For office use only	Team Control Number	For office use only
T1 ________________	**1920592**	F1 ________________
T2 ________________		F2 ________________
T3 ________________	Problem Chosen	F3 ________________
T4 ________________	**B**	F4 ________________

2019

MCM/ICM

Summary Sheet

Developing an Aerial Disaster Relief Response System

NGO's wanted to design a drone aerial disaster relief system to complete medical supplies and video reconnaissance missions. The following is our team's proposal after analysis and modeling.

Firstly， based on the data given, we found out the route range that the drone can receive signals, and calculated the road distance between various hospitals within the route range. According to the performance of the drone, we could screen out the available aircraft types.

Secondly, based on the Medical Package demand and the data processing, we calculate the number of Emergency Medical Packages that can be provided by specific hospitals in two types of Drone Cargo Bay through the establishment of 3D container model, to determine the type of unmanned units needed in the unmanned units and the need for two ISO containers.

Thirdly, considering that the ISO container utilization has reached its maximum, we also use 3 d container method to give the optimal drone. Consider the ISO Container best road distance from the hospital, which can reach the Medical Package material can meet the demand of a local hospital more than 32 days of drugs. The corresponding route and schedule are given.

Finally, the sensitivity analysis of our models is done for the case that only one ISO container no units are selected, using the same model and method to design the ISO container, and then comparing it to the delivery of our Medical Package using two ISO containers, we found that the number of Medical Package for an ISO container predominate. In the case of two ISO containers we designed, using an ISO container requires three times longer, it shows that our solution is better from the timeliness of rescue

Key words: Date processing、3Dcontainer model、shortest path、Drone Cargo Bay

Contents

1 Introduction

1.1 Background

The worst hurricane to ever hit the United States territory of Puerto Rico left the island with severe damage and caused over 2900 fatalities in 2017. The combined destructive power of the hurricane's storm surge and wave action produced extensive damage to buildings, homes, and roads, particularly along the east and southeast coast of Puerto Rico. The storm, with its fierce winds and heavy rain, knocked down 80 percent of Puerto Rico's utility poles and all transmission lines, resulting in loss of power to essentially all of the island's 3.4 million residents. Widespread flooding blocked and damaged many highways and roads across the island, making it nearly impossible for emergency services ground vehicles to plan and navigate their routes. The full extent of the damage in Puerto Rico remained unclear for some time; dozens of areas were isolated and without communication. Demands for medical supplies, lifesaving equipment, and treatment strained health-care clinics, hospital emergency rooms, and non-governmental organizations'(NGOs) relief operations. Demand for medical care continued to surge for some time as the chronically ill turned to hospitals and temporary shelters for care.

1.2 Our Work

The problem needs us to construct a mathematical model to consider for possible use in designing its Dronego fleet and the Selected drones should be able to perform these two missions medical supply delivery and video reconnaissance simultaneously or separately, depending on relief conditions and scheduling.

To start with, we will establish and provide the best drone fleet based on the distance between the highways of Puerto Rico hospitals, the number of medical kits that can be installed in different types of drone cabins, and the performance of the drones themselves. Then use the 3D container algorithm to design a reasonable ISO container packaging configuration plan. In addition, we need to design reasonable drone routes and schedules according to the performance of the drone, the distance between the roads, the number of Medical package and the rescue time. Additionally, we need to Sensitivity analysis is performed on the optimal solution determined by ourselves. To this end, we will implement the following scheme. Finally, the memo for the CEO of HELP, Inc.

Through the above analysis, the flow chart of this paper is shown in Figure as follows

