system design &
management

A Smart City Pilot in Boston:

Collecting human-centric urban data

MITsdm

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Introduction

Education

+ MS, Engineering and Management (SDM), MIT
+ MS, Nuclear and Radiological Engineering, University of Florida
+ MS, Physics, Grenoble Institute of Technology (France)

Experience

7-years work experience in the energy sector as a

+ Risk analyst, creating data models to forecast complex systems' failures
+ Product Manager

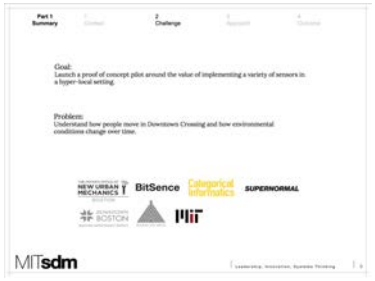
Led product portfolio management for large and medium size companies in the clean energy and radiation protection fields

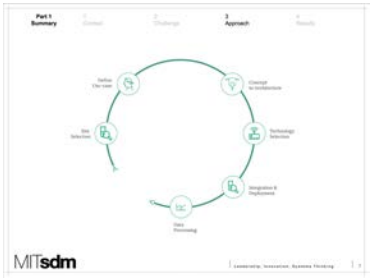
Today's Agenda

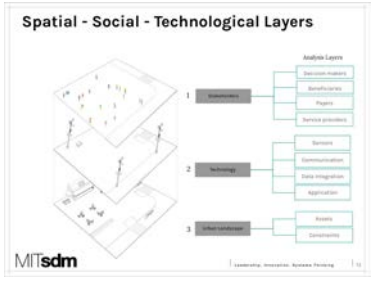
Part 1 - Pilot Description

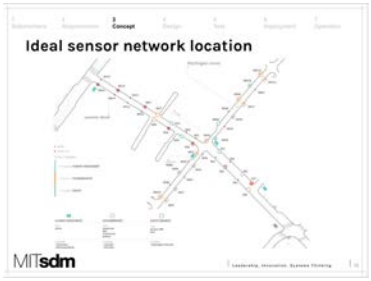
Part 2 - System Architecture

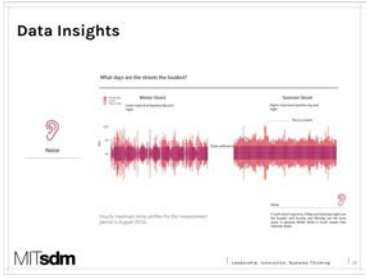
Part 3 - Pilot Data insights

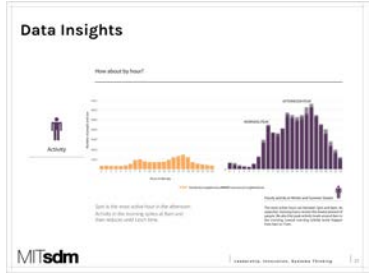


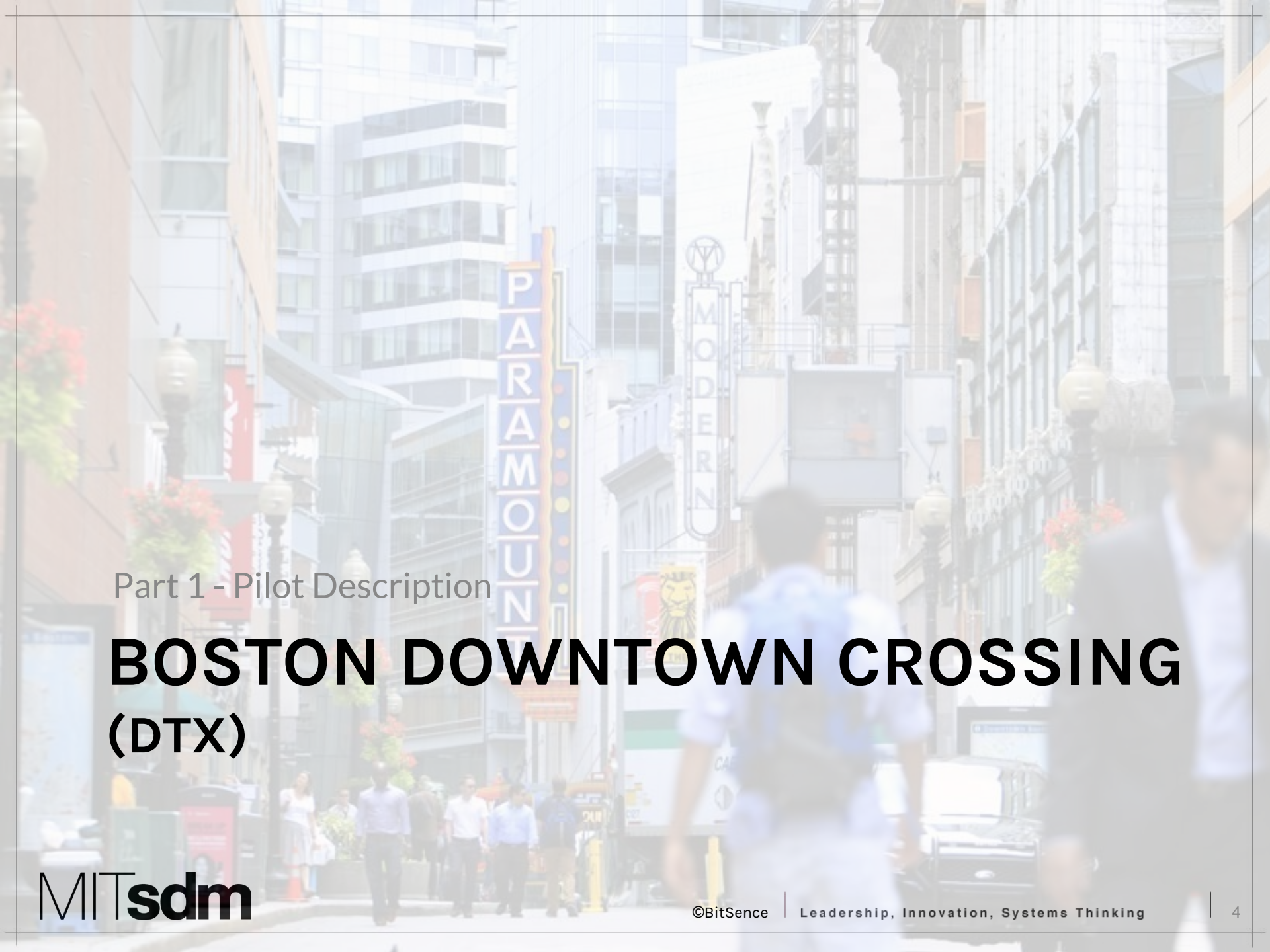












Part 1 - Pilot Description

BOSTON DOWNTOWN CROSSING (DTX)

Most experiments with sensor data have taken place in silos, where one technology was evaluated by itself, or in proprietary settings where data and methods are not shared publicly….

We want to know how sensors designed by multiple researchers/companies that are dispersed throughout an urban environment can better inform urban planning.

