INFO 7260 Business Process Engineering Final Report

The Internet of Things: VaccTitan

Shrinesh Patel

Khushboo Singh

Giselle Picardo

Vasilios Hatziioannou

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Executive Summary

The World Health Organization (WHO) came into being in 1948 and has since served to direct and coordinate international health within the United Nations' system. Their areas of focus and work lie within international health systems, promoting health through the life-course, noncommunicable and communicable diseases, corporate services, and preparedness and response. Unfortunately, despite the WHO's best efforts, there are developing nations that are all but completely stricken by disease without means of combatting them. Malaria, namely, afflicts and kills millions of impoverished lives across the globe, and it is here that our story and involvement begin. We are representatives of VaccTitan, a fictional American company that looks to sell novel technology meant to combat malaria vaccine destruction, and offer consulting services for to interpret the Internet of Things as it relates to new and improve vaccine distribution. In this report, we detail the need for our business and how we look to save millions of impoverished lives.

The History of VaccTitan

VaccTitan is an American refrigeration appliances brand that was founded in 1935, in Washington D.C. For the large part of the company's history, VaccTitan assisted with American World War II efforts by providing portable refrigeration units for tactical field use. The first of these units, named KRYO, was a rudimentary box that was able to maintain a cool temperature of 25 ^{0}F (-3.9 ^{0}C), and was tremendously useful for troops based in the Pacific theatre. The KYRO and its KYRO 2 and KYRO 3 descendants had the shape of a rectangular prism, and ranged from approximately 0.2 ft^3 (the size of a shoebox) in volume to 5.25 ft^3. These units were therefore able to be transported by hand.

As the 20th century progressed, VaccTitan's products not only saw tremendous success within war-based efforts abroad, but also domestically. They became associated with excellence in household portable cooling through the introduction of the PAGOS line of products. The PAGOS was the first portable storage unit meant for recreational use, and families in the 70's and 80's predominately used them for longer travel periods to keep their goods cool. VaccTitan championed portability and maintained that their products would always present size advantages over their larger peers and competitors.

VaccTitan's latest product, the Shribox, is an evolution in their line of portable cooling units. This unit distinguishes itself namely by the fact that it is built for more extreme terrain changes and for transporting medical grade bio-equipment, as opposed to foodstuffs. This makes the Shribox an excellent means to transport materials that are extremely sensitive to heat, such as organs for transplants, biodegradable materials, and vaccinations.

VaccTitan recognizes that excellence is built into a company from the ground up, starting with their human elements. They have invested throughout the decades in bringing in the most qualified leaders in cooling science and technology as members of their team to lead company initiatives. VaccTitan is therefore a firm capable of providing highly intuitive and valuable insights into the world of consulting. Having over half a century of experience in this industry, the company is well equipped and connected to understand value drivers, especially with regards to implementing their products across different regions.

A Brief Overview of Malaria

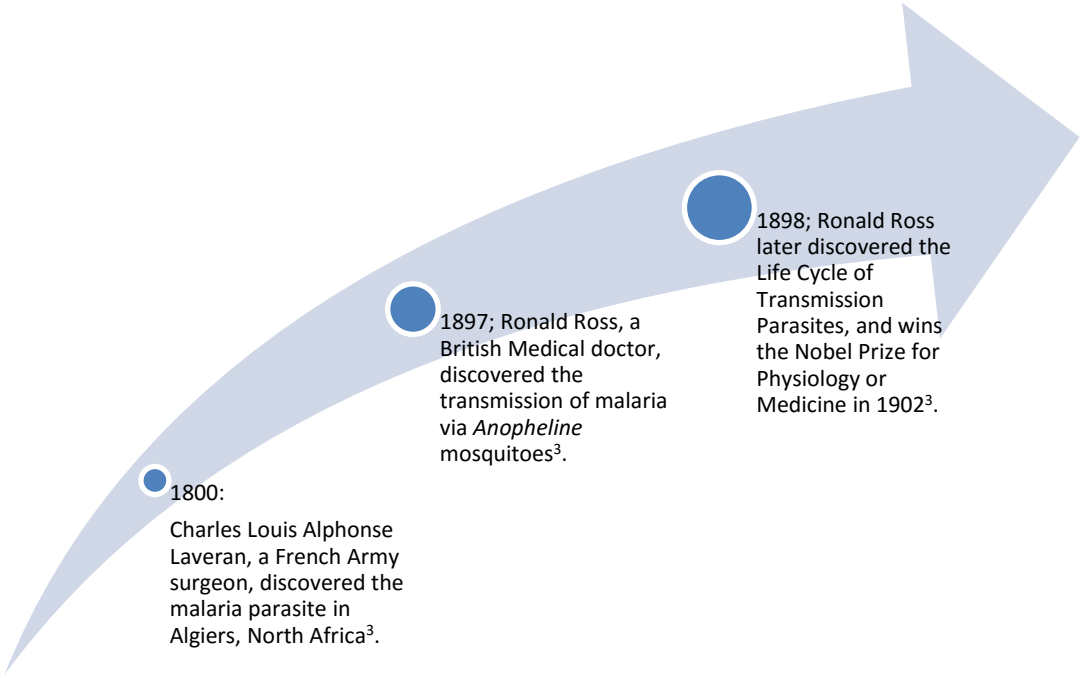
Malaria is the 2nd leading cause of death from infectious diseases in Africa, after HIV/AIDS, and is a disease of the blood that is most often caused by the Plasmodium parasite, though there are over 100 species of parasite that can cause the disease. There are four species of Plasmodium which can infect humans[1]:

1. *Plasmodium vivax*
   Occurrence: Common. 43% of the afflicted is infected by this species.
   It causes Tertian Malaria which is especially widespread in North Africa.
2. *Plasmodium falciparum*
   Occurrence: 50% of the afflicted is infected by this parasite.
   It causes Falciparum Malaria and Malignant Tertian Malaria.
3. *Plasmodium malariae*
   Occurrence: Rare. This parasite causes extremely localized cases of malaria.
   It causes Quartan Malaria primarily.
4. *Plasmodium ovale*
   Occurrence: Rare. This parasite causes extremely localized cases of malaria.
   It causes Mild Terrain Malaria.

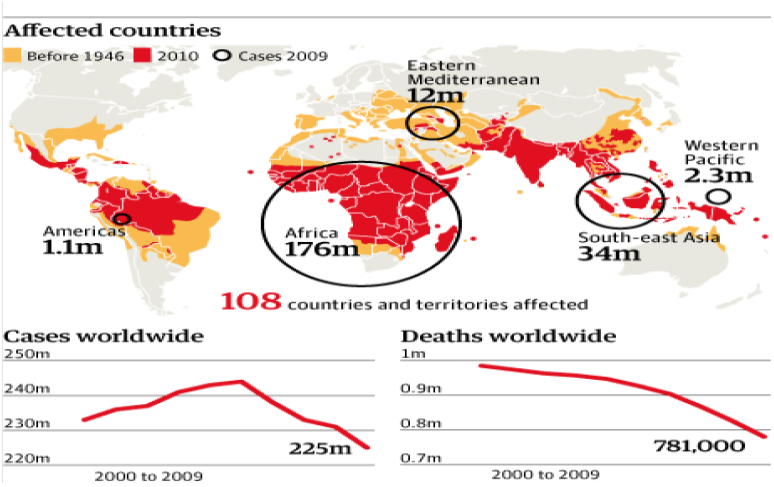
These parasites are usually transmitted from person to person by a particular type of female mosquito "*Anopheles*", which is primarily nocturnal. Malaria cannot be spread from person to person like the influenza virus, nor can it be sexually transmitted[2].

Once the parasite enters the human body, it lodges itself in the liver where it multiplies approximately 10,000 times. Two weeks after entering the body, it bursts into the blood stream infecting the red blood cells. Symptoms begin 10 days to 4 weeks after infection, although a person may feel ill as early as 7 days later. Symptoms include fever, headache and vomiting. Cases left untreated can result in infection and death.

How Malaria is a Global Threat:



Malaria is one of the oldest recorded diseases in the world. It affects half of the world's population across 106 countries and territories. According to the 2010 WHO report, out of 216 million cases, 81% were recorded within the continent of Africa. 91% of all fatal cases were recorded in Africa, and 86% of these fatal cases were children. These figures have unfortunately not decreased by any appreciable amount 5 years after, since according to the 2010 World Malaria Report, there were 214 million cases of malaria, 90% of which resulted in African deaths. Children were once again the demographic most affected by this disease, as 70% of the African death toll where of children under the age 5[4].



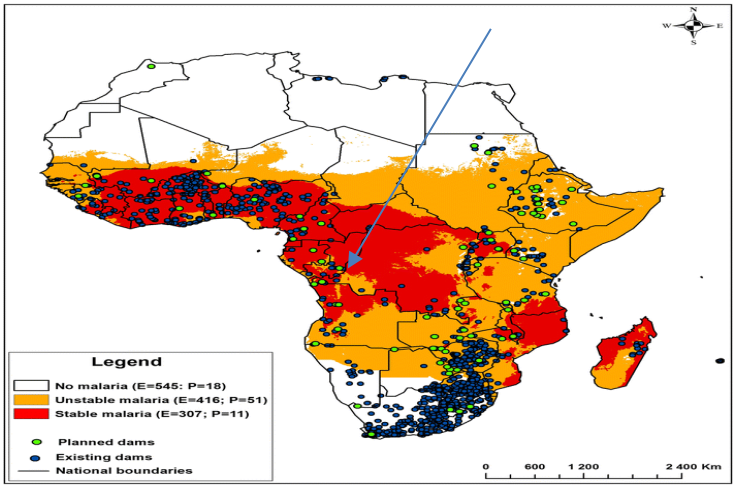
225 million malaria cases were recorded by the end of 2009 whereas more than 80% were recorded in the African continent. Even after 5 years (2015), the number of malaria cases has fallen only by 37% globally and still 15 countries are drastically affected by it. But Africa and Democratic Republic of Congo together covers the 35% affected population which dragged us to analyze the condition of the affected African countries[4].

Malaria in Nigeria

Out of thirty countries in Sub-Saharan Africa accounts for 90% of global malaria deaths. Malaria is the 2nd leading cause of death from infectious diseases in Africa, after HIV/AIDS. Almost 1 out of 5 deaths of children under 5 in Africa is due to malaria. 84 people out of 246 die every year due to Malaria

Africa	**2000**	**2010**	**2015**
Number of cases(Millions)	175	179	165
Number of deaths(Thousands)	682,000	589,448	395,000

As per WHO reports, number of malaria cases recorder in Africa is decreased by only 10 million whereas decrease in the death rate is 55% but it doesn't meet the estimated target of the people saved which is supposed to be more than 75% by the end of 2015.



Out of 54 countries in the African continent Nigeria population is highly suffered by Malaria. Looking at the geography of Africa we can easily figure out.

