Drones for Social Cause…Last Mile Delivery

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Drones for Social Goods

- Many industries are increasingly trying to become responsiveness-heavy to get close to raid delivery performance;
  - ➢ Next day →Same day → Two hours
- Drone deliveries initially proposed by Amazon is all expected to revolutionize the distribution networks of supply chains, especially Rapid “click-ship” product delivery

Advantages of Drones

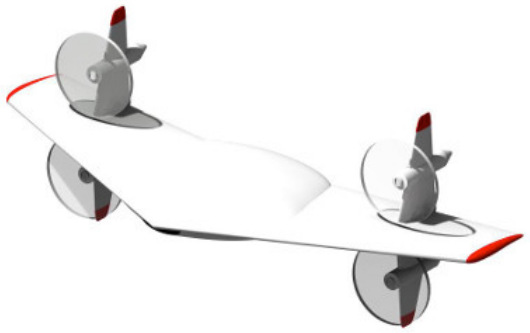
- Delivering packages for online sales
- Distribution Center goods movement
- Potentially accompany transit modes such as trucks, trains, or ships, flying ahead to report on potential hazards and delays, and assisting in streamlining delivery
- Does not impact the world trade flows

Drones for Global Health

- Dramatically increase the efficiency and speed of organ donations, key medications, and vaccines etc..
- Healthcare more accessible in urban spaces: bypassing road and rail traffic congestions, as well as to rural and third world locations where insufficient infrastructure might typically cause detrimental delays.

IDI Snowmobile & Dr. One

- IDI Snowmobile is a startup out of the Netherlands that is focusing on developing socially responsible solutions with small drones.
- Dr. One is one of their small drones that can be used to deliver small medical goods to remote locations
- Many others are coming up in this space…



Mayo Clinic Testing

Blood delivery using Drones:

- Cheaper
- Faster

Blood Delivery using helicopter and ambulance:

- Expensive
- Time-consuming

Mayo Clinic Testing

Demand

Minimum Plasma Inventory	Critical Access Hospital	Regional Hospital	Tertiary Hospital
Type O	2	10	531
Type A	2	10	739
[illegible]	[illegible]	[illegible]	181
*Type AB	2	20	96
Total	6	50	1547

Minimum Cryoprecipitate Inventory	Critical Access Hospital	Regional Hospital	Tertiary Hospital
Type O	0	2	84
Type A	0	2	82
[illegible]	[illegible]	[illegible]	20
*Type AB	0	4	13
Total	0	10	199

Minimum Platelet Inventory	Critical Access Hospital	Regional Hospital	Tertiary Hospital
Total	0	4	30

MAYO CLINIC

Blood supplies in small and large hospitals

A single patient needing massive transfusion can deplete the blood supply of smaller hospitals.

UNFPA & Drones

- UNFPA is the lead UN agency for delivering efffective supply chian solution wanted to
- expand the possibilities for women and young people to lead healthy and productive lives.
- The UNFPA and USC Center for Global Supply Chain Mangement conducted prefeasibility study focused their efforts on innovations in last-mile logistics
- Understanding how emerging technologies such as drones could really help make significant positive changes.

Define

Stakeholders

- **UNFPA** (United Nations Population Fund)
  - Luichi Hara & Ruben Vellenga
- **IDI Snowmobile** & **NLR** (National Aerospace Lab of Netherlands)
  - Gerald Poppinga
- **Amref Flying Doctors & Dr.One**
  - Mirjam Jansen op de Haar
- **USC Marshall GSCM** (University of Southern California)
  - Nick Vyas - Six Sigma Master Black Belt
  - Pallavi Basu - PhD Candidate
- **Ghana Health Services**

Purposes

- To develop a long-term, sustainable solution to the last-mile delivery system in Ghana that will not only lead to an overall more efficient and cost effective system, but one that will make meaningful impacts in the realms of disease prevention and reproductive health.

Business Case

- Ghana lacks infrastructure to ensure timely delivery of medical goods & supplies to remote areas. Last-mile delivery is difficult and has led to high rates of unwanted pregnancies and poor maternal health.

- Remote hospitals overstock medicines/vaccines due to unreliable last-mile logistics, resulting in high holding costs and high quantity of medicines/vaccines going to waste due to expiration.

