Autonomous cargo bikes: Assessment of applications in the logistics sector

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Otto von Guericke University Magdeburg

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Freight transport is facing major challenges in urban areas.
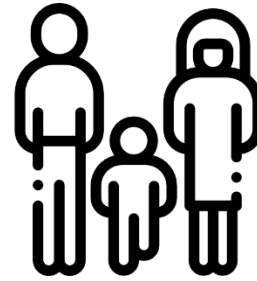
Environmental	Social	Economic
GHG emission	Congestion	High Cost
Land use	Safety issues	High quality requirements
Energy consumption	Health impact	Aging Workforce
↓	↓	↓
Lack of sustainability	**Reduced quality of stay**	**Poor efficiency**

References: e.g. Bosona2020, Boysen2021, Kraus2021

Autonomous delivery solutions are considered promising...

Environmental:

- Reduced emissions

Social:

- Increased road safety

- Less congestion

Economic:

- Increased efficiency and flexibility

- Reduced delivery costs

- Increased service (24/7 operations)

- Limited/negative impact on congestion

- No increase in efficiency

- Limited capacity and speed

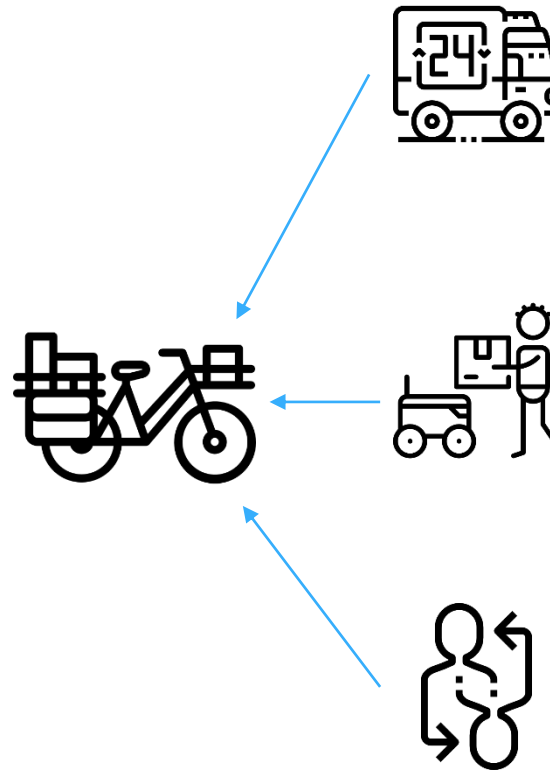- Vulnerable to theft/vandalism

- High implementation effort

- No personal handover of consignments

- Lack of acceptance

... however, they are still confronted with a variety of disadvantages.

References: e.g. Engesser2023, Graf2021, Lehmacher2021, Figliozzi2020

Cargo bikes can fill the gap between delivery robots and vans.

- Reduced congestion

- Increased flexibility

- Moderate capacity, increased speed, especially in dense areas

- Fast implementation

- Personal hand over of consignments

- Social approval, increased brand image

- Limited/negative impact on congestion

- No increase in efficiency

- Limited capacity and speed

- Vulnerable to theft/vandalism

- High implementation effort

- No personal handover of consignments

- Lack of acceptance

References: e.g. Fontes2022, Vasiutina2021, Balm2018, Rudolph2017

We need a system that combines the benefits of cargo bikes and autonomous delivery systems.

Eaasy System research project:

- development of adaptive automated driving functions for cargo bikes

Intended Benefits:

- Increase in efficiency (first studies: 20 % reduction in delivery time)

- Reduction of costs while keeping the delivery person in operation
  → allows good service and complex interactions with consignees

