URBAN MOBILITY STARTUPS FOR LIVABLE CITIES

Final Presentation – Group 4

INTRODUCTION

Urban Challenges

- High emissions & pollution

- Poor air quality & health

- Weak community ties

Eindhoven: A Partial Success

- Local accessibility

- Poor inter-zone connectivity

Solution: the 15-Minute City

- All essential amenities within a 15-min walk

Our Proposal: Zero-Emission Drone Delivery of Medicine

- Lower environmental impact than most transport

- Ideal for medical distribution

- High social impact & time-critical relevance

BUSINESS CANVAS MODEL

The Buisness Model Canvas

Key Partnerships

Definition: *Who supports the business*

- *Salveo Pharma – the main supplier*
- *Pharmacies – the customers we deliver to*
- *Delivery companies - electric drones*
- *Tech companies – for apps or tracking systems*
- *City of Eindhoven – for rules and support with the 15-minute city idea*

Key Activities

Definition: *What the business does*

- *Plan delivery routes*
- *Keep track of inventory for JIT delivery*
- *Ensure following health and safety rules*
- *collect expired medicine if necessary*

Key Resources

Definition: *What is needed*

- *Planning of drone routes*
- *Regular maintenance check for drones*
- *Charging drones daily*
- *Follow medicine handling regulations*

Value Propositions

Definition: *What is it offered*

- *Fast, reliable, and safe delivery of medicines*
  - *Fast: delivery to the chosen clusters*
  - *Reliable: fixed delivery schedule (ex: every morning)*
  - *Safe: creating safety rules to follow*
- *Ensuring delivering temperature-sensitive drugs*
- *Using Just in Time delivery*
  - *avoiding waste*
  - *no stocking cost*
  - *preventing delays*

Customer Relationships

Definition: *How the business interacts*

- *Clear communication of expected delivery time, or route changes*
- *Fast problem solving by having back up drones, and get maintenance immediately*
- *eco-friendly approach by using electric drones*

Channels

Definition: *How is it delivered*

- *Drone delivery to pharmacies*
- *No delivery person, fully contactless service*
- *A system/app that pharmacies can track orders*
- *Notifications when drone arrives to the drop off point*

Customer Segments

Definition: *Who the business serves*

- *Local pharmacies in:*
  - *Vaartbroek*
  - *Nieuwe Erven*
  - *Vlokhoven*

Cost Structure

Definition: *What the business spends*

- *Electricity costs to charge the drones*
- *Buying/renting drones*
- *Drone maintenance and repairs*
- *Salaries for drone operators, tech support, and coordination team*
- *App development costs for ordering, tracking, and route planning*
- *Insurance for drones and medical goods*

Revenue Streams

Definition: *How the business earns money*

- *Subscription plans for pharmacies*
- *Pay-per-delivery option for smaller customers*
- *Extra fees for urgent deliveries or cold-chain medicine*
- *Subsidies from the government for supporting local healthcare*

FINANCIAL MODEL

REVENUE MODEL

4.2.1 Revenue Model

Source	Description	Revenue (€)
Monthly Subscriptions	€850/month × 10 pharmacies	102,000
Pay-per-Delivery Fees	€1.75 × extra deliveries	12,000
Premium Add-Ons	Cold chain, urgent/night delivery	6,000
	Total Estimated Revenue (Year 1)	**120,000**

Table 1: Estimated Revenue Streams

Source	Type	Support (€)
MIT Innovation Subsidy (RVO)	National Public Grant	15,000
EIT Urban Mobility	EU Pilot Grant	5,000–7,500
Municipality of Eindhoven	Local Innovation Fund	2,500–5,000
Private Sponsorship	Corporate/Partner Support	5,000
	Total Estimated External Support	**20,000–30,000**

Table 2: Expected Non-Recurring External Support

CAPITAL & OPERATIONAL EXPENDITURE

4.2.3 Capital Expenditure

Category	Description	Cost (€)
Drones (2 × DJI FlyCart 30)	Delivery backbone	39,470.20
Battery System (4 units)	For daily drone rotations	4,000.00
Charging Stations (3)	Smart infrastructure	39,000.00
Landing Pads	Deployment pads for pharmacies	1,500.00
IoT Connectivity	Remote tracking and telemetry	7,500.00
Software Development	Routing & delivery app backend	9,500.00
	Total CapEx	**100,970.20**

Table 3: Initial Capital Investments

4.2.4 Operational Expenditure – Year 1

Category	Description	Cost (€)
Personnel	Ops Manager, Support, Dispatcher	95,500
Tech & Infra Maintenance	Cloud, API, digital platform upkeep	7,500
Marketing & CRM	Onboarding, pharmacy campaigns	3,900
Insurance	Drone, liability, cyber-risk	4,500
Cloud Hosting	AWS/GCP services	3,500
	Total OpEx	**114,900**

