Light Electric Freight Vehicles for Last-Mile Delivery

A case study at PostNL

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Agenda

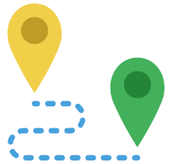
01	02	03	04	05
INTRODUCTION	**PROBLEM FORMULATION**	**METHODOLOGY**	**RESULTS AND DISCUSSION**	**CONCLUSION**
• Postal Market Developments • Rise of Light Electric Freight Vehicles	• Research Questions • Typifying the Problem	• Cost Model • Scenarios	• Results • Sensitivity Analysis	• Future Research

1 - Introduction

Postal market developments require cost savings and network capacity adjustments

Mail market

- Declining mail market (-10%)
- Liberalization & E-substitution
- Universal Service Obligation



Network optimization

Synergy opportunities?

Parcel market

- Growing parcel market (+15%)
- Capacity expansion
- Competition intensifies

1 - Introduction

Rise of LEFV but limited research regarding impact on distribution cost and network design

What is a Light Electric Freight Vehicle (LEFV) ?

- **Wide variety of types and payloads**
- **No universal definition, general consensus:**
  - Limited speed 25 km/h
  - Electrical motor assistance (typically cycling)
  - Limited payload 0.5 m^3 – 3 m^3

Benefit and limitations of LEFV

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- Easy to park
- Manoeuvrable
- Zero emission
- Limited driver training
- Low purchasing cost

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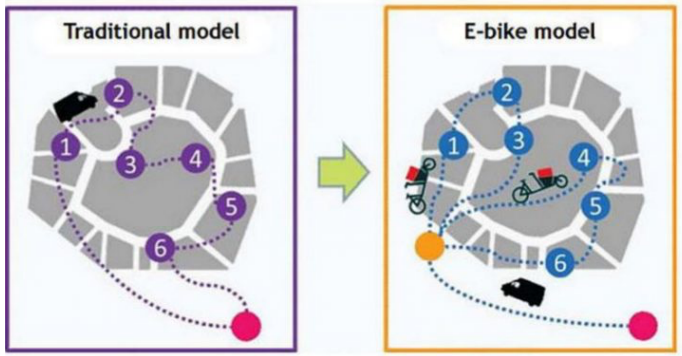
- Limited range
- Limited speed
- Small payload
- Safety

Why LEFV specifically for Postal Operators (PO)?

- **Alternative for mail delivery by bicycle**
  - Higher speed
  - Less physical strain
- **Possible solution for parcel delivery in cities**
- **LEFV could enable combined delivery of mail and parcels**
  - *Bicycles*: payload too limited for parcels
  - *Vans*: high operating cost for low value mail items



2 - Problem Formulation

Hypothesis: LEFV reduce distribution cost and enable synergy between the parcel and mail network

Research Question

Will the introduction of LEFV in the mail and parcel delivery network lead to reduced distribution costs ?

