Engaging virtual reality for transport planning

Applications in Singapore

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Applications in Singapore

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Prof. Dr. Hölscher (Co-PI

URBAN REDEVELOPMENT AUTHORITY

NHTV Breda University of Applied Sciences

PTV GROUP

Land Transport Authority

ABOUT THE FUTURE CITIES LABORATORY

Singapore ETH Centre

- ETH Zurich's first major research centre outside Switzerland
- Part of CREATE Campus with many other international universities: MIT, Berkeley, Cambridge, TUM…

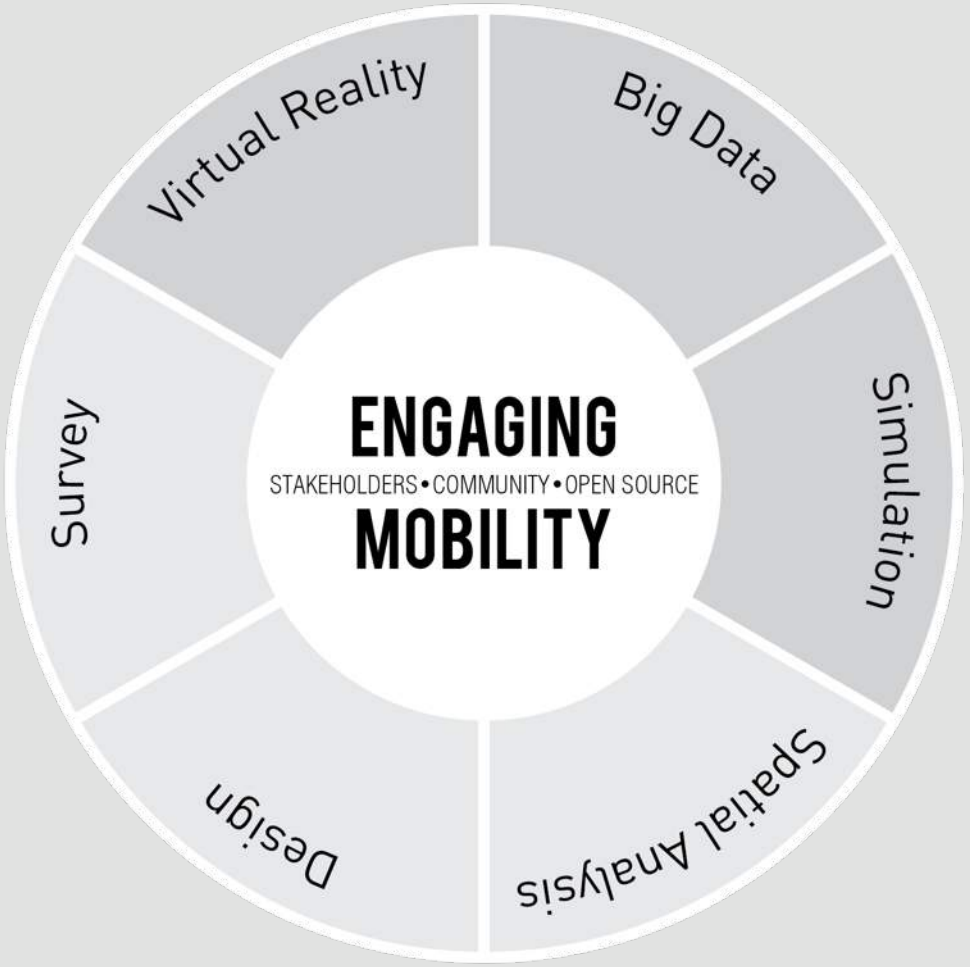
Future Cities Laboratory

Create knowledge and ideas for a sustainable urban future

- Through **science**, **technology** and **design**
- Disciplinary expertise and transdisciplinary projects
- In place in partnership and dialogue with local stakeholders

Source: Tanvi Maheshwari

ENGAGING MOBILITY AS A RESEARCH PLATFORM



We can’t address current and future urban mobility challenges alone and don’t act in an ivory tower. Therefore, our core principles are Open Source and engaging with local stakeholders and communities.

Given today’s highly specialised work and research environment, we believe in the power of working in an interdisciplinary manner.

Engaging Mobility combines cutting edge technologies with state-of-the art methods in innovative research projects.

Source: Tanvi Maheshwari

CYCLING EXPERIENCE IN SINGAPORE: ON STREET

On Road Cycling (2016) Jonas Kupferschmid

CYCLING EXPERIENCE IN SINGAPORE: OFF STREET

From Clementi to CBD in 62 minutes
(2016) The Straits Times. Available here

CYCLING IN SINGAPORE: FUTURE PLANS

Source: URA

ENGAGING VIRTUAL REALITY

Objective

To understand what is needed to make cycling viable modes of transport in Singapore

Explore VR as a research tool

Methods

Combine science, technology and design

Virtual Reality experiments

Stated preference surveys

Outcomes

Evidence-based street design recommendations

Virtual reality as a tool for transport planning

Engaging Active Mobility, Seng Poh Road (2016)

Introduction

Expert survey on cycling in Singapore

Generating and animating 3d streetscapes

Bike to to Future I

Bike to the Future II

Bike Pulse

Bike to the Future III

Source: Tanvi Maheshwari

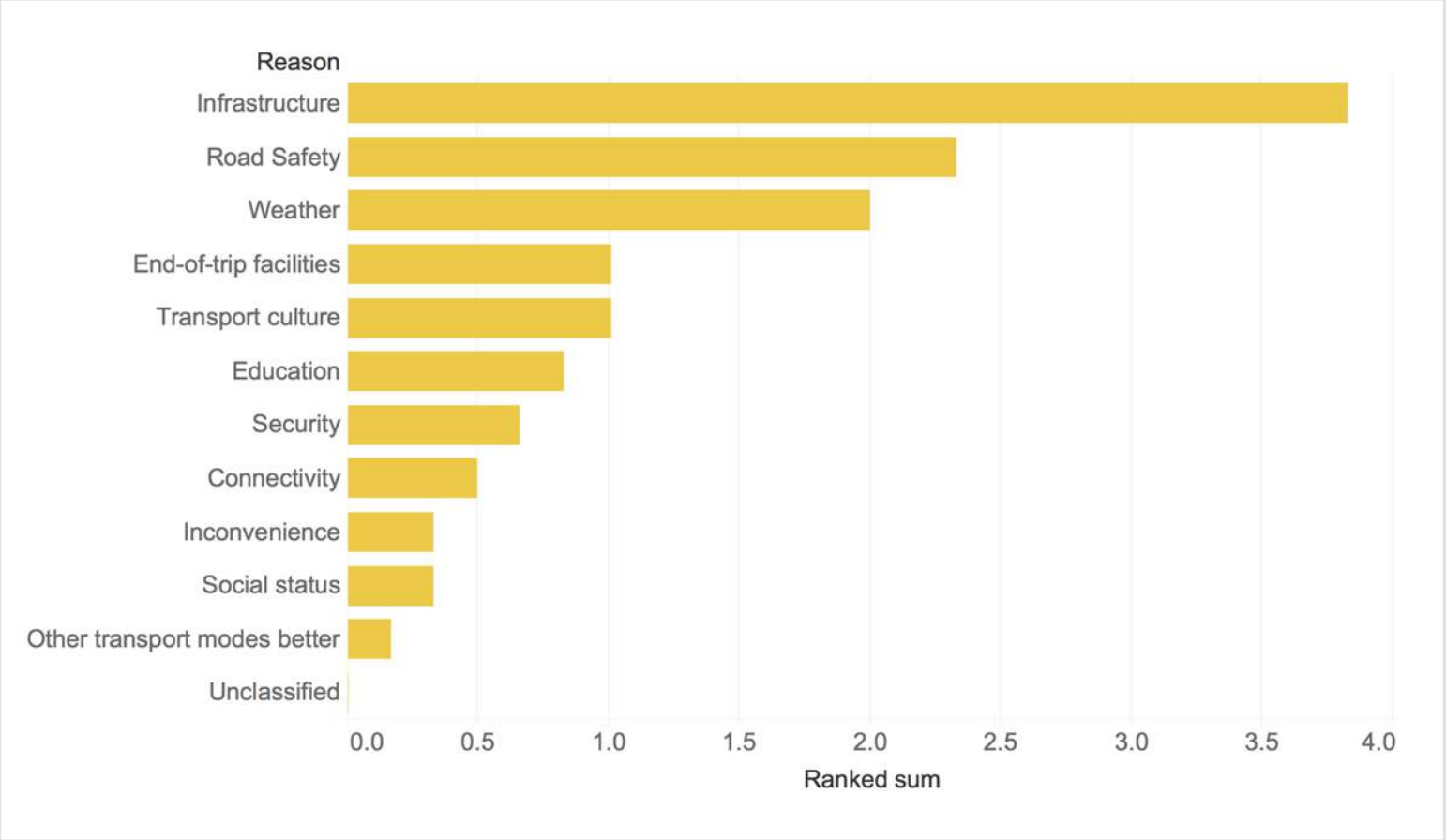
WHY ARE CYCLING ACTIVITIES SO LOW IN SINGAPORE?

Expert interviews (2016)
Source: Jonas Kupferschmid

Method

Expert interviews
Approx. 1 hour
Semi-structured
13 respondents from government, research, commuters & advocacy groups

Evaluation by ranked sum;
Experts were asked to state why people are not cycling, first mention received 0.5 points, second mention 0.3 points, third mention 0.2 points.



CYCLING IN THE NETHERLANDS

Michael van Eggermomd (2016)
Kruisstraat, Eindhoven, the Netherlands

Introduction

Expert survey on cycling in Singapore

Generating Virtual Reality for cycling research

Bike to to Future I

Bike to the Future II

Bike Pulse

Bike to the Future III

Source: Tanvi Maheshwari

WHY VIRTUAL REALITY?

Holistically understanding behaviour

Built environment influences perception of safety, comfort and pleasure

Challenges with cross-sectional and longitudinal surveys

Stated preference surveys for inexistent transport options, but limited reliability if people don't have any actual experience with it.

VR allows you to compose virtually any environment

How to create realistic experience?

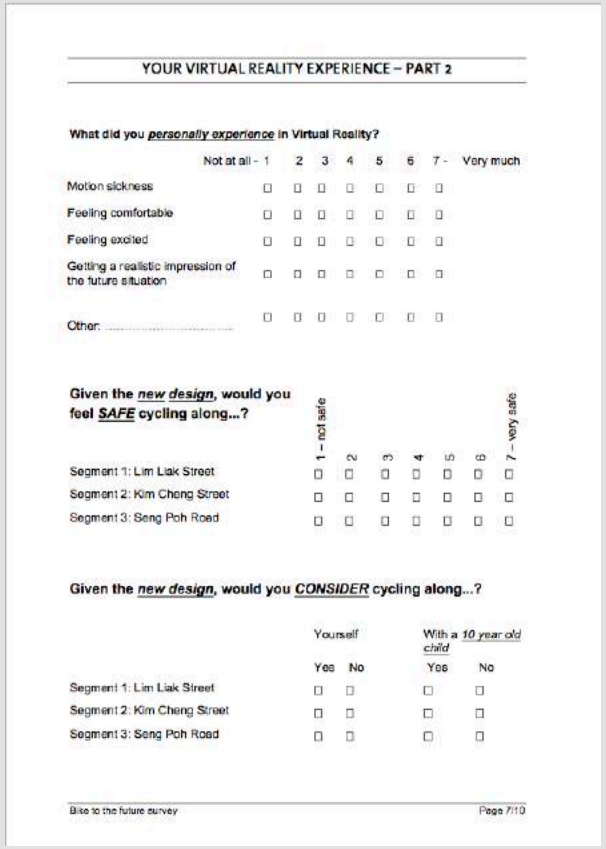
- Eye Level Perspective
- Sense of place
- What can you see (sightlines), and who can see you (multiple agents)
- Speed, volume, proximity of moving traffic
- Idea of time? (slow spectator vs. fast spectator)
- Audio feedback
- *Temperature and humidity*
- *Effect of topography*

Rendering

Photo montage

Sketch

SURVEYS



YOUR VIRTUAL REALITY EXPERIENCE – PART 2

What did you *personally experience* in Virtual Reality?

