



# Trade-offs in energy efficient traffic management strategies

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## This presentation

- Reducing fuel consumption in traffic with traffic management and traffic control
- Functional integration in a two-level approach using uniform control targets
- The individual road user, behavioral response and the use of information



Target is to reduce by 20% fuel consumption and therefore CO<sub>2</sub> emission



# Consortium



## Consortium:

 ASSOCIATION PROFESSIONNELLE AUTOROUTES ET OUVRAGES ROUTIERS			 Invented for life			 CENTRO RICERCHE FIAT
 Centro Tecnológico de Automoción de Galicia	 A <b>PACCAR</b> COMPANY			 trafik & miljø	 INSTITUT FÜR KRAFT- FAHR- ZEUGE RWTH AACHEN UNIVERSITY	
	 Innovative solutions for traffic systems	 MetaSystem			 traffic solutions	 traffic mobility logistics.
				 Find more.		
					<b>Coordinator:</b>	 ITS EUROPE



## Project goal

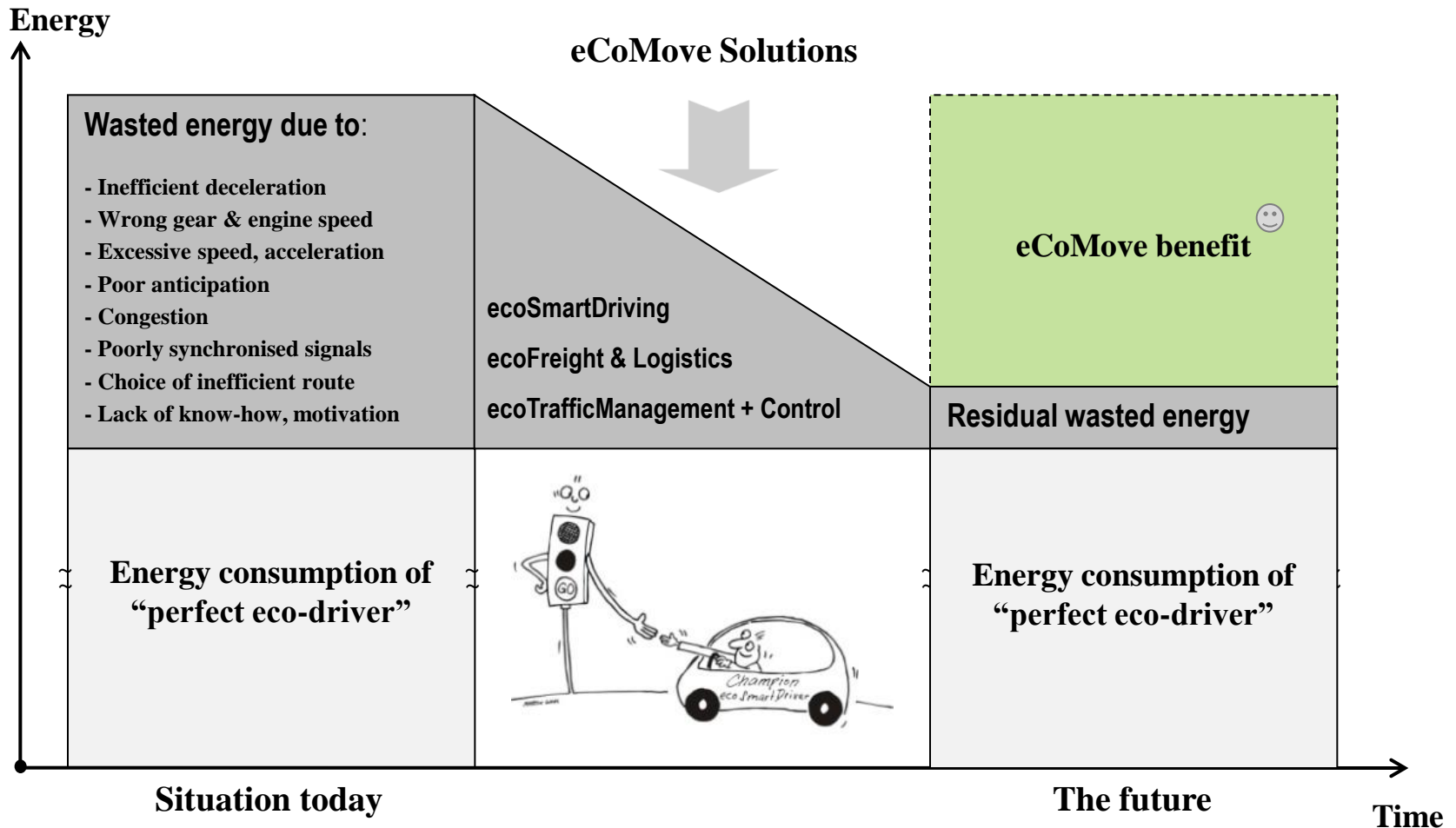


To develop a **combination of cooperative systems and tools** using V2V and V2I communication to help:

- drivers sustainably eliminate unnecessary fuel consumption;
- fleet managers manage their vehicles more economically and promote eco-driving through feedback & incentives;
- road operators balance traffic flows in the most energy efficient way.

