

# GEO3D



## A SMARTHUB JOURNEY

Analysing Smart Cities & Big Data in 3D



# About SmartHub

A STARTUP WITHIN STARHUB SINCE 2012

## BIG DATA PRODUCT DEVELOPER

Leveraging on StarHub's rich datasets, Machine Learning, and Deep Learning to create consumable products for end-users



DeepSense

LifeSphere

## DRIVER OF CONTINUOUS INNOVATION

Delivering first-of-its-kind projects across commercial and government sectors

Vector-borne  
Disease Transmission

Crowd Mobility

Real-time Geo-fenced  
Public Address System

Transport  
Competitive  
Intelligence

# Geolocation Data

## Makes These Possible

Vector-borne  
Disease Transmission

Crowd Mobility

Real-time Geo-fenced  
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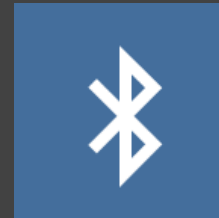
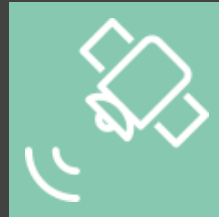
# Fragmented Ecosystem of Geolocation

## INDOORS IS A CHALLENGE

### GPS



Line-of-sight to satellites  
Worldwide range (outdoors)  
Requires active app



### WIFI

Proximity to routers  
Short-range (indoors)  
Requires active app

### BLUETOOTH

Proximity to beacons  
Very short-range (indoors)  
Requires active app

### LED LIGHTING



Camera sensing of LED flashes  
Very short-range (indoors)  
Requires active app

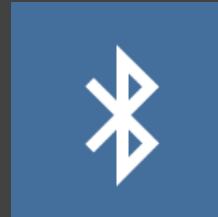
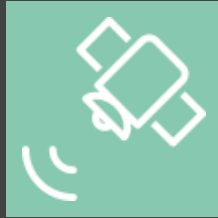
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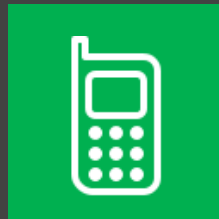
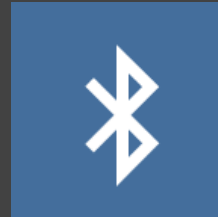
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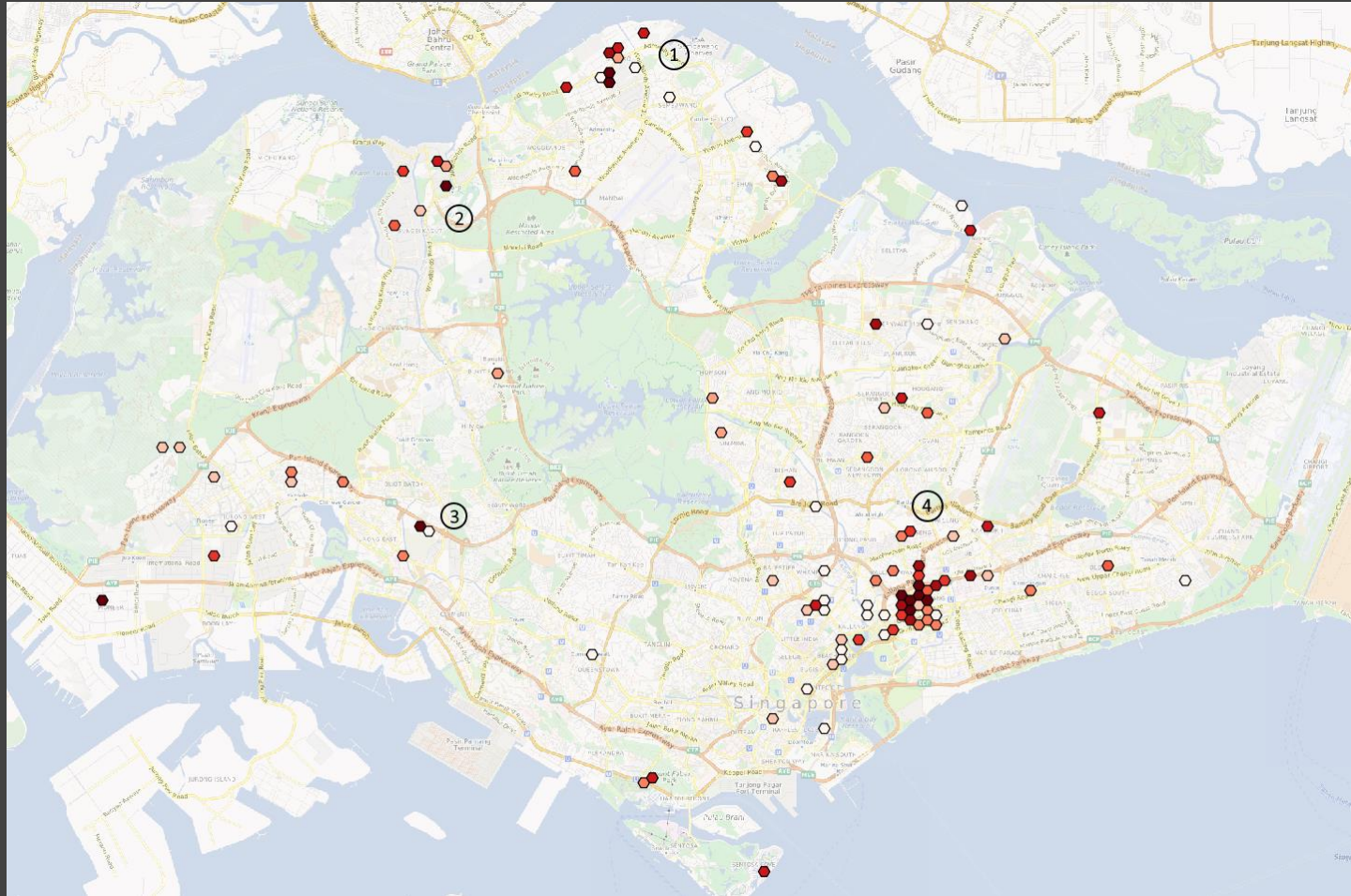
Camera sensing of LED flashes  
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### MOBILE

