Big Data for Urban Design and Planning

Bige Tunçer

Associate Professor and Associate Head of Pillar
Architecture and Sustainable Design
Singapore University of Technology and Design

World Bank Learning Event, 25-6-2018

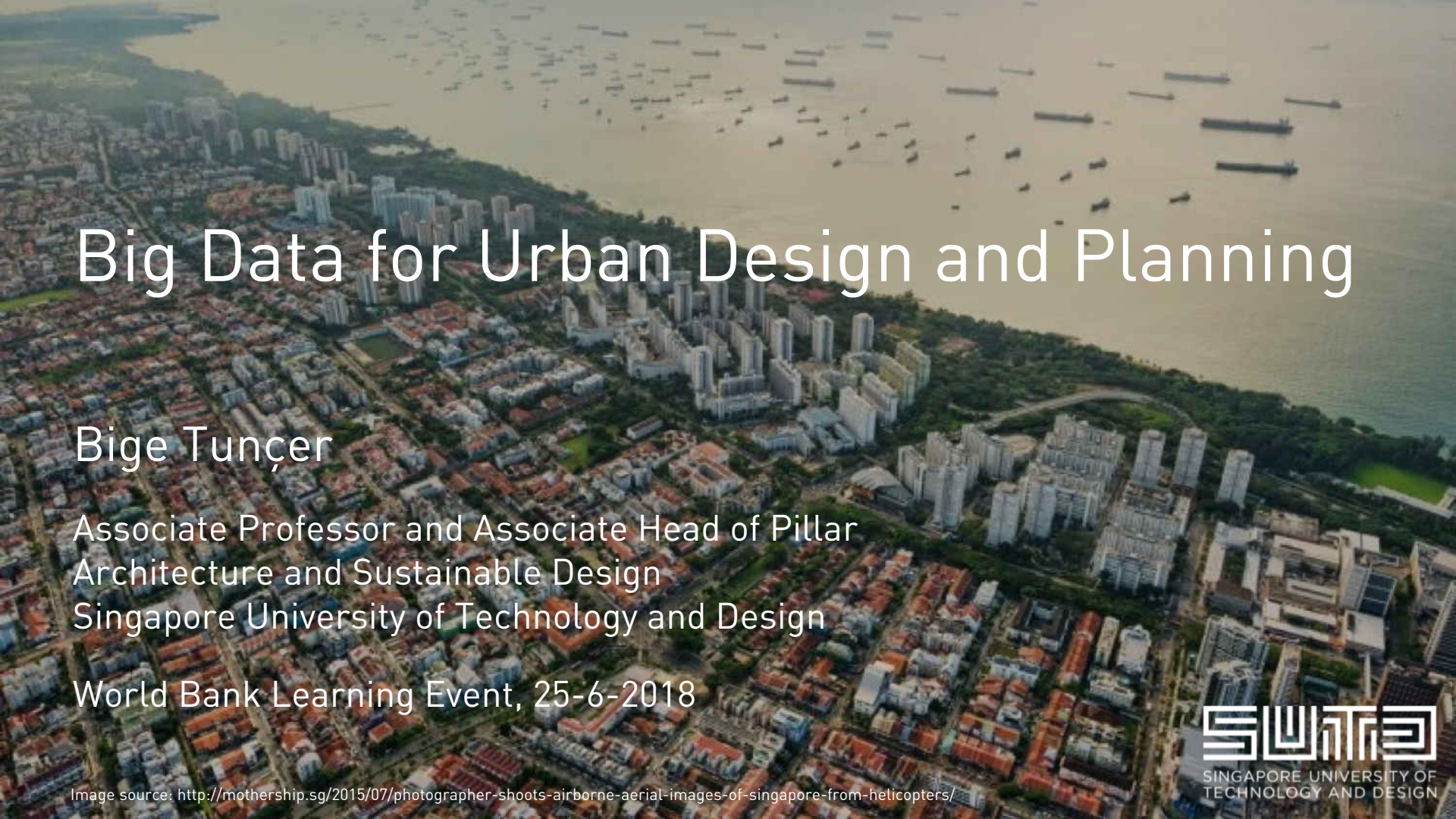


Image source: http://mothership.sg/2015/07/photographer-shoots-airborne-aerial-images-of-singapore-from-helicopters/

SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN

The use of ‘big data’ as an enabler of the smart city vision

Technology itself can’t automatically transform and improve cities and the lives of their inhabitants

Some characteristics of big data (Laney, 2001)

Volume (a huge amount of data)

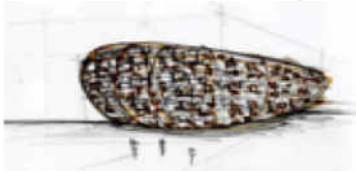
Variability (heterogeneous and often unstructured formats of data)

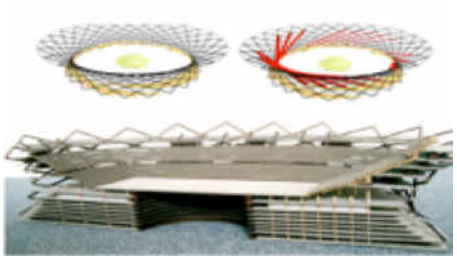
Velocity (an almost real-time processing of incoming data)

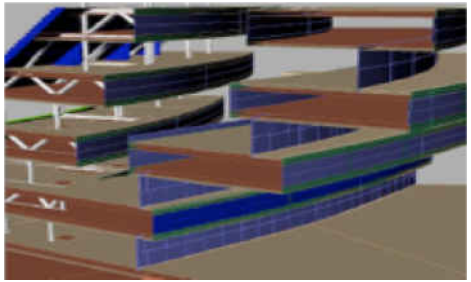
In the context of design support

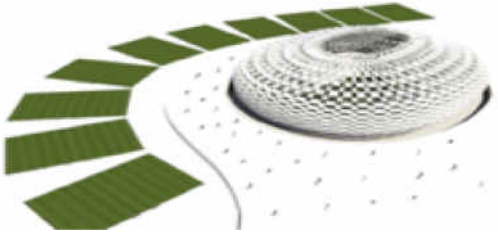
Variability (heterogeneous and often unstructured formats of data)

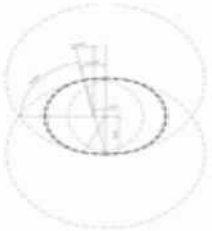
Design is a data and information intensive process

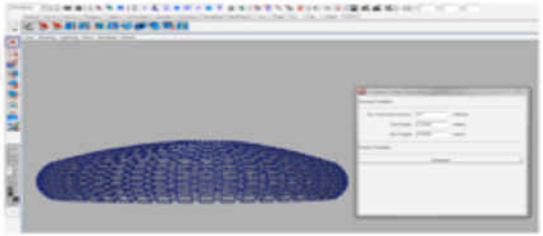






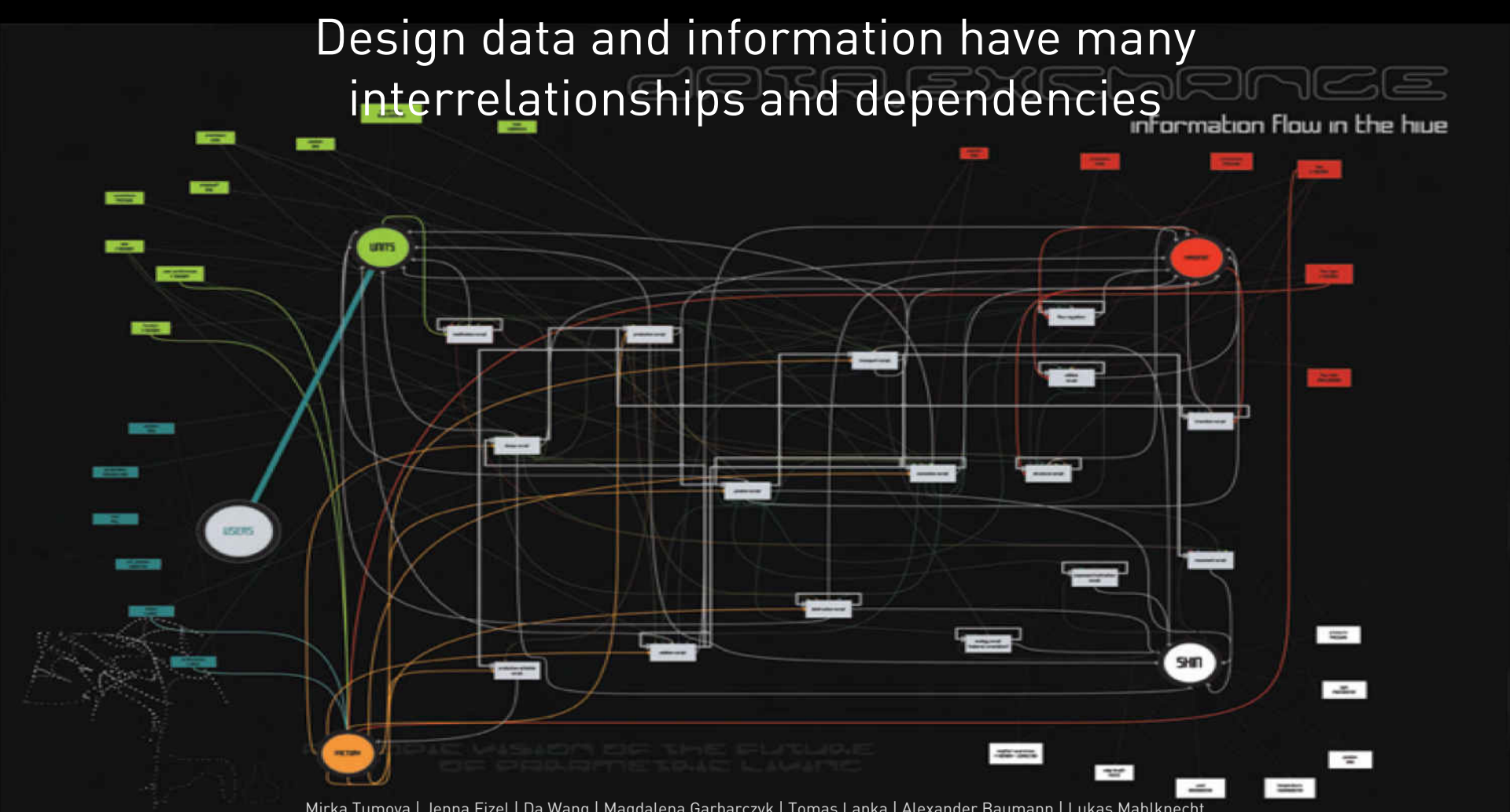






XXL Workshop Student Work
Sander Mulders, Tom van Swinderen, Juan Manuel Dávila Delgado

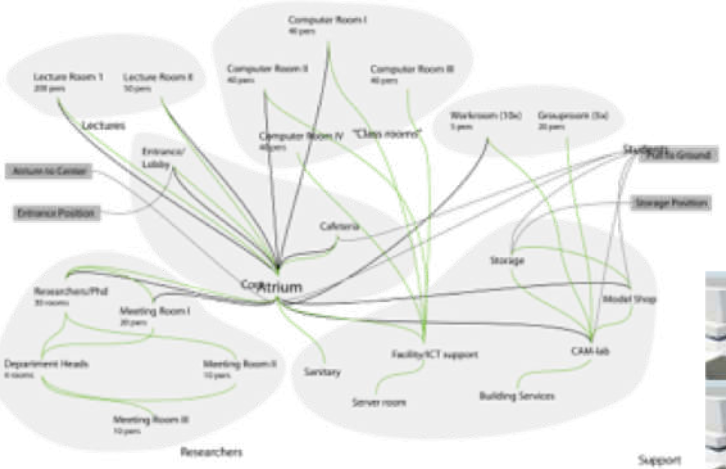
Design data and information have many interrelationships and dependencies

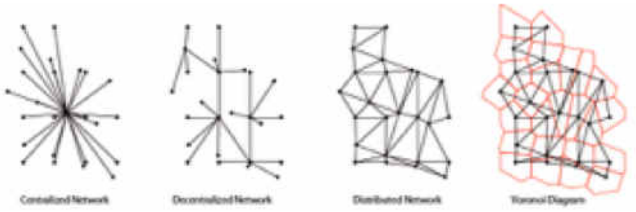


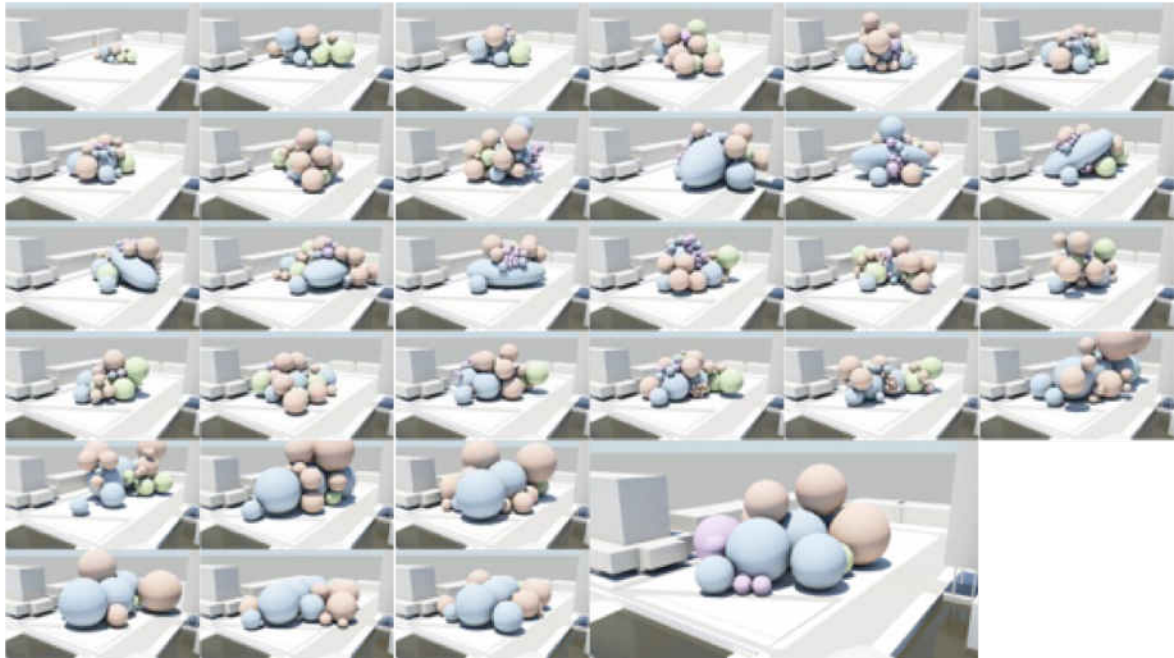
Mirka Tumova | Jenna Fizel | Da Wang | Magdalena Garbarczyk | Tomas Lapka | Alexander Baumann | Lukas Mahlknecht

Database design and implementation, and data exchange protocols for an interactive 3D design

Data and information support design decision making







Sander Mulders
School for Digital Design –
digital tools for design

Designers switch between various scales

Designers frame and solve various problems consecutively, simultaneously

Providing designers with

multi-source

multi-scale

multi-time

information, or evidence

an important contribution of big data to design support

EVIDENCE BASED DESIGN SUPPORT

Designers use evidence from existing situations in projects

Gain insights to improve these projects and gain insights for new designs

Evidence does not lead to a linear translation into design solutions

EBDS can replace some of the assumptions made during design by grounded evidence

EVIDENCE BASED DESIGN SUPPORT

The research challenge:

Which behavioral hypotheses can be drawn from specific urban data sets and their combination?

