Co-design and Coordination of Future Mobility Systems

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The Frazzoli Group at the Institute for Dynamic Systems and Control

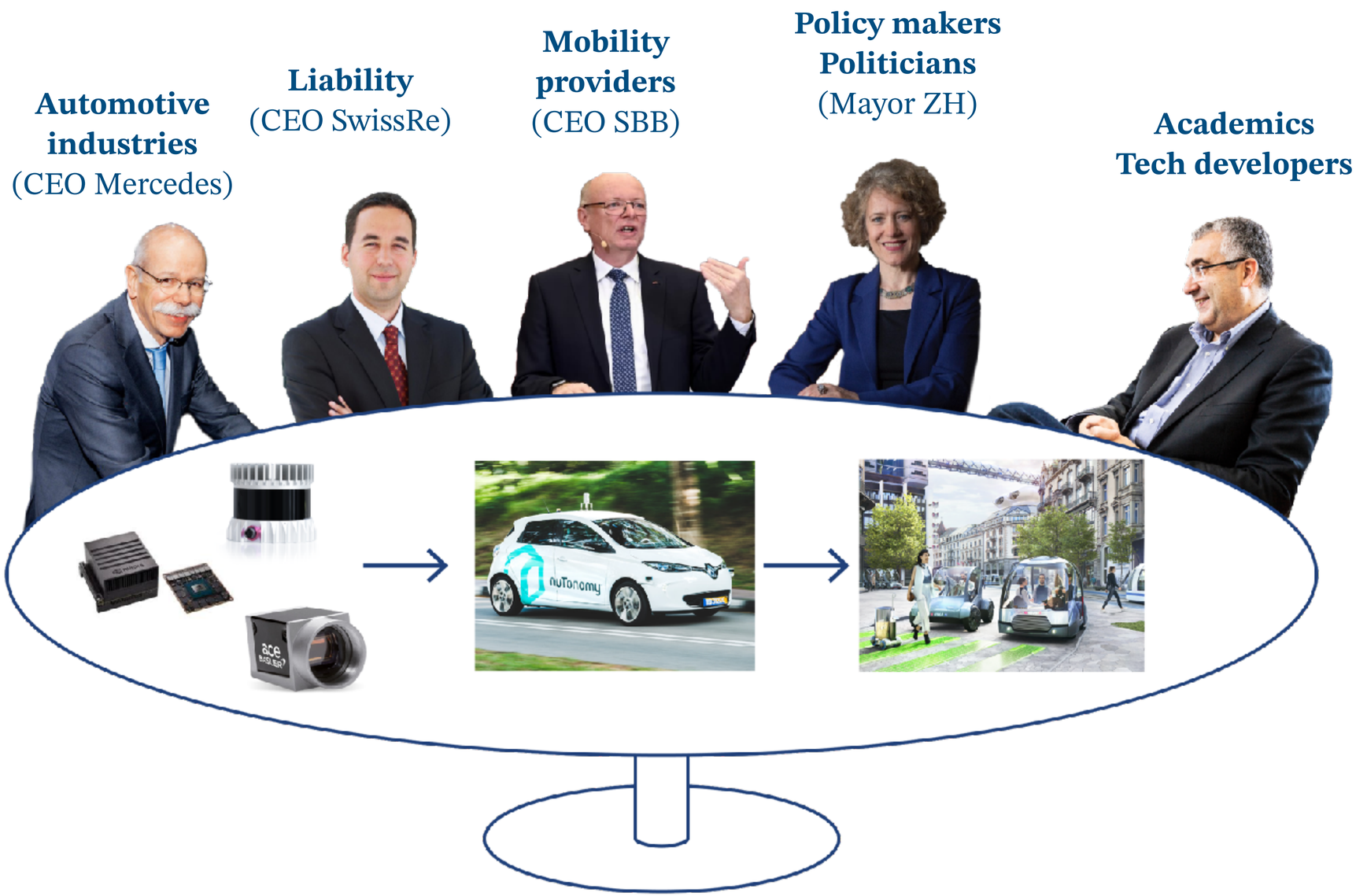
- We do research in **autonomous systems**
- We have a particular expertise in **autonomous vehicles**

Industry experience:
nuTonomy (now Motional)

Academic research: Self-driving go-karts, autonomy, and future mobility systems

Outreach: Duckietown

Mobility systems are very complex socio-technical systems



Complexity due to multiple stakeholders: Public sector view

Questions

How to meet sustainability goals while accommodating urbanization?

How to define public investments for the next 50 years ?

How to guarantee quality of life related to transportation?

How to handle private companies which use public resources?