**Nationwide** range (indoors / outdoors)  
Works **passively**

# Vector-borne Disease Transmission

## GEOLOCATION USE CASE



*Above: 4 potential Zika hotspots based on construction workers' dwell points (night)*

## HOTSPOTS IDENTIFICATION

Dwelling points with the potentially highest risk of Zika transmission

## PEOPLE'S MOVEMENT

Understanding movement dynamics in areas with persistent Zika transmission

Optimize public cleanliness  
Optimize public health operations

# Crowd Mobility

## GEOLOCATION USE CASE



## MOBILITY PATTERNS

Includes bus, MRT, driving, walking  
Travel times per route  
Crowd levels per route

## ORIGIN-DESTINATION

Find where are the popular origins or destinations for segments  
e.g. Professionals: offices  
e.g. Tourists: hotels, attractions

Optimize transport resources  
Predict effects of route diversions



# 2D Geospatial Models!

BUT WHAT DO CITIES ACTUALLY LOOK LIKE?

# Cities are **Vertical** Concrete Jungles

TOKYO, JAPAN



# GEO 3D

THE NEXT DIMENSION OF GEOLOCATION

**Sneak Peek**

# GEO 3D

THE NEXT DIMENSION OF GEOLOCATION

A Joint Research Collaboration Between





# Network Optimisation

THE QUEST FOR BETTER 3G, LTE PHONE SERVICE!



## GOALS

- To ensure full network coverage per floor
- To ensure sufficient network capacity for occupants
- To avoid interference between small cells

## CONSIDERATIONS

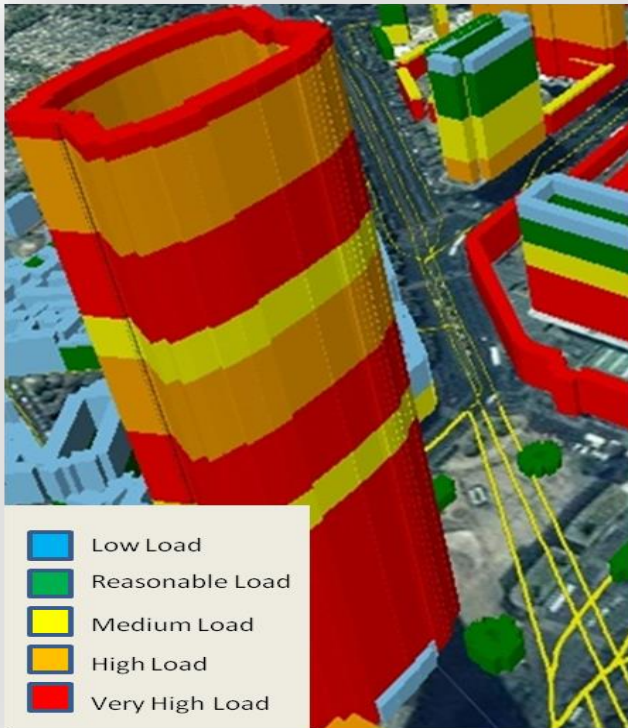
- To strike a balance between cost vs. coverage
- How many small cells are needed?
- Where are the best locations to place each cell?



# 3D Geolocation – Best in Class Event Detection Accuracy

NOKIA

70%-80% of the traffic is in-building



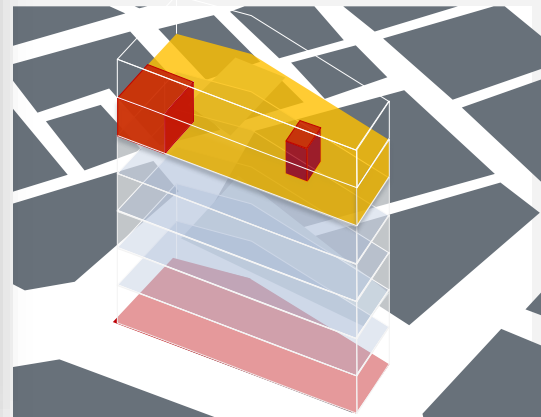
3D model locates events at different heights in-building and outdoor

3D vision of real traffic with outdoor vs indoor traffic and height with massive geolocation brings unparalleled opportunities

Best in class accuracy - horizontally and vertically

Drill down from network map to any single event /call

Continuous 3D geolocation monitoring



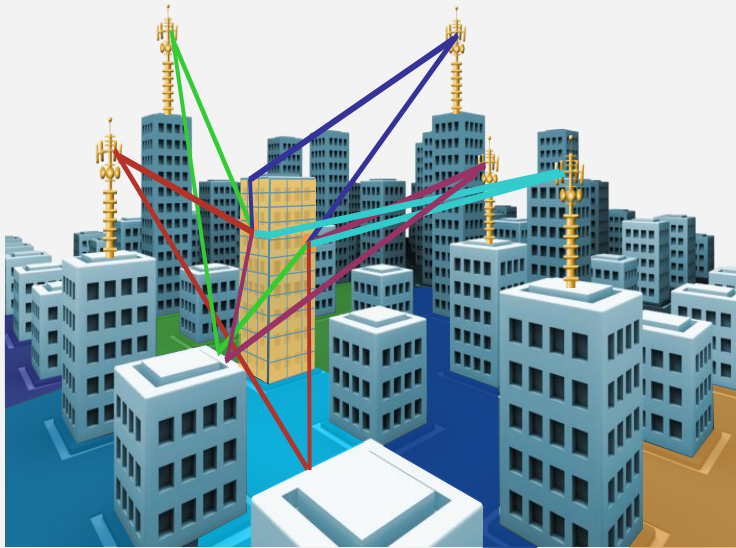
3D RSS Fingerprint & Adaptive Learning Algorithm for Geolocation

