ECTRI – FEHRL – FERSI

Young Researchers Seminar 2015

Behavioral adaptation to electric vehicles – An experimental study

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Outline

- Introduction
- Methodology
- Results and interpretation
- Conclusions
- Research considerations

Introduction

- Electric cars – a major player in reducing pollution
- „20-20-20 by 2020“

Source: daikin.at

➢ Can drivers simply switch from combustion engine cars to electric ones?

➢ How fast can a driver accommodate himself/herself to an electric car?

First step: The E-FFEKT project

- The study attempted to evaluate differences in vehicle dynamics and drivers‘ behavior between electric and conventional cars
- 90 drivers – 180 test drives – 43 km route – 50 minutes

- No major differences were observed regarding driver dynamics between the 2 technologies

- The time interval of testing was too small to reveal any results in driver adaptation to electric vehicles

Next step

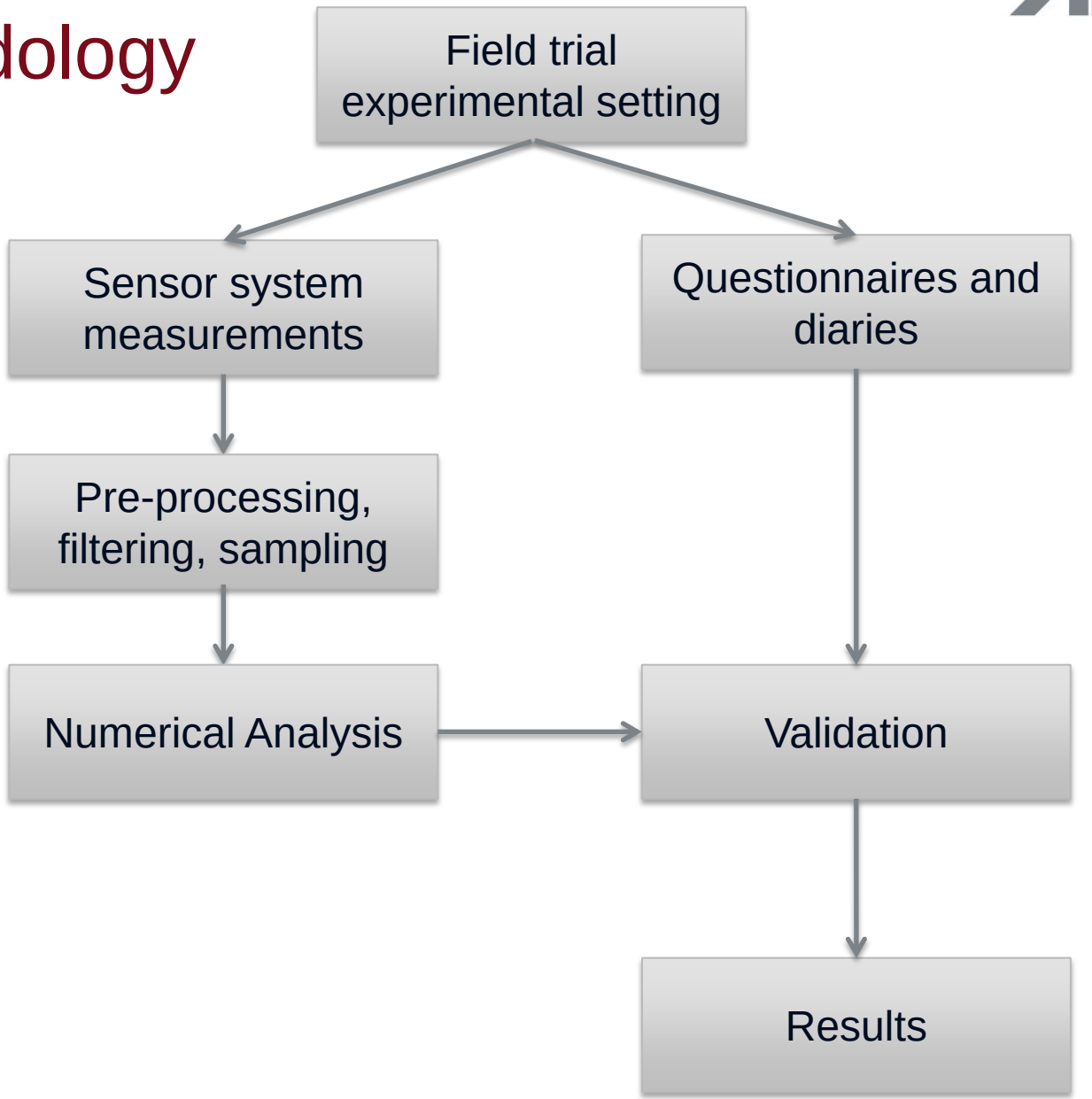
- Field operational trial
  - Naturalistic driving in and around Vienna, Austria

- Experimental setting
  - Is it possible to accurately evaluate drivers‘ adaptation to electric vehicles in an one-week interval of test trial

Field operational trial

- 6 weeks
- 4 test participants
- One week with the electric vehicle, one week with a combustion car
- > 30 hours driving time, more than 1500 km driven
- Two-step approach data collection system

Methodology



Vehicles

- Electric vehicle – Renault Fluence Z.E.

