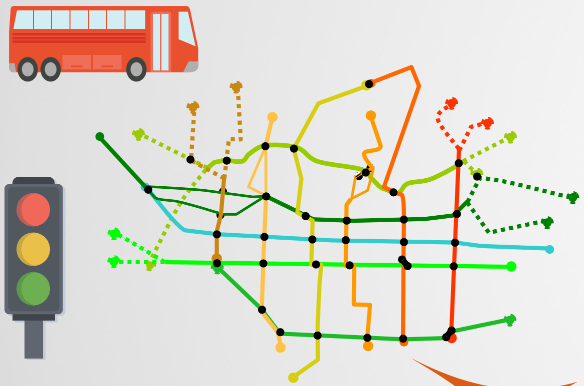
Connected and Automated Technology changing Urban Logistics

Mireia Roca-Riu

NSL Colloquium
Current Challenges for Logistics
14th May 2019

Mireia Roca-Riu : Short Bio

Improving Urban Deliveries
via Collaboration

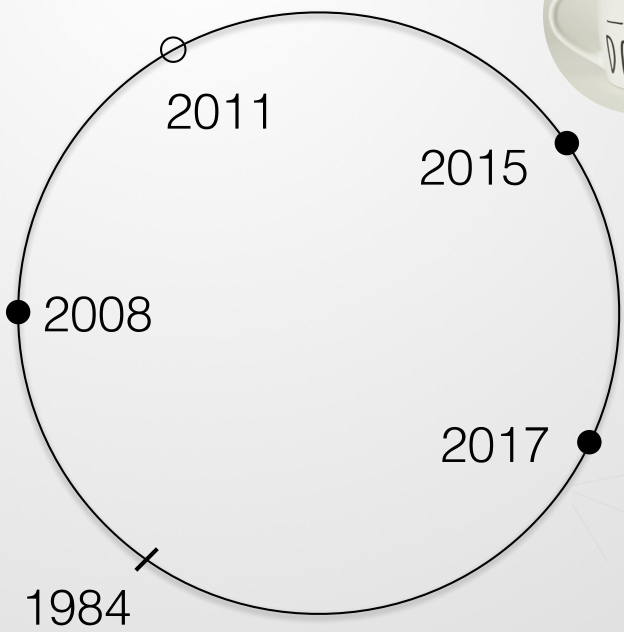


SEVENTH FRAMEWORK PROGRAMME

European Commission

UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

CENIT
CENTER FOR INNOVATION IN TRANSPORT

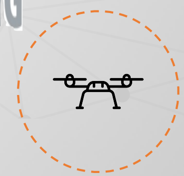


ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Maths *and*
Operations Research

HASLERSTIFTUNG

CALog



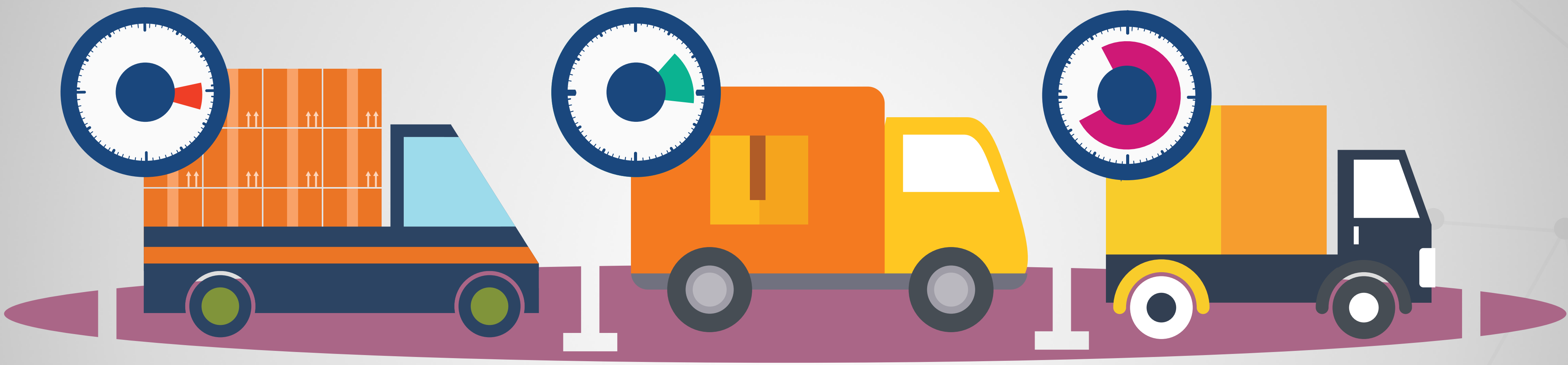
UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

Part I: Parking Assignment Problem

Part II: Dynamic Delivery Parking Spots

Part III: Automation in Urban Logistics

Part I: Parking Assignment Problem



Part II: Dynamic Delivery Parking Spots

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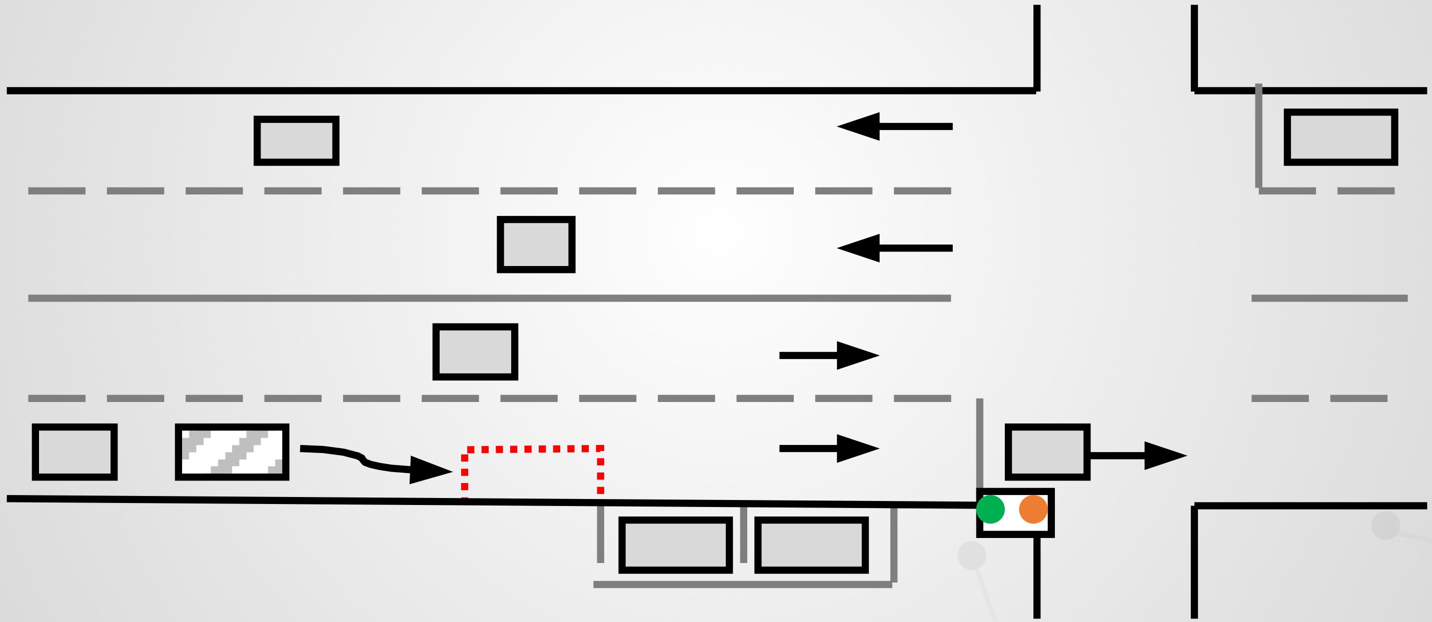
Part II: Dynamic Delivery Parking Spots