3D hotspot location for:

- Crowd Sourcing
- Traffic Monitoring
- Network Planning for superior End User Experience
- Enabling new business model and revenue (Telecom Data as a service)

# 3D RSS Fingerprinting & Adaptive Learning Algorithm for Geolocation

1



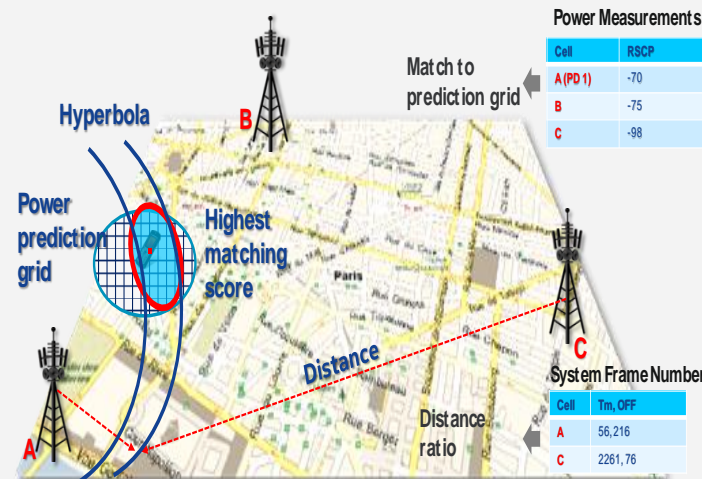
## Ray Tracing

- Receive Strength Signal
  - Transmitter power
  - Antenna gain
  - Path loss
- Free Space
- Fresnel Zone
- Multiple Knife Edge
- Proprietary prediction model: HEX3D B

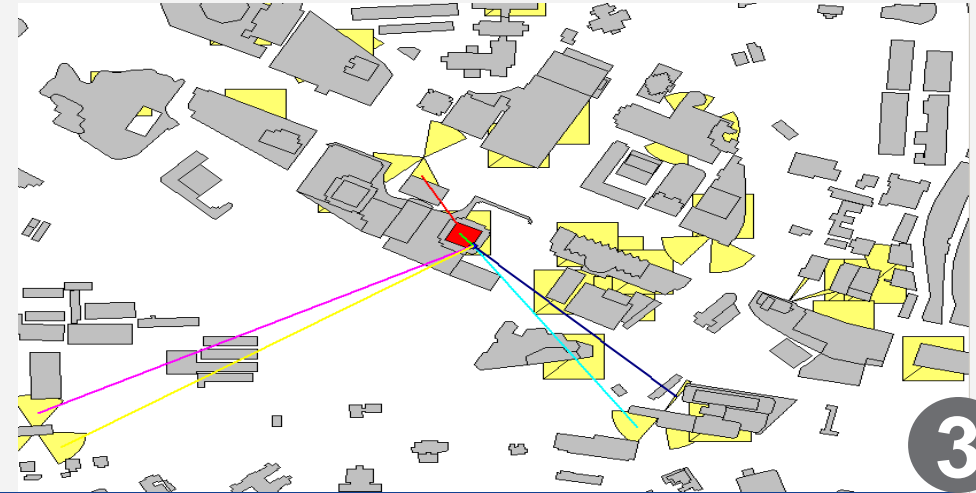
2

## 3D Geolocation

- Create 3D prediction grid
- For each MR
  - Calculate zone boundaries from TA derived distance using geometry
  - Calculate matching factor to 3D prediction grid
- Adaptive learning algorithm selects exact location



3



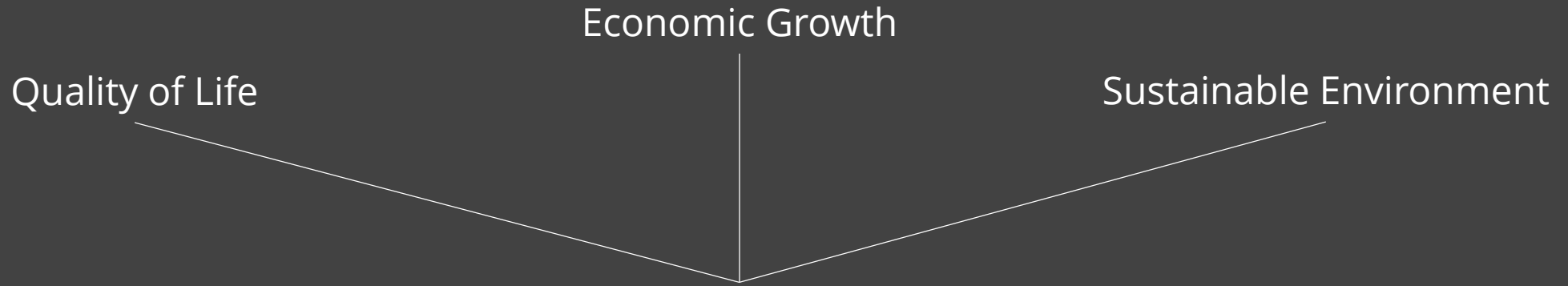
## In-Building density maps

- Locate multiple MR and events for each call
- Observe speed and cell changes during the call
- Trace to building and calculate event density
  - Set performance threshold ( e.g. EcNo -14 dB)
  - Extract number and proportion of samples above and below threshold
- Produce performance density maps