Driver	Electric vehicle	Maximum power (kW)	ABS	ESC/ ESP
#1, #2, #3, #4	Renault Fluence Z.E.	70	yes	yes

- Combustion vehicles – private vehicles of the trial participants

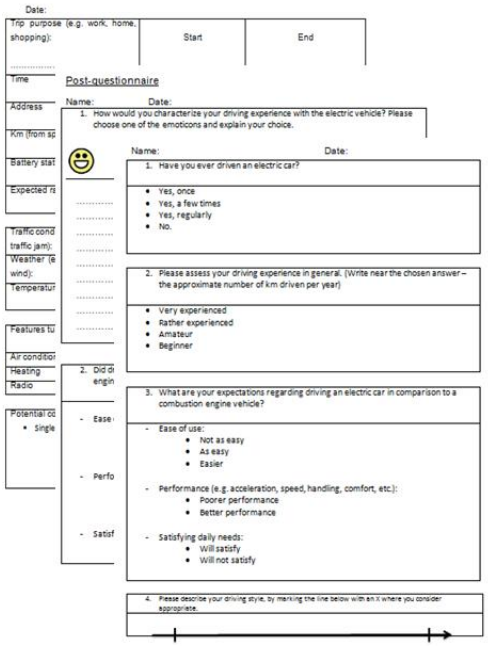
Driver	Combustion engine vehicle	Maximum power (kW)	ABS	ESC/ ESP
#1	Mercedes Benz A180, 2010	80	yes	yes
#2	Ford Galaxy, 2007	66	yes	yes
#3	Seat Ibiza, 2008	51	yes	yes
#4	Ford C-Max, 2011	70	yes	yes

Quantitative data collection

- GPS position
- GPS velocity
- 3-axis acceleration (ax, ay, az)

Qualitative data collection

- Pre-questionnaires
  - Previous experience with an EV and expectations
  - Driving experience and style
- Trip diaries
  - Trip purpose, distance, time, EV specifics
- Post- questionnaires
  - Adaptation, overall experience and meeting expectations
  - Observed differences between electric and combustion car
  - Safety
  - Influences in driving style and behavior
  - Willingness to pay


Date:

Trip purpose (e.g. work, home, shopping):

Start

End

Time

Address

Km (from sp

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Traffic cond
traffic jam):
Weather (e
wind):
Temperatur

Features tu

Air conditio
Heating
Radio

Potential co
• Single

Post-questionnaire

Name: Date:

1. How would you characterize your driving experience with the electric vehicle? Please choose one of the emoticons and explain your choice.

Name: Date:

1. Have you ever driven an electric car?
   - Yes, once
   - Yes, a few times
   - Yes, regularly
   - No.

2. Please assess your driving experience in general. (Write near the chosen answer – the approximate number of km driven per year)
   - Very experienced
   - Rather experienced
   - Amateur
   - Beginner

2. Did d
engin

- Ease

- Perfo

- Satisf

3. What are your expectations regarding driving an electric car in comparison to a combustion engine vehicle?
   - Ease of use:
     - Not as easy
     - As easy
     - Easier
   - Performance (e.g. acceleration, speed, handling, comfort, etc.):
     - Poorer performance
     - Better performance
   - Satisfying daily needs:
     - Will satisfy
     - Will not satisfy

4. Please describe your driving style, by marking the line below with an X where you consider appropriate.

Data analysis

- Quantitative analysis performed on each driver for:
  - Overall performance
  - Adaptation to the electric vehicle