Tools

Policies and regulations

Public transit pricing

Incentive and taxation systems

Complexity due to multiple stakeholders: Private sector view

Questions

Larger demands: which new business models?

How to react to government rules?

What do the customers want?

In which technology should we invest?

How to get a certain return on investment?

Tools

Pricing

Service design

Fleet sizes

Fleet compositions

Technology design

Co-design at various scales

City level

Optimal infrastructure choice

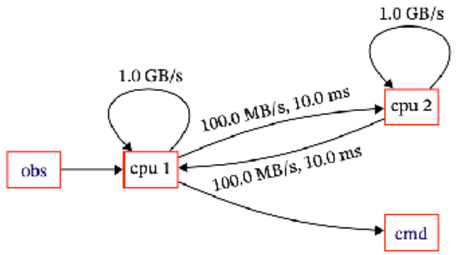
Single service level

Optimal fleet choice

Component level

Optimal sensor and control choice

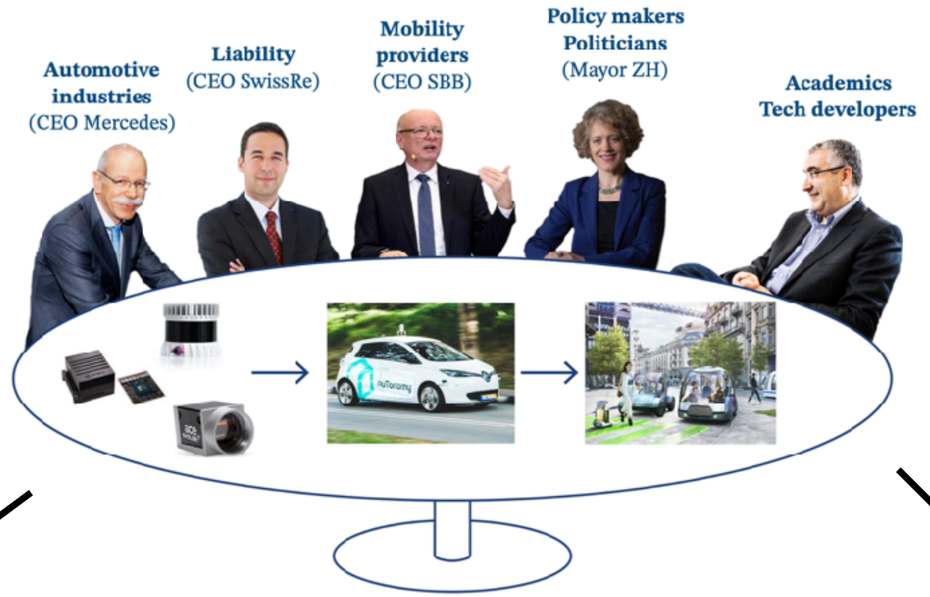
Implementation in the component level