- As employment of drones is both more reliable and faster than existing motorcycle transport, it is suggested that drone implementation would improve timely delivery, lower holding costs and reduce medicine/vaccine wastage.

Assumptions

- Drones are part of the solution
- Upper East Ghana is a good test pilot location (stable government, established supply chain, and identified need)
- Ghana government approves of this study, is ready to test and implement this process if proven successful

SWOT Analysis

Strengths:

- Operating costs are much lower than motorcycles (per km)
- Can operate where and when motorcycles cannot
- Fast (150kph) and reliable for small emergency shipments

SWOT Analysis

Weaknesses:

- Can only carry 5 kg at a time
- Initial costs are much higher than motorcycles ($2000 more)
- Technology is still very new and no experts in the field in Ghana
- Reverse Logistics
- GPS location for many rural facilities are often incorrect

SWOT Analysis

Opportunities:

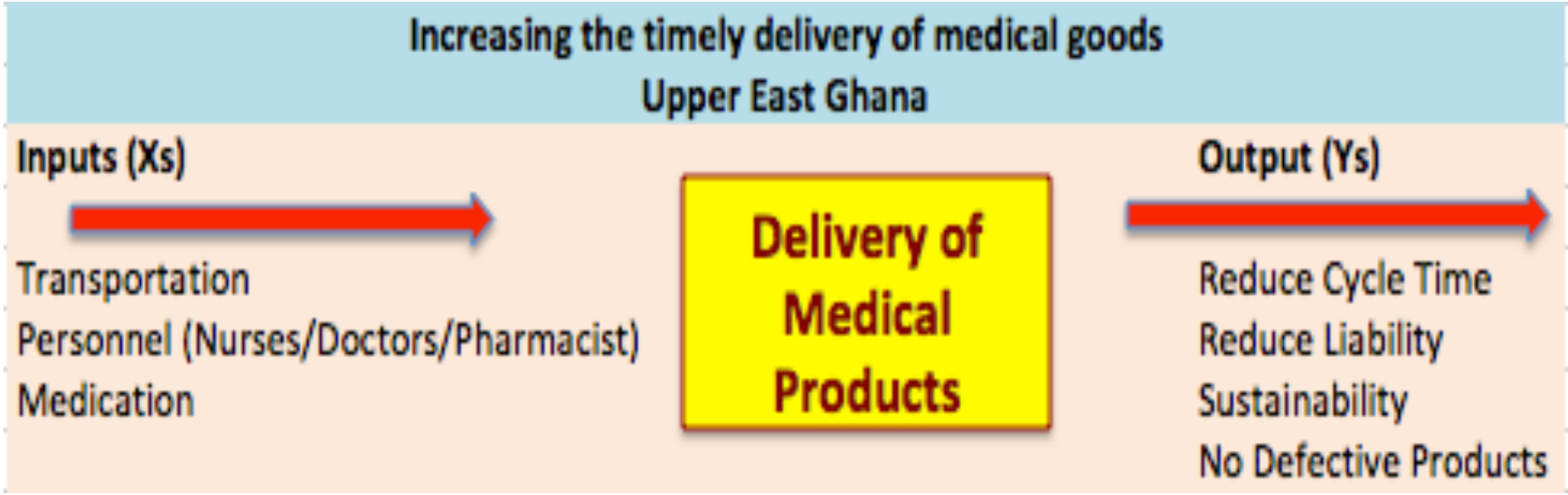
- As market/ technology advances, capacity could increase, and costs could decrease
- Could become the benchmark program for the future
- Create a lot of interest from outside inventors to help with startup
- Could create new, local drone industry in Ghana – e.g manufacturing, retail, repair, operations
- Can facilitate reverse logistics for small items such as lab samples and data forms

SWOT Analysis

Threats

- Potential lowering of gas prices or advances in alternative fuels could make motorcycles much cheaper
- Flight regulations could put a hamper on or stop operations
- No current regulations for drones
- Issues on where and how to store drones