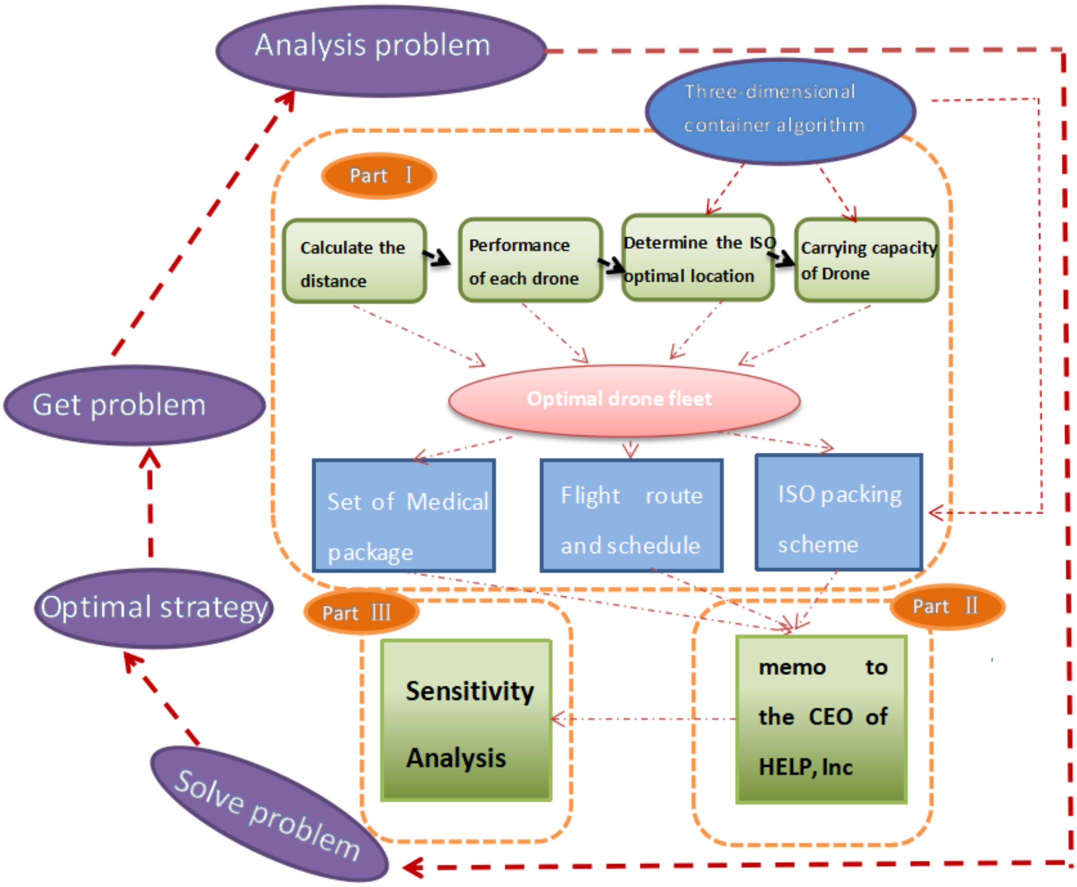

Figure 1 The Flow Chart in This Paper

2 General Assumptions

We make the following assumptions in this paper：

- It is assumed that when put the Drone into ISO Container and put the Medical Packages into Drone Cargo Bay can rotate it
- We consider that the maximum distance a drone can fly is its speed multiplied by the time it can fly
- We assume that the bearing capacity of H tethered drone is at least two drones, that is, more than two drone can be tethered

3 Symbol Descriptions

In this paper the symbols we define to construct the models are as follows.

Symbol	Description
$V_i(A_i, B_i, C_i)$	The loading solid at step I
$V_{(i)}(A_i, B_i, C_i)$	The space formed by the remaining i-k loading cubes of the DCB in step i
$L_i(l_{i1}, l_{i2}, \ldots, l_{in})$	The total number of 3 types of MP are placed into DC loading
$V_j(a_i, b_i, c_i)$	The volume of the j Medical Package

4 Model Construction

In this section, we process data such as drones that can receive signals, drone flight distances, and road distances in various regions., After that, we developed a model 3D container for calculating the number of drone packs available for different cabin types. Then, based on above, after selecting the type of drone, determine the number of drones based on the performance of the drone and the distance between the locations, and finally determine the best drone fleet, route and schedule.

4.1Data Processing

Directionless beacon (NDB) stations and airport surveillance radars, as part of the navigation system, guide aircraft to the runway plane but do not provide guidance in the direction of altitude. Therefore, here we don't consider NDB of routes and to determine the influence of location, and only consider VORTAC BORINQUEN, VOR DME MAYAGUEZ and TACAN - NDB ROOSEVELT ROADS for airlines and determine the influence of position, and because when segment of the distance between two omnidirectional beacon within 50 miles (92.6 kilometers), the route of the basic width of the center line on each side 4 miles (7.4 kilometers);When the range is more than 50 nautical miles, it is calculated according to the accuracy provided by the navigation facilities to maintain the flight path of the aircraft, and the width is usually 20KM.The route can maintain air traffic order, improve space utilization and ensure flight safety.

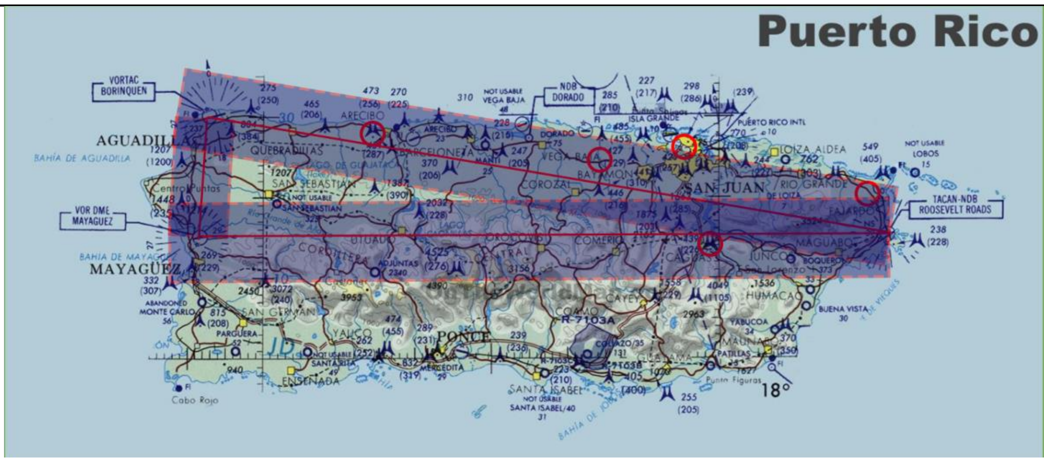

Figure 2 Drone can receive signal range

We are looking for a suitable route within this range. The scope of the voyage is shown on below Figure. According to Figure, you can find the roads in these ranges, and then calculate the road distance (km) of each hospital according to the map scale. The figure below is an abstract figure.