Key Topics

Impact of LEFV on the distribution cost

Integration of the mail and parcel network

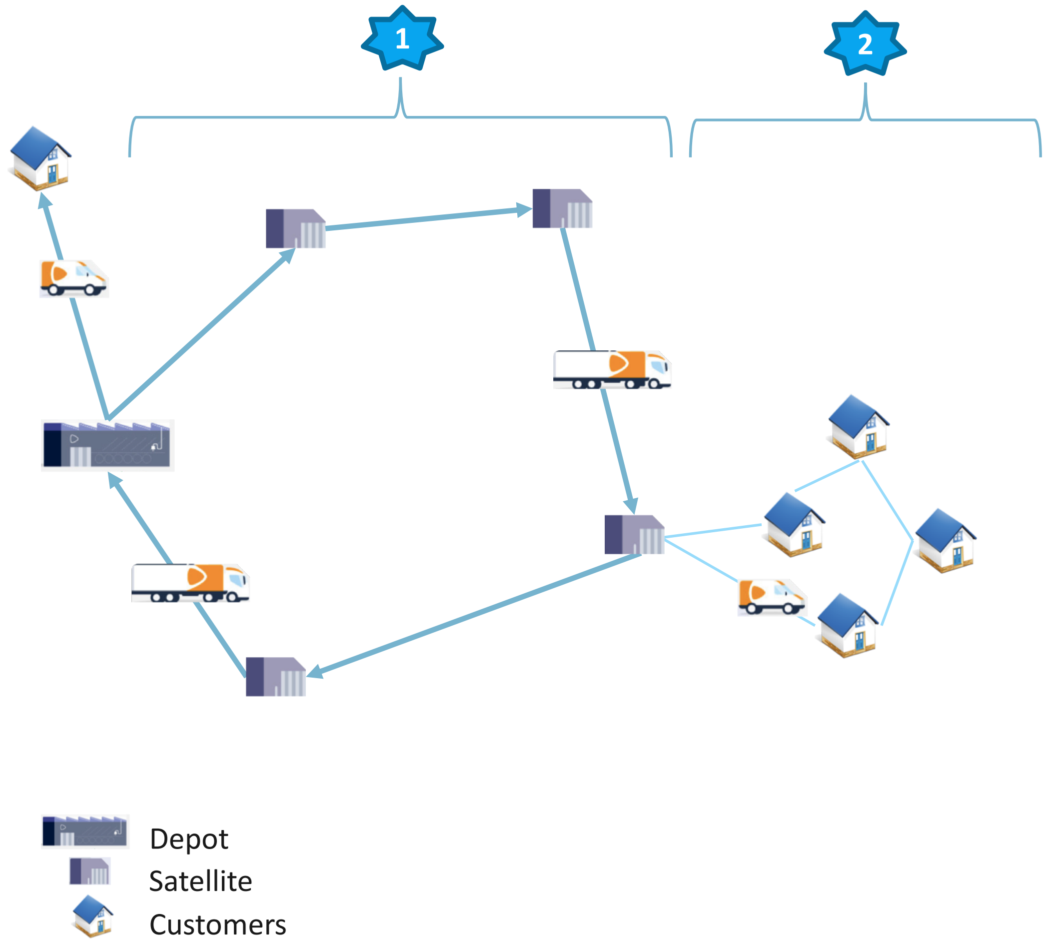
Impact of LEFV on network design

Geographical characteristics suited for combined delivery

2 - Problem Formulation

Two echelon location routing problem (2E-LRP)

Mixed multi-tier distribution system



Problem Formulation

1 ***Feeder* Tier**

- Depots to satellites
- Multi-depot vehicle routing problem (MDVRP)

2 ***Delivery* Tier**

- Two delivery options:
    - Originating from depot (direct delivery)
    - Originating from satellite (indirect delivery)
- Continous Approximation (CA)

! ***Key Assumptions***

- Heterogenous vehicle fleet (bike, scooter, LEFV, car, van)
- Capacited locations and vehicles
- One-directed

3 - Methodology

Mixed Integer Linear Programming Model (MILP model)

Decision Variables

Feeder Tier

Binary variables showing:

i. Route sequence for truck delivery from depot to satellite
ii. Allocation of satellites to active depots
iii. Open a depot

Delivery Tier

Binary variables showing:

i. Depot or satellite allocation
ii. Vehicle choice
iii. Network type

Objective Function

minimize **total cost** =

facility cost + handling cost +transport cost + delivery cost

Key Constraints

- Satellites and customers served
- Subtour Elimination
- Throughput constraints
- Vehicle Capacity
- Flow Constraints
- Physical storage capacity

3 - Methodology

Selected geographic zone and scenarios

Case: Geographic Zone

- Variety of densities
- Points of delivery: 7,876
- Daily mail volume: 6,591
- Daily parcel volume: 809