What is the relationship of these hypotheses with spatial and organizational aspects of urban spaces?

URBAN BIG DATA

Various sources for data, including:

- sensor data for all types of urban infrastructures
- [real-time] transport tracking data
- social network data [information about events or opinions]
- public app data
- user volunteered data [including geographic data]
- phone data
- open data provided by government [e.g., air pollution data, crime data, meteorological data, land use data]

INFORMED DESIGN LAB @ SUTD & FCL

Multi-disciplinary group consisting of architects, engineers, data scientists


Bige Tunçer


Hexu Xin


Pieter Herthogs


Garvit Bansal


Alexandria Chong (Zhou Wen)


Ludovica Tomarchio


Francisco Benita


Ramanathan Subramanian


Peijun He


Darshan Virupaksha


Iting Chuang


Stéphanie Hasler (EPFL)


Francesco Scandola

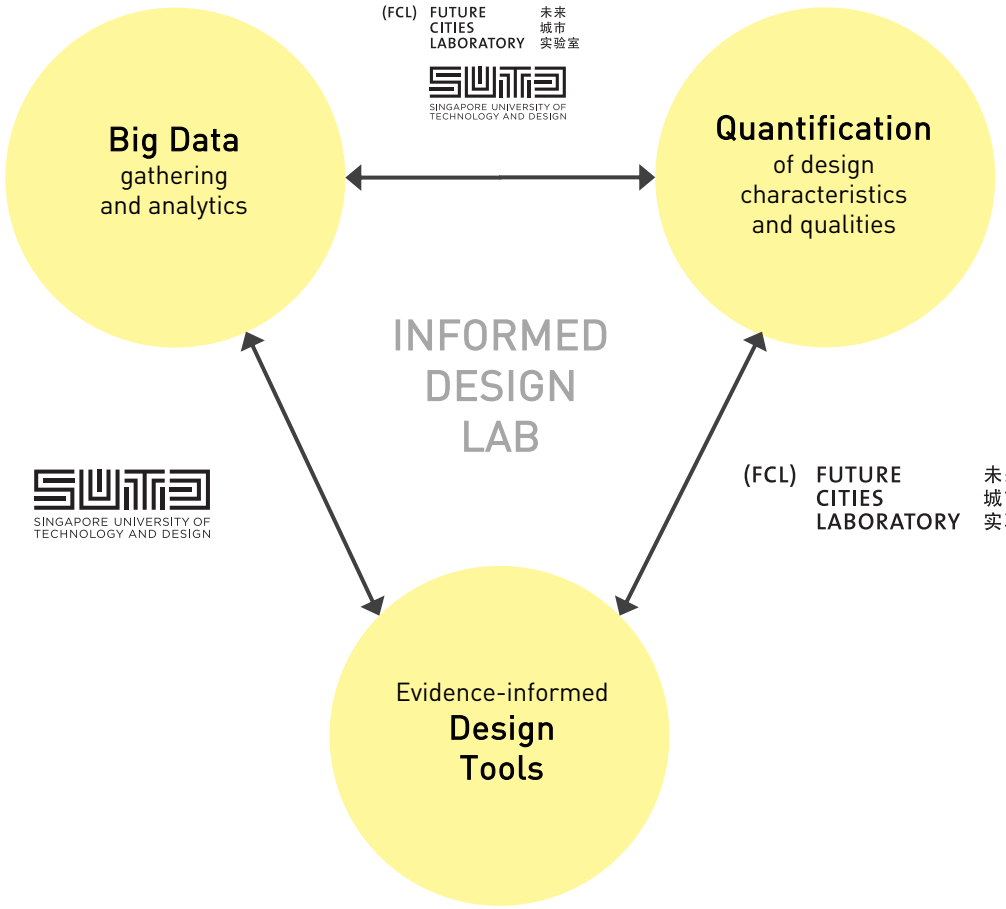

Kajol Sethia


Özgün Balaban


Sarah Nadiawandi


Sumbul Khan


Iman Abu Hashish (U. Pavia)


(FCL) FUTURE CITIES LABORATORY 未来城市实验室
SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN
Big Data
gathering
and analytics
Quantification
of design
characteristics
and qualities
INFORMED
DESIGN
LAB
SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN
(FCL) FUTURE CITIES LABORATORY 未来城市实验室
Evidence-informed
Design
Tools

Can we integrate big data, user preferences, and designer knowledge for urban design and planning support?

Multi-source, multi-scale, multi-time data collection

Data analytics and visualization

Deriving insights for designers from evidence

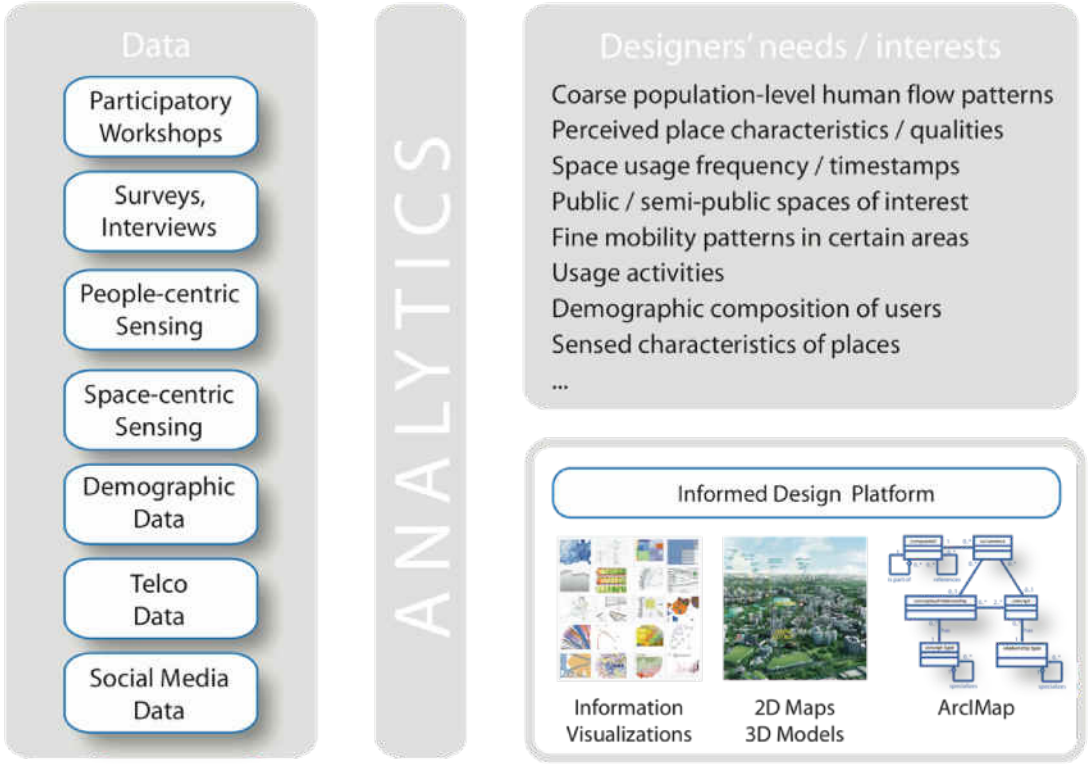
Creating and/or ranking design options building on this evidence

LIVEABLE PLACES: INFORMED DESIGN FOR ADAPTIVE PUBLIC SPACE

Bige Tunçer, Hexu Xin, Linlin You

Photograph taken by Kien To

LIVEABLE PLACES:
INFORMED DESIGN FOR ADAPTIVE PUBLIC SPACE



SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN

Institute for Infocomm Research A*STAR

Singtel

HOUSING & DEVELOPMENT BOARD

URBAN REDEVELOPMENT AUTHORITY

LIVEABLE PLACES: INFORMED DESIGN FOR ADAPTIVE PUBLIC SPACE

Some questions designers may want to answer through use of the Informed Design Platform:

Which spaces are being used, how, and how much?

How do the people who use these spaces perceive them?

Are any spaces over- or under-utilized?

What can be additional/alternative uses for spaces that increase livability?

How could spaces be modified (new- or re-design) to improve them in terms of the issues above?

Photograph provided by URA

https://www.ura.gov.sg/uol/-/media/User%20Defined/URA%20Online/master-plan/master-plan-2014/growth-areas/jld_3.jpg?h=226&w=769&la=en

http://stel.bmj.com/content/bmjstel/3/Suppl_1/S41/F3.large.jpg

Photograph taken by Kien To

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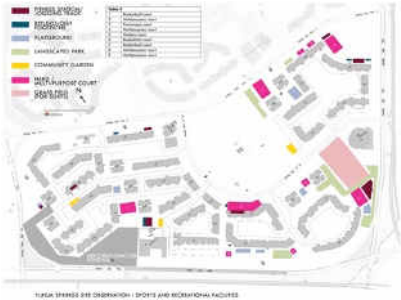
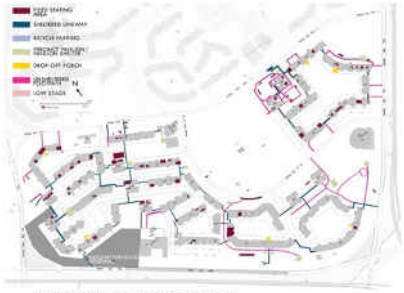
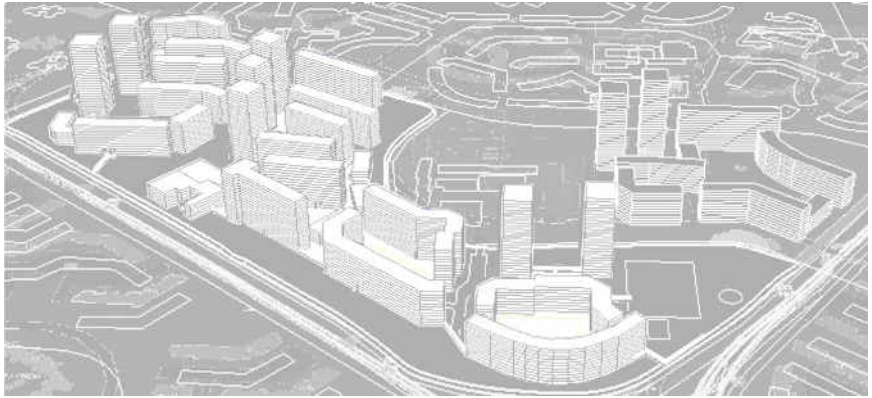
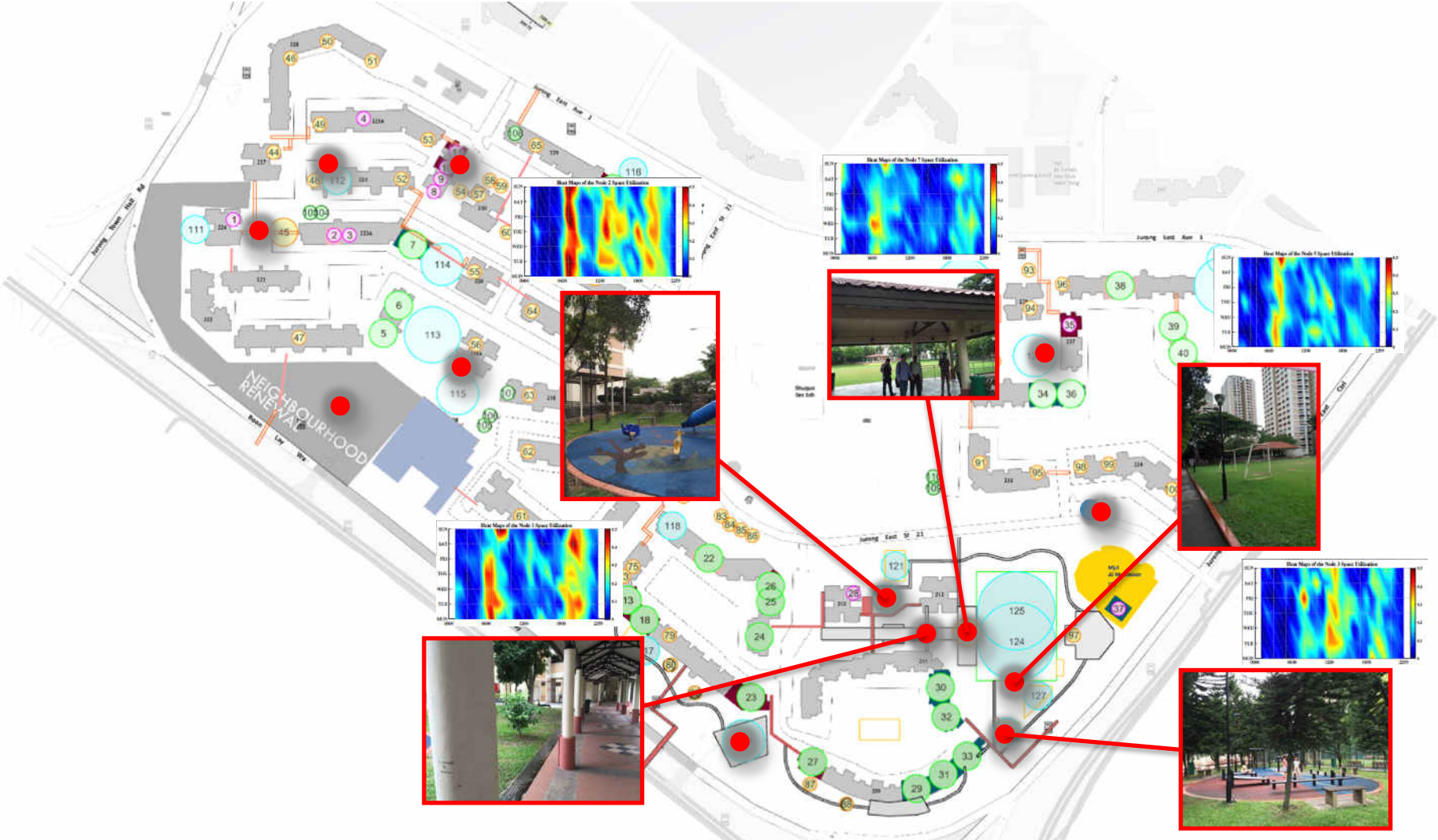
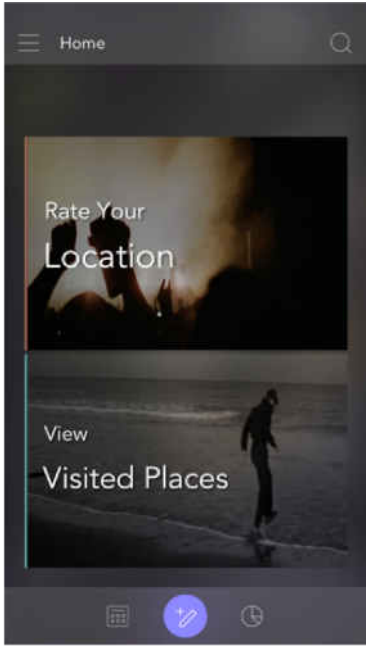