Table 4: Yearly Operational Costs

CASH FLOW

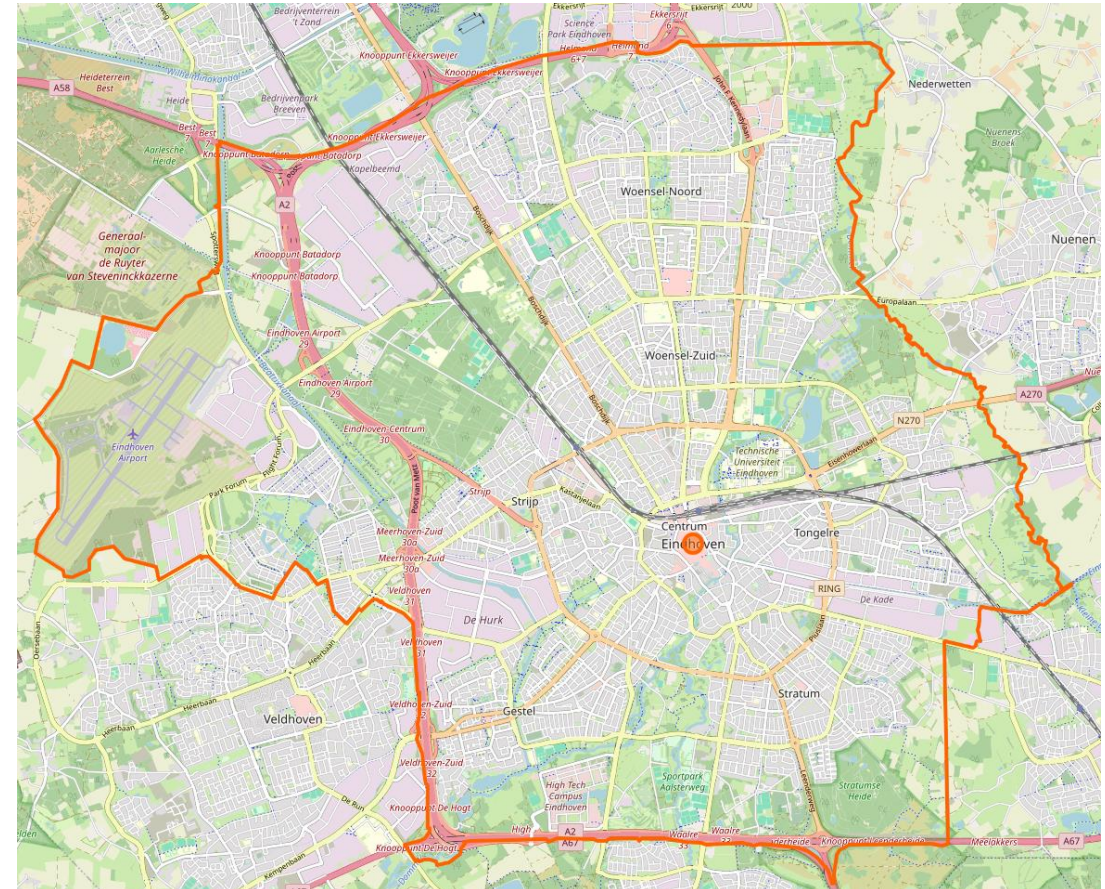| Year	Revenue (€)	OpEx (€)	Net Cash Flow (€)
0	—	—	−100,970
1	120,000	114,900	5,100
2	138,000	114,900	23,100
3	158,700	114,900	43,800

Table 5: Cash Flow Forecast for 3-Year Rollout

COLLECTING DATA

EINDHOVEN BORDERS DEFINITION

Source: OpenStreetMap

Describes the administrative borders of the city of Eindhoven.

DEFINING POIS

POIs – Points Of Interest, specifically, amenities within the administrative borders of Eindhoven

Each amenity is classified into one of seven predefined categories:

1. Education

2. Health&Wellbeing

3. Community Space

4. Food Choices

5. Nightlife

6. Active Living

7. Mobility

POIs on Eindhoven Street Network
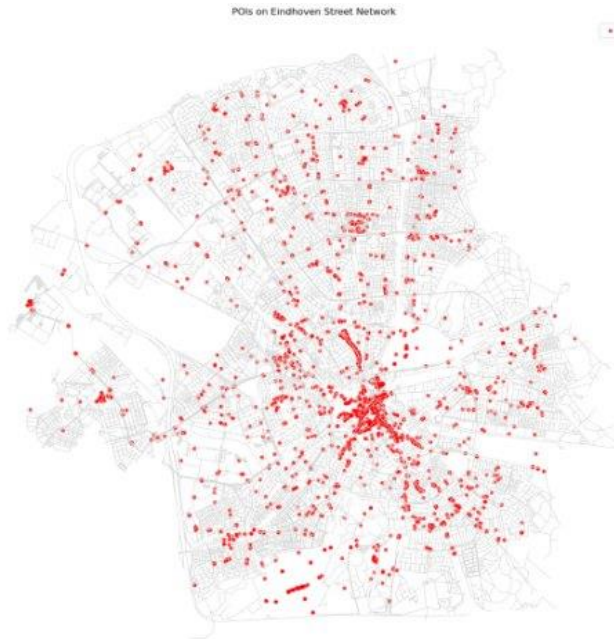
WALKABLE EINDHOVEN NETWORK

Allows us to later compute the walking distances between different amenities.

