# Simulation of Medical transports

Studying the impacts of utilizing different transportation means to transfer emergency cases in long distances

# Agenda

1. Abstract
2. Problem Statement
3. Current State vs. Future State
4. Medical Transport Simulation
5. Simulation Model & Framework
6. Simulation Variables, Indicators, Map and Dashboard
7. Simulation Challenges & Features

# Abstract

01

In 2020, there were 609 patients has been transferred from a rural city to hospitals located in different cities.

609
Patient

# Problem Statement

02

Emergency coverage is comprehensive. However, small cities lack some of health resources that are necessary for public health.

Patients, who live in small cities, need to be transferred using ambulances to larger cities.
As a result, the following issues will be raised:

Land transportation using ambulances requires medical staff to serve patients, which results in:

- Exhaustion of medical resources.
- Shortage of medical staff in hospitals when needed.

Some of the cases can not handle the time taken to be transferred using ambulances due to their serious health condition.

High average of transport duration.

# Current State vs. Future State

03

## Current Situation

- ✓ Patients are transferred from one city to another using ambulances.

## Proposed Solution

- ✓ Patients transfer from one city to another using aircrafts;
  - From sending airport to receiving airport.

- ✓ Patients transfer from one city to another using aircrafts;
  - From sending hospital to receiving airport.

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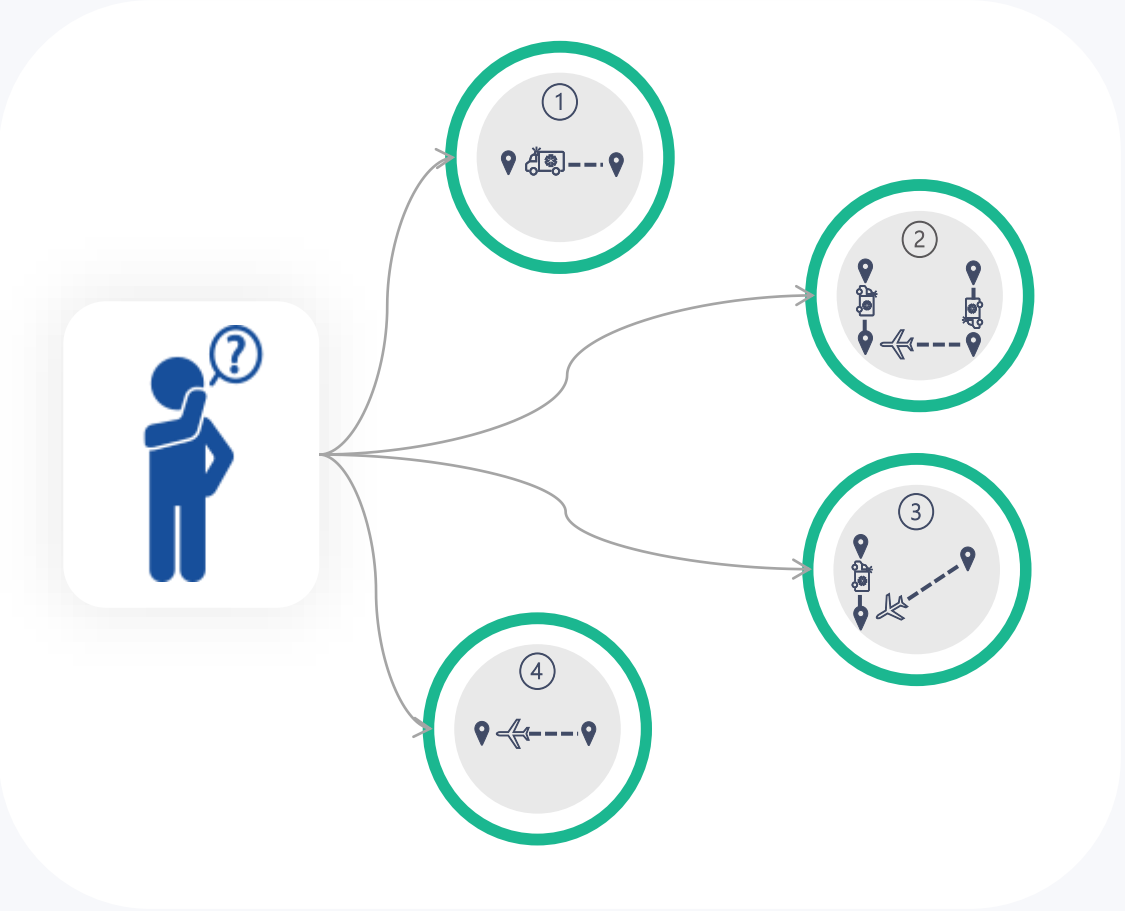
# Medical Transports Simulation