	Not at all - 1	2	3	4	5	6	7 - Very much
Motion sickness	☐	☐	☐	☐	☐	☐	☐
Feeling comfortable	☐	☐	☐	☐	☐	☐	☐
Feeling excited	☐	☐	☐	☐	☐	☐	☐
Getting a realistic impression of the future situation	☐	☐	☐	☐	☐	☐	☐
Other:	☐	☐	☐	☐	☐	☐	☐

Given the *new design*, would you feel *SAFE* cycling along...?

	1 – not safe	2	3	4	5	6	7 – very safe
Segment 1: Lim Liak Street	☐	☐	☐	☐	☐	☐	☐
Segment 2: Kim Cheng Street	☐	☐	☐	☐	☐	☐	☐
Segment 3: Seng Poh Road	☐	☐	☐	☐	☐	☐	☐

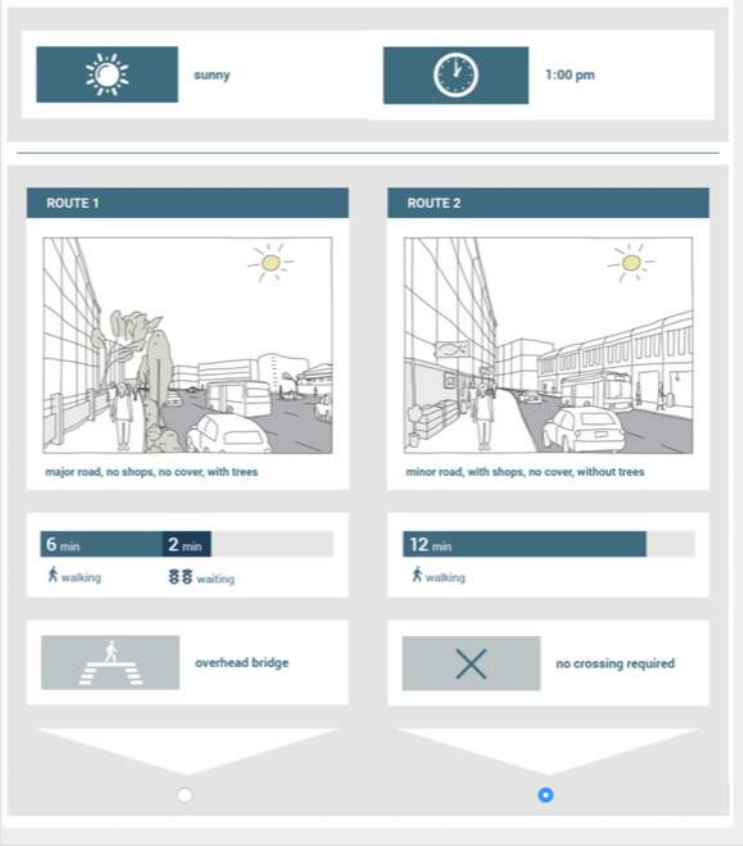
Given the *new design*, would you *CONSIDER* cycling along...?

	Yourself		With a *10 year old child*	
	Yes	No	Yes	No
Segment 1: Lim Liak Street	☐	☐	☐	☐
Segment 2: Kim Cheng Street	☐	☐	☐	☐
Segment 3: Seng Poh Road	☐	☐	☐	☐

Bike to the future survey Page 7/10

Traditional surveys

FCL Engaging Mobility, Survey conducted at Archifest (2016)



Using images

Erath A, M.A.B. van Eggermond, S. Ordonez, K.W. Axhausen (Forthcoming) “Introducing the Pedestrian Accessibility Tool (PAT): Open Source GIS-Based Walkability Analysis.”, Transportation Research Record

Using Virtual Reality

Heilig’s Sensorama. Retrieved from [Theory and Research in HCI: Morton Heilig, Pioneer in Virtual Reality Research]

VIRTUAL REALITY AS A RESEARCH TOOL

Research questions

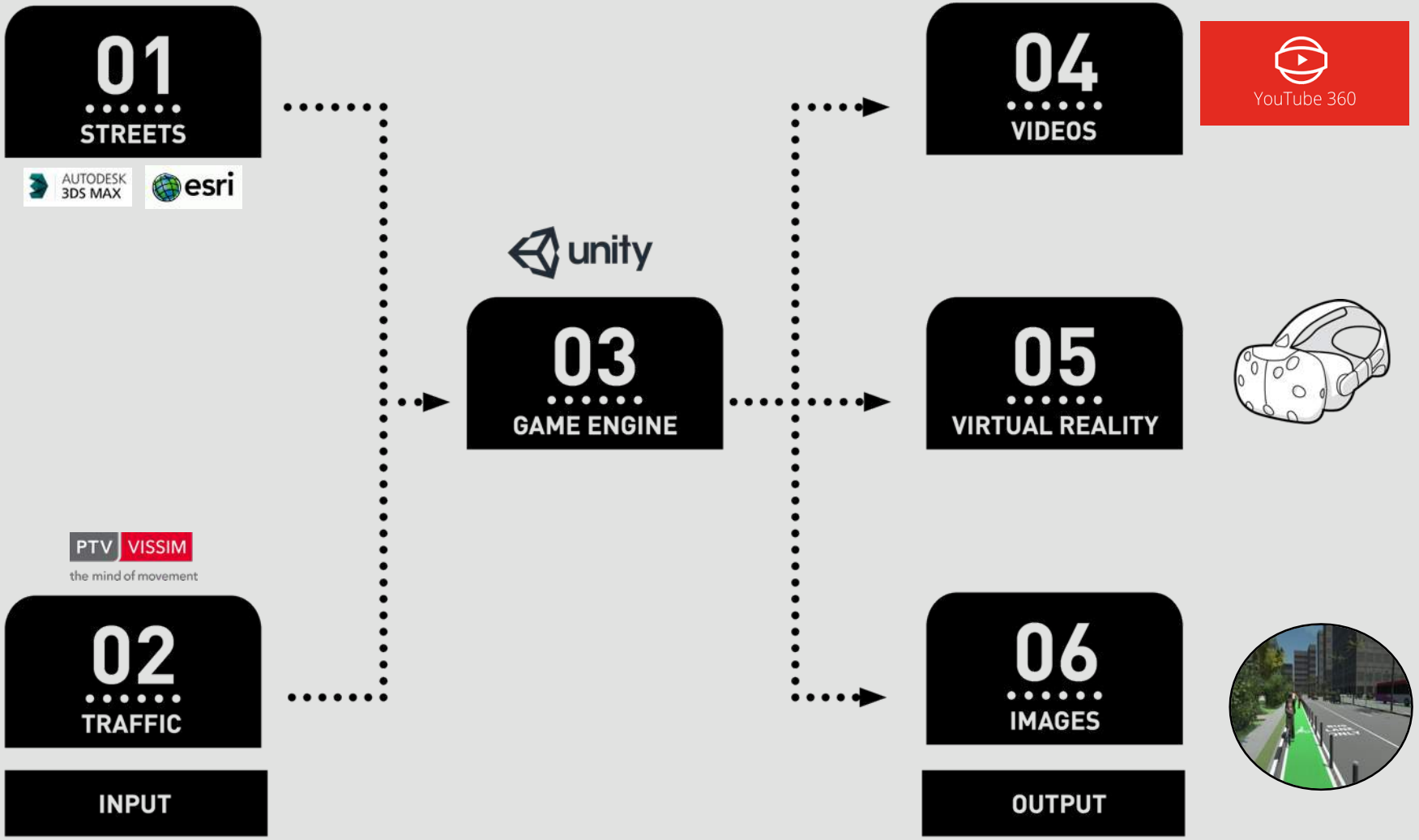
How to employ virtual reality for research

Reproducibility of real field observations

Limitations of VR in research

How can sensors of physical reactions enhance survey methods?

WORKFLOW


01
STREETS
AUTODESK 3DS MAX
esri
02
TRAFFIC
PTV VISSIM
the mind of movement
INPUT
unity
03
GAME ENGINE
04
VIDEOS
YouTube 360
05
VIRTUAL REALITY
06
IMAGES
OUTPUT

01
STREETS

PROCEDURAL MODELLING OF STREETS

ESRI CityEngine (2016)
Source: ESRI

Procedural modelling

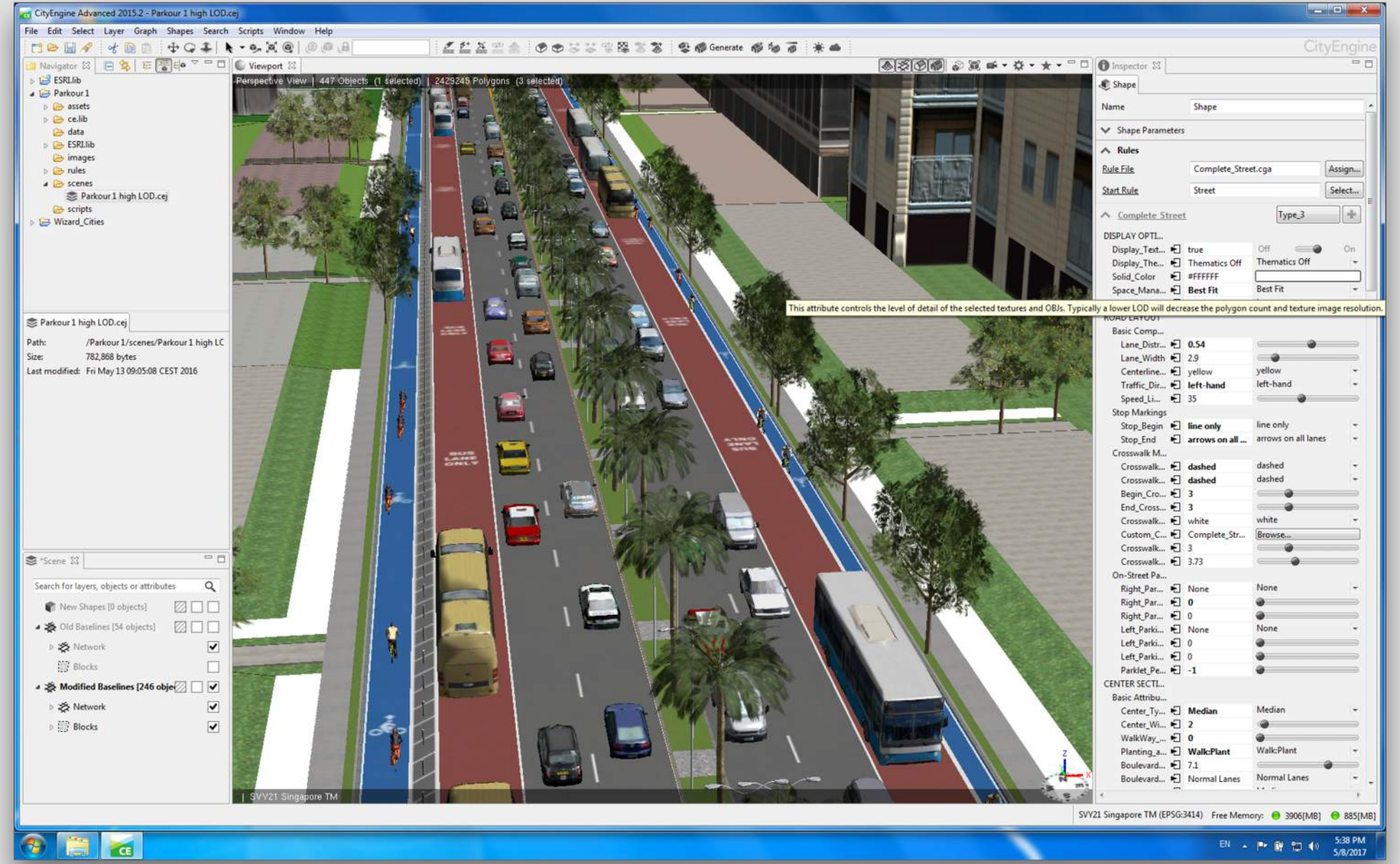
- Computer graphics technique to create 3D models and texture from a set of rules
- Programmable visualisation saves a lot of modelling efforts
- Interactive rendering allows new applications

Complete streets rule

- Developed by ESRI Research
- Robust procedural street example that incorporates knowledge and ideas from various sources of transportation planning knowledge
- We further developed those rules to fit Singapore conditions and our modelling needs.