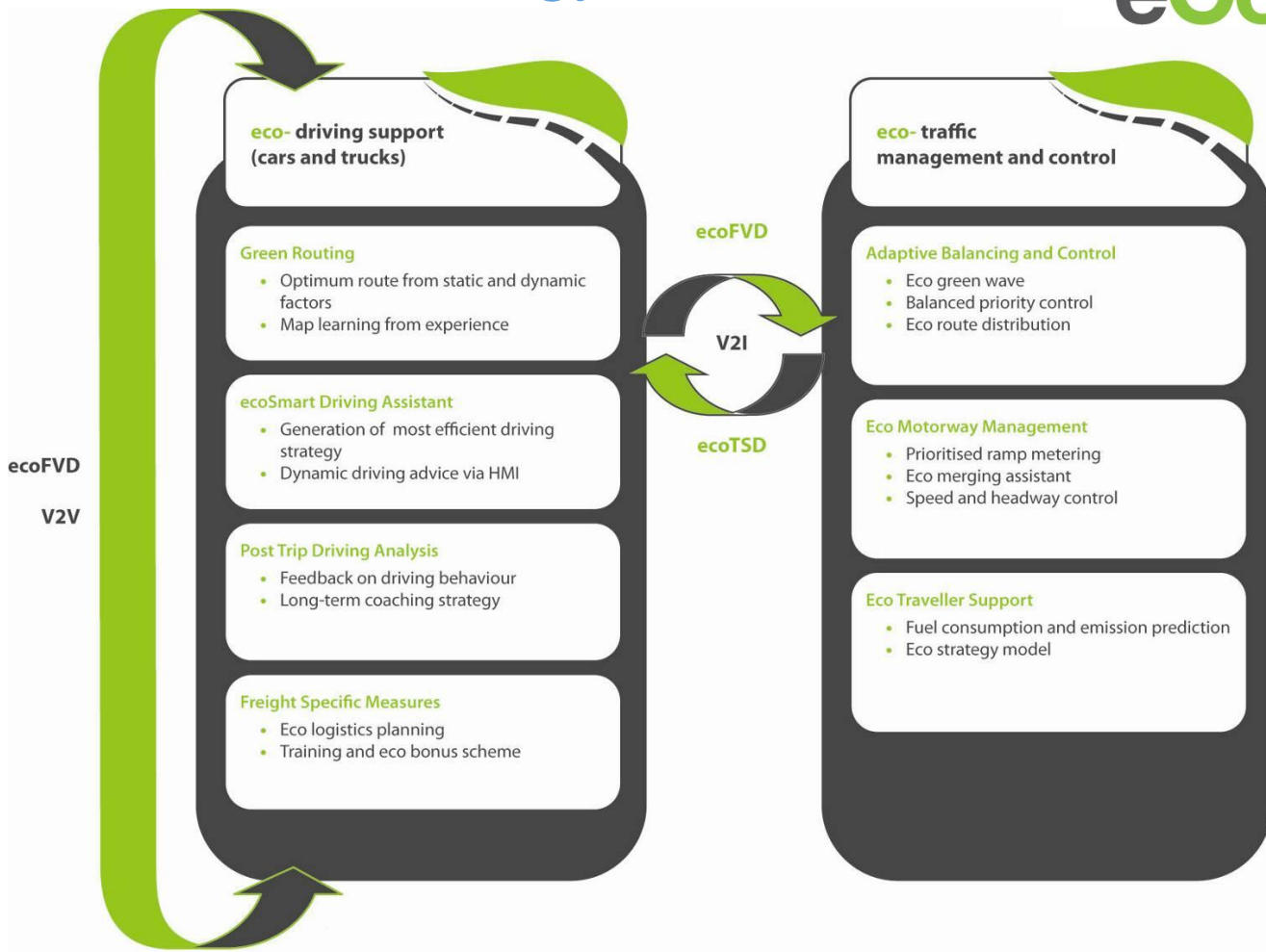


# Vision and motivation



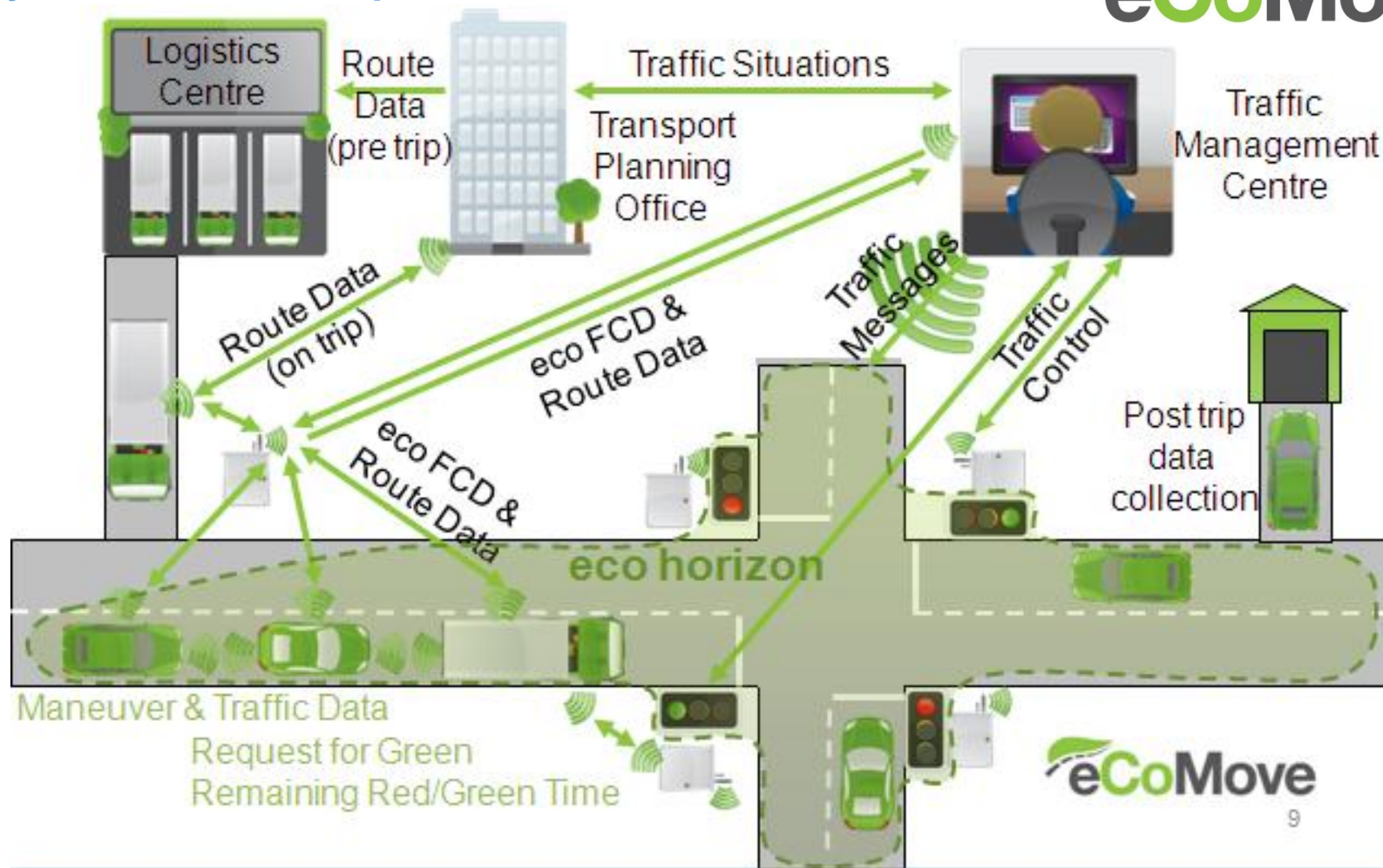


# Cooperative technology as enabler





# System concept





## Scope



- Pre-trip
- On-trip
- Post-trip
- Fixed demand
- Single mode
- No pricing



## Inefficiencies

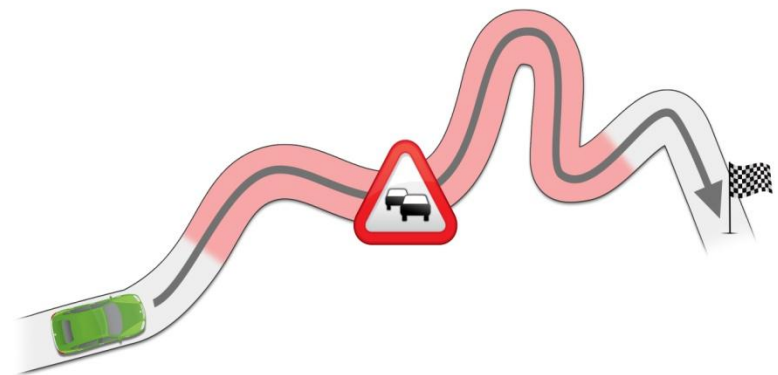