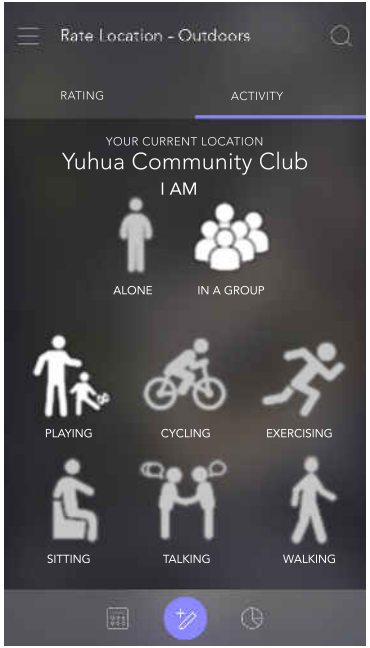


Images by Chong Keng Hua, Andre Chaszar, Bige Tuncer

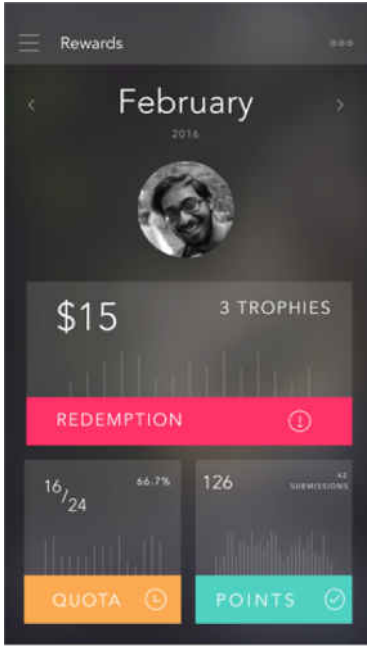

NEIGHBOURHOOD RENEWAL


Home
Rate Your
Location
View
Visited Places

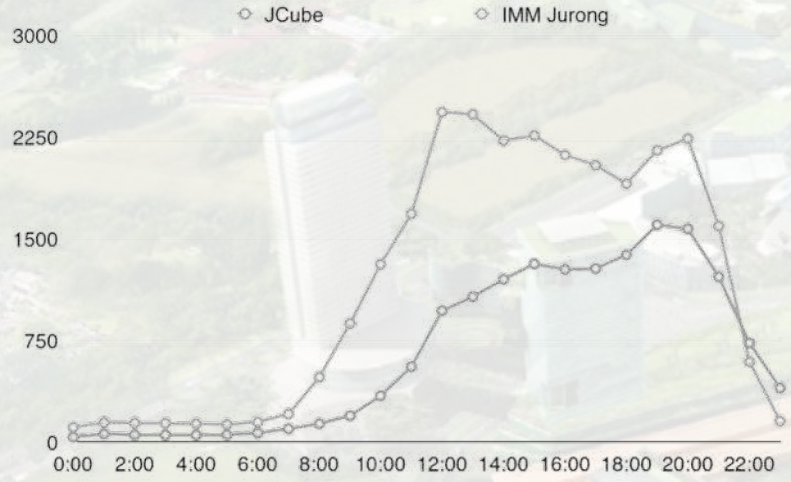

Rate Location - Outdoors
RATING
ACTIVITY
YOUR CURRENT LOCATION
Yuhua Community Club
THIS PLACE MAKES ME FEEL
THIS PLACE IS
LIVELY
RELAXING
COSY
SAFE


Rate Location - Outdoors
RATING
ACTIVITY
YOUR CURRENT LOCATION
Yuhua Community Club
I AM
ALONE
IN A GROUP
PLAYING
CYCLING
EXERCISING
SITTING
TALKING
WALKING


Visited Places
TUESDAY
MARCH 15, 2016
9:42 a.m.
Yuhua Community Club
12:10 p.m.
Yuhua Market
1:42 p.m.
Greenprint @ Yuhua
MONDAY
MARCH 14, 2016
7 a.m.
Yuhua Secondary School

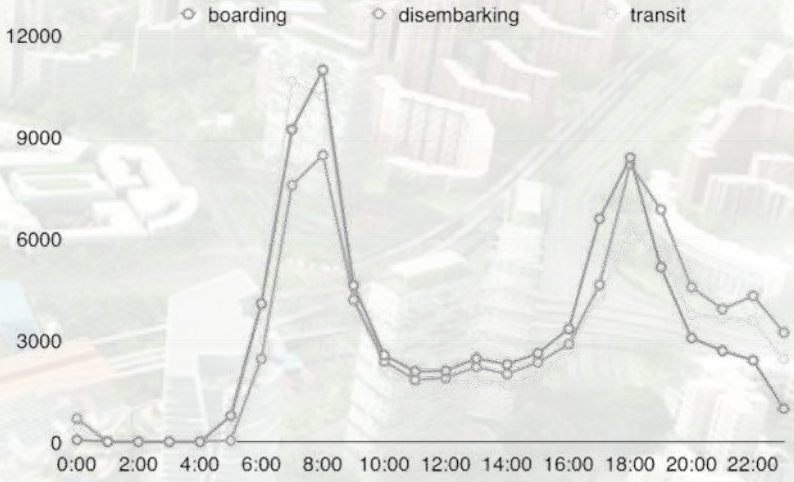

Rewards
February
2016
$15
3 TROPHIES
REDEMPTION
16/24
66.7%
126
QUOTA
POINTS

Buildings
Footfall



Fri, May 15, 2015

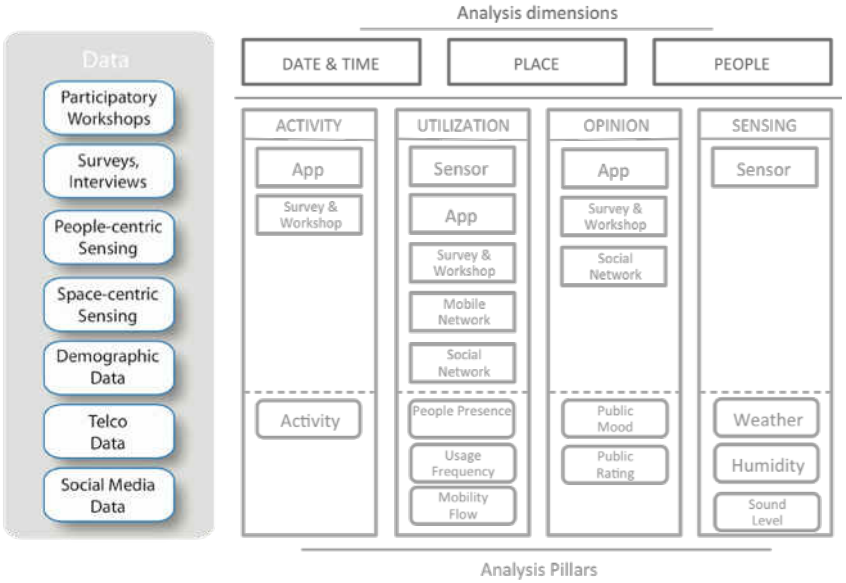
MRT Stations
Station Crowdedness

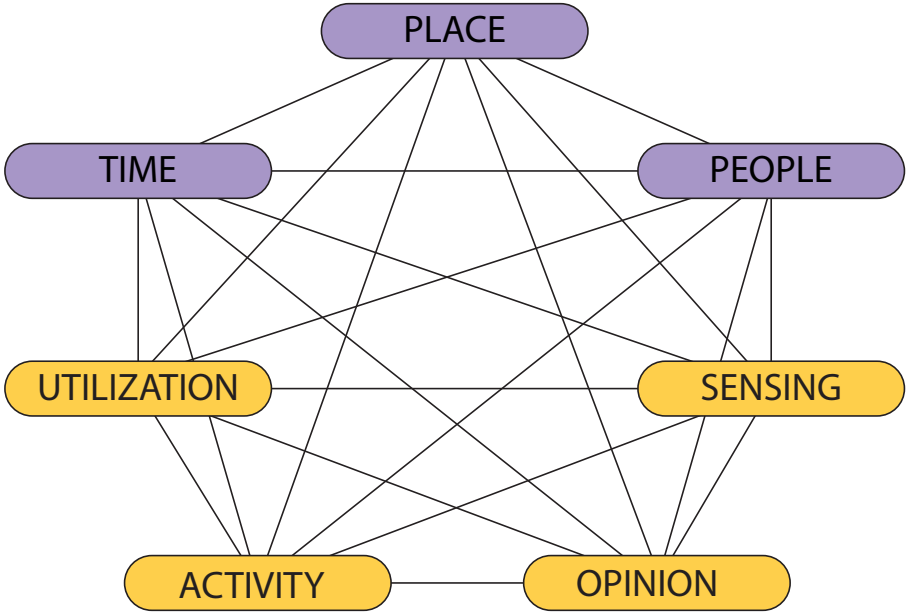


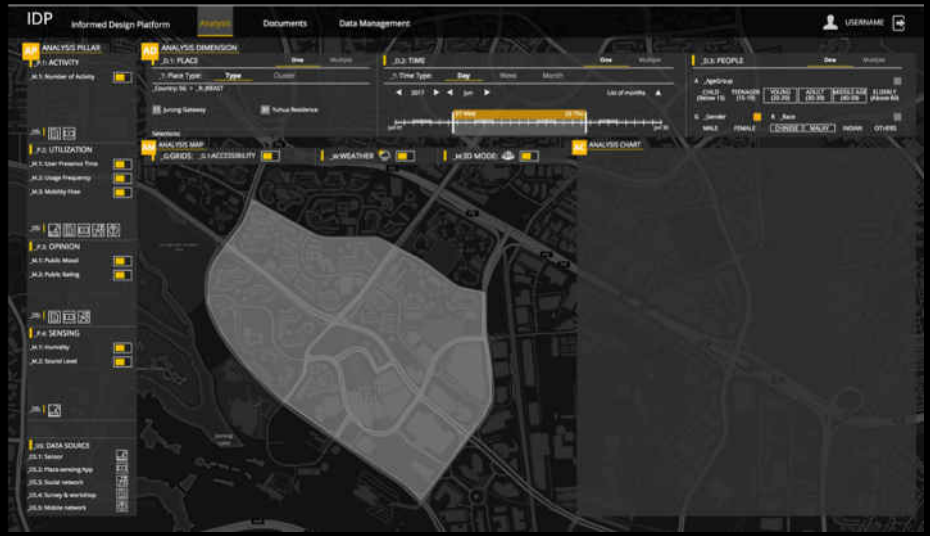
Jurong East MRT Station on **Fri**, May 15, 2015


LOW STAGE

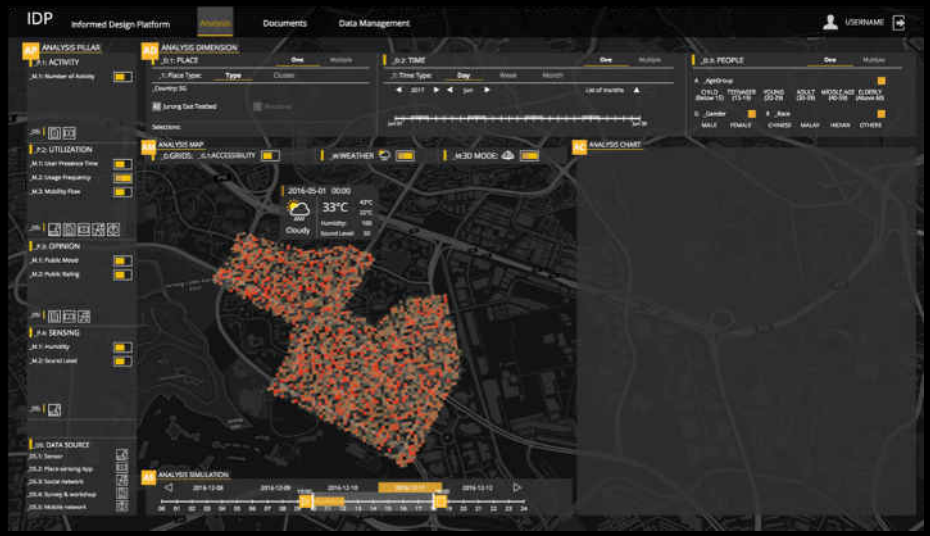
INTERCONNECTED DATA MODEL






IDP
Informed Design Platform
Analysis
Documents
Data Management
USERNAME
ANALYSIS PILLAR
ANALYSIS DIMENSION
ANALYSIS MAP
ANALYSIS CHART


