EVALUATING THE QUALITY OF BICYCLE INFRASTRUCTURE DESIGN

- Research on four continents

V SEMINARIO INTERNACIONAL EN GESTIÓN DE INFRAESTRUCTURA PARA LA OCUPACIÓN SOSTENIBLE DEL TERRITORIO

MARK BRUSSEL

DEPARTMENT OF URBAN AND REGIONAL PLANNING AND GEOINFORMATION MANAGEMENT

M.J.G.BRUSSEL@UTWENTE.NL

FACULTY OF GEO-INFORMATION SCIENCE AND EARTH OBSERVATION
WHO AM I

Background in Civil Engineering, Delft
University of Technology

Previous work experience:

- Engineering consulting, NL and Yemen
  (roads, drainage, solid waste, water supply, sanitation)
- United Nations, Indonesia, hydrology, water management
- University of Twente, ITC, application of GIS/RS in urban infrastructure and transport
MY RESEARCH INTERESTS

Application of GIS/RS in urban infrastructure and transport

- Infrastructure planning and decision support
- Sustainable Transport (PT, walking and cycling)
- LU-transport interaction, accessibility
- Urban water systems/drainage/flooding

- Contact: m.j.g.brussel@utwente.nl
CYCLING RESEARCH ON FOUR CONTINENTS

Dar es Salaam, Tanzania

Bogota, Colombia

Enschede, Netherlands

Christchurch, New Zealand

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DISCUSSION FOR EACH CITY
TO GIVE A FLAVOUR OF DIFFERENT TYPES OF CYCLING RELATED RESEARCH

- The city and its cycling
- What are we researching?
- Methodology and key results
- Lessons learned

- Overall conclusions
DAR-ES-SALAAM, TANZANIA

Facts:
- 4.5 million people
- Cycling: 5% of all trips
- Poorest segments of society

Traffic Safety

Cycling seen as a poor man's mode

Hardly any cycling infrastructure
WHAT ARE WE RESEARCHING IN DAR ES SALAAM?

- How can people be influenced to change their current travel behaviour towards bicycle use
- If we know this we can design targeted travel behaviour change strategies
METHODOLOGY: IDENTIFYING AND CHARACTERIZING CYCLING MARKET SEGMENTS

Segmentation done using the stages of change model of Prochaska and Di Clemente (1984; and further)

- In this model, when a person changes behaviour he/she typically moves through different stages of change

(Prochaska and Diclemente, 1984)
METHODOLOGY: PRIMARY DATA COLLECTION

- Data collected from commuters, both cyclists and non cyclists
- 600 personal questionnaires on:
  1. Socio-economic/demographic information
  2. Travel behavioural information
  3. Attitudes and perceptions towards bicycle use
<table>
<thead>
<tr>
<th>Statement shown to respondents</th>
<th>Corresponding stage of behaviour change</th>
</tr>
</thead>
<tbody>
<tr>
<td>I never really think about and not even consider cycling to my daily activity</td>
<td>Pre-Contemplation (PC)</td>
</tr>
<tr>
<td>I never used a bicycle but sometimes think about cycling to my daily activity</td>
<td>Contemplation (C)</td>
</tr>
<tr>
<td>I rarely or sometimes cycle and seriously consider riding to my daily activity</td>
<td>Prepared for Action (PA)</td>
</tr>
<tr>
<td>I have fairly often cycled to my daily activity</td>
<td>Action (A)</td>
</tr>
<tr>
<td>I cycle regularly to my daily activity</td>
<td>Maintenance (M)</td>
</tr>
<tr>
<td>I no longer cycle to my daily activities</td>
<td>Relapse (R)</td>
</tr>
</tbody>
</table>
**SOME RESULTS: MAIN MOTIVATIONAL FACTORS FOR CYCLING BY SEGMENT BASED ON LOGISTIC REGRESSION**