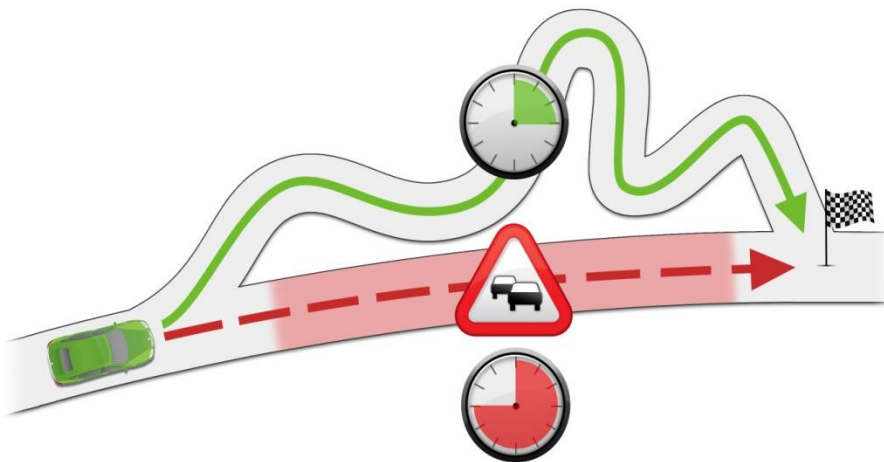
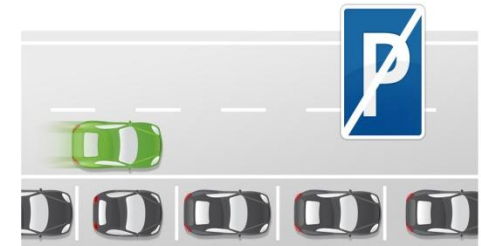
- What causes fuel waste? Examples:
  - Inefficient vehicle condition





## Inefficiencies

- What causes fuel waste? Examples:
  - Inefficient vehicle condition
  - Inefficient route choice

