envisioned what the application would look like to the end user. This was done by exploring popular design frameworks and evaluating interface designs adopted by the similar application TRANSPark. The team **produced sketches** and eventually a **high-fidelity prototype** that realizes the user interface and interactions within the app.

The team performed preliminary **data collection** in order to support our proposed functionalities. We developed **data collection methods** that could be used to acquire additional information to support every feature across every corridor. Finally, we investigated how the WBCG might pursue **development of a working mobile application** for distribution to the end users.

While this project aimed to have an impact on the logistics sector as a whole, our main focus was on road transportation and the **needs of truck drivers** transporting cargo along the Walvis Bay Corridors in Namibia. The geographic scope of such an application will eventually involve all corridors, however, to establish a pilot corridor for the app, the team, after consultation with the WBCG, decided that the section of the Walvis Bay-Ndola-Lubumbashi Development Corridor (WBNLDC, pictured in Figure 13) within Namibia would be the focus of our research due to its access to growing industries in the immediate northern region.

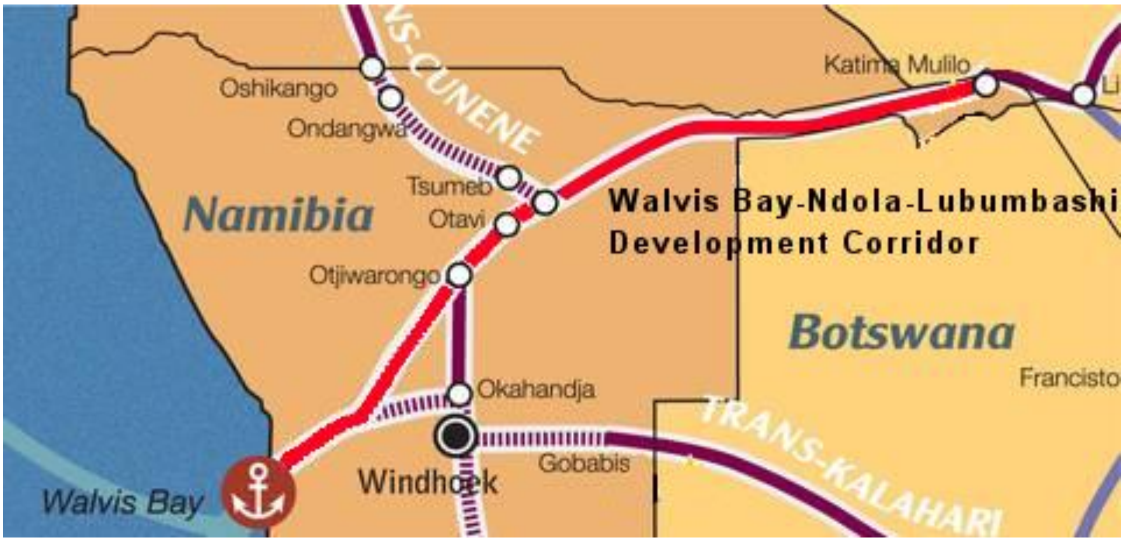

Figure 13 Walvis Bay-Ndola-Lubumbashi Development Corridor

The following chapters describe the methods and results for each of the above steps. The methods described herein were conducted from March 14th to May 3rd, 2016.

4. DETERMINING USER NEEDS

The team interviewed truck drivers in order to understand their perspective on the current state of transport safety and efficiency in Namibia. Additionally, transport company officials were interviewed with the intent of identifying pressing issues and challenges to the industry. In these first sets of interviews, the goal was to get as broad of an image as possible regarding the experience of drivers along the corridor. This was accomplished by using our interview protocol as a guideline to get the truck driver's talking about their personal experience. In doing this, we were able to touch on almost every issue facing the drivers today.

4.1 INTERVIEWS WITH TRUCK DRIVERS AND TRUCK COMPANY OFFICIALS

The team conducted surveys of truck drivers, by means of a short informal interview, in Windhoek and at the Port of Walvis Bay. Appendix B contains the qualitative interview protocol we used as a guideline for conversation. The questions attempted to gather information on the methods by which the truck drivers **navigate** the corridors, how they determine where to **stop** for **food**, **gas** or **rest** along the way, if they owned a smartphone, and what kind of challenges drivers are facing. In total, the team had conversations with 46 truck drivers throughout 40 separate interviews. More specific details on interviews locations and dates can be found in Appendix C.

The team conducted interviews with officials from transport companies and organizations in Namibia. Appendix D outlines the protocol we followed when conducting these interviews. The questions attempted to get an understanding of how the officials perceive their truck driver's experiences travelling along the Walvis Bay Corridors and assessed the company's perspective on a potential smartphone application for truck drivers. The first interview was with Mr. Willie Van Zyl, an executive member of VZ Transport who **offered details on security measures taken by officials to combat theft**. The next interview was with Mr. Harold Schmidt, the general secretary of the Namibia Logistics Association (NLA). As the head of the organization that serves 44 logistics companies across Namibia, he was able to give us a **high level perspective on the industry**. The team also held an interview with Jakkie Van der Walt and Bertie Opperman from A Van der Walt Transport. The team learned about both **A Van Der Walt's operations** and also the **challenges that smaller truck companies face** as Mr. Opperman also personally operates a smaller company with just a few trucks. The team had a conversation with Nico Oberholzer from iLogistics, a supply-chain management company that provides solutions to various companies within the logistics industry. Mr. Oberholzer informed the team on **communication issues that occur at border posts in the DRC and Zambia**. Lastly, the team met with Louis Dry from Coleman Transport who offered **recommendations for a potential mobile application**.

4.2 Issues Affecting the Trucking Industry

The following sections describe the results of interviews with truck drivers and officials in the trucking industry. A general theme was a **strong agreement between concerns expressed by truck drivers and those expressed by truck company officials**. The team was able to categorize the issues and challenges brought to our attention into four separate groups of issues.

4.2.1 Locating resources along the corridor

During interviews with both truck drivers and trucking company officials, disseminating information about roadside services along the corridors emerged as a challenge. The vast expanse of the corridors contributes to the scarcity of resources, and the available resources are not well advertised to the truck drivers.

Truck drivers reported that there is a limited number of places that offer toilets for truck drivers to use along the road in Namibia, Zambia, and DRC. Although most commercial gas stations have toilets, truck drivers can only go to places that have enough parking space for trucks. The availability of showering facilities is even scarcer, and it is common for truck drivers to go several days without showering. In addition, the availability of such amenities is **not well advertised**, hence truck drivers have no way of knowing for sure where they could find toilets and showers in a particular location. A group of Zambian drivers reported that the issue is worse in Walvis Bay and Katima Mulilo, where a large number of trucks wait for long periods of time to obtain customs clearance. Although there are toilets built around staging areas for trucks in the two towns, the number of toilets are insufficient for the large number of truck drivers, and the toilets are usually dirty. Drivers are not aware of alternative locations with toilets that they can use, and have to bear with the unhygienic ones near where they are parked.

The availability of roadside amenities is limited on the long stretches of the Walvis Bay Corridors, and truck drivers are unaware of their locations.

Trucking company officials expressed that it is difficult for them to manage truck breakdowns on the road. If the truck experiences a small mechanical issue on the road, the driver could attempt simple fixes. But they have to report to the company in the event of a serious breakdown or fuel shortage to work out a solution with officials in the company office. Two trucking company officials revealed that several larger trucking companies have their own network of repair shops and gas station chains with which they have service contracts; these companies provide a printed list of the locations of such service contractors in the truck for the driver's references. However, if contact information or addresses change, or if more businesses are added to the service network, the printouts would be rendered obsolete. On the other hand, smaller companies do not have the financial resources to establish and maintain such service contracts. Drivers who are employed by them often have to wait for the company officials to find out where they could go for repair or refuel, and have to make frequent stops to ask for directions from passersby or fellow truck drivers. Occasionally, truck drivers would request assistance from police officers regarding towing and escort; but contact information and location of local police stations were not available to truck drivers. The unavailability of location and contact information during a breakdown complicates the process of getting help and slows down the flow of goods, resulting in reduced efficiency for the trucking companies.

Drivers need to be informed of locations on repair shops, gas stations and police stations available to truck drivers to help manage breakdowns.

4.2.2 Awareness of dangerous areas

With numerous stories of theft of cargo, wheels, fuel, and even hijacking of trucks, it was apparent that safety was a big issue for truck drivers. Nearly every driver said that driving in South Africa was more dangerous than the rest of the southern African region. Drivers told us that there were long stretches in South Africa where they couldn't stop at all, no matter what. Namibia, Botswana, Zambia, and Angola were considered safer. However, drivers also said that there were certain stretches of road in these countries where they did not feel safe. In Namibia, a small stretch of road from Karibib to Usakos on highway B2 was often cited as unsafe to stop along, compared to the rest of the country. Some drivers said that they only feel safe inside paid truck ports, whereas other drivers were willing to park and sleep alongside the road. Drivers that have been driving the same route many times over said that they have learned the dangerous parts of their routes and do not park or stop there. Those driving in less well-known territories, said they rely on information given by their managers or fellow truck drivers at fueling stations, but sometimes resort to scouting the road for safe-looking places. According to Bertie Opperman, Van der Walt Transport has its own safe parking areas for trucks along routes making it easy for drivers to find safe areas to stop and sleep. Mr. Opperman noted that smaller companies, on the other hand, do not have this luxury, and drivers are often on their own when trying to park for the night.

There is no uniform view of safety across the region among truck drivers. Some may be able to learn what areas to avoid from experience, but new drivers, or experienced drivers in new areas, need to know what areas are crime-prone and thus dangerous.

Throughout interviews with drivers and officials we learned of methods by which companies have tried to counter the criminals. Some trucks have panic buttons and cameras in place inside of the vehicles. Whenever the truck driver feels unsafe, he simply presses the button to notify his manager of an emergency; however, this method requires the driver to be in the truck and thus provides no help if he encounters any dangers outside. Mr. Van Zyl mentioned that his company has made several costly investments to ensure the safety of the truck and its load. These included the introduction of a metal mesh in the tarp that covers cargo making the process of cutting open the tarp much more difficult. They had also introduced a special valve on the fuel tank to prevent siphoning.

Trucking companies have invested money into solutions to tackle theft and hijacking, but they are often very costly. Cheaper solutions are needed to ensure the safety of drivers and goods.

While crime was often the first thing brought up by drivers when asked about their concern for safety, animals on or next to the road were identified as a big problem as well. All the trucking officials that we interviewed brought up animals as a safety concern, with corridors going through areas with both wild animals (game) and free roaming livestock. At high speeds, hitting an animal has the potential to cause substantial damage to the vehicle and the driver. The issue was indicated as being more prominent at night. One driver said that signage along the roads keeps him aware, and that he therefore has to make sure he is on the lookout for these.

Accidents with animals are a high concern among both drivers and officials and measures other than signs along the road are needed to minimize the number of accidents.

4.2.3 Unhealthy lifestyle

An issue often expressed among drivers and officials alike is the health and wellness of a truck driver. Our prior research indicated that truck driving is not considered a healthy profession due to irregular working hours and minimal physical activity required while working. Interviews with workers in the trucking industry in Namibia confirmed the relevance of such problems as well as presented additional challenges specific to the region.

An additional health concern that became clear through interviews was the varying restrictions on driving hours for truck drivers. There are definite health risks for workers who remain almost completely inactive for the entire work day, and truck drivers may suffer from insomnia or hypertension even in countries with strict policies on working hours. However, many trucking companies in Namibia do not impose strict break and sleep regulations but allow drivers to make these determinations themselves. Drivers who operate under these companies offered scenarios where they will drive for longer than usual and not sleep in order to reach a safe area to stop, or will drive through the night in order to meet deadlines. Well established companies, such as Coleman Transport, reported that they have systems in place for fatigue management, something that smaller companies may not be able to afford.

Poor fatigue management can end up costing the company and the driver, and therefore drivers must be informed on the benefits of fatigue management and the consequences of sleep deprivation.

It has already been mentioned that drivers find it difficult to locate food shops along the road, however, the food that truck driver are purchasing at these shops is very unhealthy. The team visited many truck stops throughout Namibia, including stops in Swakopmund, Usakos, Otavi, Grootfontein, Rundu, and Katima Mulilo, most of which only have a very limited selection of foods consisting of fried chicken and pork, a few choices for sandwiches, and snack foods. The few healthy food items at these stops were more expensive leading drivers to opt for unhealthier options to save money. Drivers that do not stock up on food in their trucks may have to wait long periods of time before eating. Drivers we spoke too that did stock up on food did not have nearly enough variety of foods to sustain a healthy food intake.

Information on how to eat healthy on a budget along the corridors must be available to truck drivers.

Truck drivers referred to a law requiring them to get a medical checkup every other year in order to maintain their trucking license. The frequency by which drivers received additional checkups, in addition to this mandatory checkup, varied drastically among drivers according to company regulation or personal discretion. Of all truck drivers interviewed, only two indicated that they go for a personal check up every month. Only a slightly larger portion of interviewees indicated that they go at least once a year while the rest said that they only go when required for the permit. These results suggest that drivers are unsure or unaware that regular health checkups are essential especially considering the aforementioned sleeping habits and unawareness of food and clinic locations. The question then becomes what the state of awareness of health clinics is and whether or not the truck drivers are utilizing such clinics. The majority of drivers indicated that they go to a hospital in their hometown for their medical check-ups. Questions about awareness of WBCG wellness clinics the route was met with responses of very limited knowledge of such clinics. Only about a quarter of all drivers interviewed expressed awareness of the roadside clinics provided by the WBCG, and among this group, only a few said they actually utilize them.

Drivers must be made aware of the risks presented by infrequent health checkups, and locations of health clinics and services should be made available.

4.2.4 Cross-border complications

Trucking company officials informed us that regulations on driving hours, speed limits and axle load are not the same across different nations in the SADC region. These regulations are also subjected to sudden and temporary changes. One official noted that changes to regulation and temporary road closures tend to occur around weekends and public holidays, when no one would be in the trucking office to notify the drivers on the road of the changes.