Process Map – 50K



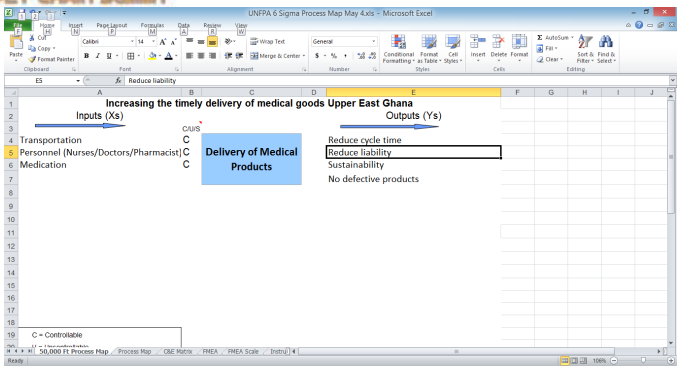
Process Map – 5K

Increasing the timely delivery of medical goods		
Inputs (Xs)		**Output (Ys)**
Patiend Nurse/Doctor Clinic/Hospital Tools & Equipment	**Diagnostic**	Cause/Diagnosis Prescription
Nurse/Doctor Pharmacy Prescription	**Medication Request**	Order Approval
Nurse/Doctor Bike/Vehicle Traffic Distance	**Delivery**	Arrival of Meds Reduce Cycle Time Sustainability
Nurse/Doctor Patient Medication Prescription	**Application**	Cure Prevention/Vaccination Total Cycle Time