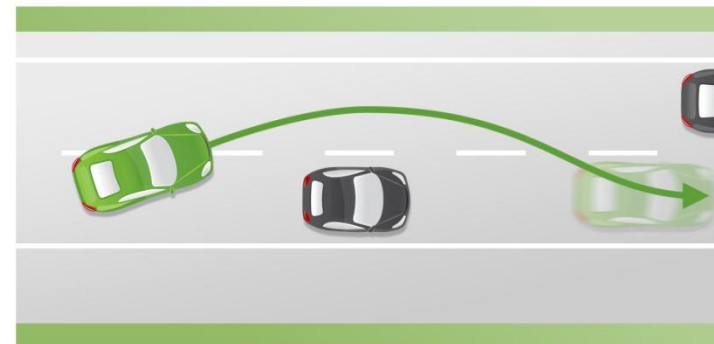
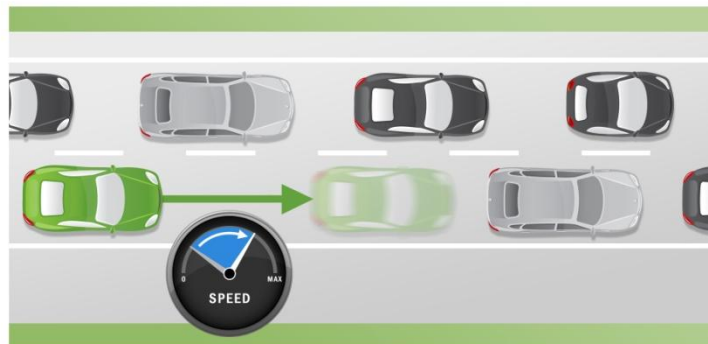
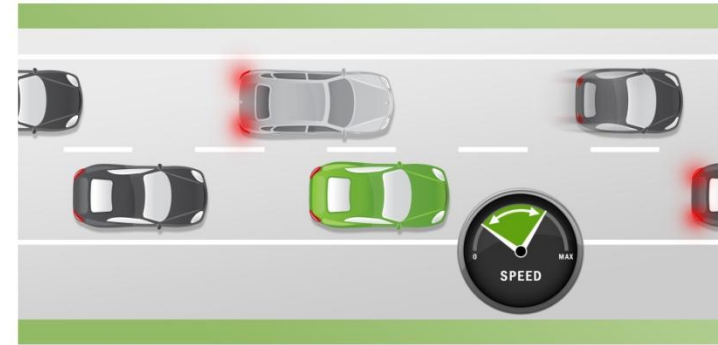




## Inefficiencies



- What causes fuel waste? Examples:
  - Inefficient vehicle condition
  - Inefficient route choice
  - Inefficient acceleration

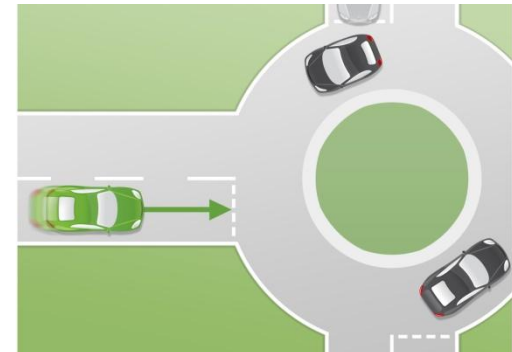
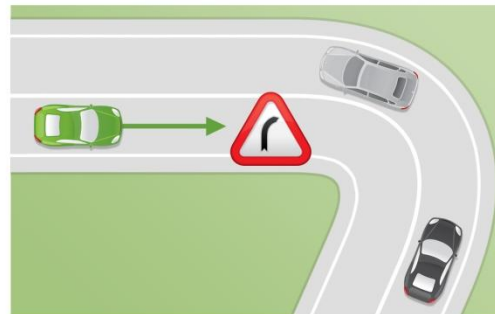
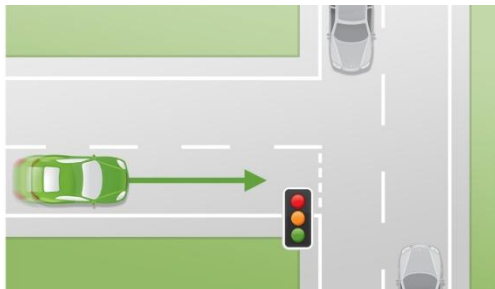




## Inefficiencies



- What causes fuel waste? Examples:
  - Inefficient vehicle condition
  - Inefficient route choice
  - Inefficient acceleration
  - Inefficient deceleration

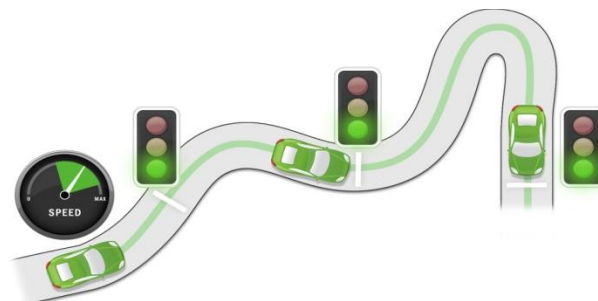




## Inefficiencies



- What causes fuel waste? Examples:
  - Inefficient vehicle condition
  - Inefficient route choice
  - Inefficient acceleration
  - Inefficient deceleration
  - Inefficient speed
  - Also: gear, idling, energy control ,etc. See paper ITS Lyon