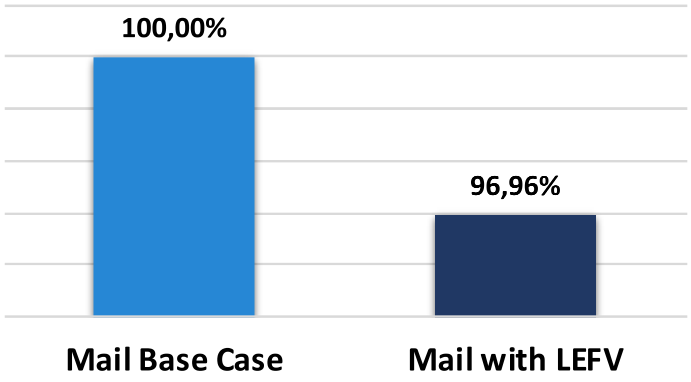
Tested Scenarios

0. *Base Cases*: Standalone mail & standalone parcel network
1. *Scenario A*: Standalone mail network with LEFV
2. *Scenario B*: Standalone parcel network with LEFV
3. *Scenario C*: Combined delivery network (current fleet)
4. *Scenario D*: Combined delivery network with LEFV

4 - Results

Scenario A: Standalone mail network with LEFV

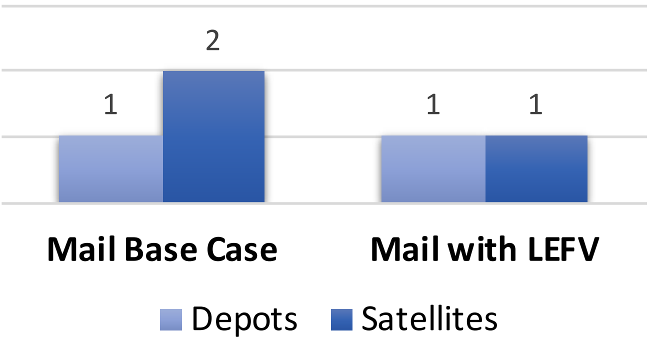
Distribution Cost



Vehicle fleet compositon

Vehicle	Mail Base Case	Mail with LEFV
Bikes	9	1
Scooter	3	3
Car	0	0
Van	0	0
LEFV	0	5

Active Locations



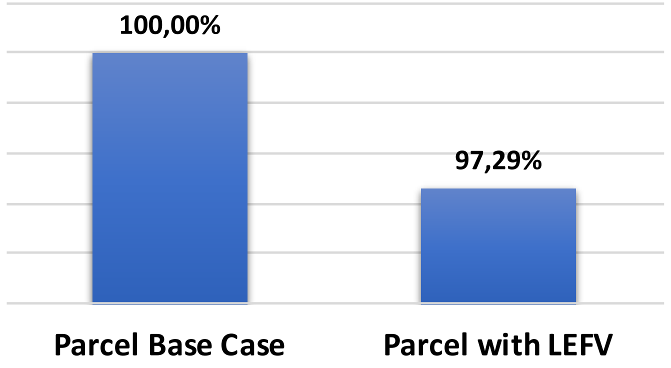
Main Observations

1. Reduction of distribution cost by 3%
2. Longer maximum service time, higher payload and a higher intra-stop speed result in subsitution of bicycles to LEFV
3. Faster linehaul speed of LEFV leads to reduction of depots