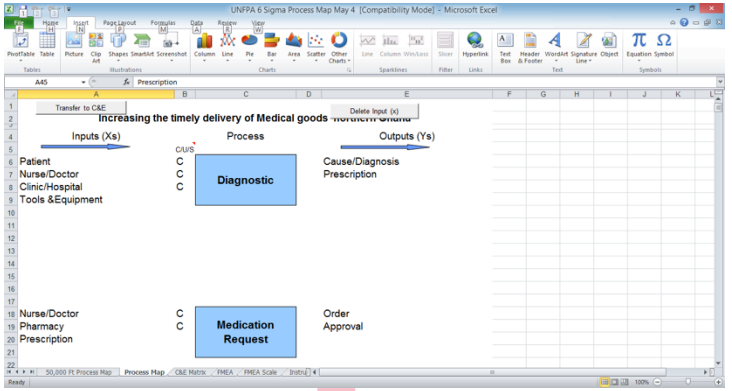
Measure

Measure Tools

1: 50,000 foot

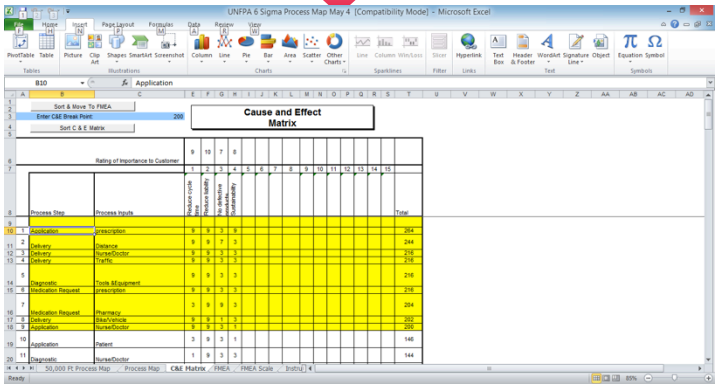


2: 5,000 foot

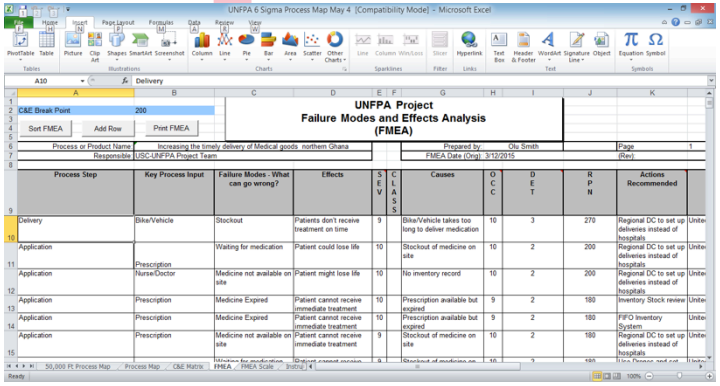


15 Inputs

3: C&E Matrix

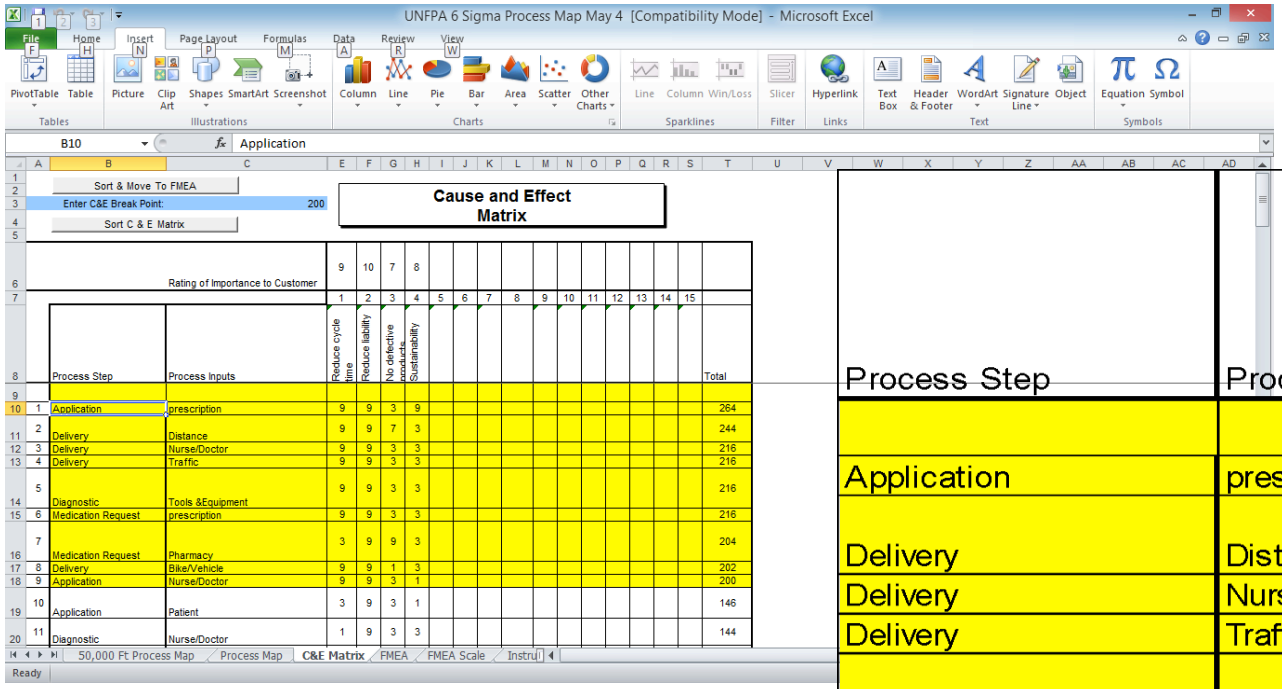


4: FMEA



Microsoft Excel 97-2003 Worksheet

C&E Matrix



Rating Importance

1. Reduce Cycle Time
2. Reduce Liability
3. No defective products
4. Sustainability

Process Step	Process Inputs
Application	prescription
Delivery	Distance
Delivery	Nurse/Doctor
Delivery	Traffic
Diagnostic	Tools &Equipment
Medication Request	prescription
Medication Request	Pharmacy
Delivery	Bike/Vehicle
Application	Nurse/Doctor

Present State Measurement

- Overstocking Cost of Malaria medicines as high as $500K/yr
- Ghana Healthcare logistics cost = $14 million/yr
- Data Identified:
  - Motorcycles & Drones
    - Operating costs
    - Capacities (speed, payload capacity)
  - Medicine & Vaccines
    - Overstocking & Understocking
    - On-time delivery percentage
    - % of hospitals that can store vaccines (cold chain capabilities)
  - Patient Percentages
    - Needing malaria vaccines
    - Malaria deaths in Upper East Ghana for past 5 years
- Analyzed process flow of goods through healthcare supply chain and role of motorcycles