Part III: Automation in Urban Logistics

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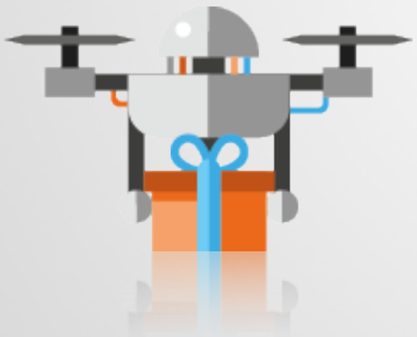
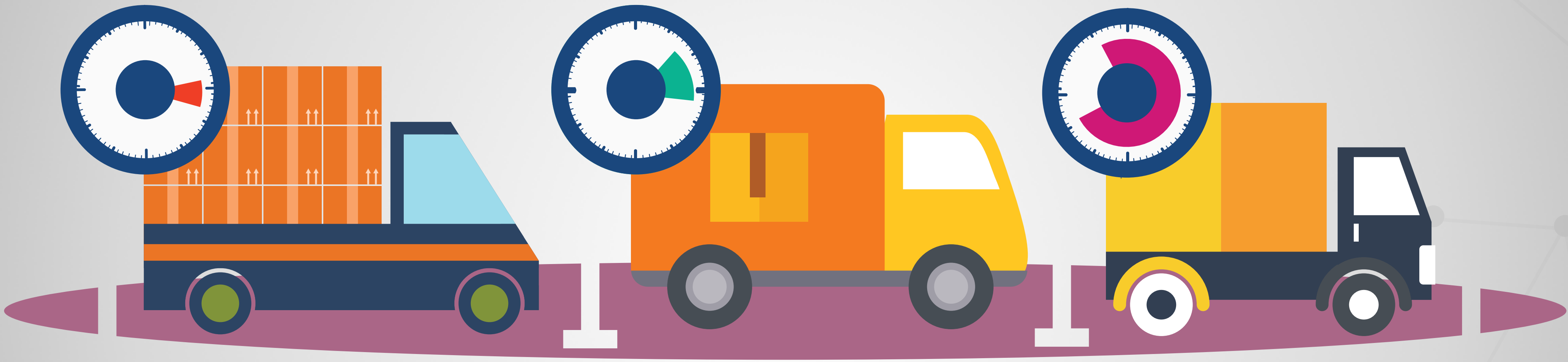


Part I: Parking Assignment Problem



Part II: Dynamic Delivery Parking Spots

Part III: Automation in Urban Logistics

Parking Slot Assignment Problem (PAP)

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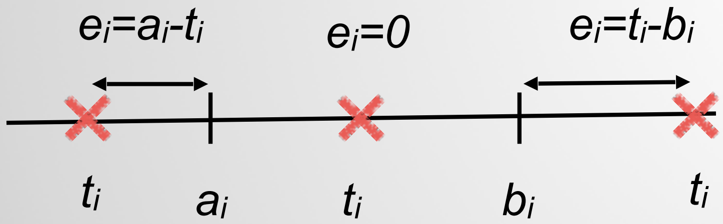
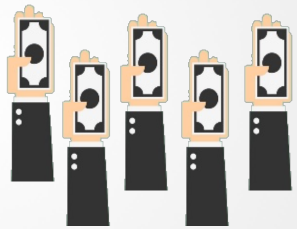
Parking Slot Assignment Problem (PAP)

Modeling approach

Minimize penalties

Optimize Social Welfare





Valuation from players

Outcome rule

Payment rule

Need assumptions on carrier's behavior

No assumptions are needed

[Roca-Riu, Fernández, and Estrada]. "Parking slot assignment for urban distribution: models and formulations." OMEGA - The International Journal of Management Sciences, 57(B): 157-175, 2015.

[Yang, Roca-Riu, and Menéndez]. "An Auction-based Approach for Prebooked Urban Logistics Facilities" OMEGA - The International Journal of Management Sciences [In Press]

Parking Slot Assignment Problem (PAP)

Minimize penalties

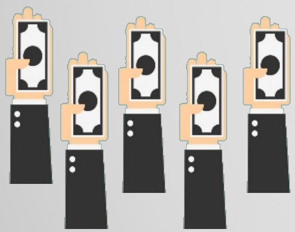
Optimize Social Welfare

Table 1
Comparison of the auction and the penalty formulations for heterogeneous carriers.

Information instance	Penalty formulation: No trapezoid	Penalty formulation: No truncated trapezoid	Penalty formulation: No binary	Penalty formulation: Some	Auction's formulation: Full
1	2547 (−20%)	2843 (−10%)	2834 (−11%)	3120 (−2%)	3189
2	1739 (−17%)	1774 (−15%)	1758 (−16%)	1932 (−7%)	2097
3	1645 (−7%)	1671 (−5%)	1646 (−7%)	1755 (0%)	1771
5	2840 (−14%)	2831 (−14%)	2754 (−17%)	3074 (−7%)	3326
6	1845 (−19%)	1838 (−19%)	1870 (−17%)	2000 (−12%)	2280
7	2435 (−9%)	2443 (−9%)	2466 (−8%)	2601 (−3%)	2686
8	1192 (−4%)	1198 (−4%)	1184 (−5%)	1253 (0%)	1253
12	1822 (−12%)	1842 (−12%)	1710 (−18%)	1951 (−6%)	2094
13	1906 (0%)	1912 (0%)	1890 (−1%)	1919 (0%)	1920
15	687 (−3%)	687 (−3%)	668 (−6%)	714 (0%)	714
16	2394 (−6%)	2376 (−6%)	2338 (−8%)	2547 (0%)	2552
17	3008 (−3%)	2999 (−3%)	2984 (−4%)	3110 (0%)	3111
18	3710 (−11%)	3742 (−11%)	3656 (−13%)	4084 (−3%)	4211
23	3557 (−10%)	3558 (−10%)	3612 (−9%)	3930 (−1%)	3970
24	1301 (−15%)	1306 (−15%)	1294 (−16%)	1465 (−5%)	1542
25	1670 (−1%)	1670 (−1%)	1664 (−1%)	1689 (0%)	1689
26	2103 (−10%)	2114 (−10%)	1996 (−15%)	2260 (−4%)	2354
28	1225 (−7%)	1219 (−7%)	1236 (−6%)	1319 (0%)	1319
29	2900 (−1%)	2892 (−1%)	2876 (−2%)	2935 (0%)	2935
30	537 (−11%)	575 (−5%)	580 (−4%)	605 (0%)	605
31	2138 (0%)	2142 (0%)	2138 (0%)	2159 (0%)	2159
32	2855 (−9%)	2838 (−10%)	2712 (−14%)	3124 (0%)	3156
33	1331 (−8%)	1349 (−7%)	1280 (−12%)	1437 (−1%)	1457
35	3361 (−10%)	3369 (−10%)	3376 (−9%)	3714 (0%)	3750
36	1489 (−15%)	1498 (−14%)	1372 (−21%)	1703 (−3%)	1757
38	3943 (−2%)	3950 (−2%)	3906 (−3%)	4063 (0%)	4063
39	2307 (−15%)	2350 (−13%)	2188 (−19%)	2587 (−5%)	2723
40	3483 (−10%)	3533 (−9%)	3364 (−13%)	3817 (−1%)	3891
41	1403 (−10%)	1405 (−10%)	1330 (−15%)	1513 (−3%)	1572
42	4708 (−6%)	4754 (−5%)	4648 (−7%)	5021 (0%)	5025
43	2841 (−4%)	2824 (−4%)	2800 (−5%)	2968 (0%)	2968
44	5597 (−11%)	5607 (−11%)	5400 (−14%)	6038 (−4%)	6304
45	6054 (−11%)	6014 (−11%)	5978 (−12%)	6655 (−2%)	6825
47	1361 (−1%)	1361 (−1%)	1346 (−2%)	1380 (0%)	1380
49	668 (0%)	668 (0%)	636 (−5%)	670 (0%)	670
52	838 (−1%)	835 (−1%)	832 (−2%)	849 (0%)	849
53	635 (−4%)	635 (−4%)	582 (−12%)	668 (0%)	668
59	2101 (−2%)	2101 (−2%)	2052 (−5%)	2163 (0%)	2163
median	2102 (−5%)	2108 (−5%)	2024 (−8%)	2161 (−2%)	2222