Code available at
https://github.com/fcl-engaging-mobility/Complete_Street_Rule

GENERATING IMAGINARY STREETS



02
TRAFFIC

GENERATING TRAFFIC WITH VISSIM

Vissim simulation ‘Big Intersection’ (2016)
Source: Jonas Kupferschmid

Challenges:

- Import of geometry
- Interaction of pedestrians and vehicles
- Modelling of cyclists
- Human (unpredictable) behaviour
- Rendering and video quality in 3D
- Shared space between pedestrians and cyclists
- Interface between Vissim and Unity3d

IMPROVING THE 3D ENVIRONMENT: FROM VISSIM TO UNITY

Output file with vehicle trajectories from Vissim (2016) Source: Jonas Kupferschmid

Prototype of virtual cycling environment Source: Michael Joos (2016)

```
$VISION
* File: C:\Users\Jonas\Desktop\Vissim\Projects\SG_3D_Parkour\SG_3d_Parkour_v9.inpx
* Comment:
* Date: 27/4/2016 5:15:26 PM
* PTV Vissim: 8.00 [08]
*
* Table: Vehicles In Network
*
* SIMSEC: SimSec, Simulation second (Simulation time [s]) [s]
* NO: No, Number (Number of the vehicle)
* VEHTYPE: VehType, Vehicle type (Select Vehicle type from the list box)
* COORDFRONT: CoordFront, Coordinate front (Coordinate of front end of vehicle at the end of the time step)
* COORDREAR: CoordRear, Coordinate rear (Coordinate of rear end position of vehicle at the end of the time step)
*
* SimSec; No; VehType; CoordFront; CoordRear
*
$VEHICLE:SIMSEC;NO;VEHTYPE;COORDFRONT;COORDREAR
2000.25;589;10;-83.750 6.321 0.000;-85.494 6.650 0.000
2000.25;625;10;-86.769 6.963 0.000;-87.459 8.598 0.000
2000.25;686;10;-13.842 -296.626 0.000;-15.616 -296.626 0.000
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2000.25;748;10;303.509 -280.943 0.000;303.508 -279.168 0.000
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2000.25;1005;10;-72.799 6.415 0.000;-74.574 6.414 0.000
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```
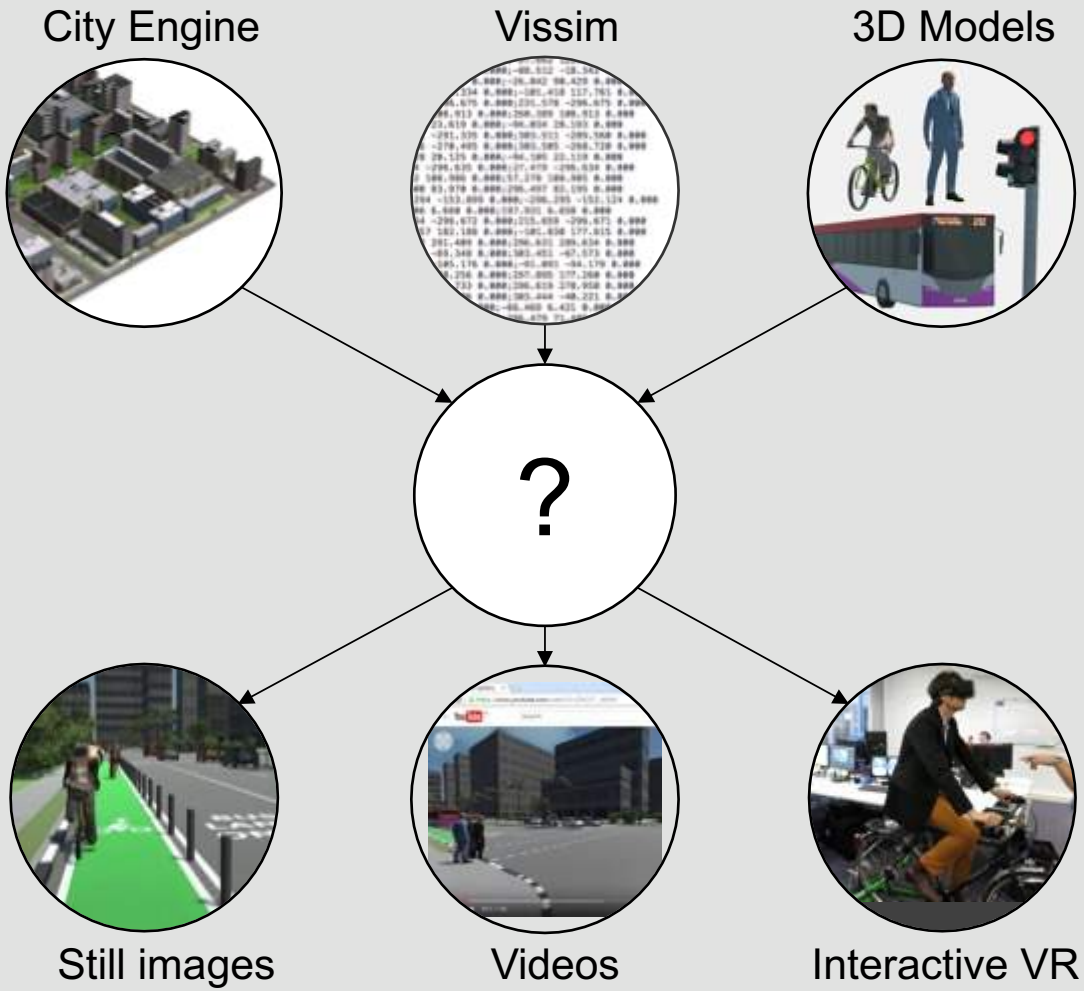

03
GAME ENGINE

PUTTING ALL TOGETHER



Input

- City Engine: procedural city 3D models
- Vissim: vehicles, cyclists, pedestrians and lights simulation data
- Other 3D models: vehicles, pedestrians, street furniture, traffic lights, etc.

Output

- High visual quality renderings for presentations and surveys
- Videos of moving traffic in 3D environment.
- 360 videos for immersive VR experience
- Interactive VR application with real-time traffic reaction

PUTTING IT TOGETHER: SCRIPTS

Traffic Data

- Interpret Vissim's traffic data
- Traffic lights system
- Traffic diversity generator

Animation

- Pedestrian adaptive movement
- Vehicle trajectory smoothing
- Vehicle brake lights
- Vehicle wheel rotation
- Animated cyclist

Code available at
https://github.com/fcl-engaging-mobility/UnityScripts

SOME PAPERS AND BLOG POSTS

Erath, Alexander, Tanvi Maheshwari, Michael Joos, Jonas Kupferschmid and Michael A. B. van Eggermond (2017). 'Visualizing Transport Futures: The Potential of Integrating Procedural 3d Modelling and Traffic Micro-Simulation in Virtual Reality Applications for Transport Planning', in *2017 Annual Meeting Compendium of Papers*, paper presented at 96th Annual Meeting of the Transporation Research Board, Washington D.C.

