Future Scenarios and Technology for Urban Transport

– Role of transport modelling in future transportation systems

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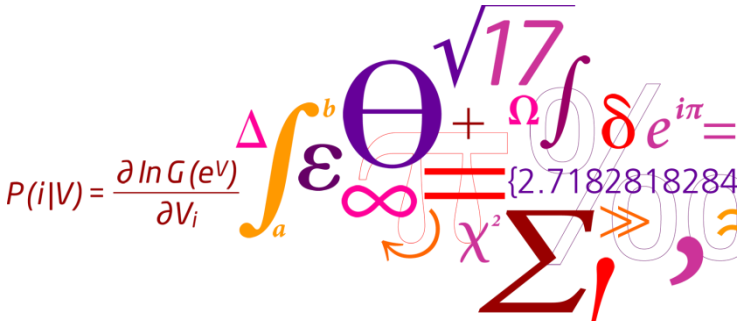
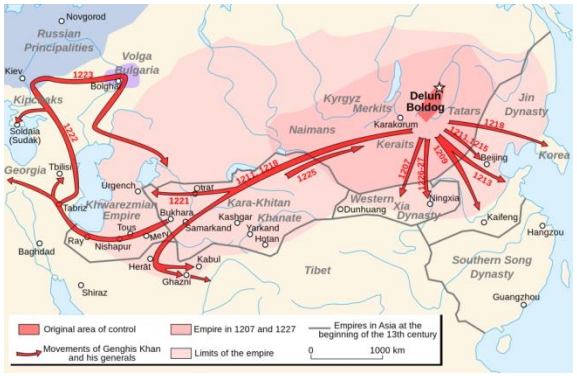
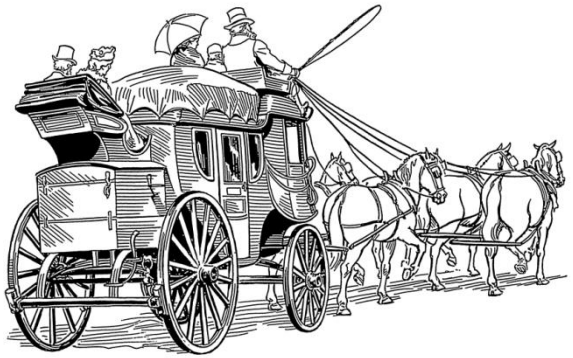


Transport Modelling
Department of Management Engineering

The first transport revolution

- Use of animals for transport
  - Gradually developed over thousands of years
  - Speed, load





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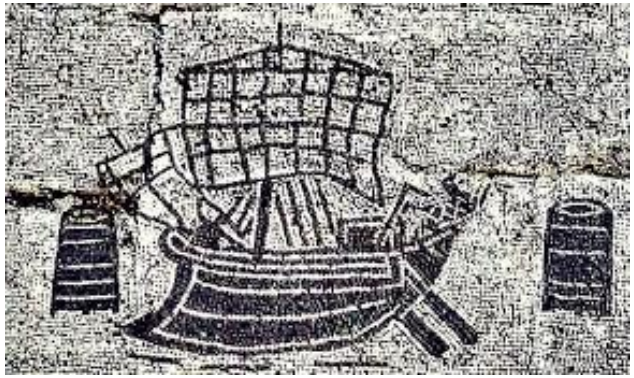
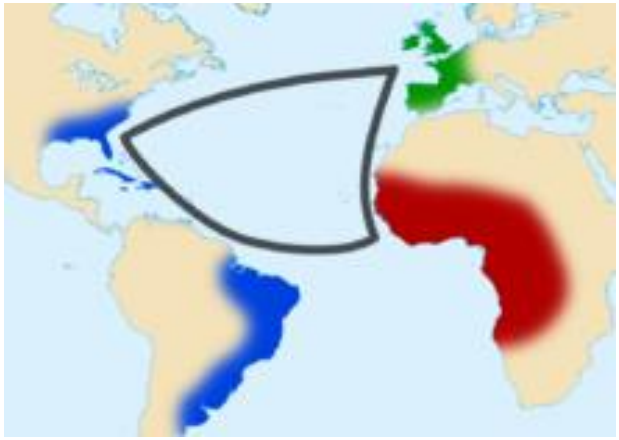
The second transport revolution

- Use of wind for sea transport
  - Gradually developed over thousands of years
  - Improved ship building technology and navigation





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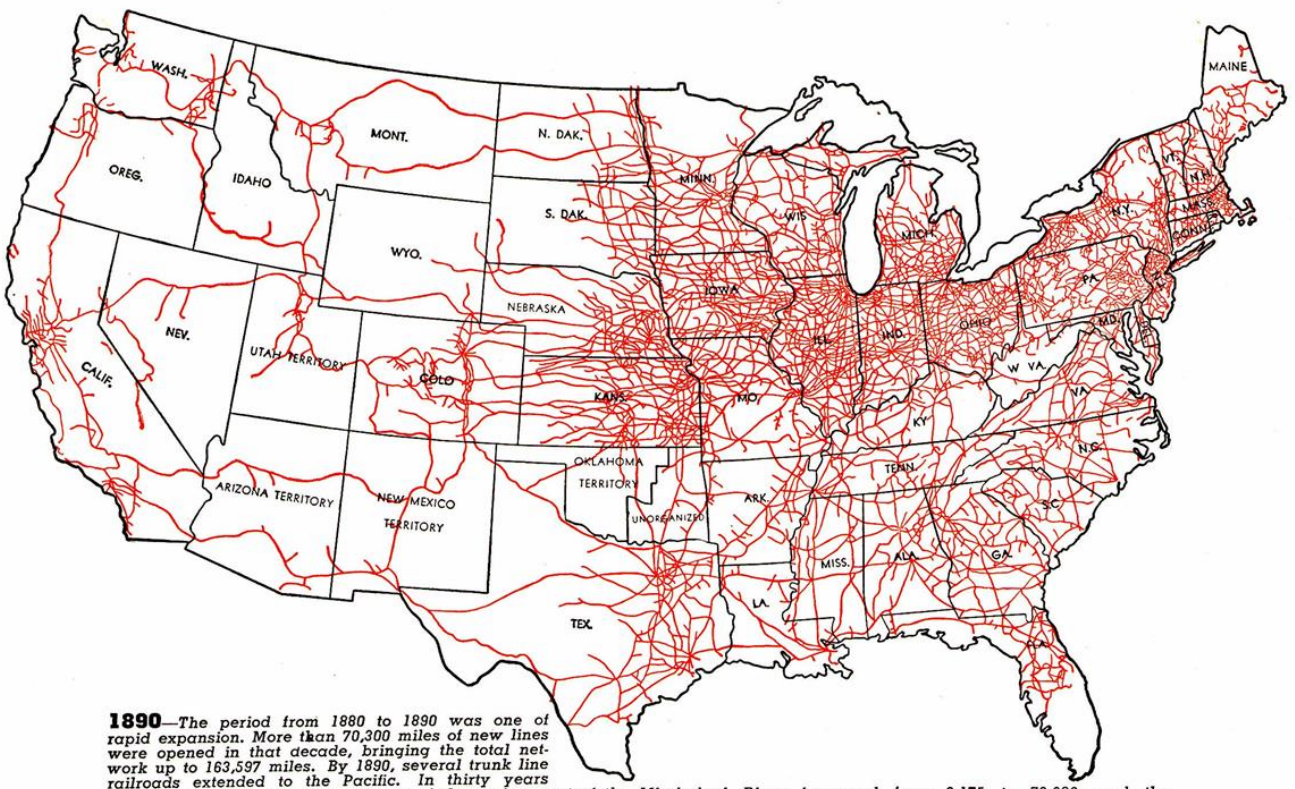
The third transport revolution

