Route choice behaviour
The role of the reference point of *prospect theory* (and preliminary results of revealed preference route choice experiment)

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Extension on the work presented at the International Choice Modelling Conference 2011

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Outline

- Build up work (background/motivation)
- Role of heterogeneity in the reference point of prospect theory
  - Hypotheses investigated
  - Model specification
  - Results and discussion
- Further developments on "what travellers actually do"
  - Setup of revealed preference route choice experiment
  - Preliminary results
  - Next steps / Challenges

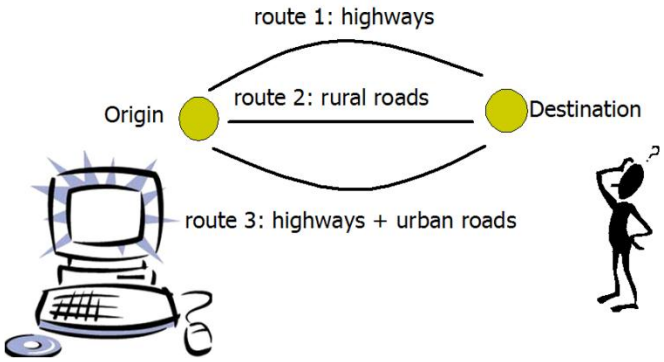
Build up work

Motivation of my PhD project

- Objective: investigate impact of traffic information provision on network dynamics
  - First it has to be understood how travellers behave and how information influences travellers behaviour
- When making route choices, do travellers behave as:
  - Utility maximizers?
  - Prospect maximizers?
  - Regret minimizers?
  - (Other)?

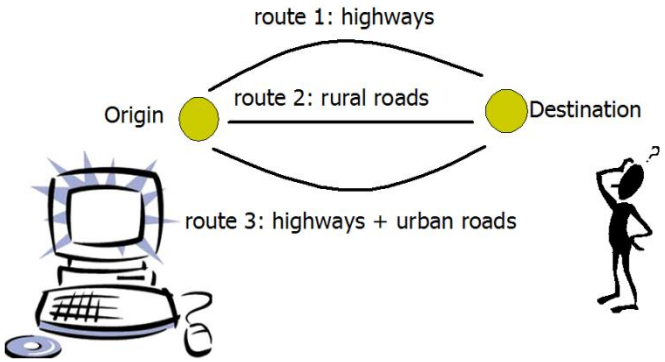
Build up work

- Comparative analysis between EUT and PT (and RT) in order to investigate their suitability to model travellers behaviour under different conditions of information provision



Build up work

Case study



- 40 consecutive route choices
- Routes with approximate length of 30 km
- Daily departures at 8:00 am and arrivals within 1 hour at the destination

- No goal such as minimizing travel time or arriving on time
- Travel purposes: meeting with colleagues and job interview
- Conditions of info provision: no info, travel time in minutes queues in kilometres

Build up work

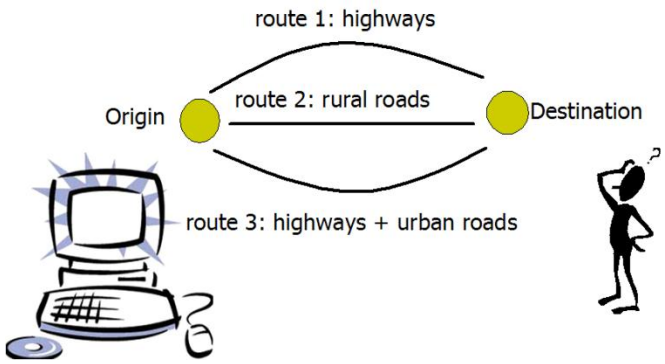
Case study

- Information was provided at the beginning of every trip
- It was not allowed to change routes after the trip had started
- The first 10 route choices were considered as experience period
- After each route choice, the travel time distributions were updated taking the new travel times into account

Route	Description	Mean travel time (min)	Variance of travel time (min^2)	10th percentile (min)	90th percentile (min)
1	30 draws from Gumbel distribution (35, 1)* 10 draws from Gumbel distribution (70, 1)	44	233	34	70
2	All draws from Gumbel distribution (53, 1.25)	53	1	52	54
3	All draws from Normal distribution (47, 12)	47	146	33	56

Build up work

- Direct application of the theories (not DCA formulation) suggesting the suitability of PT to model travellers behaviour and its potential to outperform EUT (depending on the reference point of PT)