Maheshwari, Tanvi, Jonas Kupferschmid, Alexander Erath and Michael Joos (2016). 'Virtual Reality as a Tool to Assess Perception of Safety and Comfort for Cyclists in Singapore', paper presented at Great Asian Streets Symposium, Singapore.

Joos, Michael, Alexander Erath and Jonas Kupferschmid (2016). 'Gussy up Vissim with the Rendering Power of a Game Engine'. *Engaging Mobility Blog*.

Kupferschmid, Jonas and Alexander Erath (2016). 'How to Model Pedestrians and Cyclists Interactions with out-of-the-Box Features of Vissim? *Engaging Mobility Blog*.

Introduction

Expert survey on cycling in Singapore

Generating Virtual Reality for cycling research

Bike to to Future I

Bike to the Future II

Bike Pulse

Bike to the Future III

Source: Tanvi Maheshwari

BIKE TO THE FUTURE I

Explore how to use VR as a research tool

Redesign three streets around Tiong Bahru Market to accommodate cycling infrastructure.

Invite people to cycle on these three different streets designed for active mobility in Virtual Reality

Engage and get feedback on how **safe** and **comfortable** they feel cycling given the new design.

Leverage on existing 3D models and Park(ing) Day

3D Model

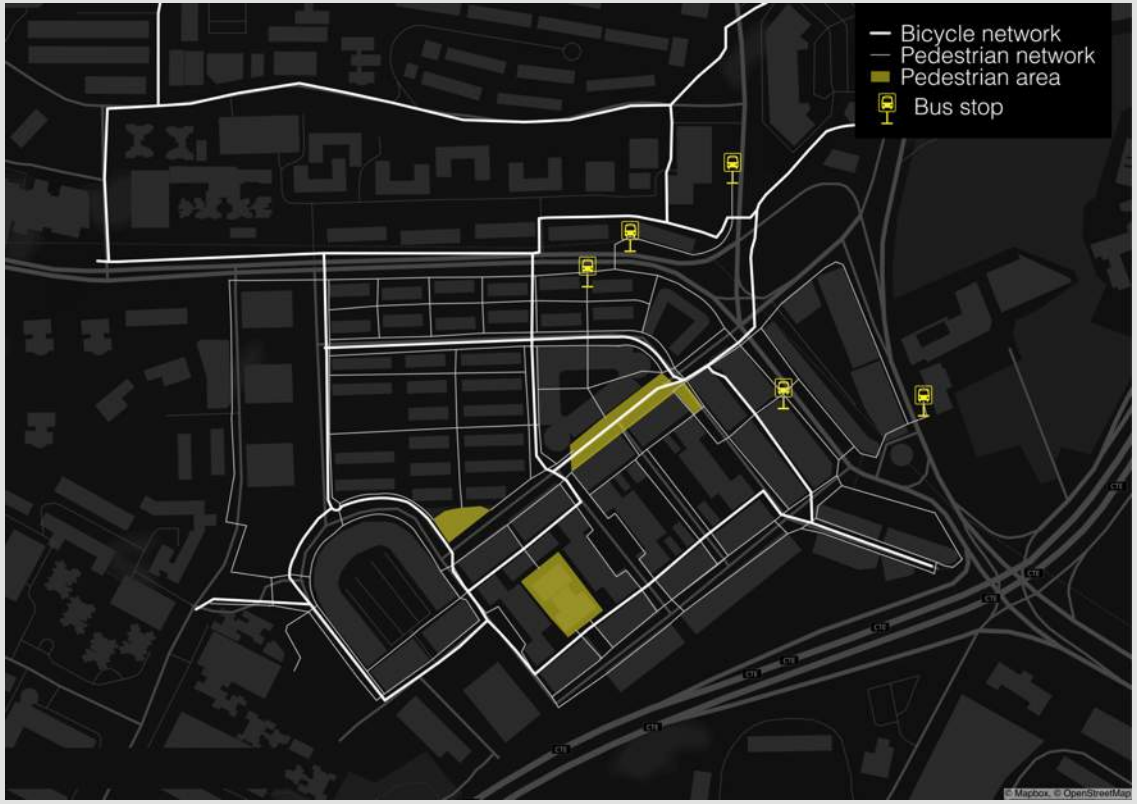
before

after

TIONG BAHRU: TRAFFIC CIRCULATION

Current

New design



DESIGN: STREETS

	Current	3D rendering with traffic	New design with traffic
Lim Liak Street			
Kim Cheng Street			
Seng Poh Road			

BIKE TO THE FUTURE I - EVENTS

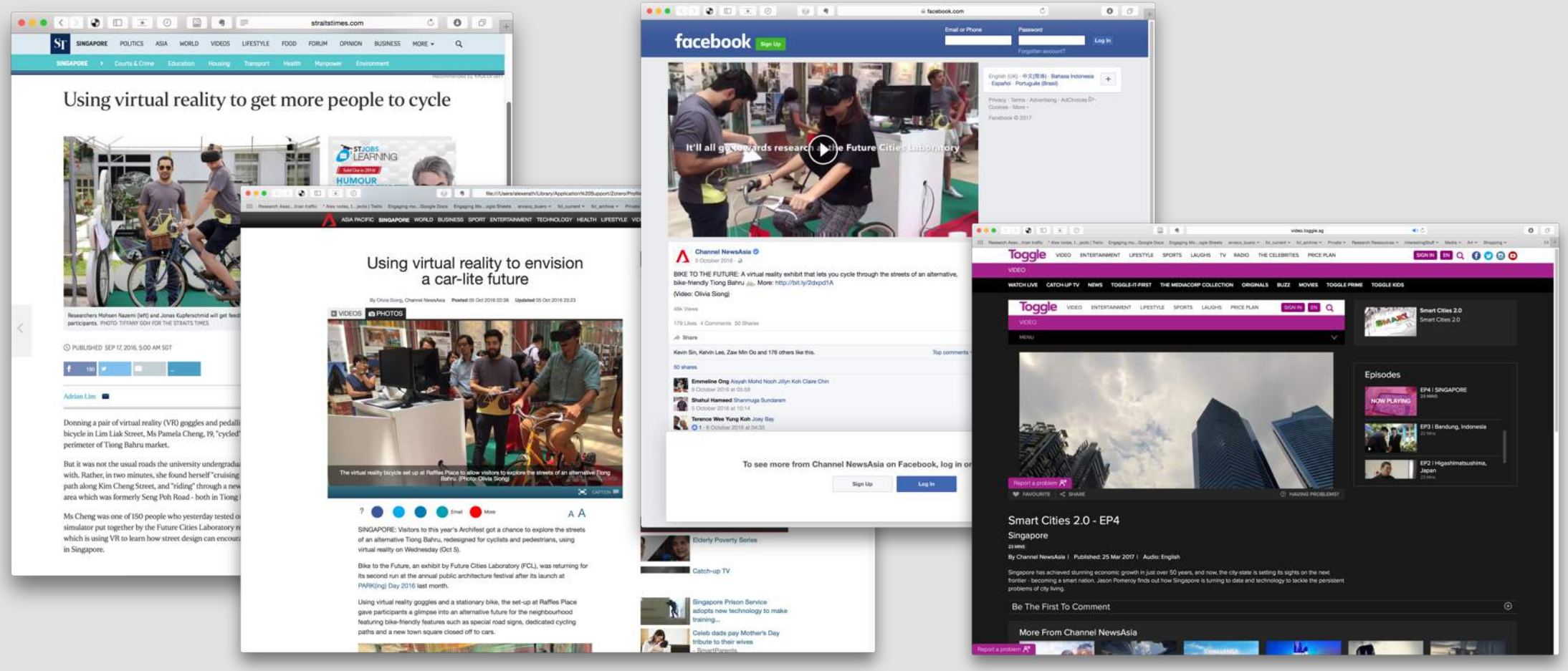
1
16 Sep 2016
Park(ing) Day
Tiong Bahru

2
5 Oct 2016
Archifest
Raffles Place

3
19-21 Oct 2016
SITCE Conference
Suntec Convention Center

4
26 Mar 2017
Car-free Sunday
Telok Ayer Street

BIKE TO THE FUTURE I – UNEXPECTED MEDIA ATTENTION



360 DEGREE VIDEO

You can watch the video here

Use Google Card Board for a VR experience


04
VIDEOS
(FCL) FUTURE CITIES LABORATORY
未来城市实验室

SURVEY DESIGN

Would you *consider cycling along* ....

Yourself
Yes ☐ No ☐

With a **10 year old child**
Yes ☐ No ☐

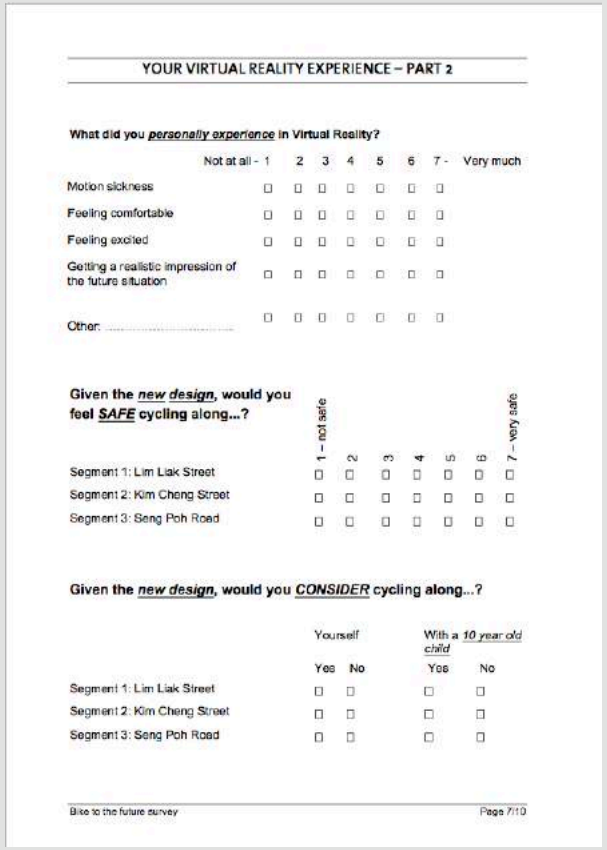
Yourself
Yes ☐ No ☐

With a **10 year old child**
Yes ☐ No ☐

Yourself
Yes ☐ No ☐

With a **10 year old child**
Yes ☐ No ☐

Bike to the future survey Page 3/10



YOUR VIRTUAL REALITY EXPERIENCE – PART 2

What did you *personally experience* in Virtual Reality?

	Not at all - 1	2	3	4	5	6	7 - Very much
Motion sickness	☐	☐	☐	☐	☐	☐	☐
Feeling comfortable	☐	☐	☐	☐	☐	☐	☐
Feeling excited	☐	☐	☐	☐	☐	☐	☐
Getting a realistic impression of the future situation	☐	☐	☐	☐	☐	☐	☐
Other:	☐	☐	☐	☐	☐	☐	☐

Given the *new design*, would you feel *SAFE* cycling along...?

	1 – not safe	2	3	4	5	6	7 – very safe
Segment 1: Lim Liak Street	☐	☐	☐	☐	☐	☐	☐
Segment 2: Kim Cheng Street	☐	☐	☐	☐	☐	☐	☐
Segment 3: Seng Poh Road	☐	☐	☐	☐	☐	☐	☐

Given the *new design*, would you *CONSIDER* cycling along...?

	Yourself		With a *10 year old child*	
	Yes	No	Yes	No
Segment 1: Lim Liak Street	☐	☐	☐	☐
Segment 2: Kim Cheng Street	☐	☐	☐	☐
Segment 3: Seng Poh Road	☐	☐	☐	☐

Bike to the future survey Page 7/10

Pre-survey

- Sociodemographics
- Habits and attitudes towards cycling
- Willingness to cycle with today's infrastructure

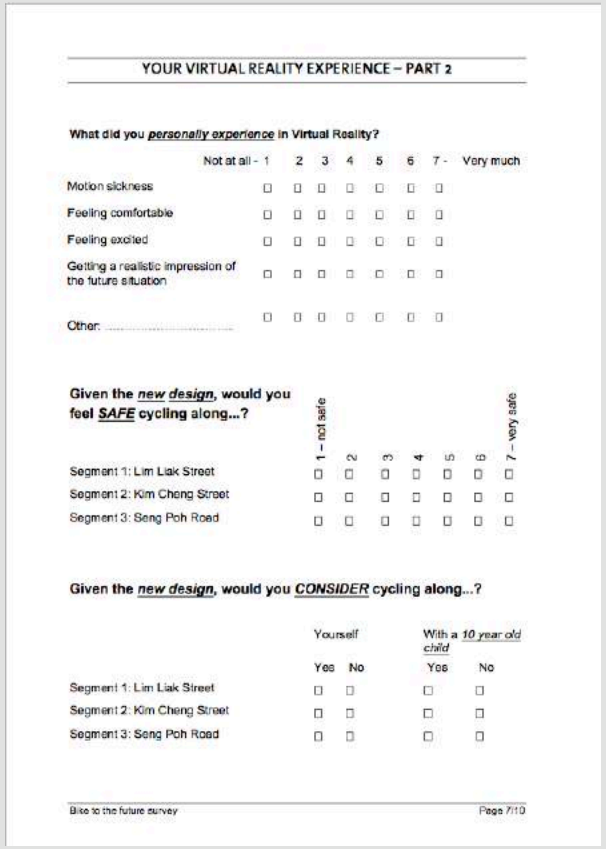
VR-Experiment

- Think aloud protocol (What do you see?)