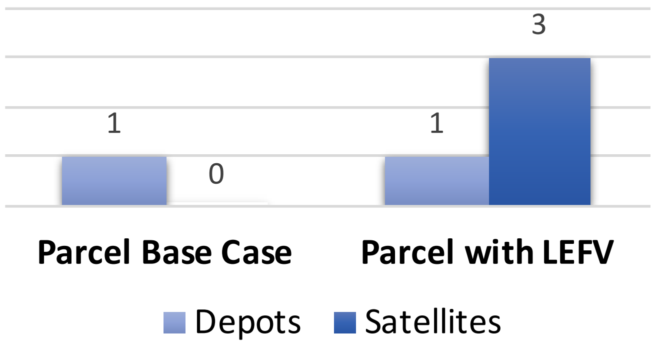
4 - Results

Scenario B: Standalone parcel network with LEFV

Distribution Cost



Active Locations



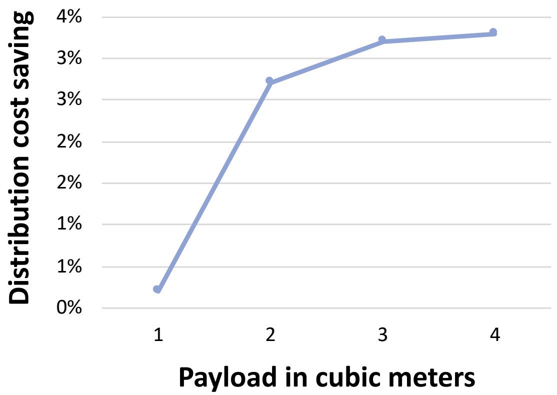
Main Observations

1. Reduction of distribution cost reduce by 2,7%
2. Substitution of vans to LEFV in *high density areas*.
3. Indirect delivery (via satellites) to overcome the long linehaul distance with LEFV
4. A payload between 2 m^3 and 3 m^3 is advised

Vehicle fleet compositon

Vehicle	Parcel Base Case	Parcel with LEFV
Bikes	0	0
Scooter	0	0
Car	0	0
Van	4	2
LEFV	0	10

Effect of Payload

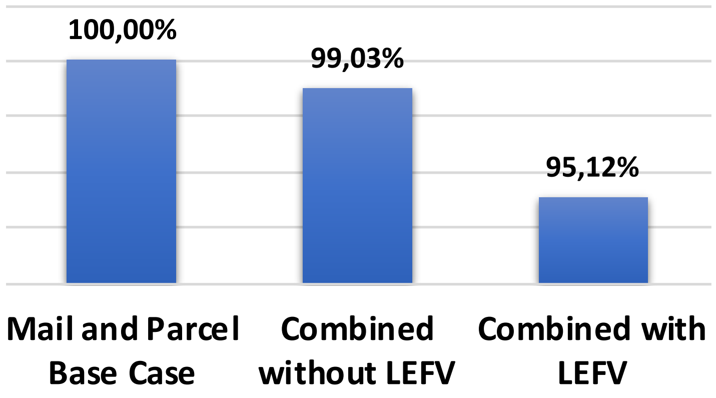


Supply Chain MANAGEMENT

4 - Results

Scenario C+D: Combined Delivery and the impact of LEFV

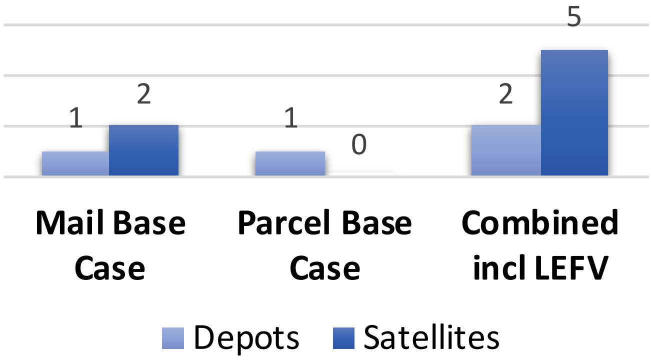
Distribution Cost



Vehicle fleet compositon

Scenario	Mail Base Case	Parcel Base Case	Combined incl LEFV
Bikes	9	0	3
Scooter	3	0	2
Car	0	0	0
Van	0	4	3
LEFV	0	0	15

Active Locations



Main Observations

1. With the current vehicle fleet network integration is severely limited (only a combination via van in rural area)
2. The introduction of LEFV leads to an additional cost reduction. *Total cost reduction is 4,9%*
3. Combined delivery with *LEFV is advised in high density areas.*
4. The changes in the vehicle composition and location structure are similar to the parcel scenario.

5 - Conclusion & Future Research

LEFV are a viable addition to the vehicle fleet for mail and parcel delivery

Conclusions

- Adding LEFV to the vehicle fleet results in lower distribution cost and can facilitate network integration for POs
- LEFV require hubs in close proximity to the delivery area
- High drop density areas are more suited for LEFV.

Future Research

- Apply the model to a larger scale dataset
- Create a model with stochastic demand (e.g., volume variations and dimensions)
- Develop a VRP including time-windows for parcel delivery via LEFV
- Develop a process design for combined delivery by POs
- Develop the optimal LEFV for delivery (payload, maneuverability)