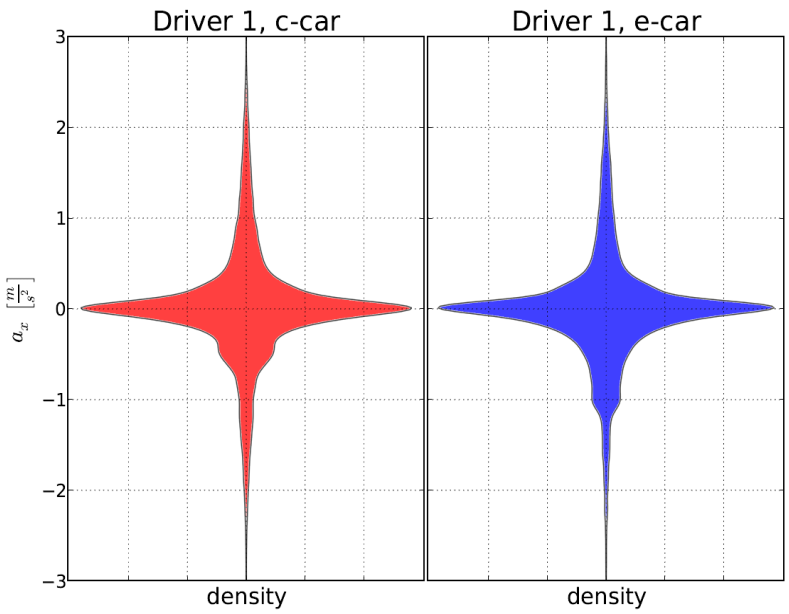
- Qualitative analysis performed on each driver for:
  - Expectations
  - Vehicle dynamics and acoustics
  - Adaptation
  - Safety
  - Vehicle range