IDP
Informed Design Platform
Analysis
Documents
Data Management
USERNAME
ANALYSIS PILLAR
ANALYSIS DIMENSION
ANALYSIS MAP
ANALYSIS CHART


IDP
Informed Design Platform
Analysis
Documents
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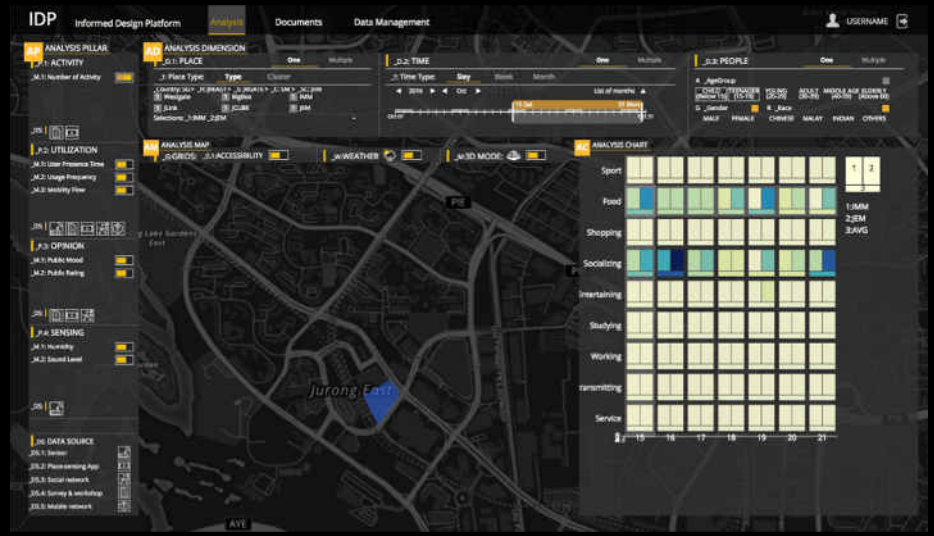
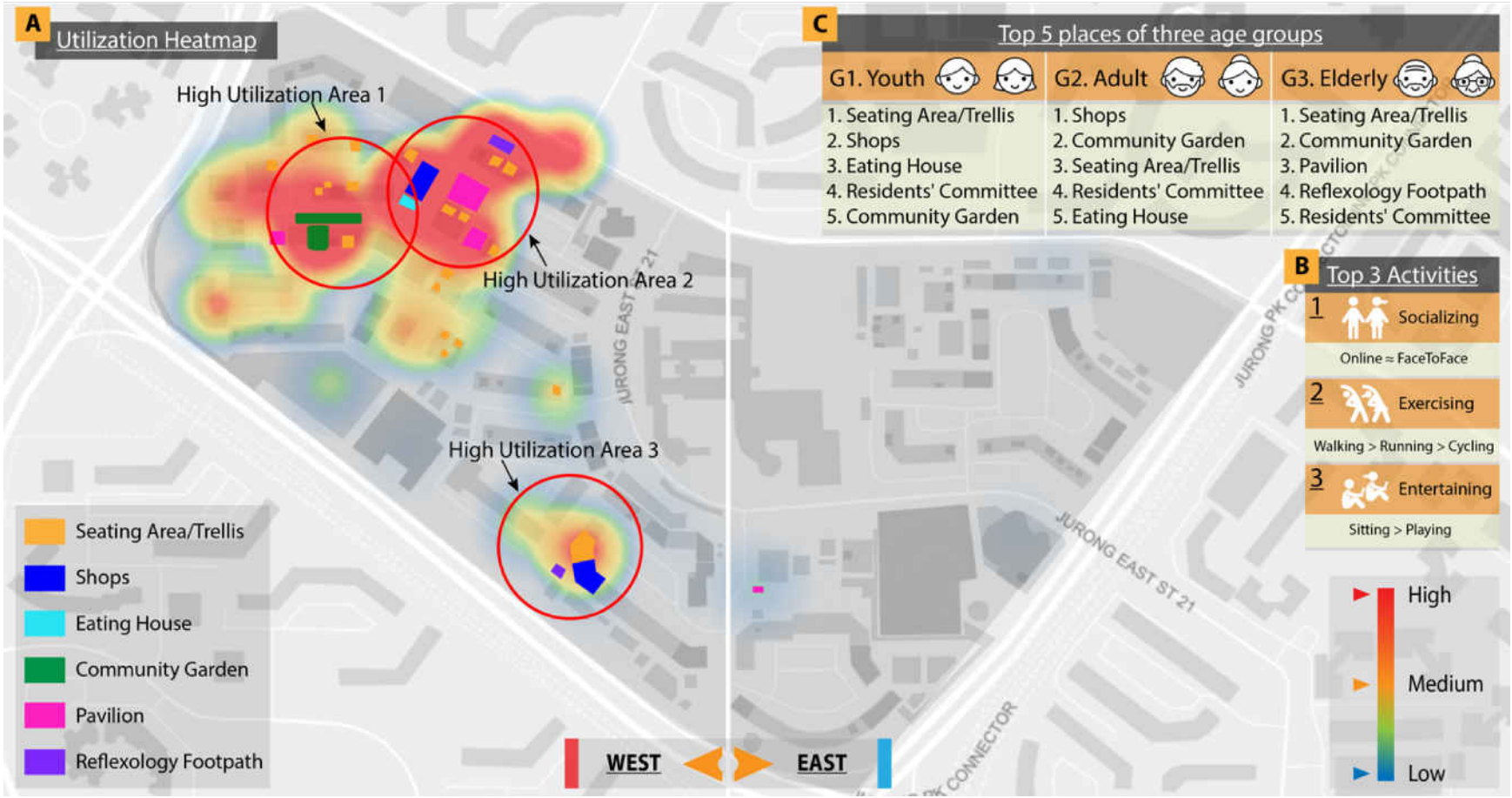
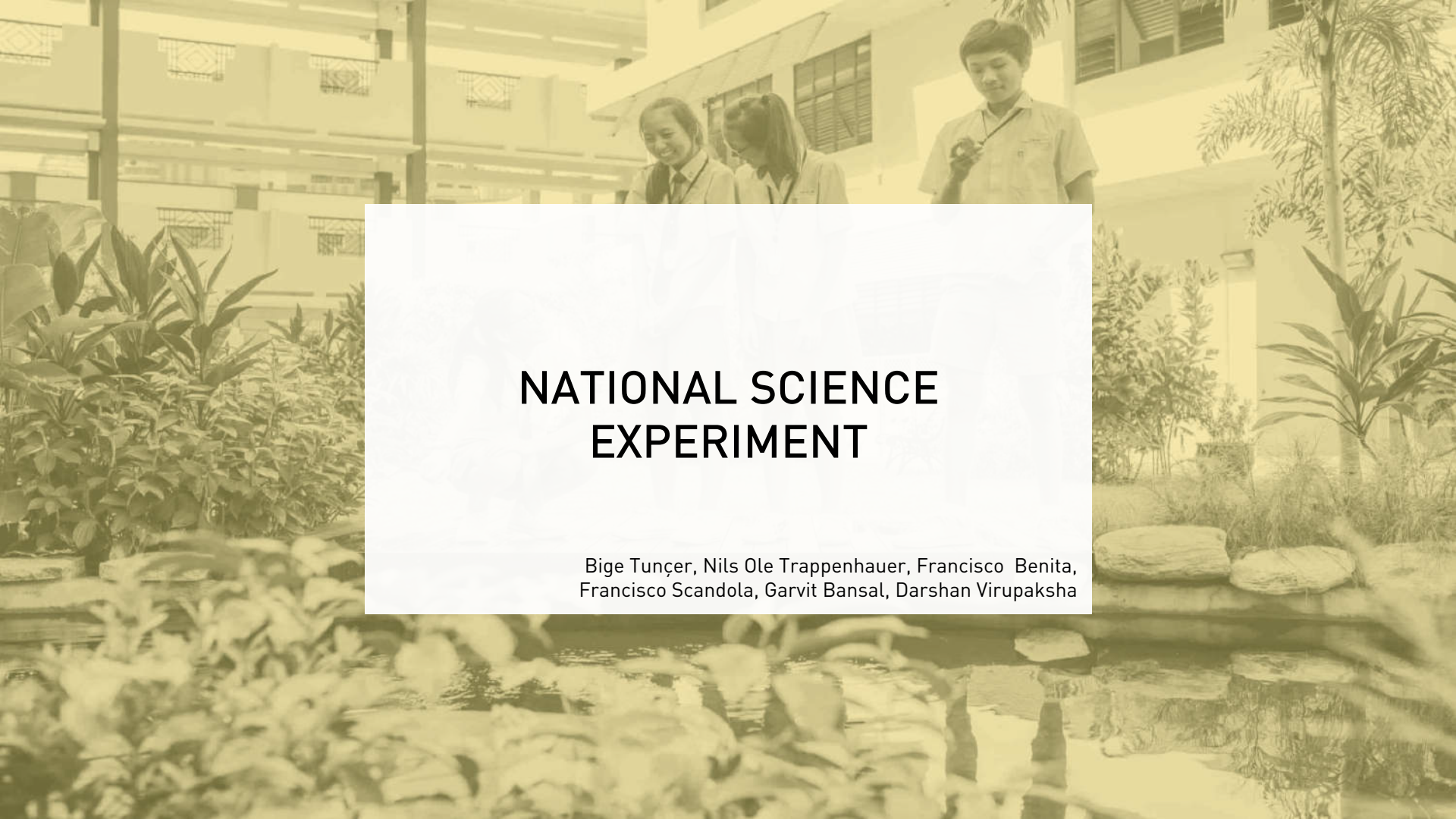
USERNAME
ANALYSIS PILLAR
ANALYSIS DIMENSION
ANALYSIS MAP
ANALYSIS CHART
ANALYSIS SIMULATION


IDP
Informed Design Platform
Analysis
Documents
Data Management
USERNAME
ANALYSIS PILLAR
ANALYSIS DIMENSION
ANALYSIS MAP
ANALYSIS CHART
Jurong East

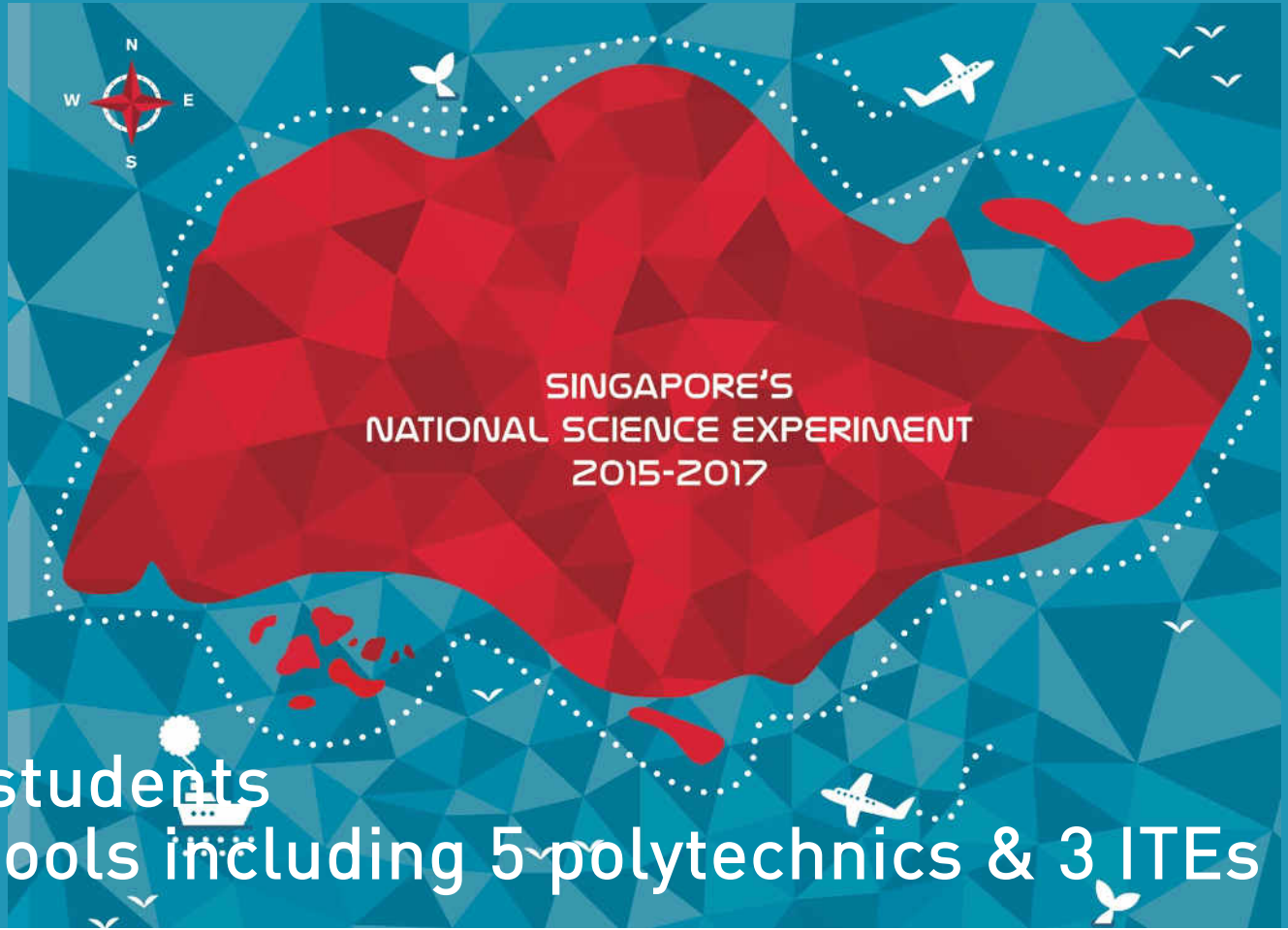

A
Utilization Heatmap
Devan Nair Institute
Jurong Interchange
IMM
Westgate
JLink
Jurong East
JEM
Library
JCUBE
Hospital
JTC
BigBox
High
Medium
Low
6
Shopping Mall
1
Hospital
1
Library
1
Transportation Hub
2
Business Building
B
Activity Weekly Distribution
Socializing
Food
Shopping
Entertaining
Working
Transmitting
Sport
Service
Studying
SUN
48.4%
31.0%
7.8%
5.4%
1.8%
3.1%
SAT
48.5%
34.7%
9.2%
1.8%
1.8%
1.1%
FRI
43.3%
34.8%
9.8%
2.1%
2.1%
4.9%
THU
43.2%
35.3%
10.2%
1.0%
3.6%
2.6%
WED
43.0%
35.1%
9.9%
1.1%
3.0%
4.2%
TUE
44.4%
33.8%
10.7%
1.9%
2.9%
2.6%
MON
42.8%
34.0%
9.8%
3.1%
3.4%
3.4%
C
Place Happiness Index
Westgate
Positive Transmission
Towards Unhappy
JTC
Negative Transmission
JLink
Jurong Interchange
JCUBE
Devan Nair Institute
BigBox
Hospital
JEM
IMM
Library
Towards Happy