The network is based on the directed graph of Eindhoven generated with OSMnx, where:

*   **nodes** represent intersections or dead ends, and

*   **edges** represent walkable paths.

Pandana Network Visualization (Eindhoven)
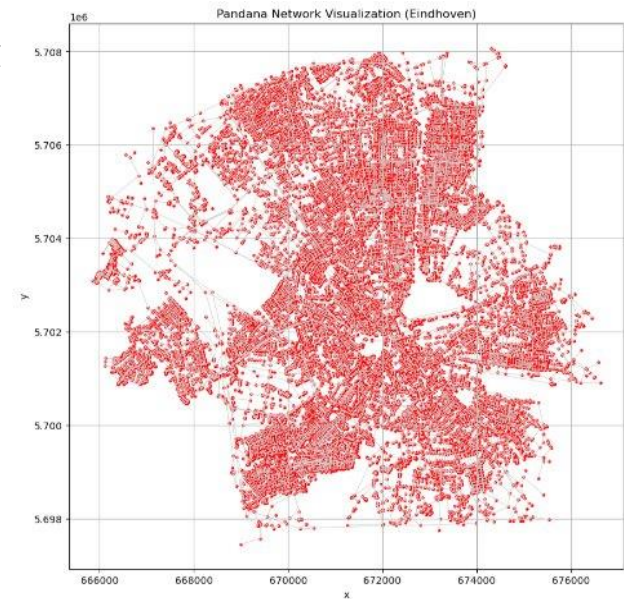
DATA PREPARATION

MAPPING AMENITIES ONTO THE NETWORK

Before clustering the amenities, the collected data had to be properly organized:

- Each amenity is linked to its nearest network node

- Distances are computed between nodes, not directly between amenities

- This is necessary because the walkable network consists of nodes and paths, not amenities

	amenity_id	name	category	node_ids
27	N36723712	Bibliotheek TU/e	community_space	9999910010
50	N25294742	TU/e ingang De Wielen	mobility	9999909965
64	N31493215	Artoislaan	mobility	42751474
65	N32575094	Castiliëlaan	mobility	5504169717
67	N34043800	KFC	food_choices	42628429

CLUSTERING

AGGLOMERATIVE CLUSTERING

- Network nodes are clustered such that the maximum distance between any two nodes in a cluster does not exceed **1500 meters**, which approximates a **15-minute walk**.

- Then, each node is assigned the cluster it belongs to.

	node_ids	y	x	cluster
3	42642687	5.702180e+06	672279.974097	1
29	25547663	5.703035e+06	674554.623329	49
106	42580601	5.699474e+06	673349.091498	12
121	42580621	5.699479e+06	673441.983902	12
167	3882669677	5.699818e+06	673695.593141	12

- POIs are linked to the cluster of their nearest network node.

	amenity_id	name	category	node_ids	cluster
0	N36723712	Bibliotheek TU/e	community_space	9999910010	52
1	N25294742	TU/e ingang De Wielen	mobility	9999909965	13
2	N31493215	Artoislaan	mobility	42751474	15
3	N32575094	Castiliëlaan	mobility	5504169717	15
4	N34043800	KFC	food_choices	42628429	1

IDENTIFYING 15-MIN NEIGHBORHOODS

For each cluster, we count the number of unique amenity categories that it contains.

Clusters with 6 or more categories are marked as existing or potential 15-minute neighborhoods.

