Problem Chosen	2021 MCM/ICM Summary Sheet	Team Control Number
MCM Problem A		2125756

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1 Hook

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2 Introduction

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3 Model formulation

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3.1 Assumptions

- Scheduling
  - Only the minimum supplies required daily are delivered to delivery locations, i.e. no rotating schedules and stockpiling of supplies to avoid needing to deliver to each daily
  - Additional time for operations is not considered: no time is needed to be spent in between flights for loading supplies or recharging the drones, and no time is needed to land and deliver supplies at delivery locations
- Packing
  - Elements can be stacked in any configuration without structural limitations
- Flight path routing
  - Paths are perfectly straight
  - Every path only has either the delivery location or storage container as origin and destination
  - Paths are modeled in two dimensions i.e. no altitude changes are considered
  - Not considering effects of having multiple drones flying at once
- Environmental effects
  - Influences from wind are neglected

- The drones are assumed to be unobstructed by terrain
- The drones do not experience any malfunctions
- The earth's curve is neglected

3.2 Flight Path Sub-model

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3.3 Packing Sub-model

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3.4 Storage Location Determination

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$$L_n = \sum_{i=1}^{m} p_i(x_i, y_i) / \sum_{i=1}^{m} p_i$$

where L_n = Location number within grouping
n being number of distinct locations (1 to 3)
i = hospitals in the group
p = package demand of hospital i
x, y = longitude, latitude of hospital i
The output lists a discrete set of groupings of the hospitals with the corresponding locations of the storage containers for each hospital group. In figure 1, one potential combination of hospitals grouped to specific storage locations is shown.

3.5 Cost Function

I've copied the ten diff eqs from Numerical Prediction Model for Fungal Growth Coupled with Hygrothermal Transfer in Building Materials here:

$$\frac{\partial u}{\partial t} = \nabla \cdot (D_u \nabla u) + \theta f(u,n) - a(u,n)u - \gamma u \quad (1)$$

$$\frac{\partial v}{\partial t} = \nabla \cdot (D_v \nabla v) + a(u,n)u \quad (2)$$

$$D_u = \sigma_1 \cdot u \cdot n \quad (3)$$

$$\sigma_1 = \sigma_1(1 + \delta), -0.5 < \delta < 0.5 \quad (4)$$

$$f(u,n) = \sigma_2 \left(\frac{f_1 n}{1 + f_2 n} \right) \cdot u \cdot \zeta(T, \phi) \quad (5)$$

$$\zeta(T,\phi) = a_1 exp(a_2\phi^2 + a_3 T^2 + a_4\phi * T + a_5\phi + a_6 T + a_7) \quad (6)$$

$$a(u,n) = \sigma_3 \cdot \frac{1}{\left(1+\frac{u}{a_1}\right)\cdot\left(1+\frac{n}{a_2}\right)} \quad (7)$$

$$\frac{\partial n}{\partial t} = D_n \nabla^2 n - f(u,n) \quad (8)$$

hygrothermal equations:

$$\frac{dH}{dT}\cdot\frac{\partial T}{\partial t} = \nabla\cdot(\lambda\nabla T) + h_v\nabla\cdot(\delta_p\nabla(\phi p_{sat})) \quad (9)$$

$$\frac{dw}{d\phi}\cdot\frac{\partial \phi}{\partial t} = \nabla\cdot(D_\phi\nabla\phi + \delta_p\nabla\phi p_{sat})) \quad (10)$$

Where P represents the total medpacks delivered, $\sum t$ is an estimate of the time for all the flights to occur, and S represents the space left after packing all the drones (computed via the packing algorithm). Also, C is our cost function output, the cost. The factor of 100000 dividing S is there to adjust the units of S (it being on the order of 10^5 while $\frac{P}{\sum t}$ is on the order of 10^0) The time estimates are computed via the basic kinematic equation assuming constant speed, $\sum t = \sum \frac{d}{v_d}$ summed over all drone flights in the given plan. Here d is distance traveled in a specified flight and v_d is the max speed of the drone flying. This estimate of the time taken for a flight is assuming the drone is flying at max speed the whole way, and assuming equality of the time taken to fly to the hospital, and the time to fly back. The assumption of perfectly sequential ordering of the flights allows us to sum the times of individual flights to get the total time.

4 Results and Analysis

4.1 Model output

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4.2 Parameter sensitivity

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4.3 Limitations/ Further Work

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Figure 2: caption 1