# New Opportunities For Smart Cities

WITH FLOOR-BY-FLOOR GEOLOCATION



# New Opportunities For Smart Cities

WITH FLOOR-BY-FLOOR GEOLOCATION

**Public Safety**

Quality of Life

Economic Growth

Sustainable Environment

# New Opportunities For Smart Cities

WITH FLOOR-BY-FLOOR GEOLOCATION



# Public Safety

Real-time Situation Monitoring

# Public Safety

## IN SMART CITIES



### POLICE

Theft  
Housebreaking  
Crimes against persons

### PARAMEDIC

Medical emergencies  
Road traffic accidents  
Industrial accidents

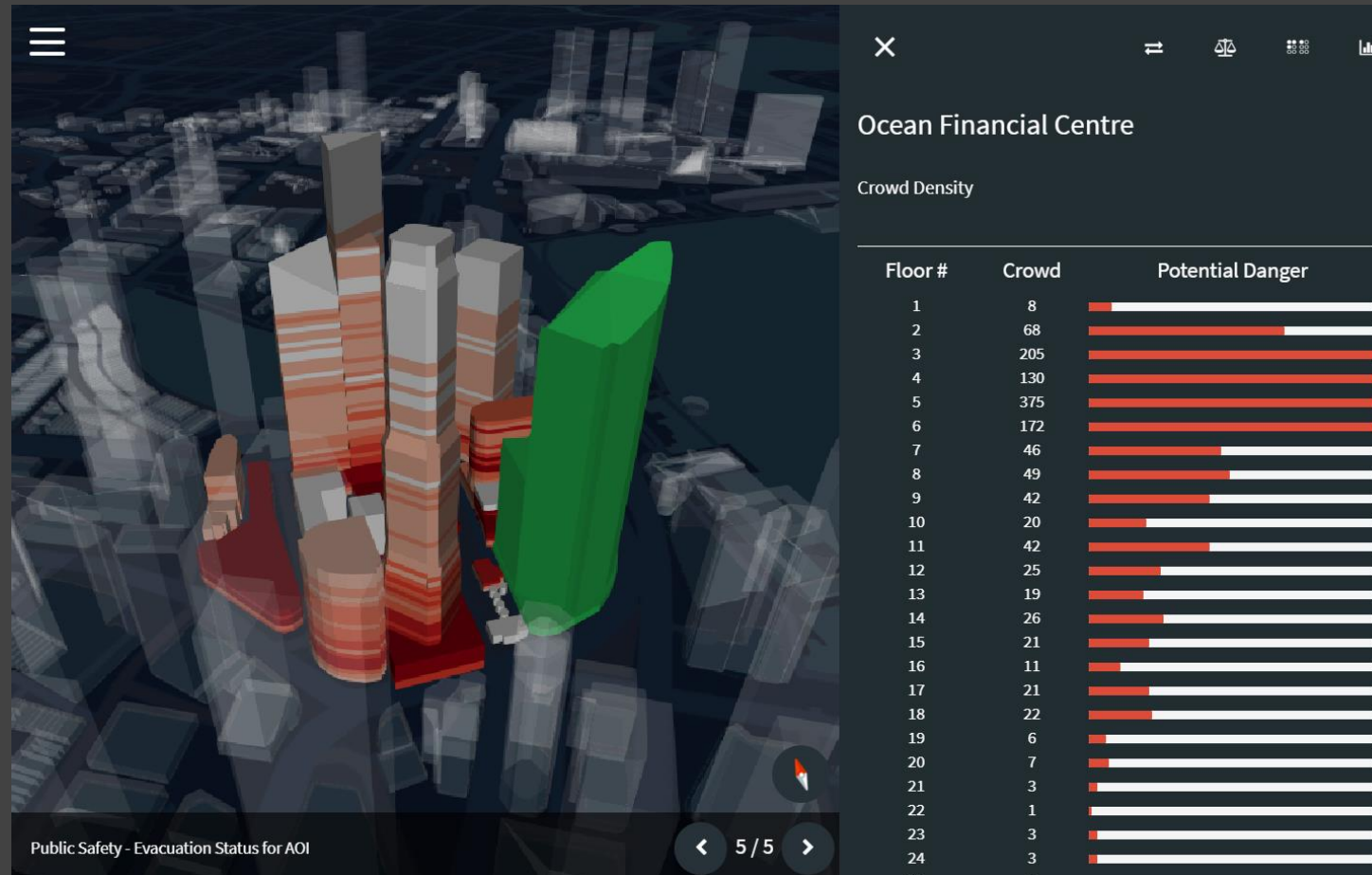
### FIRE & RESCUE

Residential fires  
Commercial fires  
Industrial fires



# Public Safety

IN SMART CITIES



## SITUATIONAL AWARENESS

In near-real time

Per floor, per building

## ACCESSIBLE ON-THE-GO

Mobile and web ready

View from a command centre

View from a mobile device

Optimize deployment of  
emergency services personnel

**Public Safety**

Quality of Life

Economic Growth

Sustainable Environment

# New Opportunities For Smart Cities

WITH FLOOR-BY-FLOOR GEOLOCATION

## Pulse of the Economy

Economic Growth

Public Safety

Quality of Life

Sustainable Environment

# New Opportunities For Smart Cities

WITH FLOOR-BY-FLOOR GEOLOCATION





# Pulse of the Economy

With Near Real-time Indicators

# Pulse of the Economy

INSPIRED BY A GOVTECH INITIATIVE

“The use of high-frequency big data ...  
to develop new indicators for better  
economic and urban planning”

- GovTech Singapore, 7<sup>th</sup> Oct 2016



# Pulse of the Economy

INSPIRED BY A GOVTECH INITIATIVE

“The use of high-frequency big data ...  
to develop new indicators for better  
economic and urban planning”

Electricity consumption

Public transport

Online job listings

- GovTech Singapore, 7<sup>th</sup> Oct 2016



# Measuring a City's **Economic Growth**

## CLUES & SIGNALS

### TRADITIONAL INDICATORS

After-the-fact, occasional statistical reports

Gross Domestic Product (GDP)

Employment Rate

Consumer Price Index

Broadband Penetration

...