Therefore, there needs to be an automatic way to provide truck drivers with updates to transport regulations and road closures so that they could operate more efficiently and avoid fines.

Drivers from DRC face language barriers when they travel to English speaking Zambia and Namibia, as the official language in DRC is French. These drivers would have a hard time seeking help if their trucks experience a breakdown in a foreign country. Additionally the language barrier is also present for English speaking drivers crossing the Zambia-DRC border when they need to complete customs clearance. Larger companies are able to hire “runners” who act as translators between the drivers and the officials and also assist with paperwork. However, the runner might exploit the fact that drivers rely on him to pass through the border, and cases of runners stealing money from the driver have been noted by Mr. Opperman. The potential dishonesty of these runners cost both the drivers and the companies’ valuable time and money.

A language barrier suggests that drivers need a way of effectively communicating with officials and the local people.

5. APPLICATION FUNCTIONALITIES

Through brainstorming and consultation with WBCG, the team proposed functionalities that the application should have to address the user needs. We processed these functionalities through a method called Quality Function Deployment (QFD) to rank them by importance**.** The team then produced the technical requirements necessary for these functionalities.

5.1 IDENTIFYING FUNCTIONALITIES

The user needs outlined in the above section were used as material to brainstorm functionalities. The goal was to come up with as many solutions to an issue as possible, and then condense the list into solutions that were similar or addressed multiple issues. Similar applications such as TRANSPark and m-ship, discussed in the background of this report, were used as references for transportation-related functionalities. Additionally, a brief meeting with the WBCG supplied input for functionalities that the WBCG deemed to be essential. The result was the following four categories of functionalities:

- Listing and mapping of essential resources including
  - gas stations, repair shops, police stations;
  - secure parking spaces;
  - toilets, shower facilities, health clinics;
  - weighbridges, and border posts.
- Notifications in areas of risk involving
  - high criminal activities, and
  - frequent animal crossing.
- Tips for healthy lifestyle habits with regard to
  - eating,
  - sleeping, and
  - getting frequent medical checkups.
- Assistance for cross-border transportation including
  - information on road regulations, and
  - a translation tool.

The full list of all functionalities can be found in Appendix E. The next sections discuss these functionalities with reference to the issues they address and potential implementation methods.

5.1.1 Listing and mapping of essential resources

Providing information on **locations** and **contact details** of various points of interests to truck drivers emerged as a highly sought-after functionality, as it addresses many of the concerns identified in the previous chapter. As the Walvis Bay Corridors cover a vast expanse and more and more new truck drivers are joining this industry without prior experience with the corridors, having intuitive ways to present location in this app would help truck drivers manage the challenge of finding what they need when they are on the road. Moreover, contact information for places such as clinics, repair shops and police stations would help the drivers communicate more effectively in the event of a breakdown or emergency.

The team chose to present location information to the users by both a **map view** and a **list view**. A map view of the points of interests in the vicinity will give the user a quick yet thorough understanding of what services are available nearby. The visual nature of digital maps would also help end users better interact with the information presented. On the other hand, a list view is a compact way of presenting information, whereas information presented on a map can be sparse and not as detailed. Considering the limited screen size of mobile devices, having a condensed way to present information may reduce the amount of time needed to supply the user with the information they need. Truck drivers often plan their journeys by deciding which towns they should to stop at between their origin and destination. By listing waypoints in a sequential order, with distances from the user's current location and the names of towns that the drivers will pass through, the truck drivers will have all the information they need to plan their stops. List view and map view complement each other, and both should be pursued in this application.

A **filter option** to limit the type of places that show up in each view should be implemented to help users quickly select exactly what they need, without irrelevant information cluttering the view. For example, the user should be able to see only gas stations and repair shops in the view they select, if they are only interested in filling up gas and fixing mechanical problems of the truck.

5.1.2 Notifications in areas of high risk

In order to tackle the safety-related issues that often affect specific stretches of the road, the application should **show notifications** about **dangers** to the user. Experienced truck drivers and company officials identified criminals and wild animals as two major threats to drivers' safety, and pointed out that certain stretches of roads are known to be prone to theft or collisions involving animals. In order to notify inexperienced drivers of the potential danger, the team decided that **voice notifications** offered the best non-intrusive way to alert truck drivers when they are approaching areas that are known to be dangerous. Similar to how navigation applications notify users of each turn, our application would detect if the driver is approaching areas that have been identified as being accident prone and read out a voice alert to advise users to be cautious. Our app should notify the users again when they are exiting the danger zones.

5.1.3 References for living a healthy lifestyle

In order to help the drivers be healthier and more productive, the app should provide quick references on how to live a healthy lifestyle on the road. These could include information on how to **rest effectively**, tips on how to **eat healthy** on a budget, prevention methods for **common diseases**, and motivation to go for **health checkups** more frequently. The app needs to have the capability to present these references, containing texts and pictures, in a format suited for mobile devices.

5.1.4 Cross-border assistance

A couple issues identified by truck drivers arose from complications when travelling across borders. These included an absence of information about rules and regulations and an inability to communicate due to a language barrier. To address the former issue, the application should provide **digitized access to essential rules and regulations** such as speed limits on communal and commercial roads, driving hour restrictions, and truck weight and length restrictions. Much of this information is already compiled online or by transport companies but the necessary steps have not been taken to make this information quickly and easily available to all drivers who utilize the corridors. Our application should provide this information in a menu that is available with or without network connectivity. WBCG should also have the capability to update the references with new information when it becomes available.

To address communication issues that are the results of linguistic barriers, it is also necessary that the app provides a **translation tool** that allows the many French-speaking drivers from the DRC to communicate with officials and locals. The tool could also be implemented throughout the app so that any text within the app is available is a variety of languages. Voice notifications could also be provided in the preferred language of the user.

5.2 Assigning Priorities to Functionalities

Next, the team prioritized the functionalities in order to understand which features should be given more focus when designing user interfaces. Prioritizing the functionalities also will allow future developers of the application to know which functionalities should be implemented before others.

We adopted a Quality Function Deployment (QFD) to prioritize functionalities. QFD is a system that is frequently used to convert qualitative descriptions of needs and requirements to quantitative measurements on how well a technical specification of a product aligns with the initial needs or issues (Pai, 2002). This method has seen widespread application in industries ranging from manufacturing to the military. The software industry has also embraced and adapted QFD methods to ensure high customer satisfaction (Liu, 2000).

Table 1 Example of a QFD table

Issues	Weight	Feature 1	Feature 2	Feature 3
Issue 1				
Issue 2				
Issue 3				
Weighted Totals				

A table similar to Table 1 is typically used in QFD. It obtains a qualitative measurement of how important each need is and well each proposed feature addresses the needs by using the following procedures:

1. Assign each feature with a score that represents how well that feature addresses each issue
2. Obtain a numerical measurement of the weight of each issue through surveying potential users

3. Multiply the score that a feature has for an issue with the weight of that issue to obtain the weighted score. Sum the weighted scores of the feature for all issues to obtain the weighted total of a feature. A higher weighted total would indicate that a feature is more important.

The team made individual assessments on how effectively each functionality addressed each identified issues. Each feature/issue pair was given a score from zero to four, with zero indicating that a feature does not address this issue, and four indicating that a feature addresses this issue very well. The scores given by each team member were then averaged and recorded in their corresponding columns. A cell in the column under Feature X would contain the score of this feature for the issues in the same row as this cell.

In order to determine the weight of each issue, the team designed a questionnaire for truck drivers. The questionnaire, found in Appendix F, covered a range of identified issues concerning dangerous areas, unhealthy lifestyles, complications when crossing the borders, and asked about how difficult it is to find various resources along the corridors. Drivers were asked to assign a score from zero to four to each issue, with a higher score indicating a higher severity or difficulty. The team traveled to Katima Mulilo and the Wenela border post between Namibia and Zambia, used by all trucks entering and exiting Namibia through the WBNLDC. During this trip, we handed out the aforementioned questionnaires to truck drivers at the border post as well as at fuel stations in Otjiwarongo, Otavi, Grootfontein, Rundu and Divundu. We collected a total of 24 responses, which were averaged and normalized on a scale from one to five. The results are presented in Table 2 Identified issues and their weights to be used in QFD (in decreasing order of severity). The detailed results can be found in Appendix G.

Table 2 Identified issues and their weights to be used in QFD (in decreasing order of severity)

Risk of theft/hijacking on roads in DRC	5
Risk of theft/hijacking on roads in South Africa	4.61
Corrupt officials at the border	3.99
Difficulty finding safe places to park	3.59
Animals walking on the road	3.54
Difficulty finding places to take shower	3.54
Driving for very long hours	3.37
Not knowing French when driving to DRC	3.37
Difficulty finding places to sleep at night	3.25
Not knowing how to stay healthy on the road	3.2
Risk of theft/hijacking on roads in Zambia	2.69
Difficulty finding health clinics	2.46
Difficulty finding healthy food	2.41
Having to drive when you are sick	2.3
Long queues at the border	2.3
Difficulty finding places to buy food from	2.24
Not getting checkups often enough	2.18
Difficulty finding clean toilets	2.13
Driving on narrow roads in Namibia	1.79
Risk of theft/hijacking on roads in Namibia	1

With inputs on the helpfulness of each feature and the importance of each issue, the weighted totals of each functionality were calculated, completing the QFD process. Figure 14 presents the features and their weighted totals, and the detailed score breakdown can be found in Appendix H.

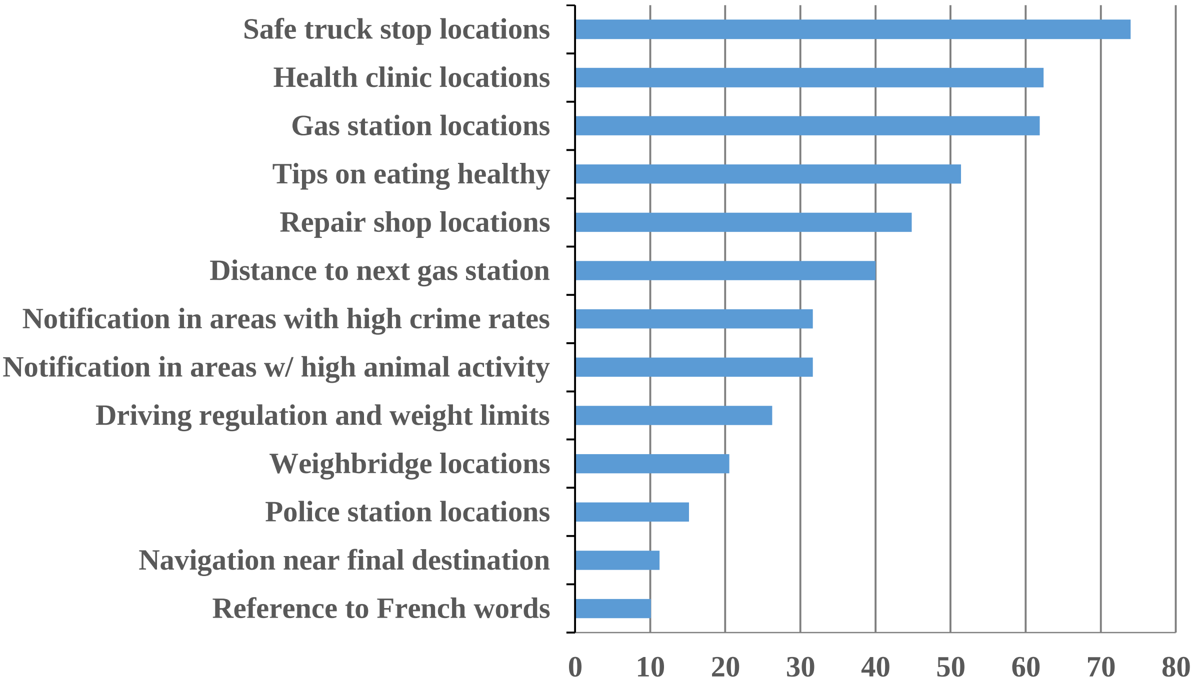

Figure 14 Results of QFD

Examining the results of the QFD revealed that even though some features are ranked above others, many of them are similar from the perspective of software development. For example, features that have to do with listing and mapping of location information can be designed to use the same code base, expediting development effort. Similarly, the code used to support notification for road closure can be extended to support notifications for roads with high criminal and animal activities. Grouping similar features and reusing code could save a significant amount of time when developing the application.

5.3 Technical Requirements

In order to implement the features determined in the previous section, it is necessary to discuss the requirements of the application from a technical standpoint. This involves the performance, reliability, and availability requirements that must be in place for the application to function properly and effectively. These requirements will aid the WBCG in communicating with a developer in the future.

Many important functionalities within the app depend on a method of mapping and geolocation, meaning the user can see their location and the location of the resource they want. Most smartphones today support global positioning (**GPS**) and there are a number of application programming interfaces (APIs) that deal with the backend logic of displaying maps and handling navigation. In implementing the corridor smartphone application, the API needs to support **custom markers, route-planning, navigation,** and **geofencing.** Custom markers will be used to specify locations of the many points of interests, and route-planning and navigation will be key in helping drivers find points of interest along their route. Geofencing is a feature that defines geographic boundaries, in order to support functionalities such as alerting the user when they enter a specific area. Notable APIs today include commercial options such as **Google Maps API** or Bing Maps API, or open-source options such as CartoDB and OpenStreetMap.

Mapping and navigation-related features require the presence of geolocation data on user's devices. Such data could be either downloaded onto the device and updated periodically (persistent) or pulled from a server when the users are using the features (temporary). The former requires that the device has data storage capability, which is present in all Android phones. Several navigation applications, such as Google Maps and MAPS.ME, allow their users to save map data packages for a region that the user specifies, so that the app could still function when the device loses Internet connectivity. Internet connectivity is needed to download the initial data packages and for subsequent updates to the connected data. However, once downloaded, the stored data would allow the application to function normally even when the data connection is lost.