POI Clusters with ≥6 Unique Amenities Categories
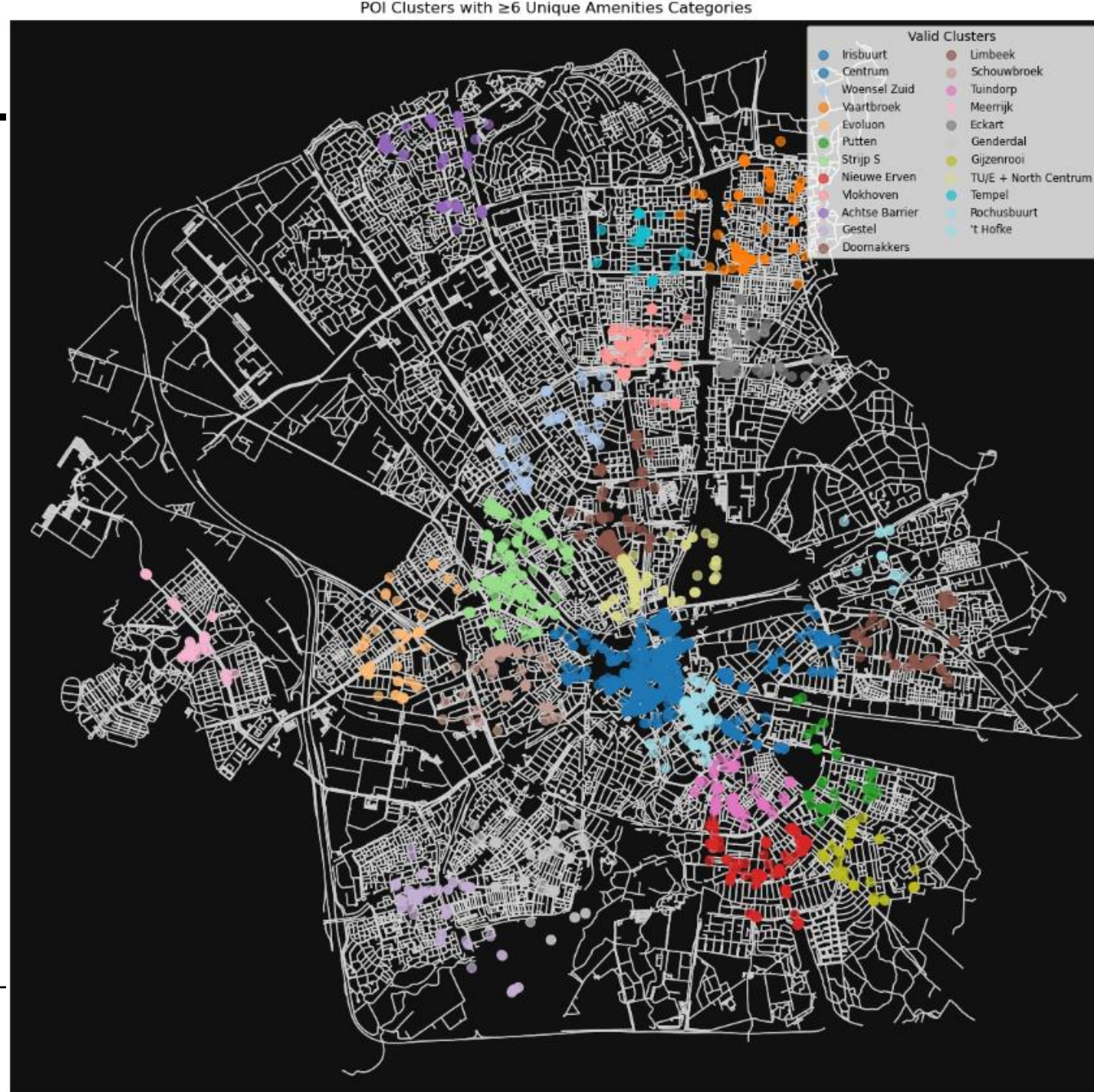
SALVEO PHARMA - FINDING HEALTHCARE LOCATIONS IN EINDHOVEN

The locations we would look for should consider:

- Availability of pharmacies, pharmaceutical labs or distributors

- One central location and other further out neighbourhoods

- The demographics of chosen areas

Salveo Pharma is a healthcare product distributor located in central Eindhoven.

Our plan would involve transportation between this central location to the clusters we choose.