– *Steve Walter*
Director, Boston Mayor's Office of New Urban Mechanics

THE MAYOR'S OFFICE OF NEW URBAN MECHANICS BOSTON

What?
A Smart City Pilot to inform urban interventions

Who benefits?
Tech companies, cities and urban planners

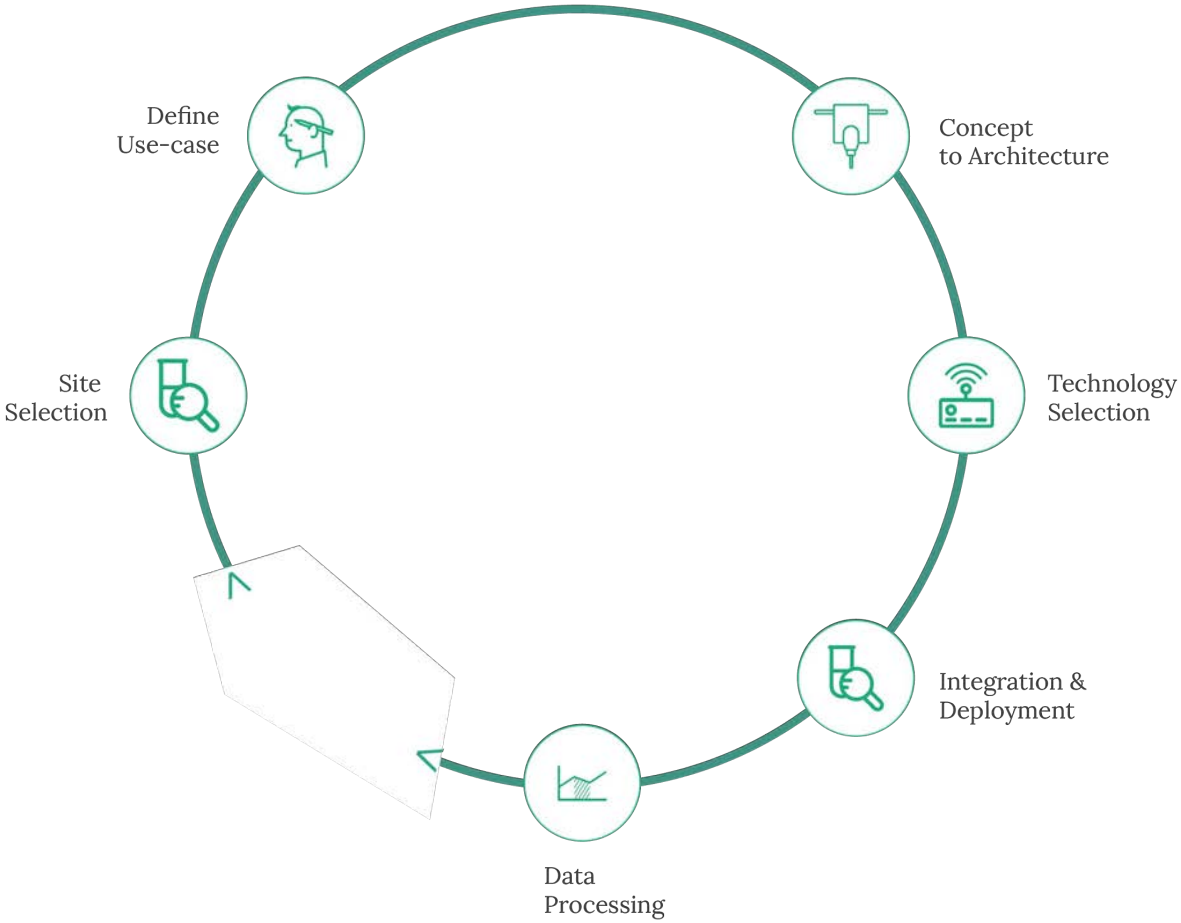
Why?
Blueprint for future IoT pilots and other cities

Goal:

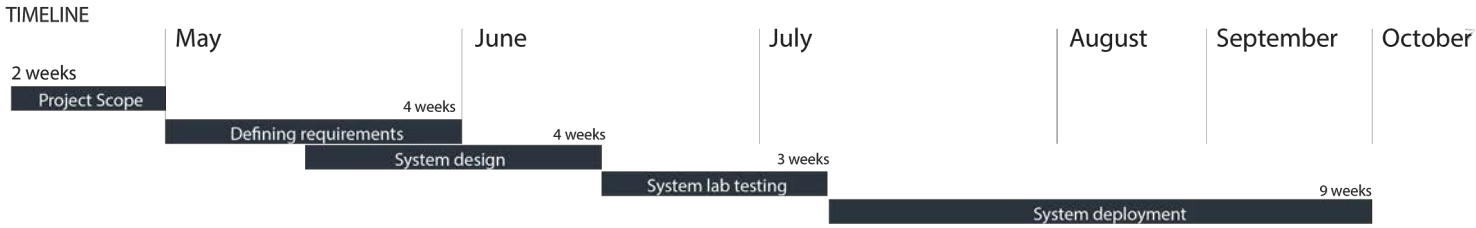
Launch a proof of concept pilot around the value of implementing a variety of sensors in a hyper-local setting.

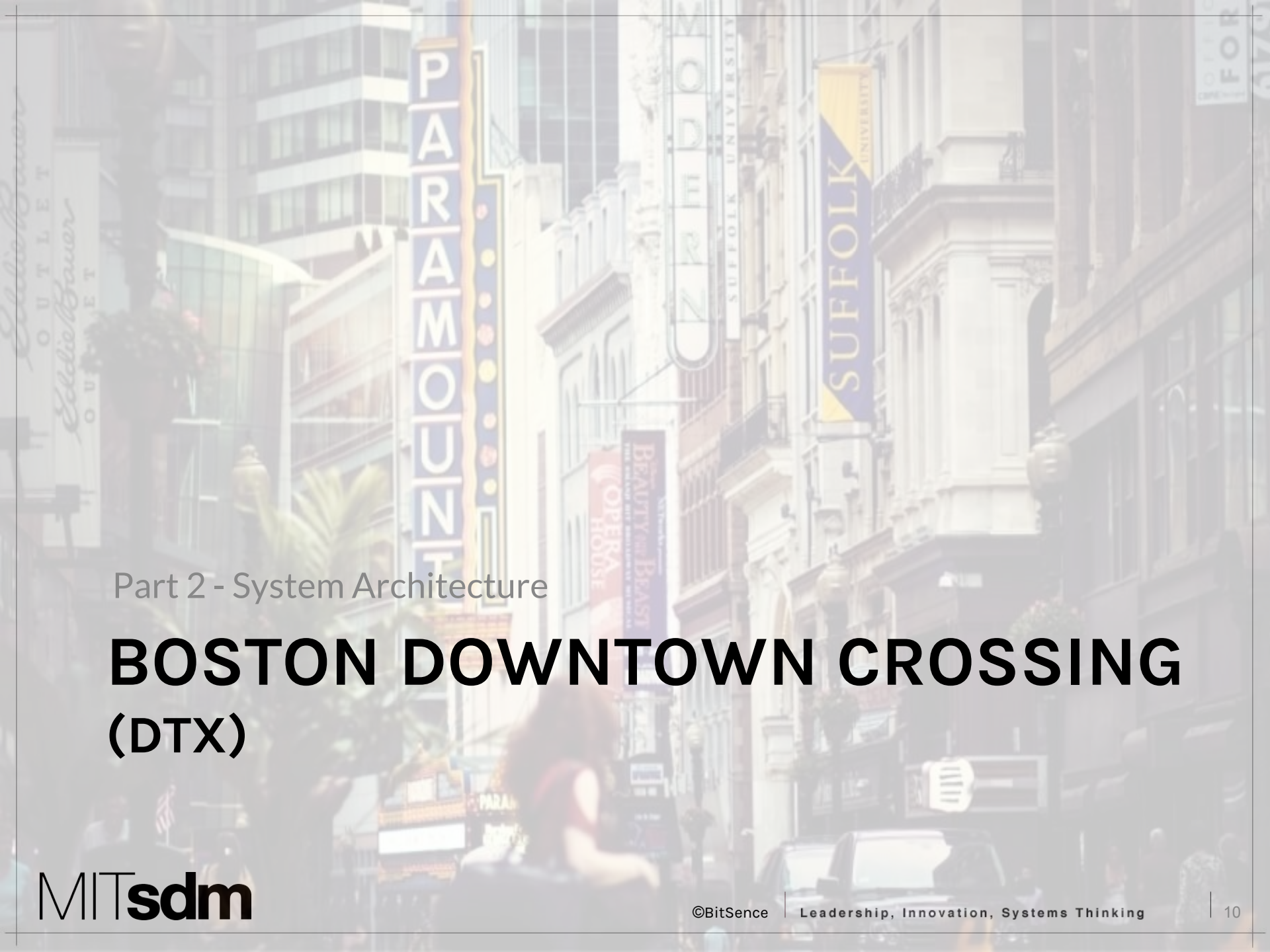
Problem:

Understand how people move in Downtown Crossing and how environmental conditions change over time.


Define
Use-case
Concept
to Architecture
Site
Selection
Technology
Selection
Integration &
Deployment
Data
Processing