Parking Slot Assignment Problem (PAP)

Optimal online readjustment with uncertain arrival times



Valuation from players

Outcome rule

Payment rule

Offline optimum

Parking Slot Assignment Problem (PAP)

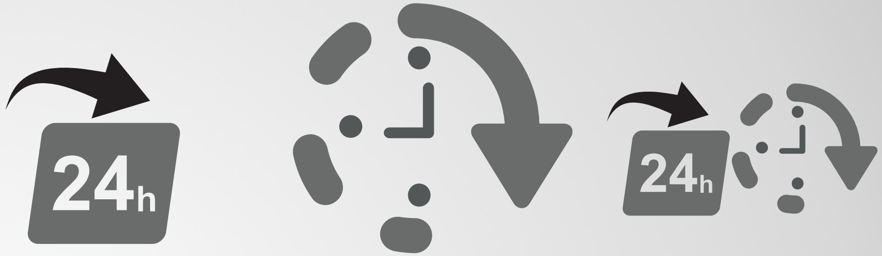
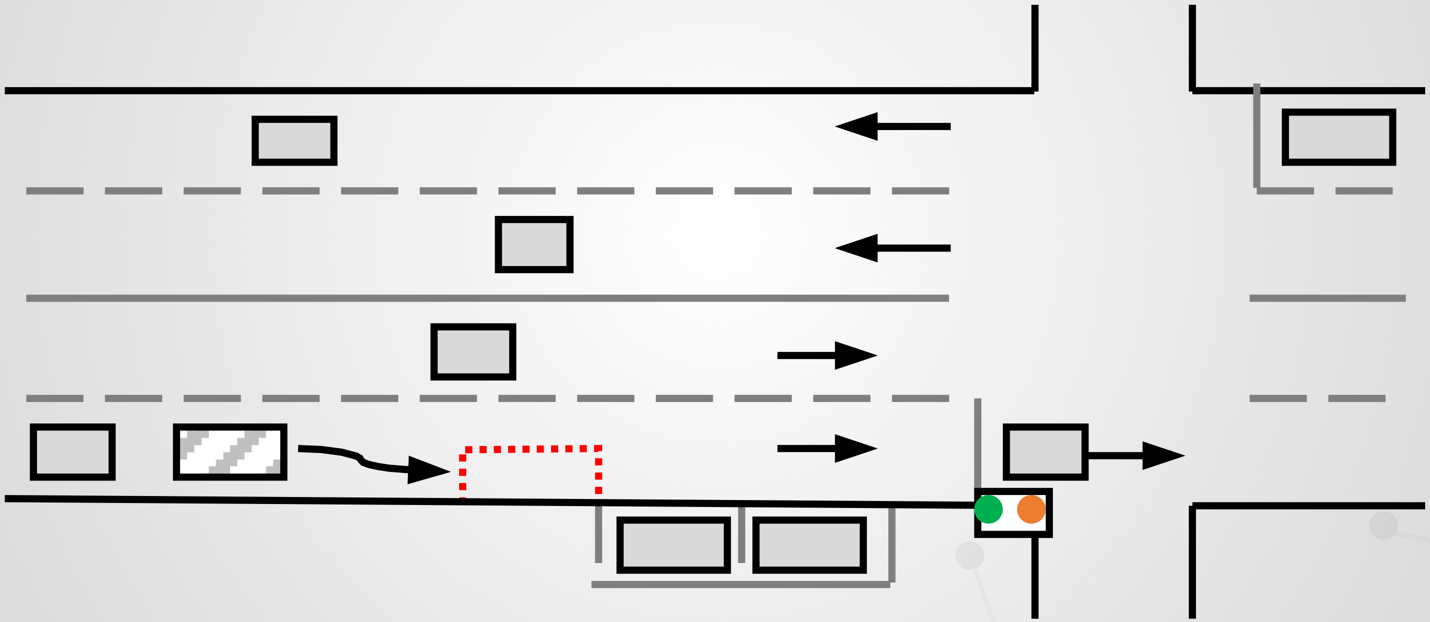


Table 5
Performance of the online readjustment formulation.

Uncertainty Level	Parking Duration	Valuation	Parking Spot	Without Readjustment	Online Readjustment	Offline Optimum
Moderate	10	Uniform	3	640	860 (34%)	860 (0%)
			6	1267	1732 (37%)	1732 (0%)
		Peak	3	620	793 (28%)	793 (0%)
			6	1230	1622 (32%)	1624 (0%)
	20	Uniform	3	632	778 (23%)	781 (0%)
			6	1251	1625 (30%)	1631 (0%)
		Peak	3	489	580 (19%)	583 (0%)
			6	963	1220 (27%)	1226 (0%)
	30	Uniform	3	536	631 (18%)	637 (1%)
			6	1056	1327 (26%)	1339 (1%)
		Peak	3	381	432 (14%)	438 (1%)
			6	750	926 (23%)	934 (1%)

Part I: Parking Assignment Problem

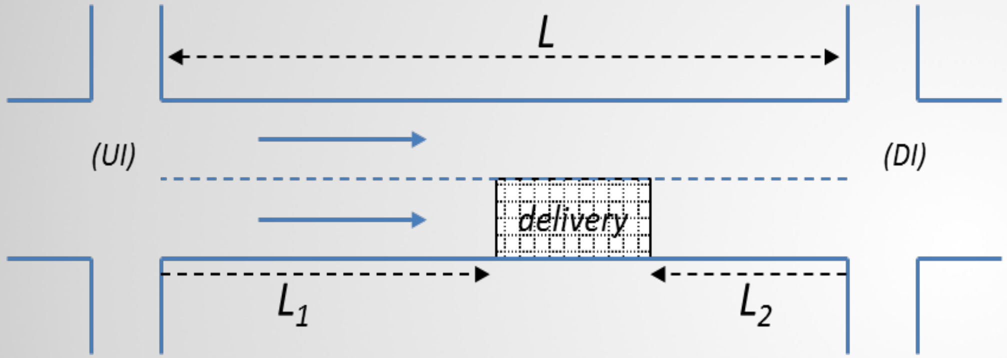
Part II: Dynamic Delivery Parking Spots



Part III: Automation in Urban Logistics

Multi-use lanes

Dynamic Delivery Parking Spots (DDPS)