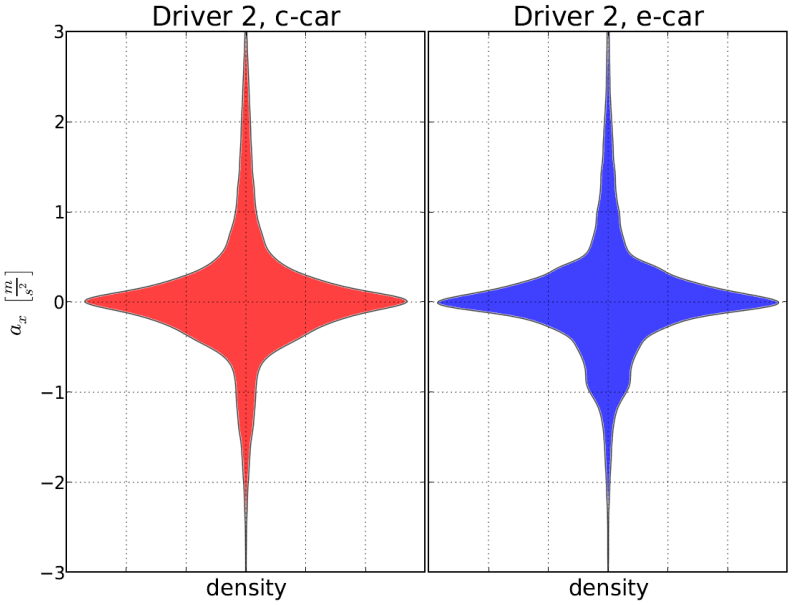
Quantitative analysis

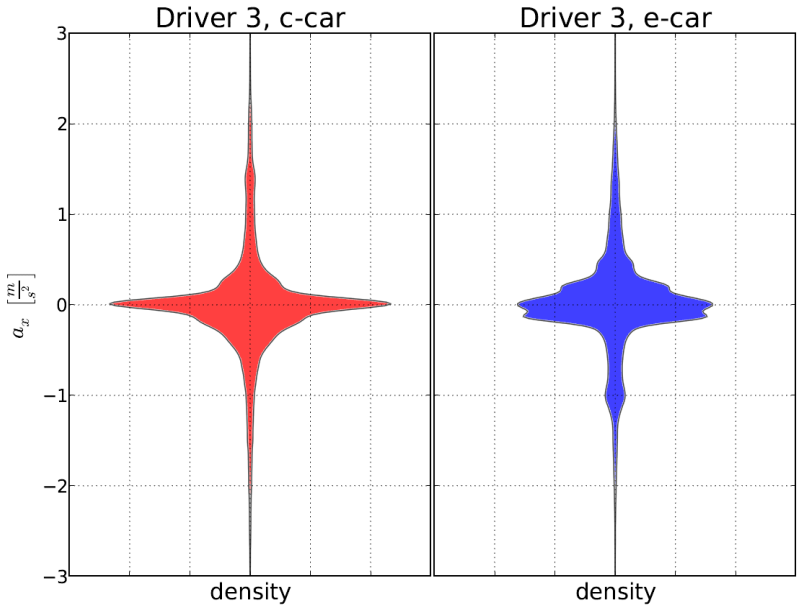
- Vehicle performance

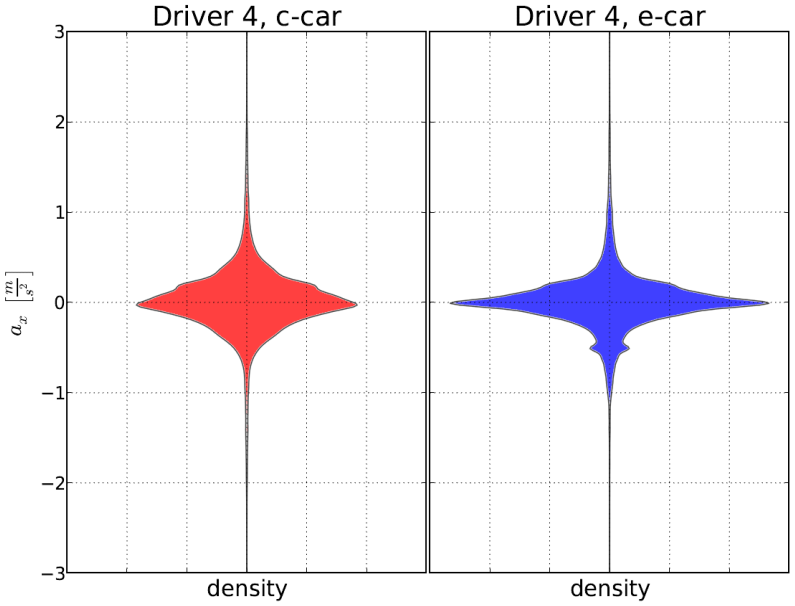
Driver	Nr of trips with electric car	Nr of trips with combustion-engine car	Mean trip length (km)
#1	6	7	11
#2	8	8	14
#3	8	6	24
#4	8	8	53