On the other hand, pulling data as needed requires an active mobile data connection on the device, which is not always guaranteed when drivers travel across borders. Appendix I contains cross-border roaming availability for mobile operators in Namibia, Zambia and DRC. Depending on whether the user is a prepaid or postpaid subscriber, data roaming could be either unavailable or prohibitively costly. The increased loading time and high data rates charged by mobile carriers may deter users from using the app. Therefore, the app should have the ability to **store data on user's device** to ensure that it has a consistent user experience and is cost effective for the user.

The discussion of offline storage brings us to an important decision that has to be made for this kind of an application. That is whether the application should be natively installed on a mobile device or available as web application accessed through internet browser on the device. The team suggests that the corridor application should be made available as a **native application** for the **Android** mobile operating system, available for devices running Android version 4.1 (Jelly Bean) and above.

All truck drivers with smartphones that were interviewed used Android devices, suggesting a very low or non-existent usage of devices running other operating systems. Thus, a web app would not stand out as a favorable cross-platform option, since the target users only use one type of operating systems. Further, given the wide range of Android devices observed in our interviews, the offline storage and background notifications required along the corridors may prove difficult to implement in a web application for many of the low-end smartphones that are currently lacking support for the latest technologies in their browsers. As an example, significant offline storage has only recently been made for smartphones through the HTML5 Storage API. A further analysis of the drawbacks and benefits of native applications compared to web applications can be found in Appendix J.

The information that should be available in the smartphone application represents a changing and growing set of data that needs to be maintained. A number of features may become outdated due to real-world changes in road-conditions or corridor events. This demands a supporting infrastructure that is consistently maintained. By storing the necessary data in a central **database on a server**, with operations such as create, read, update, and delete **(CRUD)**, one is able to ensure that users have the most up to date information on corridors. A **web interface** should be available to administrate the information stored in the database.

The smartphone application will mainly target English speaking users, but there are also truck drivers who don't speak English and could benefit from the proposed features. The development of the app thus becomes a matter of **internationalization**. The team agrees that in order to benefit all drivers using the corridors, the application should be developed with multiple languages in mind. Today, many apps are built with support for several languages and the ability to add additional languages when needed. Truck drivers who are using the WBNLDC speak **English** and **French**, both of which should be available as settings in the application. With expansion to other corridors in the future, the **Portuguese** language in Angola along the Trans-Cunene corridor should be considered as well.

Lastly, the idea of a translation tool that can translate any term or phrase requires the usage of an online **translation API**. The most commonly used translation API today is **Google Translate**, and is available as a pay-per-character service. Storing a set of reference words could also be useful, especially if the connection is poor, limiting access to the online translation API. However, given the relatively low priority of this these features, it may be less time consuming to just provide access to the translation API.

6. INTERFACE DESIGN

This chapter describes how the team made design decisions through analysis of existing designs in order to provide the simplest and most efficient experience for the user. The team brainstormed and sketched paper mockups to determine how certain functionalities would be best presented to the user. With these, we created a prototype that combined these ideas and interaction decisions into an intractable visualization of the application.

6.1 HIGH-LEVEL DESIGN DECISIONS

An intuitive interface is essential to developing an application that will most effectively satisfy the needs of users. Useful interfaces should be able to present essential information with the least amount of interaction. Many modern mobile applications follow well established design guidelines that aim to achieve a coherent user experience. Within this section is the analysis of a popular design guideline, Material Design, and that of an application with similar functionalities, TRANSPark. The section also describes design decisions we have made regarding layout, interface, and color of our proposed application.

6.1.1 Material Design

Material Design is a comprehensive interface design guide that provides templates for common functions, views and buttons, and is the design foundation for an increasing number of Android applications. It aims to promote non-invasive and user-friendly interactions that users can easily follow. Figure 15 contains examples of how Material Design is used in Google Maps. The design utilizes as much space as possible to present a continuous map, which is the main feature of the app. A few key buttons float on top of the map and their icons clearly indicate the actions they perform. These buttons are referred to as “floating action buttons,” or FABs. The search bar located at the top of the screen also floats above the map. The bar that appears on the bottom of the screen when a location on the maps is pressed is referred to as a bottom sheet. When the user taps on the bottom sheet, it slides up to present detailed information about the place selected. Motion between the different views is described as being an essential principle in Material Design. Inputs from the user should always be met with transition animations that are logical and natural.

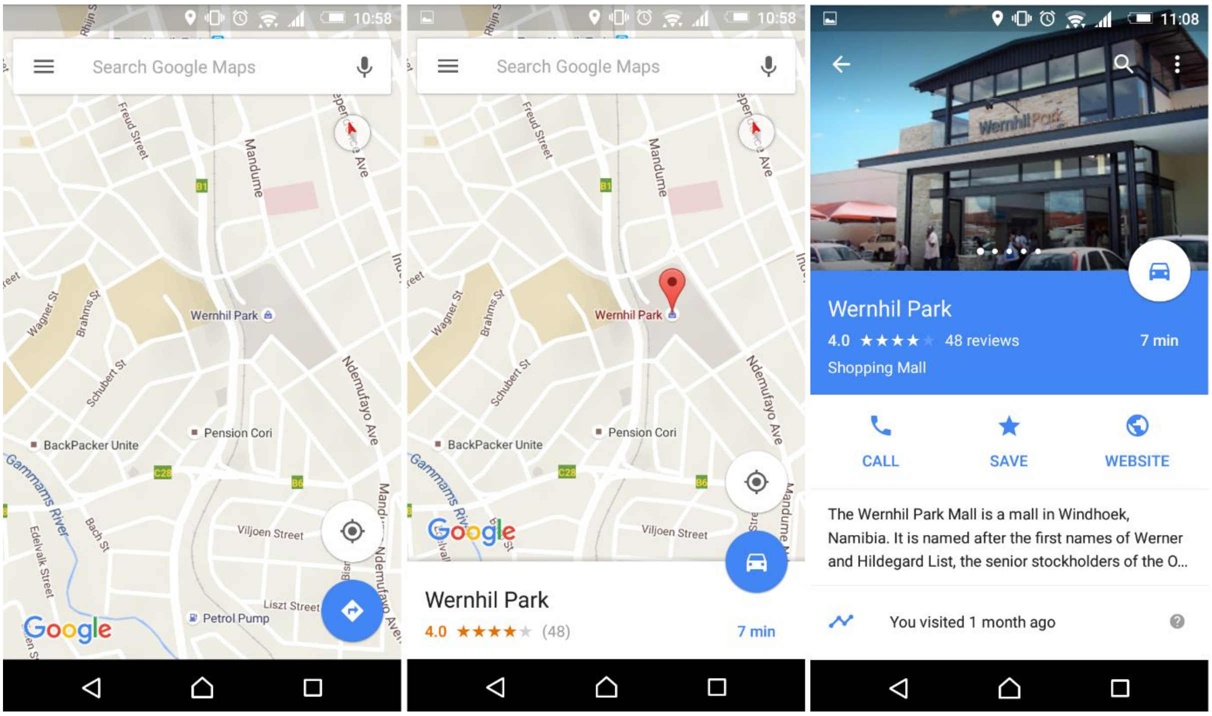

Figure 15 Material Design in Google Maps

Material Design is especially suited to our needs as the scheme is developed by Google and now forms the basis for the Android operating system. From our interview results, we saw that many of the truck drivers along the corridor utilize various models of Android phones. Components within Material Design scale well on screens of different sizes, allowing the application to look good on any device. Google provides developers and designers with extensive documentations on how to implement Material Design, which the team used as a primary reference for design.

6.1.2 TRANSPark's interface

The team analyzed TRANSPark's user interface as TRANSPark has features similar to those we had proposed. We compared and contrasted its interface with the principles of Material Design to gain insight into what to do and what not to do in order to maximize the user friendliness and efficiency of our own design.

When TRANSPark is first opened up, the user is **immediately given a map with truck stop locations** within a specified radius. The team appreciated this design decision as it provides the user with possibly the most useful feature of the application instantly without any button presses. Another notable interface decision was dedicated buttons for other useful features such as a quick switch to list view button, a map filtering button, and a button for entering the user's itinerary. A negative point to note is that the map is cut off on the top and bottom of the screen by bars where all the buttons are located. These bars are static, meaning they cannot be hidden and thus must always take up a significant portion of the screen. Phones with smaller screens may have only half the screen left for a map display.

In contrast to the principle of fluid/intuitive motion in Material Design, interacting with TRANSPark often results in sudden and illogical transition animations. For example, touching the “Filters” icon in the top left makes a page slide in from the right side of the screen, and the button to go back to the map points in the opposite direction of motion when touched. However, TRANSPark does do a good job of using callouts to present information rather than open a new page. A callout here refers to a pop up text box overlaid on the current screen as seen in Figure 16.

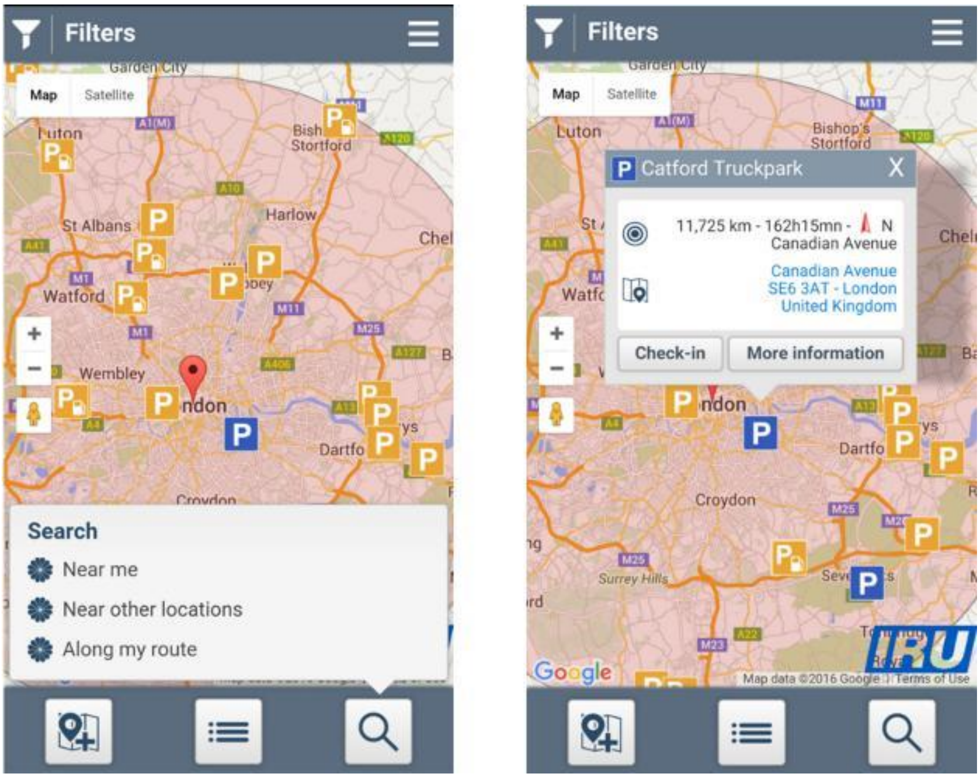

Figure 16 TRANSPark's user interface (left: search bars; right: callout for specific locations)

6.1.3 Determining a color scheme

The last step before the team began sketching pages of the application was to determine a color scheme for the final design. The color scheme must give a professional feel to the app as well as be recognizable as a WBCG product. Using an online application called *Coolors* to extract the main colors used in the WBCG logo, we obtained a suggested color scheme for our app. Figure 17 is the determined color palette with the WBCG logo for reference.

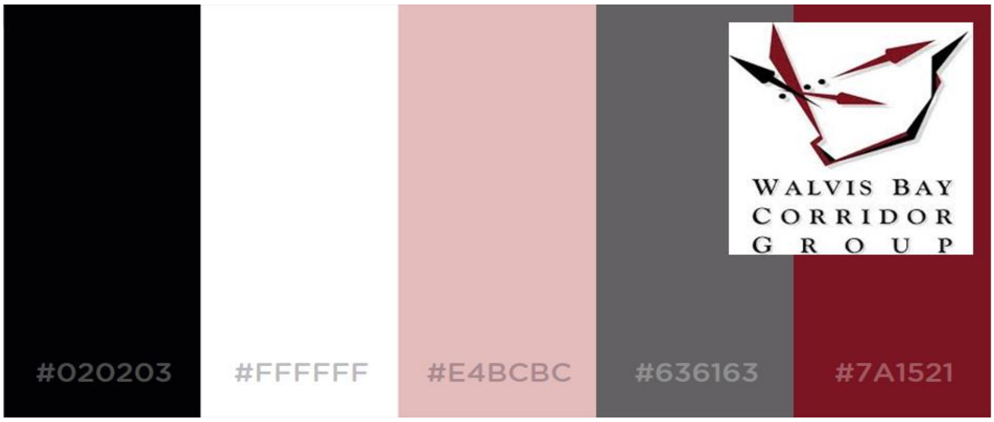

Figure 17 Color scheme inspired by the WBCG logo

6.2 SKETCHING AND PROTOTYPING

With preliminary considerations of appealing design and interface schemes analyzed and a high-level guideline established as a reference, the next step was to visualize how various functionalities might be presented to the user. The team drew up sketches on paper of what they thought different pages of the app should look like. These sketches were then developed into colored pages using a prototyping tool called *Justinmind*; these pages can then have working buttons that trigger movement from one page to another based on simulated user interactions.

6.2.1 Preliminary interface designs

During the sketching process, each member of the team came up with his or her own independent set of sketches that represented the application. These were then brought together and discussed, with the aim of combining the various sketches into a final coherent idea of what the app would look like. Figure 18 showcases a conscious design decision that was made. The main navigation drawer (well documented in Material design and used in apps such as Google Maps) was determined to be accessed from a button in the top left corner. The picture to the left depicts the traditional "hamburger" style button that one team member suggested. The picture on the right depicts the final choice of instead using another member's suggestion of having WBCG logo be a button that lets the user access the navigation drawer.