Combining factors to gain knowledge on urban conditions

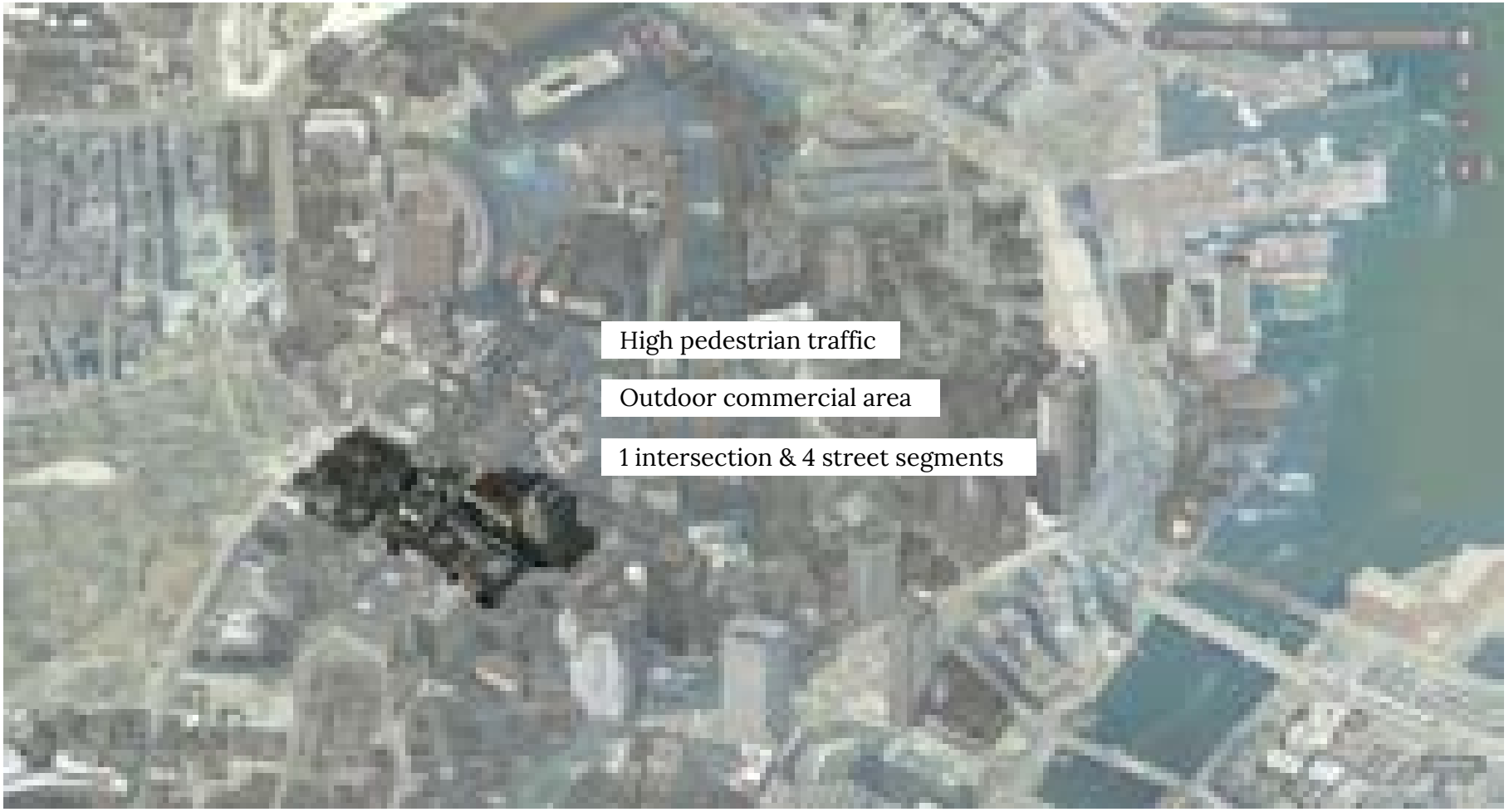




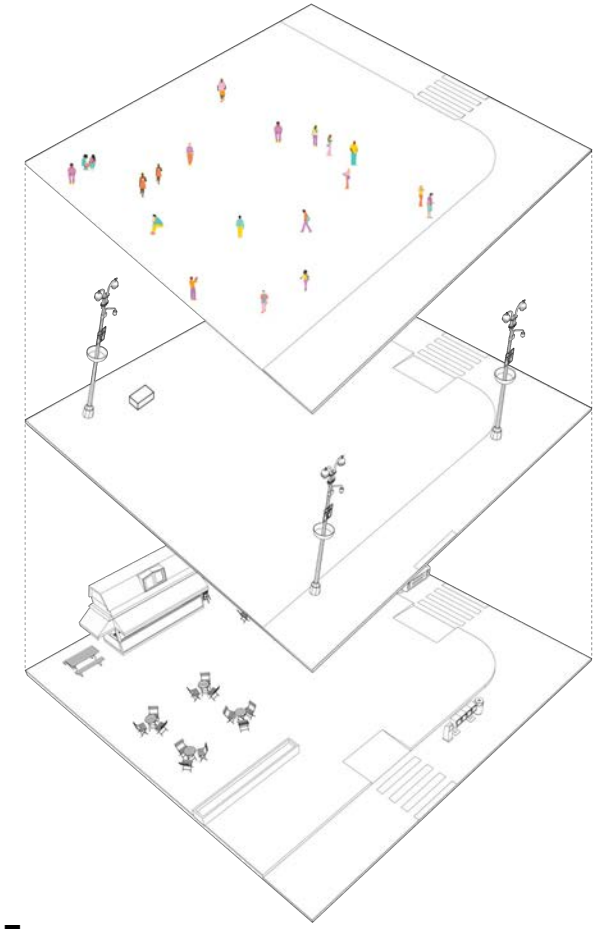
Part 2 - System Architecture

BOSTON DOWNTOWN CROSSING (DTX)

DTX Environment



Spatial - Social - Technological Layers



Analysis Layers

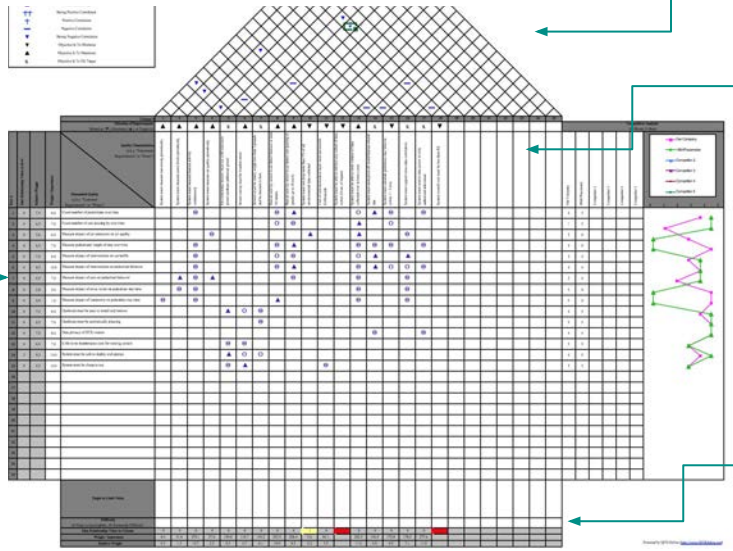
1 Stakeholders
- Decision makers
- Beneficiaries
- Payers
- Service providers

2 Technology
- Sensors
- Communication
- Data Integration
- Application

3 Urban Landscape
- Assets
- Constraints


Stakeholders
Decision makers
Beneficiaries
Payers
Service providers
THE MAYOR'S OFFICE OF NEW URBAN MECHANICS BOSTON
DOWNTOWN BOSTON BUSINESS IMPROVEMENT DISTRICT
BOSTON CIVIC MEDIA
Boston Area Research Initiative
GLOBAL CITY TEAMS CHALLENGE
MIT Sandbox Innovation Fund Program Massachusetts Institute of Technology
amazon web services
Local Government
Urban Planner/Manager
Community Advocacy
Federal Government
Education Institution
Technology Sponsor
Expertise and Hardware

Solution Constraints	No access to local power	No access to wifi network	Uneven natural light exposure	Sensors locations
Solution Priorities	Evaluate urban intervention	Traffic counting	Insights for commercial businesses	Non-invasive structures	Protect user privacy