A
Utilization Heatmap
High Utilization Area 1
High Utilization Area 2
High Utilization Area 3
JURONG EAST ST 21
JURONG EAST ST 21
JURONG PK CONNECTOR
Seating Area/Trellis
Shops
Eating House
Community Garden
Pavilion
Reflexology Footpath
WEST
EAST
C
Top 5 places of three age groups
G1. Youth
1. Seating Area/Trellis
2. Shops
3. Eating House
4. Residents' Committee
5. Community Garden
G2. Adult
1. Shops
2. Community Garden
3. Seating Area/Trellis
4. Residents' Committee
5. Eating House
G3. Elderly
1. Seating Area/Trellis
2. Community Garden
3. Pavilion
4. Reflexology Footpath
5. Residents' Committee
B
Top 3 Activities
1 Socializing
Online ≈ FaceToFace
2 Exercising
Walking > Running > Cycling
3 Entertaining
Sitting > Playing
High
Medium
Low



NATIONAL SCIENCE EXPERIMENT

Bige Tunçer, Nils Ole Trappenhauer, Francisco Benita, Francisco Scandola, Garvit Bansal, Darshan Virupaksha



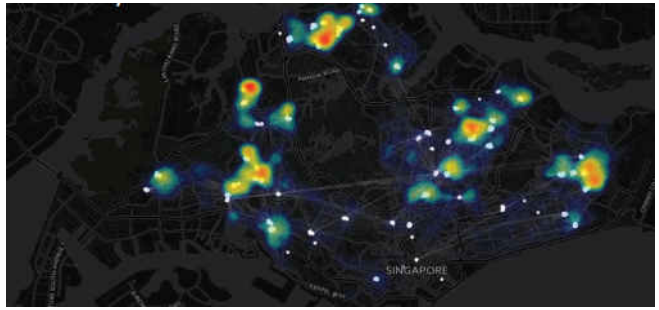
90,629 students
265 schools including 5 polytechnics & 3 ITEs

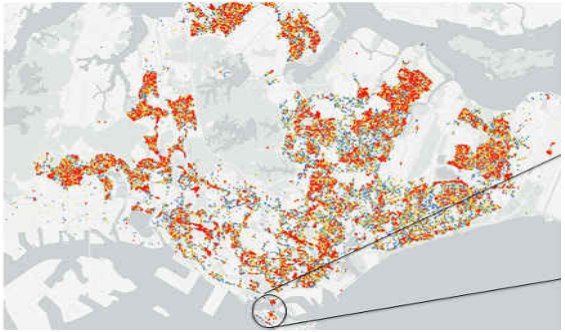
National Research Foundation
Prime Minister's Office
Singapore
Research . Innovation . Enterprise

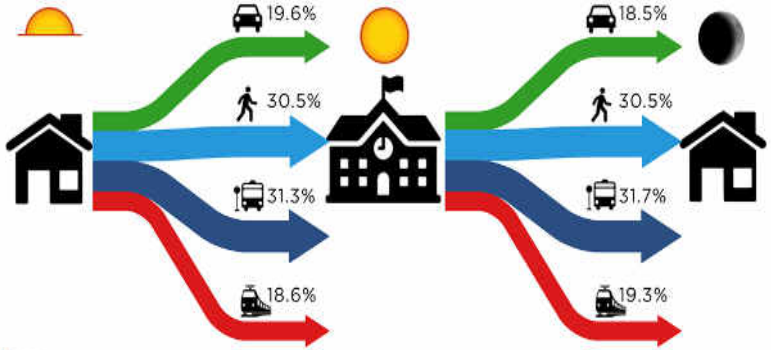
Singapore University of Technology and Design

Science Centre Singapore

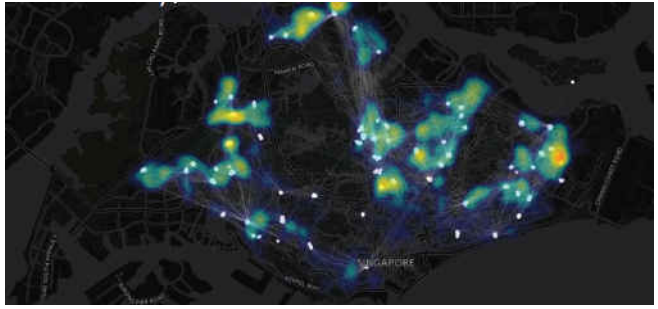
A*STAR
Institute of High Performance Computing







"Just having a good day and my teacher told a joke!"
(anecdote from a student when pressing the button)



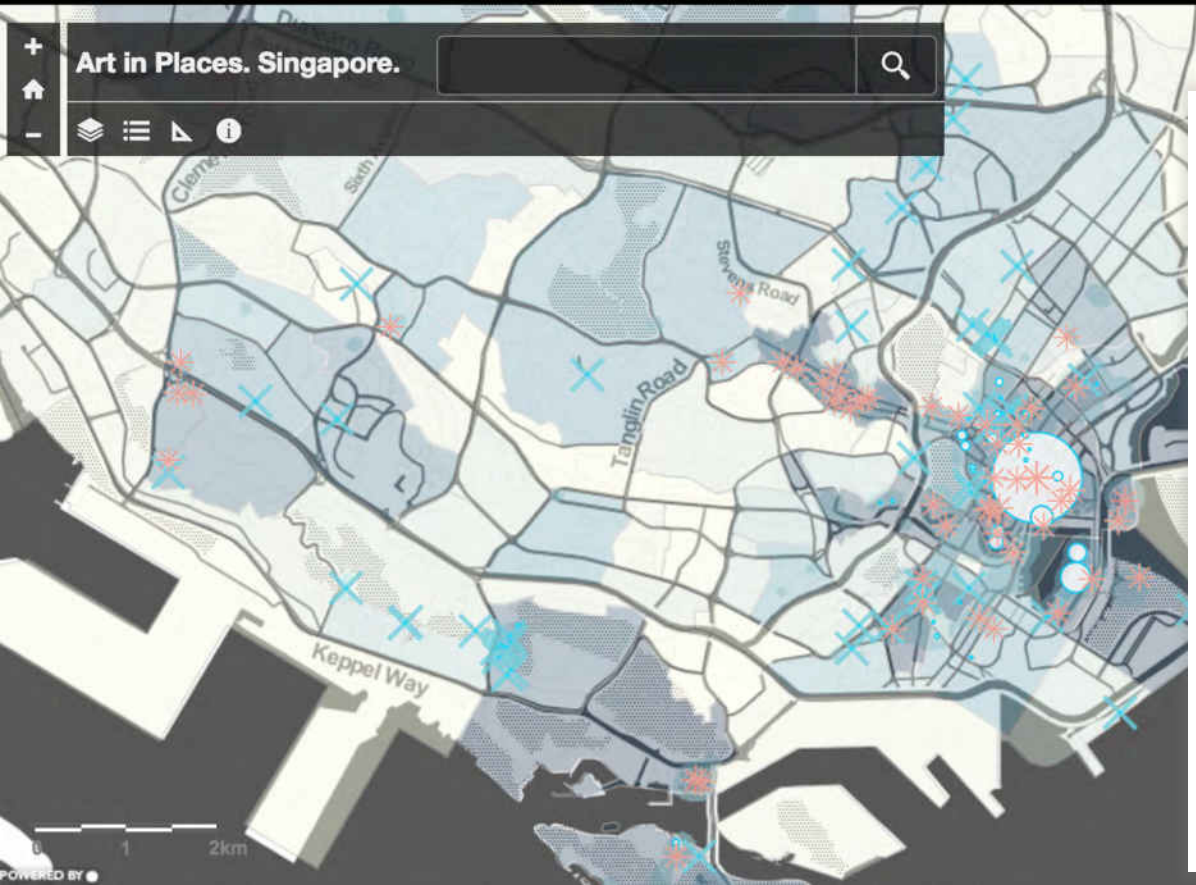

Singapore Views
National Science Experiment
Projects
Layers
Presentations
School Metrics
Type
Primary
Secondary
AirconCO2
1238-6619
TravelCO2
78-2014
Steps
69-390
Stairs
267-10030
Car
4-21
Walk
0.00-4.00
Bus
0-21
MRT
0-26

EXPLORING ART PRODUCTION AND CONSUMPTION THROUGH SOCIAL MEDIA

Ludovica Tomarchio

Yayoi Kusama's exhibition at the National Gallery PHOTO: NATIONAL GALLERY SINGAPORE

Art in Space. Singapore



HOW DO SOCIAL MEDIA AFFECT ART?

Can we develop tools and methodologies for responsive cultural city planning?

SOCIAL MEDIA DATA

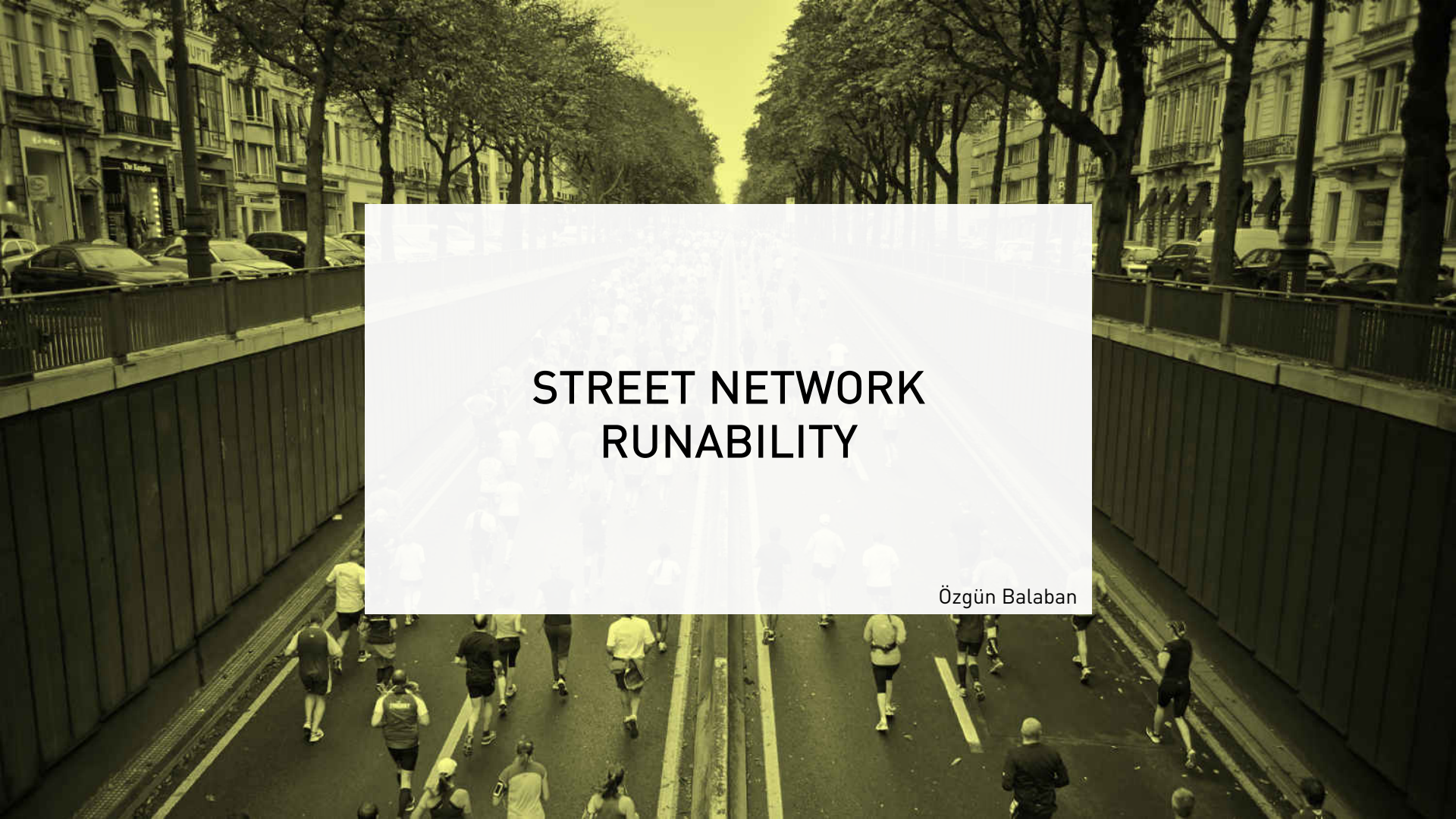
- How can we describe Hybrid Art Venues?
- What kind of aesthetic results from the mix of art and social media?
- How effective are current cultural planning practices?

MAPPING ART LOCATIONS

- How can we define and map art venues through SM?
- Which types of analyses could be useful?