Build up work

Prediction ability of the theories in scenarios 1 to 6

Scenario	Prediction ability taking reliability into account			Prediction ability *not* taking reliability into account		
	EUT	PT	RT	EUT	PT	RT
1. No info + Meeting colleagues	48.8%	47.7%	48.8%	38.7%	47.7%	40.5%
2. No info + Job interview	52.0%	51.1%	52.0%	34.0%	51.1%	34.5%
3. Info in minutes + Meeting colleagues	54.7%	61.3%	51.9%	54.7%	61.3%	51.9%
4. Info in minutes + Job interview	45.4%	53.1%	42.8%	45.4%	53.1%	42.8%
5. Info in kilometers + Meeting colleagues	40.5%	43.5%	40.5%	38.7%	43.5%	38.7%
6. Info in kilometers + Job interview	53.1%	54.1%	53.1%	51.2%	54.1%	51.2%

Role of heterogeneity in the reference point

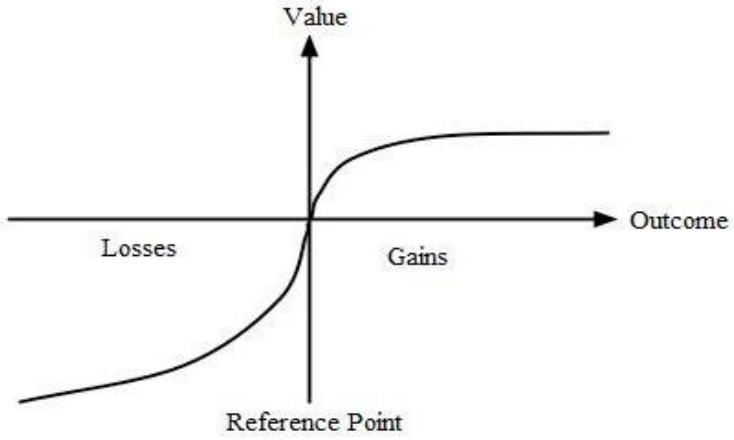
- Main Drawback regarding the use of PT:
  - Definition of meaningful values for the reference point – higher level of difficulty in repeated choices

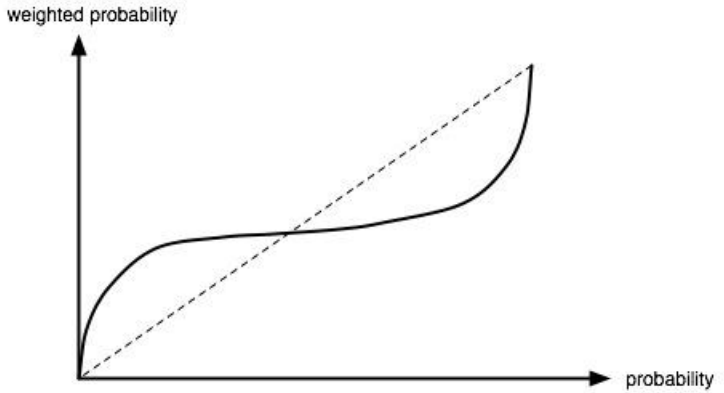
- The literature argues that usually a single reference point is used
  - This implies that all travellers value gains and losses similarly
  - In reality, however, there might be two or more reference points which may vary not only among travellers but also over time

Role of heterogeneity in the reference point

Basics of Prospect Theory

- Assumption: choices are based on gains and losses measured against a reference point





$$v(x) = \begin{cases} x^{\alpha} & if\ x \geq 0 \\ -\lambda(-x)^{\beta} & if\ x < 0 \end{cases}$$

$$w^{+}(p) = \frac{p^{\gamma}}{(p^{\gamma} + (1-p)^{\gamma})^{\frac{1}{\gamma}}} \qquad w^{-}(p) = \frac{p^{\delta}}{(p^{\delta} + (1-p)^{\delta})^{\frac{1}{\delta}}}$$

$$PT = \sum_{x,p} w^{+}(p) \cdot v^{+}(x) + \sum_{x,p} w^{-}(p) \cdot v^{-}(x)$$

Role of heterogeneity in the reference point

What is the value that travellers use as a reference to distinguish the experienced travel times into gains and losses?

Moreover, do all travellers have the same reference point or does heterogeneity in their behaviour play an important role?

Role of heterogeneity in the reference point

Hypotheses investigated

1. The reference point varies among travellers and over time
   - In case travellers' route preferences change over time, the reference point might also follow the new behaviour
2. The reference point reflects travellers' (risk) route choice preferences
   - The reference point is aligned with the travel time distribution of travellers' preferred route
3. In case pre-route information is provided, travellers' may use this as a reference point