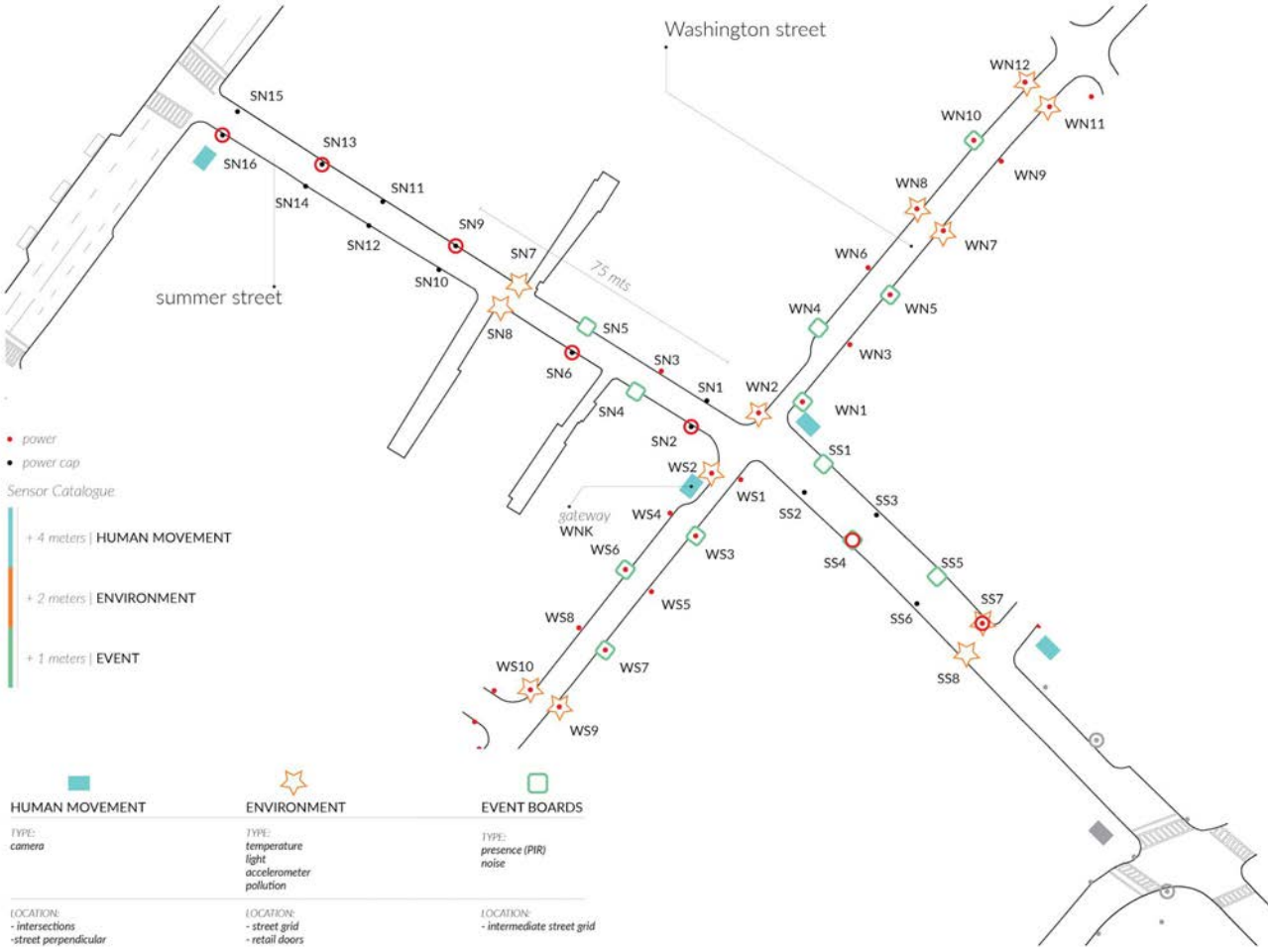


Conflicting Requirements

Functional Requirements

Comparing to existing solutions

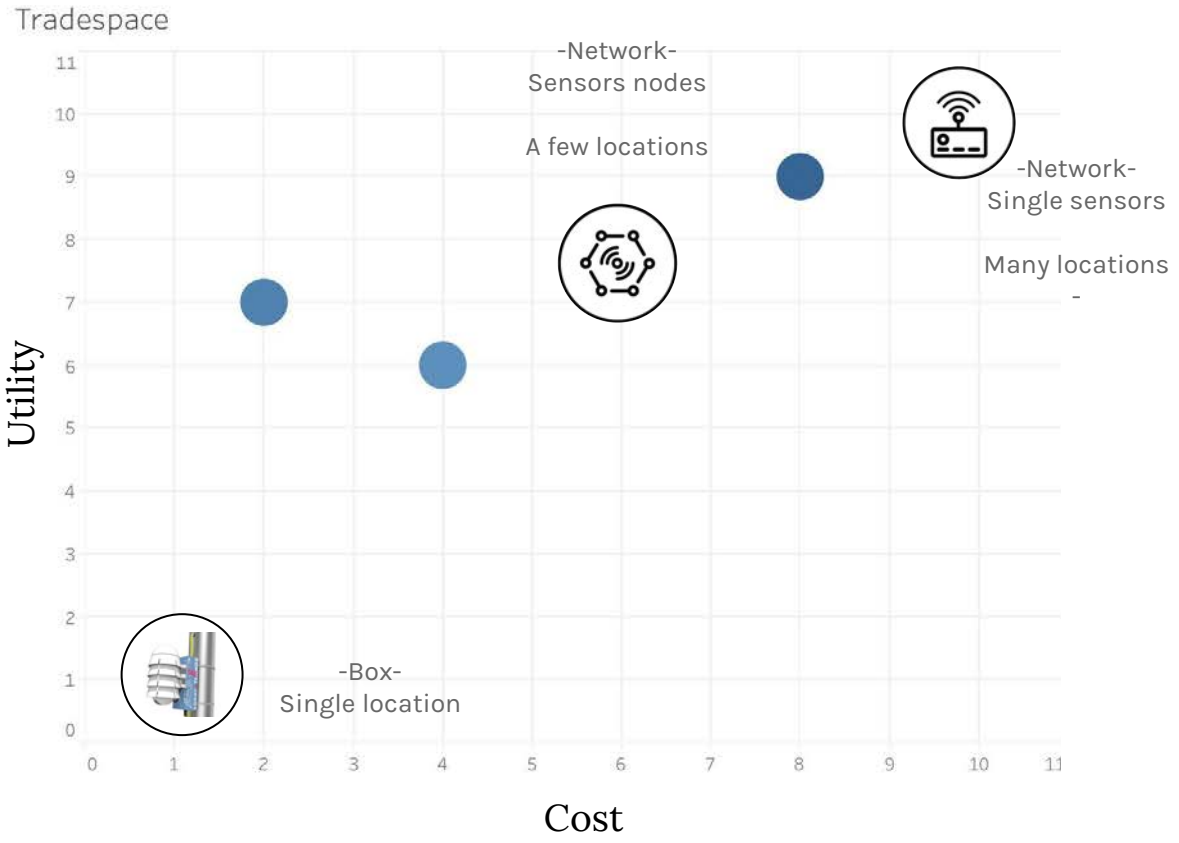
Feasibility & Priority


Washington street
summer street
75 mts
SN15
SN16
SN13
SN14
SN11
SN12
SN9
SN10
SN7
SN8
SN5
SN6
SN3
SN4
SN1
SN2
WN12
WN11
WN10
WN9
WN8
WN7
WN6
WN5
WN4
WN3
WN2
WN1
SS1
SS2
SS3
SS4
SS5
SS6
SS7
SS8
WS1
WS2
WS3
WS4
WS5
WS6
WS7
WS8
WS9
WS10
gateway
WNK
power
power cap
Sensor Catalogue
+ 4 meters | HUMAN MOVEMENT
+ 2 meters | ENVIRONMENT
+ 1 meters | EVENT
HUMAN MOVEMENT
TYPE:
camera
LOCATION:
- intersections
-street perpendicular
ENVIRONMENT
TYPE:
temperature
light
accelerometer
pollution
LOCATION:
- street grid
- retail doors
EVENT BOARDS
TYPE:
presence (PIR)
noise
LOCATION:
- intermediate street grid