- Improvement the tour without changing the entire logistics system
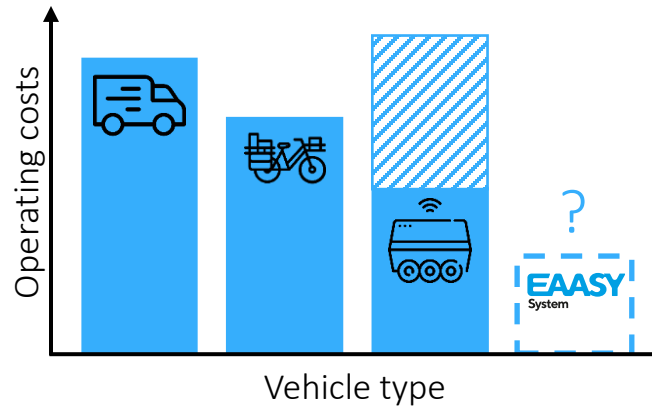 → easy and fast to implement

- **Project:** **E**lectric **A**daptive **A**utonomous **S**mart deliver**Y** System
- **Project duration**: 03/2022 – 02/2025
- **Funding:** Federal Ministry of Economic Affairs and Climate Action
- **Funding programme**: IKT für Elektromobilität
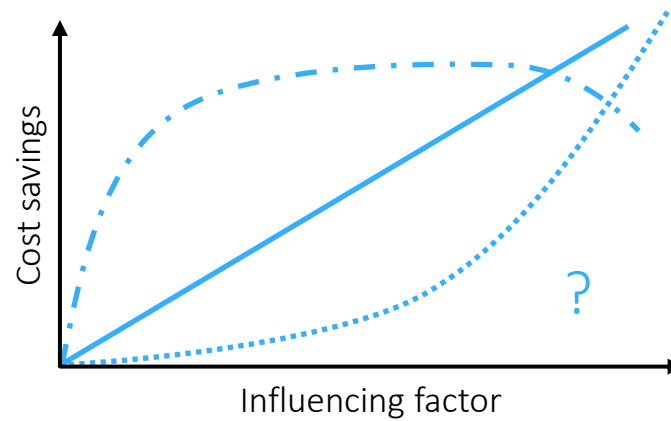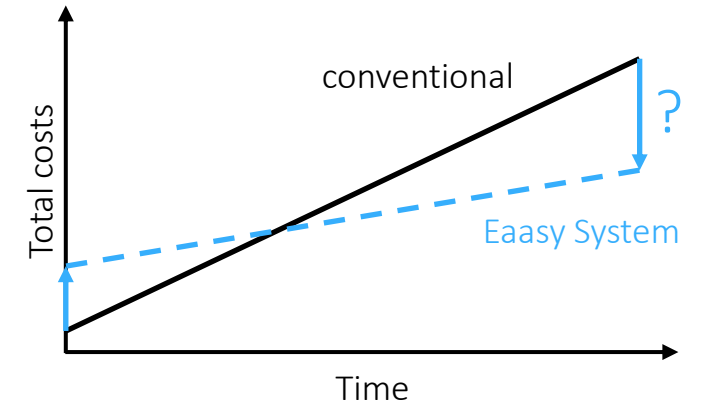
DESIGN: DEVINA ILIEVA
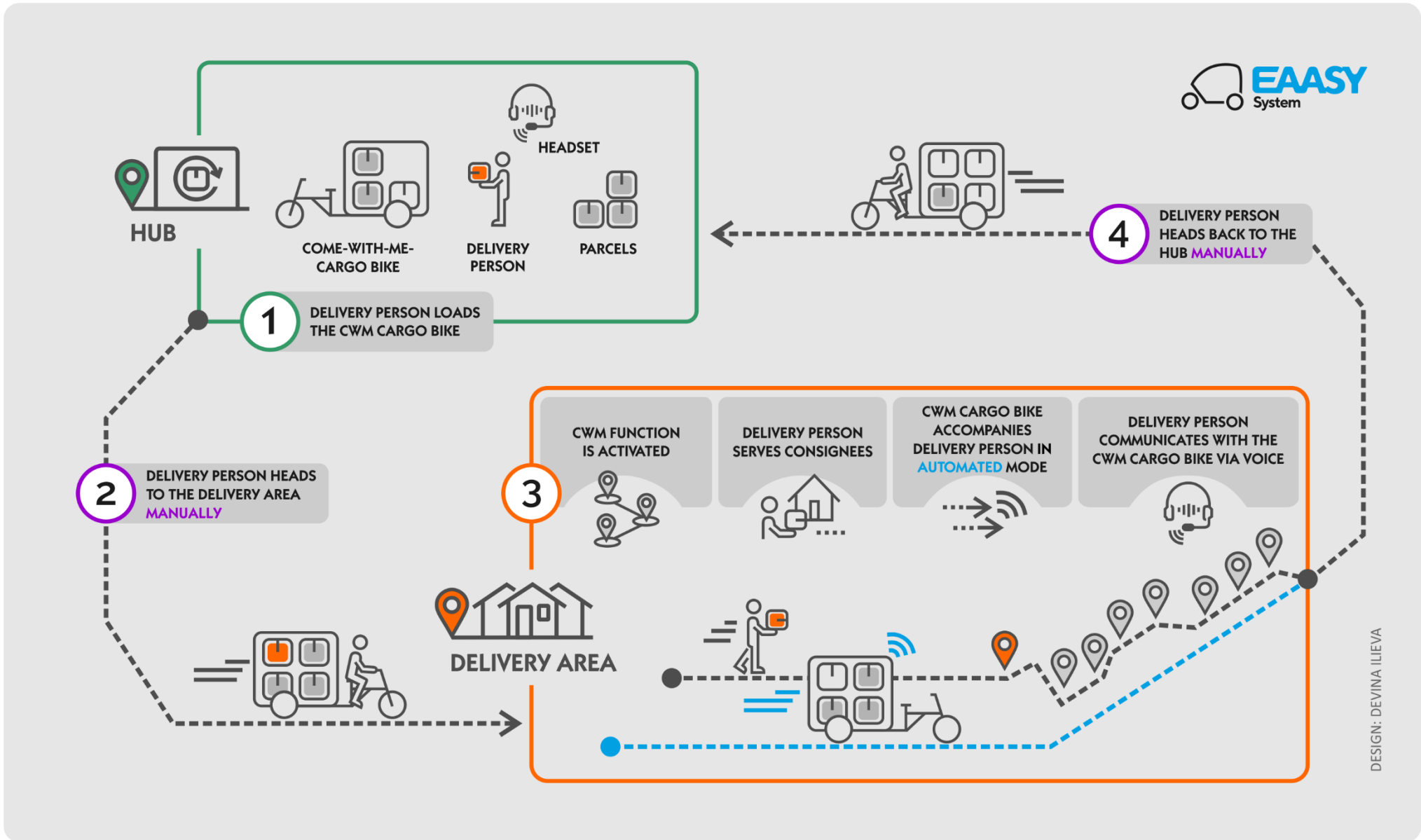
(To what extend) Will our system improve urban freight transport?