<table>
<thead>
<tr>
<th>Stage of change segment</th>
<th>Perceived motivational factors</th>
<th>Socio-economic characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-contemplation</td>
<td>Separate bicycle paths (52%)</td>
<td>Middle/high income male working mostly in government and private offices, and uses private car and public transport</td>
</tr>
<tr>
<td></td>
<td>Cycling training and education on traffic rules (15%)</td>
<td>Low income, secondary school students and women</td>
</tr>
<tr>
<td></td>
<td>Public awareness on cycling (10%)</td>
<td>Both male/female, no vehicle ownership, low/medium income, aware of benefits of cycling and cost saving</td>
</tr>
<tr>
<td></td>
<td>Other factors (23%)</td>
<td>Male dominated, low education, bicycle ownership, bicycle is an alternative</td>
</tr>
<tr>
<td>Contemplation</td>
<td>Special bicycle infrastructure (45%)</td>
<td>Regular bicycle commuters, male, income generating cycling, bicycle means more accessibility</td>
</tr>
<tr>
<td></td>
<td>Cycling training and education centres (20%)</td>
<td>medium/high education, both male/female, vehicle owners</td>
</tr>
<tr>
<td></td>
<td>Reduction of bicycle prices (13%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Enforcement of road safety rules (10%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other factors (12%)</td>
<td></td>
</tr>
<tr>
<td>Prepared for action</td>
<td>Access to bicycle loans (57%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Enforcement of road safety rules (20%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reduction of bicycle prices (15%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Free bicycles (8%)</td>
<td></td>
</tr>
<tr>
<td>Action</td>
<td>Reduction of bicycle prices (65%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Enforcement of road safety rules (20%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Traffic laws and road safety rules should be designed in favour of cyclists (10%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other factors (5%)</td>
<td></td>
</tr>
<tr>
<td>Maintenance</td>
<td>Reduction of bicycle prices (57%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Educating car drivers to change their attitude towards cyclists (35%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other factors (8%)</td>
<td></td>
</tr>
<tr>
<td>Relapse</td>
<td>Special bicycle infrastructure (60%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Enforcement of road safety rules (25%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Shorter travel distances (11%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other factors (4%)</td>
<td></td>
</tr>
</tbody>
</table>
LESSONS LEARNED

- Commuter perceptions help to understand bicycle commuting behaviour
- Only constructing physical infrastructure will have little impact
- The stage of change model tells us which target group to aim for and what is its potential for modal change
- Key motivational factors specific to user groups can guide cycling promotional strategies

Publishing: two papers published in Habitat International and Transport Policy
BOGOTA, COLOMBIA

Facts:
- 8.5 million inhabitants
- Cycling: 3% of all trips
- Ciclovia!

Safety (Traffic and personal)
Maintenance and expansion of cicloruta
Connectivity of network
Design of intersections
WHAT ARE WE RESEARCHING?
TOGETHER WITH UNIVERSIDAD PILOTO

- What is the level of satisfaction cyclists get from using Cicloruta.
- Can we develop a Bicycle Level of Service (BLOS) Model to give us the quality of the infrastructure and the perceived satisfaction of the users?
- Which factors are most determinant in the level of satisfaction?
- How can this model be used to make recommendations on future improvements?
METHODOLOGY – SELECTION OF BLOS VARIABLES

- Participant’s personal characteristics
- Experience
- Environmental characteristics (influence of weather)
- Segment variables (Bicycle lane width, Pavement condition of lane, Side path separation, Vehicle speed, Motorised traffic volume, conflicts with pedestrians etc. etc.)
- Intersection variables (Volume of cyclists, conflicts with pedestrians/cyclists, Road signs and markings, Total intersection legs, Crossing width of intersection (CWI))
METHODOLOGY – VIDEO SURVEYS OF CICLORUTA SEGMENTS
METHODOLOGY

- 183 km of cicloruta were surveyed and selected segments and intersections were filmed based on segment and intersection characteristics.

- These films were shown to focus group panels and the satisfaction of the segments and intersections was rated by 86 people.

- A multivariate analysis was performed and a logit model created that allows the calculation of BLOS scores.
RESULTS – EXAMPLE OF SEGMENT LOGIT MODEL

Box 1 Model 1

\[
\text{BLOS}_{\text{segment}} = \begin{cases} 
    \text{HS} = 0.187 \\
    \text{MS} = 1.024 \\
    \text{AS} = 1.601 \\
    \text{AD} = 1.973 \\
    \text{MD} = 2.435 \\
    \text{HD} = 2.955 \\
\end{cases} + 0.605 \cdot \text{SPS} + 0.717 \cdot \text{VS} - 0.381 \cdot \text{MTV} + 1.173 \cdot \text{CWP}
\]

where
- HS = highly satisfied;
- MS = moderately satisfied;
- AS = a little satisfied;
- AD = a little dissatisfied;
- MD = moderately dissatisfied;
- HD = highly dissatisfied;
- SPS = side path separation;
- VS = vehicle speed;
- MTV = motorized through volume; and
- CWP = conflicts with pedestrian and other cyclists.
RESULTS – SCORES OF CICLORUTA SEGMENTS

Bicycle level of service at segment level

Legend
- Moderately Satisfied
- A Little Satisfied
- A Little Dissatisfied
- Moderately Dissatisfied
- Highly Dissatisfied

Bicycle level of service at cicloruta level with intersection BLOS in selected segments

Legend
- A Little Satisfied
- A Little Dissatisfied
- Moderately Satisfied
- A Little Satisfied
- A Little Dissatisfied
- Moderately Dissatisfied
- Highly Dissatisfied
LESSONS LEARNED

- The BLOS model can be used to get an overview of the level of service provided by the bicycle infrastructure as perceived by the users.
- Evaluation of route videos is effective.
- The models show us which factors are of particular importance.
- Location based improvements can be derived from the model.