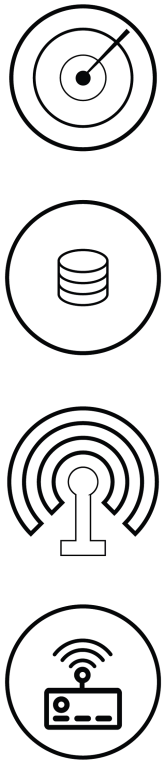
Concept Options

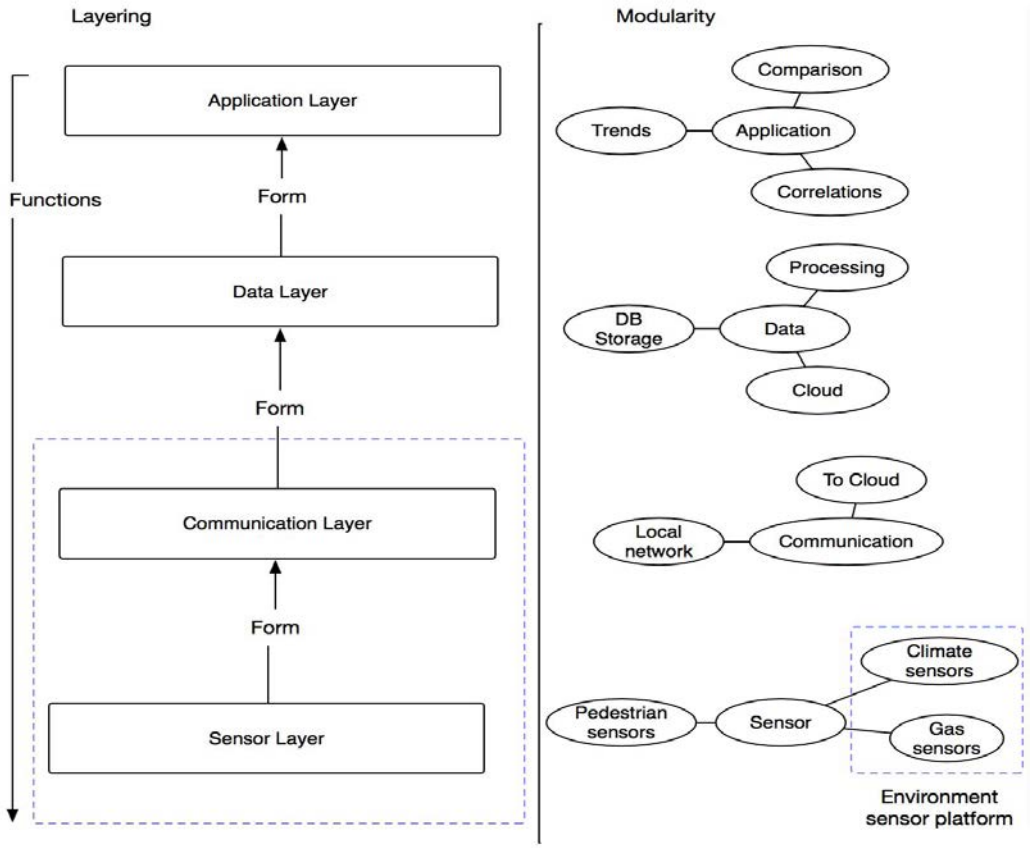
Modular sensor nodes

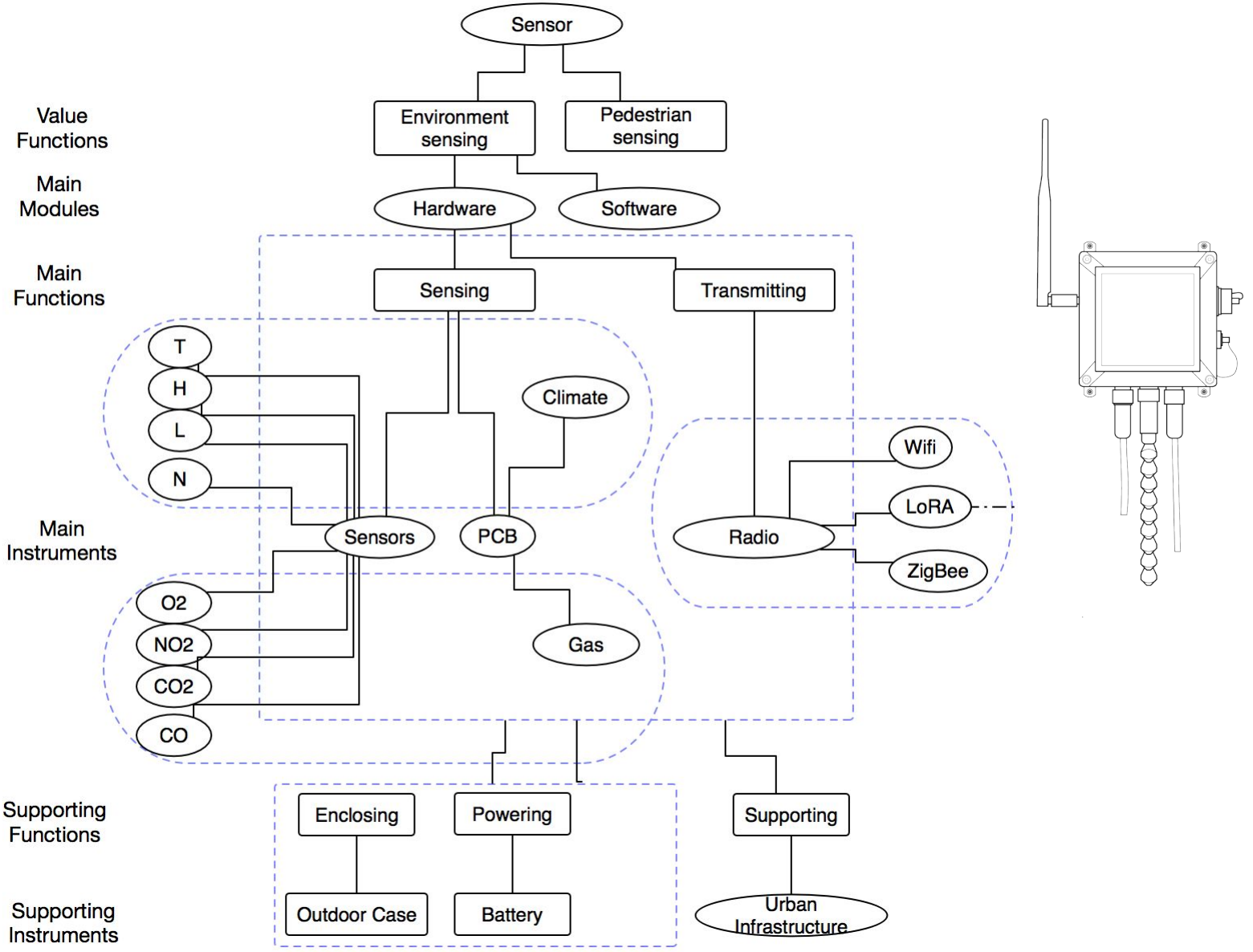
Single sensors



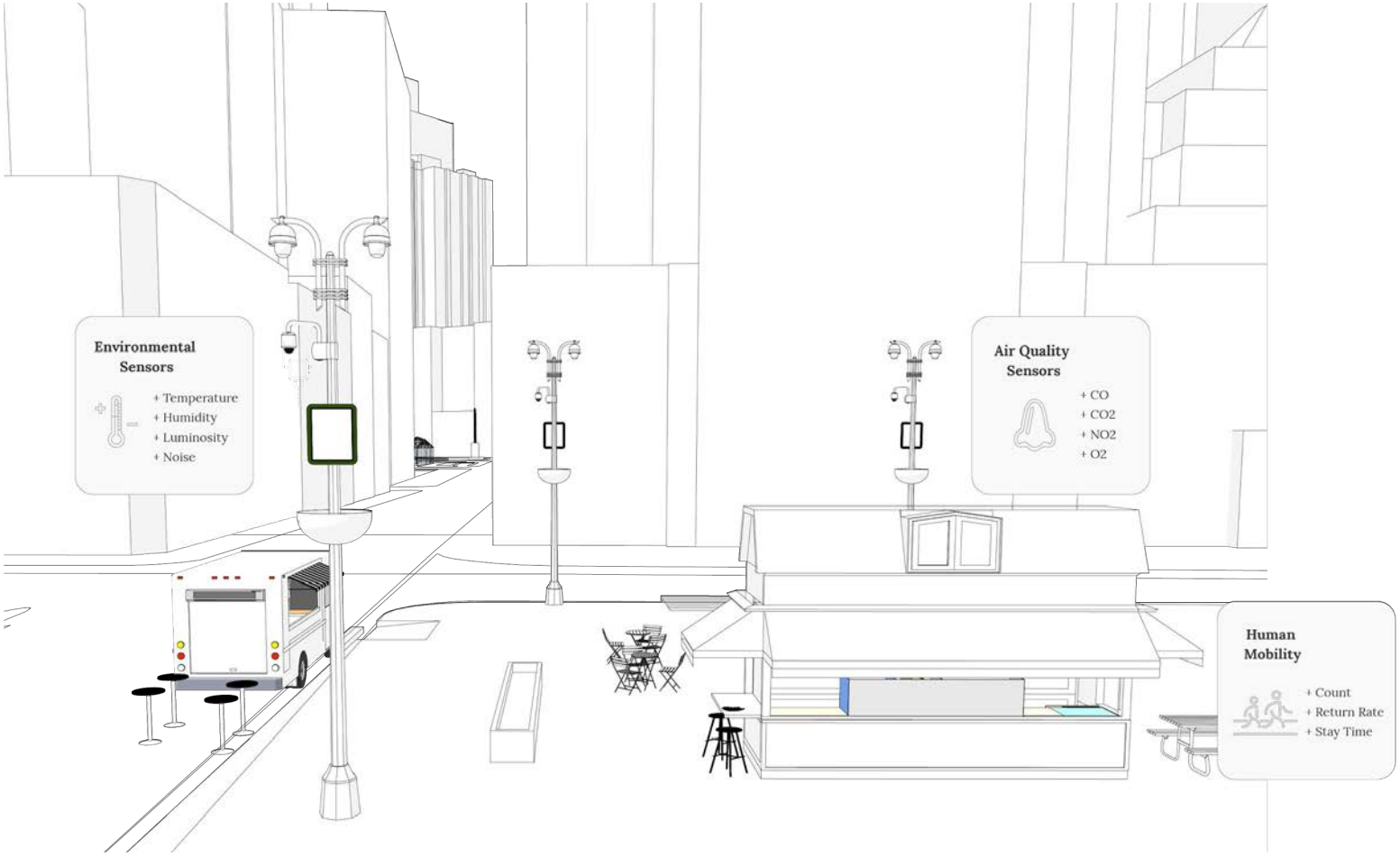
Architectural layers






Sensor
Value Functions
Environment sensing
Pedestrian sensing
Main Modules
Hardware
Software
Main Functions
Sensing
Transmitting
T
H
L
N
Climate
Wifi
LoRA
Main Instruments
Sensors
PCB
Radio
ZigBee
O2
NO2
CO2
CO
Gas
Supporting Functions
Enclosing
Powering
Supporting
Supporting Instruments
Outdoor Case
Battery
Urban Infrastructure