Which economic benefits can be realized through the introduction of Eaasy System compared to existing systems?

What are main factors influencing the system's feasibility and applicability?
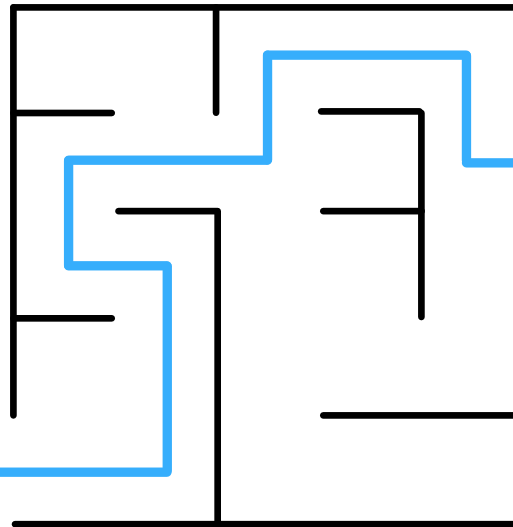
Will higher investment costs be counterbalanced by increased efficiency during delivery tours?

We need a simulation tool to prove the system's applicability.

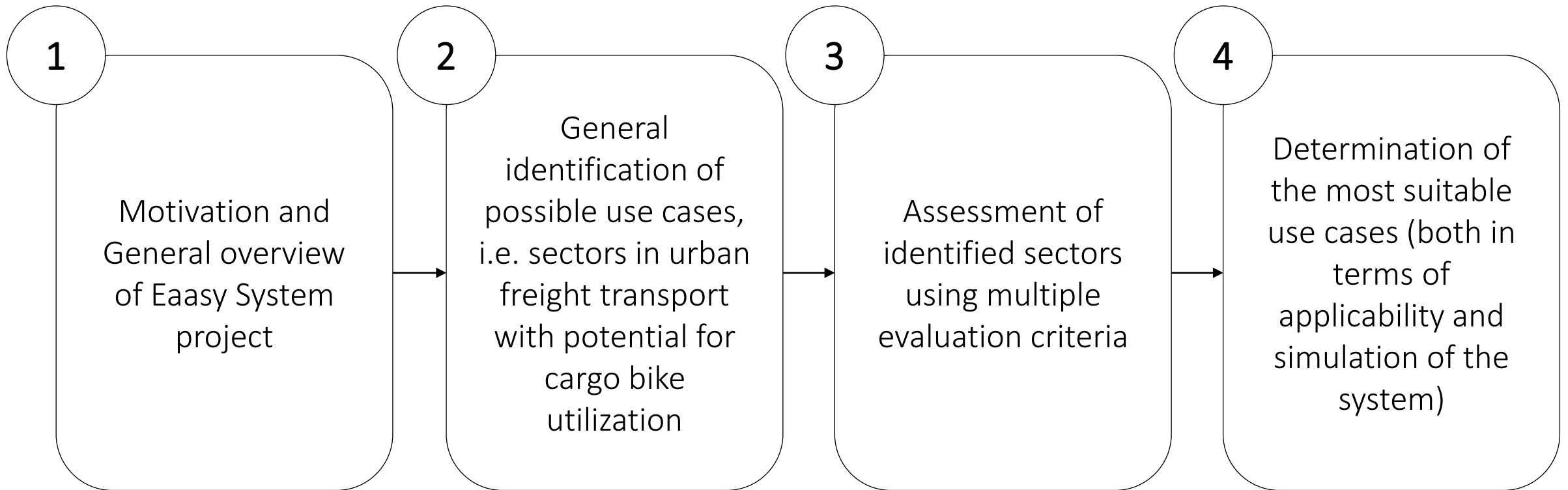System is currently still under development

No opportunity for large-scale testing under real application conditions

Need for a-priori determination of general applicability and influencing factors

Implementation of a simulation-based planning tool for the calculation of time savings and return-on-investment with respect to specific logistics segments and related delivery tours or city areas

Which logistics sectors should be included in our model?

1 Motivation and General overview of Eaasy System project

2 General identification of possible use cases, i.e. sectors in urban freight transport with potential for cargo bike utilization

3 Assessment of identified sectors using multiple evaluation criteria

4 Determination of the most suitable use cases (both in terms of applicability and simulation of the system)

Which logistics sectors are suitable for utilizing cargo bikes?

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- Improved flexibility
- Reduced impact on traffic, infrastructure and environment

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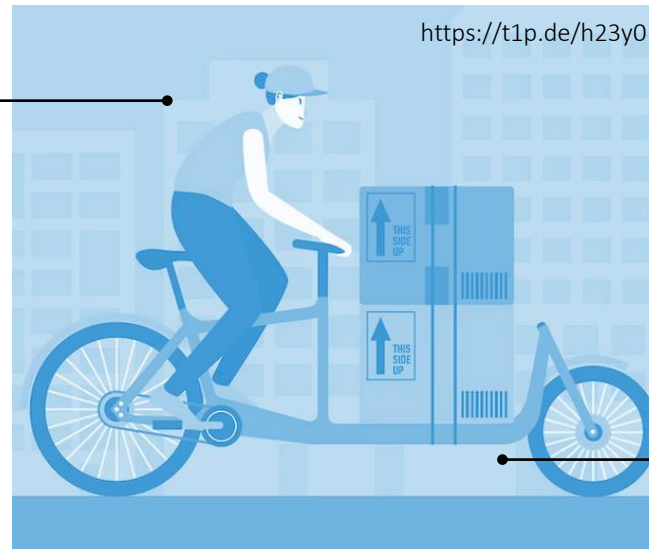
- Limited capacity
- Limited range