Analyze

Drones VS Motorbikes

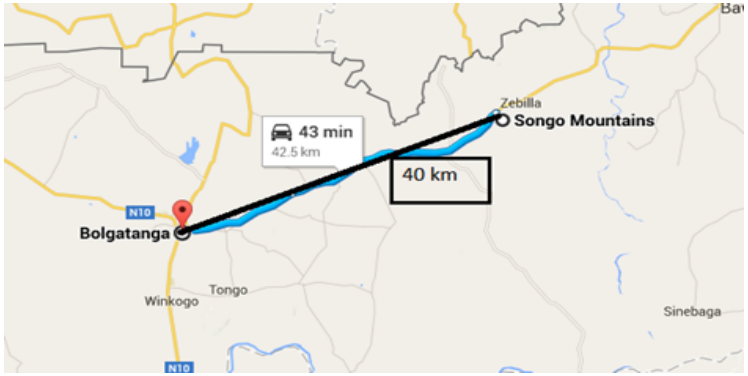
	Motorcycles	Drones	Difference (for Drones)
Initial Cost	$1500.00	$3500.00	+$2000.00
Cost (USD/ km)	$.0828/km	$.024/km	-$.0588/km
Speed (kph)	50 kph	150 kph	+100 kph
Capacity (kg)	50 kg	5 kg	-45 kg
Capacity (km)	300 km	100 km	-200 km
Refueling/ Recharging Time (hrs)	.15	1	+.85 hrs