The yellow highlighted part points to the area where malaria is unstable due to climate changes as they are covered by water resources. The water resources are highlighted in blue balls. Due to climate changes the estimated number of cases will increase in the future as rain spreads malaria drastically as well wastes high number of vaccines resulting in the increase of death rates. Due to these reasons our research led us to analyze the existing condition of malaria in Nigeria.

Malaria is a major public health problem in Nigeria where it accounts for more cases and deaths than any other country in the world. Malaria is a risk for 97% of Nigeria's population. The remaining 3% of the population live in the malaria free highlands. There is an estimation of 100 million malaria cases with over 300,000 deaths per year in Nigeria due to unavailability of vaccines, even though the funding has been increased drastically. As per WHO statistics The level of US AID malaria funding increased to about $7 million annually in fiscal year FY 2007 and FY 2008, and then more than doubled to about $16 million in FY 2009 and FY 2010[3]. The following year, 2011, was Nigeria's first as a PMI (President's Malaria

Initiative) country with initial funding of $43.5 million. Since then, funding has increased yearly from $60.1 million in FY 2012 to $73.3 million for FY 2013 and $75 million for FY 2014[3].

WHO has estimated to decrease the cases to 80% by 2020 which is possible only when the vaccines are available to the affected population. To plan the availability of the vaccine, data prediction and secure transmission of vaccine is mandatory, even though WHO and other companies are already using containers to deliver the vaccines in developed countries. But the containers that are being used are costly and heavy. So we have come up with a solution which is our “ShriBox”.

Internet of Things and its Absence in Vaccine Supply Chains

The Internet of Things is a beautifully simple phrase that describes a concept so vast and profound. To begin, IoT is the idea of basically connecting any device to the internet, and/or to each other as part of a network. These devices can be anything: watches, phones, computers, wearable technology, and portable cooling units. (Forbes). A new rule for the future is that anything that can be connected, will be connected. The inverse of this also seems to be true, as is painfully apparent in regions that are unable to sustain an internet or network of things: anything that cannot be connected will be left behind.

The Internet of Things is nothing more than illusion that fade into nothingness as we progress down standard malaria vaccine distribution supply chains in Africa. To begin with, it appears there are two separate, not well connected supply chain that are involved in the transportation from suppliers to the receiving nation, and then from the port of entry of the receiving nation down to local health centers where the vaccines are ultimately administered. The first supply chain is relatively well run and connected; it is marked by high-tech research laboratories that manufacture vaccines**,** and utilize sophisticated transportation units and storages to maintain the integrity of the vaccines away from the lab. The Internet of Things with respect to this first supply chain remains on the forefront of information technology; every single vaccine is accounted for at every single step. There is a wealth of data reserves fed by scientist, forecasters, materials experts, and transporters.

The nightmare begins when vaccines arrive in the receiving country. This second supply chain is marked beginning to end by inaccurate forecasts, inefficient inventory calculations, and ineffective distribution. The single route of information that defined the firsts supply chain has disintegrated into disorganized chaotic web that lacks any inherent integration. The largest reason for this is technological; impoverished nations that receive vaccines are most often technically incapable of maintaining a robust internet of things. Electricity may be scare, mobile communication technology may be faulty, and transportation of goods and people are nowhere near as advanced or quick as they are in the first world. High percentages of vaccines are lost in transit due to faulty of low quality transportation equipment that lacks any routine maintenance, and these figures are rarely accurately quantified and put to forecasting use[1-4].

Vaccines are extremely susceptible to temperature changes, where even slight increases in ambient temperature can lead to protein denaturation and microbe destruction. Most vaccines are transported in make-shift cooling units that are ill equipped to cool sensitive vaccines. The result is veritable millions of vaccines that must be disregard before they are even used due to damage. The Internet of Things that would normally connect health care professionals and clinicians exists only in a fractured, meandering, and wasteful state, meaning it is impossible to currently quantify just how many vaccines are lost to damage and by extension, how many are needed as replacements[3-6].

Where there is a lack of technology, there is a surplus of steps that relay information and vaccines. These redundant stages in the supply chain are a pitiful imitation of an Internet of Things that are created out of poor planning. The absence of a high-level integration system that takes into account every step of the chain means that parties are not held accountable with regards to transportation,

metrics, and vaccine usage. A manifestation of this ineptitude is overstock in local inventories, who receive influxes of vaccines that are disproportionate to what they originally predicted. The result is increased storage costs and vaccines that are not being used where they are needed. Inversely, in other parts of the distribution system, no competent inventories exist as a stop between the port of entry and administration. This causes an overreliance on portable transportation unites (wooden crates, lunchboxes) that contribute further to vaccine destruction[7,11,12].

Why VaccTitan?

We at VaccTitan present this information to the World Health Organization because they are the integrated body that manufactures and distributes malaria vaccines to countries in need. We identify a major problem in the breakdown of the distribution Internet of Things within the receptive country, and believe that we are well equipped to both solve this problem, and bring further business value to the WHO.

To begin and is detailed in our company history, we have decades of experience in portable cryotechnology, and are experts in lean manufacturing. We understand that quality products that serve customer needs on the scale of years is a key value driver, and are committed to sustaining this excellence in new markets. We understand the differences in how our products will be used for recreational purposes (KYRO and PAGOS) versus the Shribox. The latter technology is the result of years of technology evolution, and will be used to house vaccines in a temperate environment that supports their life and usability. The simplicity of this design is time tested, and will holistically solves the greatest problems of the current supply chain, including a lack of organized forecasting data, maintainable technology, and ease of use.

We also bring incredible value to the WHO in the form of not just our data provision utilizing the ShriBox, but also consulting on how to use that information. Our intelligent interpretation of market data has led to us becoming a leading manufacturer in the United States, and we are confident that our consultants and forecasting manager in the Internet of Things that we wish to build will change how vaccines are distributed for the better.

Problem Statement

Over the last decade, in excess of 165 million malaria cases have been accounted for in developing areas of the world, of which 100 million are in Nigeria. The usage and over-reliance on ill equipped transportation technology, such as cooling packs and wooden crates, results in unacceptably high amounts of damaged and unusable vaccines (over 50% of all manufacturing). This directly leads to 300,000 deaths per annum in Nigeria and millions in lost finances for vaccine suppliers and manufacturers, such as the World Health Organization[13,14].

In addition, current demand forecasting has no progressive analytics that takes into account the number of damaged or compromised vaccines. This detachment creates inaccurate future production of vaccines by 20%, further costing manufacturers $10 million in poor planning procedures. Current technological and demand forecasting constraints not only create a burden on suppliers but to all people who are in dire need of these vaccines[14,16].

Critical Success Factors

We at VaccTitan have conducted extensive market research as it pertained to current vaccine distribution chains, and have identified numerous deficiencies in the system that lead to loss of value. Because supply chain networks are international and currently involve dozens of warehouses, storage units and personnel, any mistake made in one step is carried over onto the next with devastating momentum. Not only does the Shribox provide a safer, secure and reliable alternative for transporting vaccines across extreme high heat and perilous terrain, the data analytics from its sophisticated feedback loop system provides essential and pressing demand forecast metrics. Often vaccines are lost, compromised and deemed unusable after reaching its final destination to be administered to patients. This unfortunate event not only cause financial distress for suppliers but also slows quality care operations to suffering regions.

To fix these problems and better incorporate our ShriBox and the fruits of our consulting services into the vaccine distribution system, we have identified critical success factors (CSFs). These factors are defined as essential areas of activity that the WHO absolutely must perform well if they are to achieve their mission. They were originally put forth by Senior McKinsey & Company consultant D. Ronald Daniel. We have defined major objectives that the WHO and VaccTitan must implement together if we are to save the lives of millions, as well as to halt the wasteful use of finances and manpower. The critical success factors needed to be implemented in order to achieve their objective is matched to a very specific objective and current problem with the system. The critical success factors, objective, and current problem are summarized in the table below.

Table 1: Summary of Objectives & Critical Success Factors.

Problem	Objective	Candidate Critical Success Factor
There are two separate, not well connected supply chains that move vaccines from suppliers to the receiving country, and then from the port of entry through storage system to the health care provider.	Simplify the number of steps that the vaccine must stop at along the way to reduce chance of damage, and accurately forecast when and where vaccines will be needed.	Implement the usage of one major inventory hub per nation, and bring in a forecasting manager.
Vaccines are sensitive to heat and cold, both of which can easily denature vital proteins within the serum	Prevent temperature damage to vaccines	Introduce the ShriBox whose physical structure prevents internal temperature change
Some nations lack the skills to handle incoming shipments and maintain what limited equipment they do have	Decrease the numbers of unskilled manpower hour in our distribution system as they relate to equipment handling	Teach workers how to maintain the ShriBox from a basic fundamental perspective, and ensure that the Shribox is sturdy enough to not require constant maintenance
Relying on intermittent electricity supplies and inefficient powering results in a high percentage of wasted vaccines	Reduce the reliance on localized power and electricity	The Shribox must be battery-powered completely independent of power that localized areas may provide.
Systems are not integrated enough to manage their entire vaccine supply chains	Reduce the gaping information holes exists as to what happens to vaccines when they leave storage	The Shribox will have sensors that provide real time temperature and pressure information to the forecasting manager.

Current cooling technologies are prohibitively expensive for some developing nations to use	Save money by eliminating low quality and one-time use transportation units	The Shribox must be financial feasible within 5 years of implementation and must be durable enough to last for that time
Newer vaccines require more cold chain space per dose in their shipping. Countries have to delay the time when vaccines arrive because they do not have the capacity	Provide for ample storage space of vaccines especially at the grassroots level of the distribution process	The ShriBox must be adequately sized to accommodate vaccine volumes influxes.
Little to no forecasting for physically damaged vaccines	Account for the vaccines damaged during transportation	Hold and store vaccines using the secure/safe Shribox that records substantial pressure changes
No sensor alerts when Vaccines reach below optimal temperature	Measure temperature of vaccines during its entire transit route	Record temperature of vaccines at every checkpoint with Shribox sensors to determine number of vaccines compromised
Many vaccines get lost or even stolen during transportation	Keep track of all vaccines being delivered to their appropriate destination	R.F.I.D. integrated into the Shribox to record how many vaccines go missing for future forecasting
Suppliers cannot accurately account for compromised vaccines during transportation for production planning	Quantify how many vaccines need to be produced to make up for unusable vaccines	Compile data recorded by ShriBox and send to suppliers to help accurately predict future vaccine production

Critical Success Factor Analysis

Our analysis of critical success factors begins with one that seeks to rectify the largest problem in our distribution systems and IoT, in terms of scale. Currently, there is a chasm between the first few steps of the network (vaccine manufacturing and transport) to arrival in the receptive country. More often than not, the latter location is within a more impoverished nation than the former[5]. There are widespread issues that come into place once vaccines touch down in the receptive nation, and this one is more logistical in nature. Our objective is to simplify the number of stops that vaccines rest at, as this will contributed to a more streamlined system with fewer redundant steps. This is directly tied to a need for a singular inventory hub where forecasting will be conducted. Our critical success factor here is utilizing Shribox metrics and route optimization data to identify one location within Nigeria that is geographically situated as the best place to have the major inventory hub. Situated here will be a member of our consulting arm, the forecasting manager who is in charge of analyzing and acting upon this data.