Role of heterogeneity in the reference point

Model specification - *No Heterogeneity*

- All travellers have the *same* reference point
- Travellers update expectations and the reference point after each route choice
- Reference points (*no information*):
  a. mode of travel times of the fastest route (best probable)
  b. mode of travel times of the most reliable route (risk averse)
  c. average travel time of all routes (no behavioural meaning)
  d. minimum travel time of the fastest route (risk seeker)
- Weighting function based on the probabilities of occurrence of travel times

$$\omega^{+}(p) = \frac{p^{\gamma}}{(p^{\gamma} + (1-p)^{\gamma})^{\frac{1}{\gamma}}} \qquad \omega^{-}(p) = \frac{p^{\delta}}{(p^{\delta} + (1-p)^{\delta})^{\frac{1}{\delta}}}$$

Role of heterogeneity in the reference point

Model specification - *No Heterogeneity*

- Reference points (*travel time information*):
  a. mode of travel information of the fastest route
  b. mode of travel information of the most reliable route
  c. average travel information of all routes
  d. minimum travel information of the fastest route
  e. actual information
  f. actual information_2

- Weighting function based on the probabilities of occurrence of travel information (a to e) or the travel time (f)

$$\omega^{+}(p) = \frac{p^{\gamma}}{(p^{\gamma} + (1-p)^{\gamma})^{\frac{1}{\gamma}}} \qquad \omega^{-}(p) = \frac{p^{\delta}}{(p^{\delta} + (1-p)^{\delta})^{\frac{1}{\delta}}}$$

Role of heterogeneity in the reference point

Model specification - ***Heterogeneity***

- Each traveller has its *own* reference point
- Travellers update expectations and the reference point after each route choice
- Reference points (*no information*):
  i. travel time of the most chosen route up to the previous day
  ii. travel time of the most chosen route in the previous 5 days
- Weighting function based on the probabilities of occurrence of travel times

$$\omega^{+}(p) = \frac{p^{\gamma}}{(p^{\gamma} + (1-p)^{\gamma})^{\frac{1}{\gamma}}} \qquad \omega^{-}(p) = \frac{p^{\delta}}{(p^{\delta} + (1-p)^{\delta})^{\frac{1}{\delta}}}$$

Role of heterogeneity in the reference point

Model specification - ***Heterogeneity***

- Reference points (*travel time information*):
  i. travel information of the most chosen route up to that day
  ii. travel information of the most chosen route in the previous 5 days
- Weighting function based on the probabilities of occurrence of travel information or the travel time

$$\omega^{+}(p) = \frac{p^{\gamma}}{(p^{\gamma} + (1-p)^{\gamma})^{\frac{1}{\gamma}}}$$

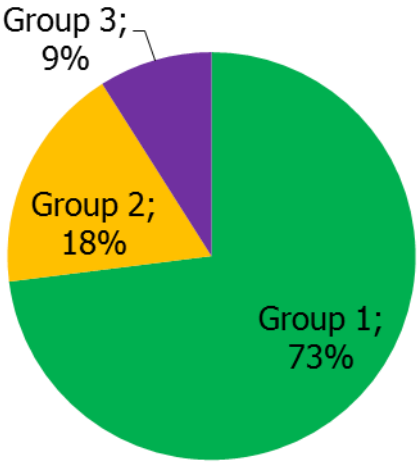
$$\omega^{-}(p) = \frac{p^{\delta}}{(p^{\delta} + (1-p)^{\delta})^{\frac{1}{\delta}}}$$

Role of heterogeneity in the reference point

Results and discussion

- As long as travellers present route choice behaviour instead of random choices, accounting for heterogeneity is without doubt the reason of significant improvements

- 3 groups of travellers were identified regarding route choices preferences:
  - group 1: strict preference for one route
  - group 2: moderate preference for one route
  - group 3: indifferent travellers



For groups 1 and 2:
H1: RP varies among travellers and over time
H2: RP reflects travellers' (risk) route preferences
H3: Travellers might use information as RP

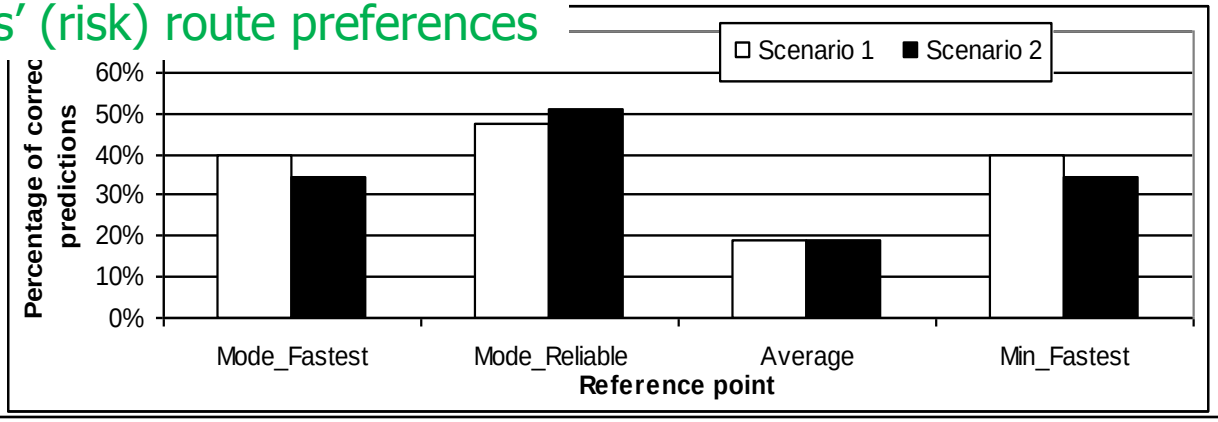
Role of heterogeneity in the reference point