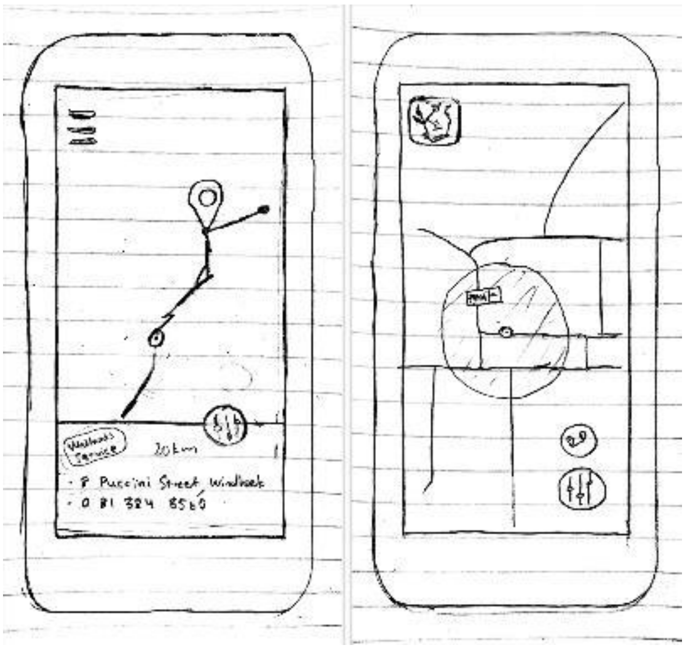

Figure 18 Sketches of map view using the traditional hamburger icon (left) and WBCG-icon (right)

6.2.2 Application prototype

Justinmind Prototyper is a software that allows for the creation of high-fidelity wireframes of applications for any device. The software has the ability to add areas of interaction to high quality photos, and provides libraries of Android buttons, menus, tabs, and title bars aligning with the design principles set out in Material Design. Using Gimp, an open-source image editor, and *Justinmind Prototyper*, the team was able to completely envision our final application with transitions and navigation. The result is a deliverable that can be provided to software developers, eliminating the design process on their end almost entirely. This section presents pictures of our prototype and discusses final design interface decisions.

When starting up the application, a user is presented with a **splash screen**, shown on the left side of Figure 19, displaying the Walvis Bay Corridor Group logo and title of the application. This will remain on the screen until the application has finished loading. This screen will prompt the user to grant the application permission to access the user's location the very first time a user starts the application. Once the app has loaded, the user will first be taken to the home screen, shown on the right of Figure 19, featuring a **map view** and a number of buttons for further navigation. By default, the application should display resources within a user-defined **radius** of his or her current location. No tapping is necessary to see what is available in the nearby area.

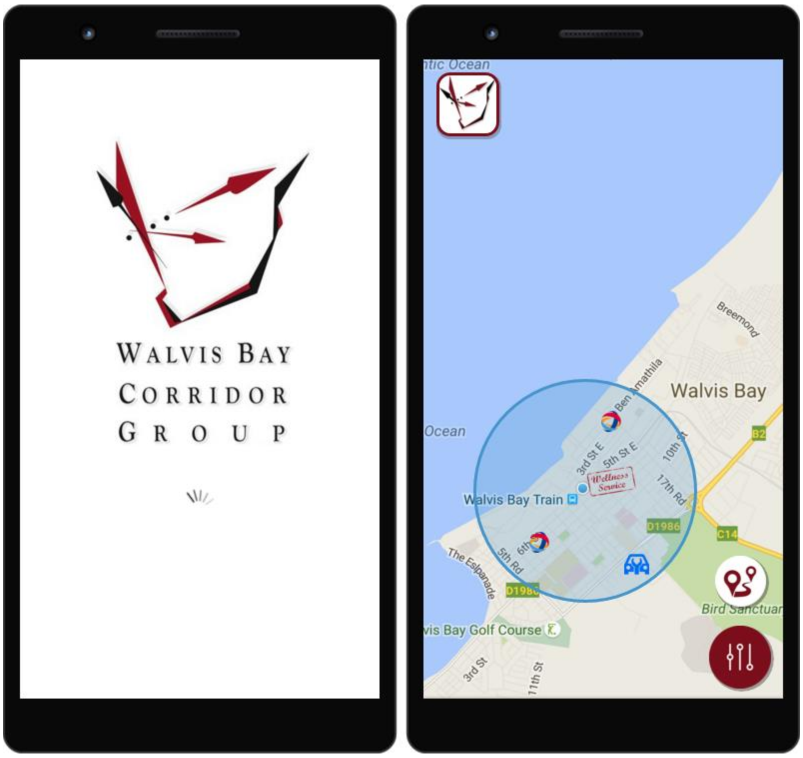

Figure 19 Splash screen and default map view

By pressing any of the resource icons available within the defined radius in **map view**, an **at-a-glance** card slides up, shown on the left of Figure 20, providing short additional details about the resource. Only showing a short description lets the user press various resources for a quick comparison. Clicking the at-a-glance card takes the user to a full screen **detailed view of the resource**, shown on the right of Figure 20, with all relevant information such as a phone number, operating hours, and services provided at this location. If available, a picture of the location provides the user an additional reference as to the location of the resource.

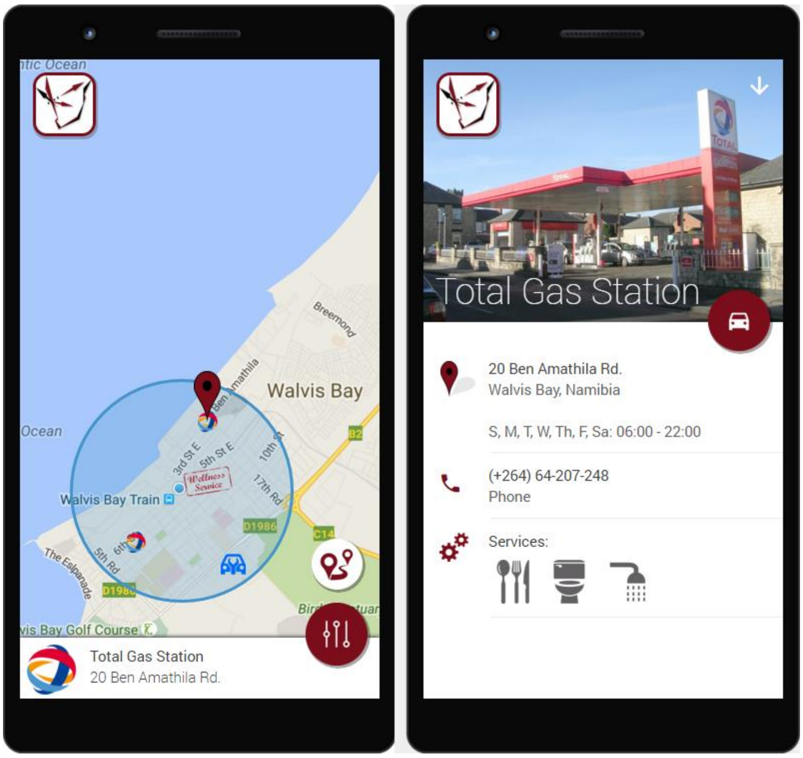

Figure 20 At-a-glance view and detailed view of resources

The button at the very bottom right of **map view** takes the user to a **filter screen**, shown on the left of Figure 21, where one can select what resources should be displayed using simple switches next to the icons and names. Apart from filtering the resources, the user also has the option to switch their viewing style to a **list view**. Upon selection of list view and pressing the **check-button** at the bottom right of the screen, the user is returned to a new screen, shown on the right of Figure 21, now featuring a list view of resources within the specified radius, sorted by distance from current location. The user can scroll through the list to see location and distance information. The **detailed resource view** still is available by simply selecting a resource from the list.

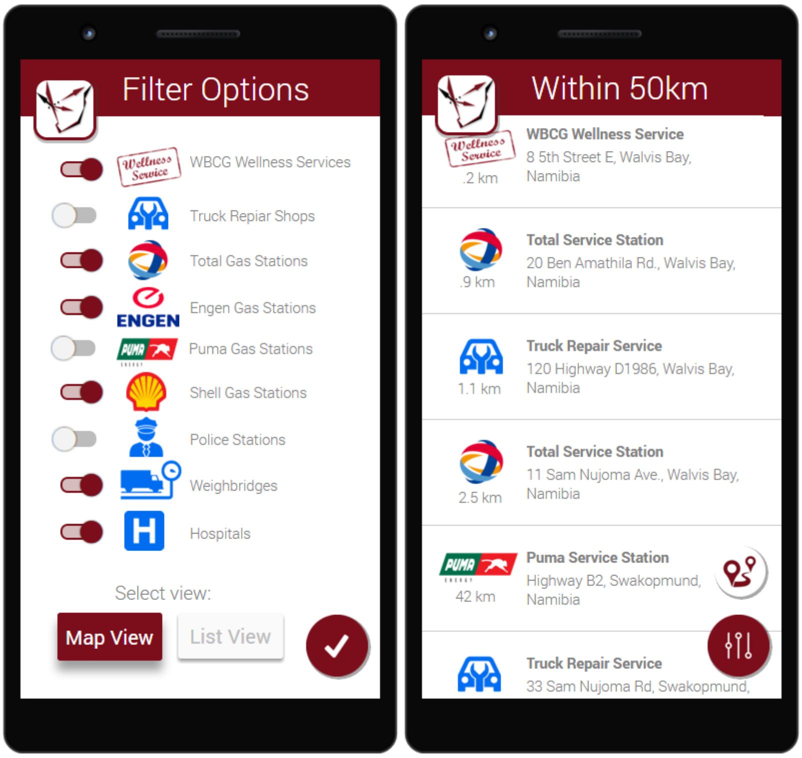

Figure 21 Filtering option and list view

The second floating action button above the filter button in the lower right corner of the screen takes the user to an **itinerary-input screen**, shown on the left of Figure 22. The user is asked to input the origin and destination of his or her trip. To make the experience easier, the users starting location can be selected as their current location, automatically determined by the GPS in the smartphone. Upon entering the itinerary and returning to the home screen, the user is now presented with an **itinerary map view**, shown on the right of Figure 22, which replaces the radius view, instead showing resources along the planned route. The filter option is still available in this mode as is the option to enter a new itinerary.

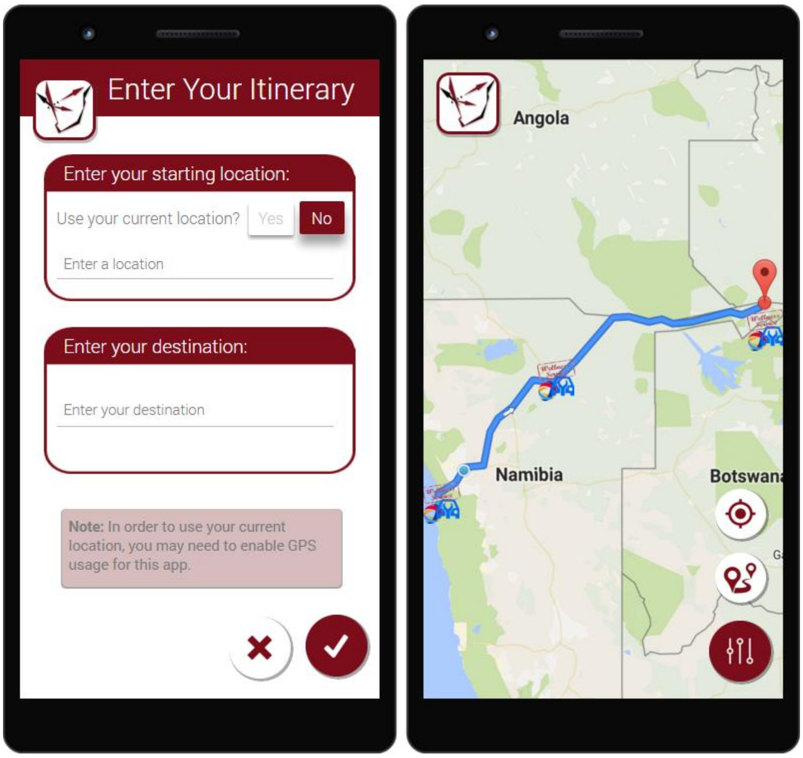

Figure 22 Itinerary entry mode and itinerary map view

Just like the normal radius map view, one can pan around and zoom on the map to plan stops along further along the route. Figure 23 shows various zoomed locations along the itinerary. A new **current location** button becomes available when the map is moved so that the user may quickly pan back to their current position along their itinerary.

Figure 23 Details of itinerary map view

The filter screen, if selected in itinerary mode, once again allows the user to select which resources to display or to switch to an **itinerary list view**, shown on the left of Figure 24. Somewhat different from the previous list view, this view focuses on the actual trip inputted by the user. With a modified scroll bar along the left side of the screen representing an overview of major towns (three houses) along the way, it becomes easy to step through the trip. The actual list on the right features all resources along the road, divided by the current location and towns along the way. The **notifications,** shown in the middle and on the right of Figure 24, are meant to help alert drivers when entering unsafe areas based on frequent **criminal activity** or **crossing of animals** along a specific stretch of road. These notifications are implemented as popups on the map, grabbing the attention of the user. When the app is not open, they appear as notifications on the users phone lock screen. The notifications should also be accompanied by a voice notification.