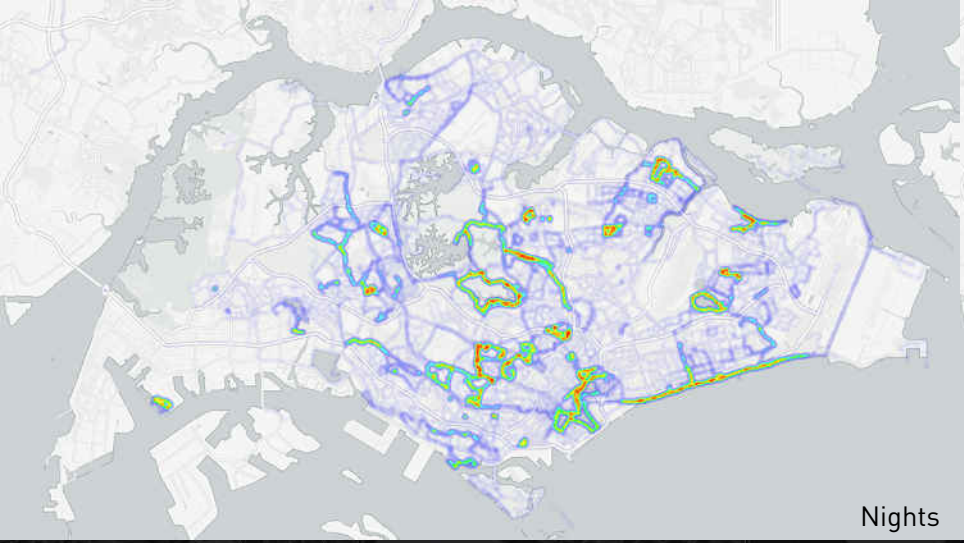
RESPONSIVE CULTURAL PLANNING

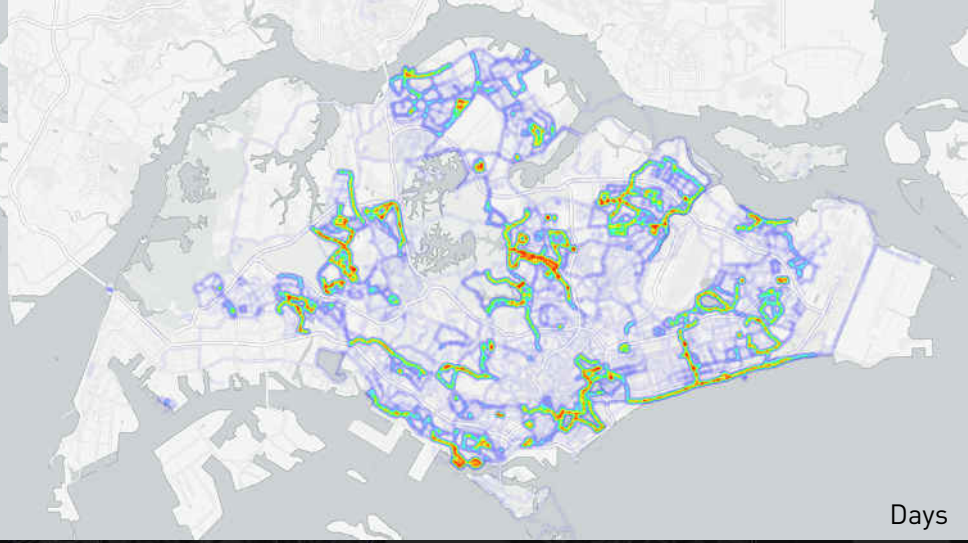
- What information from social media is useful?
- How can it be implemented in decision making?

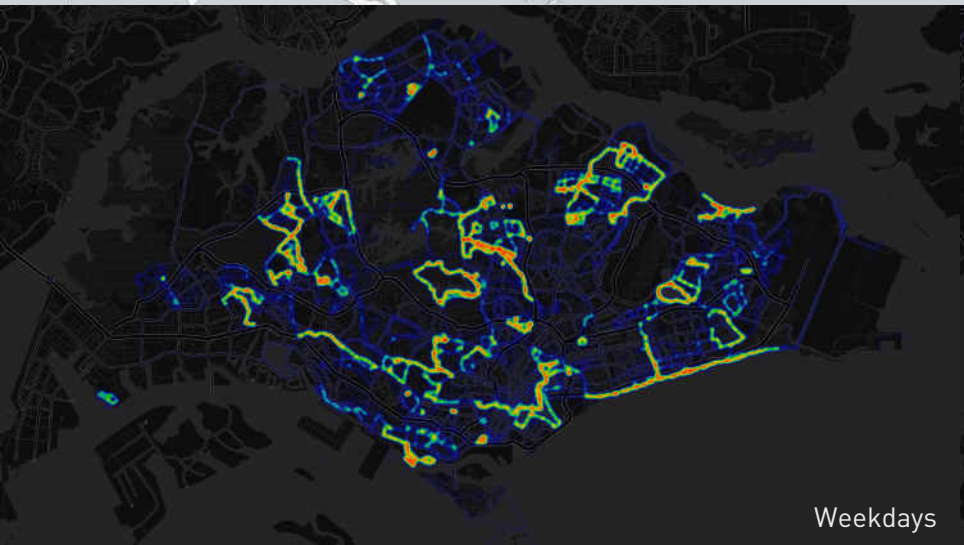


STREET NETWORK RUNABILITY

Özgün Balaban


Nights


Days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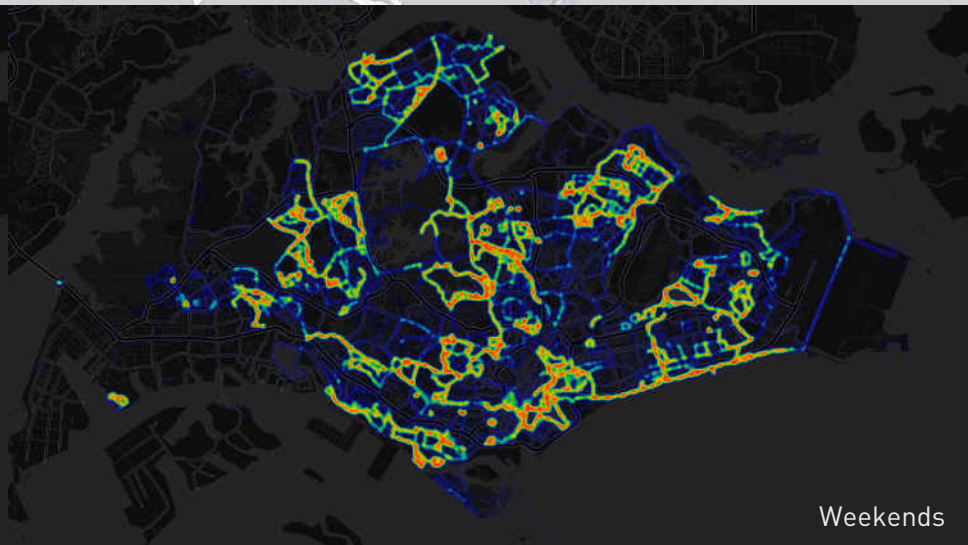
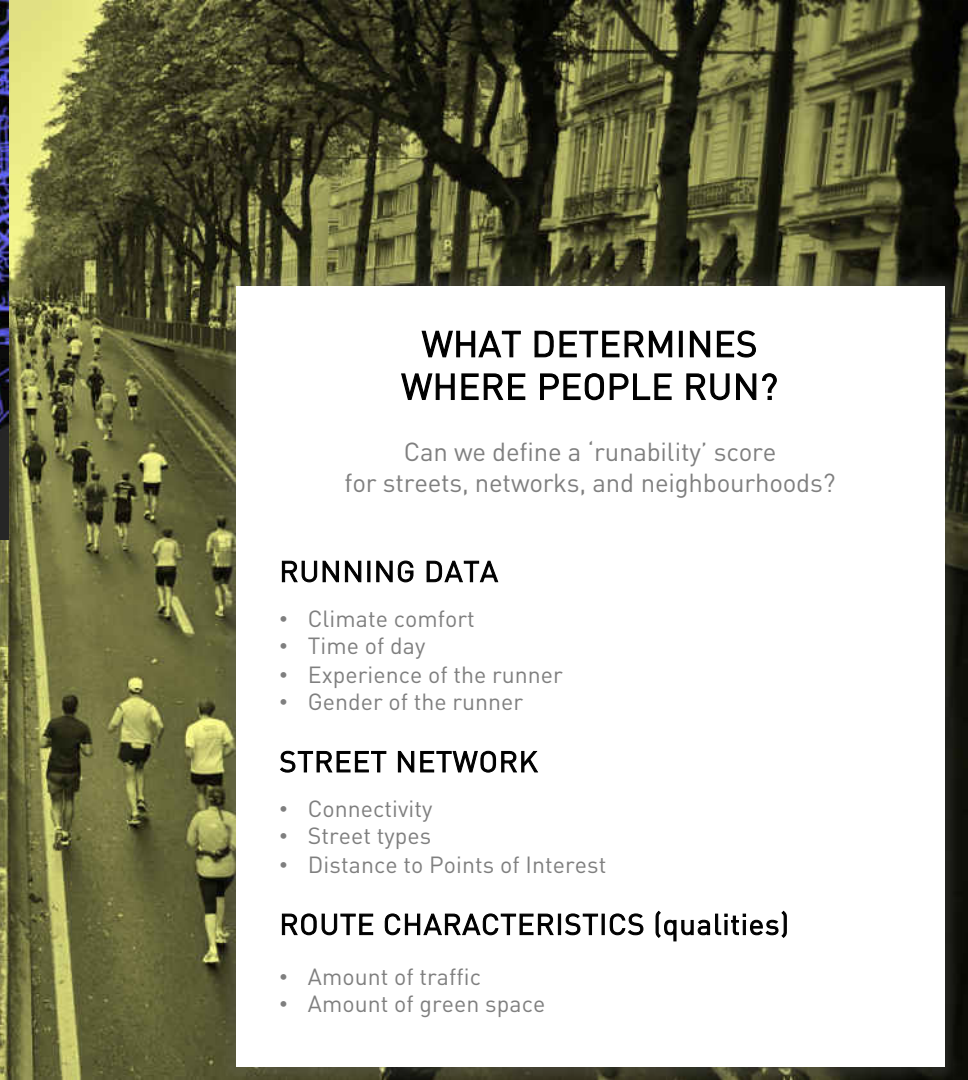

Weekends



WHAT DETERMINES WHERE PEOPLE RUN?

Can we define a 'runability' score
for streets, networks, and neighbourhoods?

RUNNING DATA

- Climate comfort
- Time of day
- Experience of the runner
- Gender of the runner

STREET NETWORK

- Connectivity
- Street types
- Distance to Points of Interest

ROUTE CHARACTERISTICS (qualities)

- Amount of traffic
- Amount of green space

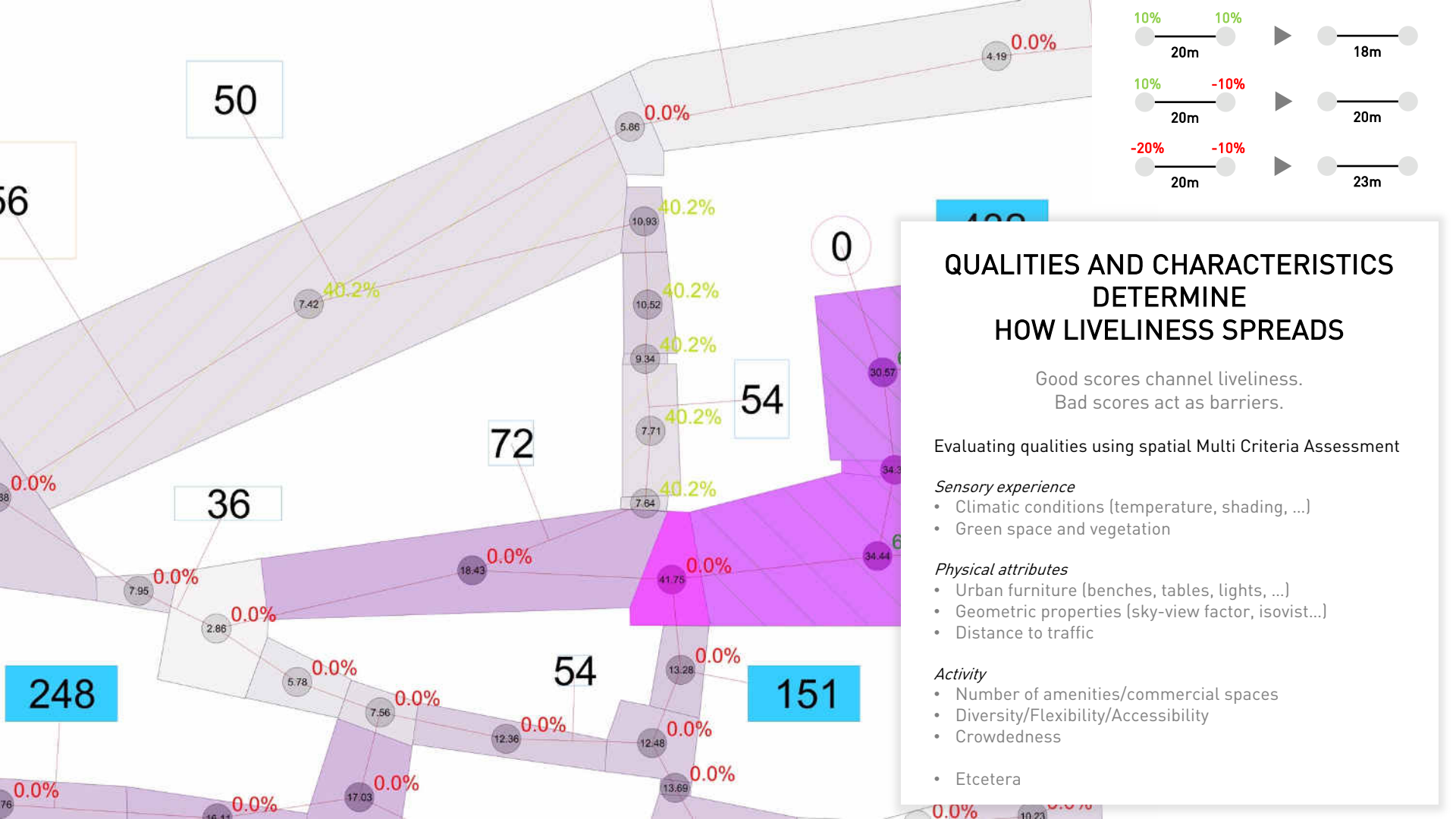
VISIT POTENTIAL MODEL (VPM)

Pieter Hertogs, Peijun He, in collaboration with Marcus Schlaepfer

The Visit Potential Model

estimates the potential presence of people in public spaces or in buildings,

and the effect of design qualities on this potential.



QUALITIES AND CHARACTERISTICS DETERMINE HOW LIVELINESS SPREADS

Good scores channel liveliness.
Bad scores act as barriers.