● "Are people earning / spending more?"

● "Is there inflation?"

● "Is the city's infrastructure sufficient?"

# Measuring a City's **Economic Growth**

## CLUES & SIGNALS

### GEO 3D INDICATORS

Near real-time, behavioural analysis

"How's the demand for healthcare services?"



Healthcare Visit Model

"Are businesses in this part of the city productive?"



Business Productivity Model

"How are different industries interacting with one another?"



Industry Network Model

# Measuring a City's **Economic Growth**

## CLUES & SIGNALS

### GEO 3D INDICATORS

Near real-time, behavioural analysis

“How’s the demand for healthcare services?”



Healthcare Visit Model

Examine healthcare facilities (e.g. hospitals)

Gather frequency of visits to these facilities by floor

Contextualize the intent of visits to these floors

Examine historical trend of visits

Aggregate and estimate demand for healthcare services

# Measuring a City's **Economic Growth**

## CLUES & SIGNALS

### GEO 3D INDICATORS

Near real-time, behavioural analysis

“Are businesses in this part of the city productive?”



Business Productivity Model

Examine buildings with different businesses per floor

Gather frequency of visits to these floors during working hours

Examine historical trend of visits

Compare against building occupancy and business directories

Aggregate and estimate manpower of businesses in this part of the city

# Measuring a City's **Economic Growth**

## CLUES & SIGNALS

### GEO 3D INDICATORS

Near real-time, behavioural analysis

“How are different industries interacting with one another?”



Industry Network Model

Examine buildings with different businesses per floor

Gather frequency of visits to these floors during working hours

Differentiate between employees / visitors via historical trends

Examine visits by employees to other businesses during office hours

Aggregate and infer links between industries



# Measuring a City's **Economic Growth**

## CLUES & SIGNALS

### GEO 3D INDICATORS

Near real-time, behavioural analysis

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Industry Network Model

## Pulse of the Economy

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Economic Growth

Public Safety

Quality of Life

Sustainable Environment

# New Opportunities For Smart Cities

WITH FLOOR-BY-FLOOR GEOLOCATION

**Pulse of the Economy**

Economic Growth

**Public Safety**

Quality of Life

Sustainable Environment

# New Opportunities For Smart Cities

WITH FLOOR-BY-FLOOR GEOLOCATION

**Insights in the Palm of Your Hand**

# Goals for Visualization

## GEO3D IN A DASHBOARD

### SCALABLE

Usable in a command centre

Usable on the street

### LOW LATENCY

Rapid dissemination of insights

Optimized for near real-time

### MODULAR

Interchangeable 2D / 3D map vis.