- Physical reactions (pedalling, steering, turning head, braking)

Post-survey

- Willingess to cycle with new infrastructure
- VR Experience (realism, motion sickness, comfort, excitement)

SURVEYS



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Feeling comfortable	☐	☐	☐	☐	☐	☐	☐
Feeling excited	☐	☐	☐	☐	☐	☐	☐
Getting a realistic impression of the future situation	☐	☐	☐	☐	☐	☐	☐
Other:	☐	☐	☐	☐	☐	☐	☐

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Segment 3: Seng Poh Road	☐	☐	☐	☐	☐	☐	☐

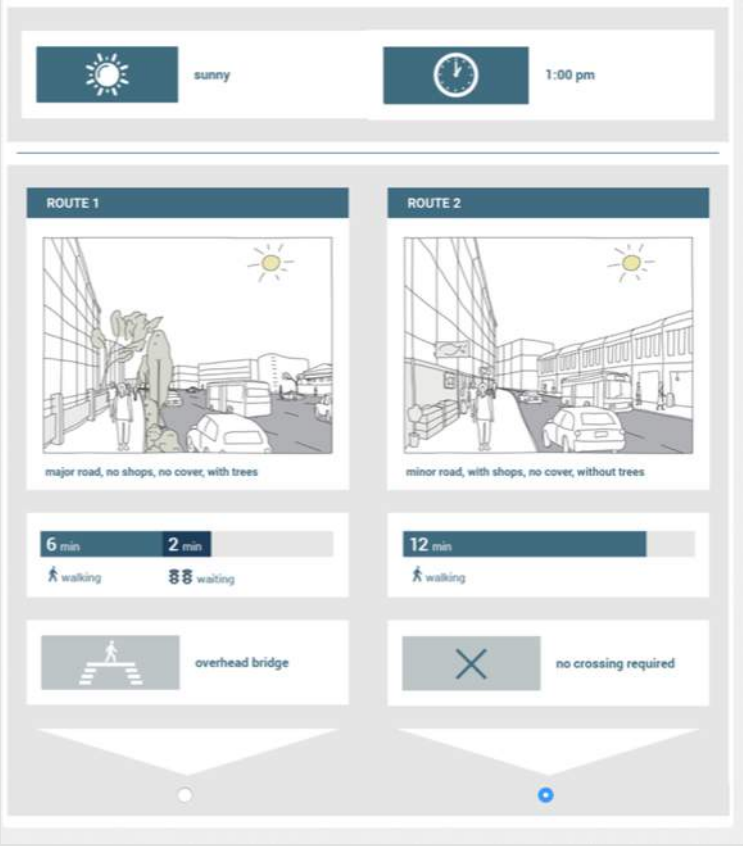
Given the *new design*, would you *CONSIDER* cycling along...?

	Yourself		With a *10 year old child*	
	Yes	No	Yes	No
Segment 1: Lim Liak Street	☐	☐	☐	☐
Segment 2: Kim Cheng Street	☐	☐	☐	☐
Segment 3: Seng Poh Road	☐	☐	☐	☐

Bike to the future survey Page 7/10

Traditional surveys

FCL Engaging Mobility, Survey conducted at Archifest (2016)



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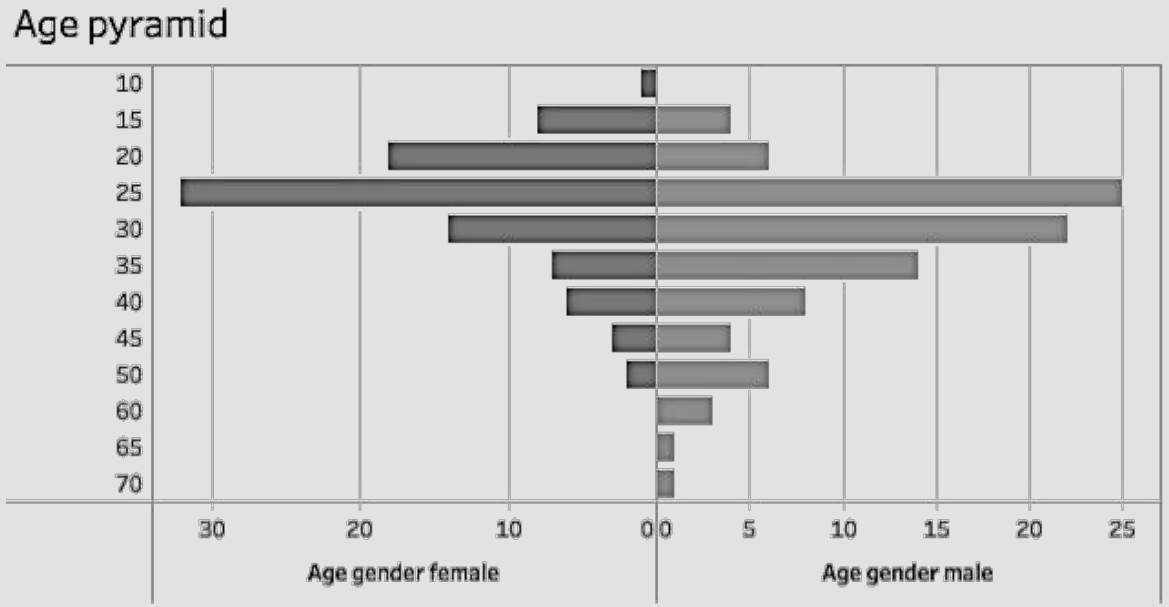
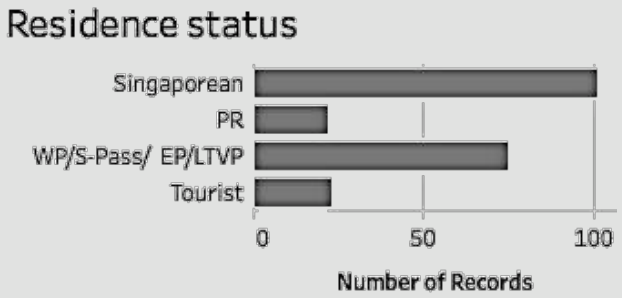
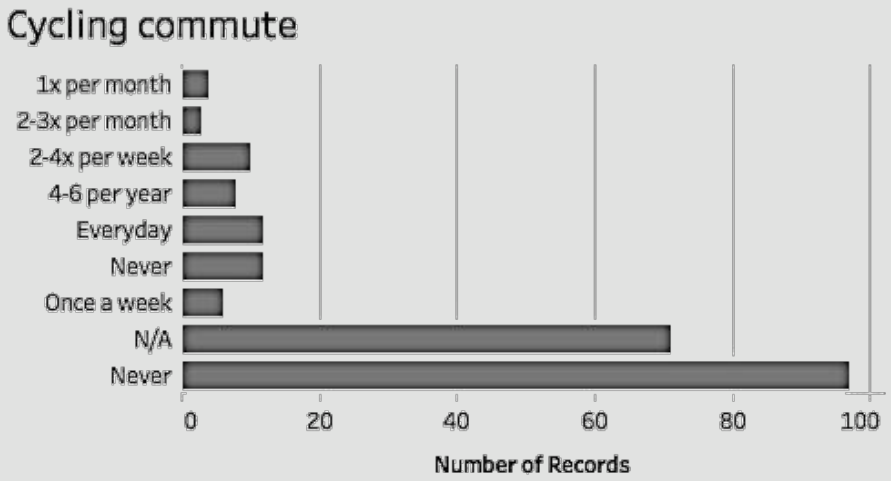
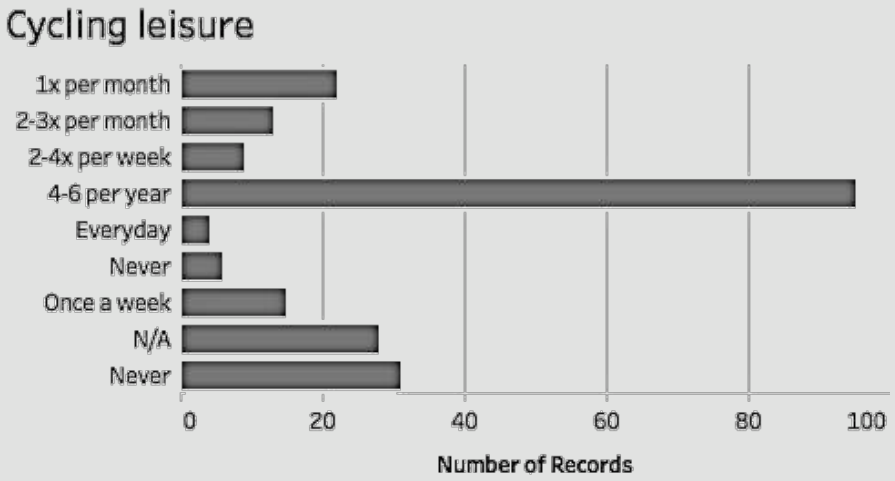
Heilig’s Sensorama. Retrieved from [Theory and Research in HCI: Morton Heilig, Pioneer in Virtual Reality Research]

Descriptive statistics









RESULTS – WILLINGNESS TO CYCLE

<u>YES</u>, I would consider cycling on this road

Before

65%

81%

59%

93%

After

RESULTS – WILLINGNESS TO CYCLE

Before

<u>YES</u>, I would consider cycling on this road <u>with a 10 year old</u>

10%

44 %

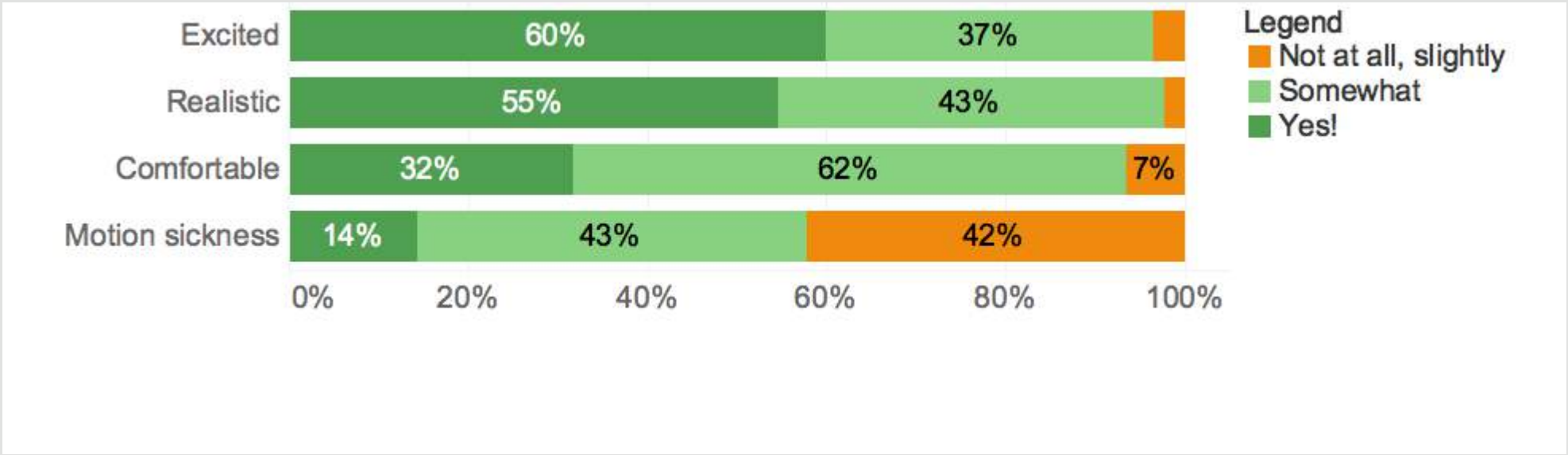
11%

74%

After

RESULTS – VIRTUAL REALITY EXPERIENCE

Did you experience the following?



MOST MEMORABLE EXPERIENCE

'Pedestrians interacting with bicyclists'

'Realistic feeling that pedestrians were about to walk in my way'

Simulation

’Good design of surroundings in 3D. Pedestrians are not paying attention to me'

Design

'That I was not competing with cars for road space'

'The new bicycle lane is very good for cyclists. I like it very much. It reduces conflict between types of commuters.'

'Pleasant experience to see a car free area that will ultimately be greener, less polluted and more kids/people friendly.

’Three different designs give us different ideas and impressions. Good experience. Thank you. Personally I prefer segment 2.'

'That the brakes didn't work was very irritating.'

'Steering was hard'

Hardware

'Brakes not working'

FINDINGS

VR really helps to communicate the experience of future street designs

- Better sense of place
- Respondents naturally look around
- Plenty of physical reactions
- Creates excitement and a lot of media attention

Limits of VR

- Tremendous amount of work
- People get motion sick
- Tremendous amount of work
- Time intensive
- 360 video is not enough for immersive experience

On which level you try to understand cycling behaviour?

- Willingness to cycle
  -> stated preference probably better suited
- Perception of safety, comfort and pleasure
  -> Behavioral reactions rather than survey

Introduction

Expert survey on cycling in Singapore

Generating Virtual Reality for cycling research

Bike to to Future I

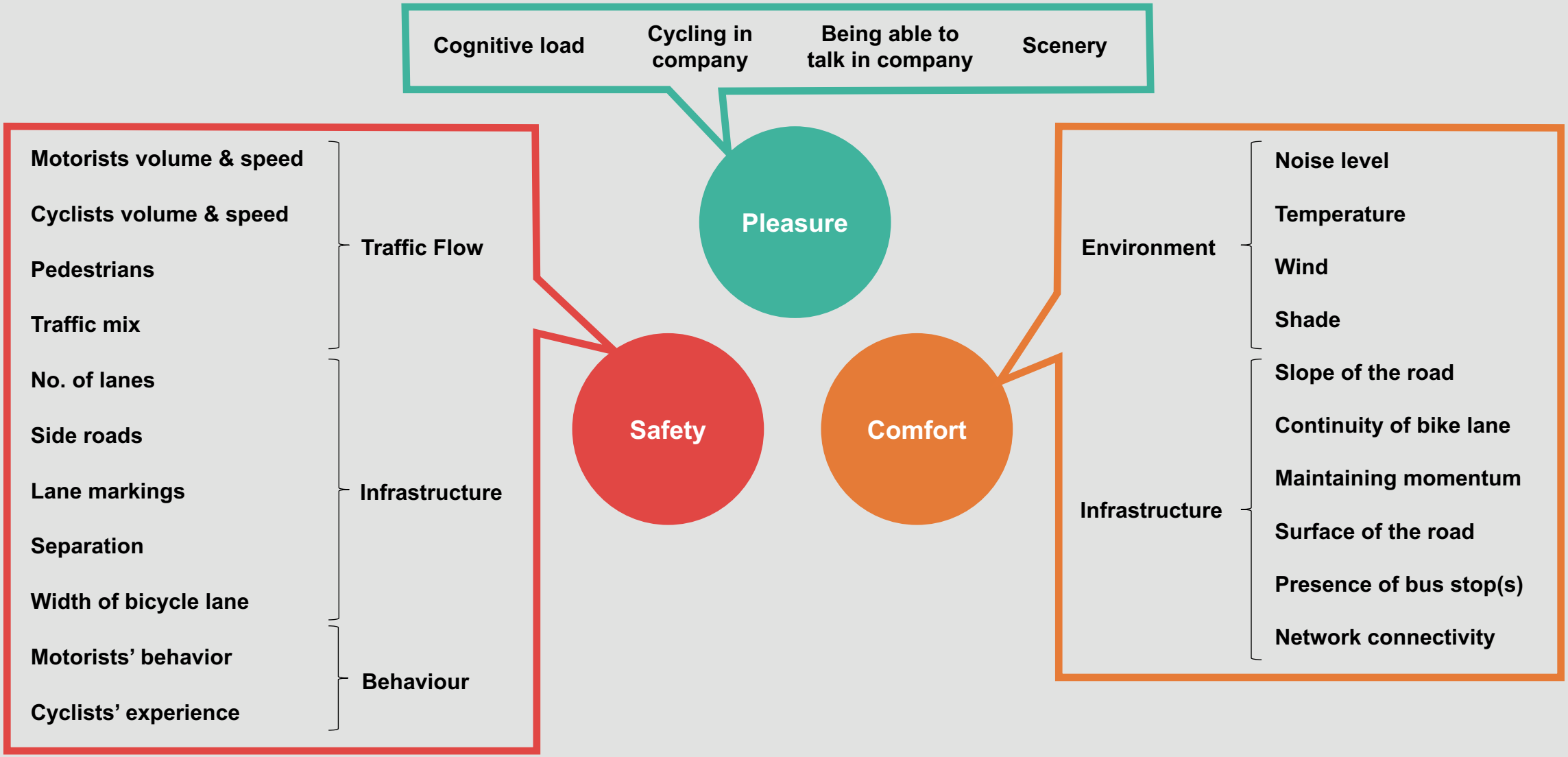