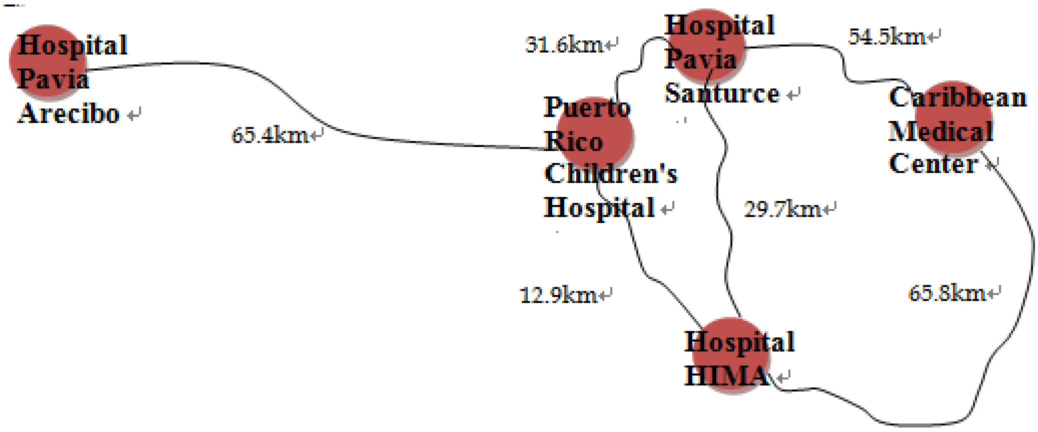

Figure 3 Distance map of hospital highway

And according to the requirements in the hypothesis, we know that the maximum operating distance of different types of drones is as follows

Drone type	Farthest flight distance (km)	Drone type	Farthest flight distance (km)
A	23.3	E	15.0
B	52.6	F	31.6
C	37.3	G	17.0
D	18.0	H	/

Table 1 The farthest flight distance of different drones

Based on the road distances of the various hospitals in Figure 3 and the performance of the different types of drones in Table 3, you can screen out some of the aircraft types for drone flight performance and determine if a H-type drone is required.

4.2 DroneGo Fleet Design

The type of drone is selected by considering the performance of the drone that needs to be selected through the ISO position.Consider the number of drone of a certain type by the space utilization of ISO. After completing the first road investigation and Medical Package delivery, in the larger ISO space, the second standard for selecting drones to reach the maximum number of medical kits that can be delivered to local hospitals

4.2.1 Three-dimensional container model

According to the distance between various locations and the performance analysis of 8 different types of aircraft, and the demand for the Drone Cargo Bay Packing Type corresponding to the required medical bags mentioned above, by using the three-dimensional container algorithm, as shown in Figure below.

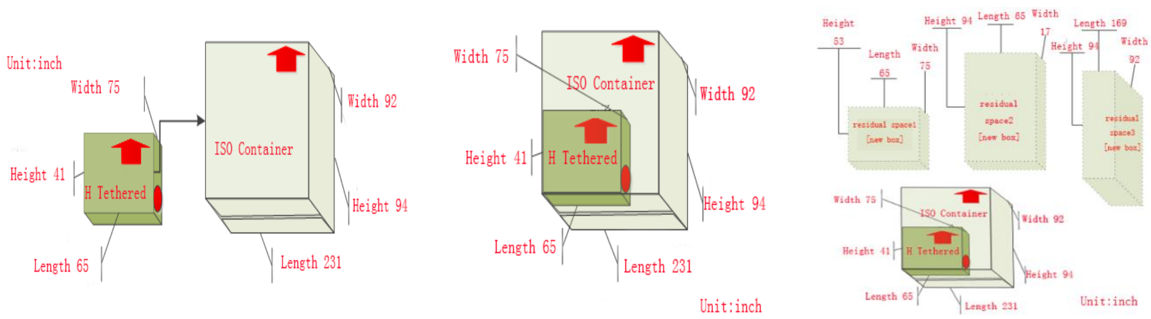

Figure 4 Three-dimensional container algorithm

For the 3D container packing problem, a multi-step decision model can be established by using the layered idea, and the face-to-face discriminant matrix is used to transform the 3D boxing problem into a 2D packing problem or a 1D packing problem to obtain a model solving algorithm.

Box Type	Length (in.)	Width (in.)	Height (in.)	Weight (lbs.)
MED 1	14	7	5	2
MED 2	5	8	5	2
MED 3	12	7	4	3
Drone Cargo Bay 1*	8	10	14	≤ 11
Drone Cargo Bay 2*	24	20	20	≤ 22

- The ability of each MED to withstand stress is not considered here.
- Here the weight of the Drone Cargo Bay is the equivalent of the number of pounds the cargo can withstand.

It is known that the MED cannot be divided and squeezed. It is noted that the actual loading of the container is from the inside to the outside and from the bottom up. The best container loading container operation procedures are three types of loading: one is with the container. The parallel plane of the box door is loaded on the left and right sides of the container, that it's the 'yoz' surface layer placed; the plane parallel to the ground is loaded in the left and right front of the container, that it's the 'xoy' surface layer method; and the third is along the plane parallel to the side of the container. Loading in the front, back, and bottom of the container, that is, loading on the 'zox' surface. In this way, the container can be decomposed into several three-dimensional layers, and the three-dimensional layer is loaded. Each layer loads several containers in a loading manner, and the container utilization rate is the largest.