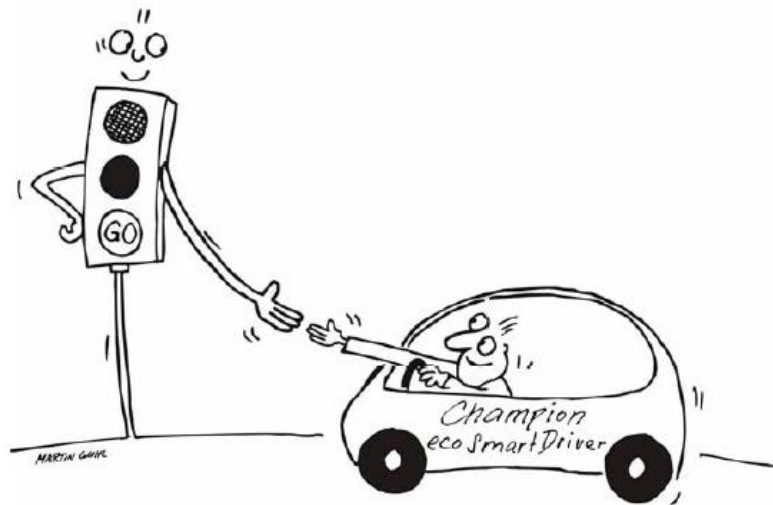
## ecoTraffic Management and Control



- Using real-state traffic and fuel consumption data, balance traffic demand and network capacity
- Using V2I, send vehicle specific route and speed recommendations for optimized driving strategy
- Optimize speeds, headways and lane change maneuvers for smoother motorway operation