Bike to the Future II

Bike Pulse

Bike to the Future III

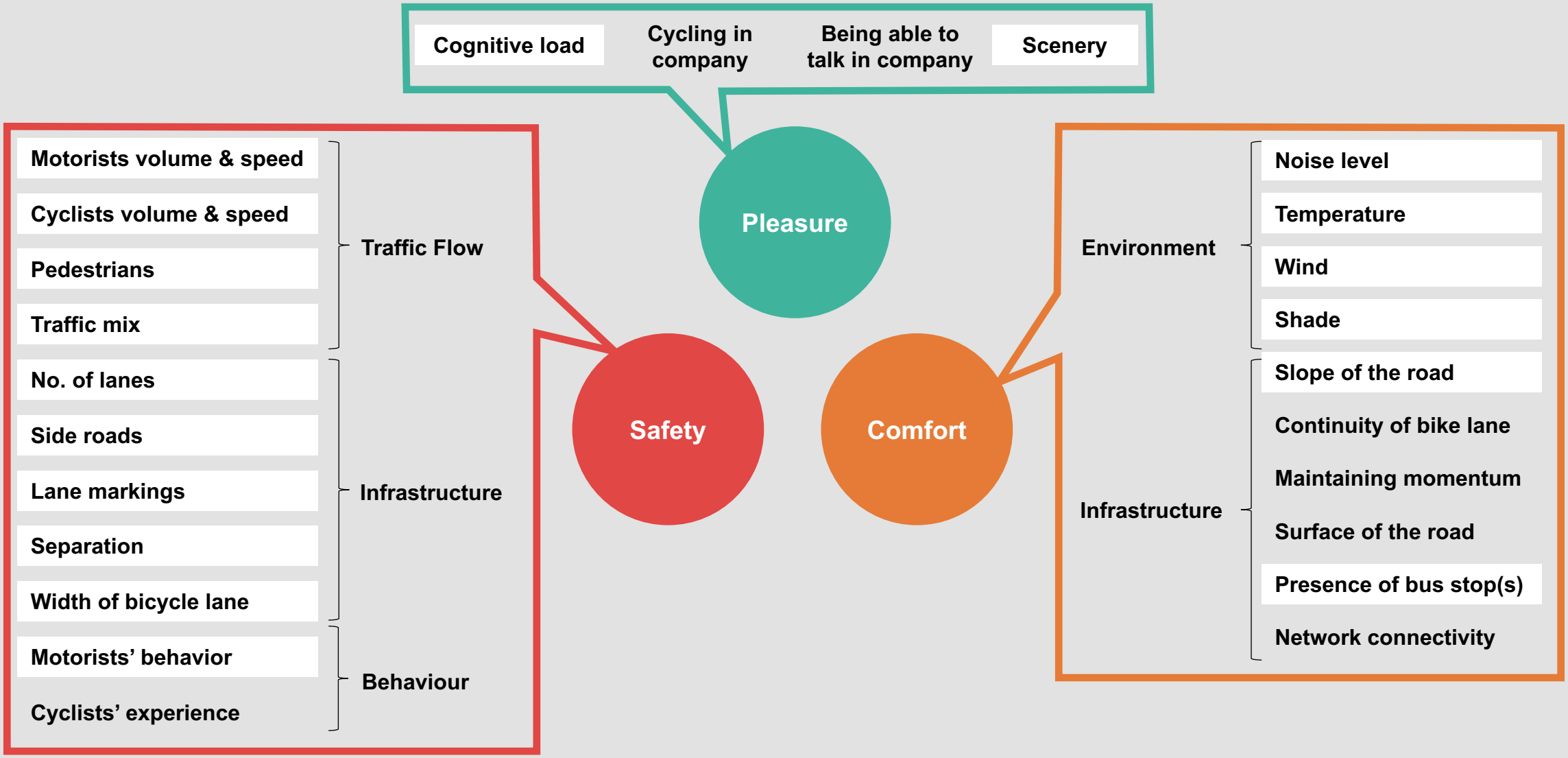
Source: Tanvi Maheshwari

MEASURING SAFETY, COMFORT & PLEASURE
LITERATURE REVIEW



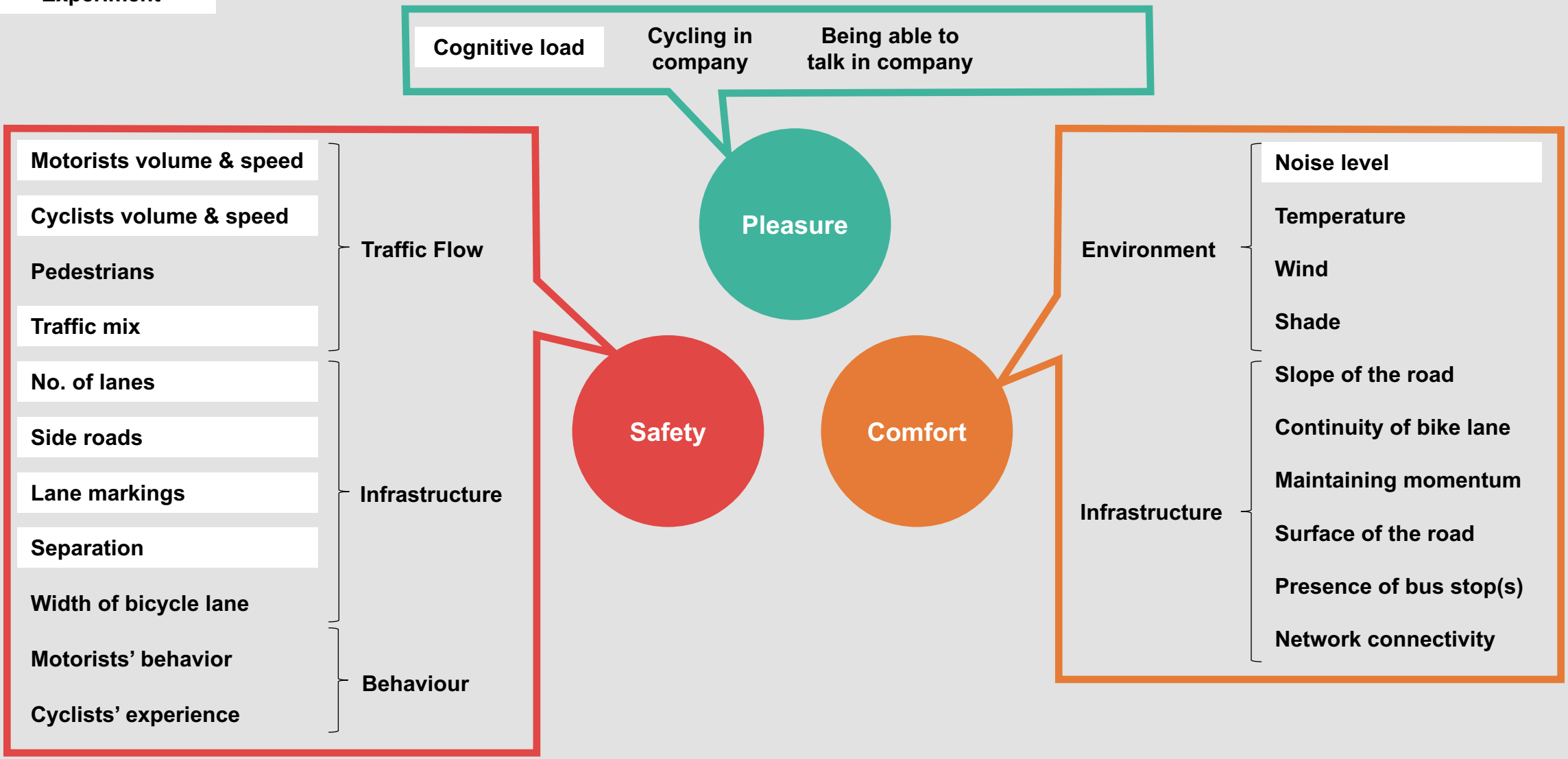
MEASURING SAFETY, COMFORT & PLEASURE

Feasibility with Bicycle Simulator



BIKE TO THE FUTURE II

Controlled Experiment



BIKE TO THE FUTURE II

Aim

Measure cyclists' perception of safety, comfort & pleasure in a controlled environment

Methodology

Development of interactive cycling simulator

Test impact of various stressors and mitigation strategies

Trigger traffic events (conflicting traffic)

Sensing of physical reactions (head movement, pedalling, steering, braking)

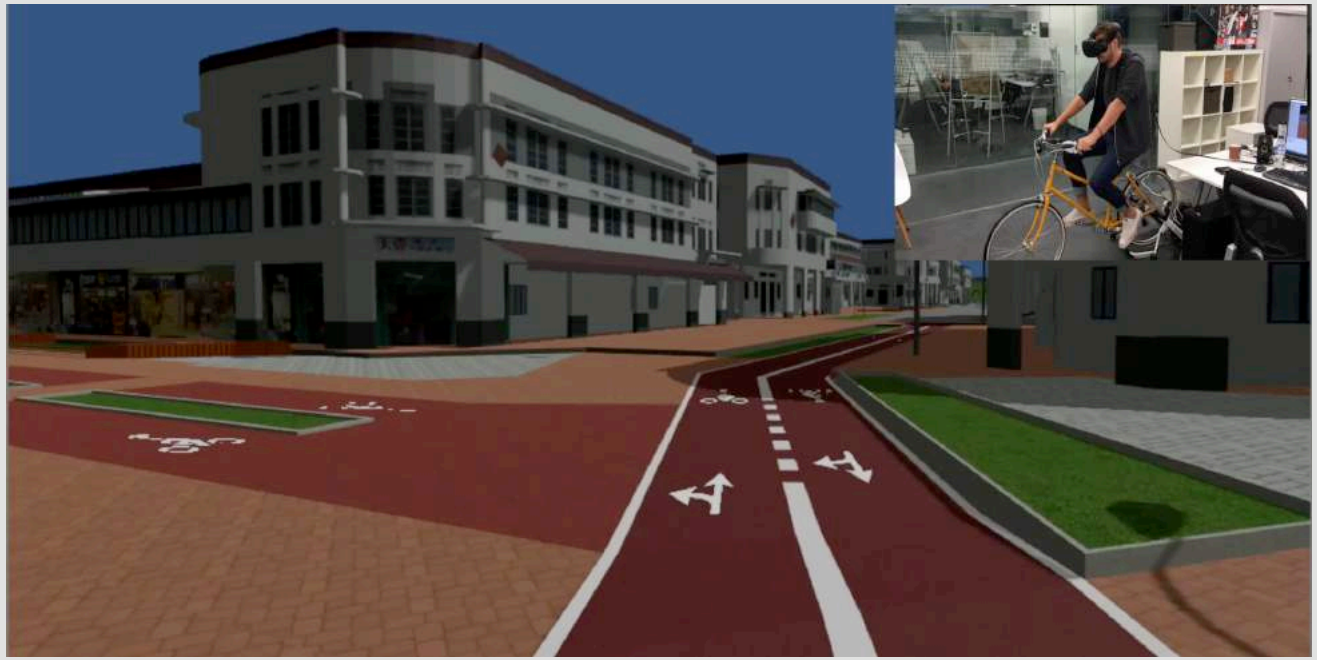
Before / after experiment surveys

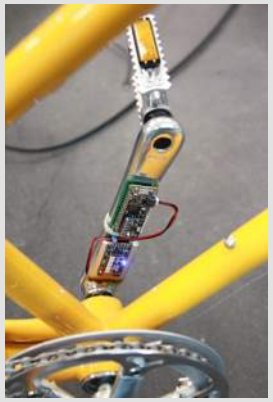
Outcomes

Insight in the perception of safety for different design options

Evidence-based design guidance

Realizing strength and limitations of using virtual reality





EXPERIMENT SETUP

Research questions

Which distance and separation to vehicles works best is needed to feel safe?

Any differences of perception in VR with regards to speeds, (passing) distance, noise

Can we observe the same physical reactions in VR as in reality?

Experiment Design

2 Road types
- 4 lane, bi-directional
- 2 lane, bi-directional

Treatments:
- Traffic
  - Speed
  - Volume
  - Mix
  - passing distance
- Separation
  - None
  - Paint
  - Planter
  - Poles
- Conflicting traffic

Road segments stretch over about 700m

Warm-up cycling with out traffic (3-5min)

Measurements

Physical reactions:
- Head movement
- Steering
- Braking
- Pedalling
- Cognitive load
- Reaction times (incoming traffic)
- Cycling speed

Pre-/post survey
- Experience with cycling
- Attitudes
- Stated levels of safety, comfort, pleasure

FIRST OUTCOME

Schramka, Filip, Stefan Arisona, Michael Joos and Alexander Erath (2017). ‘Development of Virtual Reality Cycling Simulator’, in *3rd International Conference on Virtual Reality*, paper presented at 3rd International Conference on Virtual Reality, Hong Kong.

Code available here:
https://github.com/fcl-engaging-mobility

Development of a Virtual Reality Cycling Simulator

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doi:

Abstract

This paper presents a cycling simulator implemented using consumer virtual reality hardware and additional off-the-shelf sensors. Challenges like real time motion tracking within the performance requirements of state of the art virtual reality are successfully mastered. Retrieved data from digital motion processors is sent over Bluetooth to a render machine running *Unity3D*. By processing this data a bicycle is mapped into virtual space. Physically correct behaviour is simulated and high quality assets are added to create a full immersive virtual reality experience. Our whole source code is published under an open source licence on github. Ultimately, the cycling simulator will be used for behavioral studies to measure how different street design configurations and traffic levels impact perceived cycling stress level, cognitive reactions and mobility behaviour.

Index Terms