Optimal resource allocation for computation of algorithm

We leverage co-design and game theory to solve complex socio-technical problems

Complex socio-technical system



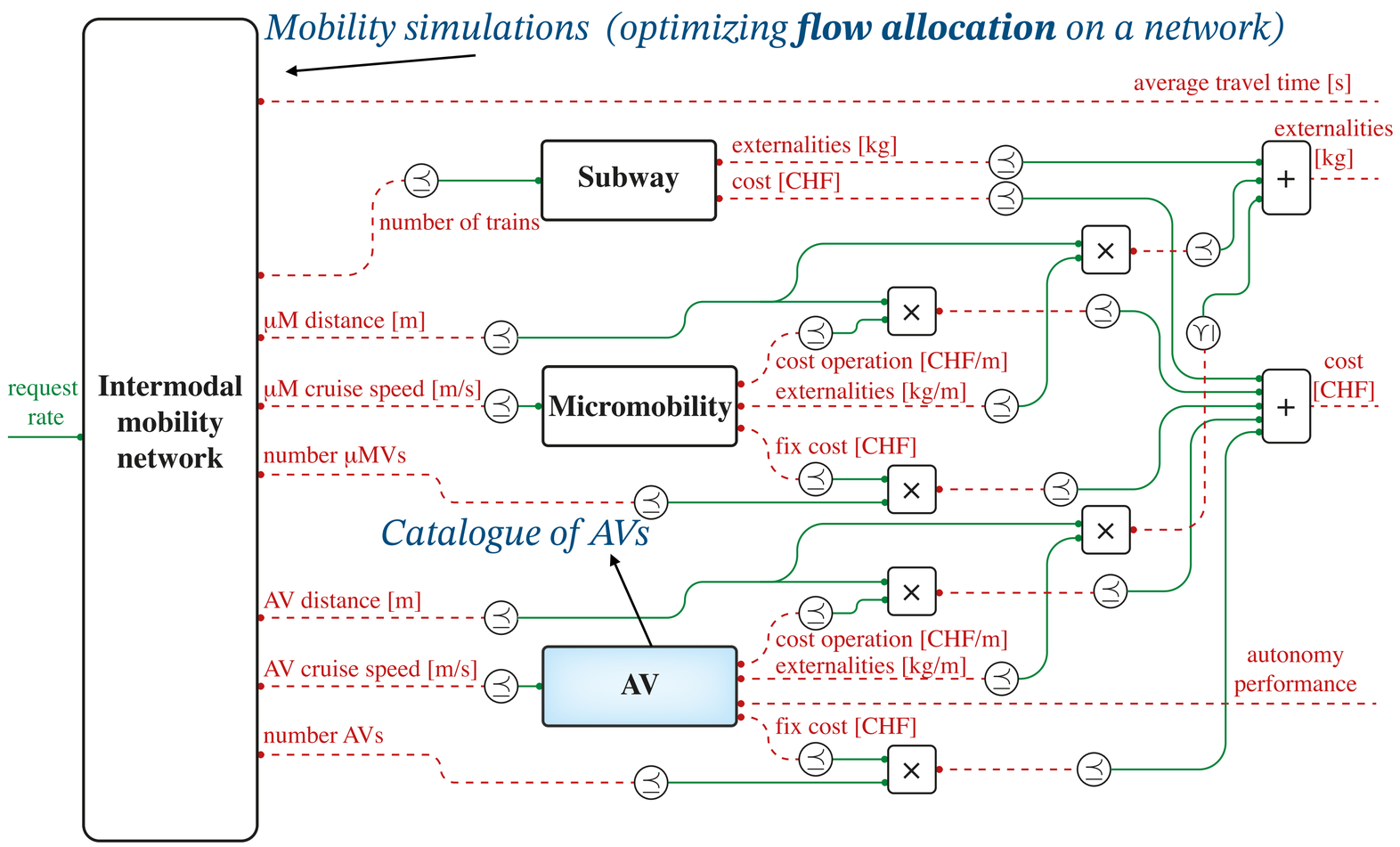
Large interconnected system

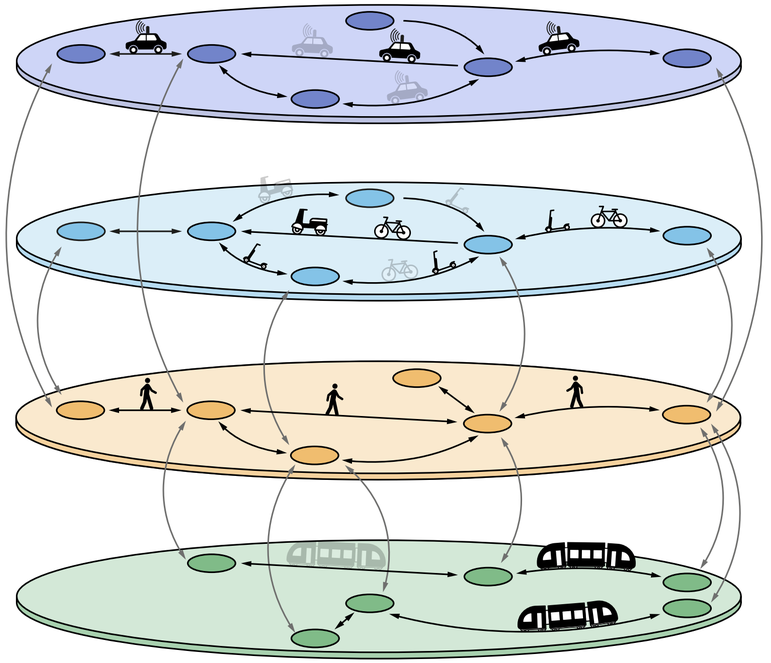
Mathematical theory of co-design
applied category theory

Many agents, many (often conflicting) interests

Game theory

Modeling the mobility system as a co-design problem





Subway:

Fun: *number* of trains to buy
Res: *costs* and *externalities*
Imp: acquisition *contracts*

Micromobility:

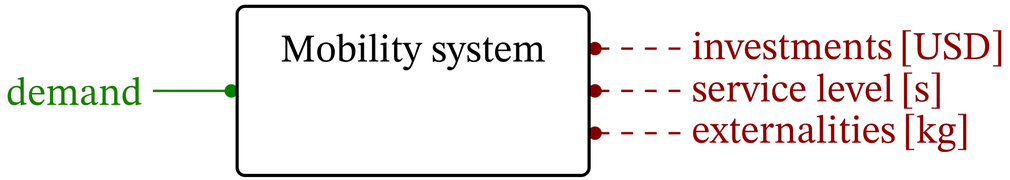
Fun: *speed* of the vehicle
Res: costs and *externalities*
Imp: vehicle *models*