Results and discussion - *No Heterogeneity*

Scenarios with no information

- Travellers tended to choose the most reliable route
  - Highest performance→ Reference point equal to the mode of travel times of the most reliable route (RP aligned to the observed behaviour)
  - Lowest performance → Reference point equal to the average travel time of all routes. Benefitting routes of intermediate performance

Hypothesis 2:
RP reflects travellers' (risk) route preferences



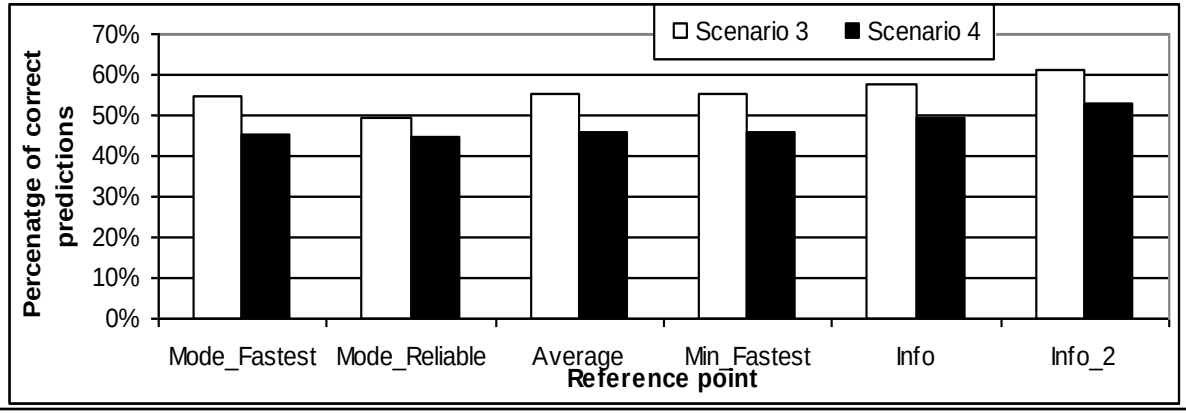
Role of heterogeneity in the reference point

Results and discussion – *No Heterogeneity*

Scenarios with travel time information

- Lower variability in PT's performance due to lower variability in the travel information
- Disappointing results in scenario 4 (similar to scenario 2)
  - Result somehow expected because the route choices were more homogeneous

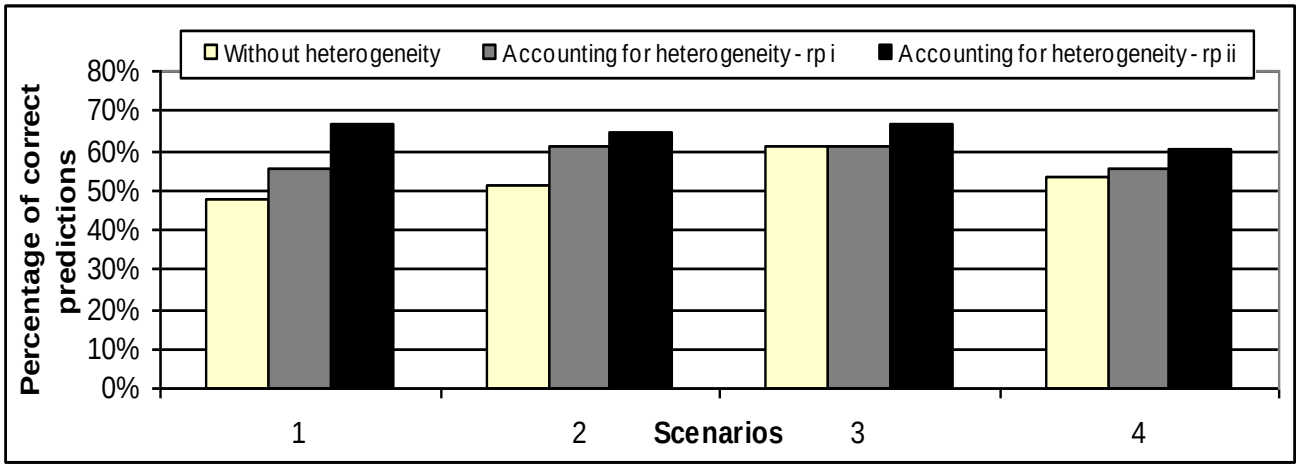
Hypothesis 3:
Travellers might use travel information as RP