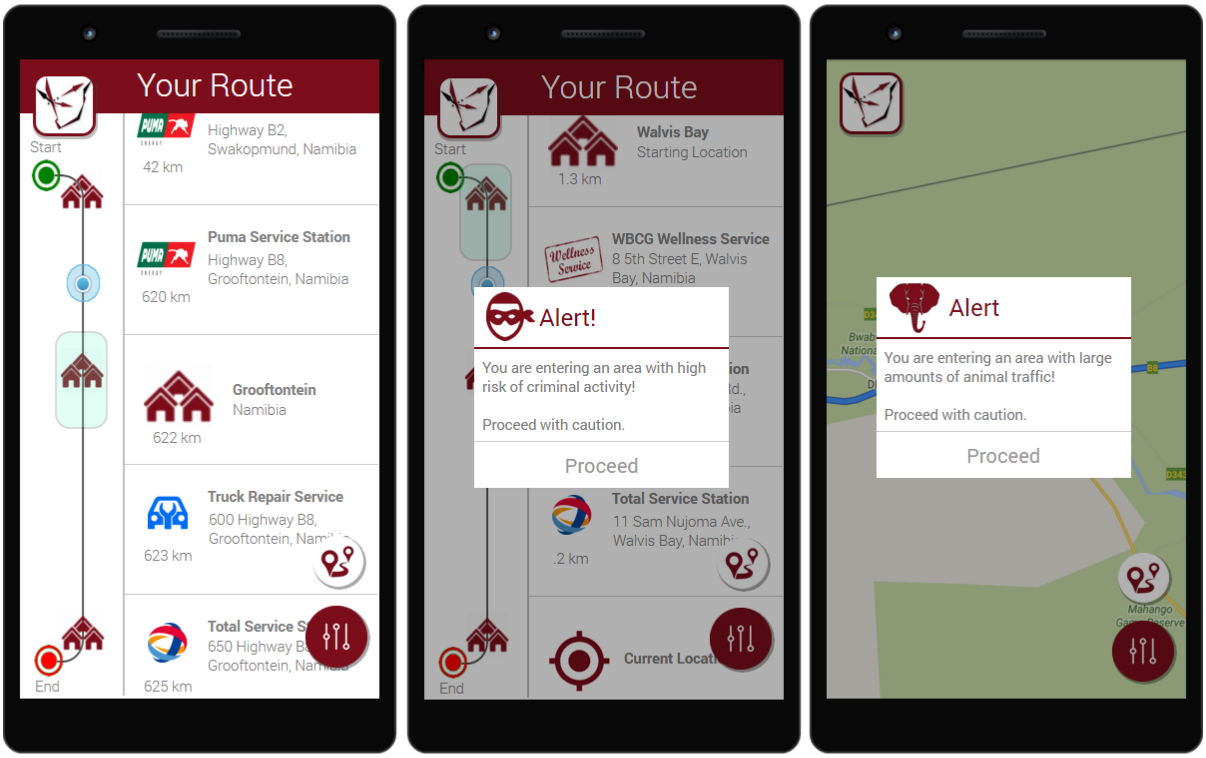

Figure 24 Itinerary list view and alerts

The button featuring the WBCG-logo in the top left corner of the app lets the user access a **navigation drawer** from almost any screen in the application. The navigation drawer, shown on the left of Figure 25, provide the user access to settings, an about page, and options to provide feedback on the application. The drawer also acts as access to additional features, such as references on corridor rules and regulation, tips for living a healthy lifestyle and a translation tool, as described earlier. The image in the middle of Figure 25 shows an example of the rules and regulations screen and the image on the right is the translation tool. Were there to be no internet connection, the regulations would still be available and the translation tool would offer a link to a screen with common phrases in different languages.

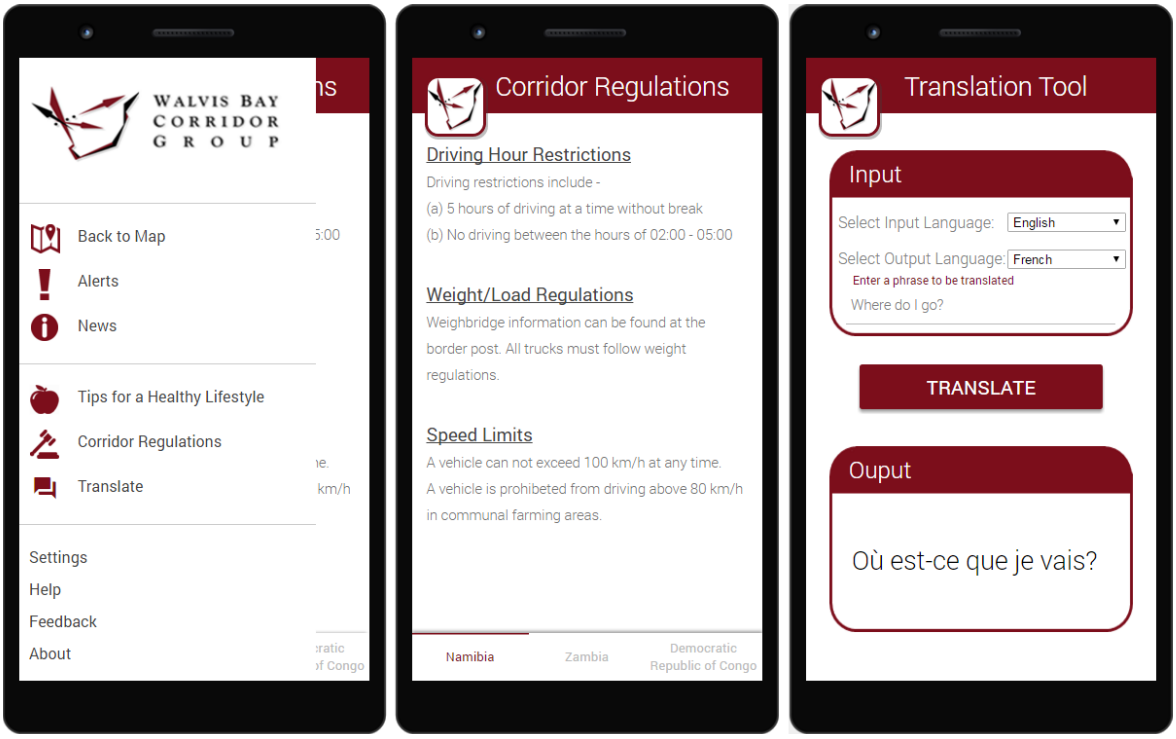

Figure 25 Navigation drawer, references on corridor rules and regulations, and translation tool

With the user-interface described above, we hope to provide truck drivers with an overall layout that is easy to grasp and learn. The most important features are available instantly or require very few taps to reach. Interactions and transition animations, while not easily captured in screenshots, will come natural to the users and will aid the user in using the application. The strong similarity between this prototype and the popular navigation app Google Maps is intended to reduce or almost eliminate the effort required for users to navigate the app.

7. APPLICATION DEVELOPMENT

The goal of this project was to design a prototype and outline the next steps for the WBCG to pursue the development of a working application. This includes the data collection necessary to support many of the location-based features, as well as finding the right firm to develop the application and its supporting back-end. This chapter describes our methods for preliminary data collection, how the WBCG should pursue the development of a mobile application, and recommendations for evolving the application in the future.

7.1 COLLECTION OF SUPPORTING DATA

The team gathered a substantial amount of the data necessary to support the proposed functionalities, focusing on the Walvis Bay-Ndola-Lubumbashi Development Corridor (WBNLDC) as the pilot corridor. In order for the application to function properly throughout all of Namibia and the other SADC countries, additional data collection must be done by the WBCG. This section describes the team's methods of gathering information by means of archival and field data collection. Additionally we discuss how a crowdsourcing method for data collection could be employed by the application in the future.

7.1.1 Archival data collection

From consultations with members of the WBCG, we obtained information and resources on the rules and regulations relevant to road transportation. Mr. Samuel Taapopi, a staff member of the WBCG's wellness service, was able to provide locations of the WBCG Wellness clinics throughout Namibia as well as the various services the clinics provide. We used our earliest interviews with drivers in Windhoek and Walvis Bay to identify the areas in Namibia where it was not safe to stop due to the risk of theft and hijacking. Information regarding operating hours, locations and contact information of hospitals, police stations, border posts, and ports were found by researching available information online.

7.1.2 Field data collection

Any required data that was not available through archival research was collected by the team ourselves. Accompanied by Mr. Samuel Taapopi, we drove along the WBNLDC to supplement the archival research. As we traversed the corridor, the team marked locations of importance for the truck drivers including gas stations, repair shops, weighbridges and police stations, and noted their contact information. For all locations of importance, the team stopped and used a smartphone application to determine their longitudes and latitudes. Specific to gas stations, we also recorded whether they provide amenities such as toilets and showers, as well as whether they sold food. While on this trip, we visited the WBCG Wellness Clinic in Katima Mulilo to talk with their staff and ask what services were provided.

After the team returned from the trip to Katima Mulilo, we contacted gas stations, auto parts shops, and repair shops in the towns along the part of WBNLDC that we did not visit (from Otjiwarongo to Walvis Bay) to further supplement the data collection trip. We requested information on their locations and the services that they provide to truck drivers.

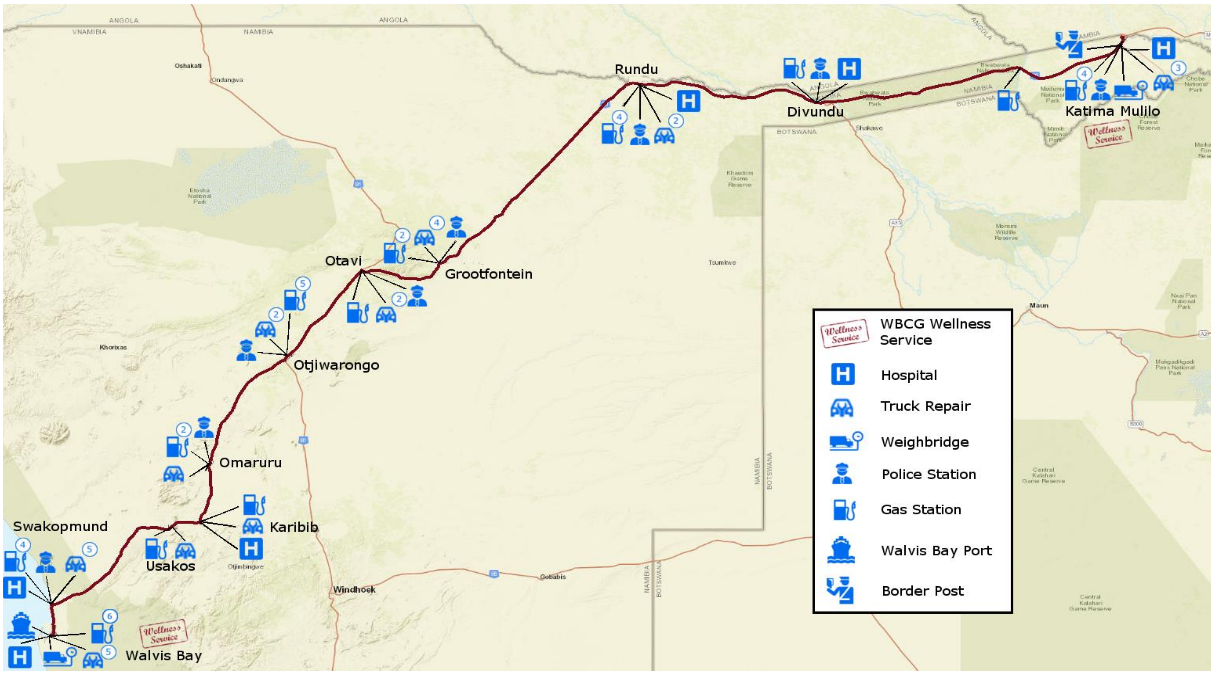

Figure 26 ArcGIS map of resources collected

Information collected in this step was documented in Appendix K through Appendix N. The team also mapped it using a geographic information system (GIS) software called ArcGIS. The map is in Figure 26 above. This map is useful in understanding the availability of amenities along corridors. The final set of services identified along the WBNLDC can be found on full-page map in Appendix O.

7.1.3 Collection of crowdsourced data

As the geographical scope of the application eventually would span all Walvis Bay Corridors, totaling 7,600 kilometers of roads across 6 countries, keeping location information accurate and up-to-date will prove to be a challenge. In contrast to funding expensive and time consuming data collection trips, an alternative solution could be to have the users participate and contribute to this process, or in other words, crowdsource the information collection process.

Crowdsourcing refers to a distributed problem solving process, in which a significant problem is broken down into small parts that individuals can manage and contribute solutions. (Brabham, 2010). Many apps that require the collection and verification of information spread across a wide geographical region use crowdsourcing to allow users to contribute to building an accurate database, and ultimately improve the user experience. For example, *Google Maps* prompts users to answer yes-or-no questions about places that they have visited to collect information such as hours of operations, wait times and quality of service, and use the collected data to help other users make more informed decisions. Figure 27 shows an example of questions asked by *Google Maps*, and a screen to thank users for their inputs. Crowdsourcing could also be done inexplicitly, as seen in another app called *Street Bump* which collects data from the accelerometer in a device without user intervention. The data are then used to identify potential potholes on the road.