## Some examples to save fuel *and* time



-5% per intersection  
-16% for trucks in network

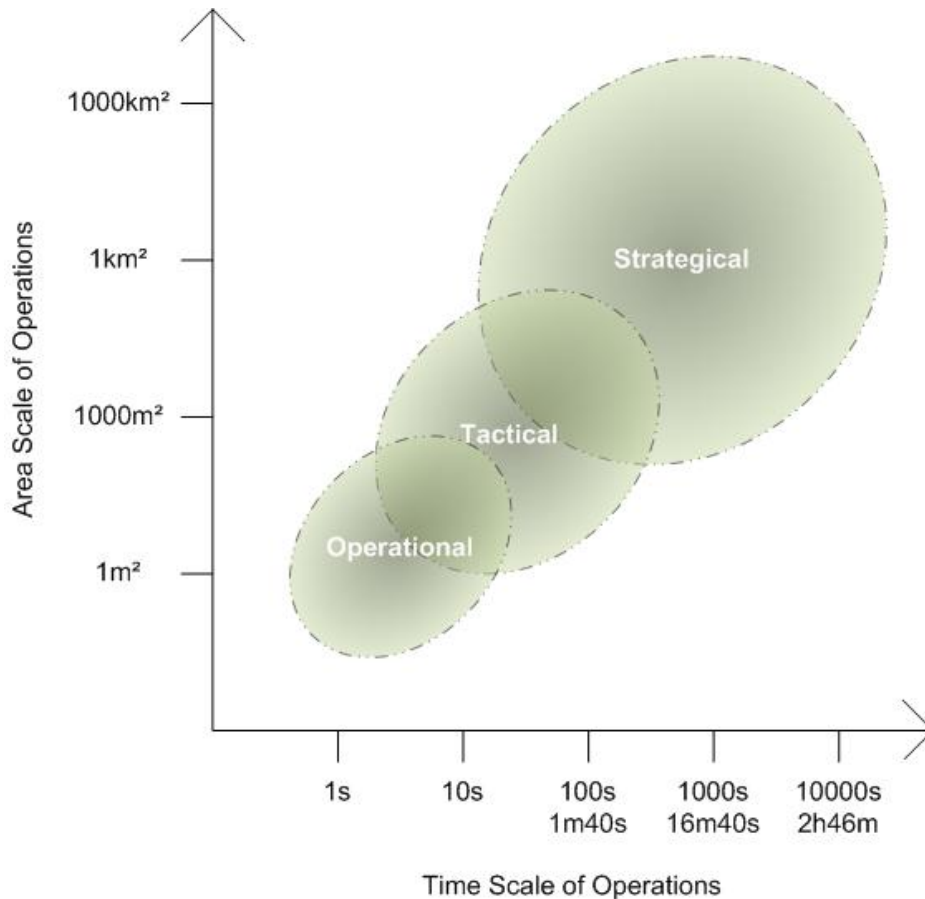


-17%  
to  
-45%





# Architecture



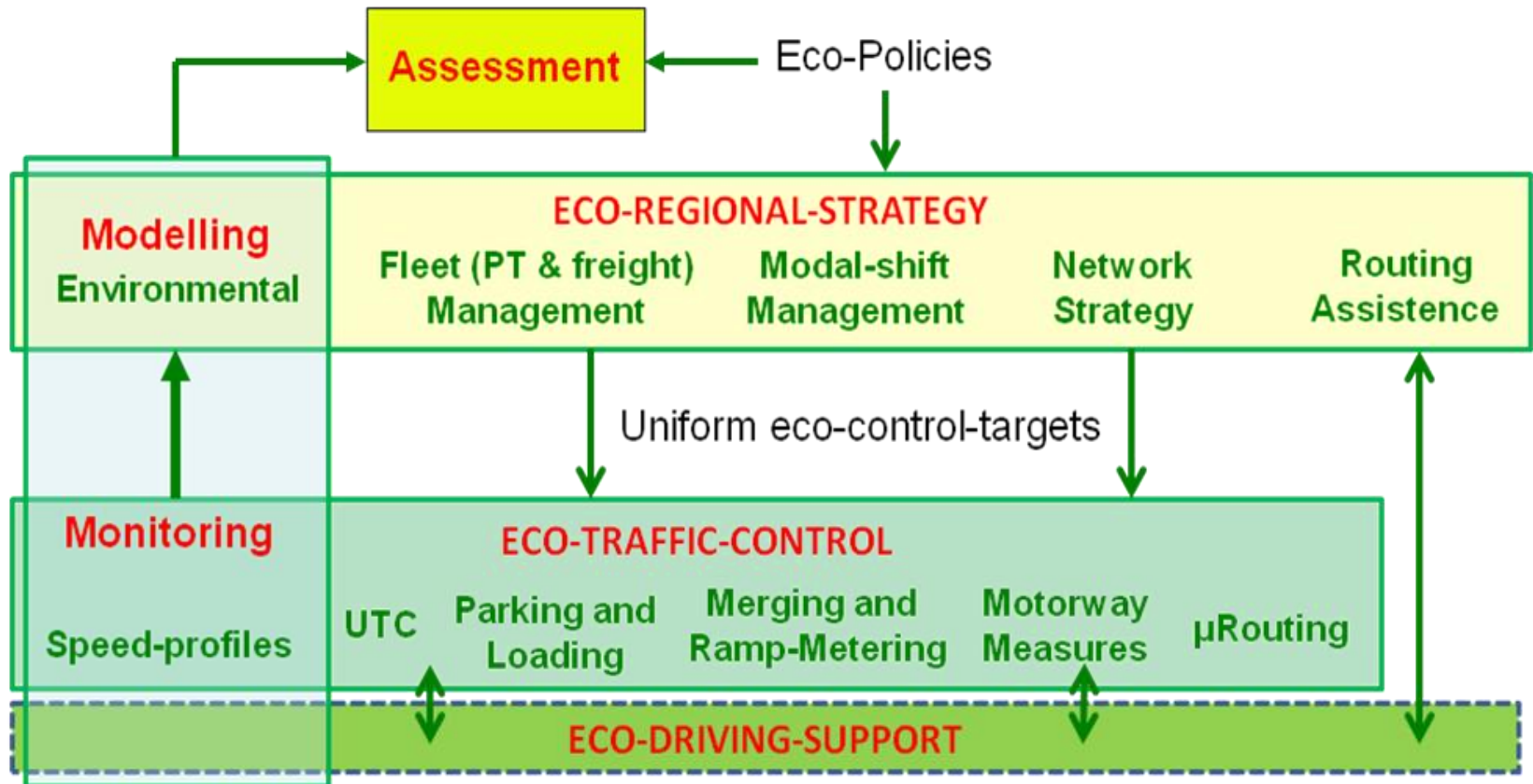
## ■ Recap SURF 2000

- Zones (strategy)
- Areas (control)
- Crossroads (micro)

## ■ How to define the interfaces?



# Uniform Control Targets





## Examples



- Reduce CO2 emission
- Increase/decrease throughput
- Increase/decrease road usage
- Increase/decrease travel time
  
- Specify: importance, location, conditions, relative/absolute
- Ex-ante and ex-post evaluation



## Towards integrated solutions



Traffic Information

Green Wave

Traffic Signal Priority

Speed Advice



## Towards integrated solutions



- 1. Add eco-elements to existing applications and develop new ones based on inefficiencies

ecoRoute Advice

ecoGreen Wave

ecoBalanced Priority

ecoApproach Advice



## Towards integrated solutions



- 1. Add eco-elements to existing applications and develop new ones based on inefficiencies
- 2. Distinguish between strategic (central) and tactical (local) operations

ecoRoute Advice

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ecoApproach Advice



## Towards integrated solutions



- 1. Add eco-elements to existing applications and develop new ones based on inefficiencies
- 2. Distinguish between strategic (central) and tactical (local) operations
- 3. Define collaboration schemes for multiple applications and apply uniform control targets





## But what about the individual road user?

“KPI: operational efficiency: competence from a user’s perspective”



## Remember these: Wardrop Principles

- Maximum own utility and cost on all routes used are equal and less than any unused route (UE)
- Optimize the use of available road capacity and the average or total network cost are minimal (SO)



## Summary

- Move people and goods
- Multi-objective strategies
- Network optimization and minimize total loss (*SO*)
- People 'state' ITS is useful and pleasant
- Expectations of individual road user (*UE*) met?
  - Individual interests overlooked, gain unclear
  - What about acceptance and behavioural response?



## Two options:

- Do nothing – might lead to disproportionate outcomes with the risk of measures being ineffective (i.e. loosing the acceptance of road users, behavioural adaptation – red light violation, rat run, etc.)
- Find solutions which efficiently use network capacity without violating individual preferences for route, mode, departure time, etc. (i.e. ‘regulation flexibility’)