All health locations in Einhoven
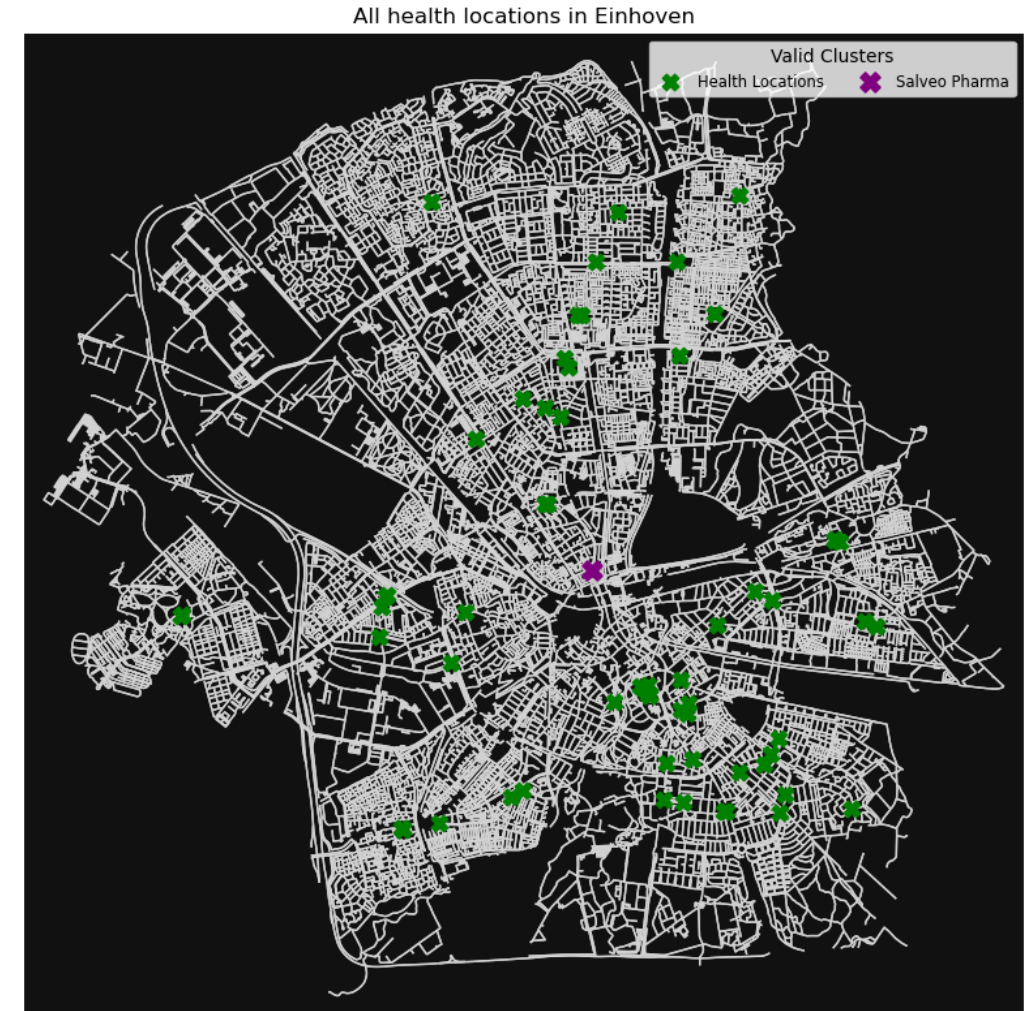
FINAL BLUEPRINT

The chosen 15-minute zones include:

- **TU/e and North Centrum**

- **Nieuwe Erven** (Stratum region)

- **Vlokhoven** (Woensel-Zuid by the Winkelcentrum)

- **Vaartbroek** (North-East Einhoven)

Clusters Containing Health & Wellbeing Locations

Relevant Clusters
- Cluster Vaartbroek
- Cluster Nieuwe Erven
- Cluster Vlokhoven
- Cluster TU/E + North Centrum
- Health & Wellbeing
- Salveo Pharma B.V.

DRONE TRANSPORT

REQUIREMENTS

- Temperature control

- Payload capacity >20kg

- Necessary infrastructure (charging stations/ landing pads)

- Permits

- Secure packaging

- Autonomy

- Ability to withstand harsh weather

AIR ZONES

- Eindhoven is situated within a Controlled Traffic Region (CTR) due to its proximity to Eindhoven Airport and nearby military airbases like Volkel and De Peel.

- Flights are only permitted with a Specific Category, which can be assigned by applying for an operating permit (Operational Authorization - OA).

- We can apply for this permit at the Human Environment and Transport Inspectorate (ILT) by submitting a Specific Operations Risk Assessment (SORA) detailing the safety measures and risk mitigation strategies for our drone operations.