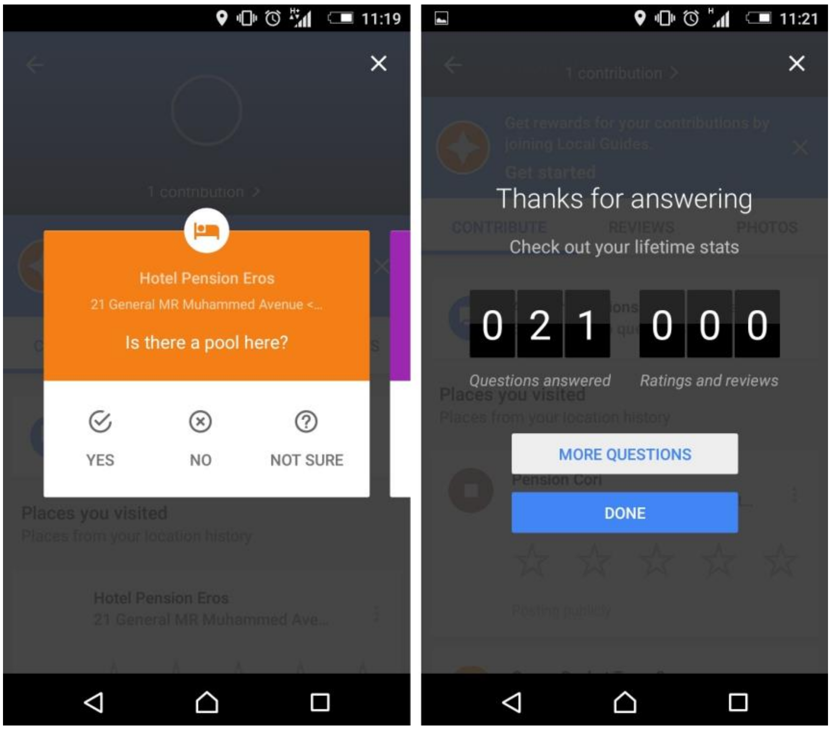

Figure 27 Crowdsourcing in Google Maps

Crowdsourcing in this application could be two-fold: First, we propose that **users can add information on resources** that have not yet been mapped. It might be because they were missed in the initial scouting or because they were made available at a later time. When adding new resource, the user should be prompted to pick the type of service (clinic/hospital, police station, gas station, repair shop, etc.) and provide additional details on contact information and services provided by the resource. Secondly, a way of keeping the already provided information updated would be to prompt users to verify that the location details (such as phone numbers, services provided, hours of operation) are up-to-date, in a similar fashion to the approach used in Google Maps described above.

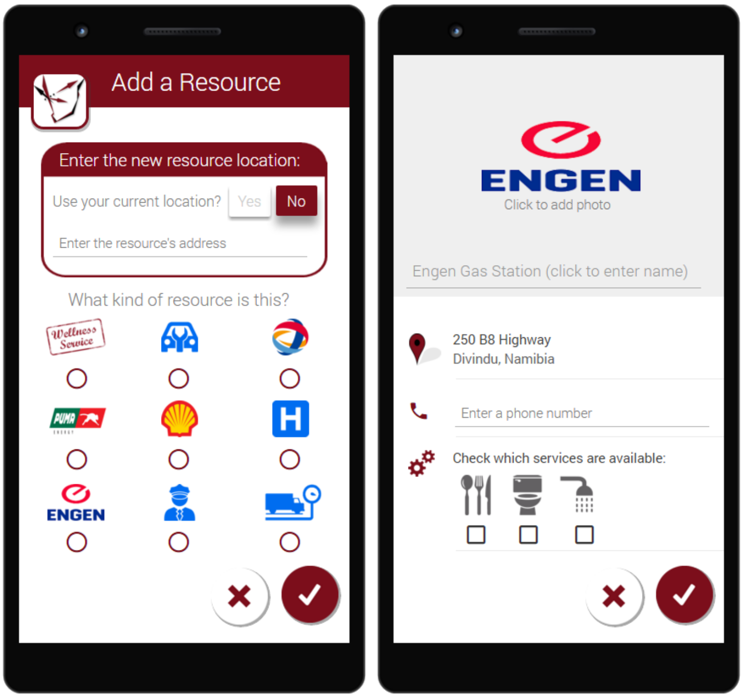

Figure 28 Prototype screens showing a crowdsourcing feature

The team prototyped how the app would prompt users to enter missing information, shown in Figure 28. The screen on the left prompts the user to enter the location of the resource (or choose current location) and select the type of resource. The next screen allows the user to enter additional information about the resource. All of this data would then be sent to a server to be verified for accuracy before being reflected in the application.

7.2 Pursuing the Development of a Mobile Application

Thousands of companies today offer end-to-end solutions for smartphone app development, including analysis, development, testing, and publishing. Because much research has already gone into the features this app should have and the app's technical requirements, several steps that normally rely on external app development agencies can be cut out. Further, the team has developed a prototype in *Justinmind* that gives an encompassing representation of how the proposed application should work and look like, which can act like a guideline for any agency that is chosen to produce the final application, something that many development firms like to get from a customer.

The team also came up with a viable solution for the infrastructure needed to support the application. Figure 29 represents the **proposed architecture for the app**. At the center is a database of geolocation information and other supporting information that could be stored and served from a cloud infrastructure provider such as Amazon Web Services (AWS), Heroku, or the Google Cloud Platform. This information would be maintained from an administrative desktop web interface, seen in the bottom right corner. At the user-end is the proposed Android smartphone application that stores its version of data but gets updated from the cloud database. The application relies on GPS for tracking its own location.

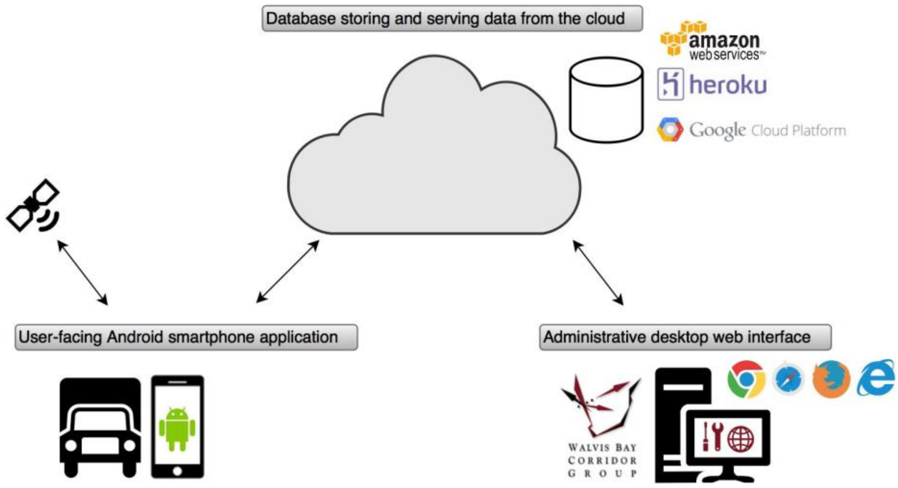

Figure 29 Supporting infrastructure for corridor application

The **price** of hiring an application development company can vary greatly depending on the scope of the project, preliminary work already done, and most importantly, location of the company. In order to provide an estimate, the team reached out to a number of firms and provided them with a description of the features and the proposed architecture above. Many of these correspondences consisted of conversation about the proposed architecture, as well as the design, but the initial email sent can be found in Appendix P. We had email conversation with companies in South Africa, Namibia, India, and the U.S. Firms in South Africa and Namibia were considered for their proximity. The U.S and India are two of the biggest countries in terms of app development businesses, and are thus popular choices in the industry. Figure 30 presents the **average upper price quotes** we obtained from firms in these countries. As most firms were unable to give exact prices and instead opted for a range, we chose the upper price in this range. **U.S.-based companies** provided the team with similar **pricing estimates averaging US$26,648**. The companies in India significantly undercut their prices with an average price of US$12,750. Out of the agencies we reached out to in Namibia and South Africa, only one responded from each country. They are still included in the figure but it should be noted that prices may vary greatly from their individual estimates.

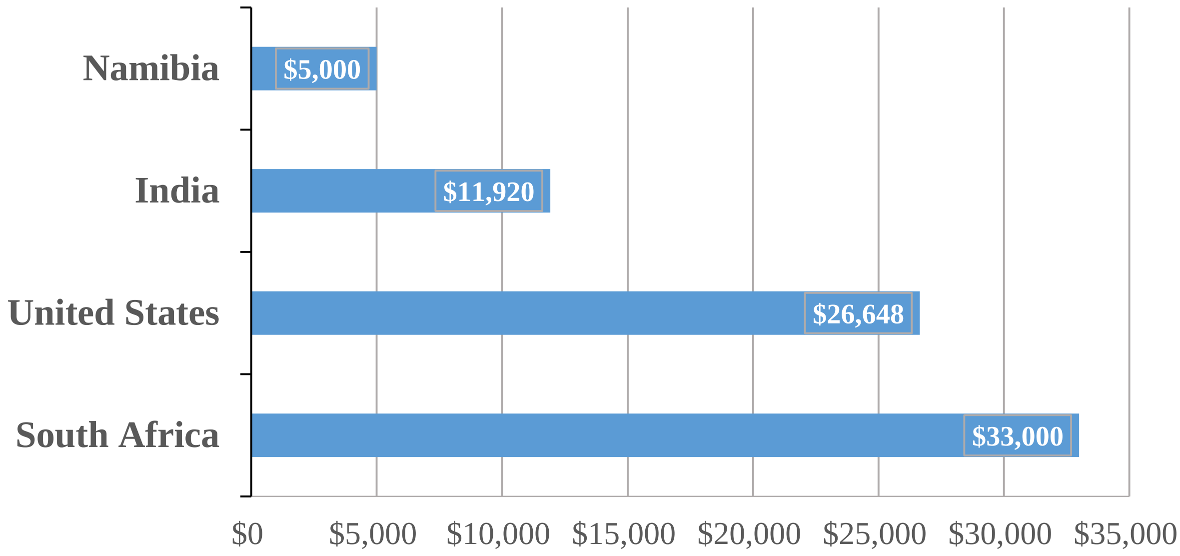

Figure 30 Average development costs in four countries in USD

Aside for the cost estimation, most firms provided us with an estimated **timeline for development**. This ranged from one to five months, with most companies giving a minimum of three months. The team concluded that the above average estimates should provide the WBCG with ballpark estimates of the absolute minimum one can expect to pay for the application described in this report. Depending on the specific choice of firm, these prices and the timeline estimates may very well double. All the firms reached out to, along with their responses or lack thereof, can be found in Appendix Q.

If this application were to be implemented, the functionalities identified in this report, along with their technical requirements and the Justinmind Prototype showcasing the interface design should make up the set of material provided to the team taking on the project.

8. CONCLUSIONS

Working on this project gave the team a comprehensive understanding of the importance of transport and logistics to Namibia's economy. We learned about the relevance of the Port of Walvis Bay in the future of Namibia's development because of its ideal harbor conditions and access to major markets across the globe. Through our research and conversations with members of the Walvis Bay Corridor Group, we also became aware of the crucial role that the Walvis Bay Corridors play in increasing the attractiveness of the port of Walvis Bay. Truck drivers form the backbone of the transportation industry and it is essential to help them stay safe and efficient, and a smartphone application that ensures this can positively impact the outlook of Namibia's logistics industry.

Through our series of interviews with drivers and officials, we were able to identify major issues faced by drivers on the corridors. They form a substantial perspective of the current situation for truck drivers in Namibia. In our project, this information formed the foundation and motivation for the development of a smartphone application. It is clear that it can also be used as a basis for additional research into specific issues or the proposal of projects addressing issues by means other than a smartphone application.

The functionalities that we recommended were proposed with their technical feasibility and their importance to the users in mind. We believe that these functionalities effectively address the needs of the truck drivers, and will make driving on the corridors safer and easier. A set of technical requirements for this application were also proposed, in order to help future undertakers of this project with development work.

By designing and visualizing the user-interface of the smartphone application, the team has not only completed this task for any developer that eventually would implement our proposed application, but also created a powerful tool that will aid in the process of getting the necessary backing for development. An interactive prototype will let anyone understand exactly how the app can help the end users, and captures more than a technical specification or functionality description can alone.

The data collection trip supplied the WBCG with an initial database to support the functionalities of the app and verified the effectiveness of our data collection methods. This database is the first of its kind for Namibia, and its usefulness extends beyond the logistics industry into others sectors of the economy, such as tourism.

Our initial search for development agencies resulted in price and time estimates that the WBCG can use to select a contractor to take up the development effort. The recommendations on the architecture reflects what the team believes to be the most cost effective way to support the functionalities that the app should include.

In conclusion, this project laid down the foundation upon which the WBCG can pursue a smartphone application that would give them an edge in the competitive logistics industry in southern Africa. We sincerely hope that this app would eventually reach the hands of truck drivers, and improve their safety and efficiency when they are driving on the Walvis Bay Corridors.

APPENDICES

Appendix A: TRANSPARK

TRANSPark was launched as an initiative by the International Road Transport Union (IRU) in 2009. With the main goal of helping commercial drivers and road transport fleet managers find secure parking areas, it is available free of charge as web application and native application for both iOS and Android. The application is advertised as being available in more than 40 countries. In Africa, it is available in Botswana, Democratic Republic of the Congo, Kenya, Malawi, Mozambique, South Africa, Tanzania, Zambia and Zimbabwe (“New app launched to help truck drivers”, 2015). The TRANSPark database of information provided originated from the publication “Truck Parking Areas 2009” by the IRU and the International Transport Forum (ITF).

The main feature of TRANSPark is the ability to search for and locate parking areas and fuel stations. This can be done for a certain country, city, along a set itinerary, or within a radius of up to 400 km of the current location. The search allows for customized filtering based on several parameters encompassing both security and comfort. Security options includes availability of surveillance cameras, guards, fences, flood lighting, and whether the stop accepts dangerous goods. Comfort options includes sanitary facilities, boarding and food options, medical assistance, electricity, vehicle repair and vehicle wash. The application has the option to add missing park stops and offer certification schemes for truck park owners. A number of other points of interests such as weighbridges, toll gates, and checkpoints can be found in mapped too.