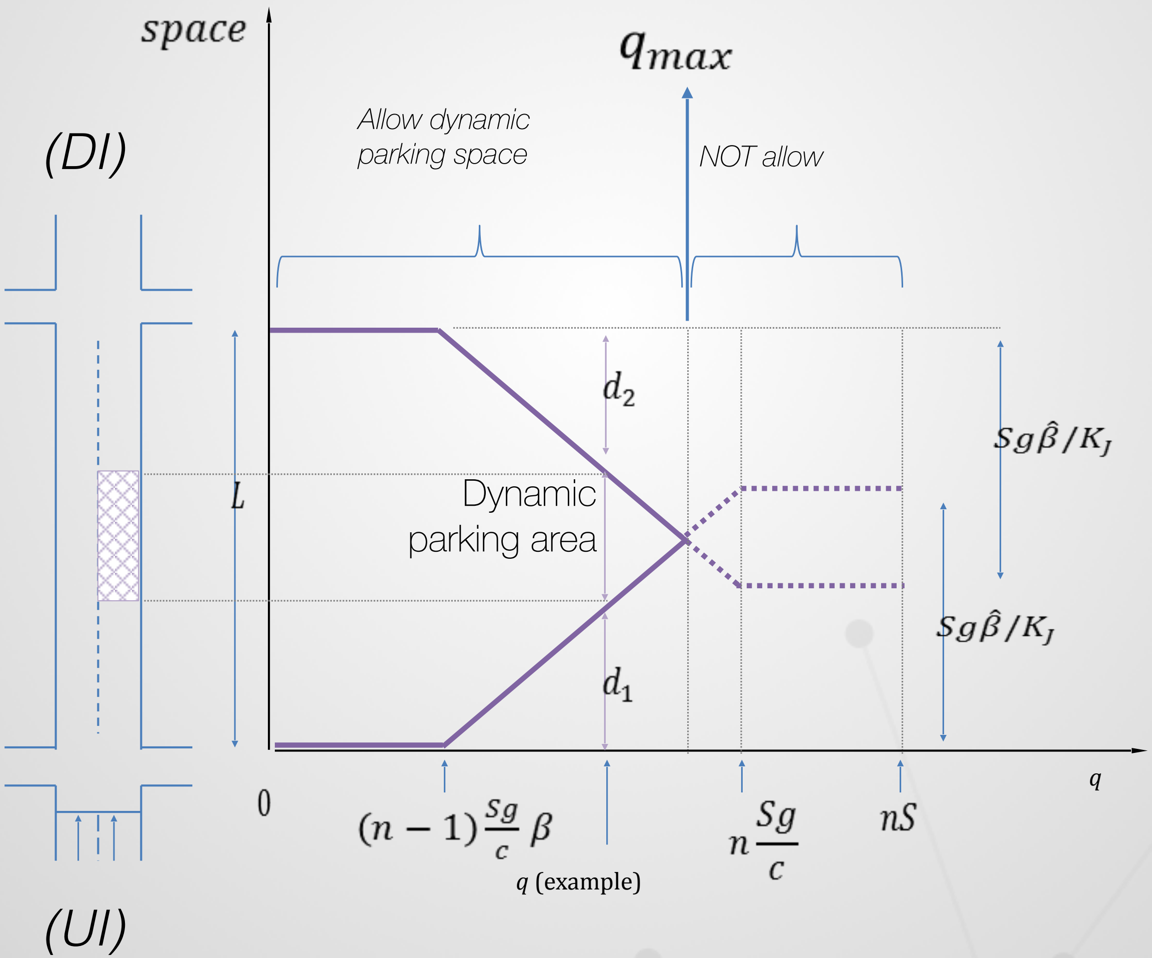
n lanes per direction
L length of the link
L_1, L_2 distance *UI/DI*
q arrival flow rate (small turn)
c, g cycle, green signal length
green wave coordination
S, K_J saturation flow, jam density
β, merging factor

Minimum distance that guarantees that no traffic spillover is caused to other links

d_1, d_2 minimum distance to *UI/DI*

Dynamic Delivery Parking Spots (DDPS)

Distance to Down/Upstream Intersection (*UI/DI*)



Dynamic Delivery Parking Spots (DDPS)

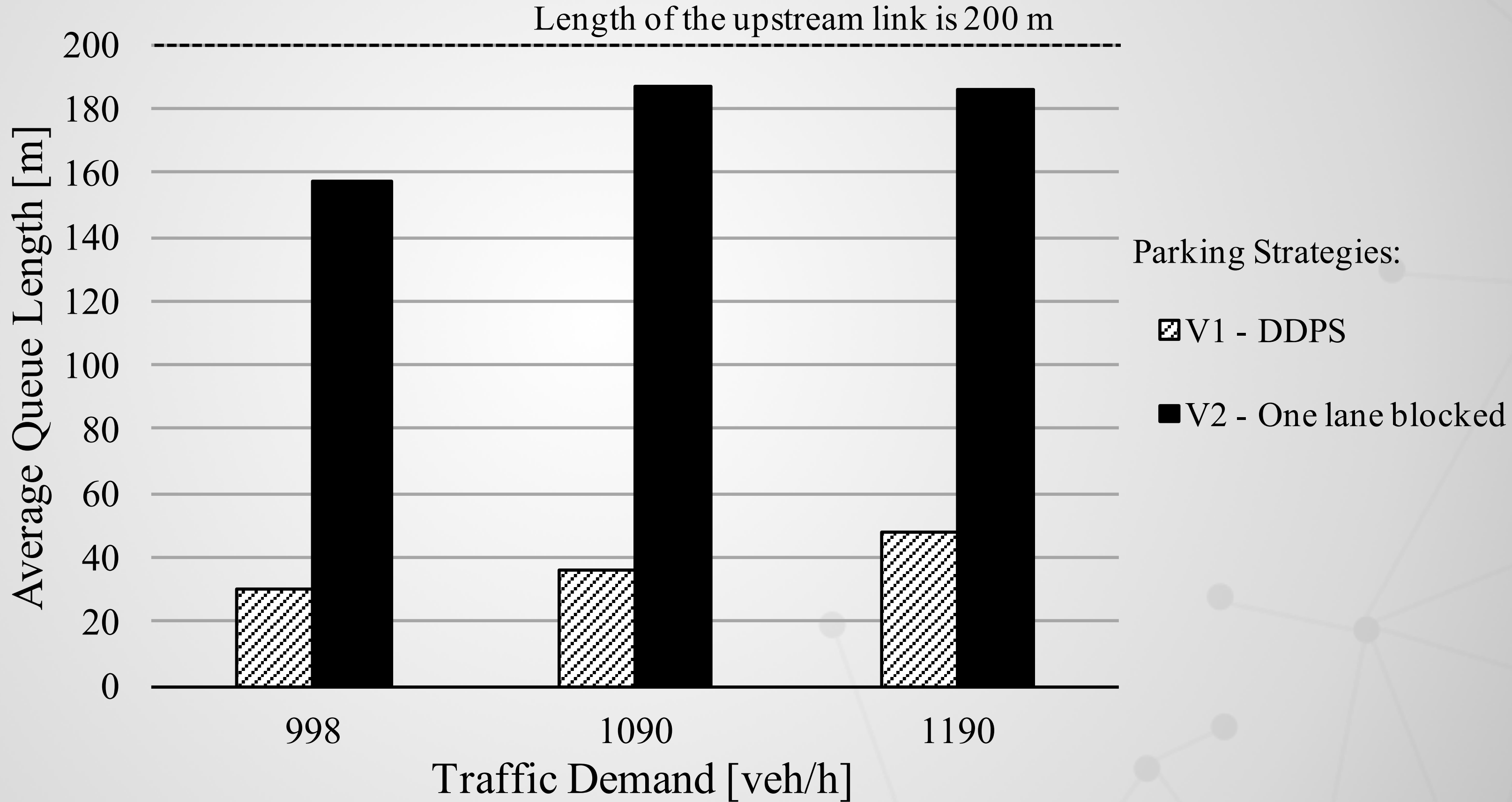
Validation & evaluation with simulation

1. Validate the results of the analytical model in more realistic scenarios
2. Evaluate the performance of DDPS through comparison with illegal delivery parking

Data
2 lane-link
120m length of the link
35s, 70s, cycle, green signal length,
green wave coordination

Dynamic Delivery Parking Spots (DDPS)