ENSCHDEDE, THE NETHERLANDS

Facts:
- 160,000 inhabitants
- Cycling: 36% of all trips
- Good quality infrastructure
- Issues with parking/PT

Bicycle parking
Space on bike lanes
Bus is competitor
WHAT ARE WE RESEARCHING?
DO PEOPLE CHOOSE ROUTES BASED ON INFRASTRUCTURE SERVICE LEVEL?

Do people choose their routes according to the Bicycle Level of Service of the infrastructure or based on other reasons?
DATA COLLECTION

Questions about:

- Gender
- Age
- No. of cycling days/week
- Route choice
- Reasons
GIS DATA MODELING
SECTIONS AND INTERSECTION – DYNAMIC SEGMENTATION

Sections

Centerline

Sub-segments

Segments

Intersection

Vertex of section

Turn connections

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Results - Individual BLOS indicator visualization

Legend
Indicator Score
- 1 4
- 2
- 3 6
Centerline

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Results - Real routes and shortest routes (to Stadskantoor)

Routes of Shortest Distance and Real Routes to Stadskantoor

Routes of Shortest Time and Real Routes to Stadskantoor

Legend
- Stadskantoor
- Stadskantoor_origins
- Traffic lights
- Routes of shortest distance
- Real Routes
- Bicycle Network

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LESSONS LEARNED

- For 45% of all trips the actual route taken by people has a better BLOS score than the shortest distance or shortest time routes.
- However, BLOS scores of real routes and shortest distance routes are remarkably similar.
- The municipality is advised which routes to improve.

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CYCLING IN CHRISTCHURCH

Facts:
- 350000 inhabitants
- Cycling: 7% of all trips
- Reconstruction after Earthquake
- 50 Km of new cycleways
- Aim: best cycling city in the Southern Hemisphere

Bad design at crossings
Parking on bike lanes
Driver behaviour
ARE YOU GETTING CONFUSED??
In this research we develop a GIS based multi-criteria evaluation of cycling routes to help planning and design choices and to add to transparency to the design process.

There is no “one best plan”, or “one best design”. It depends on who you are talking to!
TWO ROUTES
Technique for decision making of complex problems

Based on a set of (two or more) alternatives that are evaluated on the basis of one or more criteria.

These criteria can be given a certain preference/ importance over other criteria (weight)

Scores of criteria and subcriteria are calculated and weighed, arriving at an overall score that indicates the overall attractiveness of the alternatives.
STAKEHOLDER BASED SELECTION OF CRITERIA
COMBINING DEMAND AND SUPPLY CRITERIA

Main criteria chosen:

1. Comfort
2. Road Capacity
3. Junction Safety
4. Directness & Efficiency
5. Connectivity to Public Transport
6. Attractiveness
7. Trip Generators & Attractors
STAKEHOLDER GROUPS

- Parents of school going children aged 10-17
- Current cyclists (commuters)
- Potential cyclists (commuters)
Stakeholder Analysis of 7 Main Criteria

Potential Cyclist Commuters

Current Cyclist Commuters

Parents of 10-17 Aged Children
Information on a Detailed Level for 17 Sub-criteria

Route Scores: Equal Weights for all 17 Sub-criteria

Route 1 Individual Sub-criteria Scores

Equally Weighted Scores

(M) Distance Cycling South to North Along Route Option 1

Route 2 Individual Sub-criteria Scores

Equally Weighted Scores

(M) Distance Cycling South to North Along Route Option 2

Raw Performance

- Visibility
- Sp.&Vol.
- Fac. Cap.
- Right Turn
- Delay
- Noi. & Pol.
- Non-slip
- Roughness
- Ef. Width
- Traf. Com.
- Det. Fac.
- Connect.
- Bus
- Pub. Area
- Lighting
- Population
- Destinat.
KEY CONCLUSIONS

- The network based SDSS enables more transparent decision making
- The method helps designers identify priorities and solve local design problems
- It works at the local level, but it can work also at the level of entire networks

Publishing: Paper being submitted to the journal of Transportation
OVERALL CONCLUSIONS

- GIS based methods can help in the analysis of the quality and level of service of infrastructure and in the evaluation of alternative planning and design options.

- The role of civil engineers is changing. In our work, we need to look at people, their preferences, how they behave and how they think.

- We need to involve them in our engineering design.

- So whatever you do, put people central!

- AND PUBLISH!

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THANK YOU FOR YOUR ATTENTION!