DTX sensing Infrastructure



Testing and Validation

Hardware

	Sensors	Gateway*	Cloud**
Lab test	• Power • Sensor readings	• Power • Local communication	• N/A
Site test	• Battery life	• Remote communication	

Software

	Sensors	Gateway*	Cloud**
Lab validation	• Time and ID • Sensor data	• Time and ID • Local database	• Latency • Local/external DB Sync**
Site validation	• Frames dropped*	• Local/External DB Sync**	


HI, I'M AN
ENVIRONMENTAL
SENSOR

Highlights from operations

External Factors

- Liability (harm to people walking by)
- Hardware theft / Physical damage
- Hide human sensor in florist
- Poor sun exposure of the solar panels
- RF interferences and dropped frames

Internal Factors

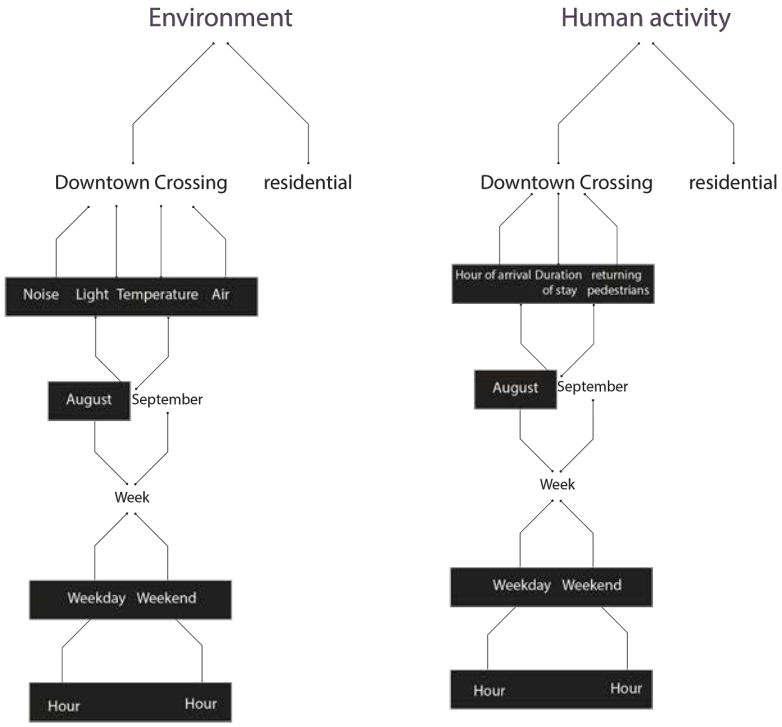
- Battery charging
- Ethernet connection

Part 3 - Pilot Data Insights

BOSTON DOWNTOWN CROSSING (DTX)

Data Insights

Data universe

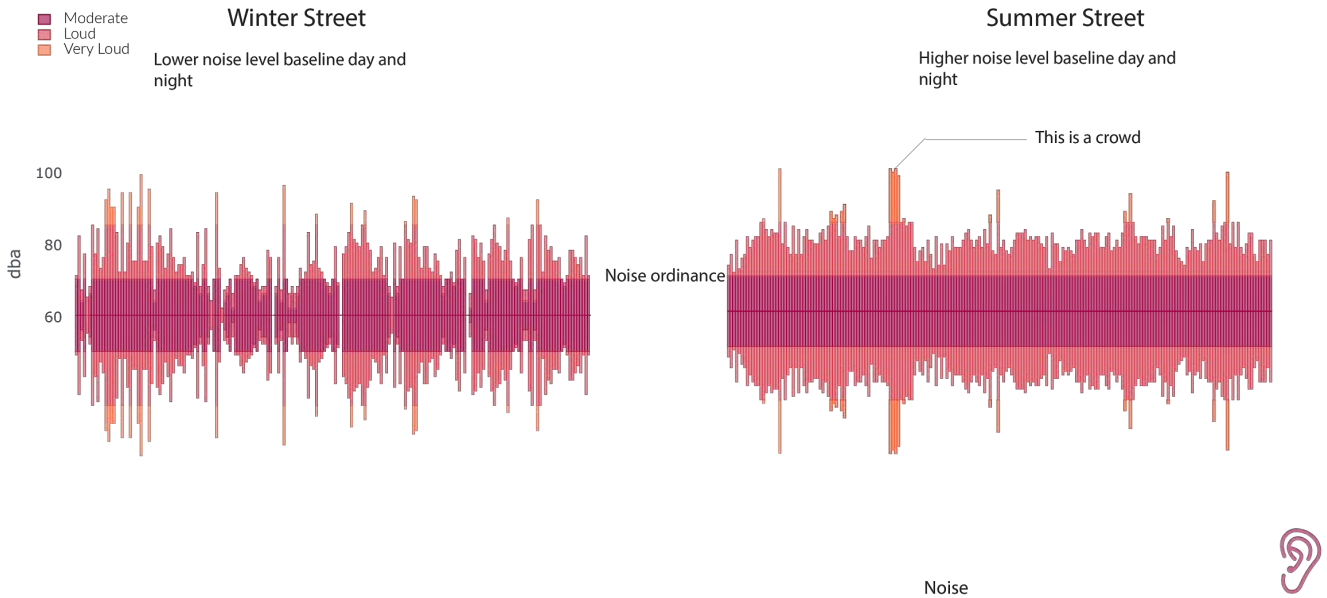


Selected path for today's presentation

Data Insights

Noise

What days are the streets the loudest?



Hourly maximum noise profiles for the measurement period in August 2016.

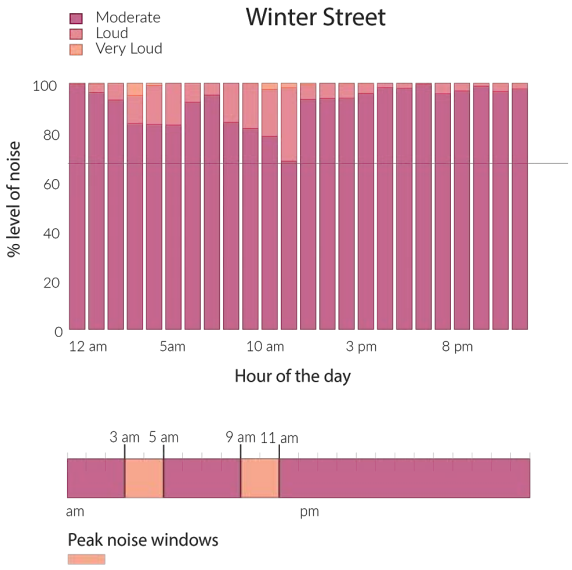
Noise

In both street segments, Friday and Saturday nights are the loudest and Sunday and Monday are the most quiet. In general, Winter street is much noisier than Summer street.

Data Insights

Noise

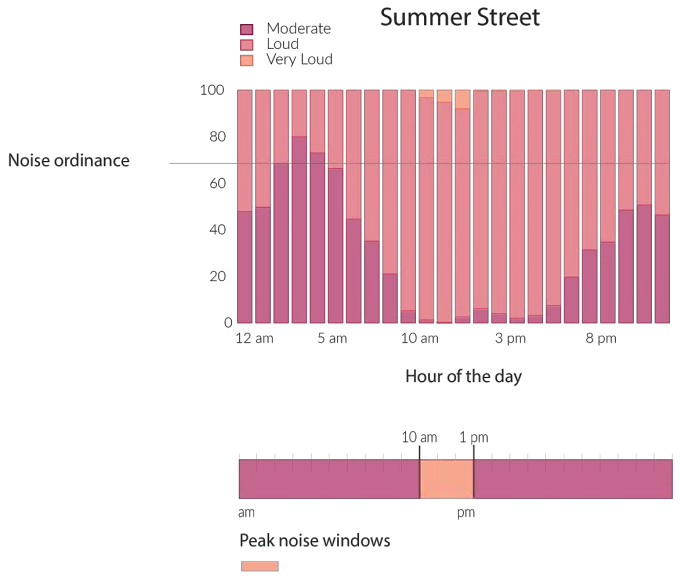
At what times are the streets the loudest?



92% louder than a lawnmower.

7.5% louder than a passing train.

0.5% louder than a jet flying over.



33.3% louder than a lawnmower.

66% louder than a passing train.