Validation & evaluation with simulation



Validation Scenarios

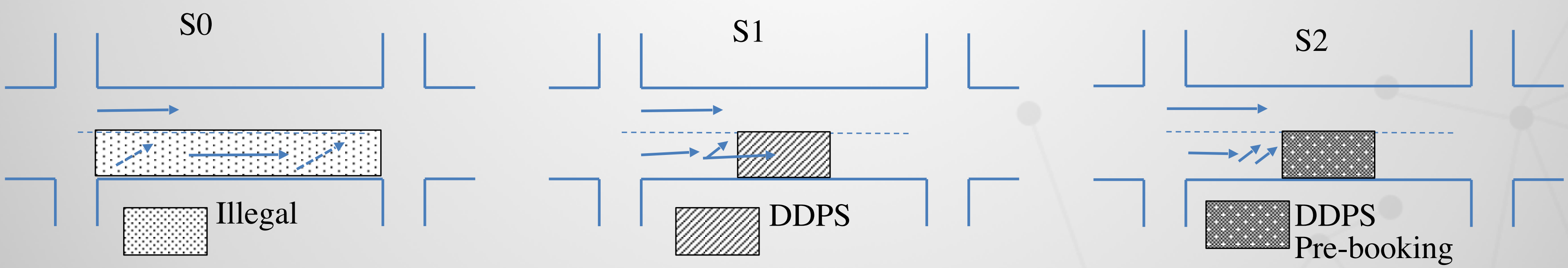
V1. DDPS according to analytical model

V2. One lane fully blocked (multi-use lane)

Dynamic Delivery Parking Spots (DDPS)

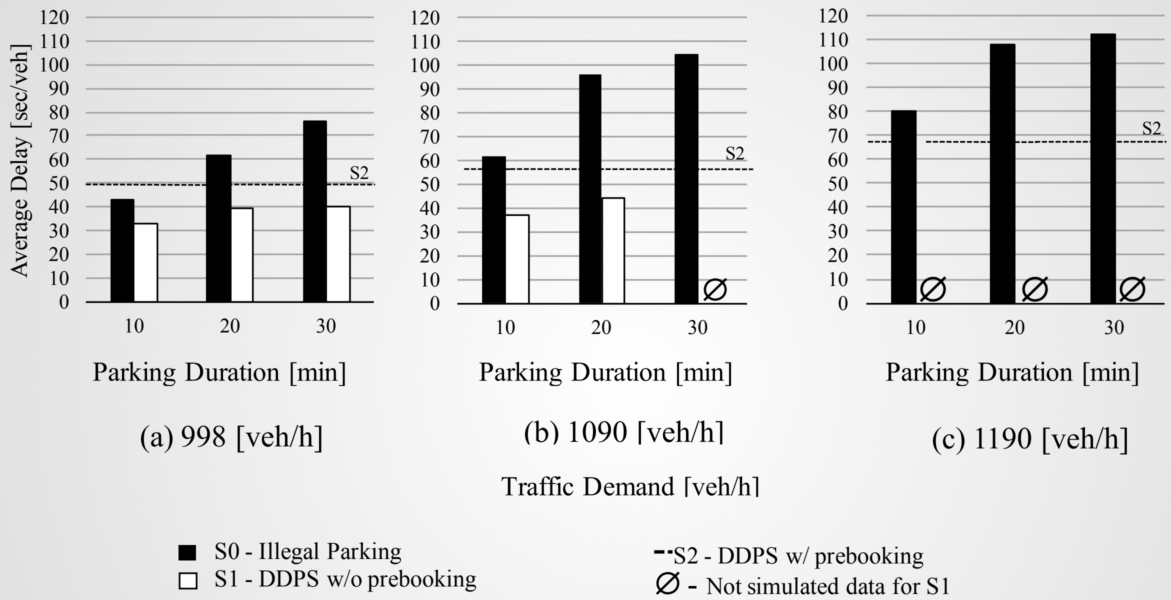
Validation & **evaluation** with simulation

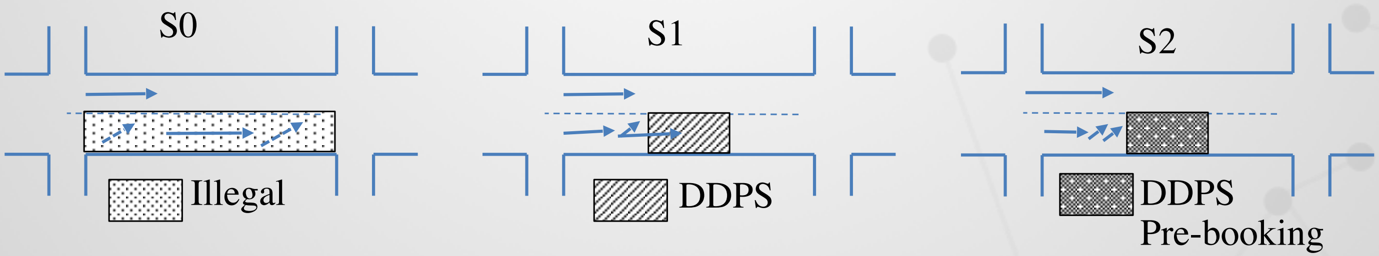
Evaluation Scenarios
S0. Random illegal parking (current situation)
S1. DDPS
S2. DDPS with pre-booking



Dynamic Delivery Parking Spots (DDPS)

Validation & **evaluation** with simulation



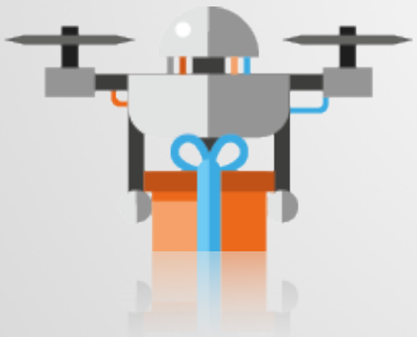


[Roca-Riu, Cao, Dakic, Menendez] Designing Dynamic Delivery Parking Spots in Urban Areas to Reduce Traffic Disruptions. Journal of Advanced Transportation ,2017.