$V_{\mathrm{i}}(A_{\mathrm{i}}, B_{\mathrm{i}}, C_{\mathrm{i}}) = V_{(\mathrm{i}-1)}(A_{(\mathrm{i}-1)}, B_{(\mathrm{i}-1)}, C_{(\mathrm{i}-1)}) - V_{(\mathrm{i})}(A_{\mathrm{i}}, B_{\mathrm{i}}, C_{\mathrm{i}}),\ \mathrm{i} = 1,2,\ldots,\ \mathrm{k}$

Set $V_{(0)}(A_{(0)}, B_{(0)}, C_{(0)}) = V(A, B, C)$

Edge matrix discrimination

$$\mathrm{r}(F_{\mathrm{ij}}) = \begin{pmatrix} \mathrm{r}(A_{\mathrm{i}-1})/\mathrm{a}_{\mathrm{j}} & \mathrm{r}(A_{\mathrm{i}-1})/\mathrm{b}_{\mathrm{j}} & \mathrm{r}(A_{\mathrm{i}-1})/\mathrm{c}_{\mathrm{j}} \\ \mathrm{r}(B_{\mathrm{i}-1})/\mathrm{a}_{\mathrm{j}} & \mathrm{r}(B_{\mathrm{i}-1})/\mathrm{b}_{\mathrm{j}} & \mathrm{r}(B_{\mathrm{i}-1})/\mathrm{c}_{\mathrm{j}} \\ \mathrm{r}(C_{\mathrm{i}-1})/\mathrm{a}_{\mathrm{j}} & \mathrm{r}(C_{\mathrm{i}-1})/\mathrm{b}_{\mathrm{j}} & \mathrm{r}(C_{\mathrm{i}-1})/\mathrm{c}_{\mathrm{j}} \end{pmatrix}$$

Establish a multi-step decision local optimization model, which divides the container loading process into k steps. The i-th step is to determine the layer $V_{\mathrm{i}}(A_{\mathrm{i}}, B_{\mathrm{i}}, C_{\mathrm{i}})$ from the loadable solid $V_{(\mathrm{i-1})}(A_{(\mathrm{i}-1)}, B_{(\mathrm{i-1})}, C_{(\mathrm{i-1})})$ of the container.
The layer is most utilized after being placed in a coordinate plane:

If #MED j cannot be inverted, it is specified as

$$\begin{pmatrix} \mathrm{r}(A_{\mathrm{i}-1})/\mathrm{a}_{\mathrm{j}} & \mathrm{r}(A_{\mathrm{i}-1})/\mathrm{b}_{\mathrm{j}} & 1 \\ \mathrm{r}(B_{\mathrm{i}-1})/\mathrm{a}_{\mathrm{j}} & \mathrm{r}(B_{\mathrm{i}-1})/\mathrm{b}_{\mathrm{j}} & 1 \\ 1 & 1 & \mathrm{r}(C_{\mathrm{i}-1})/\mathrm{c}_{\mathrm{j}} \end{pmatrix}$$

Set $r(x) = x - [x]$, $[\mathrm{x}]$ Indicates that x is rounded up, The fractional part of $0 \le r(x) \le 1$, Use (1) to indicate the next step when selecting a certain step #MED j (j=1,2, ..., n) Edge matrix discrimination

$$\max_{V_i, L_{(4)}} \eta_i = \frac{\sum_{j=1}^{n} l_{ij} v_j}{V_i} \times 100\%, \quad i = 1\ldots, \quad k$$

Restrictions:

$$\sum_{j=1}^{n}\sum_{h=1}^{i} l_{hj} g_j \le G, \quad l_{ij} \ge G, \quad i = 1\ldots, \quad k, \quad j = 1,2,\ldots, \quad n$$

Where：

i Represents the steps of allocation

G The allowable weight of Drone Cargo Bay

g The weight of Medical Package

$V_i(A_i, B_i, C_i)$ The loading solid at step i

$V_{(i)}(A_i, B_i, C_i)$ The space formed by the remaining i-k loading cubes of the DCB in step i， called step i+1 of the loadable solid （k is the total number of steps in the Drone Cargo loading process）

$L_i(l_{i1}, l_{i2}, \ldots, l_{in})$ The total number of 3 types of MP are placed into DC loading

$v(a_i, b_i, c_i)$ The volume of the j Medical Package

Solve how to place the container in order to maximize the utilization of the shipping container

Drone Cargo Bay 1*

$V_{(0)} = (8,10,14), L_0 = (0,0,0)$

Since this type of drone is only responsible for meeting the medicine needs of Fajardo, San Juan and Arecibo, it is only considering the combined packing of #MED 1 and #MED 3, #MED 1 and #MED 2: It is possible to invert the #MED 1, #MED 2, and #MED 3 by the (1) matrix. And (1) find that for #MED 1, #MED 2, #MED 3, the smallest element that is not all rows is the same as the smallest element of the column, but can be determined from the third edge length,
so place #MED 1 first here.
$V_{(1)} = (14,7,5)$ can be converted to $V_{(1)} = (7,5,14)$ along the ‘yoz’ surface layer #MED 1 can be placed 2
$V_{(1)} = (1,2,0)$, $L_1 = (0,0,2,0)$