Role of heterogeneity in the reference point

Results and discussion - ***Heterogeneity***

- By taking heterogeneity into account the PT's prediction ability substantially increases (condition $ii - 5\ past\ days$)
  - Quicker adaptation to new behaviour
- Under the i condition, the robustness was also improved (increase in the minimum amount of correct predictions 2 →8)



With and without accounting for heterogeneity

What do travellers actually do?

Setup of the revealed preference experiment

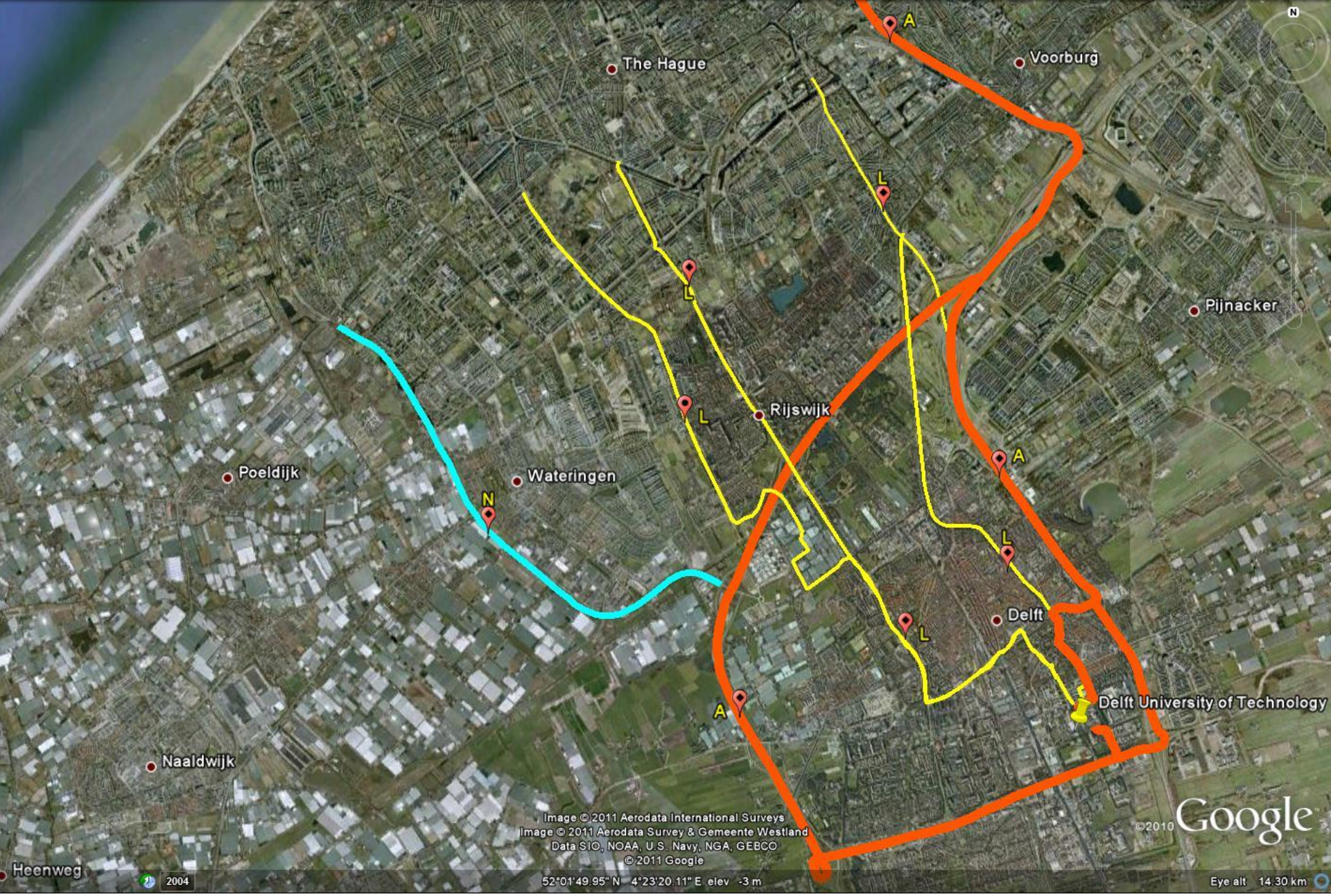
- Investigate travellers' route choice behaviour in order to discuss:
  - whether travellers actively look for information or are passive receptors of information
  - whether travellers comply with information and in particular under which type of conditions
  - if and how provision of travel information influences travellers' behaviour

- Use of GPS devices, real-time traffic information via TomTom devices and travel diaries

What do travellers actually do?