- Machines as power source
  - Fast technology development, US rail network development 1880-1890



1890—*The period from 1880 to 1890 was one of rapid expansion. More than 70,300 miles of new lines were opened in that decade, bringing the total network up to 163,597 miles. By 1890, several trunk line railroads extended to the Pacific. In thirty years from 1860 to 1890, the total mileage of the region west of the Mississippi River increased from 2,175 to 72,389, and the population of that area increased fourfold.*

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Transport achievements, in general

- Faster (usually)
- More comfortable (in general)
- Much larger volumes
- More reliable (usually)
- Cheaper (per unit)

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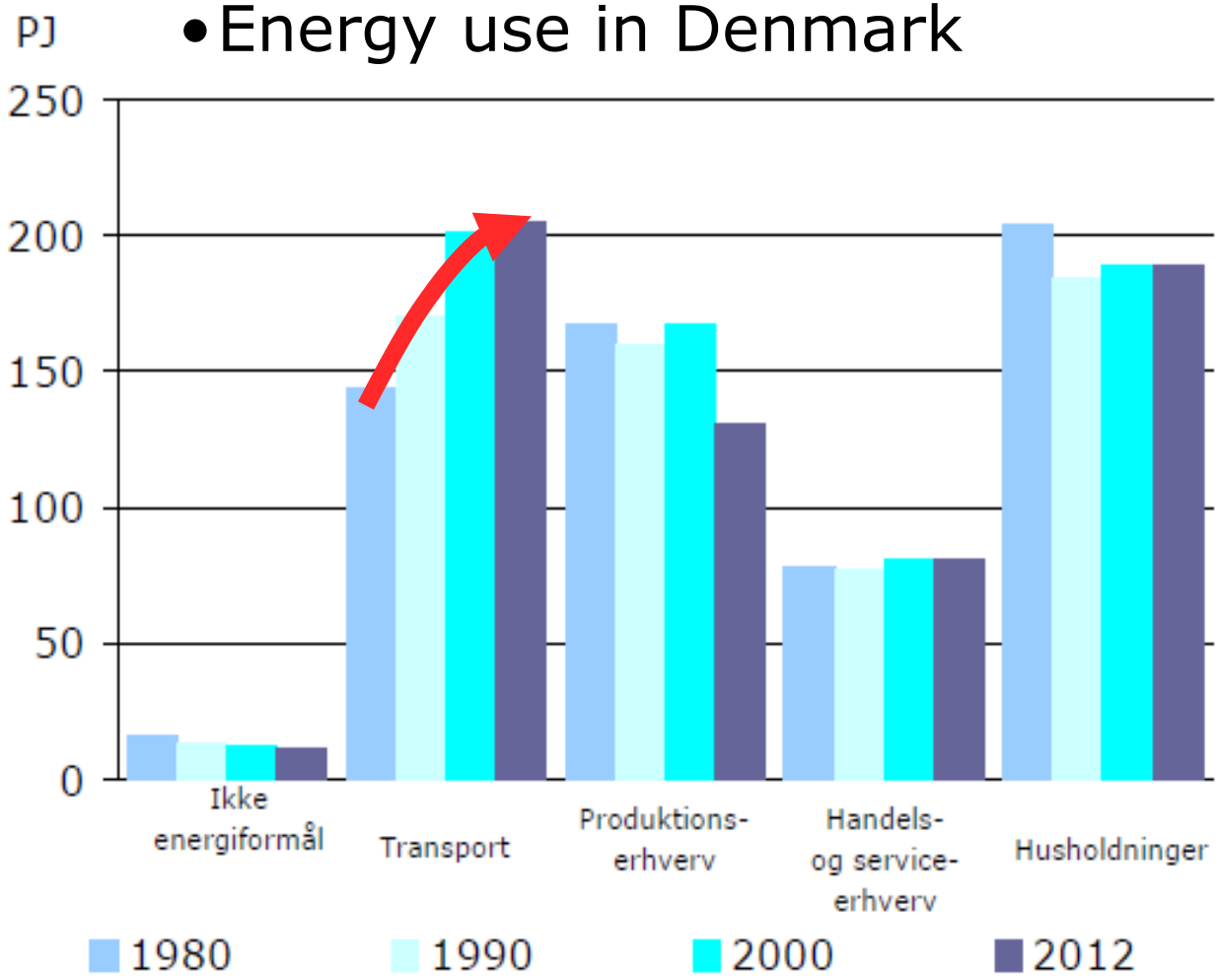
However, challenge with regard to energy use and climate,…

- Energy use in Denmark



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…and capacity problems in the transport network