- Close coordination with air traffic control by submitting a detailed flight plan and maintaining two-way radio communication (RTF) throughout the operation.
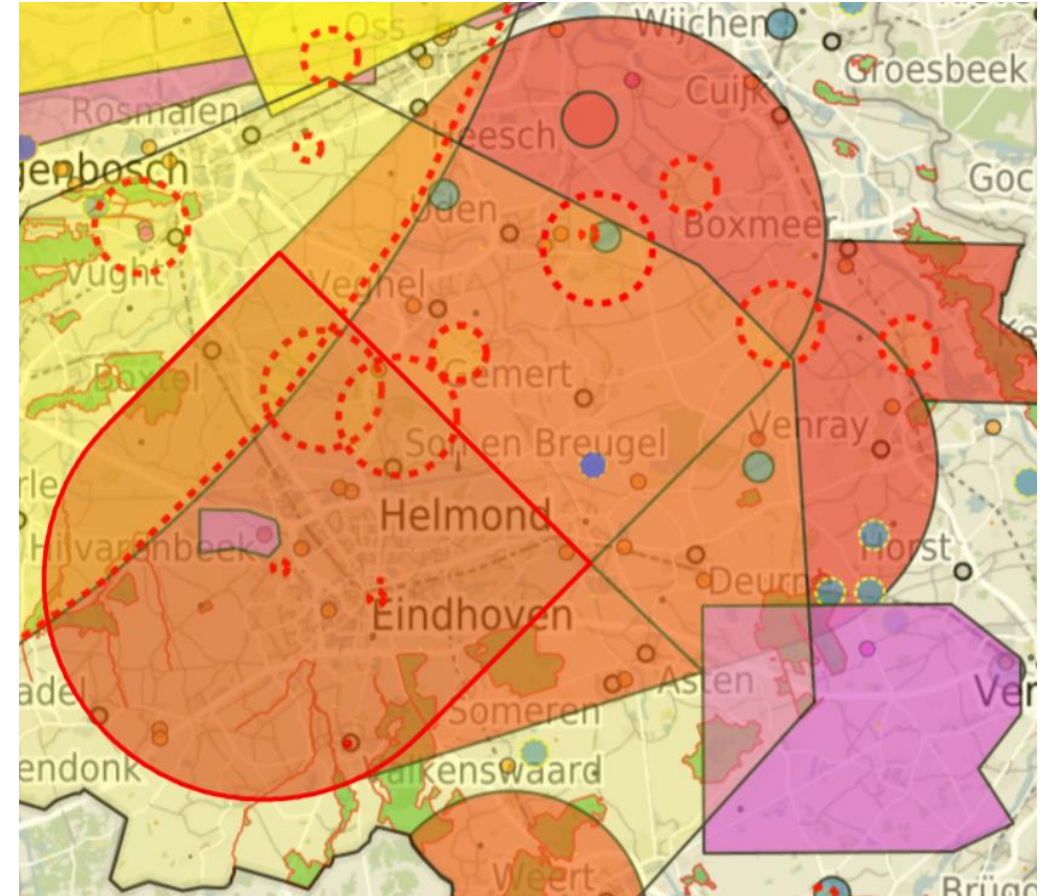
COMPARISON TO OTHER TRANSPORT MODES

- Lower environmental impact than most modes of transport, but only slightly higher in energy consumption than cargo e-bikes

- Speed advantage – bypassing road traffic (15 min drone, almost a third of 42 min estimated for e-vans)

- On-demand delivery

- Cheaper than most other transport modes (cost per delivery for drones is estimated at EUR 1.92, while for e-vans it is at EUR 4.59)

- Reduced human labor
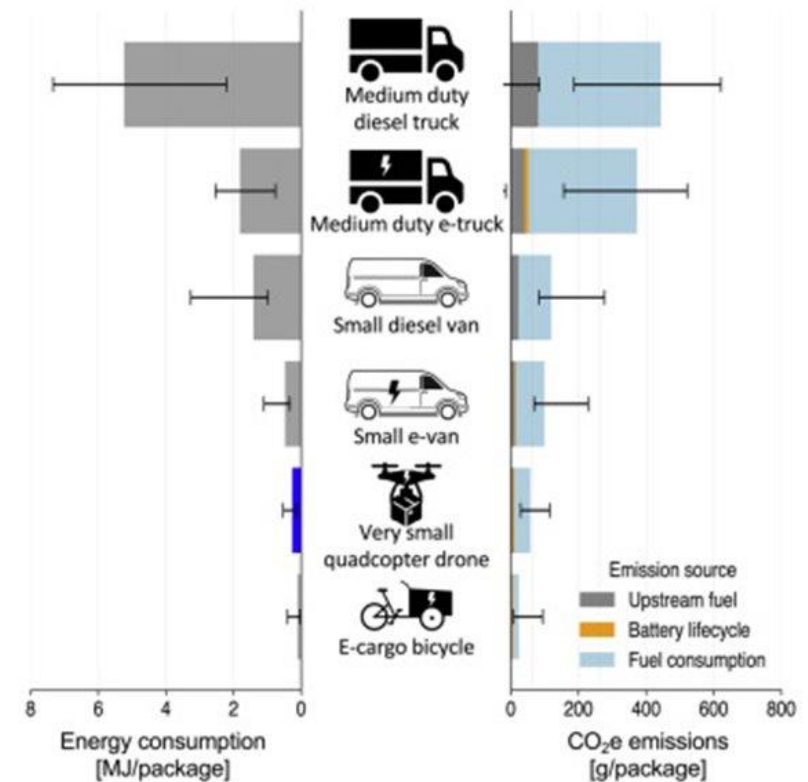
CHOSEN DRONE MODEL – DJI FLYCART 30

- Hovering endurance, max weight, max battery capacity:
  - 18 mins (30 kg weight load, dual battery mode)
  - 8 mins (40 kg weight load, single battery mode)
- Max flight distance, max weight, with max battery capacity:
  - 16 km (30 kg weight load, dual battery mode)
  - 8 km (40 kg weight load, single battery mode)
- Max wind speed resistance – 12m/s

SIMULATION STUDY

KEY VARIABLES & CONSTRAINTS

- The average pharmacy dispenses about 341 prescriptions per day.

- Average prescription weights 25g per unit.

- Our project concerns 10 pharmacies in the city of Eindhoven.

- Drone specification:
    - Average speed: 20 m/s
    - Maximum capacity: 30kg
    - Maximum range: 16km

- Number of drones: 2 (preferably just 1, and the other as a backup).