Acceleration – deceleration patterns

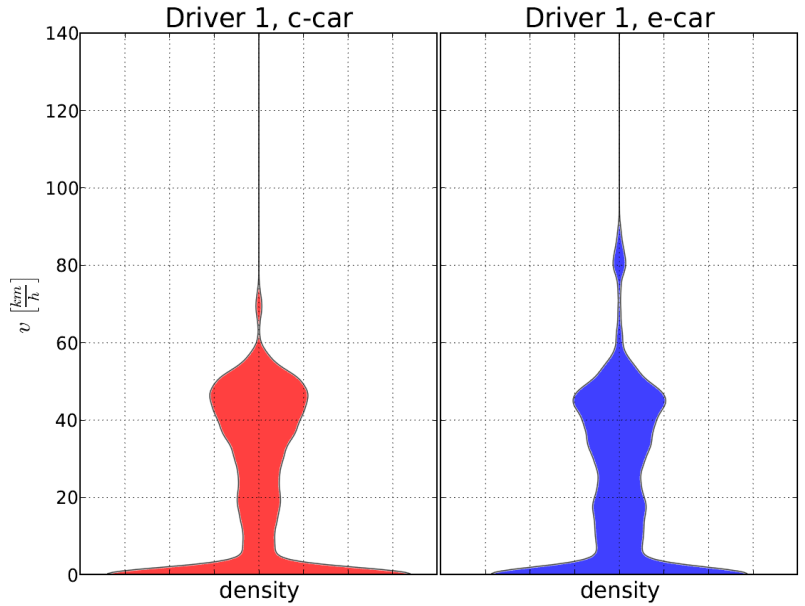


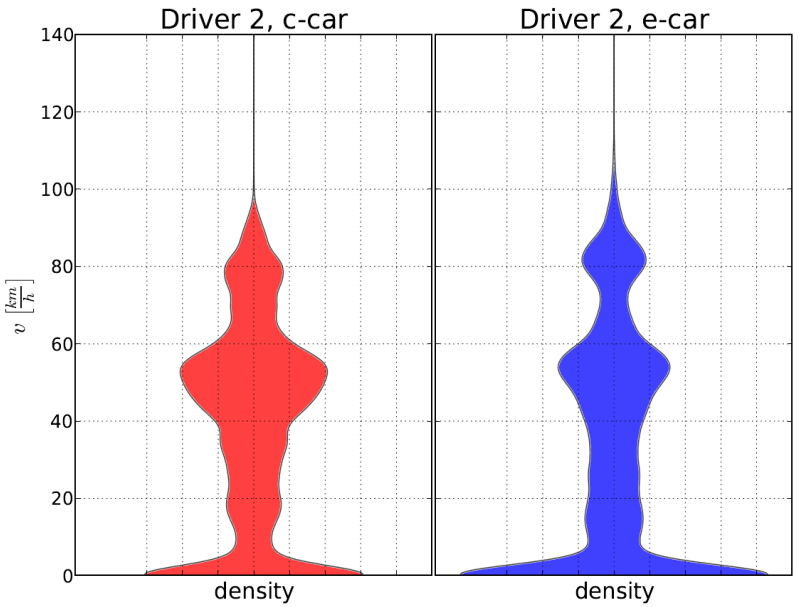


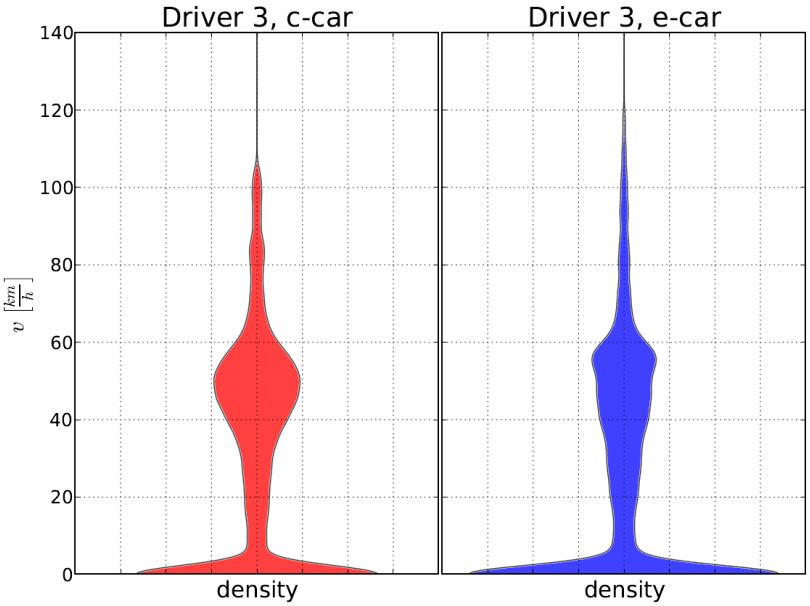


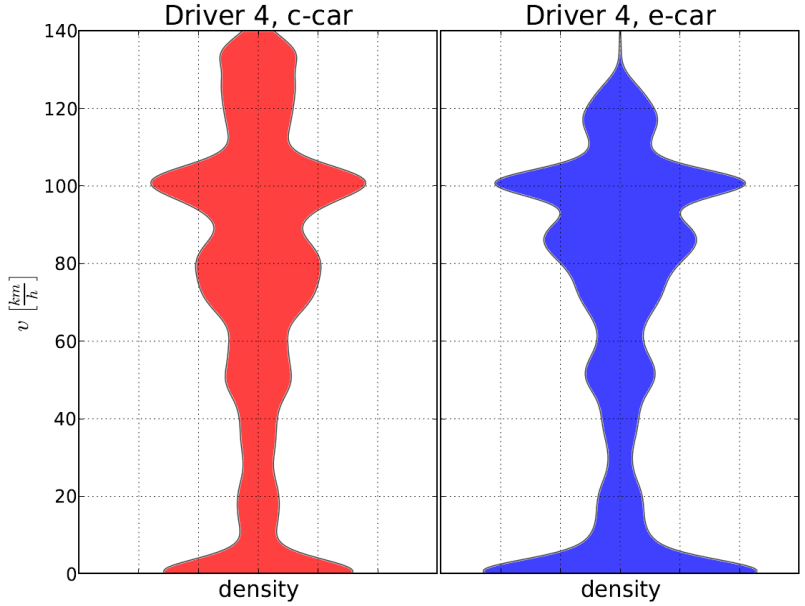