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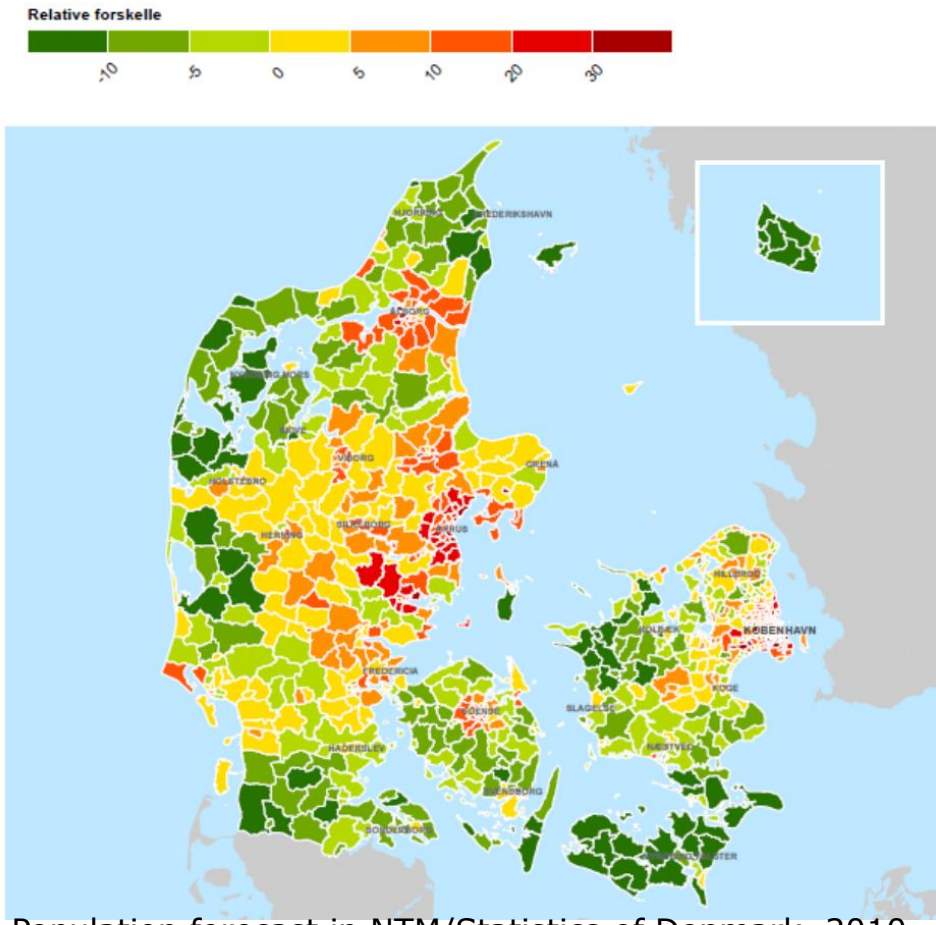
Recent Demand changes in Denmark

- Urbanization
  - Challenges both in urban and rural areas
  - Changed commuting patterns
- MaaS
  - Enable non-car owners to use cars
- Car ownership
  - Changes due to changed taxation
  - Energy efficient micro cars
- Changed goods transport and delivery concepts
  - Internet sale almost 25% of retail



Population forecast in NTM/Statistics of Denmark, 2010-2030

http://www.dr.dk/nyheder/penge/danskernes-internethandel-naermer-sig-100-milliarder-kroner

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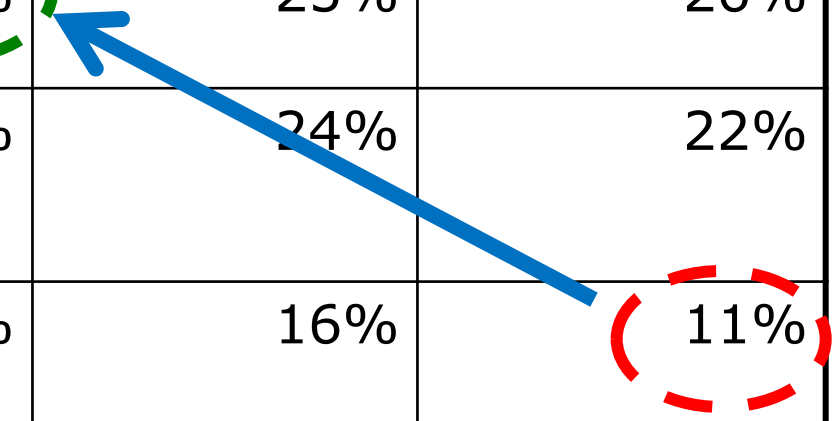
Public transport market share (%), commuting

(National Transport Survey)

Distance from work to station	Distance from home to station		
	<400 m	400-800 m	800-2000 m
<400 m	31%	25%	26%
400-800 m	25%	24%	22%
800-2000 m	27%	16%	11%



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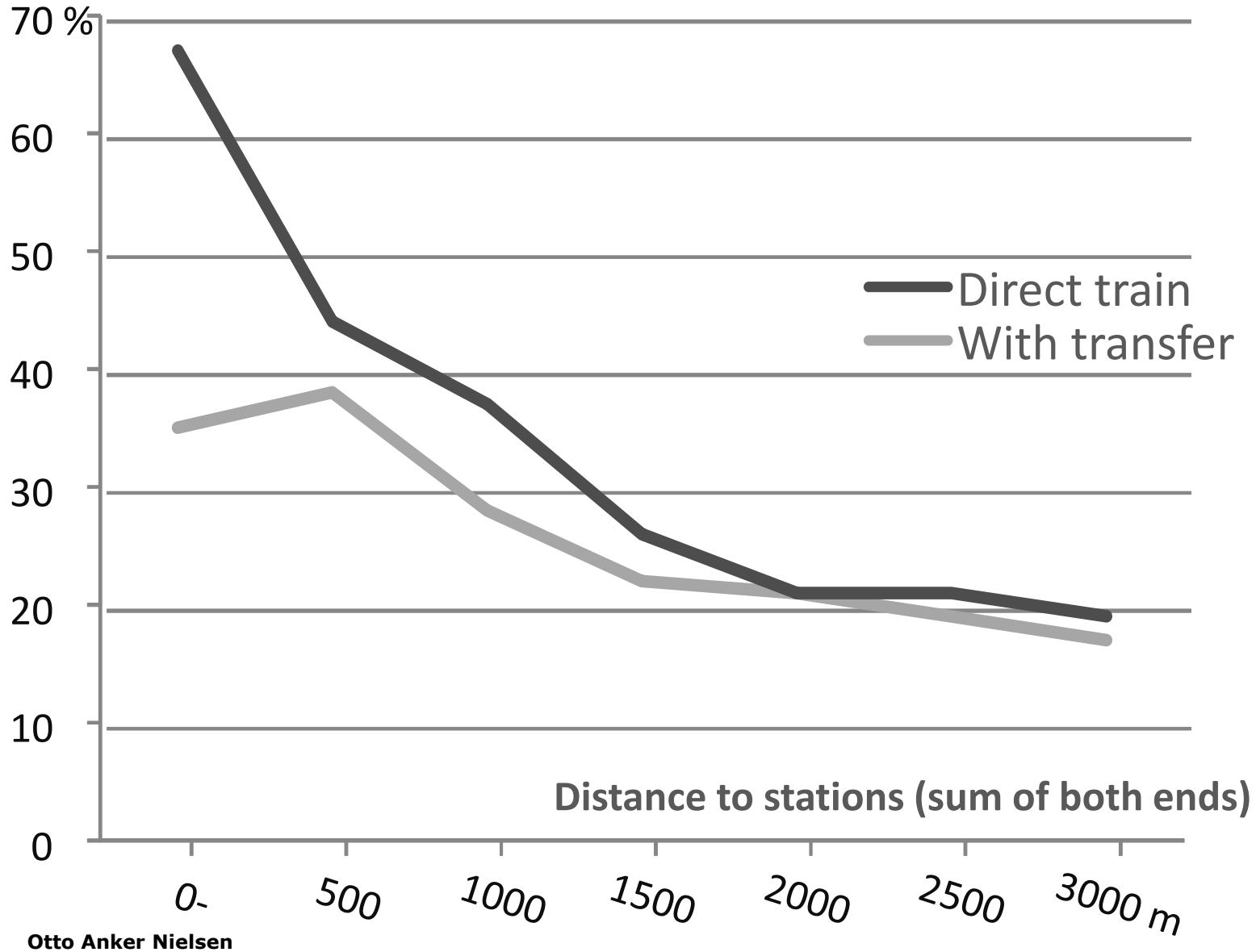
Market share public transport (%)
Copenhagen region, commuting