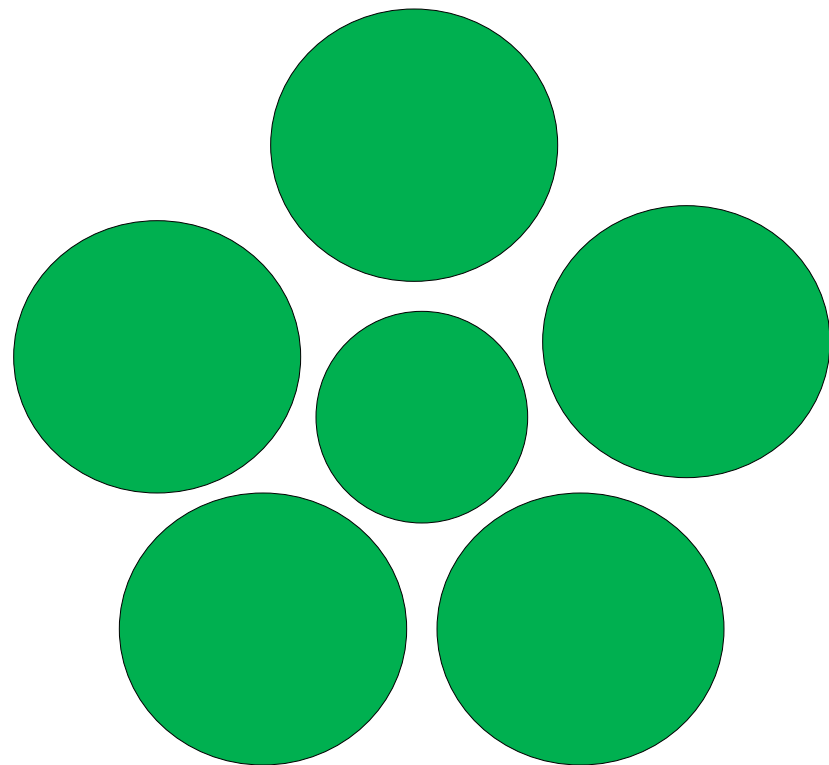
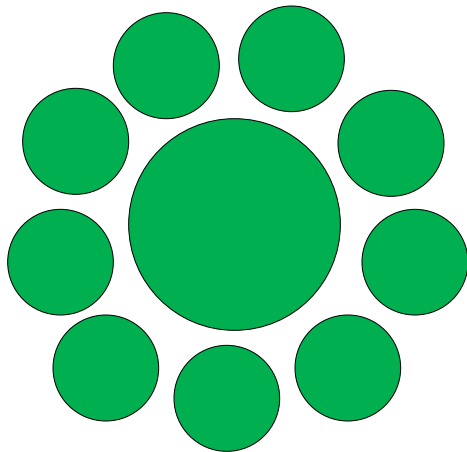


## When reducing fuel consumption

- Balancing different interests and goals
- Social dilemma and altruism
- What is equity and what is fair?
  
- Learn from social networking and use cooperative systems (like) to literally ‘work together’



# Is information everything?

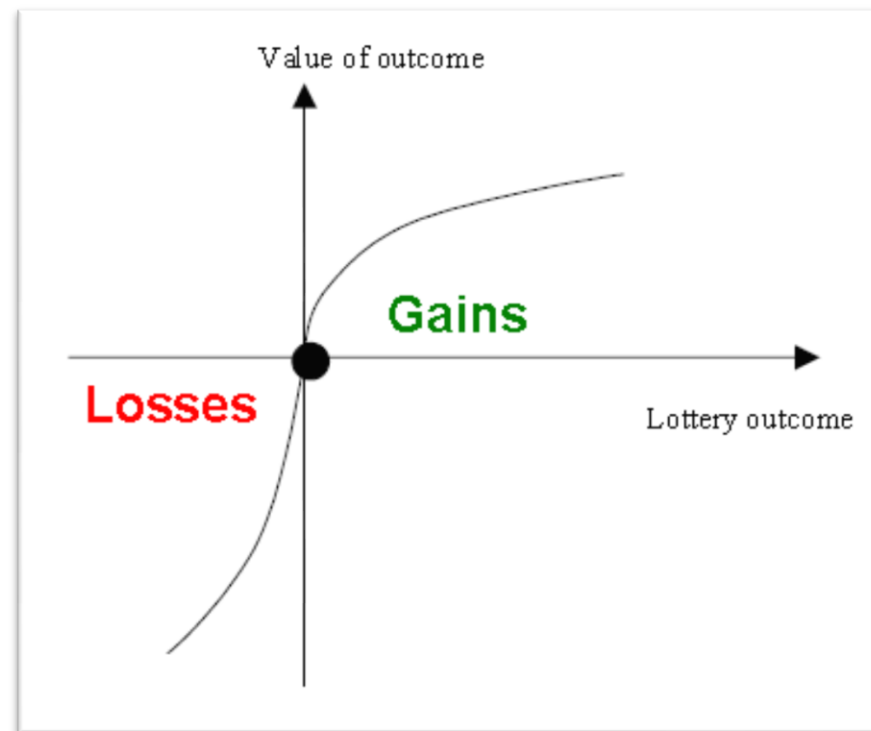




## Prospect theory

(e.g. Avineri, 2008)

- Sensitivity 'bad' versus 'good' outcomes
- Psychological effect loss about 2x psychological effect of same-size gain (e.g. € 50,-).
- Strong relation with reference point (discussion KPI)





## Information Utopia - Goal Framing

(e.g. Avineri, 2010)