Setup of the revealed preference experiment

- General characteristics:
  - 32 commuters in the Netherlands
  - 8 weeks of data collection (May 9th to July 12th, 2011)
  - 44% women and 56% men
  - Age ranged from 23 to 60 years old
  - Commute frequency varied between 2 and 5 days/week (61% commuting 5 days/week)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52°01'49.95" N 4°23'20.11" E elev -3 m
Eye alt 14.30 km

What do travellers actually do?

Setup of the revealed preference experiment

Period	Treatment	
	No info **(or public info sources)**	***Info*** **(free info sources + *TomTom*)**
Initial 3 weeks	100% (32 participants)	0% (0 participants)
Last 5 weeks	20% (6 participants)	80% (26 participants)

What do travellers actually do?

Setup of the revealed preference experiment

- Travel diary consisted of 5 sections related to:
  i. general information such as date of the trip, origin and destination
  ii. behavior and reaction towards pre-trip information, such as whether they had received or actively looked for pre-trip information, sources of information provision, how they had reacted to it, etc.
  iii. behavior and reaction towards en-route information
  iv. feedback about the trip just made, such as actual travel time, whether the participants would have chosen the same route, etc.
  v. expectations about the next trip with respect to their intended route choice, expected travel time, flexibility, etc.

What do travellers actually do?

Preliminary result (route choice behaviour of 10 participants during 5 weeks)

- 306 trips (190/116)
  - General route choice set was quite comprehensive, but one new route (in The Hague) had not been mentioned by any of the participants
  - Individual choice set appeared to be smaller for 4 out 10 participants
  - Preference for highways in Delft and local roads in The Hague
  - Good estimates of average commuting times
  - Perceptions of route characteristics is biased in favor of the preferred routes (almost all participants considered their preferred route to be reliable, but there was quite a large variance in travel times)

What do travellers actually do?

Preliminary results (route choice behaviour of 10 participants during 5 weeks)

- Significant increase in the amount of participants checking en-route information
  - Travellers are more willing to look for information while driving (or just before starting the trip) and not to plan the best departure time
- For 90% of the participants, the route suggested differed from their intentions less than 30% of the times (compliance rates with information over 70%)
- For one of the participants the route suggested differed from the expectations between 30% and 50% of the times (compliance rate with the advice reduced correspondingly to 50% and 70%).
- All participants were satisfied or very satisfied with the information. Most of them considered it to be reliable over 70% of the times

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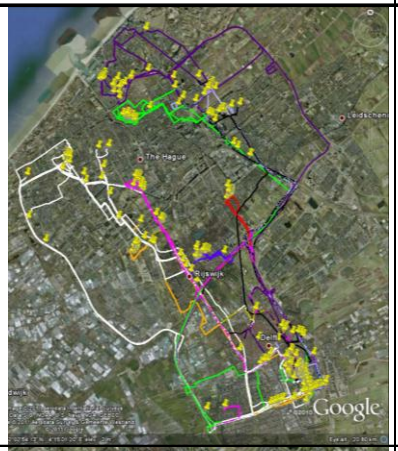
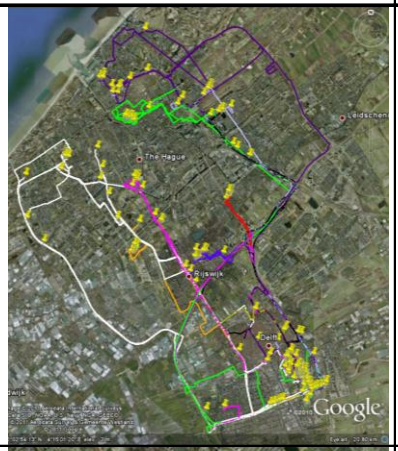
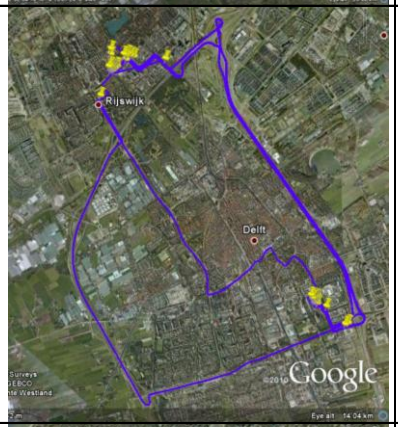
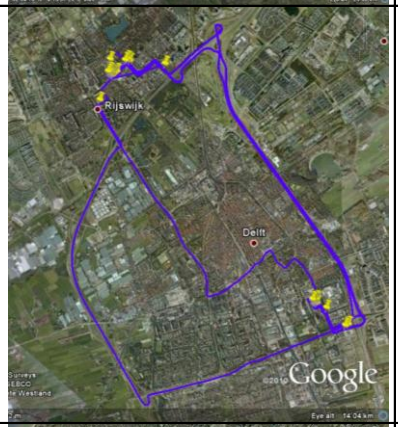
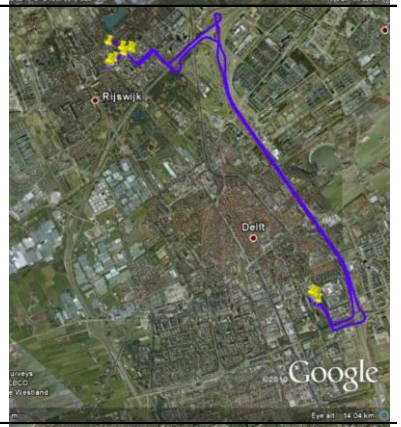
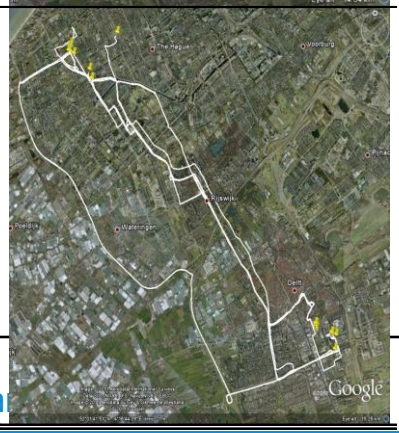
All			
1			
2			