Cargo bikes are suitable for logistics segments involving the delivery or transport
of small to medium-sized goods over short distances in dense urban areas.

References: e.g. Eisenmann2021, Thoma2019, Orving2018, Melo2017

Which logistics sectors are suitable for utilizing cargo bikes?

Freight

- Postal services
- Press services
- Courier and express services
- Parcel services
- Combined delivery
  - Postal & Press
  - Postal & Parcel
- Home delivery services
- Small retail
- Waste collection
- Internal transport

Service with goods

- Craftsman
- Suppliers, Mobile sales stands
- Stage or event technicians
- Public services (e.g. public gardening)

Service without goods

- Craftsman (only installation)
- Care services
- Other business trips

References: e.g. Bohne2021, Leerkamp2020, denBoer2017, Rudolph2017

Which additional criteria should be considered assessing the utilization of automated cargo bikes?

Process characteristics

- Dense network with large amount of stops
- High proportion of distances travelled on foot

Environment/infrastructure

- Environment with (many) slow road users or low overall speeds
- Poor accessibility for fully automated vehicles

Service

- Complex activities or interactions that cannot (yet) be automated

Market potential

- Integration with existing systems
- Demand towards innovation

Which logistics sectors are suitable for automated cargo bikes?

	Process characteristics	Environment	Service	Market potential
Postal services	+	+	+	+
Press services	+	+	+	+
Parcel services	+	+	+	+
Combined delivery	+	+	+	+
Express/Courier	-	+	+	-
Home delivery services	-	o	+	-
Retail	-	+	+	+
Waste collection	+	+	+	o
Internal transport	o	o	o	+
Craftsman	-	o	+	-
Suppliers, sales	-	o	+	o
Event logistics	+	+	+	o
Public services	+	+	+	o
Service without goods	o	o	+	-

Summary: There are multiple use cases for automated cargo bikes.

- Automated cargo bikes are a promising solution for automation of urban freight transport as they combine benefits of delivery robots and conventional cargo bikes.

- There are many logistics sectors suitable for cargo bikes, but not all of them offer potential for automation.

- The automation of cargo bike related mail, press and parcel deliveries is promising.

- The use of automated cargo bikes for event logistics, waste collection, and public services is also promising, however, there is a lack of data to investigate the applicability.
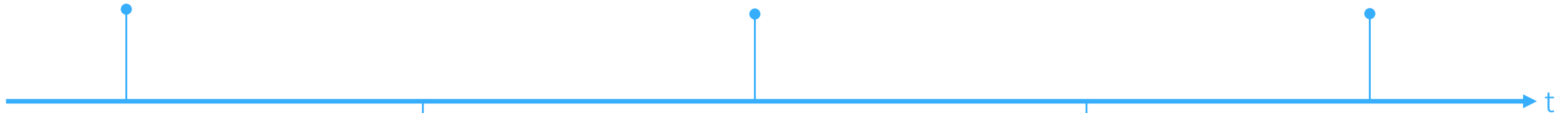
What's next?