Velocity patterns







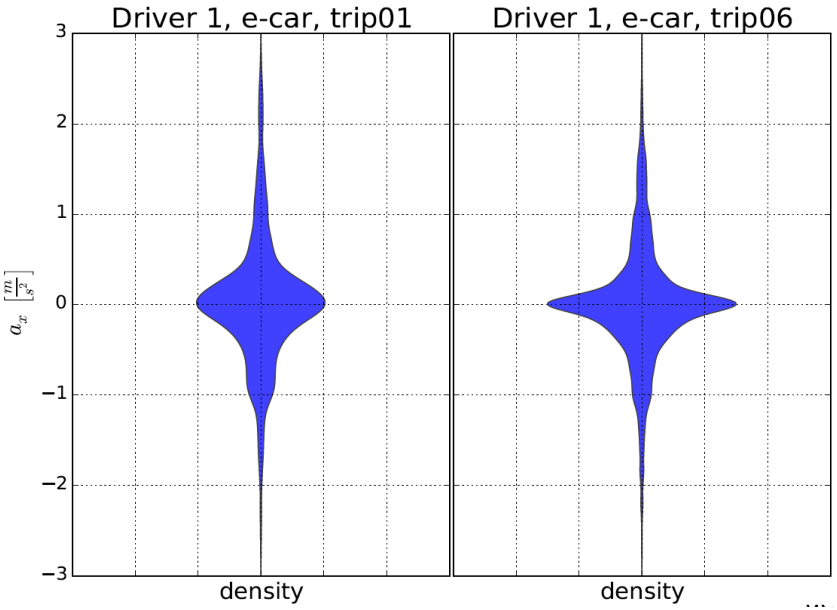


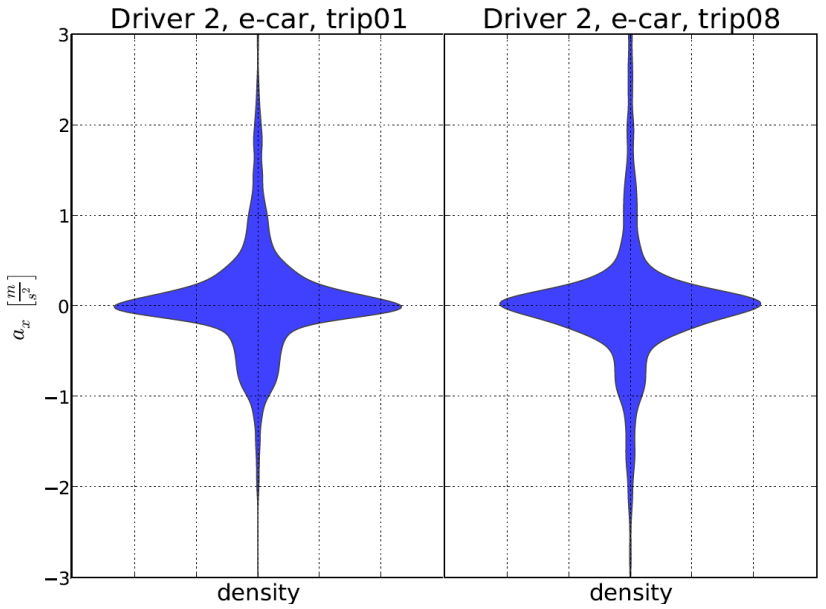
Adaptation

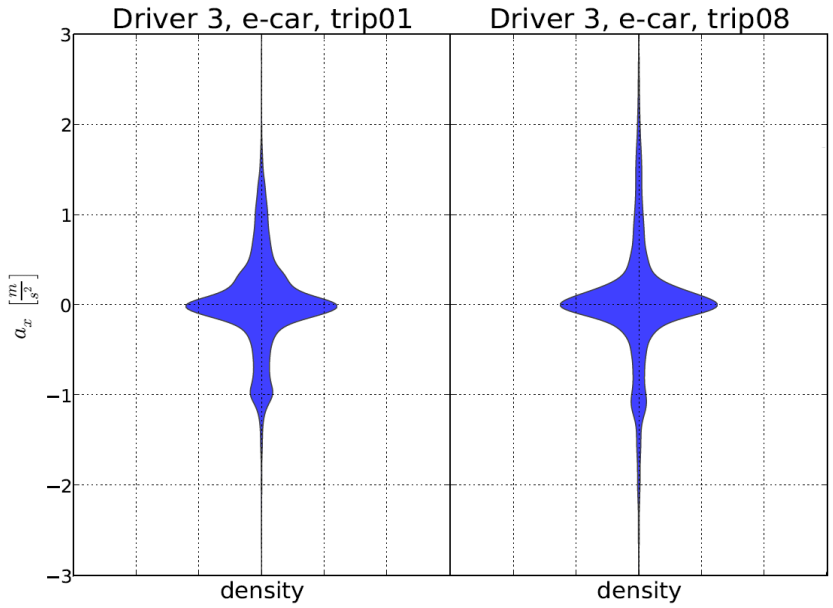
- Driver adaptation to the electric vehicle