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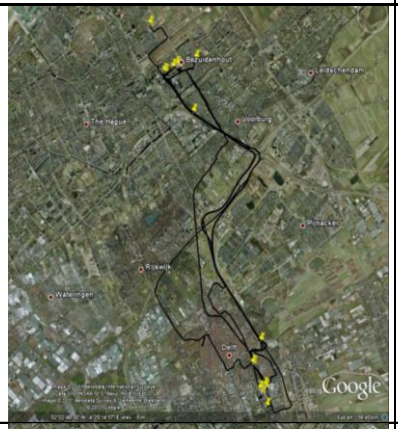
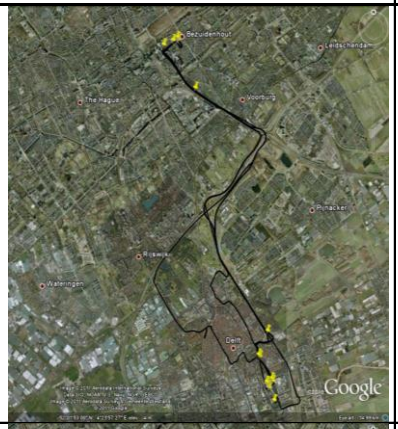
5			
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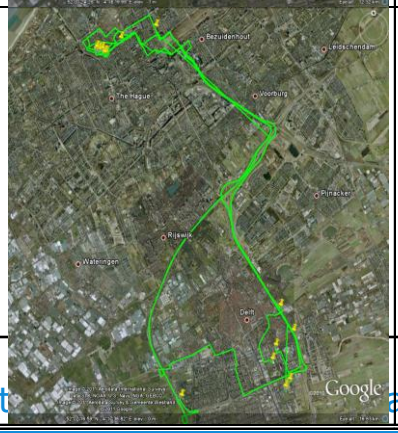
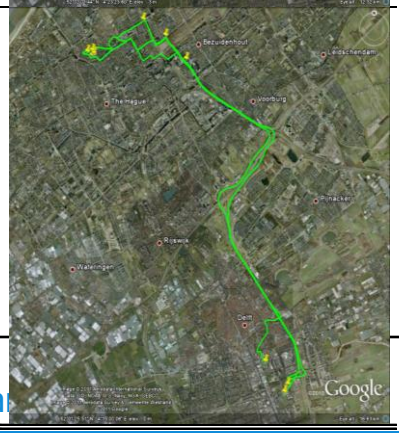
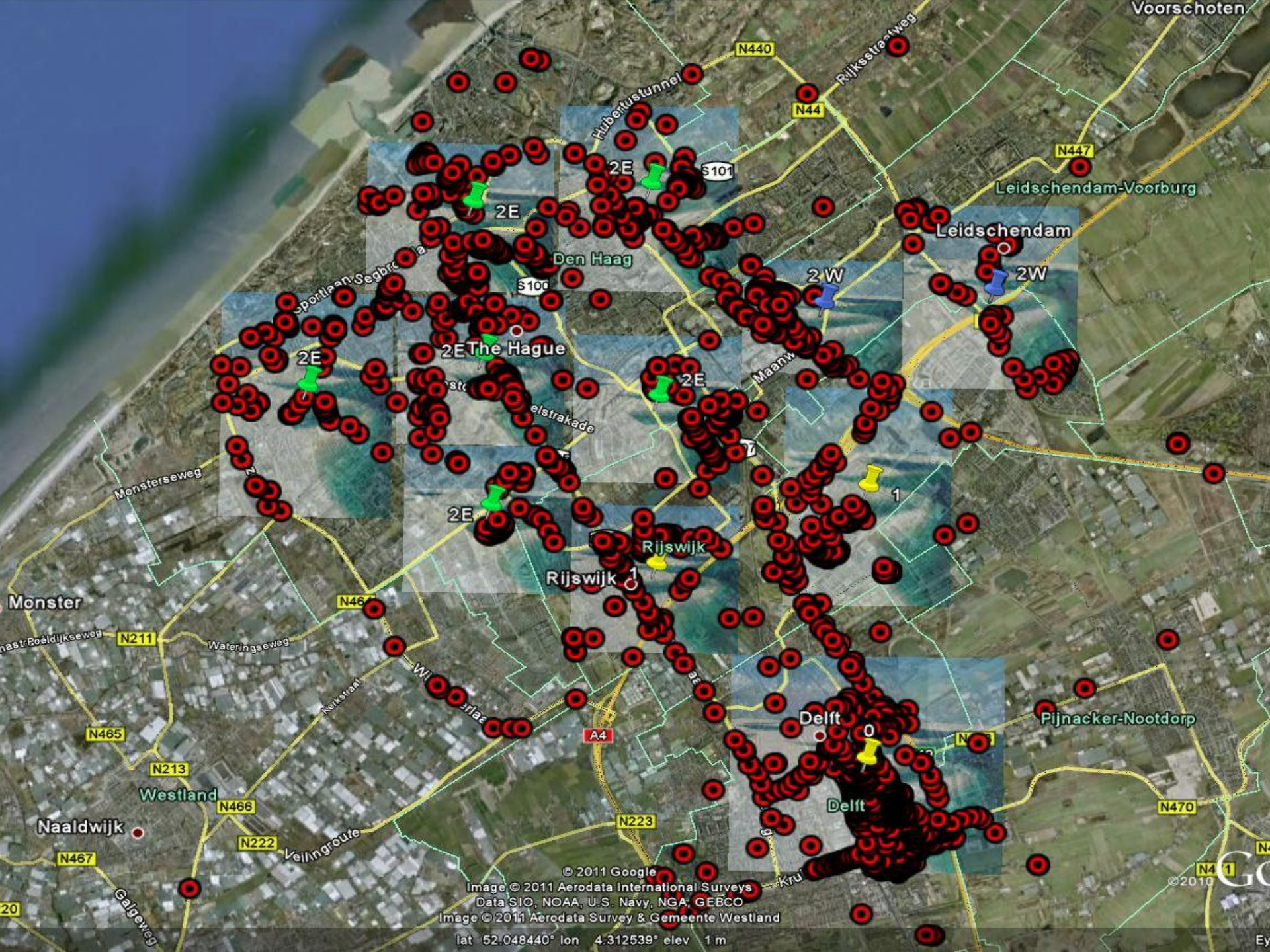
7			