Conduction of large scale work cycle analysis (parcel + postal + press)

Conduction of field tests, validation of simulation model

Implementation of web-based planning tool

Implementation of simulation model (generic system behavior)

Model adjustment, application to other use cases

Accompanying trip with a CEP service provider in Berlin:

- Example of a parcel delivery tour section suitable for utilizing autonomous cargo bikes

- Parcels are at present already being delivered with cargo bikes

- Multiple, closely located stops

- High proportion of idle time (get on/off the bike, scanner operation, sorting parcels)

- Previous project: AuRa (Autonomes Rad, autonomous bike)

- Aim: development of bike-sharing system with autonomous driving cargo bikes

- First insights on autonomous driving cargo bikes
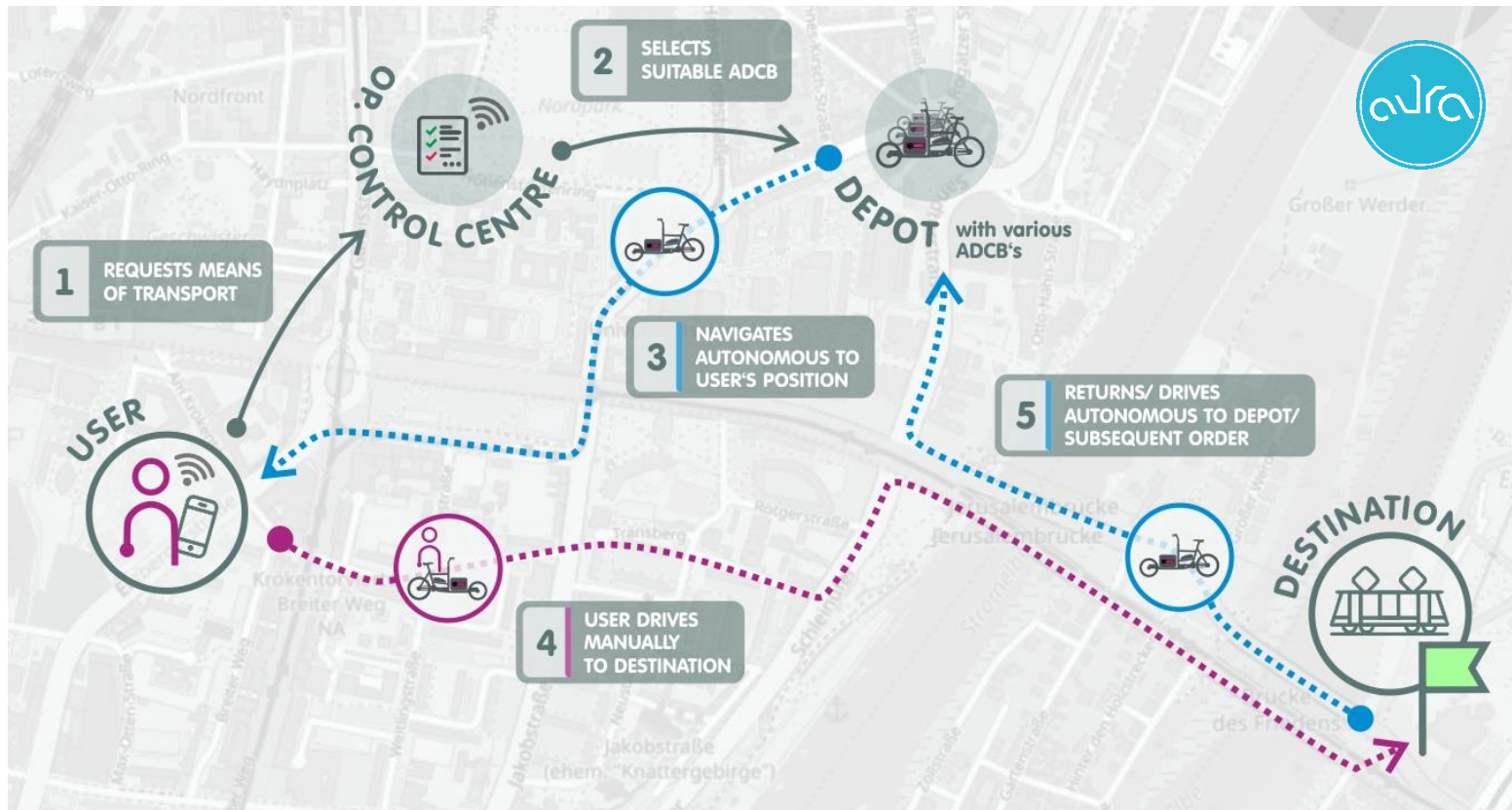
ONOMOTION is among the participating partners in the Eaasy System project providing the platform for the prototype.