FMEA

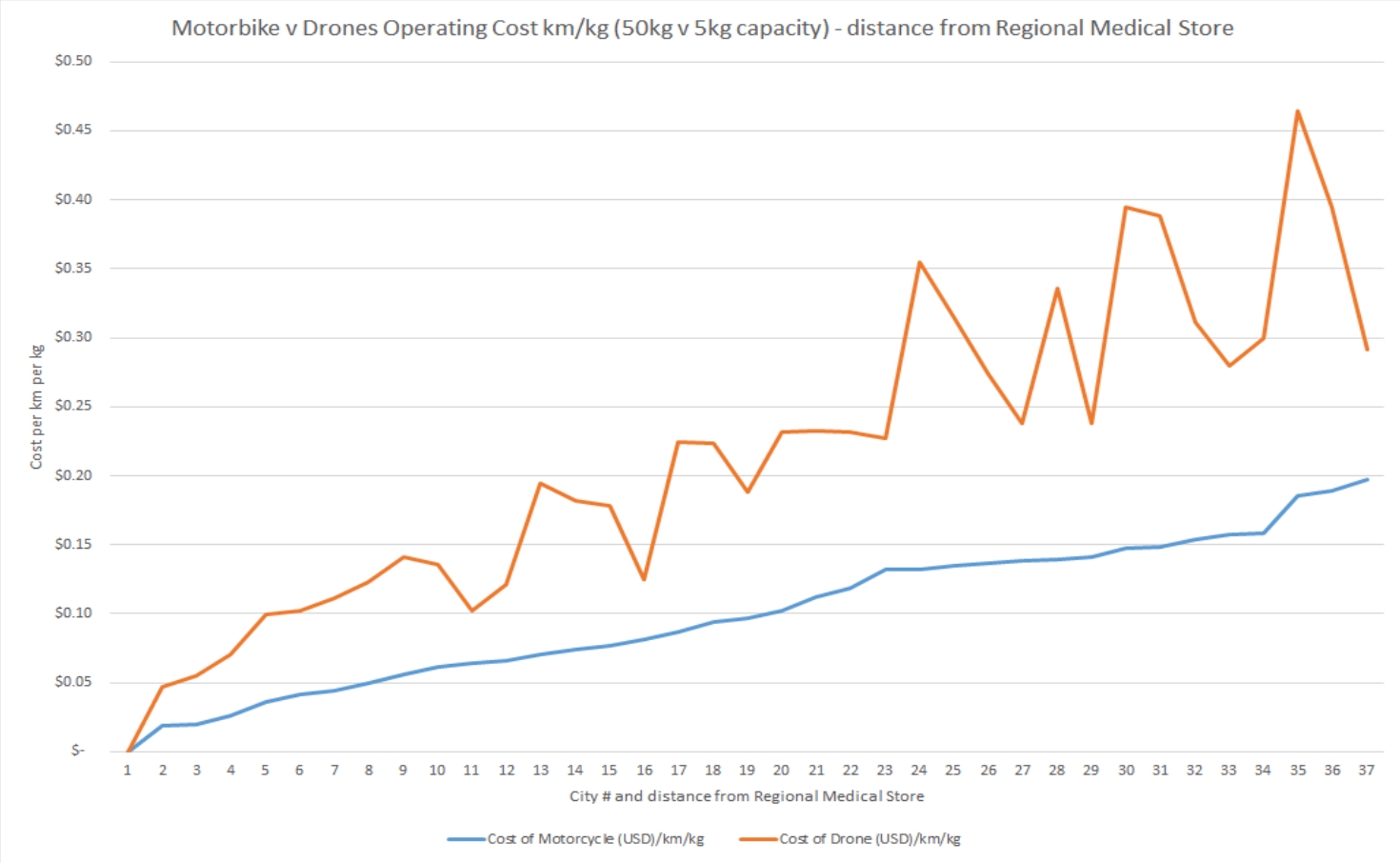
Process Step	Key Process Input	Failure Modes - What can go wrong?	Effects	SEV	CLASS	Causes	OCC	DET	RPN	Actions Recommended
Delivery	Bike/Vehicle	Stockout	Patients don't receive treatment on time	9		Bike/Vehicle takes too long to deliver medication	10	3	270	Regional DC to set up deliveries instead of hospitals
Application	Prescription	Waiting for medication	Patient could lose life	10		Stockout of medicine on site	10	2	200	Regional DC to set up deliveries instead of hospitals
Application	Nurse/Doctor	Medicine not available on site	Patient might lose life	10		No inventory record	10	2	200	Regional DC to set up deliveries instead of hospitals
Application	Prescription	Medicine Expired	Patient cannot receive immediate treatment	10		Prescription available but expired	9	2	180	Inventory Stock review
Application	Prescription	Medicine Expired	Patient cannot receive immediate treatment	10		Prescription available but expired	9	2	180	FIFO Inventory System
Application	Prescription	Medicine not available on site	Patient cannot receive immediate treatment	9		Stockout of medicine on site	10	2	180	Regional DC to set up deliveries instead of hospitals
Application	Prescription	Waiting for medication	Patient cannot receive immediate treatment	9		Stockout of medicine on site	10	2	180	Use Drones and set up Distribution Channels and
Diagnostic	Tools &Equipment	Diagnosis tools not working	Patient cannot receive immediate treatment	9		Clinic/Hospital not equipped properly	5	4	180	Inventory Stock review
Medication Request	Prescription	Medicine not available on site	Patient cannot receive immediate treatment	9		Stockout of medicine on site	10	2	180	Regional DC to set up deliveries instead of hospitals
Diagnostic	Tools &Equipment	Patient misleading doctors with wrong symptom description	Issue may get worse	6		Miscommunication	2	9	108	Training
Diagnostic	Tools &Equipment	Diagnosis tools not available on site	Patient cannot receive immediate treatment	9		Inavailability of medical equipments	4	3	108	Inventory Stock review

Road vs Straight-Line

- Developed list of 37 town/cities in Upper East Ghana
- Measured straight-line and road distance from Capital
- Road distance x $.828/km = Motorbike cost/ km
- Straight-line x $.024/km = Drone cost/km



Operating Costs/km/kg



Capacity and Maintenance

	Motorcycles	Drones
Constraint 1 (Motorbike = kph, Drone= battery)	50	100
Average Distance Traveled (km)	60.24324324	44.65083784
Trips/ Hour	0.829968596	2.239599632
Work Day (hrs)	14	14
Jobs per day (before charging/ refueling)	11.61956034	31.35439485
Average Distance Traveled (km)	36.40694444	28.44152778
Avergage Distance Per Day (km)	423.0326878	891.7668921
Constraint 2 (Motorbike = fuel tank, Drone = speed)	300	150
Stops per Day	1.410108959	5.945112614
Charging/ Refueling Time (hrs)	0.15	1
Stoppage Time (hrs)	0.211516344	5.945112614
Actual Hrs per Day	13.78848366	8.054887386
*Actual Trips per day	11.44400842	18.03972283
*Actual Distance Per Day	416.6413787	513.0772779