Easy to add-on other visualizations

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**OpenStreetMap**

Raw base maps  
Building heights



Post-process 3D Models  
UV Mapping



**CESIUM**

WebGL Layer  
Map Projection in 3D  
Position 3D models

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● **Custom 3D Tiles**

● **Custom Texturing**

● **Custom Shaders**

# Custom 3D Tiles

## PERFORMANCE OPTIMIZATIONS



### Nationwide Tiling

~ 50 buildings per tile

One mesh per tile

One draw call per tile

Fade in/out over distance

Scalable across the country whilst maintaining a **smooth frame rate**

# Custom Textures

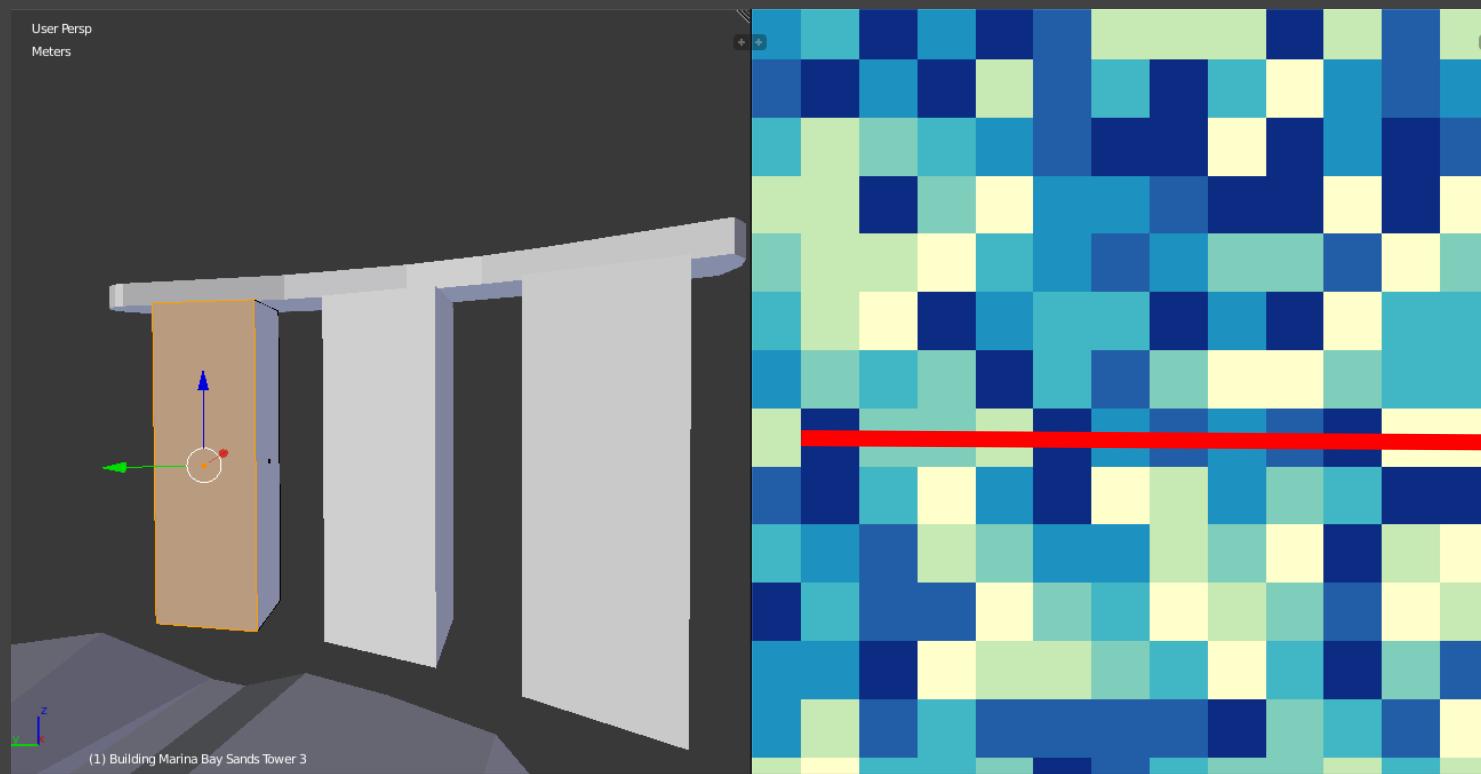
## PARALLELIZING VISUALS

### Scalable

~2500 buildings

10000+ floors

Rendered in parallel

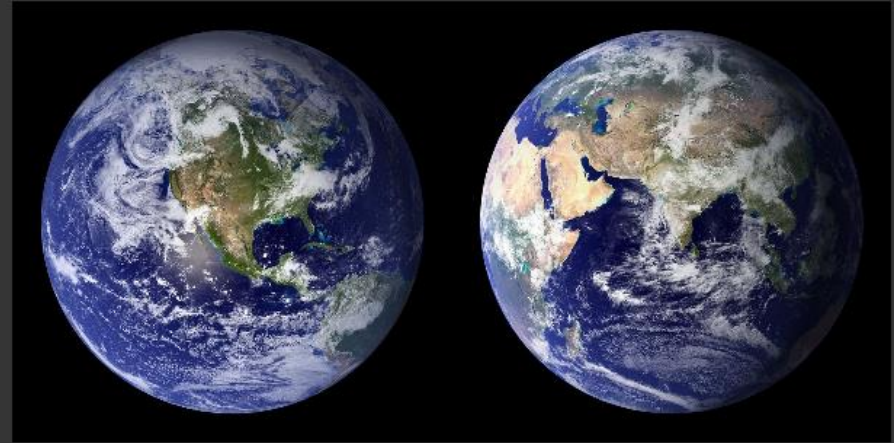
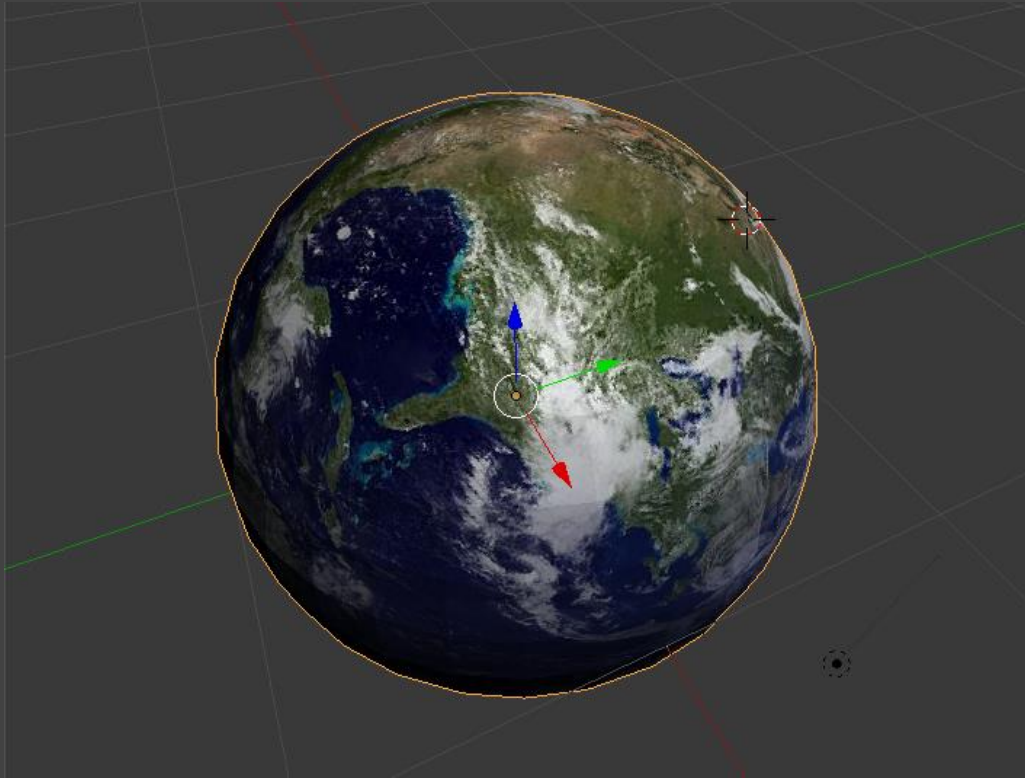