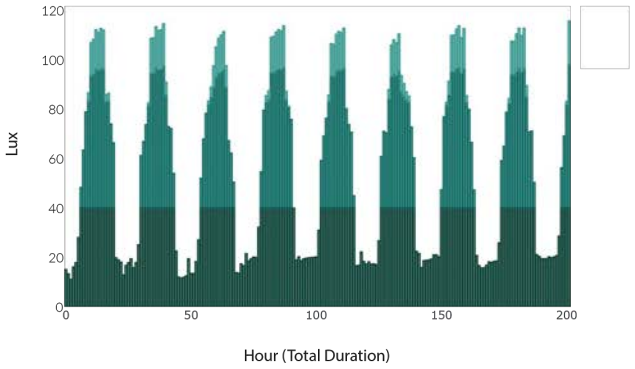
0.7% louder than a jet flying over.

Data Insights

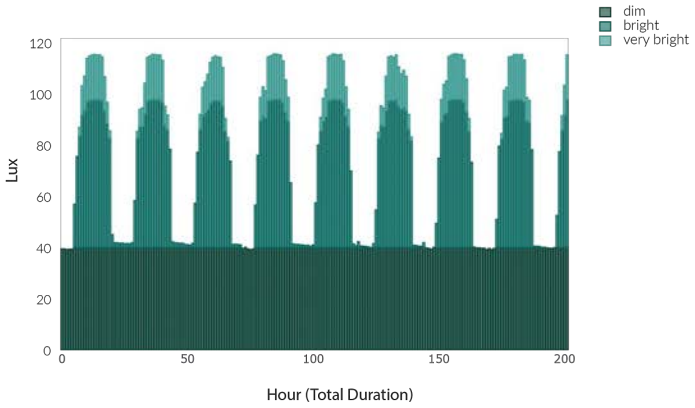
Light

How much light is received?

Winter Street



Summer Street



Luminosity

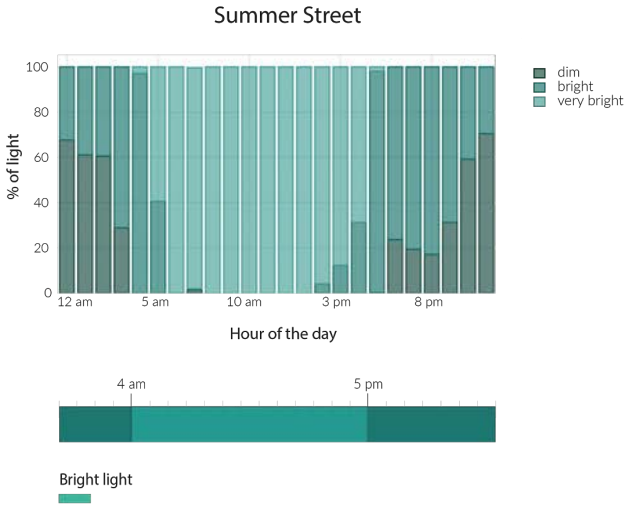
Overall, Winter street receives less light during the day. Particularly, during the month of August.

Data Insights

Light

How much light is received?