What do travellers actually do?

Challenges and next steps

- Build up 2 models of route choice behaviour (Discrete Choice formulation) having as a base utility and prospect theory and compare them
- Data issues to be tackled:
  - Great amount of ODs (travel times on the alternative routes)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What do travellers actually do?

Challenges and next steps

- Data issues to be tackled:
  - Route dominance!!!

What do travellers actually do?

Challenges and next steps

Route	# times	AVG TT	Ranking
1	228	0:13:25	**1**
2	4	0:21:48	5
3	4	0:14:38	2
4	23	0:15:57	3
5	7	0:19:41	4

Route	# times	AVG TT	Ranking
12	55	0:17:33	2
13	2	0:31:03	4
21	1	0:20:49	3
22	1	0:09:20	**1**

Route	# times	AVG TT	Ranking
14	419	0:23:46	3
15	160	0:17:56	2
16	37	0:25:46	4
17	5	0:28:32	8
18	6	0:28:23	7
24	4	0:26:51	5
26	10	0:15:51	**1**
34	4	0:29:34	10
44	3	0:30:27	11
46	112	0:27:11	6
47	69	0:31:41	12
48	1	0:40:20	14
54*	8	0:52:24	16
56	11	0:44:04	15
57	14	0:39:25	13
58	85	0:29:04	9

Thank you for your attention

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