**One pixel** per floor via UV Mapping



# Texturing a Model

TRY THIS IN BLENDER

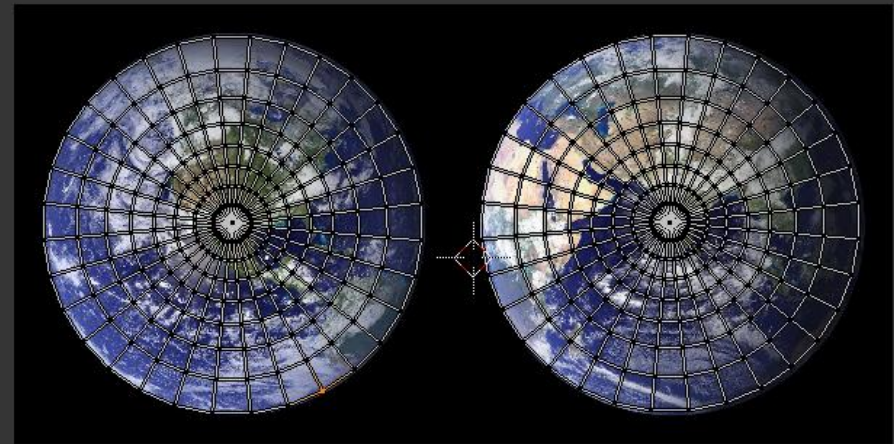
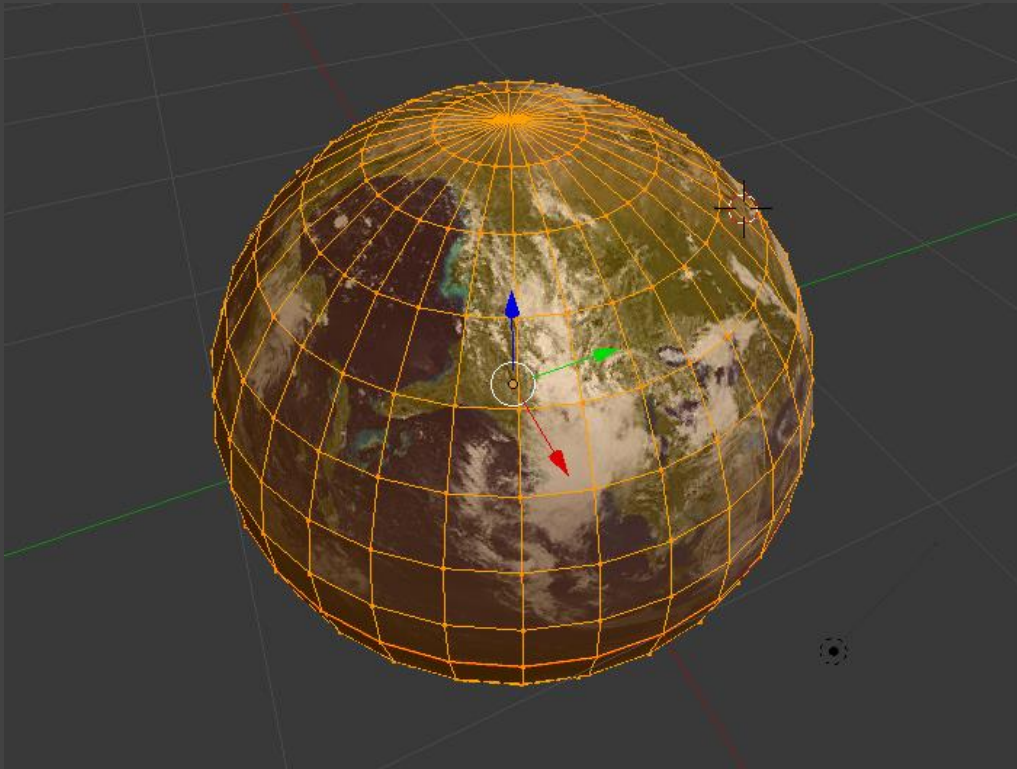


## UV Mapping

Mapping each vertex to a normalised coordinate on a texture

# Texturing a Model

TRY THIS IN BLENDER



## UV Mapping

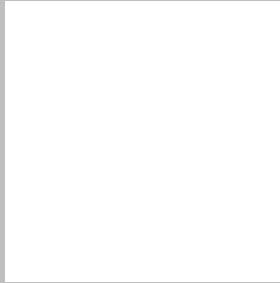
Mapping each vertex to a normalised coordinate on a texture

# Custom Shaders

## TRANSITIONING BETWEEN TEXTURES

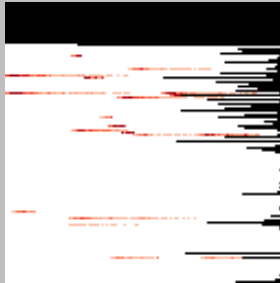
### Texture 1:

Current timestamp



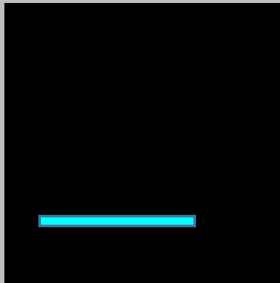
### Texture 2:

Next timestamp



### Texture 3:

Highlighted Building / Floor



# Custom Shaders

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### Texture 1:

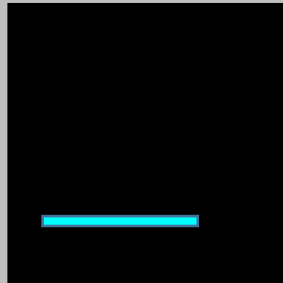
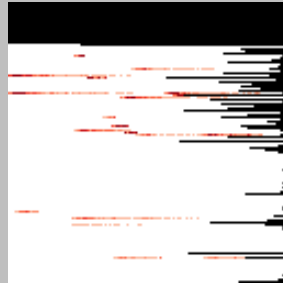
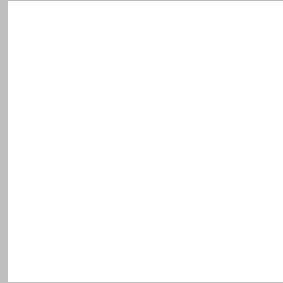
Current timestamp