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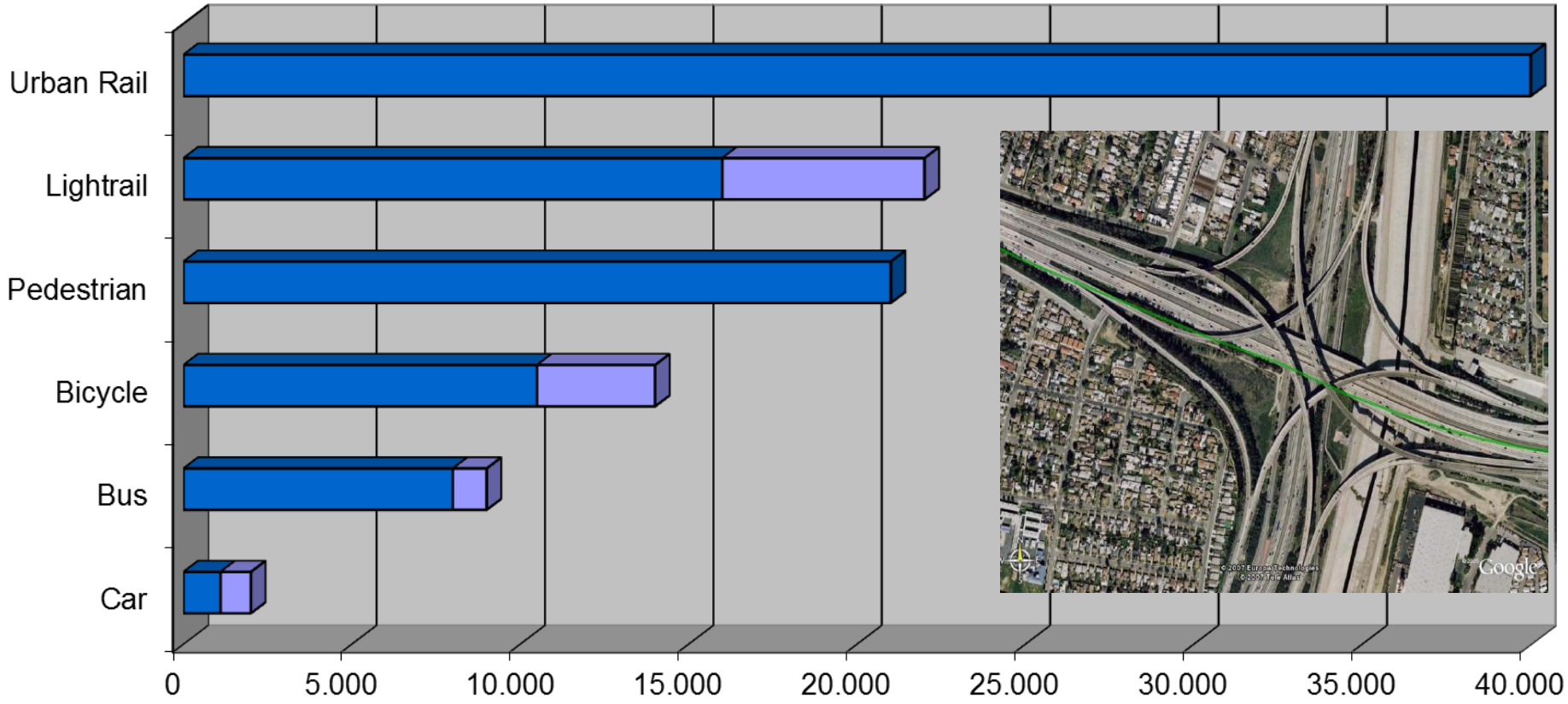
Forecasted growth in congestion in Copenhagen

- Growth in delay time of 98% until 2025
- This could be reduced to a growth of 68% by unrealistically massive infrastructure investments
- Status quo in delay time could only be obtained by introducing road pricing

> "If we do nothing, the sheer number of people and cars in urban areas will mean global gridlock. Now is the time for all of us to be looking at vehicles the same way we look at smart phones, laptops and tablets: as pieces of a much bigger, richer network."
>
> — **Bill Ford**, executive chairman, Ford Motor Company

Capacity for different modes of transport (Passengers per hour per lane)



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Challenged urban transport infrastructure

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Urban space for non-transport purposes!