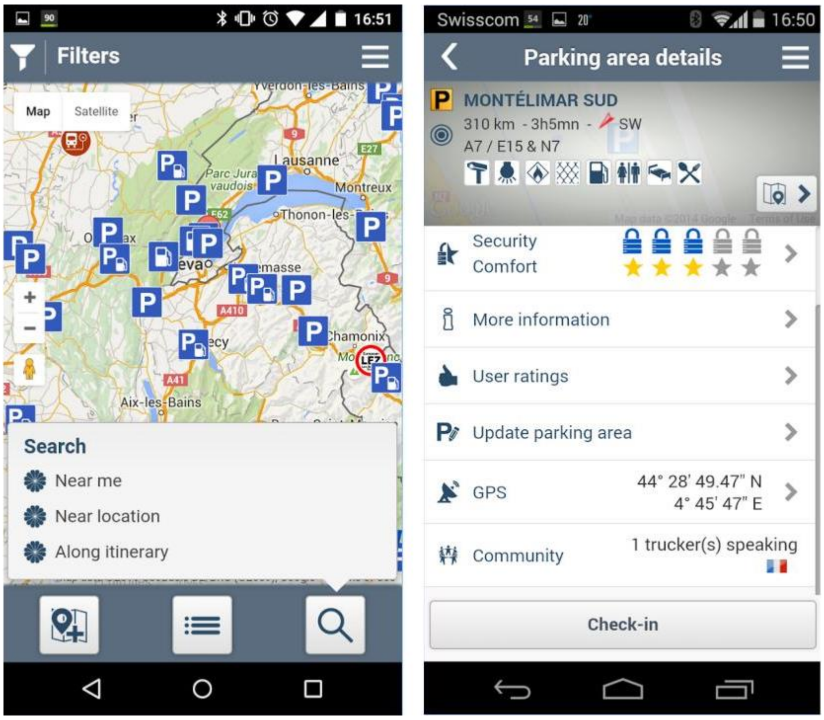

Figure 31 Screenshots of TRANSPark for iOS (left) and Android (right)

TRANSPark also has a community feature where users can create a profile and interact with other users in various ways. By signing up, you are able access a number of social features. It allows one to check-in at parking areas and notify other drivers where you are located. The app has its own feed where registered users also can share statuses, photos, and other information to a feed similar to other social networks today. Finally, the community feature includes the options to subscribe to channels to get updates from IRU.

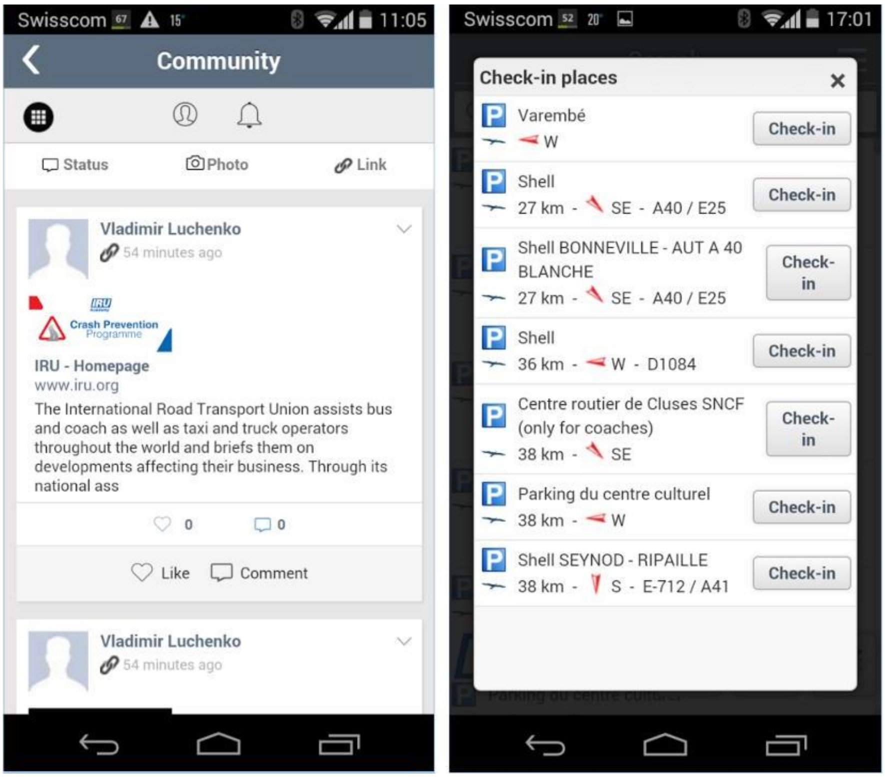

Figure 32 TRANSPark's community feature (left) and check-in functionality (right) on Android

Appendix B: TRUCK DRIVER INTERVIEW PROTOCOL

Good afternoon, we are University students from the United States working with the Walvis Bay Corridor Group focusing on road transportation along the corridors. Our research involves looking into the feasibility of and how a smartphone application could be used to assist users of the Walvis Bay Corridors. Any information you share with us will be viewed as confidential and anonymous.

1. How do you usually find your way when you are driving on the road?
    a. Use a map, smartphone, road signs…?
2. How do you determine where to stop to fill up on gas, sleep, get food…?
3. Do you or your company plan your trip along the road before you depart? If so, how?
4. Do you often drive the same route?
    a. If so, do you tend to stop at places you have stopped at before?
5. Does your company have restrictions on how long or what hours you can drive continuously, or time of the day during which you should not drive?
6. Is the Port of Walvis Bay your usual destination?
7. Are there any challenges that you often come across during your drive along the road in Namibia?
8. Do you feel safe driving and taking breaks on the roads in Namibia?
9. Is there any information that you wish was available while you were driving?
10. What is your course of action in the event of an emergency?
    a. Panic button?
11. Does your company provide health or wellness services?
    a. Are you aware of wellness services provided along the corridors?
        i. WBCG Wellness Service?
    b. How often are you required to have a checkup?
        i. Blood pressure, cholesterol

Appendix C: LOCATIONS OF INTERVIEWS WITH TRUCK DRIVERS

Accompanied by Mr. Samuel Taapopi, an employee of WBCG's Wellness Service, the team travelled to the Windhoek Truck Port and the Windhoek Lager Brewery multiple times between 14/3/16 and 18/3/16 to conduct these interviews. In total, the team conducted 20 interviews, some of which were with multiple drivers simultaneously.

Figure 33 Interview locations in Windhoek

The team then travelled to the Port of Walvis Bay from 21/3/16 to 24/3/16 with Mr. Immanuel Shipanga, our project supervisor at WBCG. Here, we interviewed an additional 16 drivers at three different locations around the port.

Figure 34 Interview locations in Walvis Bay

Appendix D: TRUCKING COMPANY OFFICIALS INTERVIEW PROTOCOL

Good afternoon, we are University students from the United States working with the Walvis Bay Corridor Group focusing on road transportation along the corridors. Our research involves looking into the feasibility of and how a smartphone application could be used to assist users of the Walvis Bay Corridors. The aim of this interview is to get a better understanding of how challenges facing truck drivers affect the transportation of goods along the corridors.

1. What is your job title?
2. How many drivers (and trucks) does your company employ?
3. Could you provide a brief description of the overall process of your company?
    a. Getting a job assignment?
    b. Selecting a driver?
    c. Determining the route?
4. Which corridors does your company utilize when transporting goods?
    a. Any outside of Namibia?
    b. Which corridor is used most frequently?
5. Are your drivers usually familiar with the corridor they will be driving on?
6. What are the major challenges that are reported by your truck drivers regarding their drive along the Walvis Bay Corridors?
7. Is theft a major concern of yours? What kinds of precautions do you take to combat theft?
    a. How often does theft occur for your cargo transports?
    b. Does a certain corridor suffer from theft or robbery more often?
8. Are your truck drivers provided with navigation information before they depart?
9. Are there services available to your drivers to provide them with information regarding gas, sleep, or eating establishments?
    a. What kind of service could you foresee providing this information?
10. In an emergency, what methods do your trucks have of getting help or support?
    a. How do you obtain the information that you give to your truck drivers?
11. Do you have a database for amenities/stops along the way for your drivers?
12. How many of your truck drivers do you believe own smartphones?
13. If a smartphone application were available that could assist your drivers along the corridor, would you be inclined to ensure they use it?
    a. How feasible would supplying each of your drivers with a web enabled device be to ensure the access to such an app?
14. How is your company ensuring the wellness of your truck drivers?
    a. Scheduled checkups?
    b. Utilizing free alternatives? (e.g. provided by WBCG)
    c. How feasible would supplying each of your drivers with a web enabled device be to ensure the use of such an app?

Appendix E: List of App Functionalities

- Listing and mapping of police station locations
- Listing and mapping of weighbridge locations
- Listing and mapping of repair shop locations
- Listing and mapping gas station locations
- Listing and mapping health clinic locations
- Listing and mapping of safe truck stop locations
- Listing and mapping of locations of border posts
- Listing and mapping of locations of hospitals
- Providing information on healthy eating habits
- Distance to next gas station
- Providing driving regulations with regards to driving hours, speed limits, and axle load in different countries
- Notification when entering roads where animals are sighted frequently
- Notification when entering areas with high risk of theft or vandalism
- Reference to simple words in French
- Navigation on smaller roads near final destination

Appendix F: Quantitative Survey for Truck Drivers

We are university students from the United States working with the Walvis Bay Corridor Group focusing on road transportation. This survey is being conducted as part of research into a potential smartphone application that aids truck drivers. Information you share with us through this survey will be viewed as confidential and anonymous.

1. How big of a problem is following issue to you when you are transporting goods?

Issues	Small Problem				Big Problem		Where?
	0	1	2	3	4	n/a	
1.1. Driving for very long hours							
1.2. Having to drive when you are sick							
1.3. Animals walking on the road							
1.4. Risk of theft/hijacking on roads in South Africa							
1.5. Risk of theft/hijacking on roads in Namibia							
1.6. Risk of theft/hijacking on roads in DRC							
1.7. Risk of theft/hijacking on roads in Zambia							
1.8. Navigating on smaller roads							
1.9. Not getting checkups often enough							
1.10. Long queues at the border							
1.11. Corrupt officials at the border							
1.12. Not knowing how to stay healthy on the road							
1.13. Driving on narrow roads							
1.14. Language barriers							

2. How difficult is it to find the following items when you are driving in Namibia?

Amenities	Not difficult				Very difficult
	0	1	2	3	4
2.1. Toilet					
2.2. Places to take a shower					
2.3. Safe place to park					
2.4. Clinics					
2.5. Places to buy food from					
2.6. Places to get healthy food (fresh fruit, vegetables and so on)					
2.7. Places to sleep overnight					

Appendix G: RESULTS OF QUANTITATIVE SURVEY

How big of a problem is the following issue to you when you are transporting goods?

Issues	Small problem			Big problem		
	0	1	2	3	4	NA
Driving for very long hours	5	2	3	6	7	0
Having to drive when you are sick	10	3	2	4	5	0
Animals walking on the roads	3	3	4	2	11	0
Risk of theft/hijacking on roads in South Africa	1	1	0	2	19	0
Risk of theft/hijacking on roads in Namibia	17	2	2	2	1	0
Risk of theft/hijacking on roads in DRC	1	1	0	2	20	0
Risk of theft/hijacking on roads in Zambia	4	6	5	6	3	0
Navigating on smaller roads	7	5	6	4	2	0
Not getting health checkups often enough	9	4	3	3	5	0
Long queues at the border	0	5	4	4	11	0
Corrupt officials at the border	7	3	1	2	11	0
Not knowing how to stay healthy on the road	10	6	1	6	1	0
Driving on narrow roads	1	2	2	8	7	3
Language barriers	11	3	0	3	6	1

How difficult is it to find the following items along the road when you are driving?

Amenities	Not Difficult		Very Difficult		
	0	1	2	3	4
Toilet	4	3	3	4	10
Places to take a shower	4	3	2	5	10
Safe places to park	5	7	3	7	2
Clinics	7	8	1	4	4
Places to buy food from	4	9	5	2	4
Places to get healthy food (fresh fruit, vegetables and so on)	4	6	1	4	9
Places to sleep overnight	5	5	1	6	7

Appendix H: Results of Quality Function Deployment

Feature	Score
Listing and mapping of safe truck stop locations	73.96
Listing and mapping health clinic locations	62.38
Listing and mapping gas station locations	61.865
Providing information on healthy eating habits	51.41
Listing and mapping of repair shop locations	44.825
Distance to next gas station	40.015
Notification when there are road closures ahead	32.025
Notification when entering roads with high crime rates	31.67
Notification when entering roads where animals are sighted frequently	31.66
Providing driving regulation and weight limits in neighboring countries	26.23
Listing and mapping of weighbridge locations	20.56
Listing and mapping of police station locations	15.18
Navigation on smaller roads near final destination	11.23
Reference to simple words in French	10.11

Appendix I: DATA ROAMING AVAILABILITY AND RATES IN NAMIBIA, ZAMBIA AND DRC

To		From								
		Namibia		Zambia			DRC			
		MTC	Telecom	MTN	Airtel	Zamtel	Vodacom	Tigo	Orange	Airtel
Namibia	MTC			23 ZMW/MB*	N/A	N/A	N/A	N/A	N/A	N/A
	Telecom			N/A	Rate unavailable	N/A	N/A	N/A	N/A	N/A
Zambia	MTN	N$0.20/MB*	N/A				N/A	N/A	N/A	N/A
	Airtel	N/A	N$1.31/MB*				N/A	N/A	N/A	1 - 2 U/MB **
	Zamtel	N/A	N/A				N/A	N/A	N/A	N/A
DRC	Vodacom	N$0.13/MB*	N$0.2/MB*	116 ZMW/MB*	Rate unavailable	Rate unavailable				
	Tigo	N/A	N/A	N/A	N/A	N/A				
	Orange	N/A	N/A	N/A	N/A	Rate unavailable				
	Airtel	N/A	N/A	N/A	164 ZMW/M	N/A				

* Only available to postpaid mobile subscribers
** See Airtel (DRC), 2016 for detailed pricing
MB: Megabyte; N$: Namibian Dollar; ZMW: Zambian Kwacha; U: Congolese Franc

Appendix J: COMPARISON OF NATIVE AND WEB APPLICATIONS

Native Application		**Web Application**	
Benefits	Drawbacks	Benefits	Drawbacks
Built-in support for large amounts of offline storage	Development on one platform excludes other platforms	Allow single version to be run and developed on multiple platforms (iOS, Windows Phone, Android)	Requires internet connection to function well on many phones.
Mature market of Android developers	Require users to download and install updates	May be updated and released instantly on server side for rapid development	HTML5 is fragmented across platforms and may cause rendering issues, especially for low-end phones
Can exist as a background task	Increased cost and time for multiple platform development		No support for push notifications on low-end phones
Native access to system notifications			Functions erratically on low quality data connections