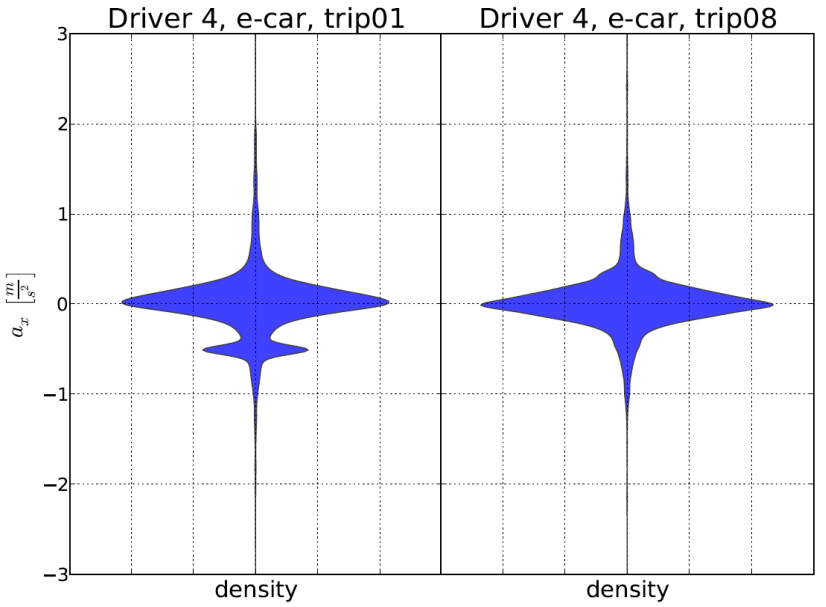
Driver	Length of first trip (km)	Length of last trip (km)	Maximum speed limit first trip (km/h)	Maximum speed limit last trip (km/h)
#1	10	10	100	100
#2	14	21	130	130
#3	27	24	100	100
#4	51	54	130	130