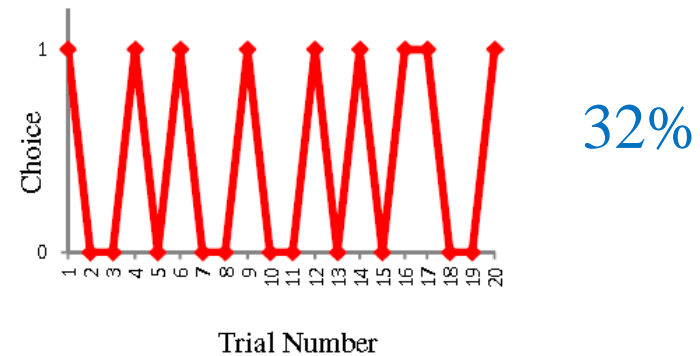
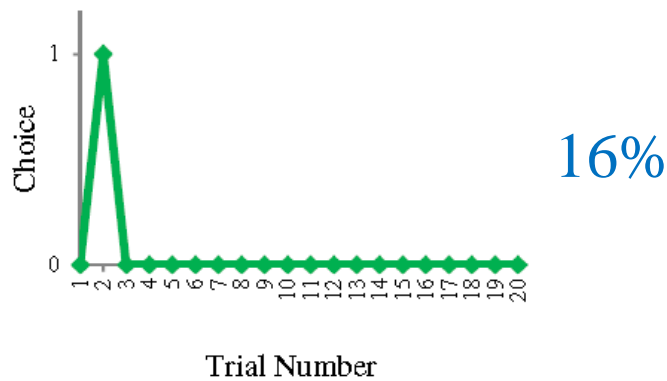
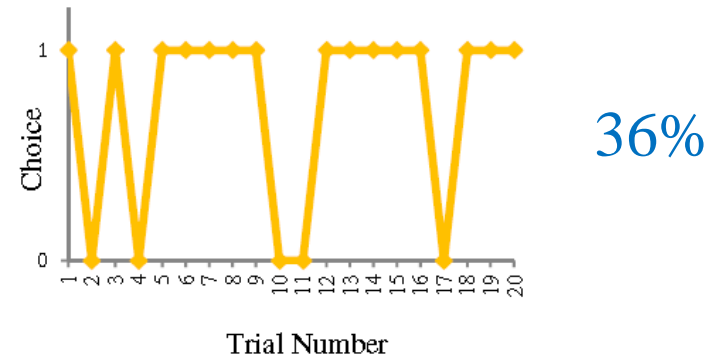
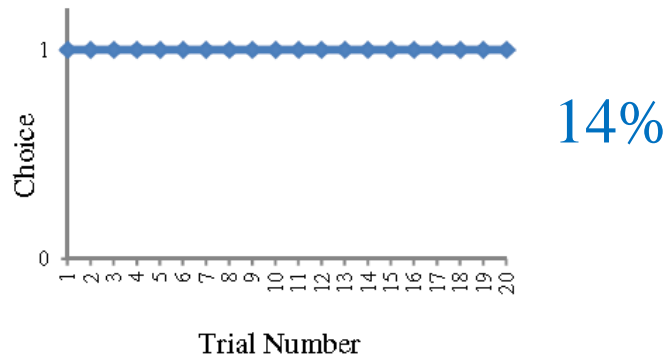
- Car: 25 minutes
- Bike: 20 minutes
- Car: 25 minutes
- Bike: you save 5 minutes travel time
- Bike: 20 minutes
- Car: your trip will be 5 minutes longer





# Route choice types

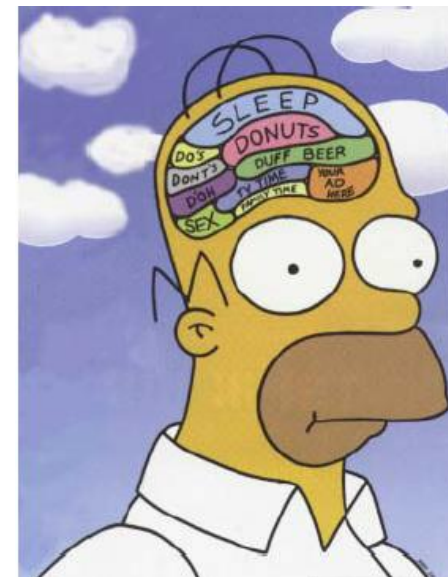
(e.g. Tawfik et al., 2010)





## Us

- Limited cognitive abilities
- ‘Rational Man Theory’ is naïve
  - Memory, Computation, Emotion, etc.
- Biased reasoning, minimize cognitive load
- Randomness in choice outcomes
- Current models underestimate human factors. E.g. information is not all





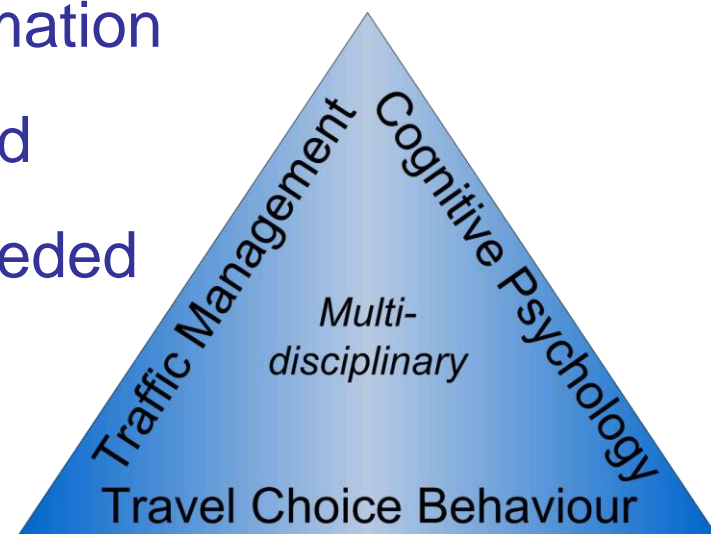
## Defining regulation flexibility

- Are people capable of observing and rightly assessing changes in a traffic system?
  - Change blindness – 70%
- What affects people's (dis-)interest and which conditions lead to behavioral change?
  - Indifference band – 20%
- What is the impact of rewards and penalties
  - Monetary stimuli – 60%



## To conclude

- Significantly reducing fuel consumption realistic
- Integrated and uniform approaches required
- System perspective ineffective on long run
- It does not stop at providing information
- Multi-disciplinary approach needed
- More empirical (field) research needed





## Can we find the balance?

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