- Requests made by the 10 pharmacies over 2 days: Request Log.

- Precise distances between the different locations: Distance Matrix.

- Time window for deliveries: 08:30 AM to 06:00 PM (570 minutes).

- Service time or halt time for the drone at the warehouse and each pharmacy: 15 minutes.

REQUEST LOG

- Daily demand: **~341 prescriptions/pharmacy**

- 2-day total: **up to 750 units** (incl. safety margin)

- Orders accumulate **gradually**, with **random sizes ranging from 10 to available stock**, which introduces **randomness** to reflect **real-world variability**.

- Final log: **Grouped & summed per pharmacy**

- Converted to weight: **25g per unit**

Pharmacy	Request [g]
Apotheek SGE Woensel	18 975
Apotheek Lingmont	18 800
Dierenartsenpraktijk Heesterakker	18 950
Medisch Centrum Aalsterweg	18 950
Dental Clinics	18 975
Apotheek Arnouts	18 750
SGE Woensel	18 825
Apotheek de Roosten	18 750
Tandartsenpost	18 850
Tandartspraktijk van de Vondervoort	18 750

DISTANCE MATRIX

	Salveo	A. SGE Woensel	Lingmont	Heesterakker	Aalsterweg	Dental Clinics	Arnouts	SGE Woensel	de Roosten	Tandartsenpost	Vondervoort
Salveo	0	2984	3747	4694	2660	3088	2816	2979	3069	2291	2761
A. SGE Woensel	2984	0	1282	2285	5565	5855	5484	52	5844	5166	5626
Lingmont	3747	1282	0	1033	6088	6240	5820	1239	6237	5676	6105
Heesterakker	4694	2285	1033	0	6894	6971	6531	2246	6972	6482	6888
Aalsterweg	2660	5565	6088	6894	0	718	907	5553	681	412	220
Dental Clinics	3088	5855	6240	6971	718	0	462	5837	386	866	499
Arnouts	2816	5484	5820	6531	907	462	0	5463	475	830	713
SGE Woensel	2979	52	1239	2246	5553	5837	5463	0	5826	5153	5611
de Roosten	3069	5844	6237	6972	681	386	475	5826	0	837	463
Tandartsenpost	2291	5166	5676	6482	412	866	830	5153	837	0	470
Vondervoort	2761	5626	6105	6888	220	499	713	5611	463	470	0

CAPACITATED VEHICLE ROUTING PROBLEM (CVRP)

Setup

- Limited vehicles start from one depot

- Each location visited once by a single vehicle

- Vehicles return to depot once and cannot redeploy

Objective

- Minimize total distance traveled

- Penalize use of additional vehicles to reduce fleet size

Post-solution

- Number of routes = number of vehicles used

- Vehicles can be reused if delivery times are met

Key Internal Constraints:

- All nodes reachable from depot or other nodes

- Vehicle load $\leq$ capacity

- Routes must connect nodes logically

SOLVING CVRP WITH GOOGLE OR-TOOLS

Tools & Framework

- CVRP is NP-hard, but solvable using heuristics
- We used Google OR-Tools, an open-source suite for:
  - Vehicle routing
  - Scheduling
  - Constraint & integer programming

Solution Strategy

- Initial Heuristics:
  - PATH_CHEAPEST_ARC: builds fast initial route by picking nearest nodes
- Refinement:
  - GUIDED_LOCAL_SEARCH (GLS): improves solution by penalizing overused paths
- Enables efficient, near-optimal routing in our simulation

DELIVERY ROUTE SUMMARY

Metric	Value
📍 Total Distance	10,062,178 m (~10,062 km)
⚖️ Total Load	188,575 g (~188.6 kg)
⏱️ Total Time	352 minutes (~5.9 hours)
📦 Average Load/Trip	~18,857 g
🗺️ Average Distance/Trip	~1,006,218 m
🕐 Average Time/Trip	~35 min

All routes follow: **Salveo Pharma B.V. → Destination → Return**

DELIVERY ROUTES VISUALISED

- Routes start from Salveo Pharma to the partner pharmacies..

- 10 delivery routes to be taken throughout each designated delivery day (Monday, Wednesday, Friday).