**Simulation of Medical transports** aims to help decision makers improve transferring patients by providing a set of different scenarios that defines the impact of utilizing aircrafts and ambulances in transferring patients, as well as providing them with a list of KPIs that helps in taking the right decisions regarding patient transportation.



# Simulation Model

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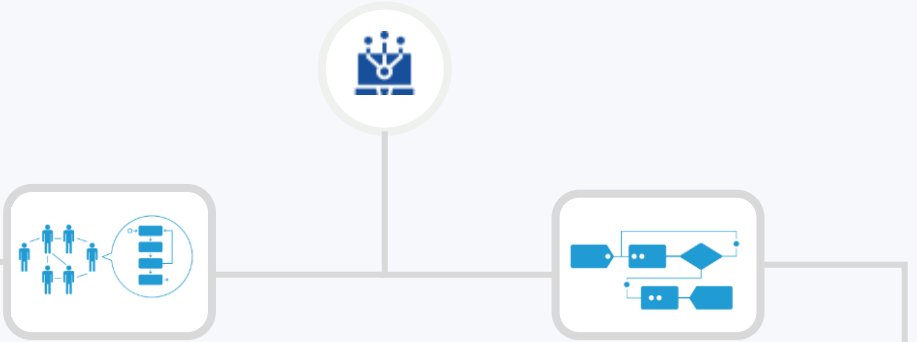
**Simulation of Medical transports** is built using two simulation paradigms (Hybrid model):



## Agent Based Modeling

List of Agents included in the model for each scenario:

- Patient agent
- Ambulance
- Aircraft
- Hospital
- Airport
- Emergency Call

## Discrete-Event

Agent movement from one point to another in the model is represented as a sequence of discrete events.

# Simulation Model

06

Each emergency call is represented as an agent in the model, this agent has some characteristics that are taken from a database containing information about the emergency case, such as patient transport date, sending hospitals, receiving hospitals, hospitals locations, etc.

As the model provides the ability to interpret four different scenarios, there are multi-agents specified for each scenario, to illustrate this with one of the scenarios, the first scenario is transferring patients from sending hospital to the receiving hospital using ambulances according to the emergency call received. For this scenario, patient and ambulance agents are created; patient agent will have a state chart that assigns available ambulances for transferring patients and when assigned, the ambulance will enter the process flow that indicates patient movement from one point to another using ambulance agent in a timely manner.

For that matter, a hypird simulation model has been developed using Agent-based and discrete event modeling paradigms.

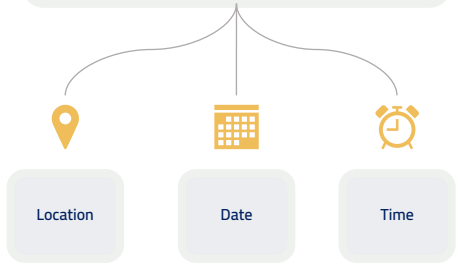
# Simulation Framework



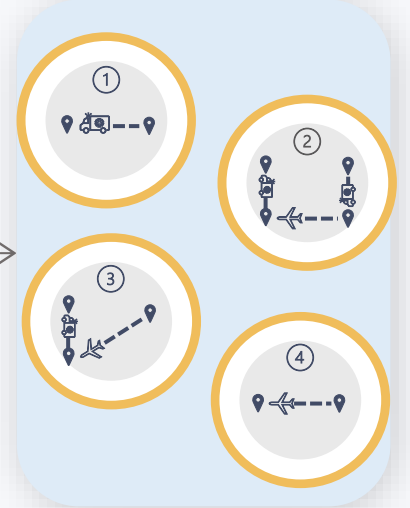
Emergency Calls Received in 2020

When model time matches patient emergency call time


An agent representing patient is created with its exact information including:




Each scenario interacts with the created agent



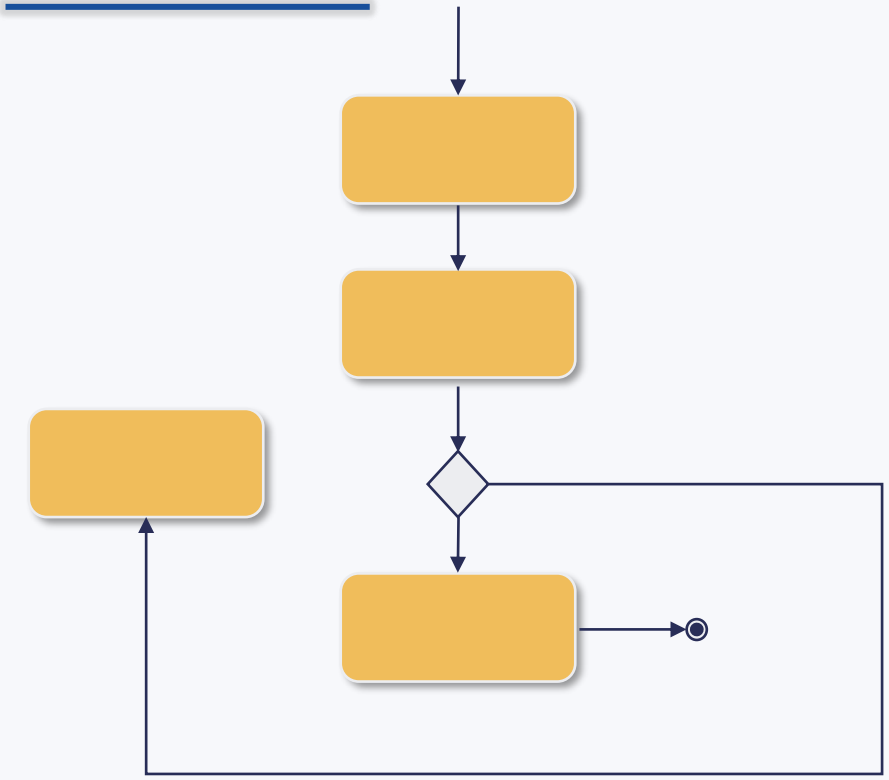

Insights & KPIs

The model contains all information about the different scenarios and transportation types such as speed and limitation of each vehicle.

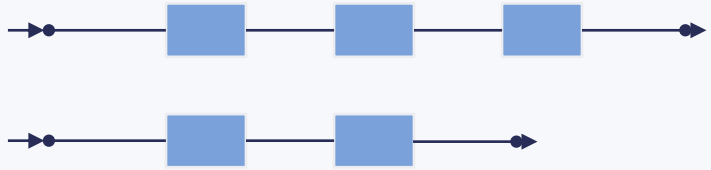
# Simulation Framework



State chart:



Process flow:



The model contains number of processes in the DES paradigm and number of resources in the ABS paradigms **for each agent**. Each resource may have different groups of predefined activities that would be executed based on a specific process request.

# Simulation Variables



Simulation adjustable variables

- Number of doctors
- Number of nurses
- Number of ambulance drivers
- Number of other health workers
- Cost of patient transportation

Other options:

- Night-flight ban
- If aircrafts are allowed to transfer patients within short distances.

# Simulation Map



The developed simulation model presents a GIS map showing patient transfer process from the sending hospital to the receiving hospital. Furthermore, it enables the user to add a medical transport to any of the four scenarios with its location either by entering it manually using longitude and latitude coordinates or by automatically by clicking once on the map.

# Simulation Indicators



The developed simulation model presents some strategic indicators,  from these indicators:

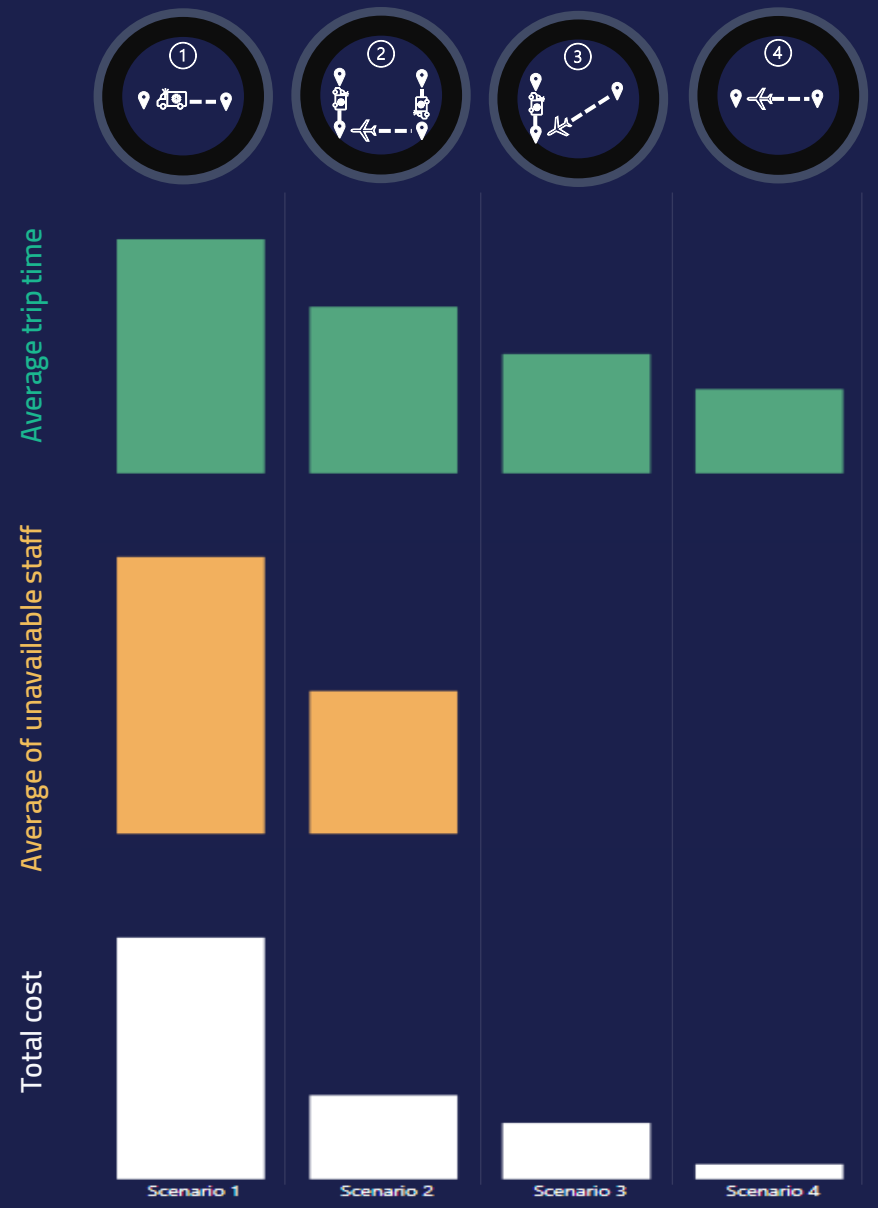
- Average of transport duration
- Number of proposed aircrafts per type
- Average of unavailable medical staff
- Impact of transferring patients (crowding and waiting time)
- Total Cost of Transportation
- Percentage of aircrafts utilization
- Number of unavailable medical staff per specialty

# Simulation Analysis



## For a hypothetical city,

Based on the provided indicators of the simulation, transferring patients using aircrafts is recommended; as it is less expensive to implement, has the lowest average of trip time, and has the lowest average of unavailable medical staff.



# Simulation Challenges



Building the model using discrete-event simulation paradigm is not sufficient for the problem to be solved, but by combining discrete-event and agent-based simulation paradigms, the model is becoming:

- ✓ Easy to scale (E.g., Input any data related to patient's emergency calls, add and modify different agents' properties)
- ✓ Flexible to add different scenarios regarding patients' transportation.
- ✓ Easy to add new resources with their specified locations (which only be performed by using agent-based)

# Simulation Features




- User-friendly interface in which decision makers can input data, run the model, analyze the results and interpret the insights in a timely manner.
- Enabling decision makers to input any patient transportation historical data and it will provide them with the expected KPIs regarding utilizing different transportation means to transfer emergency cases.
- A powerful model in which two simulation paradigms are combined to simulate model's complexity in an effective way.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