### Texture 2:

Next timestamp

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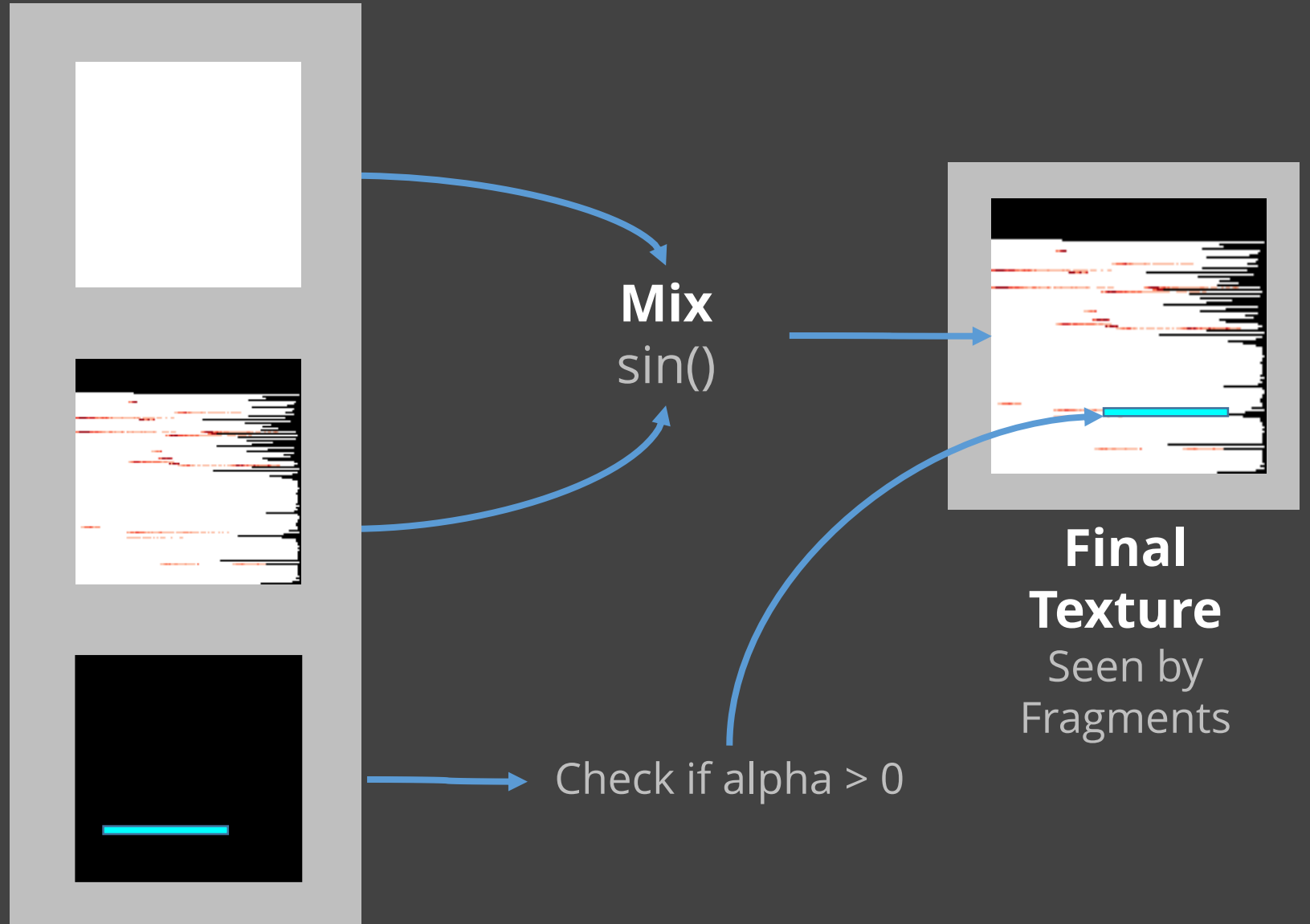
**Mix**  
sin()

Check if alpha > 0

# Custom Shaders

## TRANSITIONING BETWEEN TEXTURES

- Texture 1:**  
Current timestamp
- Texture 2:**  
Next timestamp
- Texture 3:**  
Highlighted Building / Floor



# In Summary

THREE KEY TAKEAWAYS

# Key Takeaways

## THE FUTURE OF GEOLOCATION FOR SMART CITIES

### GEO3D: A NEW DIMENSION

A big leap in geolocation technology

A research collaboration between StarHub and Nokia



### NEW OPPORTUNITIES

Understand cities like never before

Many exciting use cases incoming

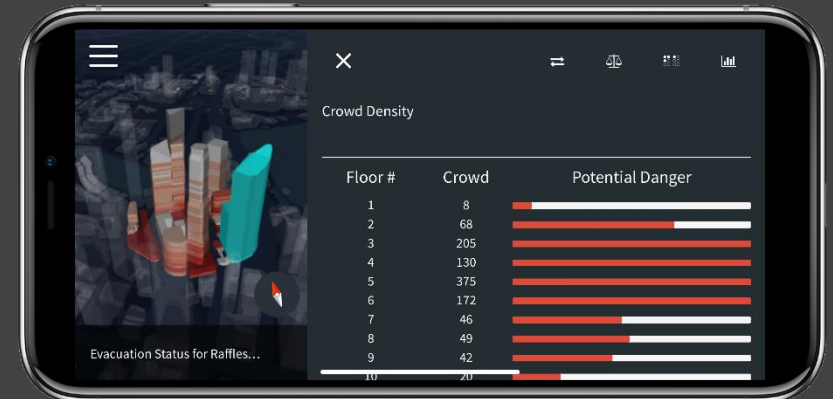
Public Safety

Pulse of the Economy

### INSIGHTS IN THE PALM OF YOUR HAND

Building a scalable 3D engine to serve Geo3D insights

Scale up to command centres or down to phones



# JOIN US IN OUR JOURNEY!

[victor.bh.chua@starhub.com](mailto:victor.bh.chua@starhub.com)

Victor Chua, Senior Data Analyst