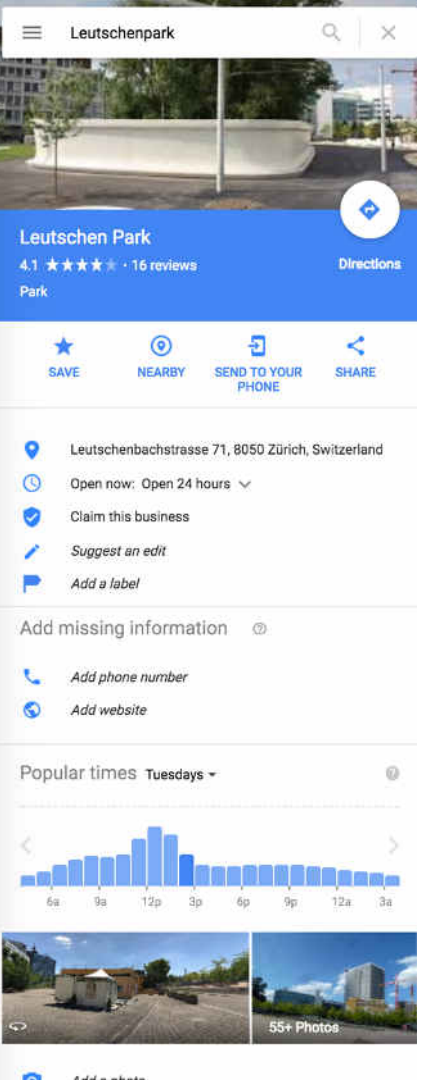
Evaluating qualities using spatial Multi Criteria Assessment

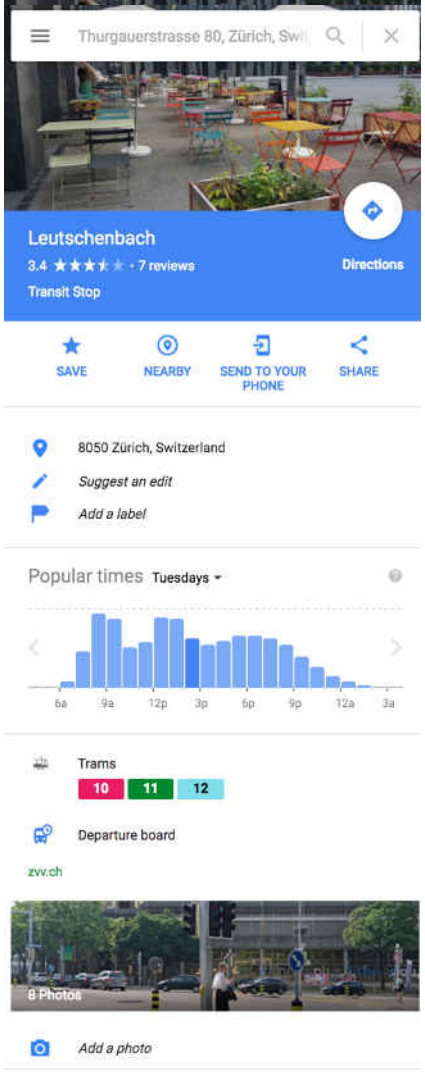
Sensory experience
- Climatic conditions (temperature, shading, ...)
- Green space and vegetation

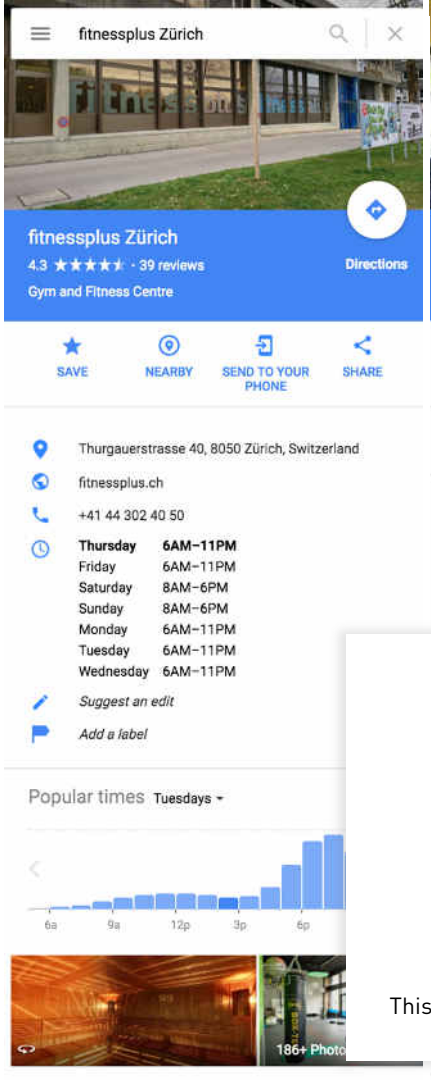
Physical attributes
- Urban furniture (benches, tables, lights, ...)
- Geometric properties (sky-view factor, isovist...)
- Distance to traffic

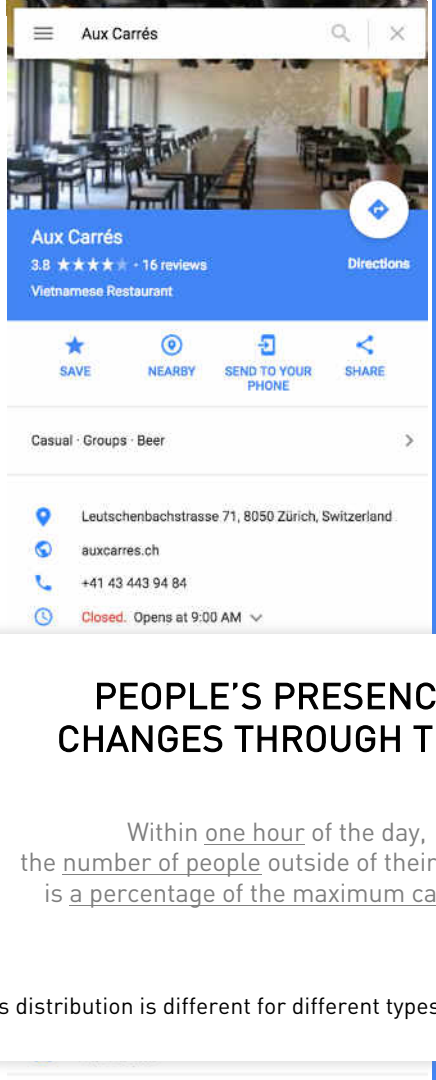
Activity
- Number of amenities/commercial spaces
- Diversity/Flexibility/Accessibility
- Crowdedness

- Etcetera









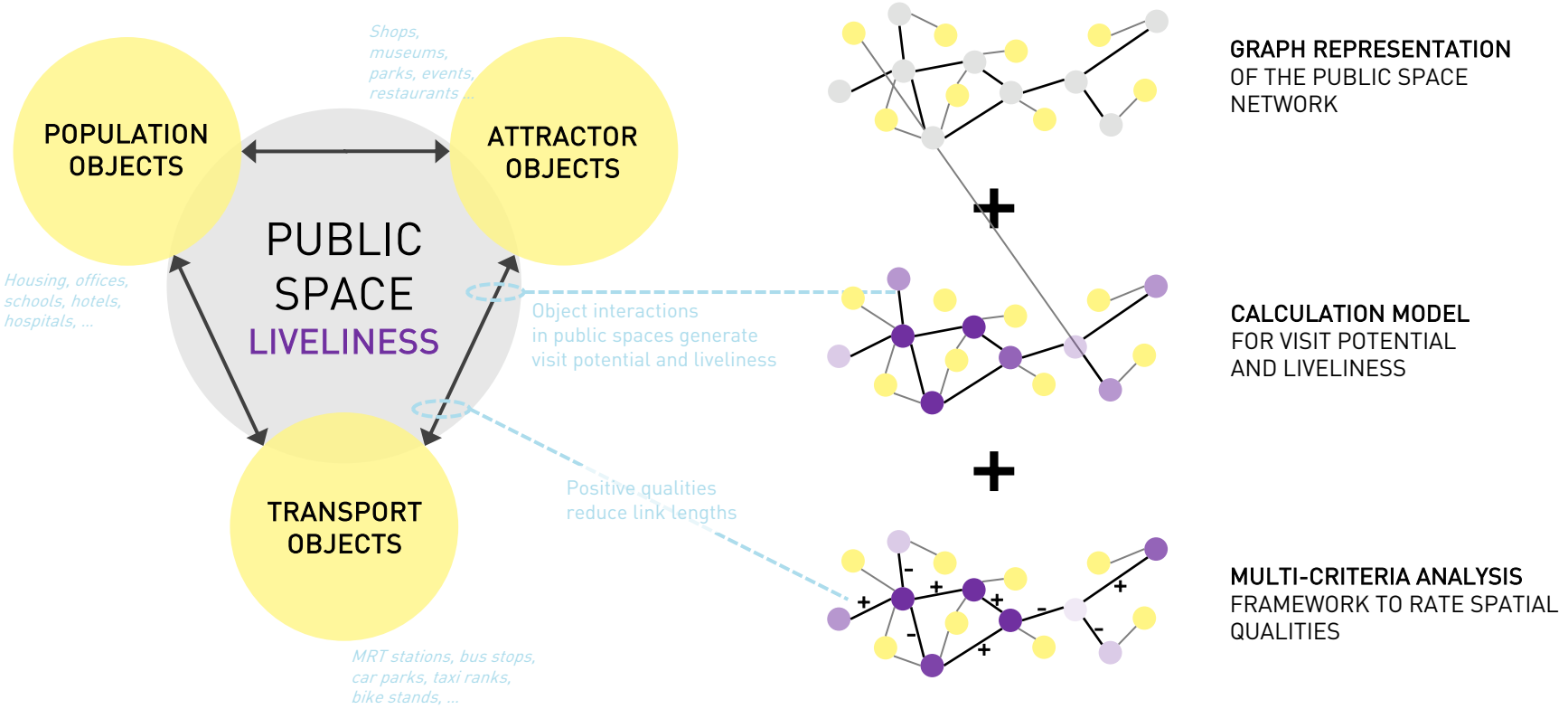
PEOPLE'S PRESENCE CHANGES THROUGH TIME

Within one hour of the day,
the number of people outside of their building
is a percentage of the maximum capacity.

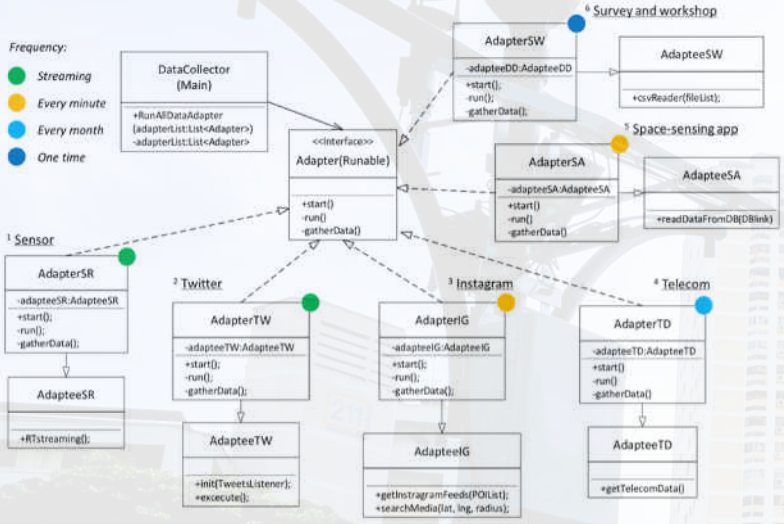
This distribution is different for different types of buildings.

A weighted graph model calculating

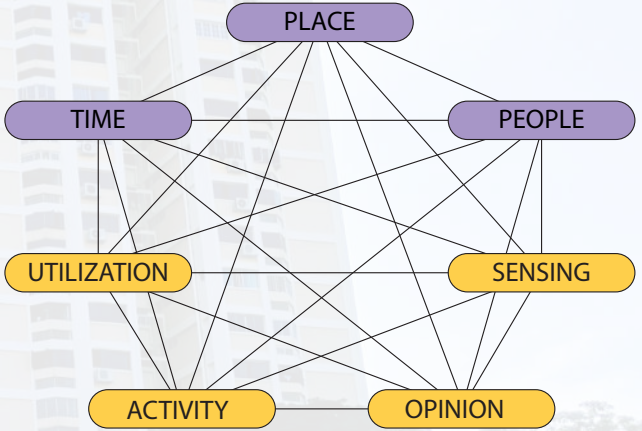
interactions, proximities, and accessibilities