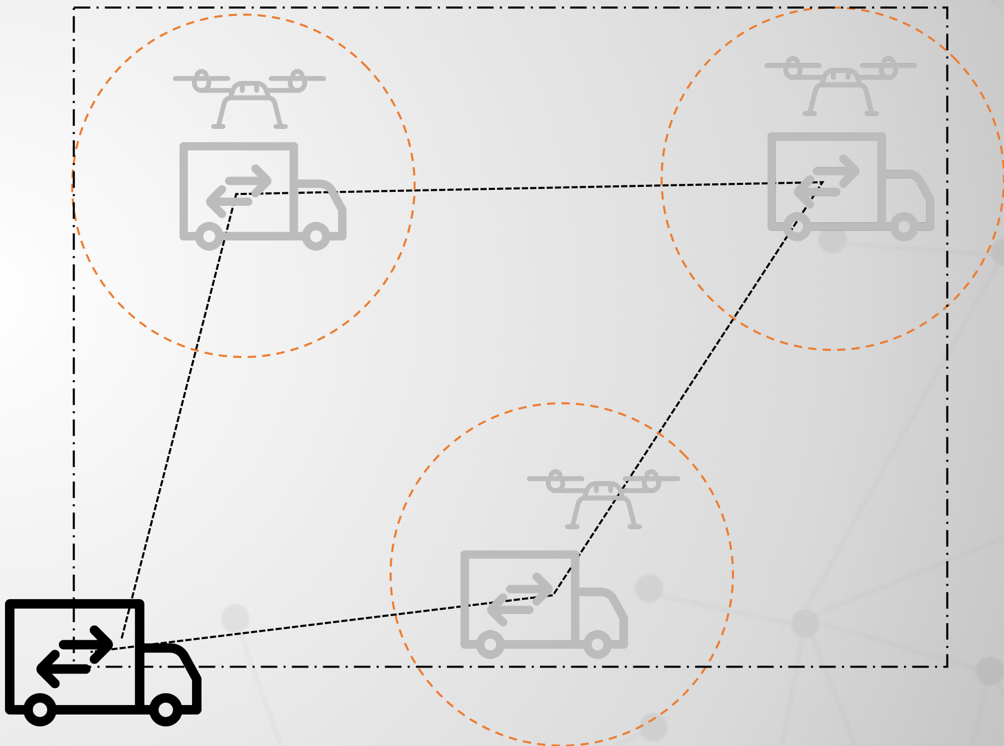
Part I: Parking Assignment Problem

Part II: Dynamic Delivery Parking Spots

Part III: Automation in Urban Logistics



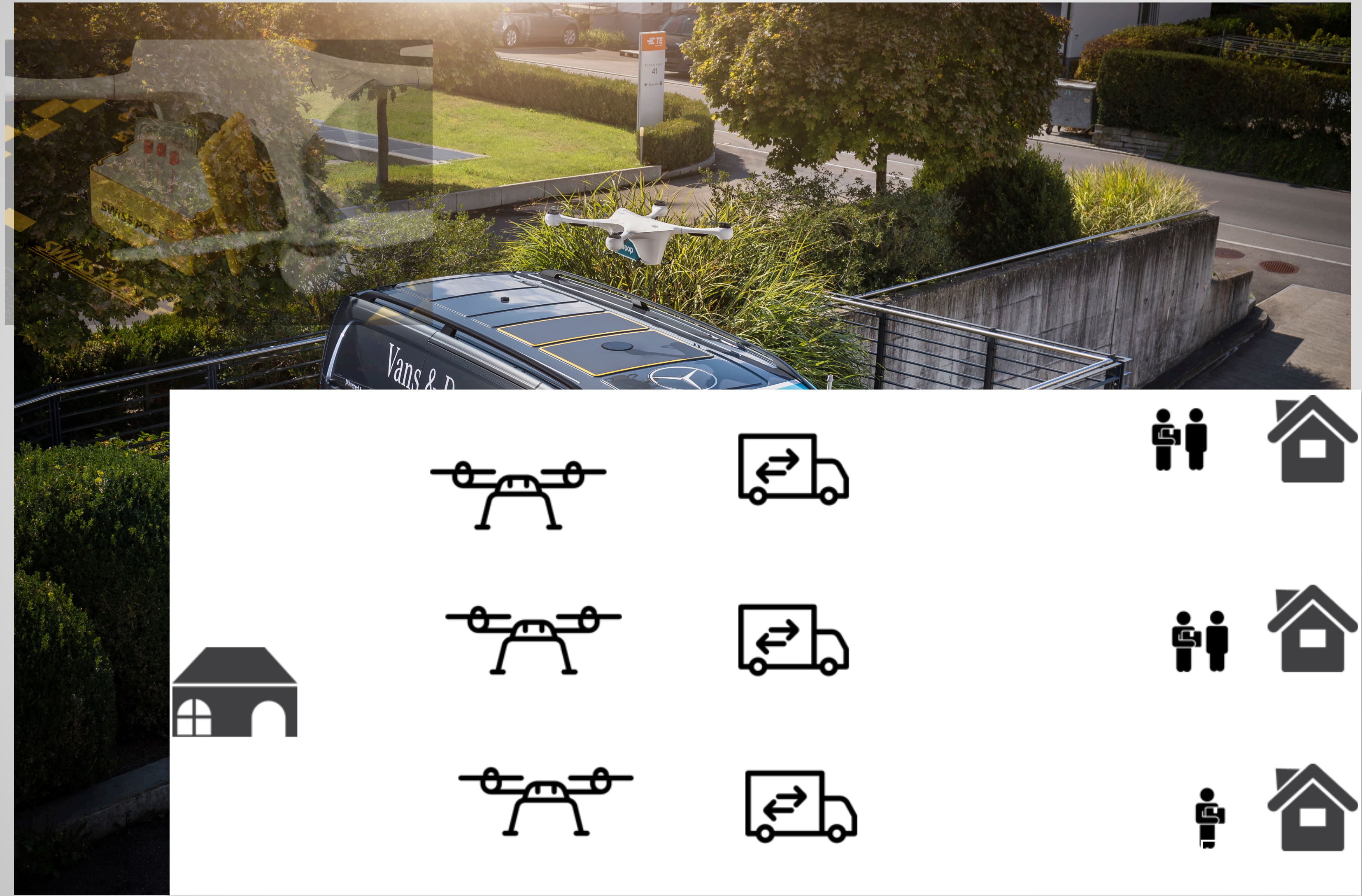
Automation in Urban Logistics (CALog)



Automation in Urban Logistics (CALog)

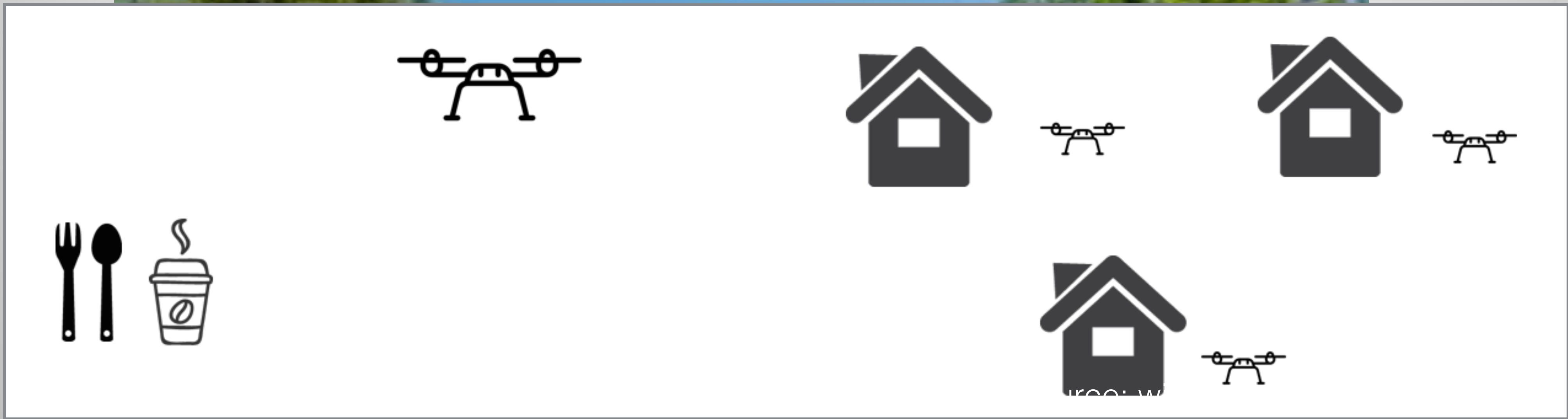
Swiss Post, 2017. Switzerland. Blood Samples

Automation in Urban Logistics (CALog)



Siroop, 2017. Zürich. E-commerce

Automation in Urban Logistics (CALog)

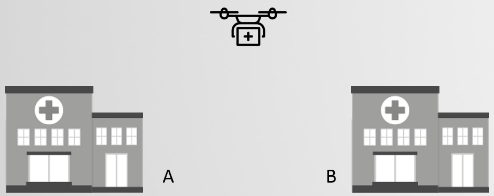


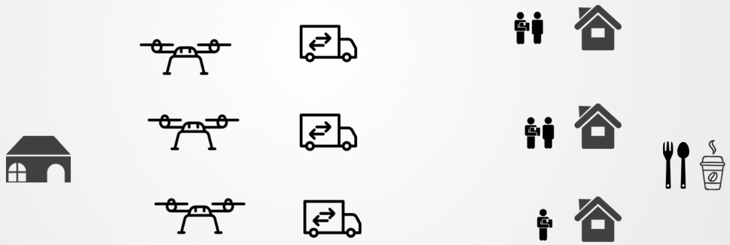
Wing, 2019. Australia. Meals, beverages & others
Finland. ??