A key to the success of the Shribox is its physical composition. We believe that in order to achieve our next objective of preventing temperature damage to vaccines, our Shribox must be constructed through intelligent programming and efficient use of materials, which is our critical success factor. This built in advantage makes the Shribox inherently superior to currently used alternatives. Based on projections formulated, we seek to ensure a **95%** reduction in vaccines that are renders unusable due to ambient temperature damage.

It would be complete folly to introduce a revolutionary technology and not provide the means to support its use through the entirety of the distribution channel. Relatively speaking, the ShriBox is extraordinarily advanced; compared to the wooden boxes and lunch boxes it will be replacing as refrigeration units, it is a technological wonder capable of saving millions of lives. However, it will require maintenance in order to unleash its full potential. The relevant critical success factor is teaching those who will be handling the Shribox every day to maintain it on a basic level. This is to avoid Bullwhip effects where damage costs are caused at a certain step, and increase exponentially due to damaged equipment. To this end, we implement a support team to transport and conduct low-level cleaning and maintenance on the ShriBoxes after the local clinic has no more use for them. The transportation and maintenance will be conducted before the Shriboxes are used to transport new vaccines at the start of a new distribution cycle.

The most important objective we face as a company in this endeavor is stopping temperature damage caused by haphazard transportation units. Units currently in use are makeshift coolers that rapidly gain heat from the ambient environment, which serves to destroy and denature vaccines inside. The critical success factor is for the ShriBox to have a temperature control design so as to maintain a steady internal sate that preserves the vaccines inside, which will be based on a renewable and inexpensive battery power system. The ShriBox in this way acts almost like a computer, and will be able to automatically correct any internal changes in temperature to one within an accepted range. Keeping vaccines at a certain temperature fends off the biggest cost black hole that exists in this distribution network and IoT in general.

A vital objective that we must meet is to reduce the information black holes that exist in current distribution channels as they pertain to vaccines metrics. There are simply no systems that are held accountable to the WHO or any other healthcare governing body about vaccine temperature ranges as a function of time or location. As a result, officials and researchers are left in the dark about which aspects of a distribution chain is in most need of overhaul. The critical success factor that pertains to this objective is fitting each and every ShriBox with a sensor that records and relays real time temperature and pressure information to the forecasting manager. This manager will analyze this data with his team and will be better equipped to make forecasting decisions.

The next objective is to save money by eliminating the use of current storage units. These “units” are little more than wooden boxes and crates overlaid with ice packs, or simple lunchbox-type containers that are unable to maintain temperature within an exact range. Unfortunately, the only reason these units are used is because with regards to cost, there are no other options. Local health care centers simply do not have the finances or resources to implement other types of storage units on a wider scale. There are crippled because the usage of these substandard units causes millions of dollars of vaccine waste. The critical success factor to accomplish the goal of saving money is to ensure that the ShriBox is a financially feasible alternative. It would be completely ineffectual for the ShriBox to work from a technological standpoint, but be prohibitively expensive. In line with this factor is smarter manufacturing to reduce construction costs, the incorporation of durable building materials to prevent breakdown and replacement costs, and using low-cost construction supplies. Ultimately, the costs of the ShriBox will be less than costs associated with current waste and inefficiencies within **4 years**. Please view our cash flow analysis (Page 33-34) for an in-depth review.

Our next objective is to provide ample storage space for vaccines, in order to end the wasteful process of delaying vaccine influxes due to lack of space. Currently, vaccines that are unable to be shipped to a final destination remain in transportation limbo, which opens them up to increased chances of damage. The critical success factor that will address this objective is that the ShriBox will be adequately sized to accommodate an increased number of vaccines. In local health centers, there are no standard units for vaccine storage, as this need is met with whatever containers are available and can vary widely in size. The ShriBox will be built to exact specifications and will be capable of cooling over 5,000 vaccines, which can easily provide for even the larger African villages that we will target[6].

In underdeveloped countries such as Kenya, items that are being transported such as vaccines are attached by an aged withered rope to old wooden box on a bike or scooter. Often there are incidents where the dangerous and uneven roads cause the bike to fall over and damaging the vaccines. Most of the vaccines may be unscathed; however those that are physically damaged are now useless to those patients who need desperately need them. Usually the physical damage is noticeable to the point where the vaccines are leaking from their bottle but there are some cases where hairlines fracture can become susceptible to hazardous environmental factors that can cause infection or contamination. The current market has little to no solution to not only prevent physically damage to vaccines, but to record and analyze the loses. VaccTitan's Shribox is the most durable, secure, pressure sensitive medical transportation product on the market that records and accurately analysis pressure limits that's detrimental to the physical stability of vaccines. When the pressure inside the ShriBox exceeds stable limits, the sensor will record and send the data to the application notifying the WHO on-site employee there's possible damaged vaccines. From here, the WHO on-site employee will check each vaccine and record the quantities that are deemed unusable. This will ultimately help provide accurate future forecasting for demand production of malaria vaccines.

In addition to bumpy and dangerous roads that Africa has to offer, the heat creates another obstacle to keep these vaccines at optimal temperatures. Year round the average temperature in Africa reaches to 33-degrees Celsius which is 29 degrees above what vaccines need to be kept at. Currently vaccines are transported in containers and boxes with cooling packs that provide no way to record fluctuations in temperature that could compromise the efficiency of the vaccines. With the Shribox, temperature is continuously recorded and monitored to ensure the vaccines are useful and effective when administered to patients. If at any point the rise in temperature causes denaturing of the biological

makeup of the vaccine, the Shribox will make note and send the data to its corresponding application. The Shribox logistics will save production costs of 9 million dollars a year on employee salary. Also, the Shribox will improve future demand forecasting and save time and create a more efficient and production operation.

With outdated and non-existing technological advances in Africa, it's very difficult to track all vaccines that are in transit. From leaving the airport to arriving at its final destination, vaccines are handled by many people and pass through multiple check points. During this time vaccines are either lost or stolen and often never recovered. In order to reduce the risk of losing vaccines from these unfortunate events, the vaccines should be stored in our novel Shribox. Inside of the Shribox is a GPS locator that tracks the location of the Shribox at all times. In the event the Shribox has been mishandled and relocated to an offsite destination, the GPS can pinpoint its exact location to be recovered and reverted back to its appropriate destination. From there, the vaccines will be scanned using an RFID tag system to double check its authenticity from its initial placement into the Shribox. Not only does this check authenticity but it will also confirm the quantity of vaccines that were successfully transported.

In the current market there is little to no data analysis for demand forecasting on compromised vaccines in relation to inefficient transportation methods. The most common method for demand forecasting malaria vaccines are morbidity cases and number of injections per patient for different strains of malaria. However, vaccines that become inactive or lost due to human error and environmental occurrences are inaccurately accounted for in demand forecasting. In order to develop a more effective and efficient production system for malaria vaccines, these factors need to be recorded and documented. VaccTitan's Shribox is the one product on market that currently records and tracks compromised vaccines during the transportation process. The logistics are sent to its corresponding application system where they are analyzed to properly predict future vaccines loses from heat, physical damage and misplacement. Resolving each of these factors will help determine quantity and production timing of these vaccines.

Discussion of Technology Solution: The ShriBox

To understand the requirements and technologies involved to manufacture the ShriBox container we need to understand when and what will be required. Malaria vaccines are temperature sensitive and require special storage, transportation and handling to ensure that they maintain potency. This is particularly crucial to deliver a greater volume of vaccines to a greater number of people. Malaria vaccines should be kept in refrigeration and transported at +2°C to +8°C. Even though the containers for delivering the malaria vaccines are available in the market but either some are quite heavy or costly[7].

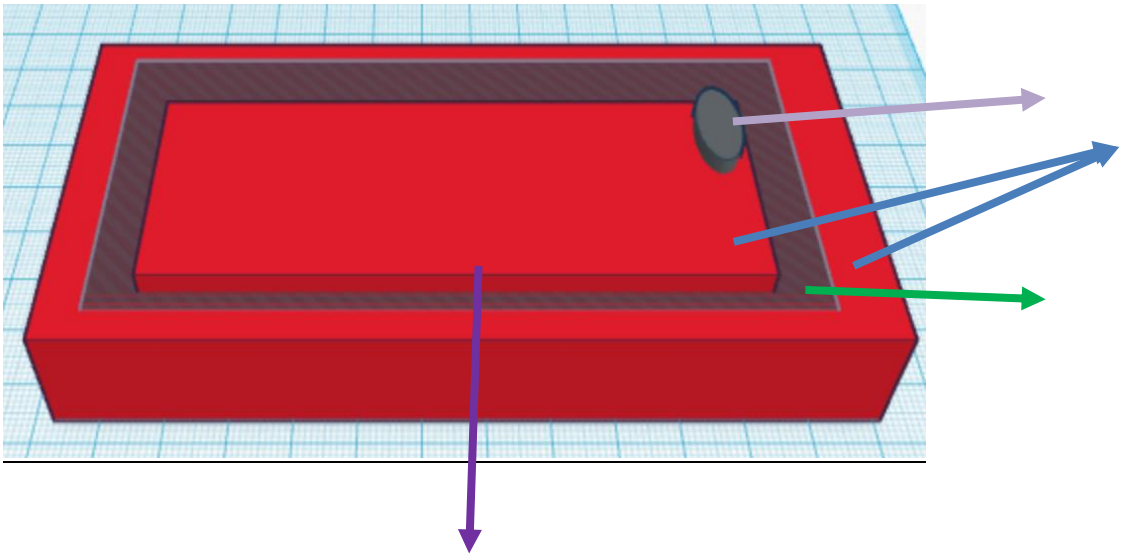
The RCW25 and Aircontainer Big Box are related technologies that we have juxtaposed with what we expect our ShriBox to resemble. Please refer to the Porter's Analysis of this paper for an in-depth look into these technologies. The schematics of these containers are compared in the table below.

Containers Characteristics	**Domestic RCW25[8]**	**Aircontainer Big Box[9]**	**Aircontainer Big Box with Wheels[9,10]**	**ShriBox**
Cargo Dimension (L x W x H meters)	0.710 x 0.550 x 0.490	0.950 x 1.212 x 0.850	0.960 x 1.212 x 0.850	0.610 x 0.610 x 0.610
Purchase price per unit	$792	$2,219	$2,219	$400
Corresponding Vaccine volume	1,080	1,560	780	1,154
Life of containers	10 years	10 years	10 years	>10 years

Taking into account of the information available, the container designed by VaccTitan are smaller in size and easy to carry named as ShriBox. As compared with all the containers, DomesticRCW25 is cheaper, smaller in size and can carry good amount of vaccines[11]. That is why we have designed ShriBox which has all the qualities of this container as well equipped with below benefits:

- Provides data for future predictions.
- Maintains temperature stability.
- Introduces IoT in the field of vaccine safety and analytics.
- Easy to carry so that even a single person can carry it.
- Compact to fit on smaller vehicles during transportation to the remote areas.