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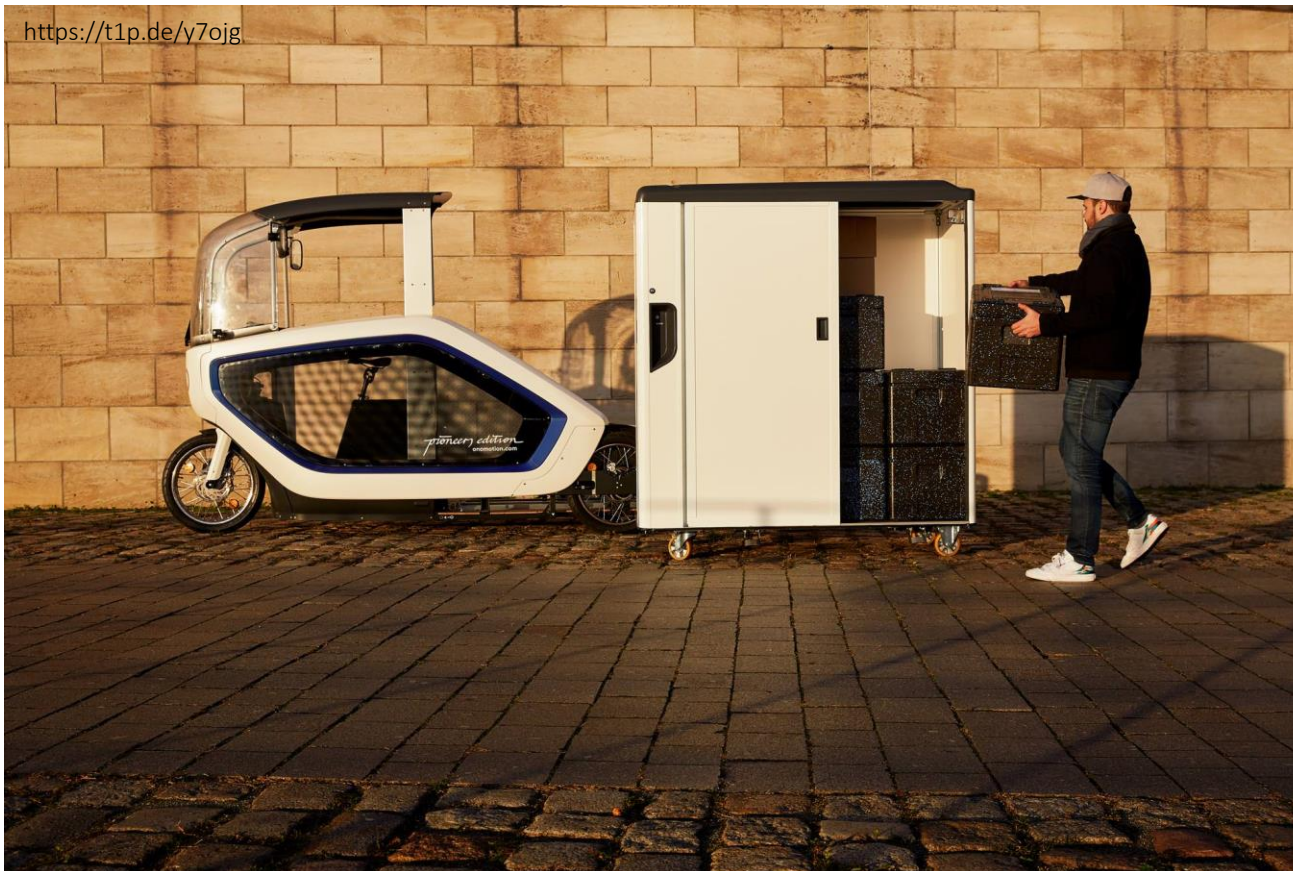
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