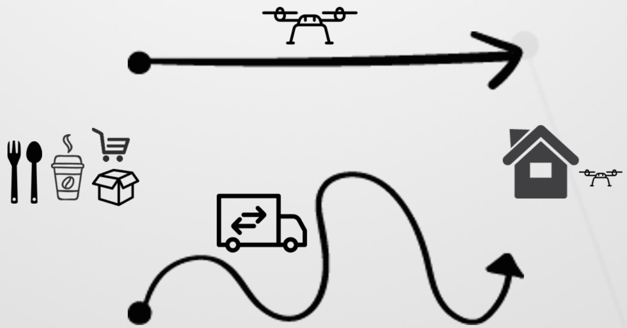
Automation in Urban Logistics (CALog)

Flytrex, 2018. Iceland. Food, groceries, e-commerce?

Automation in Urban Logistics (CALog)



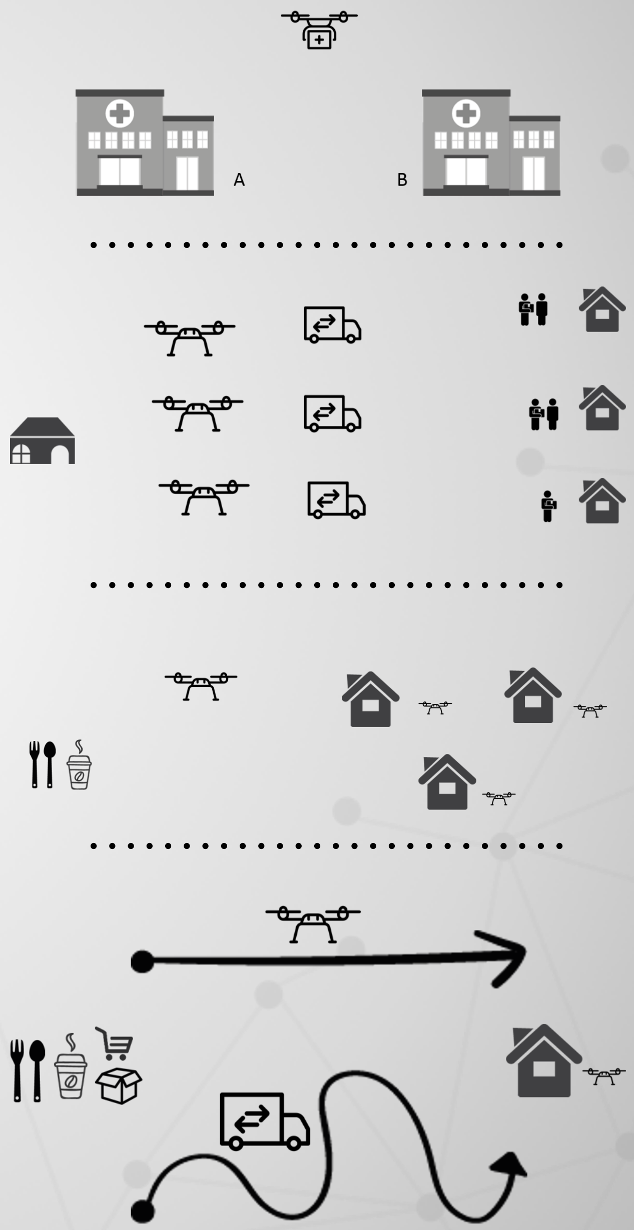




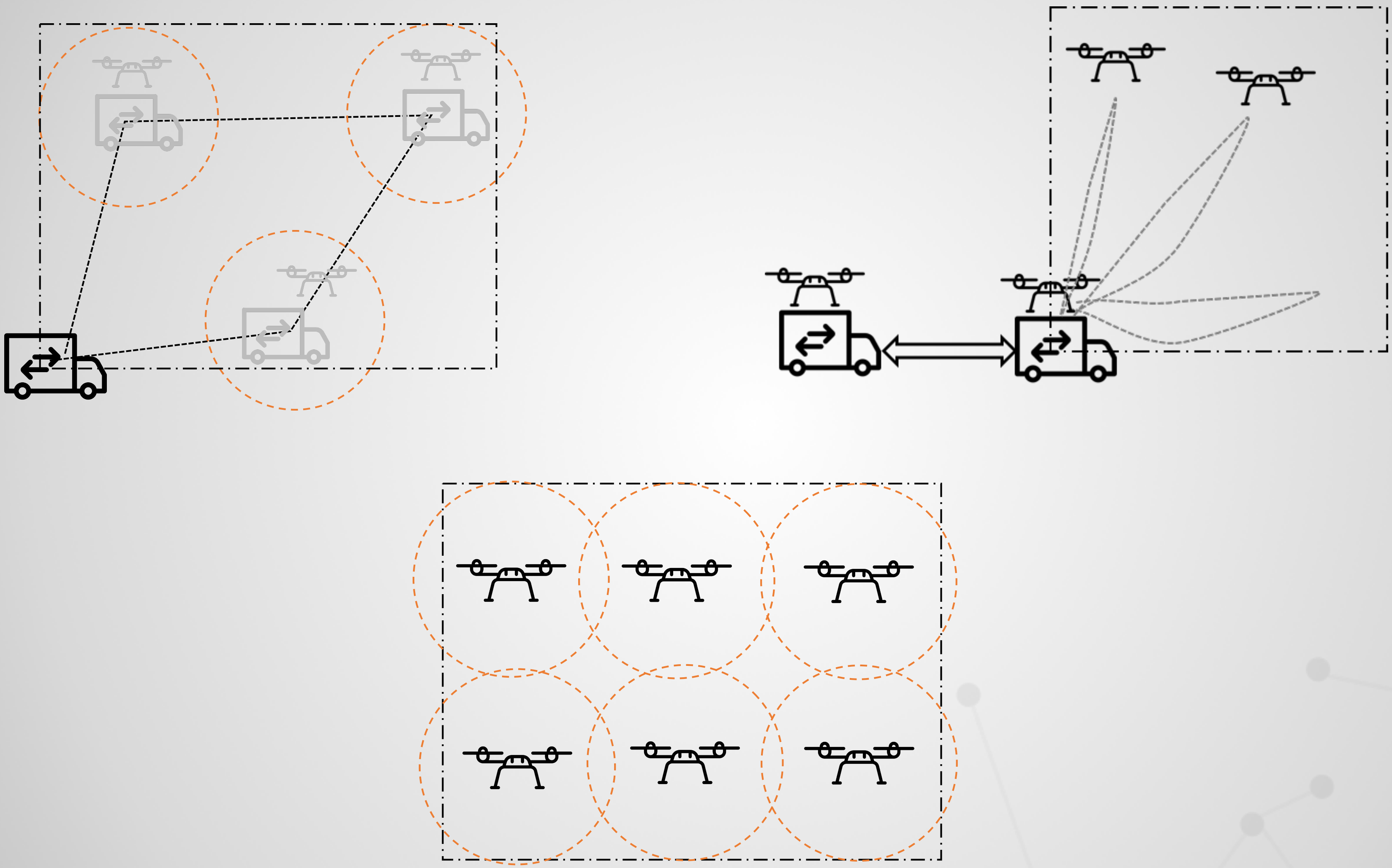
Automation in Urban Logistics (CALog)

Strengths:
- Very fast connection
- Environmental impact
- Low cost
- Accessibility

Weaknesses:
- Small packages & limited range
- Regulations BVLOS
- Launching/Landing
- Data protection
- Noise



Automation in Urban Logistics (CALog)



Chauhan, Unnikrishnan, Figliozzi, 2019. “Maximum coverage capacitated facility location problem with range constrained drones” Transportation Research Part C: Emerging Technologies, 99, 1-18.