3D Design of ShriBox



MW=Mineral Wool-for insulation in the box container.

TS=ThermoShields -for maintaining the temperature

AS=Aluminium sheet-To make the box durable

Coil= Refrigeration

S = Sensors (Temperature, Pressure)

Location Tracker = Ultimate GPS Module - 66 channel w/10 Hz updates - MTK3339 chipset

RFID = To scan each vaccination. Its reusable.

<u>Measurement:</u>

MW = 2 feet x 2 feet x 0.2 feet (L x W x Thickness)

TS = 7 pounds

AS= 4 feet x 4 feet

Estimated Cost including Manufacturing:

All the parts will be purchased, assembled and manufactured in China due to the availability of the required materials which is easily available as well as cost effective when the materials are purchased in bulk

ShriBox Characteristics	**MW**	**AS**	**TS**	**Coil**
Dimension/Weight	2 feet x 4 feet x 0.2 feet	4 feet x 4 feet	7 pounds	1
Price per piece	$0.5	$70	$40	$80

Characteristic	**Cost**
Temperature+ Pressure + 8 GB chip	$110
Location tracker	$20
RFID	$0.2
Total	$111

The materials will be purchased and after analysis of the product manager it will go for manufacturing which will be crafted and assembled in the VaccTitan factories located at China.

Excluding aluminum which is the lightest and durable material available in the market are new for the market and considered due to their outstanding qualities.

Mineral wool

It a very good insulator, light in weight and cost effective.2 feet x 4 feet x 2 inches of 60 pieces will cost $12.

Aluminum

It is a durable, light weight and cheap metal. Thermoshields is used to provide the refrigeration required to maintain the temperature between +2°C to +8°C for malaria vaccines.

Sensors

IoT enabled sensors will be connected to VaccTitan mobile application. It will capture temperature and pressure inside the ShriBox. The required temperature can be maintained as the sensor will display the temperature inside the ShriBox all the time. Pressure will be also measured using the sensors so that if anyone opens the box, pressure change can alert the

VaccTitan mobile application that some changes are being made inside ShriBox.

Location-tracking

GPS would be used to track the locations. VaccTitan mobile application can track the location of the ShriBox all the time. Chips are being inserted into sensors so that if anytime the GPS is not working, all the information related to temperature and pressure can be analyzed later when ShriBox comes in contact with the network. The stored data will be updated into VaccTitan mobile application when ShriBox will come out of the GPS enabled area.

Ultimate GPS Module - 66 channel w/10 Hz updates - MTK3339 chipset benefits-

- Ultra low power usage: 20mA current draw while tracking
- RTC battery-compatible
- Built-in data logging
- Fix status output
- Ultra small size: only 0.05 feet x 0.05 feet x 0.01 feet

RFID

It is used to track the vaccination id at each check point. It will help solve the main problem of the vaccine industry which is “Piracy”.

Coil

The coil is used for standard refrigeration purposes.

ThermoShield

Due to its super effective radiant heat barrier properties, Thermoshield is without doubt today’s most revolutionary hi-tech coatings product in the world because it:

- Reduces temperatures dramatically by up to 45%.
- Cuts air conditioning and refrigeration equipment running costs.
- Stops thermal ageing and thermal shock by reducing heat load, Ultra Violet penetration and degradation.
- Reduces roof maintenance by up to 80%.
- Protects by eliminating blistering, peeling, cracking and fading.
- Converts rust and increases metal life.
- Reduces the risk of serious burns caused by high surface temperatures on metals.

- The most advanced radiant barrier insulating coating available, and has waterproofing properties.

This is how the ShriBox will look after manufacturing. Considering the functionality of ShriBox, security will be taken care using sensors, RFID and GPS tracker. To maintain the temperature between +2°C to +8°C inside the box, coils and batteries are used. The batteries used are rechargeable with electricity. Data produced by sensors and trackers will be sent to VaccTitan Mobile application. Live data will be monitored by ShriBox employees. If security measures and transportation locations are compromised, an alert message will be sent to the mobile application. Please view **Appendix A** for visuals pertaining to the ShriBox app. The figures attached give an overview of the app log-in (A), dashboard (B), location (C), pressure (D), and temperature(E).

Discussion of Forecasting Solution: Logistic Consulting

The problem with the current supply chain of vaccines during logistic and shipping is: vaccines are damaged/lost during transit. Temperature is not controlled and maintained during the entire route, moreover vaccines are even stolen from boxes and thus suppliers cannot easily predict the total vaccines lost/damaged during the route. Vaccine production planning is hampered and there are financial problems encountered and thus suppliers suffer from meeting the demand need of vaccines and also cannot maintain the vaccine quality as it would be at the time of manufacturing.

VaccTitan is capable of providing highly intuitive and valuable insights into the world of consulting. Having over half a century of experience in this industry, the company is well equipped and connected to understand value drivers, especially with regards to implementing their products across different countries and thus having a forecasting department in the supply chain will enable VaccTitan to efficiently monitor metrics real time. Metrics like temperature/pressure and location will be monitored real time and once the vaccines are received by the receiving country clerk, decisions and checks points are enabled that will monitor the ShriBox metrics that have the vaccines and thus in case of any change in the metrics, this alert will be send to the logistic planning head and the production of X amount of vaccines can be immediately started. This will save time and have an efficient vaccine manufacturing when it comes to analyzing the waste generated in the supply chain. Thus a feedback loop would enable estimation/ prediction of the number of malaria vaccines to the manufactured.

Future demand forecasting is dependent on the country VaccTitan will be delivering its services. As a short term goal in the logic model, VaccTitan will be focusing on the country Nigeria in the continent of Africa and will be expanding the countries it delivers it services in Africa. Depending on if there is the need for Malaria vaccines, the vaccines will be shipped in a ShriBox to the health care center depending on the safest and shortest route. Thus vaccines can also be stored in a location which will maintained and analyzed by the forecasting head. Transport and storage data are analyzed separately to accommodate for differences in endpoints across the various studies and also because the factors that could potentially influence temperature variations could be expected to differ between transport and storage situations. To complement descriptive statistics, a series of multivariate meta-regression analyses will be pursued to identify factors that might be associated with the level of exposure to freezing temperatures and pressure change in the ShriBox during transportation[12].

Feedback loops are designed in the shipping and distribution of vaccines. These feedback loops play a very important role since ShriBox metrics are monitored real time. In case of loss/wastage of vaccines, notification is send to the forecasting team and thus the right amount of vaccines can be manufactured to supply the demand. Once vaccines have been administered to the population and the ShriBox is empty, a ShriBox can be reused and thus this ShriBox is packed and send to the distribution head via the transportation department. VaccTitan consulting comes into place since forecasting can be determined for a country basis previous existing data like vaccine usage, waste generated due to vaccine counterfeit, Malaria cases and deaths, investigation vaccine cold chain requirements, innovation practices for the

shipping and distribution of vaccines, efficient usage of sensors that capture metrics like temperature, pressure keeping in mind the Internet of Things.

Swim Lane Schematics

Please refer to **Appendix B** for our Swim Lane illustration. The Swim Lanes should be interpreted with our critical success factors listed above.

Cash Overview: Consulting and Forecasting Logistics

As per 2015 WHO report, there were 165 million malaria cases in the world. Out of which 164 million people were saved and there were 395,000 death cases. 100 million cases were reported in Nigeria out of which 300,000 death cases were reported in Nigeria. Approximately 75% of deaths were reported in Nigeria compared to the rest of world. The total number of lives that survived in Africa is 99,700,000.

Our target is to make a sufficient number of ShriBox's that can carry a total of 100 million vaccines. It has been estimated that Malaria cases are going to increase in the future due to environmental climate changes. To take care of the future influxes, ShriBox manufacturing will be progressed in phases. Data captured using the IoT system will be integrated with the feedback loop to predict the number of boxes required for demand forecasting. The following formula will be used to predict the number of boxes:

$$\text{Total number of boxes required} = \frac{\text{Total number of malaria cases}}{\text{Number of vaccines carried per box (1154)}}$$

Estimating the total number of boxes required when the total number of malaria cases in Africa is 100 million.

$$\text{Total number of boxes required} = \frac{100 \text{ million}}{1154}$$

$$= 13{,}000 \text{ boxes}$$

This figure is an approximation; we attempt to manufacture a number close to this figure moving forward.

Figure 1: Cost Analysis and Breakdown of one ShriBox

Cost Analysis of one Box

Category	Item	Price	Qty/Measurement
Security Tracking Data Equipment	Temperature + Pressure	$109	1
	8 gb chip	$1	1
	RFID	$0.20	1
	GPS Tracker	$20	1
Materials	Mineral Wool	$0.50	2 feet x 4 feet x 0.2 feet
	Aluminum	$70	4 feet x 4 feet
	Thermoshield	$40	7 pounds
	Coil	$80	1
	Battery	$40	1

Total cost of one box = $ 361 ,$421 including Transportation and manufacturing

The above figure summarizes the estimated cost for the production of one ShriBox is $421 including manufacturing and transportation cost from China to US. The selling price of one ShriBox would be $1000. After analyzing the requirements in Africa using the current forecasting manufacturing process, the quantities of ShriBox's will be increased/decreased as per the requirement. As per the current requirement, more than 10,000 units should be manufactured by 2021.

Figure 2: The rate at which a ShriBox can be damaged by year's usage.

Total Wastage Description

Years	Total Units	Damage %	Wastage Quantity
1 to 2	7000	5	350
3rd	9900	8	792
4th	12400	10	1240
5th	14400	12	1728
Total Wastage		**10640**	**3760**

Damage% includes number of containers lost and damage. Wastage is divided into 4 parts. Staring 8 quarters (1-2 years), there is a damage of 5%. Due to which the quantity wasted would be 350 containers. In the next year (9-12 quarters), the damage% is increased by 3% resulted into damage of 792 containers. For the 4th year (13-16th quarters), damage increased by 2% resulting damage of 1240 containers. In the last year, damage% increased by 2% resulted in 1728 container loss. The total wastage is 3760 units which leads VaccTitan with 10640 ShriBox.

Cost Analysis of IoT based ShriBox:

The below Figure explains the quantity prediction and manufacturing of the desired ShriBox, assumed that WHO will purchase the ShriBox's form VaccTitan. Below data represents VaccTitan expenditure and profit analysis report for the next 20 quarters.