AV:

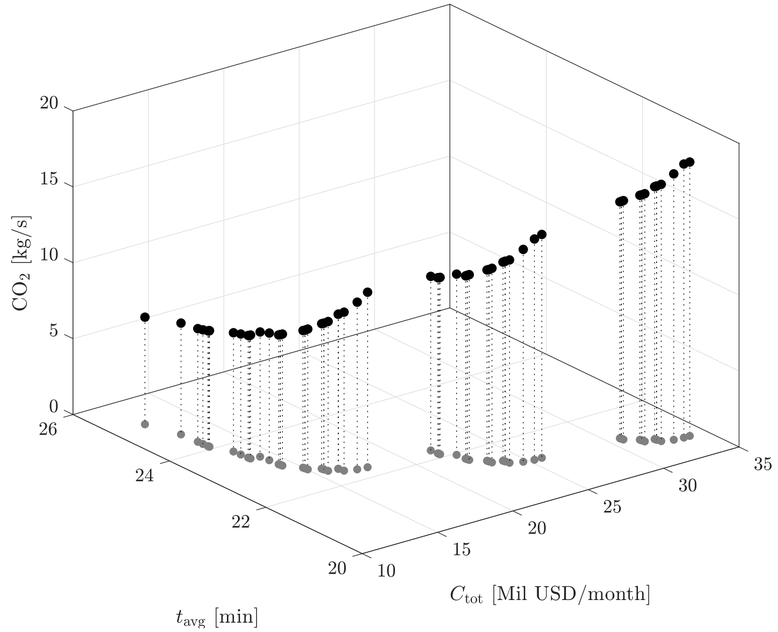
Fun: *performance* of the vehicle
Res: costs, *externalities, performance*
Imp: vehicle *models* and autonomy

In submission to TNSE: https://bit.ly/35a5Wyx

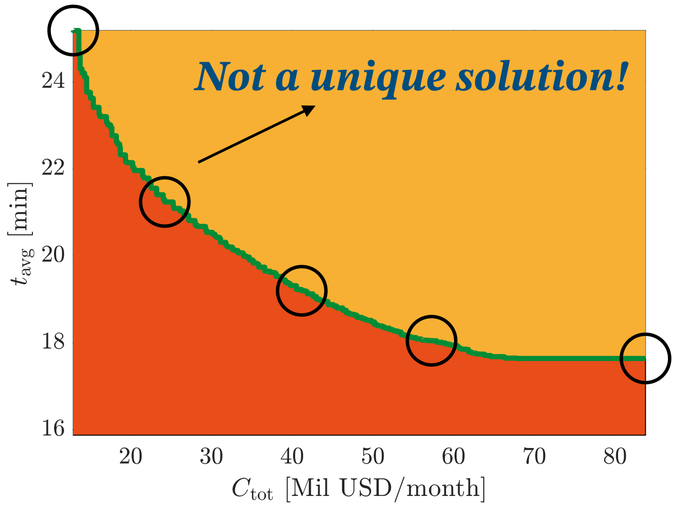
Co-Design produces actionable information for stakeholders

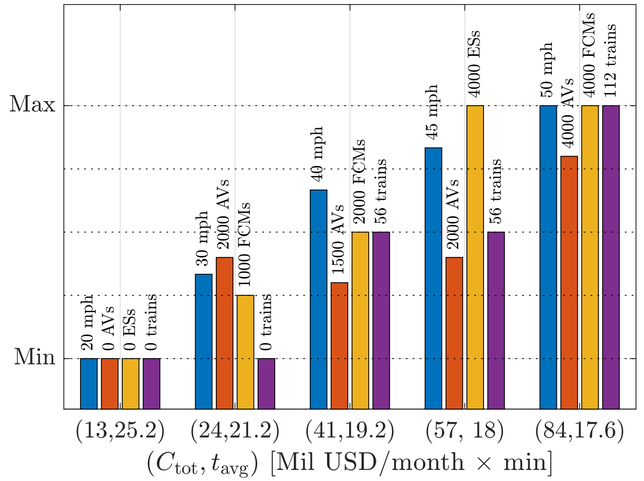


Fixed a **demand**, we find the **Pareto front** of **incomparable**, **minimal solutions** as **cost**, **time**, and **externalities**



Convert **externalities** into **cost** and interpret the results:





Results for real world case study of Washington D.C.

Which one is the best? Depends on what is at the upper level (policy-making, etc.)