Mobility as a Service (MaaS)
Shared Economy

- Taxi variants

- Co-driving
- Carpooling

- Rented cars /shifting drivers

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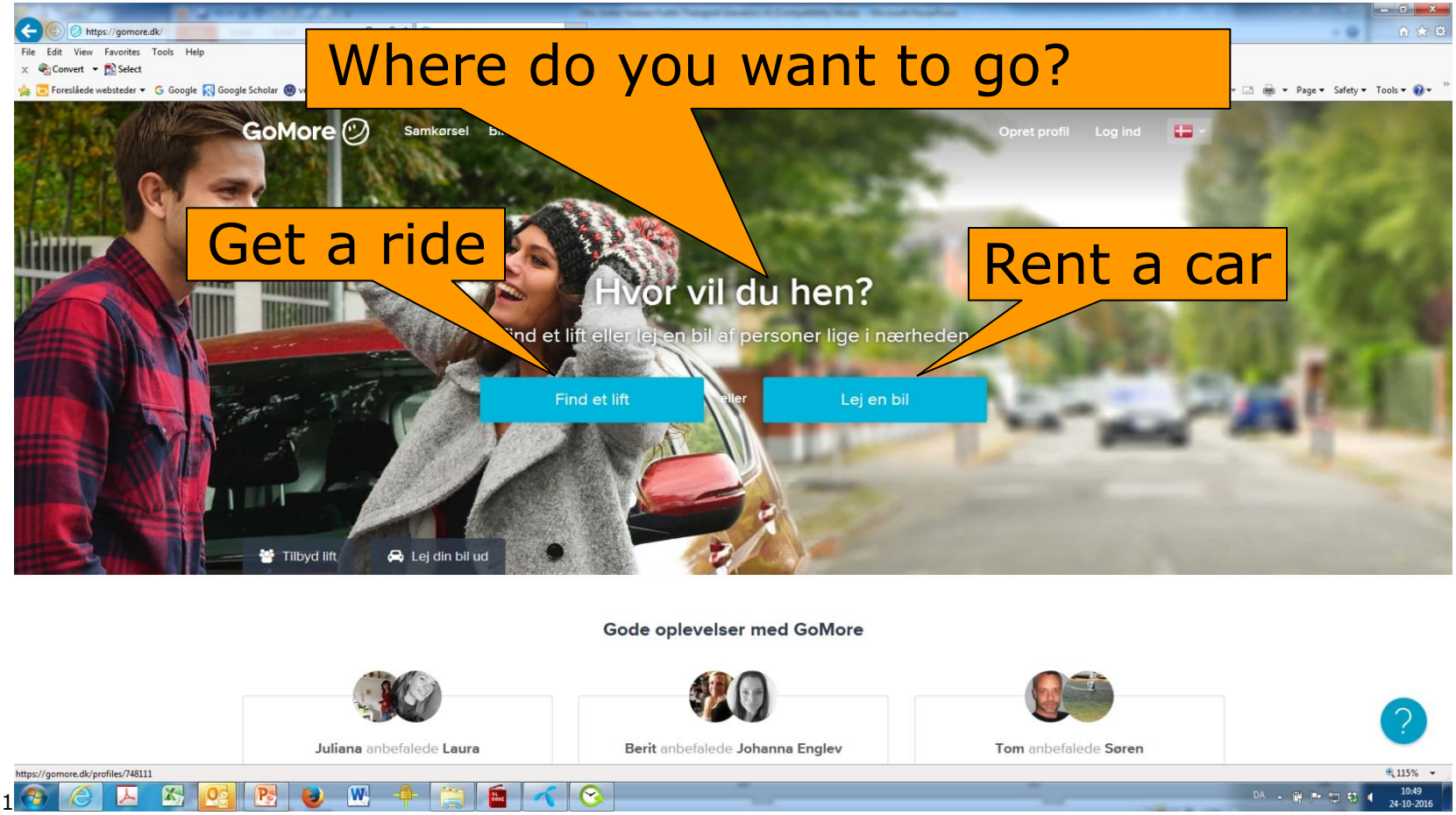
Different concepts by same provider

- 10% of the Danish population is member of GoMore
  - (515,056 members as of 24 Nov, 2016)



Mobility as a Service (MaaS) Shared Economy

- With or without driver?
- Issue with regard to asymmetry in transport patterns
  - Last mile issue

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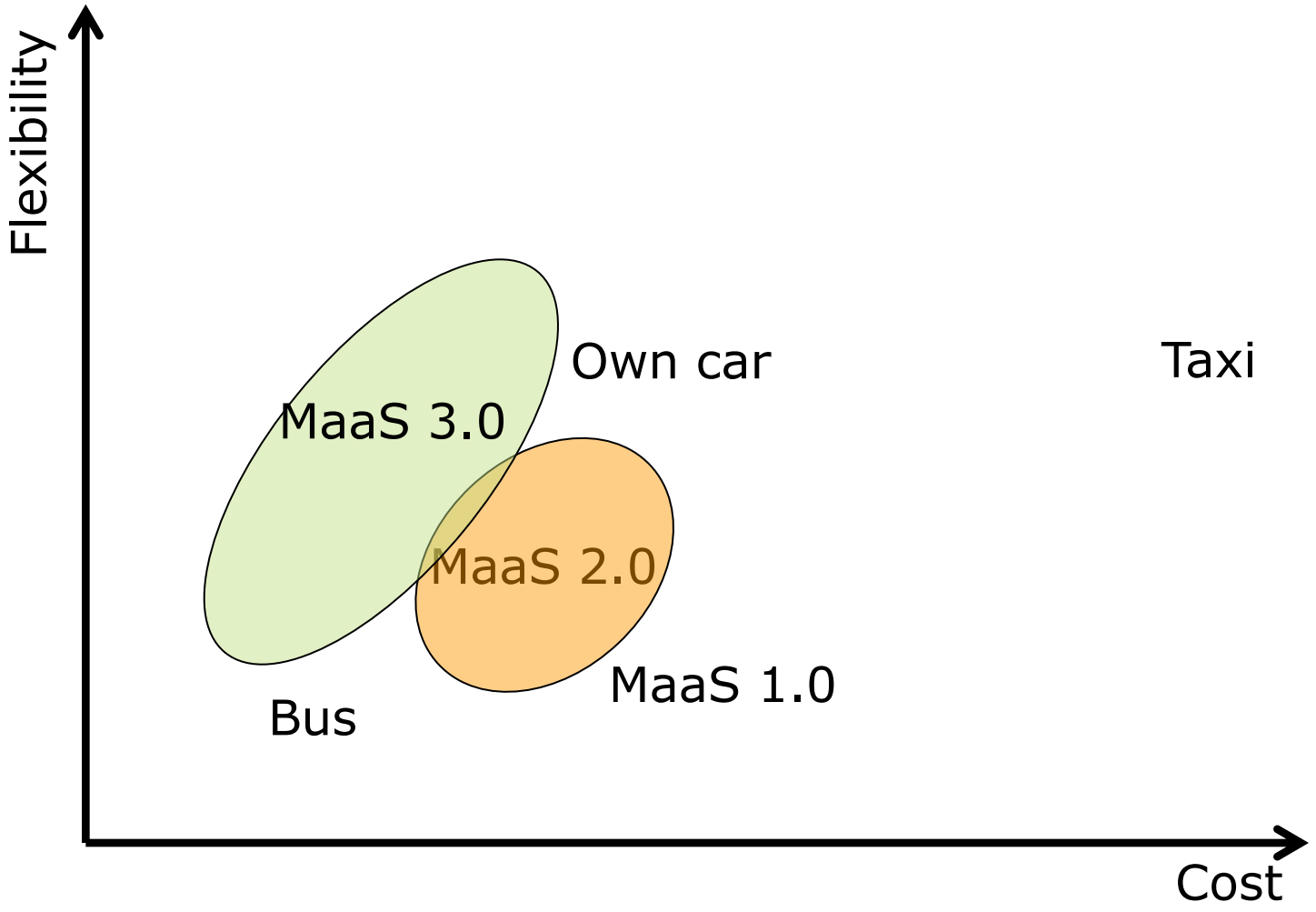
Mobility as a Service as a concept