Figure 3: ShriBox Revenue and Costs Analysis for 5 Years

Cost Analysis for 5 years			*$421/ unit*	1000		
Quarter	**Units Manufactured**	**Total units available**	**Units after Damage**	**Initial Cost**	**Revenue**	**Profit**
1	1000	1000	1000	421,000	1,000,000	579,000
2	900	1900	1900	378,900	900,000	521,100
3	900	2800	2800	378,900	900,000	521,100
4	900	3700	3700	378,900	900,000	521,100
5	900	4600	4600	378,900	900,000	521,100
6	800	5400	5400	336,800	800,000	463,200
7	800	6200	6200	336,800	800,000	463,200
8	800	7000	6650	336,800	800,000	463,200
9	800	7800	7450	336,800	800,000	463,200
10	700	8500	8150	294,700	700,000	405,300
11	700	9200	8850	294,700	700,000	405,300
12	700	9900	8750	294,700	700,000	405,300
13	700	10600	9058	294,700	700,000	405,300
14	600	11200	9658	252,600	600,000	347,400
15	600	11800	10258	252,600	600,000	347,400
16	600	12400	10858	252,600	600,000	347,400
17	500	12900	10118	210,500	500,000	289,500
18	500	13400	10618	210,500	500,000	289,500
19	500	13900	11118	210,500	500,000	289,500
20	500	14400	10640	210,500	500,000	289,500
Total	**14400**			**6,062,400**	**14,400,000**	**7,758,600**

Each quarter the quantity of Shribox's manufactured decrease by 10% because each ShriBox is reusable. Total units available explains the manufactured ShriBox's available after each quarter which is targeted to increase by 80-90% per quarter to meet the production of more than 10,000 ShriBox's. Units after damage has been explained in the previous table of Figure 2. Fourth column represents the units damaged after every 4th quarter. Cost, revenue and profit as per the production and business is mapped for 5 years.

The second major revenue source for VaccTitan as a result of our partnership with the WHO will be from our consulting and forecasting services. As detailed in our swim lane of the IoT as it pertains to Nigerian vaccine distribution, we are implementing a forecasting department wedged in between the traditional roles. The role of this forecasting manager is to first receive all data and metrics from the ShriBox across the country that elucidate the state of the vaccines with regards to constant temperature, pressure, and R.F.I.D. The volume of unprocessed data will need to be examined by the forecasting manager, who will use his knowledge of mathematics, route optimization, and deterministic operations to decide how to best relay the next batches of vaccines around the country.

This function becomes exponentially more difficult as the number of ShriBoxes in use rises. Managing ever-increasingly larger influxes in data that ultimately can be used to save millions of lives is no small task, and we have decided to charge the WHO on a per unit basis. For each ShriBox that is both in transit, we look to earn $1000 in consulting fees. We have plotted below our units in transit, costs, revenue, and profit per quarter for the next 5 years. Key assumptions are:

- With regards to units in transit, we assume 1000 Shriboxes will be sufficient to get started in Nigeria in Q1. From Quarters 2-5, we introduce 900 ShriBoxes per quarter. From Quarters 6-9, we introduce 800 ShriBoxes per quarter. From Quarters 10-13, we introduce 700 per quarter, 600 per quarter from Q14 to Q16, and finally 500 per quarter from Q17 to Q20. We assume that we will decrease the units per quarter in order to both increase our reach, but also to maintain the ShriBoxes and data that we already have.
- With regards to cost, we foresee an initial cost of approximately **$25,000,000**. This amount is approximate and will be used to set up servers, train staff for basic maintenance procedures, and establish our percent. This cost decreases by approximately **15%** every quarter from Q1 to Q2. We reason that as we become more established, we are better able to predict where costs will come from and prepare for them.
- We look to charge the WHO **$1200** for the data from one Shribox. This revenue rises with the number of ShriBoxes in use and transit.
- These numbers represent an ideal case, and will not mirror what will happen exactly within the business model. They are used to roughly estimate the breakeven point and provide a model that we can refer to as we utilize the ShriBox. Again, these figures will not take into account miscellaneous delays.

In the Figure 4 below, we summarize the revenues, costs, and profits associated with our consulting services**.** To aid in these projections, we have attached the units manufactured, total units available, and units in transit after damage to each figure. These values are projections from Quarters 1-20, which is approximately 5 years.

Figure 4: Consulting Revenue and Costs Analysis for 5 Years

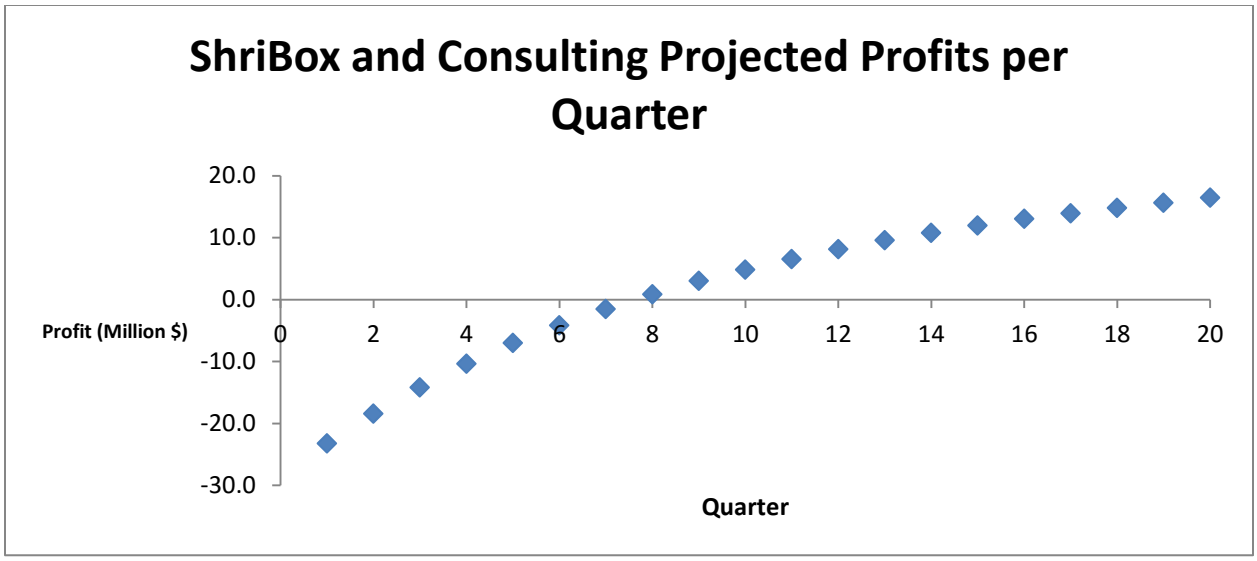
Quarter	Units Manufactured	Total units available	Units after Damage	Initial costs	Revenue	Profit
1	1,000	1,000	1,000	25,000,000	1,200,000	-23,800,000
2	900	1,900	1,900	21,250,000	2,280,000	-18,970,000
3	900	2,800	2,800	18,062,500	3,360,000	-14,702,500
4	900	3,700	3,700	15,353,125	4,440,000	-10,913,125
5	900	4,600	4,600	13,050,156	5,520,000	-7,530,156
6	800	5,400	5,400	11,092,633	6,480,000	-4,612,633
7	800	6,200	6,200	9,428,738	7,440,000	-1,988,738
8	800	7,000	6,650	8,014,427	8,400,000	385,573
9	800	7,800	7,450	6,812,263	9,360,000	2,547,737
10	700	8,500	8,150	5,790,424	10,200,000	4,409,576
11	700	9,200	8,850	4,921,860	11,040,000	6,118,140
12	700	9,900	8,750	4,183,581	11,880,000	7,696,419
13	700	10,600	9,058	3,556,044	12,720,000	9,163,956
14	600	11,200	9,658	3,022,637	13,440,000	10,417,363
15	600	11,800	10,258	2,569,242	14,160,000	11,590,758
16	600	12,400	10,858	2,183,855	14,880,000	12,696,145
17	500	12,900	10,118	1,856,277	15,480,000	13,623,723
18	500	13,400	10,618	1,577,836	16,080,000	14,502,164
19	500	13,900	11,118	1,341,160	16,680,000	15,338,840
20	500	14,400	10,640	1,139,986	17,280,000	16,140,014
Total	14,400			160,206,745	202,320,000	42,113,255

With these assumptions in mind, we identify our breakeven quarter at Q8, about 2 years into the business. Our projected profit at the end of five years (20 Quarters) is $50.5 M. A summary of our profits (ShriBoxes sold and consulting combined, as a function of quarter is provided in the table and graph below.

Profits generated from ShriBox Sales and Consulting (Millions USD) as a function of Quarter

Quarter	Profits (Millions USD)
1	-23.2
2	-18.4
3	-14.2
4	-10.4
5	-7.0
6	-4.1
7	-1.5
8	0.8
9	3.0
10	4.8
11	6.5
12	8.1
13	9.6
14	10.8
15	11.9
16	13.0
17	13.9
18	14.8
19	15.6
20	16.4

Total Profit:	50.5


ShriBox and Consulting Projected Profits per Quarter
Profit (Million $)
20.0
10.0
0.0
-10.0
-20.0
-30.0
0
2
4
6
8
10
12
14
16
18
20
Quarter

Logic Model

We at VaccTitan believe in setting high, but achievable goals for our company and value-driving products. Within Nigeria, we have established a set of outcomes that will be realized on a specific time frame. The outcomes can be classified as short term (1 year), medium term (3-10 years), and long term (10+ years). To begin, we identify our long term goals as reducing then number of vaccines wasted from 50% (as is currently), to under 5%. This means out of every million vaccines manufactured to save lives within Nigeria, only about 5,000 would fail to be administered. This presents a tremendous opportunity to both present the value of our product and make a positive impact on global health; we also plan to expand the reach of our product into other nations located near Nigeria. This will occur after we have established the Shribox as a life-saving technology within Nigeria. Eventually, we see ourselves as the #1 vaccine transporting technology, working with the WHO, UNICEF, and the United Nations as the primary supplier of portable cooling units for vaccine use.

These feed directly from our medium term outcomes. Within 3-10 years, we look to break even with our costs and revenue, and generate a profitable business with the Shribox. A stronger, more robust forecasting team is crucial to this medium term outcome. We must grow internally and equip our teams on the ground to deal with the continuously growing volume of data. Our third medium term outcomes are consolidating the IoT that we have built thanks to our data influx from all around Nigeria. This IoT is a far superior one that existed before ShriBox introduction, and actually provides accountability and visibility for vaccine distribution and status from the beginning to end of the network. Once we have this data influx, we will be well equipped to establish a central inventory hub in Nigeria, one that is best located to achieve our distribution goals.