	Motorcycles	Drones
Initial Cost	$ 1,500.000	$ 3,500.00
Operator Salary ($)/ month	$ 130.000	$ 207.00
Tire Maintenance/ Km	$ 0.027	$ -
Engine Maintenance/ Km	$ 0.032	$ -
Drone Maintenance/ year	$ -	$ 1,000.00
Insurance Cost (.5%)/ year	$ 75.000	$ 175.00
Average Distance Traveled	60.24324324	44.65083784
Trips per day	8	18.03972283
Distance Per Day	300	513.0772779
Days per year (5 day work week + holidays)	251	251
Drone Maintenance	$ -	$ 1,000.00
Tire Maintenance/ year	$ 2,048.16	
Engine Maintenance/ year	$ 2,409.60	
Operator per year	$ 1,560.000	$ 2,484.00
Insurance Cost (5%)/ year	$ 75.000	$ 175.00
Cost of maintenance + insurance/ year	$ 6,092.76	$ 3,659.00

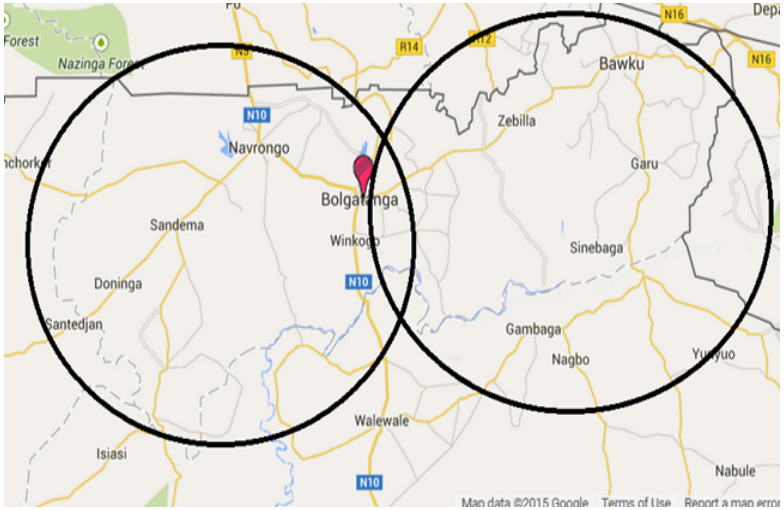
Design

Potential Solutions

- Logistics Decision Making:
  - Regional DC control to set-up delivery (presently controlled by hospitals)
- Medicine/Vaccine Procurement
  - Regional DC control (unless emergency) (presently controlled by hospitals)
- Inventory Stock Review and Delivery Plan
  - Handle on a Weekly basis
- FIFO Inventory system

Potential Solutions

- 3 drones for Upper East Ghana
  - 2 drones (1 Eastern/1 Western Sector) for shipments 10kg or less (non-emergency)
  - 1 drone to cover emergencies throughout Upper East Ghana



Validate

Current State VS Future State

- Monitor operating/maintenance costs for reductions
  - Maintenance = 50% decrease expected
  - Cost/Shipment - As drones have lower operating costs and wear & tear, cost/shipment should decrease
- Current system metrics (e.g. overstocking/ understocking costs, overstocking rates, Malaria deaths, unavailability of contraceptive, unwanted pregnancies) should all decrease
- Track hospitals that need emergency deliveries the most, and develop “heat map” to route drones
- Prove “cold chain” has expanded = 100% of hospitals

Voice of Customers

- On time delivery of medicine to hospital
- Avoid stock out of necessary items
- Reduce liability of hospitals
- Sustainability of program

Benefits

- Reduce high death rates associated with Malaria
- Reduce high occurrences of unwanted pregnancies
- Improve reliability of transport
- Reduce transit times
- Reduce spoilage of essential medications due to overstocking (and its associated costs)
- Expand cold-chain capabilities with JIT delivery services

Logenix International

LMI

USAID
FROM THE AMERICAN PEOPLE

JSI

CHEMONICS

MEBS GLOBAL

LLamasoft
Supply Chain By Design

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WILLIAM DAVIDSON INSTITUTE
AT THE UNIVERSITY OF MICHIGAN

Global health Supply Chains. Dakar
Senegal 2015

Q&A