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The fourth transport revolution

- Digital age transportation with self driving Autonomous vehicles

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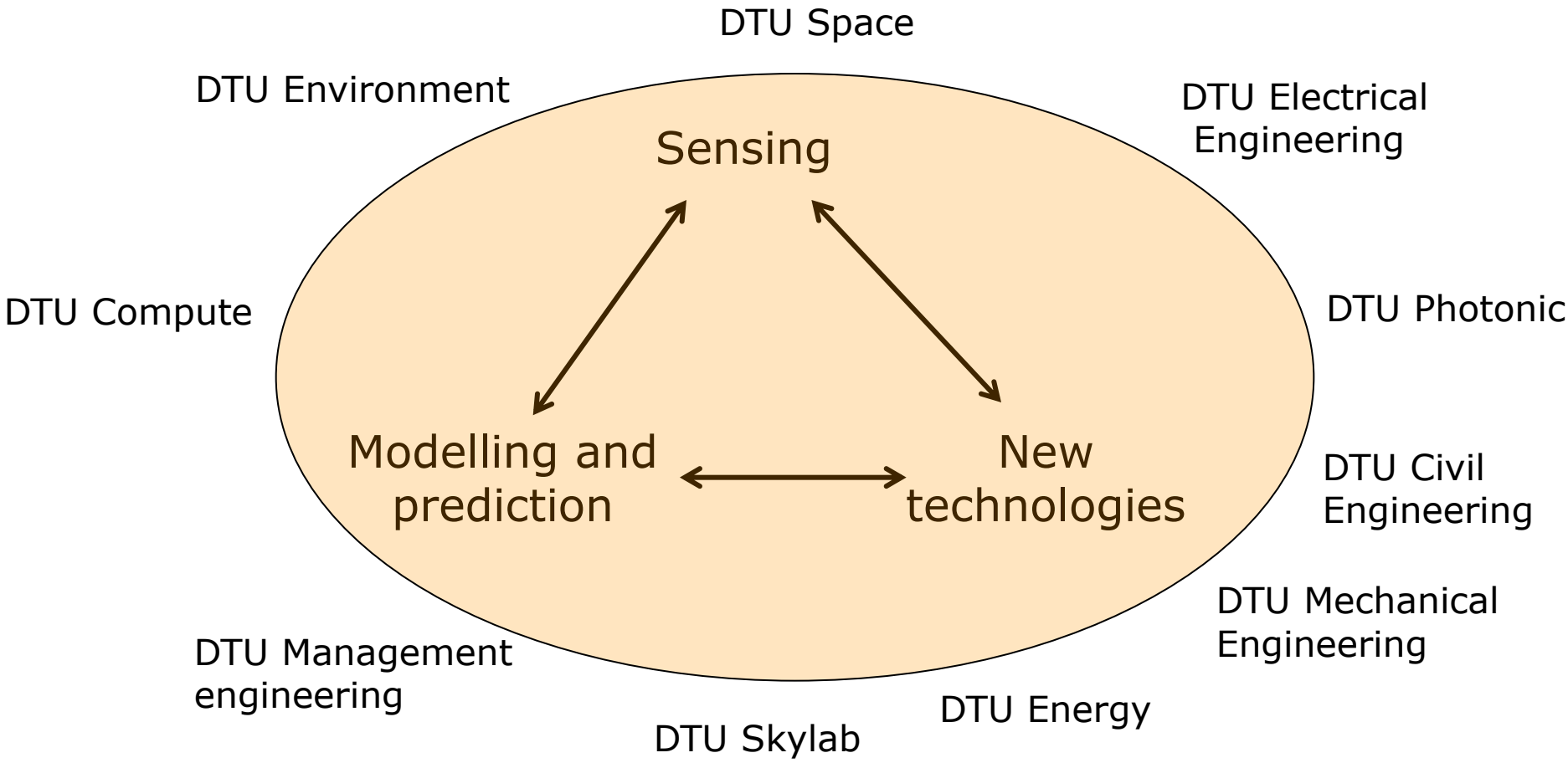
Enabling technologies



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Phases of introducing autonomous cars

Level of automation;

1. Safety features
2. Assisted driving
3. Platooned trucks
4. Platooned cars
5. Self driving vehicles
6. Autonomous vehicles

Location of operation

1. Special lanes
2. Motorways
3. Highways
4. Rural roads
5. Urban arterials
6. Everywhere

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Assisted autonomous cars - Benefits

- Safer
- More comfortable
- Better use of time
- Platooned trucks (and cars)
- More capacities at motorways
- Improved traffic control?
  - Depended on level of connectivity
  - Traffic signal control, etc.
  - Public versus private market

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When we reach complete autonomous cars!