Our short term outcomes, beginning within 1 year (Q1 to Q4), start with providing quantified and successful vaccine delivery. This means that our ShriBox is providing a real benefit to vaccine transportation, and is not some experiment gone wrong. This will be validated by the emergence of a young but functional Io system, one that is formulated by the metric provided by the ShriBoxes in transit. A related short term outcome is the generation of data and the subsequent forecasting logistics provided by our forecasting manager. Another short term outcome is to establish a partnership with a key vaccine distributor. We look to the leaders in this sphere, primarily the WHO, as potential partners and bodies who can get our ShriBoxes on the ground.

We now take a step back from these impactful outcomes and identify the outputs that generate them. The most important outputs are the benefits provided by the ShriBox, as well as the ShriBox itself. These are internal temperature corrections, pressure monitoring, location tracking and insights, and R.F.I.D authentication. This data is the holistic and quantified benefit that our ShriBoxes provide to this new IoT, and allows us to forecast what to do in the future. A key output is the number of vaccines that can be transported by the ShriBox (detailed as 1154). Previously, there was no standard number of transportation.

Our necessary inputs to begin this whole process include staff, raw materials, the VaccTitan app, capital and time. These are critical to even begin our process, and are provided via our preexisting business. As

we recall, one of our key assumptions is that VaccTitan is a leader in the American portable cooler industry, and is well equipped to provide these inputs.

Please refer to **Appendix C** for an illustration of our Logic Model.

The 6 W's of the ShriBox and Consulting Logistics

VaccTitan has conducted substantial research when it comes to analyzing technology and logistic consulting in vaccine distribution. The Six W's, are questions whose answers are considered basic in information-gathering. They constitute a formula for getting the complete story on a subject. According to the principle of the Six W's, a report can only be considered complete if it answers these questions starting with an interrogative word. 5 Whys is an iterative interrogative technique used to explore the cause-and-effect relationships underlying a particular problem in the vaccine distribution and logistics. The Porter's Five Forces is a simple but powerful tool for understanding where power lies in a business situation. This is useful, because it helps us understand both the strength of our current competitive position, and the strength of a position we consider moving into vaccine distribution.

- **Who**

1. Who is in need of the vaccine? (Who is in need to the vaccine? Who were are pitching to? & the country in terms of health)
2. Who is impacted by the efficient vaccine distribution & shipping?

- **What**

1. What will happen if this vaccine is not deliver on time?
2. What people/administration/health care providers are impacted by delay in distribution & shipping?
3. What is the cost of a ShriBox? And what differentiates it from the current logistics/ scenarios

- **Where**

1. Where will the vaccine delivery process have maximum impact?
2. Where are the Countries where we will be shipping the vaccines to?

- **When**

1. When are the vaccines needed?
2. When did the VaccTitan establish itself in the market?

- **Why**

1. Why are vaccines needed?
2. Why do we need ShriBoxes?

- **How**

1. How should the vaccine distribution and shipping process work?
2. How can the process be made efficient when it comes to time efficiency?

Analysis answers to the 6 W's

1. Who is in need of the vaccine?

Malaria vaccine has been the most deadly parasite globally and is most prevalent in Africa. Malaria vaccine is proven to be a preventive if received at the right age. Target groups that require the vaccine are children at 6, 10 and 14 weeks of age and the fourth dose is to be given 18 months later.
The WHO would require efficient distribution and shipping of these vaccines to the required country/region/village in perfect conditions so that no damage is caused to the vaccine during the supply chain[13].

2. Who has the maximum impact when it comes to efficient vaccine distribution & shipping?

With the introduction of new vaccines, developing countries are facing serious challenges in their vaccine supply and logistics systems. Storage capacity bottlenecks occur at national, regional, and district levels and system inefficiencies threaten vaccine access, availability, and quality. As countries adopt newer and more expensive vaccines and attempt to reach people at different ages and in new settings, their logistics systems must be strengthened and optimized. Vaccine packaging must be designed to meet effective vaccine delivery. Immunization information helps in making efficient forecasting and real time decision making[14].

3. What will happen if vaccines are not delivered on time?

Delivery routes must be streamlined in order to leverage and ensure vaccine delivery. Vaccines may be required for two major purposes- one in times of an outbreak and other to maintain its inventory. In times of outbreaks in many villages, the shortest part distance algorithm must be used in order to deliver vaccines reducing transport distances.

Immunization information systems enable better timely decision-making. Information technology has long been a feature of modern supply chains. When deployed successfully, information can speed order

processing, and improve decision-making, demand forecasting thus enabling smooth and efficient supply chains.

4. What people/administration/health care providers are impacted by delay in distribution & shipping?

Malaria vaccination could be on demand in times on an outbreak or it could be to fill up inventory basis future demand. Delay in distribution and shipping of the Malaria vaccine can cause rise in the total number of child deaths and can potentially kill the population in an epidemic. However, with population estimation numbers and full inventory, vaccines can be administered to individuals preventing major impacts on shipping.

5. What is the cost of a ShriBox? And what differentiates it from the current logistics/scenarios?

The cost of the sophisticated temperature, pressure & location sensor controlled ShriBox is 432$, when currently transportation containers are iceboxes and refrigerators for temperature control which prove to be inefficient. The transportation containers currently have barcodes which are scanned only at particular locations and not tracked real time during the course of the supply chain. Also the boxes are not pressure controlled and thus having problems like vaccine counterfeit.

Since the ShriBox is temperature and pressure controlled there can be no manual intervention in the supply chain thus preventing vaccine counterfeit issues. The ShriBox also has a location sensor that provides real time location information thus determining time to reach the location.

6. Where will the vaccine delivery process have maximum impact?

Organized distribution of vaccines is a crucial part of the overall supply chain so that they reach the target destination. Right from manufacturing to distribution and shipping of vaccines to delivery to end users/healthcare providers will help enable maximum impact. Using the ShriBox will enable maximum impact with reduced losses.

7. Where are the Countries where we will be shipping the vaccines to?

The malaria vaccine will be shipped to one continent that is Africa where we shall deliver malaria vaccines in a sophisticated sensor controlled ShriBox to one country Nigeria.

8. When are the vaccines needed?

The Malaria is needed in 2 cases, one during an outbreak and one to store vaccines in an inventory basis future forecasted numbers.

9. When did the VaccTitan establish itself in the market?

VaccTitan is an American refrigeration appliances brand that was founded in 1935, in Washington D.C. For the large part of the company's history, VaccTitan assisted with American World War II efforts by providing portable refrigeration units for tactical field use.

10. Why are vaccines needed?

Vaccine supply and logistics systems around the world are unable to keep pace with growing immunization need and the volume of vaccines the cold chain is required to deliver keeping in mind new strategies. Choosing the right cold chain equipment is strategically important, as such choices can facilitate changes in delivery routes and frequencies, which in turn could have an impact on vaccination schedules and strategies[14].

11. Why do we need a ShriBox?

Vaccines are sensitive to cold as well as heat and during the supply chain of distribution and shipping and the WHO cannot meet demands due to inaccurate forecasting and inefficient inventory. Thus we need a sophisticated ShriBox that can help solve these problems. ShriBox can be used to determine smarter logistics to relay vaccines when needed.

12. How should the vaccine distribution and shipping process work?

Keeping the business process diagram short and concise, Vaccines are manufactured and stored in temperature controlled locations by the manufacturing head which is in the US. Vaccines are received by the receiving country clerk and are stored in ShriBoxes, which are then delivered to health care centers in Nigeria. At every checkpoint, the metrics of the ShriBox to understand and predict logistics so as to meet delay and supply vaccines that contributes to waste.

13. How can the process be made efficient when it comes to time efficiency?

Current non value added outbreaks in the process should be eliminated in order to improve efficiency. Faster modes of travel, shortest path algorithms, location tracking sensors, temperature and pressure controlled sensors will be embedded on a ShriBox to monitor the supply chain distribution to meet the minimum WHO Performance, Quality, and Safety specifications without causing damage to vaccines through unreliable boxes.

ShriBox require maintenance, which necessitates the availability of properly trained technicians, replacement parts, a system to monitor equipment performance, and the capability to rapidly respond to breakdowns and failures. Although existing supply chains should already have maintenance plans in place, recent cold chain assessments reveal consistent deficiencies in this area and thus comes VaccTitan and its vaccine distribution and shipping keeping in mind logistics which helping enable data analysis with respect to time.

<u>6 W's for Consulting Logistics</u>

1. Who requires forecasting for physically damaged vaccines?

Failure to store and handle vaccines properly can reduce vaccine potency, resulting in inadequate immune responses in patients and poor protection against disease. Patients lose confidence in vaccines and their providers when revaccination is necessary because the vaccine(s) they received may have been compromised (exposed to inappropriate conditions/temperatures or handled improperly). Storage and handling errors can also result in significant financial loss if the vaccine(s) cannot be used.

Thus the quantity of vaccines that have been damaged during the transportation must be recorded and stored so that accurate forecasting for vaccine manufacturing can be established[15].

2. What kind of consulting logistics will VaccTitan offer?

VaccTitan's latest product, the Shribox, has an embedded sensor that can monitor temperature, pressure and monitor the location of the vaccines. Thus VaccTitan will offer consulting in terms of the demand of vaccines required, total vaccines wasted and thus increase in vaccine production. Analysis and interpretation of ShriBox metrics along with data analytics from its sophisticated feedback loop system provides essential and pressing demand forecast metrics.

3. When in the supply chain of vaccines does demand forecasting and logistics take a role?

Vaccines can be damaged due to heat exposure, freezing, breakage, missing inventory, theft etc and thus from the time the vaccines are stored in the ShriBox until the vaccines are administered to patients in the health care center, every metric will be monitored by the forecasting head in order to cater to unexpected vaccine losses

4. Where will the sensor alerts be sent?

Decisions boxes capture data from the ShriBox at every given location wherein this data is analyzed by VaccTitan Consultants for QC analysis. The Data helps in analyzing and forecasting the demand of the number of vaccines required.

5. Why can't suppliers accurately measure the demand of vaccines required during transportation?

With outdated and non-existing technological advances in Africa, it is very difficult to track all vaccines that are in transit. From leaving the airport to arriving at its final destination, vaccines are handled by many people and pass through multiple checkpoints. During this time vaccines are either lost or stolen and often never recovered. There is no accurate projection of the quantity of vaccines lost/damage during transportation and thus suppliers cannot accurately measure demand.

6. How helpful are the metrics that are received by the ShriBox?

The Data received from the ShriBox sensors will enable smarter logistic planning thus enabling time saved during production leading to efficiency. VaccTitan provides its own consultancy in regards to data received from ShriBox metrics thus enabling the feedback loop network on information and helping build the IOT concept.

5 Why Analysis on the need for the ShriBox

Why do we need a Shribox?

- Because of the damage caused to vaccines during shipping

Why is damage caused to vaccines?

- Because vaccines are transported in wooden/ thermocool boxes that do not have temperature control, and are ill-equipped to handle the stresses of inter-country travel

Why are the vaccines transported in wooden boxes?