Adaptation: acceleration – deceleration

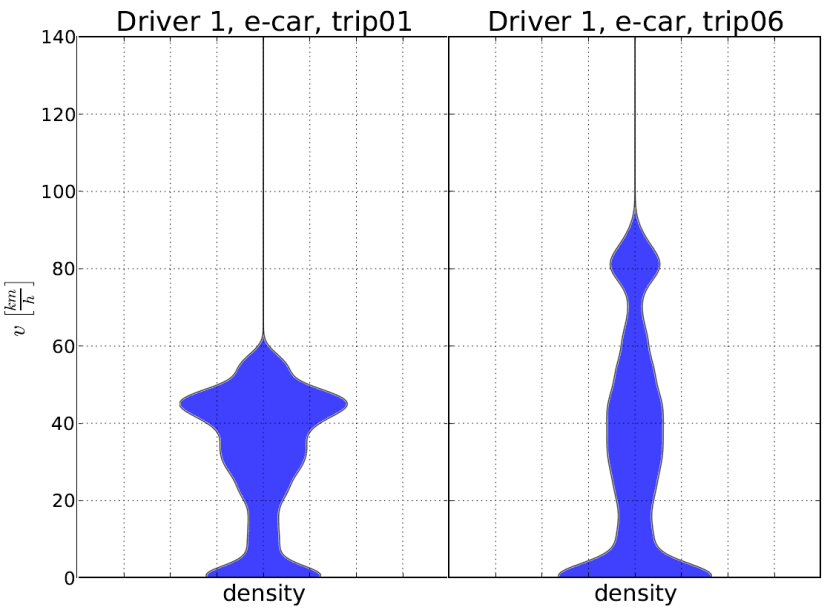


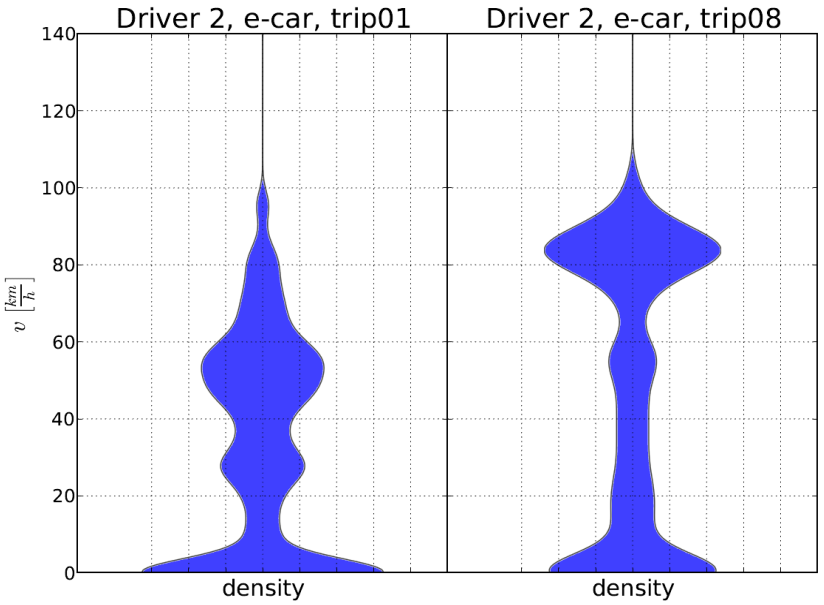


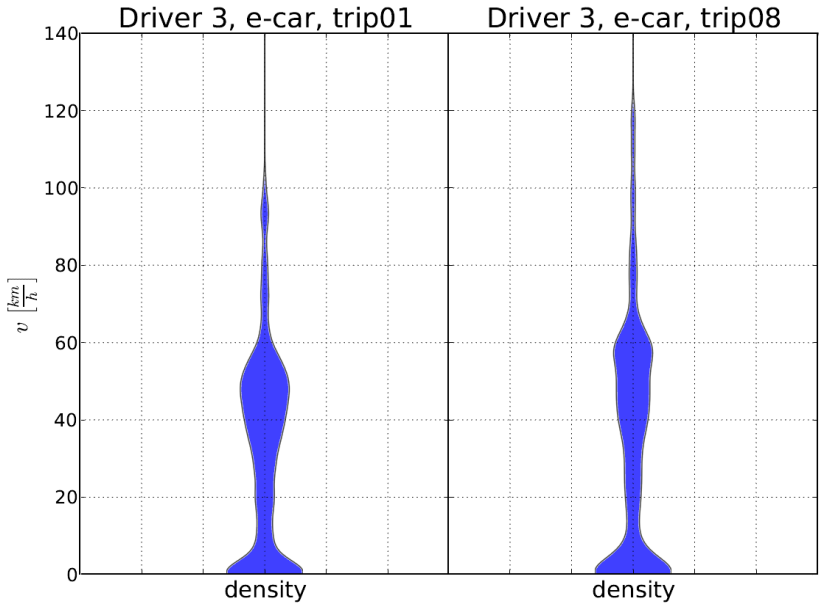


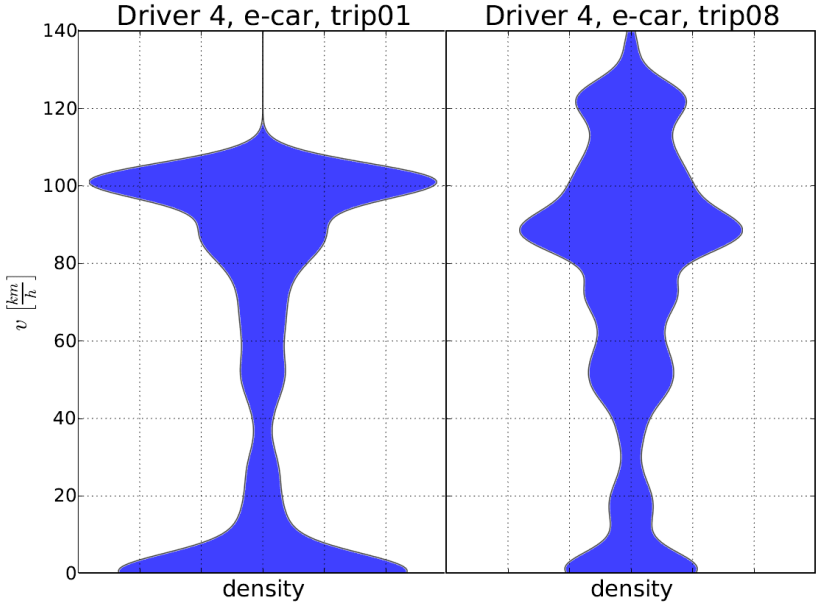


Adaptation: velocity









Qualitative analysis

- Expectations of the electric vehicle
  - As easy to use
  - Same or even better performance
  - Satisfied daily travel needs
- Vehicle dynamics and acoustics
  - Same or even better acceleration performance
  - Acoustic profile could affect safety or lead to under-evaluation of speed
- Adaptation
  - Overall – less than a day
- Safety
  - As safe, although issues may arise (due to acoustic profile)
- Vehicle range
  - All drivers recharged the vehicle as often as possible

Conclusions

- Drivers have the ability of easily adapting to the electric vehicle
- No significant differences were found between electric and combustion cars in terms of vehicle dynamics and performance
- Drivers do not expect an electric vehicle to have the same performance as a conventional car
- The noise level of the electric vehicle could lead to potential safety issues
- The range of the electric car is still a drawback, willingness to pay is low

Discussion and research considerations

- Experimental setting
  - It is possible to evaluate the adaptation and short term behavior changes of drivers to electric vehicles after one week test trial;

- E-ENDORSE – "*The effects of electric vehicles and electric powered two-wheelers on road safety "*
  - Electric vehicle dynamics & acoustics (internal and external)
  - Test trial on dedicated test track with professional driver
  - "Hidden speedometer test"

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THANK YOU!

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