Not satisfied here:

$$1 \ge \min_{1\le j\le 3}\{a_j, b_j, c_j\}, 2 \ge \min_{1\le j\le 3}\{a_j, b_j, c_j\}, ,0 \ge \min_{1\le j\le 3}\{a_j, b_j, c_j\}$$

However, the length, width and height of #MED 2 are all smaller than the #MED 1's, so the packaging equipment of #MED2 and #MED 1 has reached the maximum, only one, too.
The same reason
#MED2 and #MED 1 packaged equipment has reached the maximum, there is only one.
Finally, it can be found that if the selected drone type is with Drone Cargo Bay 1*, then if the drone corresponds to the medical package demand of a specific hospital, the medical package configuration scheme can be known.

Drone Cargo Bay 2*
$V_{(0)} = (24,20,20), L_0 = (0,0,0)$

Since this type of drone only needs to be responsible for the drug needs of Jajardo, San Pablo, San Juan, Bayamon and Arecibo, it is only considered #MED 1 and #MED 3, #MED 1 and #MED 2 and #MED 3, #MED 1 and #MED 2 combined packing situation
It is possible to invert the #MED 1, #MED 2, and #MED 3 by the (1) matrix. And (1) find that for #MED 1, #MED 2, #MED 3, the smallest element that is not all rows is the same as the smallest element of the column, but can be determined from the third edge length.
With the method of Drone Cargo Bay 1*, you can get the best configuration method for the medical package in Drone Cargo Bay 2*.

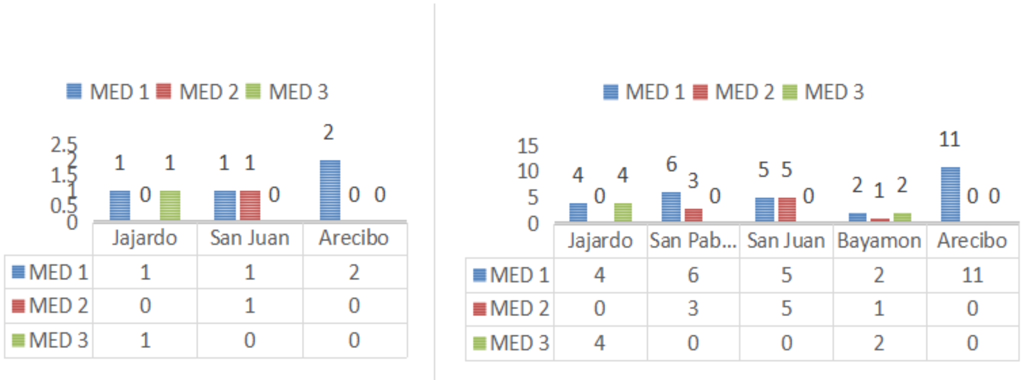

Figure 5 Drone Cargo Bay Optimum allocation method

After using this model to determine the optimal configuration method of different types of drone Cargo Bay drones, the drone fleet can be further determined according to the distance weight of each hospital and the flight performance of the drone. At the same time, this model also helps to solve the problem of loading the drones into the ISO container.

4.2.2 ISO Container Allocation And Location

The loading problem of the drone into the ISO Container is based on the daily hospital demand for the specific medical package, so that the medical package can be transported as much as possible while completing the road survey and drug delivery within one day. The distance between the various roads shown in Figure 3 and the optimal performance of the different drones in Table 1. To find the optimal drone fleet, the distance conditions must be considered, because the optimal performance of each drone has been Knowing that an ISO container can only be placed in one location, we are here to consider the maximum performance of the drone, and consider the drone fleet to start at the same time, as soon as possible to reduce the rescue time to ensure the timeliness of air rescue.

According to the distance of the roads at various locations in Figure 2, since the drones have to complete the road survey in addition to the medical packages, we consider that the drones must fly along the road direction when the first time the materials are delivered, but the best performance. The flight distance of the drone is only 52.6km. Obviously, in some areas, a drone cannot complete the task of transporting materials. This requires a group of unmanned units to complete the distribution of medical packages in individual areas, and the front loading The box model knows that not all types of drones can be randomly assigned, and the ability of a particular hospital medical package that can carry the drones of different types of drone cabins is solely responsible. Details are as follows:

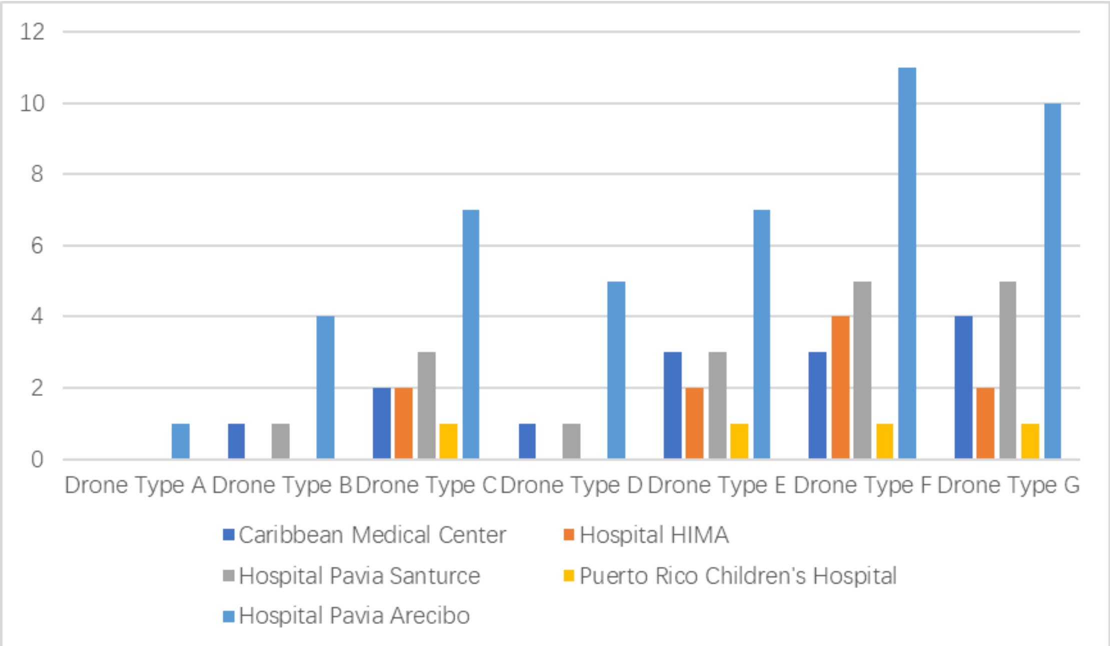

Figure 6 Hospital and drone pairing

Therefore, considering the above considerations, since the ISO container is shipped and sent to the bay, we decided to put two ISO containers on the signal-covered coastline, divide the five cities into two parts, and use the shortest path method. Find the optimal distance between the two parts, that is, the sum of the distances from the point to the part is the minimum

$$\min \sum_{i}^{n} X_i$$

Where

X_n is the road distance between the two locations

i is one of the routes (i=1, 2...n)

The locations of the two ISO containers point are:

Figure 7 ISO Container Location

After determining the location of the two ISO containers, in order to ensure that the drone can complete the mission, and use the drone as little as possible and reduce the flight time to deliver the medical packages as soon as possible, it is preferred to have a higher speed and flight range. The drone B, while selecting the drone C with the ability to load the Cargo bay 2 in order to meet the delivery task, the results of the aircraft when the drone can reach the number of daily basic medical packages in the hospital are as follows:

Figure 8 Basic drone configuration to complete the task

In the case of selecting a drone fleet to complete the mission, consider selecting a two-outer drone to increase the space occupancy of the ISO container and increase the number of distribution medical packages (if necessary, reduce the frequency of use of the DroneGo system) Due to the different loading capacity of Cargo bay 1 and Cargo bay 2, the following configurations were selected considering the type of drone, maximum effective load, box size and flight performance characteristics: (except for Hospital Pavia Santurce and Hospital Pavia Arecibo) In addition to man-machine F delivery, other hospitals can use the smallest drone E to deliver)

Restrictions:

$$\begin{cases} 4x = y \\ x + y \le a \end{cases}$$

Use the linear programming to find the maximum minimum value, which is the maximum number of days the hospital can sustain after completing the task.

$$\begin{cases} 1+3x = k_1 \\ 2+3x = k_2 \\ 1+4y = k_3 \\ 1+x = k_4 \\ 2+11y = k_5 \end{cases}$$

(See Appendix for the minimum number of drones required to maintain n days)

Where:

x the number of drones E
y the number of drone F
a ISO extra space
k_i The maximum number of days that a health care package received by each hospital can be maintained

According to the above: Three-dimensional container algorithm

$$V_0 = (231,92,94), L_0 = (0,0,0)$$

Since the two ISO containers are placed in different locations, the number of drones installed in each container and the number of H required are different. According to different aircraft types, the equipment is different, as shown in Figure 5, so this There are two different container allocation options, as image shown:

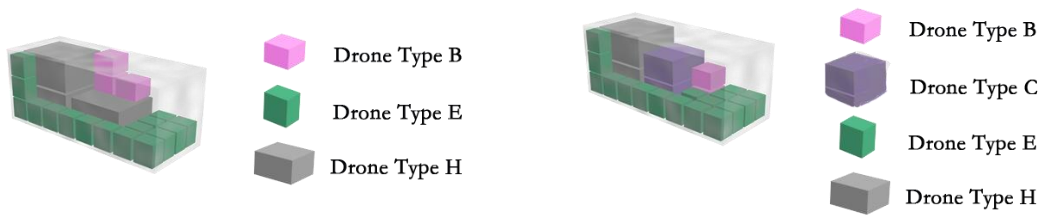

Figure 9 ISO Container packing scheme

ISO Best packing plan

ISO Ⅰ	3H	3B	25E	5F	/
ISO Ⅱ	2H	2B	31E	6F	2C

Optimal drone combination and set of Medical Package:

Type	5B	2C	56E	8F	5H	Total
MED1	8	7	152	0	0	167
MED2	2	3	31	73	0	109
MED3	4	2	122	73	0	201

4.2.3 Drone routes and schedules

In the data processing, the drone selection strategy has been formulated: the drone with the fastest flight speed can be selected within the range of the flight distance, so as to achieve the purpose of transporting the medical kit to each hospital as soon as possible. Therefore, under the premise that the route detection is the basic requirement, the sum of the flight path distances of the drones of the entire rescue system must be sufficiently small.