Computer graphics, simulation, game engines, human mobility, virtual reality, movement tracking

I. Introduction

Urban transport policies are shifting their focus to active modes of transportation: walking and cycling. To make these modes of transport attractive for a wide audience, transport infrastructure must cater for the needs of active mobility for a safe and comfortable cycling experience. Incorporating such infrastructure in the existing urban fabric and adapting existing street designs proves to be a considerable challenge, especially with regards to the limited available road space and budget constraints. Urban designers and transport planners who want to improve the infrastructure conditions in particular for cycling often face difficult trade-offs, since there is a lack of understanding with regards to basic questions how different road users perceive and value possible infrastructure scenarios. To address this matter the right tools need to be chosen. According to Simpson[17] creation and interaction within a three dimensional visual simulation is the key to modern urban planning. Recent research also shows that it becomes feasible to develop immersive virtual reality for spatial planning support. The advantage of these systems is the sensation of being in the environment [18]. Also can such an environment be used to measure actual perception and discuss design decisions within the scenario. By taking these factors into account we developed a functional *virtual reality cycling simulator* prototype within the environment of a state of the art game engine. New experimental street designs can easily be imported into our existing framework. Those can be enriched with additional assets and other objects provided by *Unity* to create a more realistic environment. With built-in measurement and evaluation tools proper scientific data can be extracted.

To achieve all this, a robust hard- and software framework is developed which is able to track all essential parts of the bike. Technologies like *Bluetooth Low Energy*, *Gyroscopes* and *Accelerometers* were combined into small tracking sensors. Furthermore all components achieve the performance required by state of the art virtual reality applications.
The results of our development brought us a good tool for further research. In its current state, the cycling simulator is capable of supporting behavioral studies to measure how different street design configurations and traffic levels impact perceived cycling stress level, cognitive reactions and mobility behaviour. The source code is published on github under *MIT* license [4].

II. Related Work

In this section we introduce existing work in the area of bicycle simulation, followed by problems of the latest generation of virtual reality technologies and how different approaches handle them. Furthermore we introduce a theory that explains why motion sickness occurs during *VR* simulation.

Introduction

Expert survey on cycling in Singapore

Generating Virtual Reality for cycling research

Bike to to Future I

Bike to the Future II

Bike Pulse

Source: Tanvi Maheshwari

BIKE PULSE