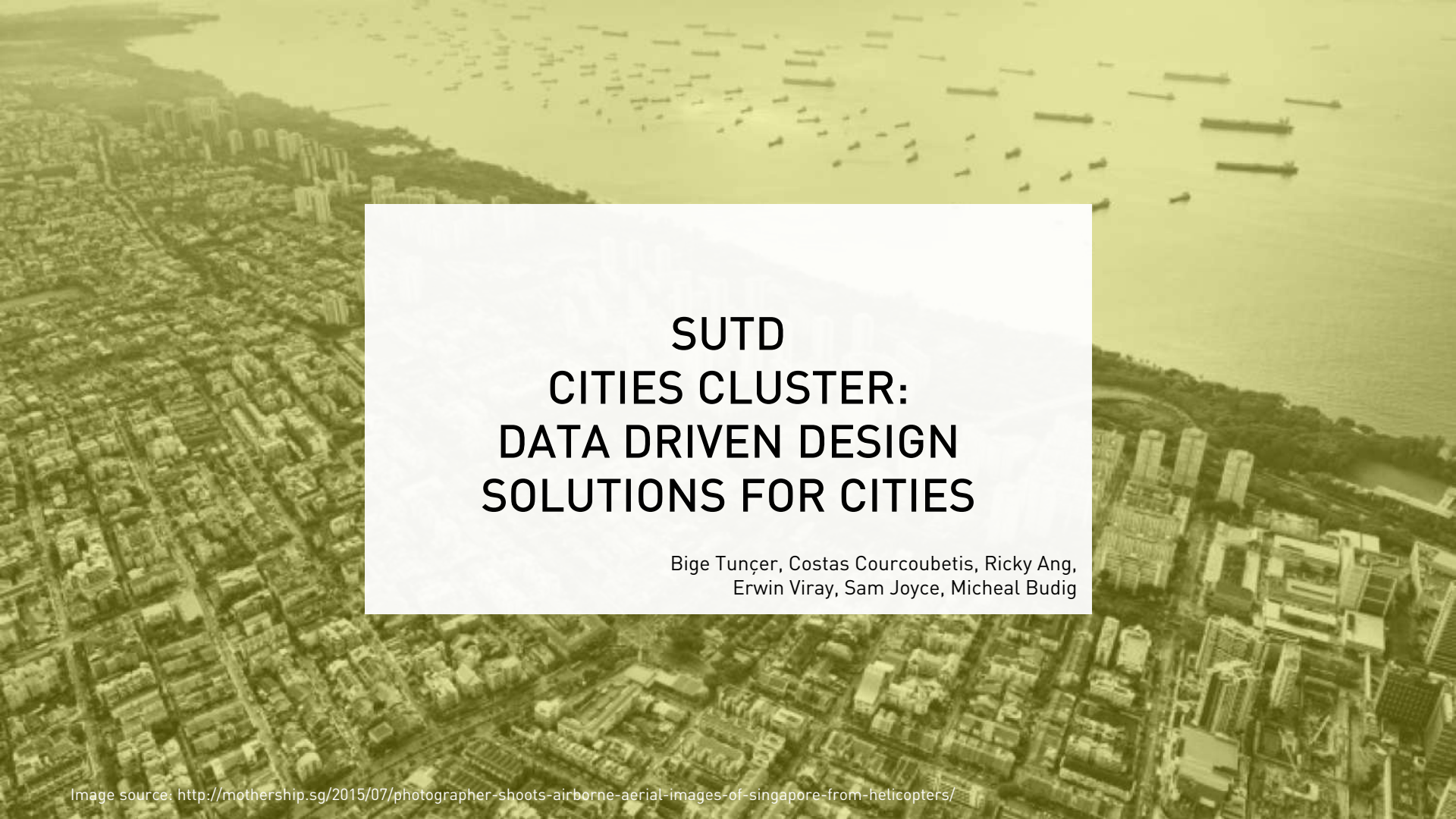
MNDRF SUL Liveable Places project. Data sources overview. Credit: Bige Tuncer & Linlin You, 2016



Informed Design Platform Data Model
Credit: Bige Tuncer, 2016



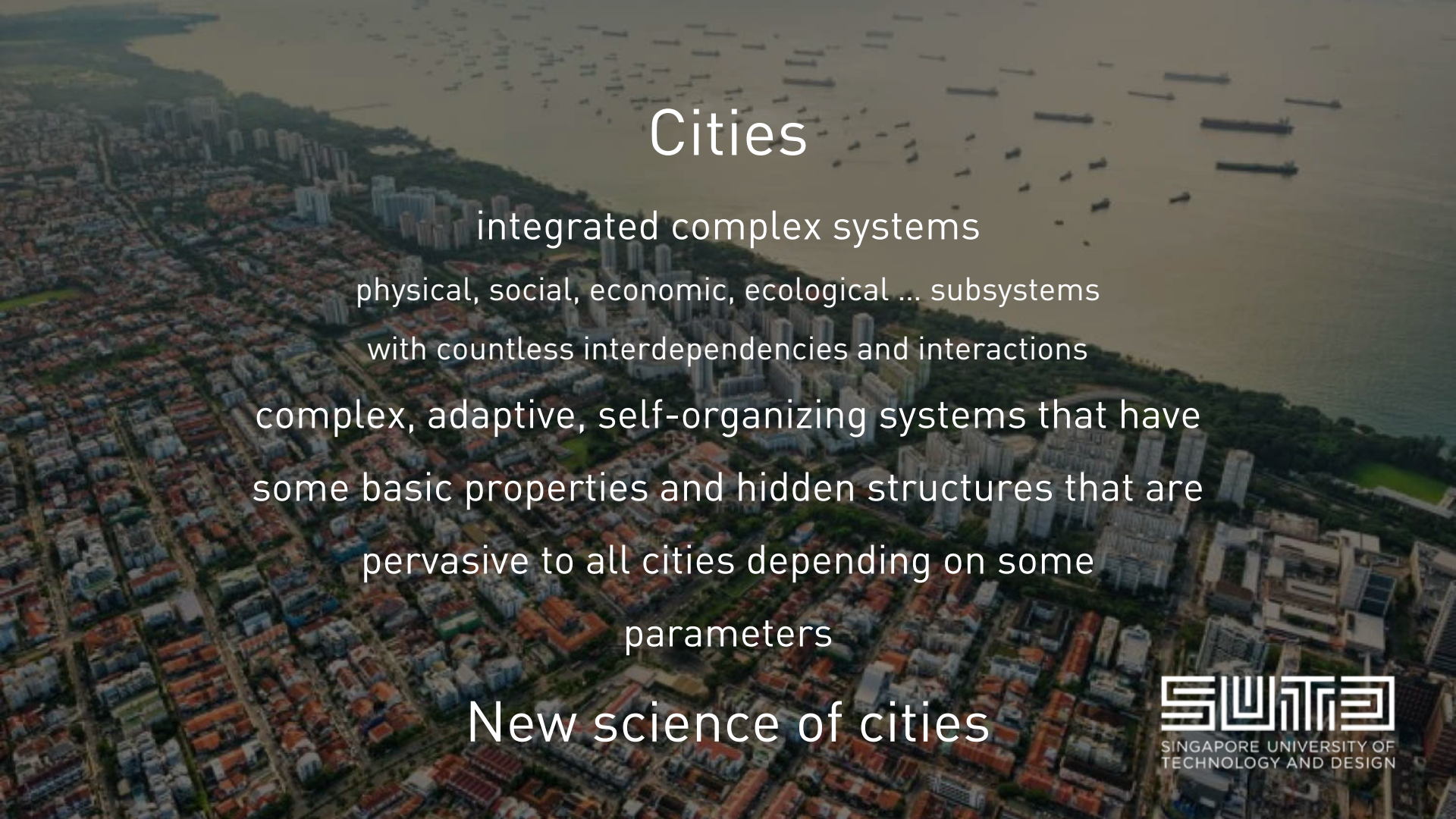
Sensor set-up
Photo: Pieter Herthogs, 2017



SUTD
CITIES CLUSTER:
DATA DRIVEN DESIGN SOLUTIONS FOR CITIES

Bige Tunçer, Costas Courcoubetis, Ricky Ang,
Erwin Viray, Sam Joyce, Micheal Budig

Image source: http://mothership.sg/2015/07/photographer-shoots-airborne-aerial-images-of-singapore-from-helicopters/



Cities

integrated complex systems

physical, social, economic, ecological ... subsystems

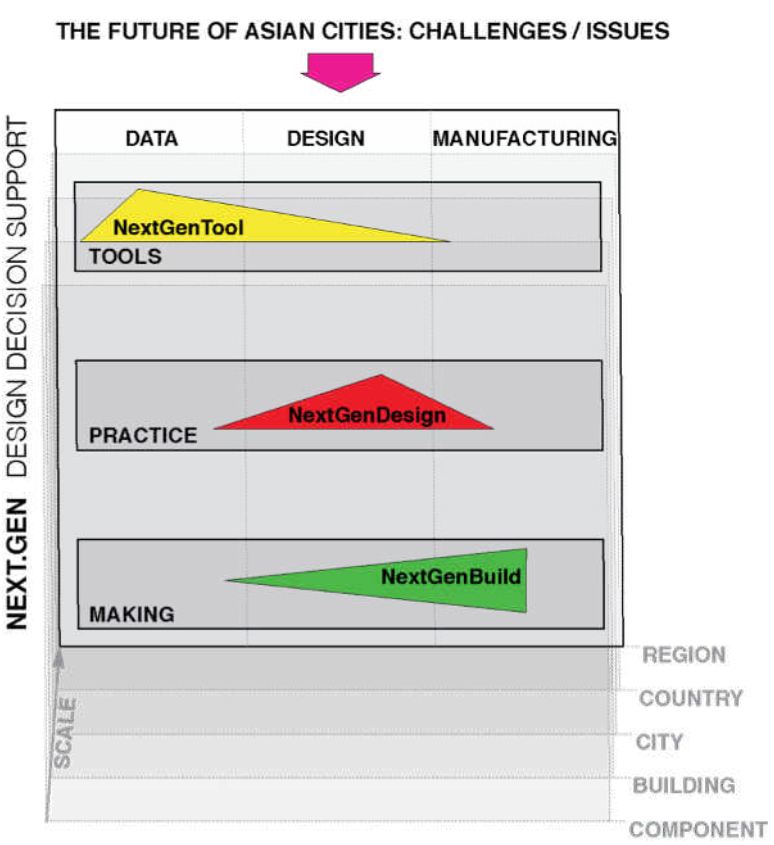
with countless interdependencies and interactions

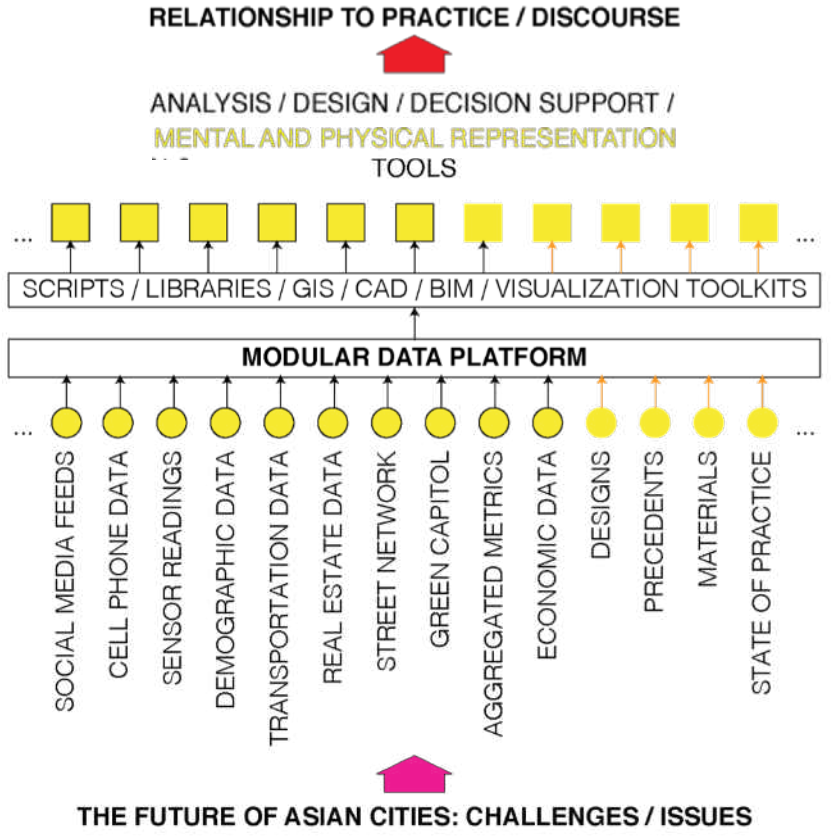
complex, adaptive, self-organizing systems that have some basic properties and hidden structures that are pervasive to all cities depending on some parameters

New science of cities

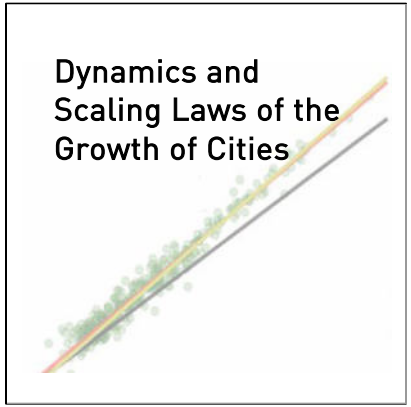
SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN

APPROACH


THE FUTURE OF ASIAN CITIES: CHALLENGES / ISSUES
NEXT.GEN DESIGN DECISION SUPPORT
DATA
DESIGN
MANUFACTURING
NextGenTool
TOOLS
PRACTICE
NextGenDesign
MAKING
NextGenBuild
SCALE
REGION
COUNTRY
CITY
BUILDING
COMPONENT


RELATIONSHIP TO PRACTICE / DISCOURSE
ANALYSIS / DESIGN / DECISION SUPPORT /
MENTAL AND PHYSICAL REPRESENTATION
TOOLS
SCRIPTS / LIBRARIES / GIS / CAD / BIM / VISUALIZATION TOOLKITS
MODULAR DATA PLATFORM
SOCIAL MEDIA FEEDS
CELL PHONE DATA
SENSOR READINGS
DEMOGRAPHIC DATA
TRANSPORTATION DATA
REAL ESTATE DATA
STREET NETWORK
GREEN CAPITOL
AGGREGATED METRICS
ECONOMIC DATA
DESIGNS
PRECEDENTS
MATERIALS
STATE OF PRACTICE
THE FUTURE OF ASIAN CITIES: CHALLENGES / ISSUES

RESEARCH



Agencies

Companies

EDUCATION

SUTD as a regional hub for “CITIES”

A global educational network that generates interaction, exchange, and collaboration

Nurture technically grounded leaders ready to operate in ASEAN+

Changi AeroCity Implementation Testbed Site and Competition

Parallel and joint multidisciplinary studios and workshops

Overseas field trips to ASEAN countries for students

Workshop and seminar series to support these educational components

Courses in SUTD Academy

Undergraduate Research program

SOME LIMITATIONS

Data collected may not represent all users of spaces

Evidence and insights derived shed light on only a subset of design parameters that are important for design

Data privacy concerns

SOME CONCLUSIONS

Deep understanding of both real and perceived utilization and appreciation of existing public spaces

Starting to relate these to physical attributes of places

Developing the methodology and technical infrastructure for this

Ongoing work

INFORMED DESIGN LAB


Bige Tunçer


Hexu Xin


Pieter Herthogs


Francisco Benita


Ramanathan Subramanian


Peijun He


Francesco Scandola


Kajol Sethia


Özgün Balaban


Garvit Bansal


Alexandria Chong (Zhou Wen)


Ludovica Tomarchio


Darshan Virupaksha


Iting Chuang


Stéphanie Hasler (EPFL)


Sarah Nadiawandi


Sumbul Khan


Iman Abu Hashish (U. Pavia)

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SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN

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