- Because there no new technology that has been adopted, nor have other alternative storage units in use

Why is there no new technology adopted?

- Because acquiring sophisticated temperature controlled boxes are prohibitively expensive in developing nations

Why are the alternative technologies expensive?

- Because most boxes have temperature/pressure/location sensors that track the vaccine in the supply chain and are composed of sturdy and durable materials.

5 Why Analysis on the need for Logistic Forecasting/Planning

Why is a there little or no forecasting of vaccines during the supply chain?

- Because the amount of vaccines damaged during transit are not completely accounted for due to old technologies and not having accurate tracking mechanisms

Why is tracking not accurate?

- Because vaccines are transported in wooden/ thermocool boxes that do not deliver metrics real time, and are ill-equipped to handle inter-country travel

Why is there no real time planning for the no. of vaccines required?

- Because there no estimation of the loss generated during the supply chain nor can suppliers predict the no. of vaccines required in a particular country.

Why is there no estimation of losses generated?

- Because the current boxes used for vaccine delivery cannot deliver the right forecasting of the no. of vaccines lost/damaged during transit thus acquiring metrics real time is practically impossible.

Why is the right forecasting not delivered?

- Because vaccine carrying boxes do not have temperature/pressure/location sensors that track the vaccine in the supply chain and so losses caused during transit are not measured and analyzed for future demand forecasting.

Porters 5 forces

- The threat of new entrants →
- The threat of substitute products or services →
- The bargaining power of customers (buyers) →
  - The bargaining power of suppliers
  - The intensity of competitive rivals

Porter's forces helps us analyze and understand the shape of industry competition keeping in mind who our suppliers are, power of buyers, new substitutes in the market and new entrants[16].

- The threat of substitute products or services

The already existing products and services to transport and ship vaccines are basis the current market analysis. 'Domestic RCW25', 'Air Container Big Box', 'Air Container Big Box with Wheels', 'Passive Vaccine Storage Device', are a products that are currently used for vaccine distribution, however these devices/equipment's do not have location and pressure controlled sensors that solve the IOT problem. What distinguishes VaccTitan's ShriBox is that the box is temperature, pressure & location controlled that enables consultants to deliver analysis basis data capture during every step in the process[17].

- The threat of new entrants

Another clear reference to imperfect competition lies in the dimension entitled 'threat of new entrants', which considers eventual barriers to entering the market. New entrants are refrigeration companies that manufacture refrigerators to store vaccines. These could be potential new entrants in the market.

According to Porter's 5 forces, threat of new entrants is one of the forces that shape the competitive structure of an industry. Porters threat of new entrants definition revolutionized the way people look at competition in an industry[18].

- The intensity of competitive rivals

The intensity of rivalry among competitors in an industry refers to the extent to which firms within an industry put pressure on one another and limit each other's profit potential. If rivalry is fierce, competitors are trying to steal profit and market share from one another. This reduces profit potential for all firms within the industry. According to Porter's 5 forces framework, the intensity of rivalry among firms is one of the main forces that shape the competitive structure of an industry. High intensity of competitive rivalry can make an industry more competitive and decrease profit potential for the existing firms. On the other hand, low intensity of competitive rivalry makes an industry less competitive and increases profit potential for the existing firms.

- The bargaining power of customers (buyers)

VaccTitan does not have customers who they will be bargaining their product/service. VaccTitan is pitching the ShriBox along with consulting logistics to the WHO. The WHO is the only customer who we would be pitching or product/service and offering logistic planning based on the metrics delivered by the sensors on the ShriBox. However in the long term, the bargaining power of the customer can increase, VaccTitan will be pitching its product and consulting services to other potential customers and vaccine manufacturing firms like the UNICEF.

- The bargaining power of suppliers

ShriBox is manufactured in China and the suppliers who deliver the raw materials to manufacture a ShriBox are also located in China. Raw material like mineral wool, ThermoShields, Aluminum sheet, coils for refrigeration and sensors from suppliers like 'Energylux', 'Shanghai LEEG Instruments Co., Ltd ', 'Coil Master', and 'China Mowco Rockwool Manufactures' are suppliers who offer our need keeping in mind the competitive price from alternative suppliers as well. The sensor controlled ShriBox will be delivered to the distribution department in the US from China and this ShriBox will travel to Nigeria providing smarter metrics which would be captured at every stage enabling and solving the Internet of things in vaccine distribution and shipping in Health

Conclusion

Malaria is the 2nd leading cause of death in Africa and being an infectious disease almost 1 out of every 5 death in Africa is due to Malaria. As per WHO reports, number of malaria cases recorded in Africa is decreased by only 10 million, whereas decrease in the death rate is 55% but it doesn't meet the estimated target of the people saved each year. WHO has estimated to decrease the number of malaria cases by 80% by 2020 which is possible only when the vaccines are able to reach the affected population. Currently, methods of transportation do not overcome most obstacles that delay or destroy useful vaccines. With dangerous terrain and extreme heat seasons, vaccines become easily susceptible and vulnerable to harmful factors causing them to become inactive. Overtime, documenting such compromised vaccines during transportation would improve overall demand forecasting for future production. Currently however, there are little to no information systems or logistics that help accurately predict and track inactive vaccines. After preliminary beta testing, VaccTitan has developed a breakthrough product that accurately measures and tracks vaccine integrity throughout its transportation process

VaccTitan's ShriBox is a temperature, pressure, and location sensor device that has the capabilities of providing highly intuitive and valuable insights into the world of demand forecasting. With extensive market research in current vaccine distribution chains, numerous deficiencies have been identified within the transportation process. Supply chain networks currently involve dozens of storage units transfer checkpoint and personnel where any mistake made in either step is carried over to the next. Our ShriBox and the fruits of our consulting services in the vaccine distribution system will solve these problems. With our critical success factors, VaccTitan will improve vaccine longevity during transit and deliver proprietary logistics from ShriBox's integrated applications system, contributing to the IoT idea.

We at VaccTitan believe in setting high, but achievable goals for our company and value-driving products. As a long term outcome we have tremendous opportunity to both present the value of our product and make a positive impact on global health; we also plan to expand the reach of our product into other nations located near Nigeria. Eventually, we see ourselves as the #1 vaccine transporting technology, working with the WHO, UNICEF, and the United Nations as the primary supplier of portable cooling units for vaccine use coupled with consulting logistics.

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Appendices

Appendix A: VaccTitan app for ShriBox

Figure 1: App Log-In Screen

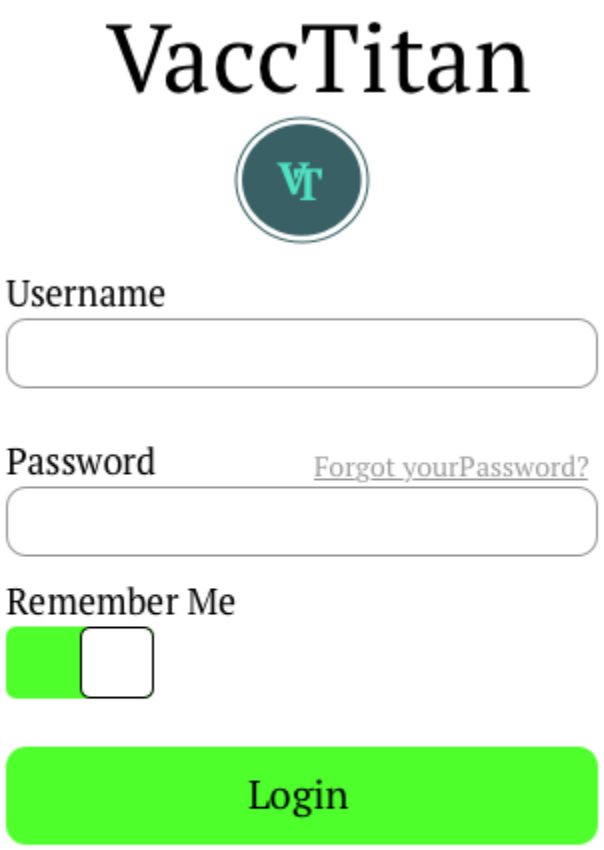


Figure 2: App Dashboard (ShriBox count)