Wigginton Conway, M. (2015) Better Measures of Bike Accessibility, Conveyal, Available here

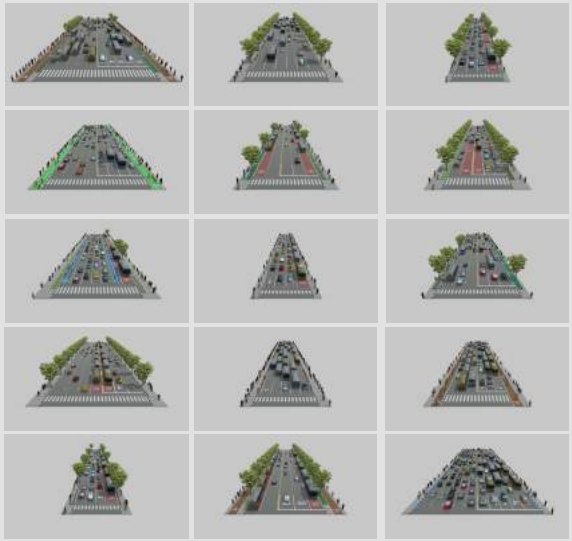
Inspiration & Vision

Web-based survey inspired by MIT Place Pulse project

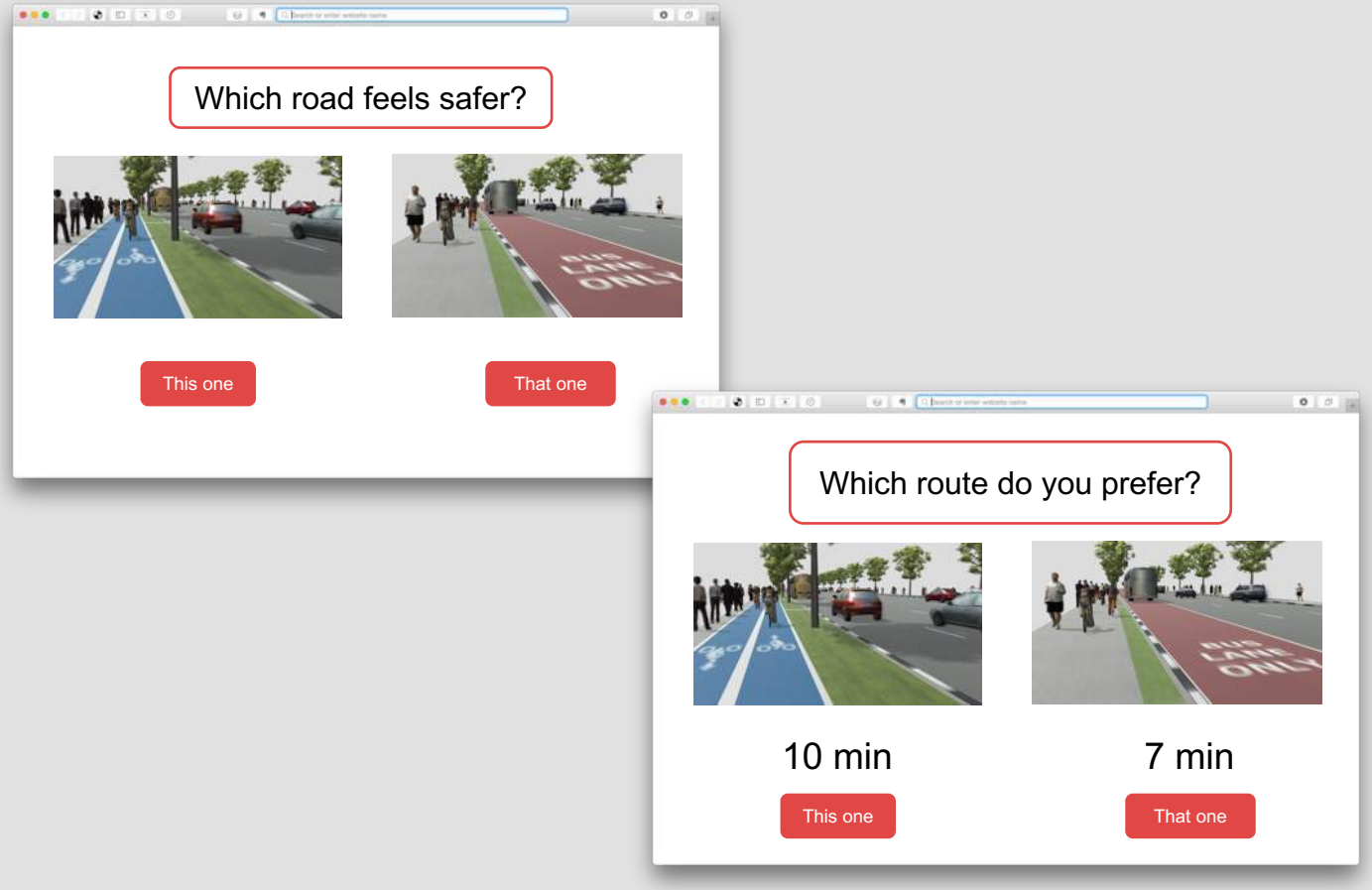
Parametrically generating hundreds of relevant street design configurations

Testing it from different view angles (pedestrian, cyclist, bus driver, car)

Choice modelling



Bike Pulse



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Psychologist
Cognitive experiment

URBAN REDEVELOPMENT AUTHORITY

Land Transport Authority

PTV GROUP

NHTV Breda University of Applied Sciences

APPENDIX

A BIKE LANE IS NOT A BIKE LANE

Trucks and cars!

Our children need to ride here??

Dangerous design!!

We demand bicycle lanes!

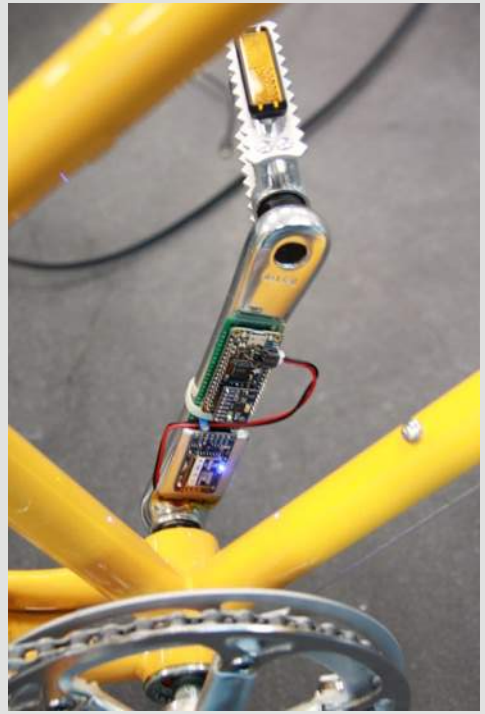
THE HARDWARE

Schramka, F., Müller Arisona, S., Joos, M. (2017) Development of a Virtual Reality Cycling Simulator. Working Paper

Steering

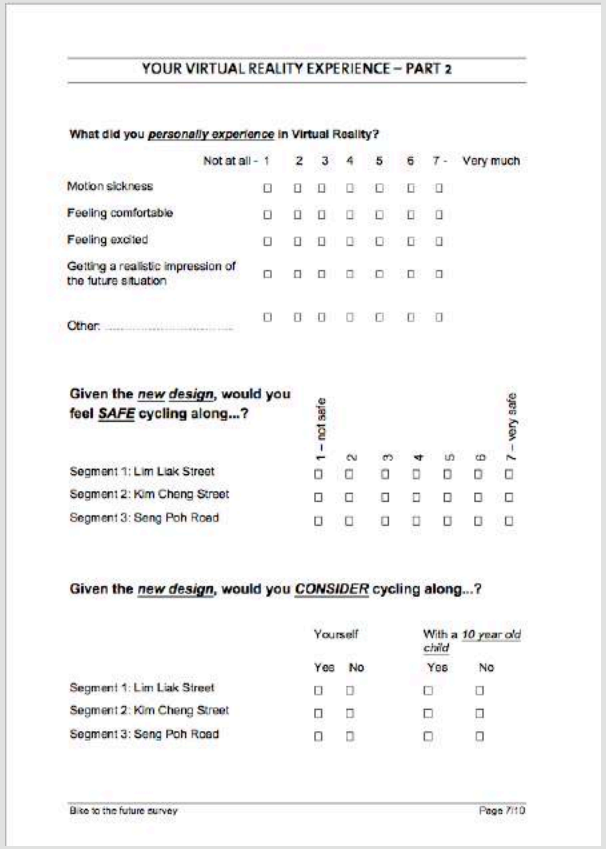
Tilting

Pedalling



Acceleration / Braking

SURVEYS



YOUR VIRTUAL REALITY EXPERIENCE – PART 2

What did you *personally experience* in Virtual Reality?

	Not at all - 1	2	3	4	5	6	7 - Very much
Motion sickness	☐	☐	☐	☐	☐	☐	☐
Feeling comfortable	☐	☐	☐	☐	☐	☐	☐
Feeling excited	☐	☐	☐	☐	☐	☐	☐
Getting a realistic impression of the future situation	☐	☐	☐	☐	☐	☐	☐
Other:	☐	☐	☐	☐	☐	☐	☐

Given the *new design*, would you feel *SAFE* cycling along...?

	1 – not safe	2	3	4	5	6	7 – very safe
Segment 1: Lim Liak Street	☐	☐	☐	☐	☐	☐	☐
Segment 2: Kim Cheng Street	☐	☐	☐	☐	☐	☐	☐
Segment 3: Seng Poh Road	☐	☐	☐	☐	☐	☐	☐

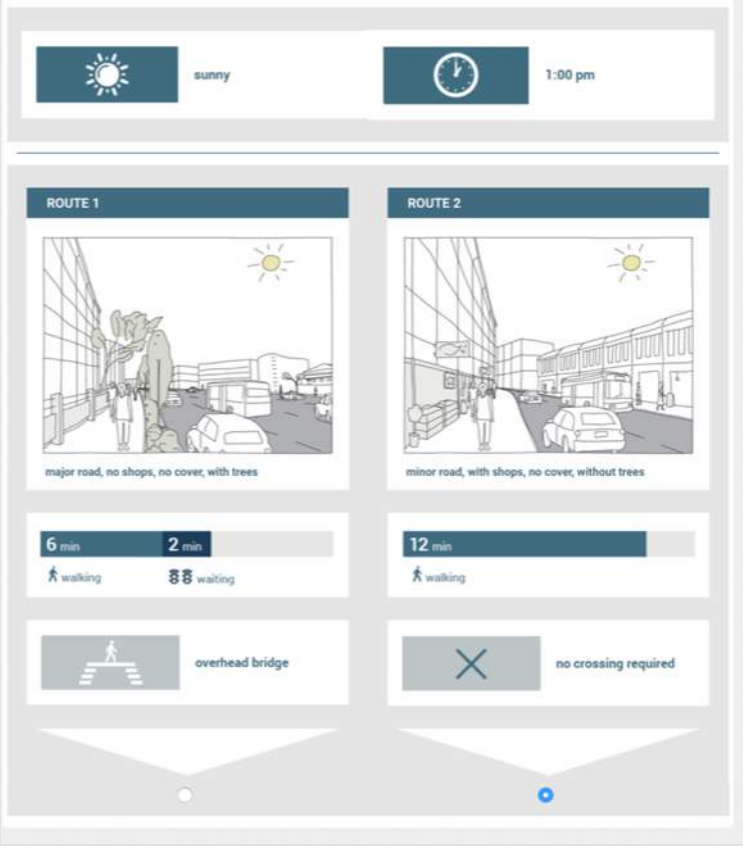
Given the *new design*, would you *CONSIDER* cycling along...?

	Yourself		With a *10 year old child*	
	Yes	No	Yes	No
Segment 1: Lim Liak Street	☐	☐	☐	☐
Segment 2: Kim Cheng Street	☐	☐	☐	☐
Segment 3: Seng Poh Road	☐	☐	☐	☐

Bike to the future survey Page 7/10

Traditional surveys

FCL Engaging Mobility, Survey conducted at Archifest (2016)



Using images

Erath A, M.A.B. van Eggermond, S. Ordonez, K.W. Axhausen (Forthcoming) “Introducing the Pedestrian Accessibility Tool (PAT): Open Source GIS-Based Walkability Analysis.”, Transportation Research Record

Using Virtual Reality

Heilig’s Sensorama. Retrieved from [Theory and Research in HCI: Morton Heilig, Pioneer in Virtual Reality Research]

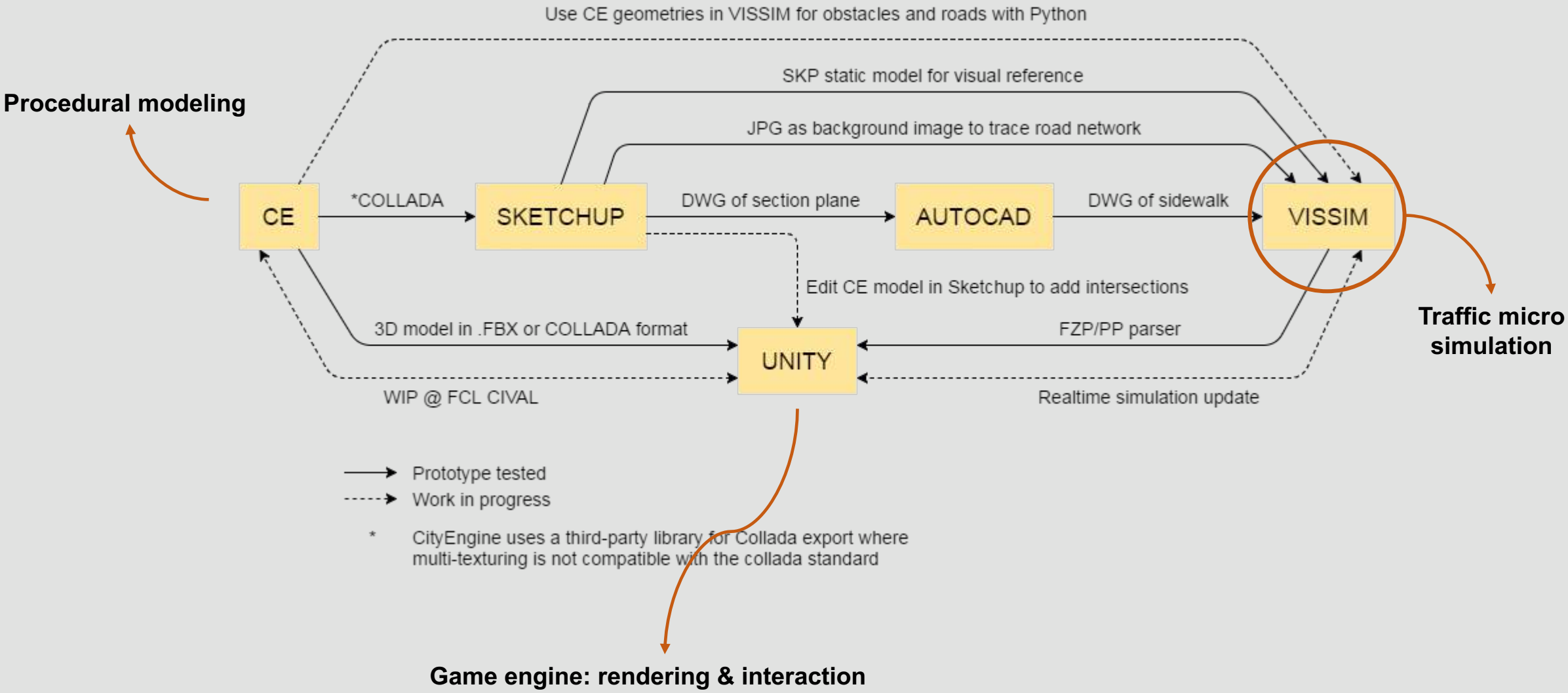
ENGAGEMENT

Google Cardboard,
Samsung Gear VR
HTC Vive

Virtual reality headset
S$1,000
Computer
> S$2,000

Virtual reality headset
S$180
Smartphone
> S$400

Virtual reality headset
S$2
Smartphone
> S$200


Use CE geometries in VISSIM for obstacles and roads with Python
SKP static model for visual reference
JPG as background image to trace road network
Procedural modeling
CE
*COLLADA
SKETCHUP
DWG of section plane
AUTOCAD
DWG of sidewalk
VISSIM
Traffic micro simulation
Edit CE model in Sketchup to add intersections
3D model in .FBX or COLLADA format
FZP/PP parser
UNITY
WIP @ FCL CIVAL
Realtime simulation update
Prototype tested
Work in progress
* CityEngine uses a third-party library for Collada export where multi-texturing is not compatible with the collada standard
Game engine: rendering & interaction