Clusters Containing Health & Wellbeing Locations with Routes
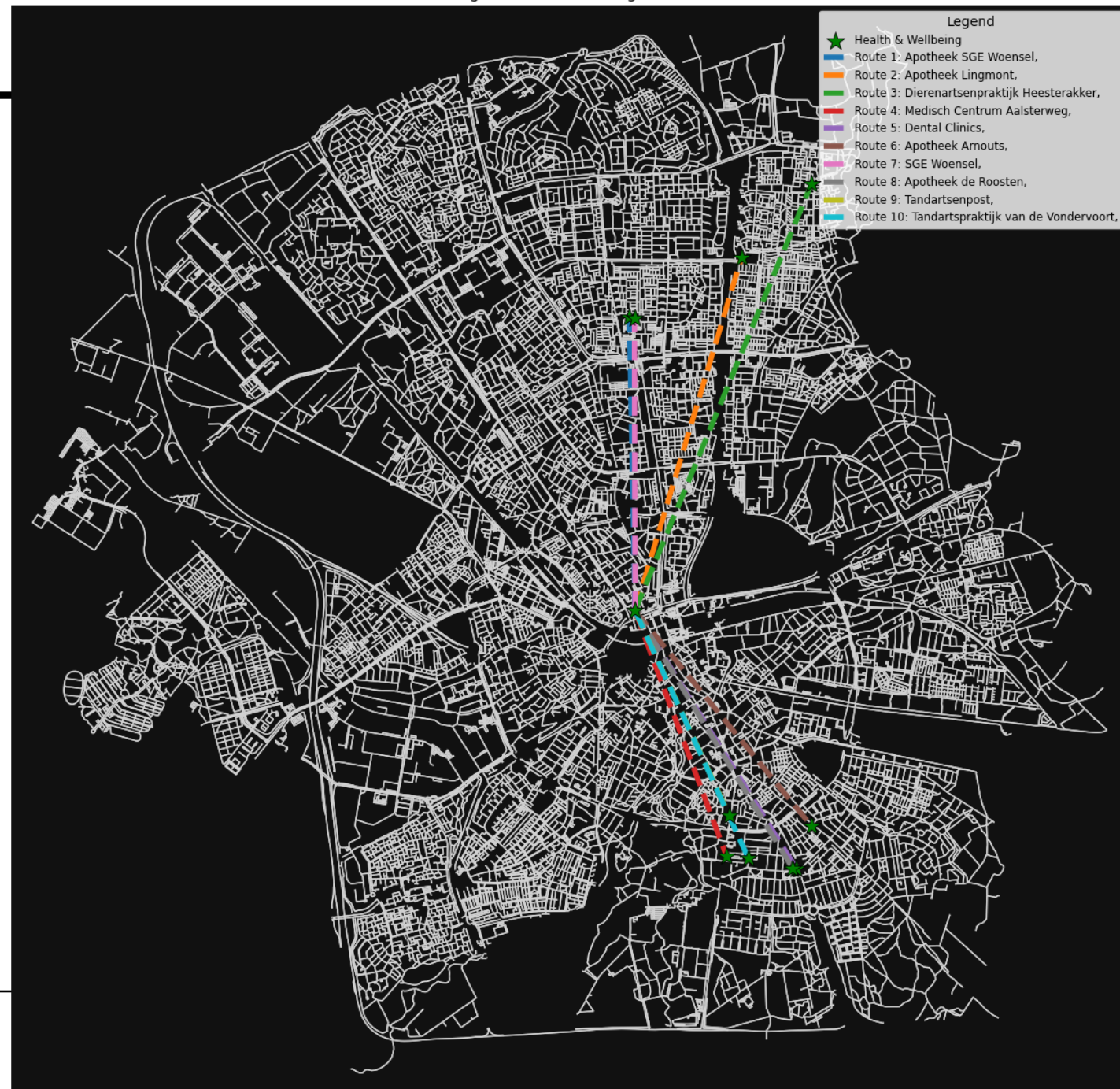
EVALUATION OF THE RESULTS

- Total Trips: 10

- Total Time: 352 min
  - 300 min: loading/unloading
  - 52 min: total flight time

- Battery Limit: 18 min

- Issue: flight time exceeds battery capacity

- Possible solutions:
  - battery swapping
  - battery recharging

Delivered To	Start Time (min)	End Time (min)
Apotheek de Roosten	15.0	33.0
Medisch Centrum Aalsterweg	48.0	67.0
Tandartsenpost	82.0	101.0
Apotheek SGE Woensel	116.0	136.0 R
Dental Clinics	177.5	197.5
Apotheek Arnouts	212.5	232.5
SGE Woensel	247.5	267.5 R
Tandartspraktijk van de Vondervoort	309.0	329.0
Apotheek Lingmont	344.0	365.0 R
Dierenartsenpraktijk Heesterakker	406.5	429.5

Conclusion: 429.5 min < 570 min (from 8:30 AM to 6:00 PM)
→ **One drone is sufficient**

LIMITATIONS & FUTURE DIRECTIONS

Technical Constraint

- Limited range and payload of current drones

- Scaling beyond Eindhoven may require:
  - Advanced drones
  - Charging pads or maintenance stations

Financial Limitations

- One drone ~20,000EUR

- Budget restricts number of units

- Positive revenue forecasted might allow for greater expansion in the future, but is not yet feasible

Regulatory Barriers

- Eindhoven lies in Controlled Traffic Region

- Operation requires special permits

- Expansion = new licenses & permits

THANK YOU FOR YOUR ATTENTION