In addition, because we can consider the advantages and disadvantages of the rescue system from the number of medical packages that can be transported by one shipping container, and the number of days that the medical packages provided by the two shipping containers of drones are consistent for each hospital, we must not only let the shipping containers When the plane is full, it is necessary to properly allocate the types and quantities of drones in the two transport containers.

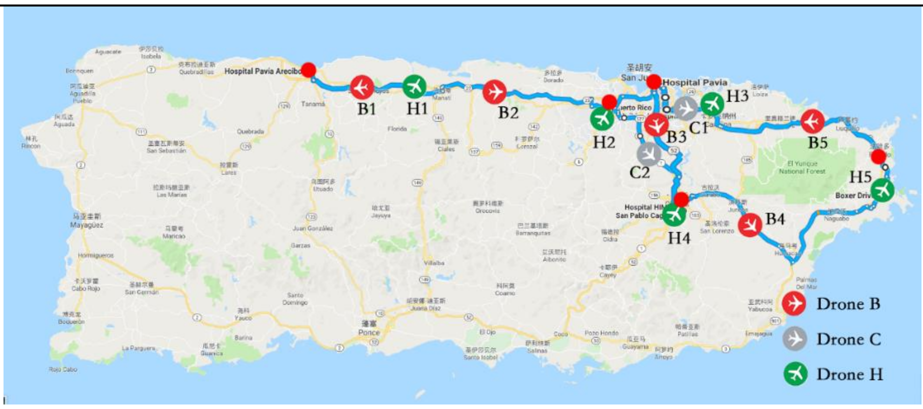

Figure 10 optimal Drone routes

First, since the drone fleet started flying on the main road, the round-trip process from the bay location to the main road was achieved by H Drone. In addition, if there is a group of drone fleets in the day to detect the main roads, other batches of drone fleets do not have to have video capture capabilities (this means that the first batch of F Drone can be used to transport the medical packages separately). Also, the drone's power is limited.

After considering the drone's fastest delivery of the medical kit to the hospital, it is also necessary to consider whether the drone can return to the location of H Drone and return to the container. Finally, adhering to the basic principle of delivering materials to the hospital as quickly as possible, we use the formula of the shortest path to calculate the approximate location where H Drone will carry the drone fleet to the main road, and then use software optimization to determine the specific location.

The first-time fleet	*The starting point*	*destination*	*Time1 (min)*	*The place of return*	*Time 2(min)*
Line 1 (B1)	H1	City 1	10.02	H3	40
Line 2 (B2)	H2	/	/	H1	40
Line 3 (B3)	H3	City 3	11.46	H2	34.02
Line 4	H4	City 3	0	H3	26.25
(C1+C2)	H4	H2(city 2)	29.63	H2	26.63
Line 5	H5	H4(city 4)	37.67	H4	37.67
(B4+B5)	H5	City 5	19.97	H5	39.94

In the future batches fleet	*The starting point*	*destination*	*Time1 (min)*	*The place of return*	*Time 2(min)*
Line 1 (10*E)	ISO shipping container 1	City 1	3.12	H1	14.52
Line 2 (15*E)	H2(city 2)	City 2	0	City2	0
Line 3 (5*F)	H3	City 3	11.46	H3	22.92
Line 4 (3*F)	H4	City 3	9.79	H4	19.59
Line 5 (31*E)	H4(city 4)	City 4	0	City4	0
Line 5 (3*F)	H5	City 4	12.00	H5	24.00

Table 2 Delivery Routes and Schedule

Where:
Time 1 How long to get to the destination
Time 2 How long to get to the place of return
City 1 Caribbean Medical Center, Fajardo
City 2 Hospital HIMA, San Pablo
City 3 Hospital Pavia Santurce, San Juan
City 4 Puerto Rico Children's Hospital, Bayamon
City 5 Hospital Pavia Arecibo, Arecibo

5 Sensitivity Analysis

In order to verify the optimality of the model, we designed a model with only one ISO container. The packing situation is:
(image)
Found that the medical kit it transported was enough for 18 days in the local hospital.
Compared to two ISO containers, the medical kit is enough for 32 days.
There is a certain advantage in the number of medical kits shipped, but since there is only one ISO container, there is only one starting point. After the calculation, the rescue time is three times more, so our model is optimized in terms of rescue time.6 Advantages and Disadvantages

6.1 Advantages

Objectively analyzed, the core advantages of our models are:

- The three-dimensional graph well presents the allocation problem in the concrete space.
- Establish 3d container model to solve the problem.
- we consider the natural disaster the continuity of time, the supply of Medical Package is not only meet the dosage of the day, the selection of drone fleet but also consider the natural disaster cases without charging power supply for drone, the optimal configuration.
- Taking into consideration the urgency of time, the choice of method is a few drones set out at the same time, the method of second rescue as the main target, a series of drones, after a reconnaissance mission, some drones can use their own capacity to achieve the effect of the delivery of the goods as soon as possible.
- Route designing not only considers the drone, but also consider the flight of drone, both the departure point, also has the recovery in drone after the electricity consumption basis points, reasonable route design.