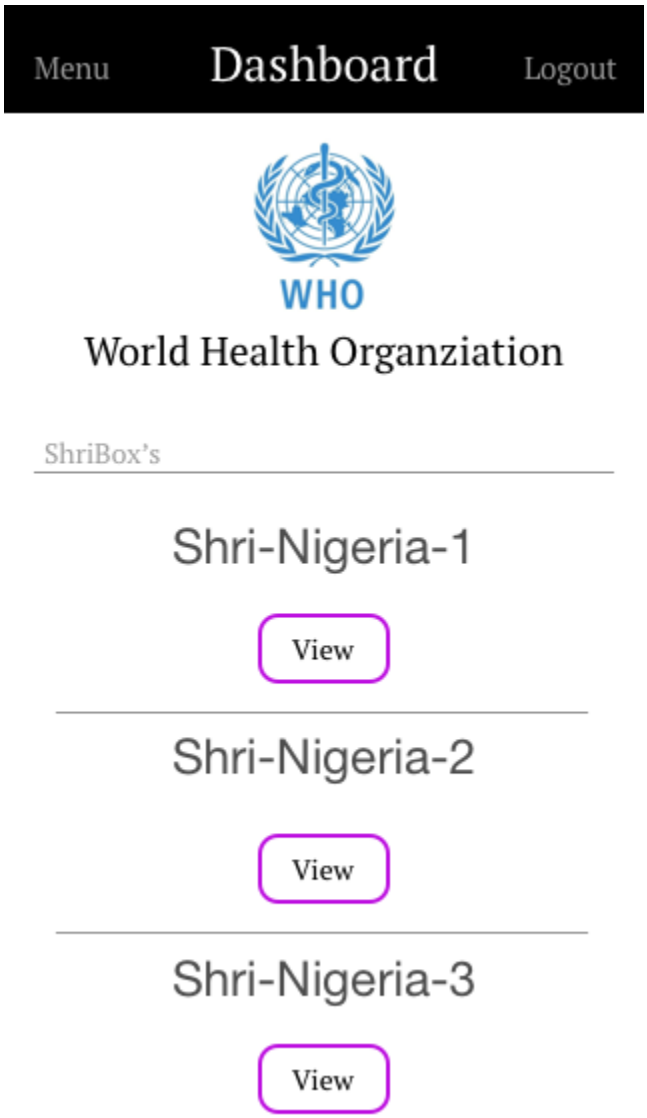


Figure 3: ShriBox #1 Location details

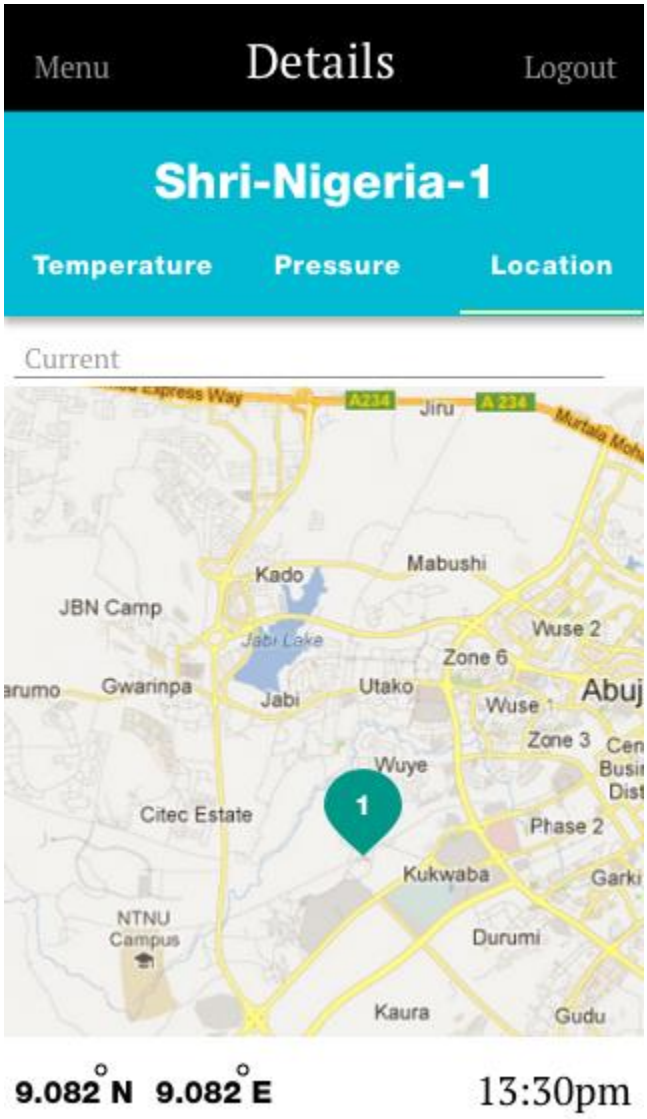


Figure 4: ShriBox #1 Pressure details

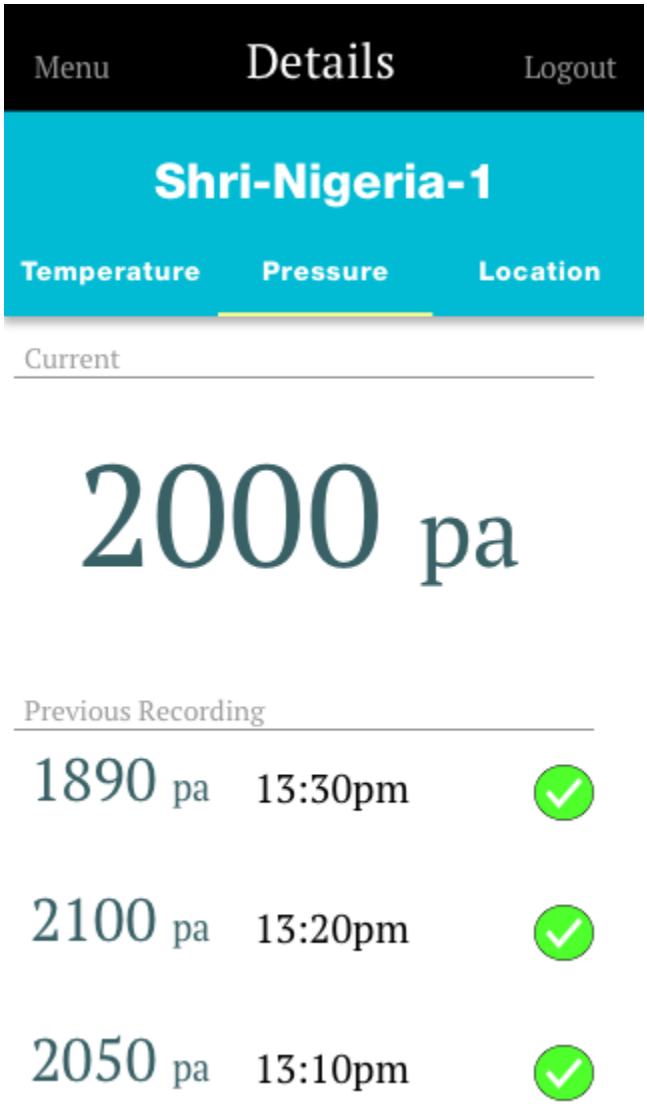
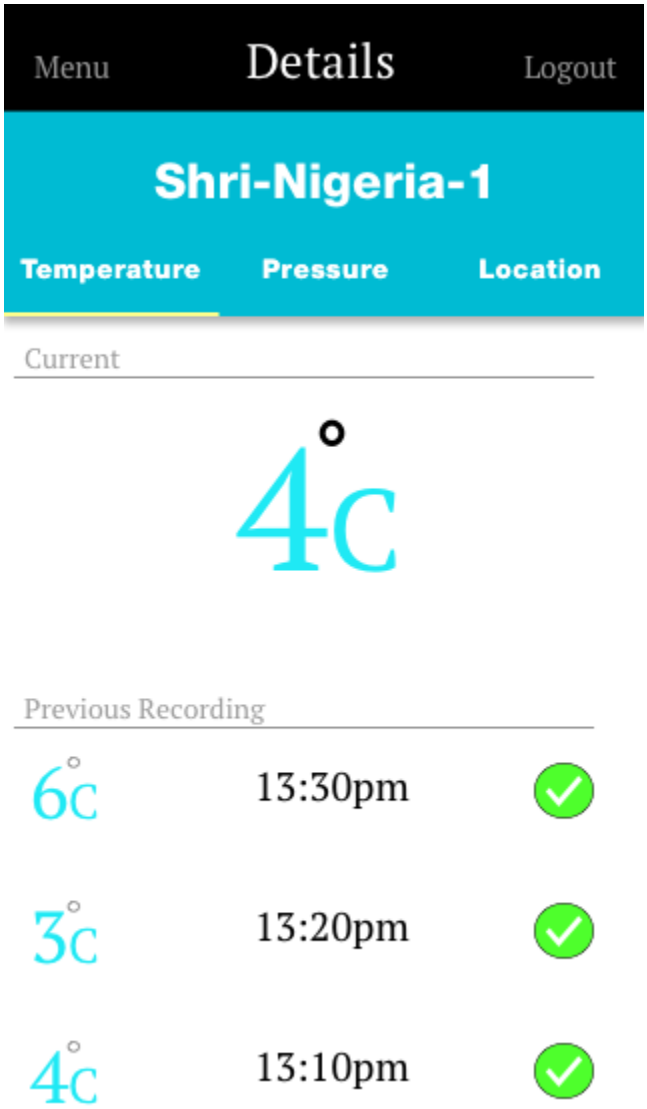
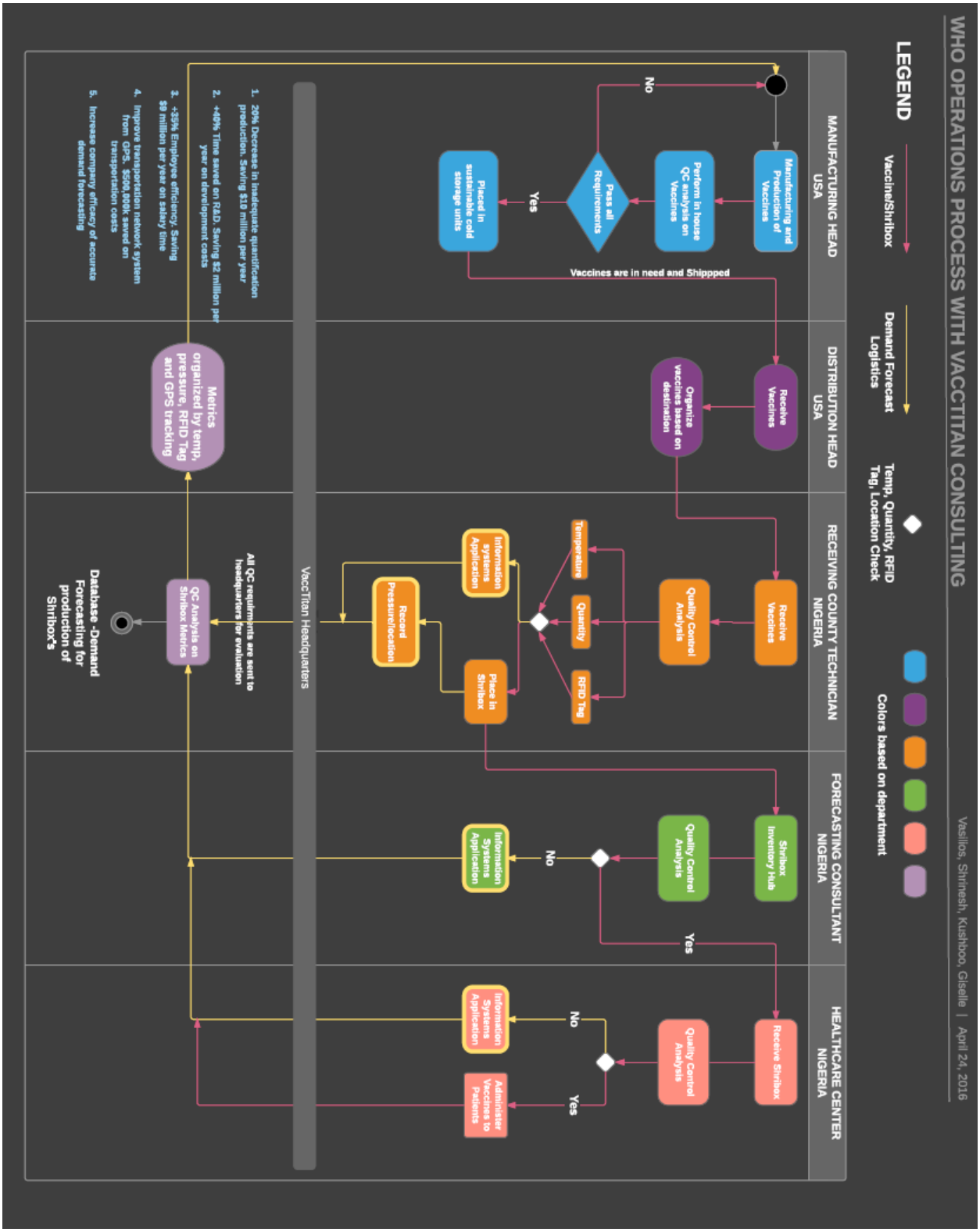


Figure 5: ShriBox #1 Temperature details



Appendix B: Swimlane Process Overview



Appendix C: Logic Model