- New use of cars
- New user groups
- Parking
- Mobility as a service
- Non-person transport with passenger cars

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New use of cars

- Moving office
- Moving hotel room
- Assumingly this will lead to (much) more transport

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New user groups

- Mobility as a Service
- Children
- Handicapped
- Elderly
- Drunk (going home from party)

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Parking

- Idle empty driving
  - Does not ”hurt” the car owner
- Driving for parking space
  - Empty return run

- Results
  - City centers (Urban spaces) can be relieved for parked cars
  - But roads may suffer of more congestion due to empty cars driving around
  - And more car driving in general

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Mobility as a service

- Autonomous cars solves the imbalance of the flow of passengers and freight over time and space
- Empty return runs
- Repositioning cars to predicted demand
  - Swarms of empty vehicles driving around

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Will autonomous MaaS cars replace private cars in the long run?

- MaaS becomes
  - Cheaper
  - Easier to use and more reliable
  - But still some transaction costs
- Private cars may become
  - Cheaper (relatively to income)
  - More flexible when autonomous
  - Still convenience of owning
  - And we become richer!

Shared economy is not new,…

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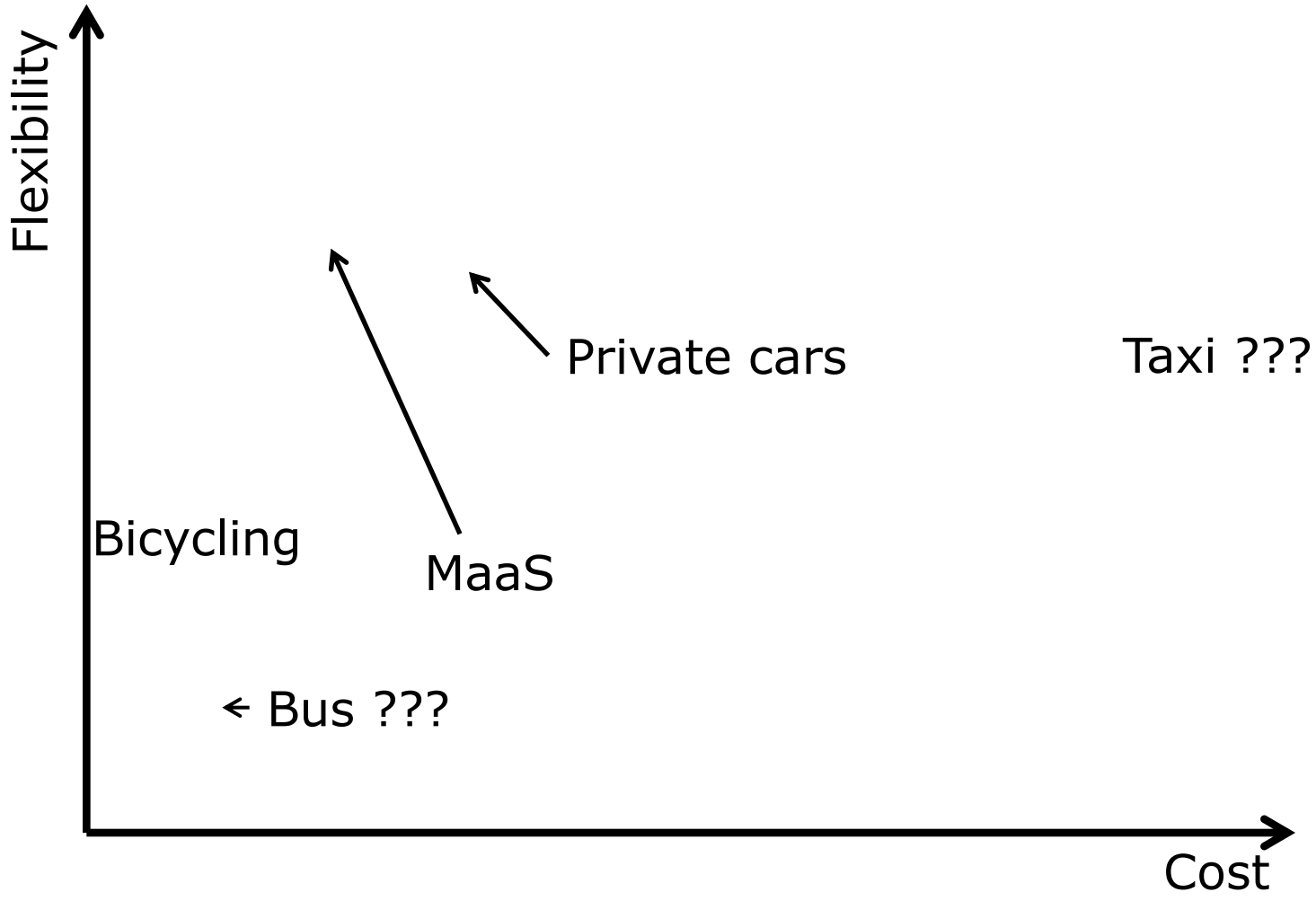
Change of cost and flexibility of autonomous cars



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Non-person transport with autonomous passenger cars

- Packages, letters, etc.
- Challenge the postal and delivery business

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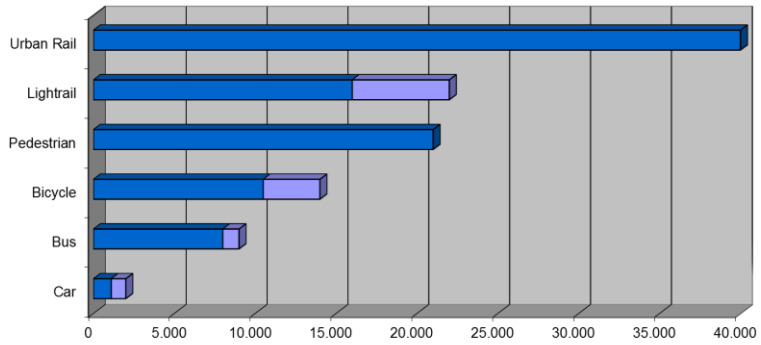
Results

- More people can travel by car
- It is convenient to use time more efficiently in the car and hence travel longer
- A lot of empty car driving
  - Parking, Mobility as a service, non-person transport with cars, freight
- Cheaper and more freight transport
- => Increase in demand exceed increase in capacity
  - Hyper congestion
- Unless road user charging
- Or other economic policies