Automation in Urban Logistics (CALog)

Cost

D'Andrea, 2014. Guest Editorial Can Drones Deliver?, IEEE Transactions on Automation Science and Engineering, 11 (3) 647-648.

CO_2 Emissions

Goodchild, Toy, 2018. Delivery by drone; An evaluation of unmanned aerial vehicle technology in reducing CO2 emissions in the delivery service industry, Transportation Research Part D: Transport and Environment, 61, 58-67.

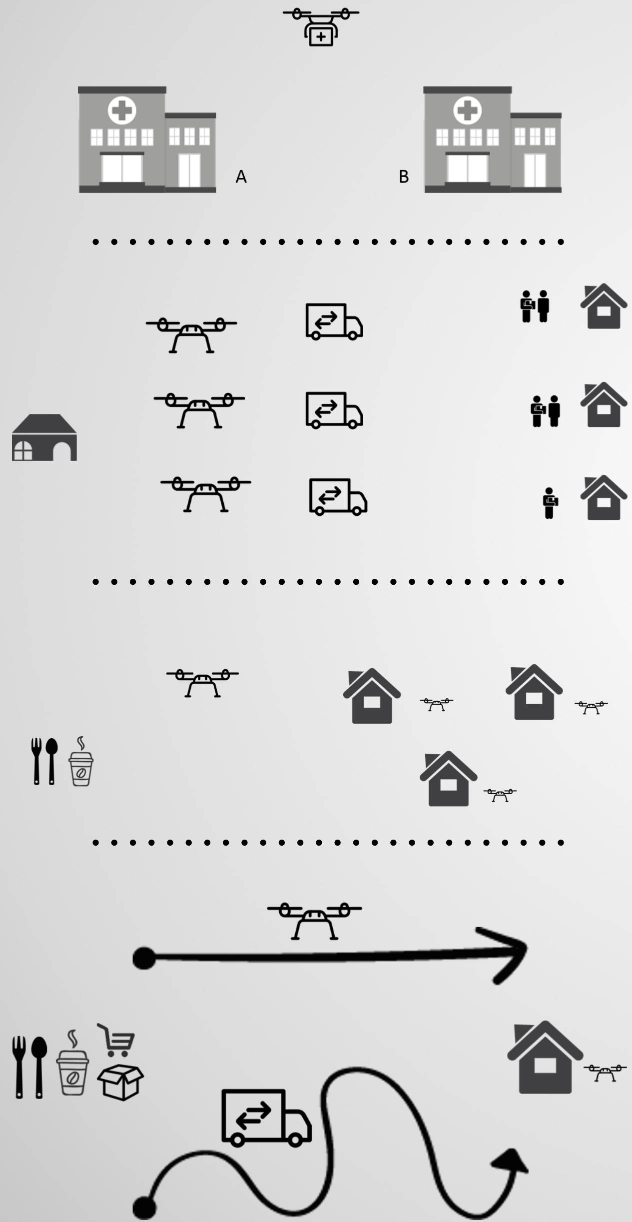
Figliozzi, 2017. Lifecycle modeling and assessment of unmanned aerial vehicles CO2 emissions, Transportation Research Part D: Transport and Environment, 57, 251-261

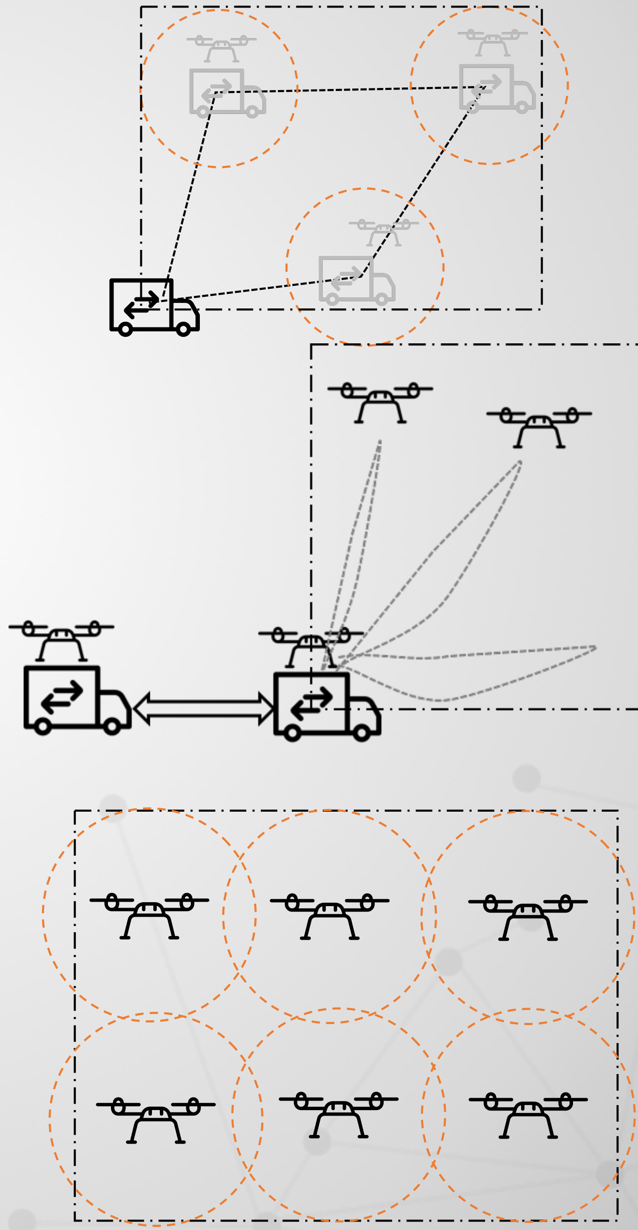
Automation in Urban Logistics (CALog)

" Cargo that it's, small, light, valuable and time-sensitive, where cost is much less of a factor"

Wang, 2016. The economics of Drone Delivery,
https::\\spectrum.ieee.org\automation\robotics\drones\the-economics-of-drone-delivery".

Automation in Urban Logistics (CALog)

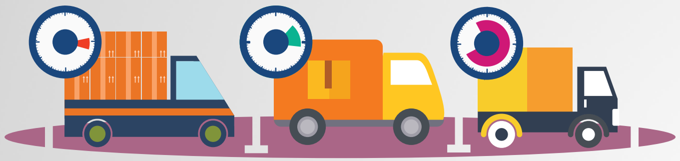




Overall View

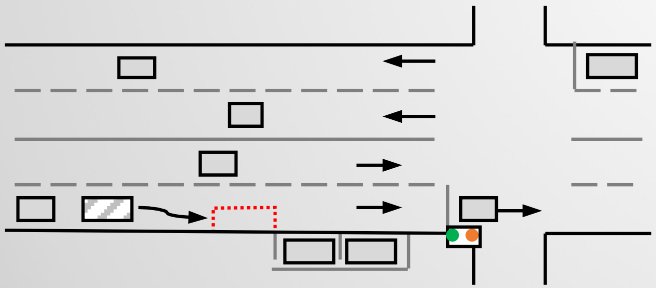
Parking Slot Assignment Problem

Part I



Dynamic Delivery Spots

Part II



Automation in Urban Logistics

Part III

Vielen Dank!

Mireia Roca-Riu

14th June 2019

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