6.2 Disadvantages

- In timetable for sending goods routes and formulate ignored the drone to the ground when the unloading time.
- Setting model in the process, the optimal location of the coastline of the selection of the approximate as a straight line, this to a certain extent, affected the ISO container location selection.
- We extended the flight working time of the H-type drone needed in the course making, which affected the course design to some extent.
- In the process of selecting the best model, we consider the factor is the number of Medical Package, delivery time, space utilization, etc., there are no factors into consideration, such as elevation, altitude, etc.

7 Conclusion

From the analysis of the models we proposed, the requirements of the best drone can be clearly determined by the distance between the local hospitals, the performance of the drone, and the type of drone cabin. However, in order to achieve the purpose of completing the rescue, we will prefer to use the rescue time to select the best drone fleet. Therefore, first of all, we will first find the distance between the roads of the hospital in the range where the drone can receive the signal, and compare it with the farthest distance of each type of drone, and select the possible team. The drone fleet then uses the three-dimensional container model to carry out the assembly configuration of the medical kits for different types of drone cabins. Because of the different performances of different types of aircraft cabins, the drone fleet can be screened. In addition, in order to achieve the possible use of ISO container space, we consider to deliver as many medical packages as possible while meeting the daily medical package requirements of each hospital, so we have established the final no The drone fleet designed a reasonable route with the shortest rescue time, including the recycling process of the drone. In order to verify the optimality of the model, we designed a model with only one ISO container. The result is that an ISO container transports the medical package better than the two ISO containers, but the time is better. Too long to get the best of the two ISO containers we designed, and finally gave a one-page memo.

8 Part Ⅱ

8.1Memo

To: CEO of Help,Inc.
From: Team B 1920592
Subject: Shortest Path
Data: January 28, 2019

In this paper, we propose a complete process for handling the problems of developing an efficient emergency rescue system. Therefore, the best emergency rescue system and the delivery routes as well as schedule can be put forward based on the previous result by analyzing and modeling. And the specific process and result are as follows.

According to searching, selecting needed data and geographical environment, in order to deliver medical kits fast and meet the needs of many days there, we not only have to find container stops that meet the smallest distance from each hospital but also try to fill the containers with drones which are efficient for rescuing.

Based on the above analysis by using shortest path model and three-pack model, not only that the best shipping containers stops and the delivery routes and schedule are successfully predicted, types and number of drones and choice of packing are determined, too.

The recommend goals for the emergency rescue system as follows:
a) No waste of resources and a great deal to meet the needs of the disaster area, we choose two shipping containers to transport drones and medical

packages.

b) Try to optimize the curve of the bay to improve the accuracy of the best place to calculate.
c) In order to make the space ratio of the container higher, choose a drone with a small size but excellence flight performance.
d) In the pursuit of maximizing space utilization, we must balance the number of medical packages transported by drones in two shipping containers.
e) In addition to using the three-packing model to solve the problem of shipping container loading in the drone, it is also necessary to make the cargo bay reasonably loaded with the medical packages.

9 Reference

[1]Convention on International Civil Aviation
[2]https://blog.csdn.net/chun0/article/details/51837191
[3]http://www.docin.com/p-1668299486.html
[4]https://www.taodocs.com/p-55477284.html
[5]https://jingyan.baidu.com/album/948f5924f90f4ad80ff5f9c9.html?picindex=5
[6]https://www.cnblogs.com/hxsyl/p/3270401.html

10 Appendix

```
a= [1 2 1 1 2];
b= [3 2 3 1 11];
c=zeros (40,5);

for d=1:70
    c (d+1, :)=c (d, :);
    for i=1:5
        if a(i)<d
            a(i)=a(i)+b(i);
            c (d+1, i) =c (d+1, i)+1;
        end
    end
end
```

```
pts = [
    18.33 -65.65;
```

```
    18.22 -66.03;
    18.44 -66.07;
    18.40 -66.16;
    18.47 -66.73
    ];

[LA1, LA2] =meshgrid(pts :2));
[LO1, LO2] =meshgrid(pts :1));

R = distance (LA1, LO1, LA2, LO2, almanac('earth','wgs84'));

num2str(R,'%10.2f')
```

1	0	1	1	0
1	1	1	2	1
1	1	1	3	1
2	2	2	4	1
2	2	2	5	1
2	3	2	6	1
3	3	3	7	1
3	4	3	8	1
3	4	3	9	1
4	5	4	10	1
4	5	4	11	1
4	6	4	12	1
5	6	5	13	2
5	7	5	14	2
5	7	5	15	2
6	8	6	16	2
6	8	6	17	2
6	9	6	18	2
7	9	7	19	2
7	10	7	20	2
7	10	7	21	2
8	11	8	22	2
8	11	8	23	2
8	12	8	24	3
9	12	9	25	3
9	13	9	26	3
9	13	9	27	3
10	14	10	28	3
10	14	10	29	3
10	15	10	30	3

11	15	11	31	3
11	16	11	32	3
11	16	11	33	3
12	17	12	34	3
12	17	12	35	4
12	18	12	36	4
13	18	13	37	4
13	19	13	38	4
13	19	13	39	4
14	20	14	40	4