Appendix K: LOCATIONS OF GAS STATIONS

Gas Stations	Town	Latitude	Longitude	Amenities
Shell	Katima Mulilo	-17.49679	24.26968	Toilet, food shop, shower
Marina Service Station (Engen)	Katima Mulilo	-17.50315	24.27021	Toilet, food shop, shower
Crossroads Service Station (Puma)	Katima Mulilo	-17.52250	24.26833	Toilet, food shop, truck stop
E-Four Service Station (Engen)	Kongola	-17.82165	23.39828	Toilet, food shop, ATM
Engen	Rundu	-17.91404	19.76953	Toilet, food shop, shower
Engen	Rundu	-17.92052	19.77079	Toilet, food shop, shower
Jakaranda Service Station (Engen)	Rundu	-17.92311	19.75667	Toilet, food shop
Suidwes Diensstasie (Total)	Rundu	-17.93210	19.77135	Toilet, food shop
Engen	Divundu	-18.10137	21.54434	Toilet, food shop, supermarket
Total	Grootfontein	-19.56011	18.11034	Toilet, food shop, shower
Puma	Grootfontein	-19.56608	18.10259	Toilet, food shop
Shell	Otavi	-19.64493	17.34955	Toilet, food shop
Omega Service Station (Shell)	Otavi	-19.86741	17.15253	Toilet, food shop
Engen	Otjiwarongo	-20.45394	16.62339	Toilet, food shop, ATM, 24/7
Shell	Otjiwarongo	-20.45552	16.65291	Toilet, food shop
Paradise Service Station (Puma)	Otjiwarongo	-20.46222	16.65084	Toilet, food shop
Engen	Otjiwarongo	-20.46240	16.65028	Toilet, food shop
Puma	Otjiwarongo	-20.46401	16.65045	Toilet, food shop, shower, security
Puma	Omaruru	-21.41503	15.96146	Toilet, food shop
Narraville Motors (Total)	Omaruru	-21.42460	15.94831	Toilet, food shop
Atlantic Service Station (Puma)	Karibib	-21.93491	15.85678	Toilet, food shop
Engen	Usakos	-21.99867	15.58752	Toilet, food shop, restaurant
Puma	Swakopmund	-22.66676	14.54222	Toilet, food shop, 24/7
Crossroads Service Station (Puma)	Swakopmund	-22.66906	14.53289	Toilet, food shop
Total	Swakopmund	-22.67816	14.52836	Toilet, food shop, ATM
Engen	Swakopmund	-22.67921	14.53393	Toilet, food shop, 24/7
Engen	Walvis Bay	-22.94841	14.53027	Toilet, food shop
Engen	Walvis Bay	-22.95216	14.50636	Toilet, food shop
Atlantic Service Station (Puma)	Walvis Bay	-22.95534	14.50077	Toilet, food shop
Shell	Walvis Bay	-22.95589	14.50687	Toilet, food shop
Engen	Walvis Bay	-22.95682	14.49990	Toilet, food shop, WIFI

Appendix L: Locations of Repair Shops and Police Stations

Repair Shops	Town	Latitude	Longitude	Phone number
Goodyear Tires	Katima	-17.50406	24.27005	
A Van Der Walt Transport	Katima	-17.49664	24.27208	081-351 4834
Tractor & Truck Repair	Katima	-17.51190	24.26863	066-253 216
Trentyres	Rundu	-17.93210	19.77135	066-255 503
Advance Truck Repair	Rundu	-17.92407	19.75683	066-255 541
Dunlop Tyre	Grootfontein	-19.56473	18.10461	067-242 626
Diesel Auto Repair	Grootfontein	-19.56771	18.10551	081-413 2006
Raino’s Truck And Auto Repairs	Grootfontein	-19.56679	18.11707	067-242 436
Repair 24/7	Otavi	-19.64493	17.34955	081-405 2468
JWA 24/7 Breakdown and Recovery	Otavi	-19.64402	17.34400	081-208 3992
Trentyres	Otjiwarongo	-20.45396	16.65339	067-221 402/3
Car & Truck Repair Center	Otjiwarongo	-20.46334	16.65257	067-304 212
Car & Truck Repairs	Karibib	-21.93912	15.84866	081-128 8934
Pitbull Tow-In Usakos	Usakos	-22.00401	15.58534	081-311 8381
Midvaal Diesel & Turbo	Swakopmund	-22.67352	14.54234	064-417 1800
Cs Auto & Truck Repair	Swakopmund	-22.68303	14.53280	064-405 759
Pupkewitz Repair	Walvis Bay	-22.94538	14.51962	064-203 746
Jake’s Diesel Service	Walvis Bay	-22.96211	14.49895	064-207 919
MB Truck Spares	Walvis Bay	-22.96024	14.49996	064-206 665

Police Station	Latitude	Longitude	Phone number
Katima Mulilo	-17.491311	24.278375	066-262 300
Divundu	-18.003566	21.350595	066-258 306
Rundu	-17.911091	19.769292	066-262 300
Grootfontein	-19.562104	18.101647	067-242 111
Otavi	-19.640727	17.342949	067-234 006
Otjiwarongo	-20.458842	16.650346	067-300 600
Omaruru	-21.420273	15.952931	064-570 340
Karibib	-21.939714	15.847651	064-550 008
Usakos	-22.000703	15.585512	064-530 003
Swakopmund	-22.675017	14.525691	064-403 117
Walvis Bay	-22.956011	14.507739	064 219 048

Appendix M: Locations of Hospitals and WBCG Clinics

Hospital	Latitude	Longitude	Number
Walvis Bay State Hospital	-22.96589	14.50029	064-216 300
Swakopmund Hospital	-22.66960	14.53050	064-410 6000
Karibib Health Centre	-21.93225	15.86401	064-550 073
Rundu Hospital	-17.91634	19.76744	066-265 500
Andara hospital (near Divundu)	-18.06280	21.44789	066-259 311
Katima Hospital	-17.49927	24.27839	066-251 400

WBCG Clinic	Latitude	Longitude	Hours of Operation
Walvis Bay	-22.95033	14.50420	08:00 - 17:00; occasional Moonlight Hours: 18:00 - 22:00
Katima Mulilo	-17.51070	24.26676	08:00 - 17:00; occasional Moonlight Hours: 18:00 - 22:00

Appendix N: Locations and Hours of Operations of Border Posts and Weighbridges

Name	Latitude	Longitude	Hours of Operation
Wenela Border Post (Katima Mulilo)	-17.47770	24.24619	M-F 6:00-18:00
Walvis Bay Port	-22.95001	14.50066	M-F 6:00-22:00; Sat 6:00-12:00; Sun/ Public holidays 6:00-12:00 and 13:00-17:00

Weighbridges	Latitude	Longitude	Hours of Operation
Katima	-17.51070	24.26676	M-F 6:00-22:00; Sat, Sun & Public holidays flexible hours (8 hours/day)
Walvis Bay	-22.95720	14.52368	M-F 6:00-22:00; Sat, Sun & Public holidays flexible hours (8 hours/day)

Appendix O: MAP OF COLLECTED DATA

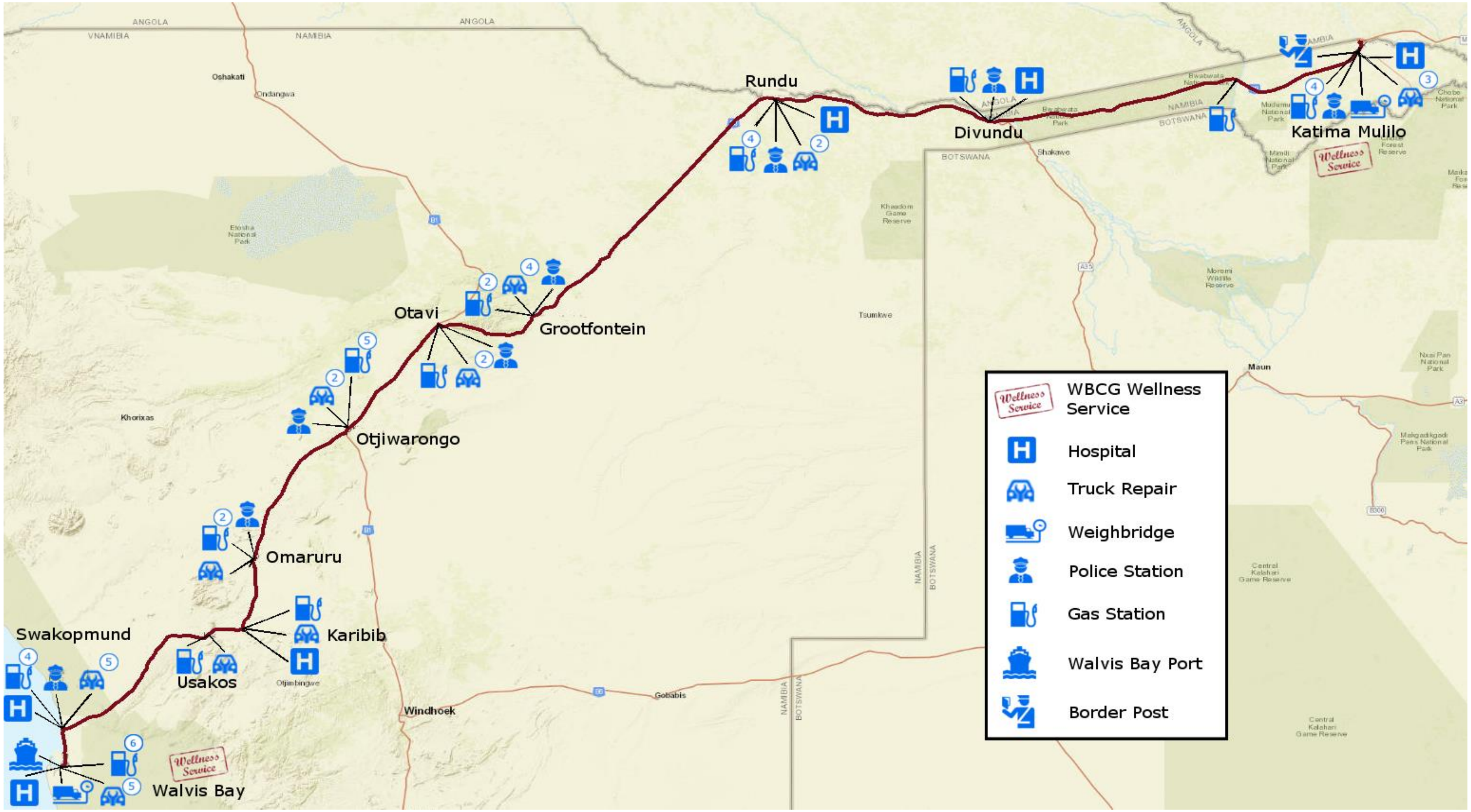

Figure 35 Map of important resources along WBNLDC

Appendix P: EMAIL FOR APPLICATION DEVELOPMENT FIRMS

Hello,

We are students from the US working with a transport-related group whose goal is to promote the utilization of Namibia's major highways. We are researching the potential development of a smartphone application for truck drivers using the roads in southern Africa. The application would provide the following functionalities:

- Mapping of various points of interests (safe parking areas/gas stations/repair shops/police stations/weigh-bridges) within a radius of the driver or along a planned itinerary.
- Alerts when driving into certain areas along the road.
- News feed with information related to transportation.
- Offline storage of important information due to limited connectivity along stretches of roads.

Our proposed design would be a user-facing application for Android devices deployed via cloud provider such as AWS or Heroku. Necessary would also be an administrative web interface for maintaining of data (locations of importance, etc.) as well as the delivery of other content (news, etc.).

We are now doing research into the steps the organization would have to take to actually have this application developed. We are interested in the kind of price range one should expect for such an app and what the timeline would be for development. It is worth noting that this would be a small scale application with a limited potential reach (~1000 users).

This email is for research purposes only and doesn't imply interest from the organization in pursuing your services for application development.

Let us know if you have any additional questions for us.

Christine McCarron, Tim Petri, Steven Souto, and Billy Zhou

Appendix Q: COST AND TIME ESTIMATES FROM APP DEVELOPMENT FIRMS

Company Name	Country	Price	Timeframe	Comment	Contact information
Macoscope	U.S	$25,000	1 month		Diana Dubko diana@macoscope.com
Small Planet	U.S			No response	
Zco Corporation	U.S	$30,000	2 months		Katie Meurin katie.meurin@zco.com
Provectus	U.S	$45,000	5 months		Maria Zhigil mzhigil@provectus.com
App Solutions	U.S	$6,591	2 months		John Tataw J.Tataw@theappsolutions.com
Nomtek	U.S			No response	
Kagiso Interactive SA	South Africa	$33,000	4 months	30% variation	Jaco Gerrits jaco@kagisointeractive.com
Floodlight Studios	South Africa			No response	
Dragonfly Digital	South Africa			No response	
Blacksnow Digital	South Africa			No response	
Golife Mobile	South Africa			No response	
The Bold Circle	South Africa			No response	
Palma Online Solutions	South Africa			No response	
Creative Spark	South Africa			No response	
The Nine Hertz	India	$7,500	3 months	Similar apps in portfolio	Preeti, preeti@theninehertz.com
Contus	India	$15,000	3 months		Prabhakar Pasupathy prabhakar@contus.in
Techaheadcorp	India	$20,000	n/a	Similar apps in portfolio	Shanal Aggarwal shanal@techaheadcorp.com
OpenXcell	India	$8,600	4 months		Tanbeer Shaikh sales@openxcell.com
Dot Com Infoway	India	$6,000	3 months		Reuben Peter Nayagam R. reuben.rajasamson@dci.in
Prismetric	India	$8,500	4 months	Similar app in portfolio	Manmeet Singh manmeet@prismetric.com
App-king	Namibia	$5,000	n/a		Asen asen@app-king.net
Vtech	Namibia			No response	
StarTech	Namibia			No response	

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