IE 479 Fall 2025 Project 2

Perishable Emergency Distribution Network Project

Due Date: December 24, 23:59

1 Introduction

This project aims to design an optimized **perishable emergency logistics network** for a national disaster-response agency responsible for distributing **temperature-sensitive relief items** during crises. These items include emergency medicines, vaccines, blood products, essential medical kits, infant nutrition, and other perishable relief supplies that must remain within strict temperature ranges.

During both normal preparedness operations and large-scale disaster events, these perishable emergency goods are produced or stored at various facilities across Turkey. After preparation at these sites, the items are transported to the nearest **Local Emergency Depot (LED)**. LEDs serve as the first nodes in the emergency supply chain, functioning as collection and sorting points where shipments from various origins are organized for further distribution.

From the LED, the products are transported to **Central Emergency Storage Hubs (CESHs)**. These hubs act as regional emergency distribution centers, consolidating shipments and enabling efficient handling of long-distance deliveries. Each LED is assigned to a specific CESH, where supplies are temporarily stored, sorted, and prepared for the next leg of their journey.

If the delivery involves another region—such as transporting supplies from unaffected zones to an impacted disaster zone—the goods are transported **between CESHs**. This stage involves direct transport from one CESH to another. At the destination CESH, products from different origins are grouped based on their final destinations. The final delivery then proceeds from the destination CESH to the LED closest to the impacted area or facility. From this local LED, the supplies are dispatched to hospitals, shelters, field clinics, or emergency distribution points, ensuring that temperature requirements are maintained throughout the journey.

The transportation process consists of three primary legs:

1. **First Leg:** The journey from the originating LED to a CESH.
2. **Second Leg:** Transport between two CESHs.
3. **Third Leg:** The journey from the destination CESH to the final LED near the relief site.

In some cases, the first and second CESHs may coincide.

In Turkey, the transportation of these emergency goods predominantly relies on ground transportation, with refrigerated trucks equipped for crisis-response conditions. The routes connecting LEDs to CESHs are called **main lines**, while those connecting two CESHs are called **express lines**. Larger refrigerated trucks are used on express lines to facilitate long-distance emergency relief transfers. The second leg of the journey is completed when the express truck arrives at its designated CESH. The first and third legs, involving transport between LEDs and CESHs, rely on main lines.

The objective of this project is to design a perishable emergency logistics network that **minimizes the travel time spent on each route**, preserving the usability of the relief supplies and ensuring rapid delivery to disaster zones.

2 Case Questions

Part 1

As explained above, the network consists of main lines and express lines. The network includes all cities of the Ege, Marmara, Akdeniz, and İç Anadolu regions (40 cities). However, because of logistical and emergency-response constraints, the CESH can be located only in **Adana, Ankara, Antalya, Bursa, Edirne, Eskişehir, Mersin, İstanbul, İzmir, Kocaeli, Konya, Muğla** (12 cities). Assume that every city in the network has one LED.

Design issues related to this network include selecting the location of CESHs and the assignment of LEDs to CESHs. Assume that there is no fleet size restriction and an express line truck is available for every CESH pair. Trucks for main lines travel at **100 km/h**. Trucks for express lines travel **1.1 times faster**. Construct a delivery network with **4 CESH** while minimizing the maximum travel time spent on one trip. (A trip refers to either the route connecting an LED to a CESH or the route between two CESHs, *not* the entire origin-to-destination path). Report the locations of these centers, their related assignments, and your objective value.

Part 2

During its journey from an LED to the assigned CESH, the delivery truck may stop at various other LEDs, which are also assigned to the same CESH, to pick up their parcels. Similarly, during its journey from the CESH to the LED, the delivery truck may stop at various other LEDs, which are also assigned to the same CESH, to deliver the parcels. There is no capacity restriction for the trucks. However, one thing to consider is the duration of these trips. Since the working hours of a driver on the main lines are between **6:00 pm and 6:00 am**, a truck operating on the main lines can work at most **12 hours**.

Locate 4 CESH as determined in Part 1. The agency wants to minimize the number of trucks needed to satisfy the demand of each LED. Each LED assigned to a CESH must be visited exactly once within the planning horizon, and each route must start and end at the same CESH while potentially visiting multiple LEDs. As in Part 1, you need to minimize the total travel duration across all routes, ensuring that the duration of every route remains within the maximum allowable main-line working time (a route may include many trips, e.g from CESH to LED, from LED to LED, from LED to CESH). Provide your results and the associated routes clearly.

Part 3

- Assume that you found X^* trucks in the previous part; however, the agency can afford only $X < X^*$ trucks. Provide a feasibility analysis describing how much more a truck driver has to work in one day.
- Assume that you found X^* trucks in the previous part; however, the agency already has $X' > X^*$ trucks. Provide an analysis describing how much the total travel distance will change (when minimized for X' trucks).

It is sufficient to provide a three-step analysis for each case.

Part 4 (Bonus)

Assume that you must determine the location and routing decisions at the same time. The objective is to construct a network such that the **longest delivery time** is as small as possible. There are **20 trucks** available on the main lines, and there is no limit on the number of trucks available for express lines. Trucks on main lines can work up to **8 hours**, and trucks on express lines cannot travel longer than **12 hours**. Other data utilized in Part 1 remain valid.

Explain how you would model the problem. What would be your results when locating 4 CESH? What are your comments? How would you compare the results with the previous parts?

Some Useful Information About the Case and Reports

1. In this project, you are provided with a **40×40 distance matrix** that contains the pairwise distances (in kilometers) between all cities in the Ege, Marmara, Akdeniz, and İç Anadolu regions. These 40 cities each contain one **Local Emergency Depot (LED)**. This matrix constitutes the primary numerical dataset used throughout the project.

   - Each entry represents the **ground distance** between two cities.
   - This distance matrix is essential for computing travel times on **main lines** and **express lines**.
   - No additional geographic or distance data is required for Parts 1–4.

2. You will be solving a **facility location and routing problem**. Specifically, you will be:

   - Selecting **4 Central Emergency Storage Hubs (CESHs)** from the 12 eligible candidate cities,
   - Assigning each of the 40 LEDs to one of these CESHs,
   - Designing routes and evaluating travel times using the provided distance matrix.

   This is a **site selection** problem (you choose among provided candidate sites), not a site generation problem.

3. When writing your mathematical formulations:

   - Clearly state all **assumptions** you adopt about the operation of the network,
   - Define all **parameters** (cities, distances, speeds, sets),
   - Define **decision variables** for hub selection, assignments, and routing,
   - Provide the full **objective function** and **constraints**,
   - Optionally include explanations describing the logic behind each constraint.

4. Include an **Executive Summary** in your report summarizing the purpose, data, and overall findings.

5. Structure the report into clearly labeled sections corresponding to the case questions.

6. You **do not need to include** code, screenshots, or solver logs unless they are essential to explaining your approach. The report should focus on modeling, reasoning, and results.

7. Submit your project as a **single ZIP file** containing:

   - Your **report (PDF)**,
   - Your **code** (if any),
   - Any additional files needed to reproduce your solution.

8. Name your ZIP and PDF files as `GroupNumber_Project2`. For example: `Group13_Project2.pdf` and `Group13_Project2.zip`.

9. If you encounter any issues or have questions, do not hesitate to contact with Egehan Uğraş and Alkım Abanuz.

Prepared for IE 479 – Facility Planning for Emergency Field Health Logistics, Fall 2025.