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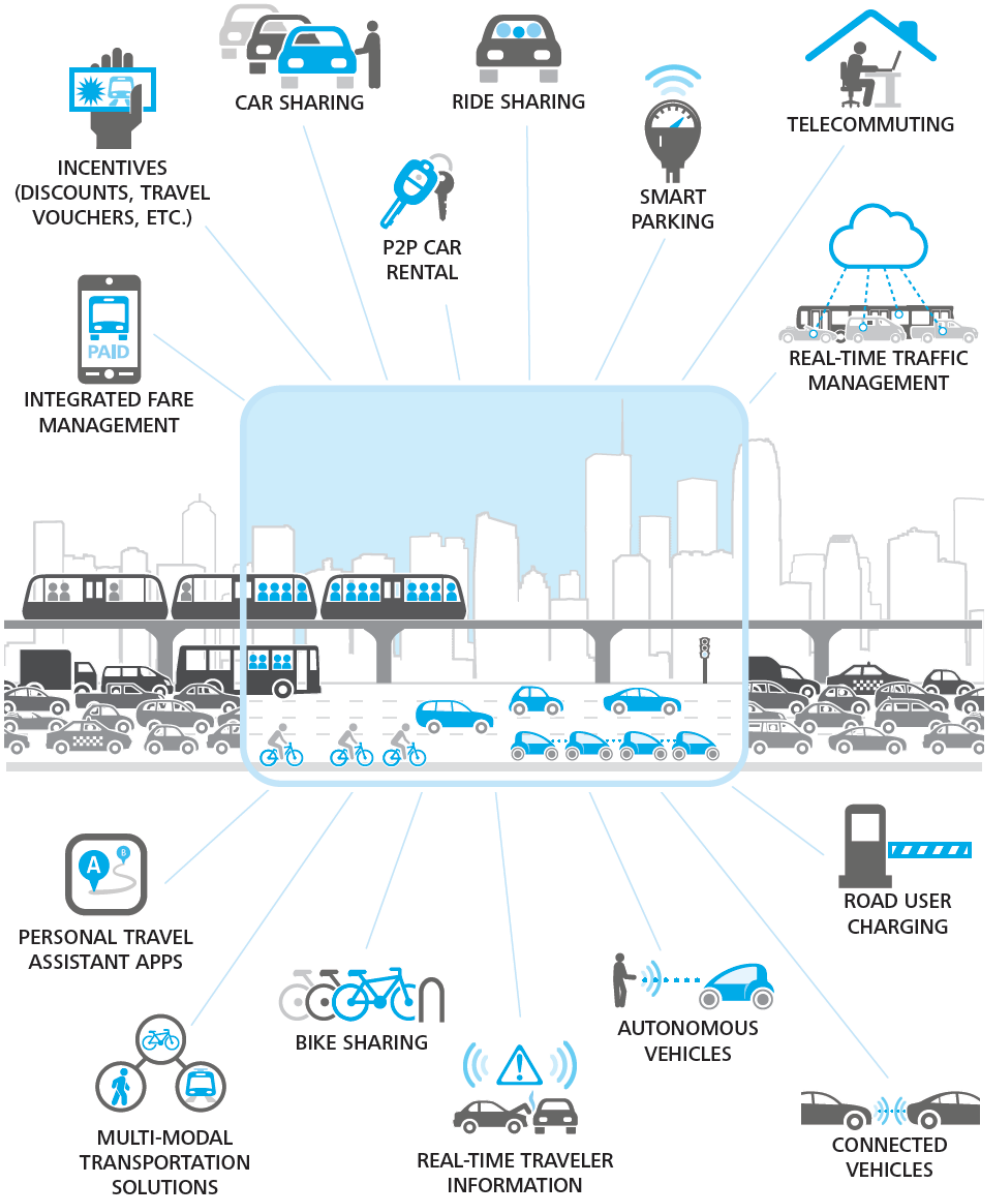
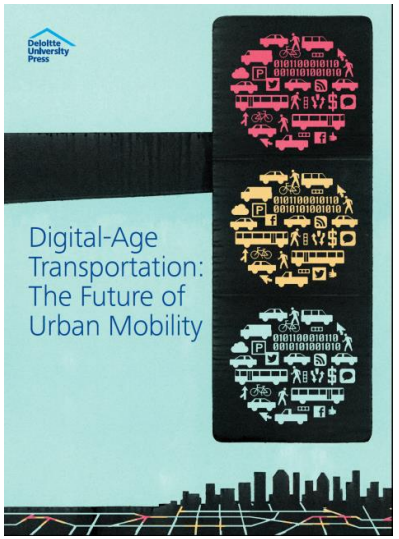
Role of public transport

- Efficient land use capacity use for railways combined with flexible access/egress modes
  - Bicycle
  - Autonomous busses
  - MaaS



There´s no silver bullet solution to the problem of gridlock – next generation urban transport systems will connect transportation modes, services, and technologies together in innovative new ways that pragmatically address a seemingly intractable problem



- http://www2.deloitte.com/content/dam/Deloitte/tr/Documents/public-sector/EN_Digital-Age-TRANSPORTATION_16.07.2014.pdf

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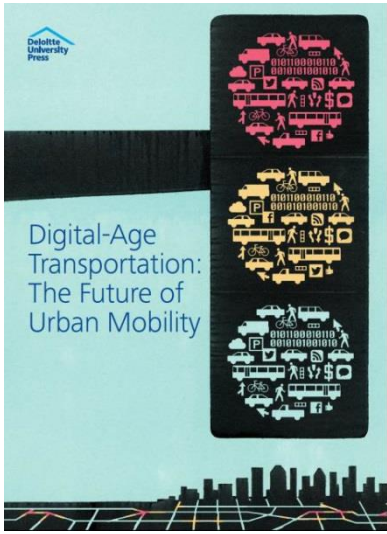
Smart mobility visions



- The result of these innovations—and of the ecosystem of creative players that have been drawn to transportation, from information technology companies to ridesharing pioneers to app makers—is that the mobility field will look very different going forward. It will be:
- **Massively networked**, with ubiquitous connectivity throughout the system
- **Dynamically priced**, so as to balance supply and demand
- **User centred**, taking into account users' needs, priorities, data flows, and dynamic responses to conditions
- **Integrated**, so that users can move easily from point A to point B, regardless of mode, service provider, or time of day
- **Reliant on new models of private-public collaboration**, which take advantage of the increasingly diverse ecosystem of public, private, and non-profit entities that are working to meet the mobility challenges of the 21st century

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