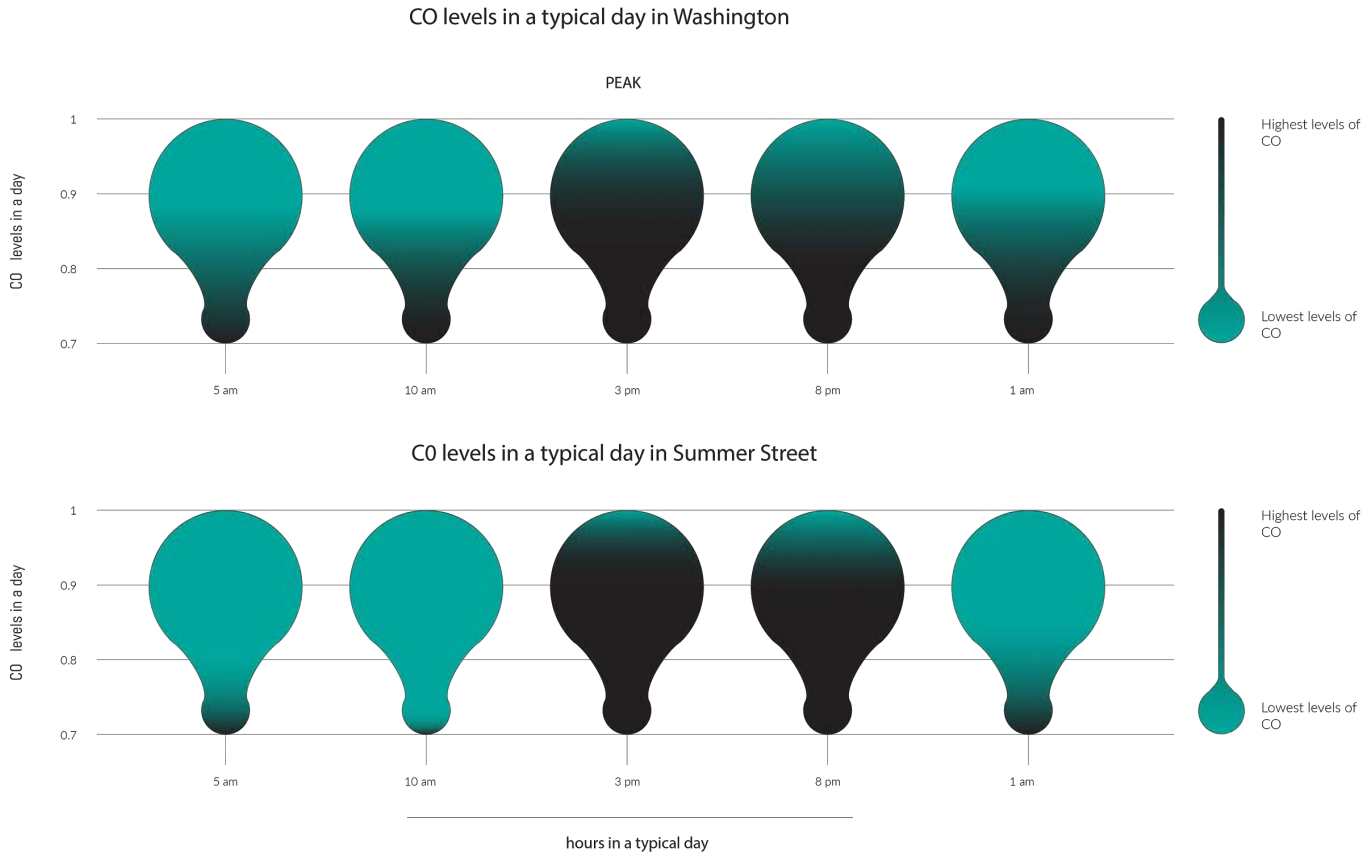
Dim 20%
bright 36%
very bright 44%



Dim 50%
bright 28%
very bright 22%

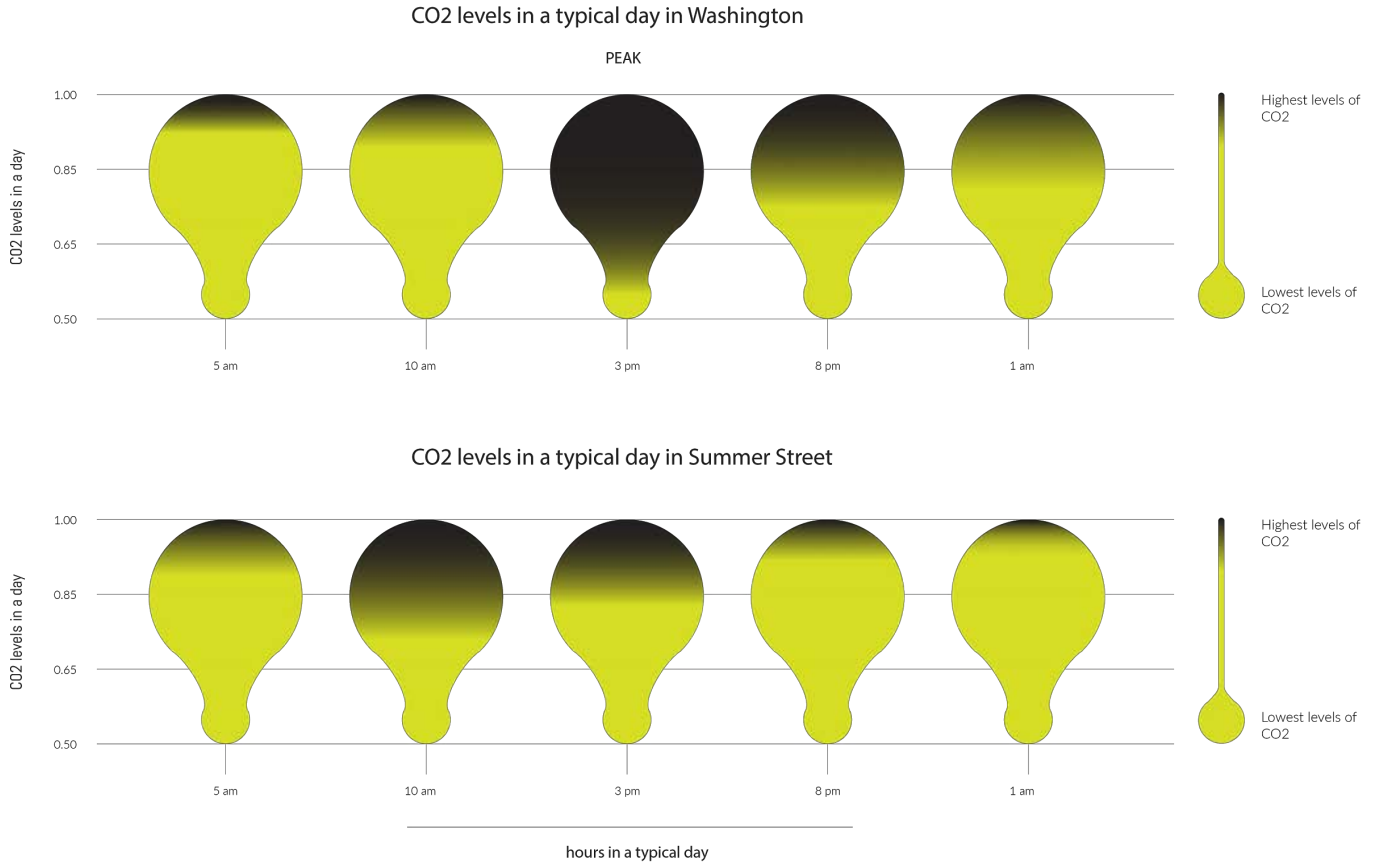
Data Insights

Air



Data Insights

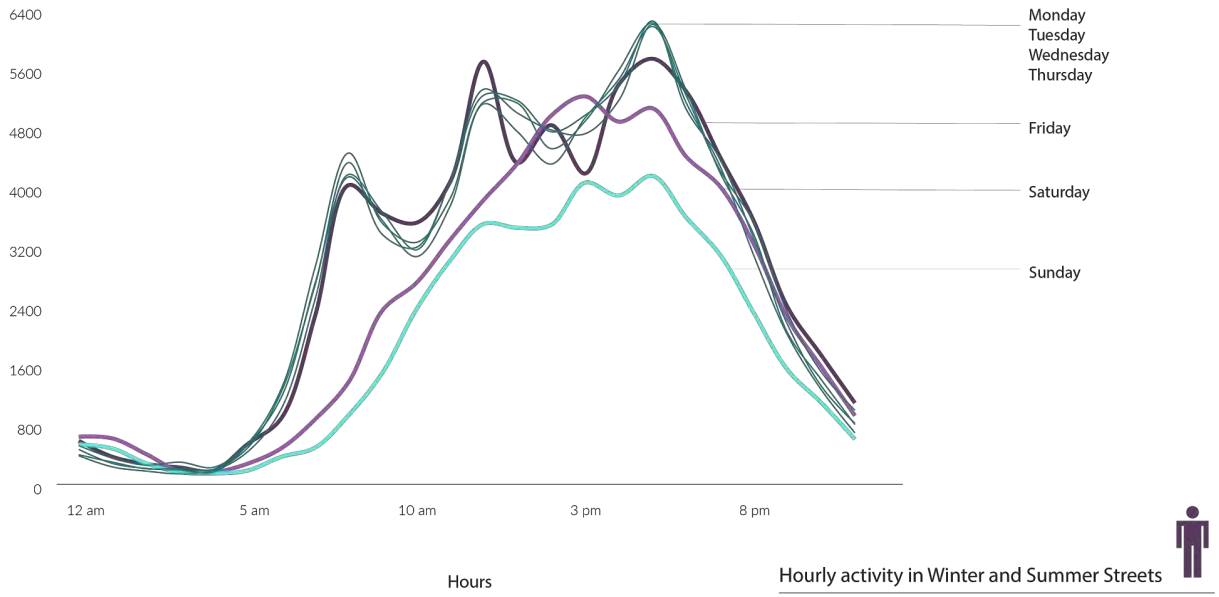
Air



Data Insights

Is there a pattern in the days?

Activity



Hourly activity in Winter and Summer Streets

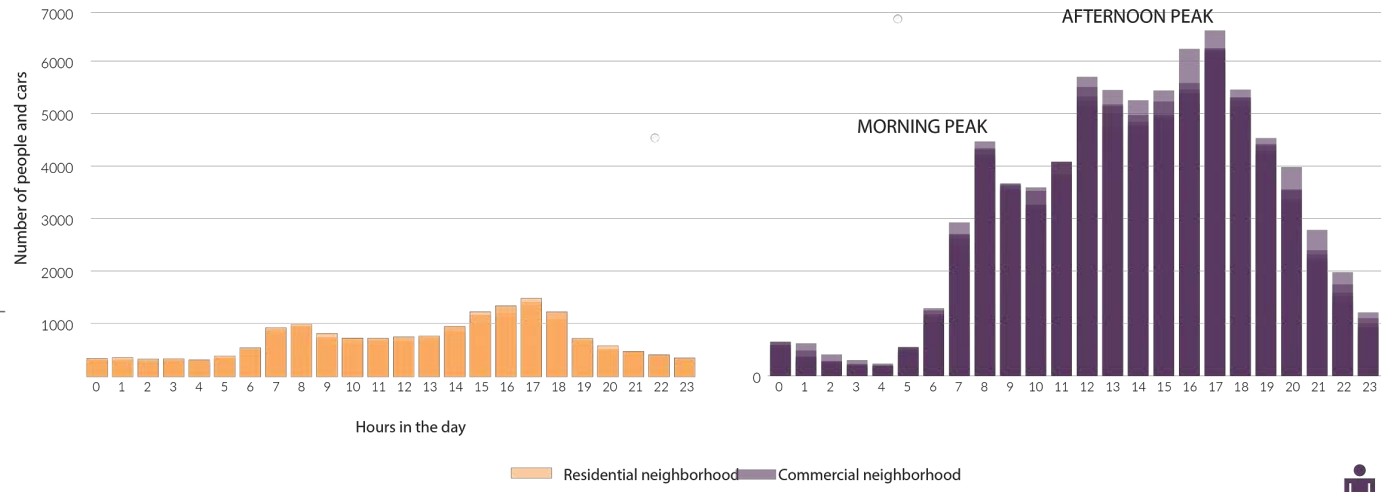
80%
Never stop at the location

20% Stop or Return

Data Insights

Activity

How about by hour?



5pm is the most active hour in the afternoon

Activity in the morning spikes at 8am and then reduces until lunch time.

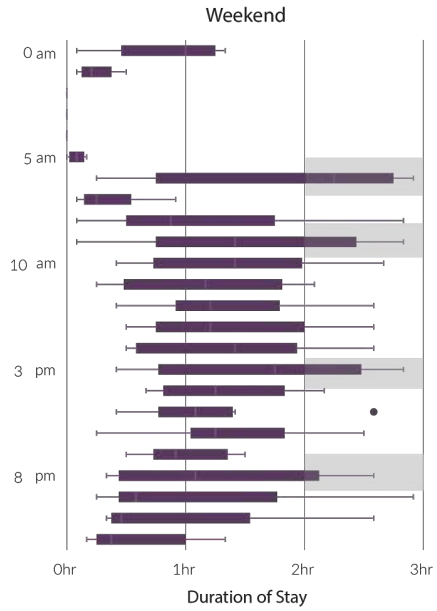
Hourly activity in Winter and Summer Streets

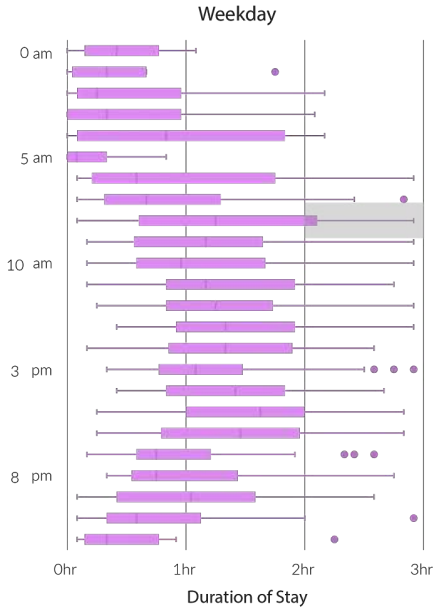
The most active hours are between 5pm and 6pm. As expected, morning hours receive the lowest amount of people. We also find peak activity levels around 8am in the morning. Lowest morning activity levels happen from 9am to 11am.

Data Insights

Do people stay longer on weekends?

Activity

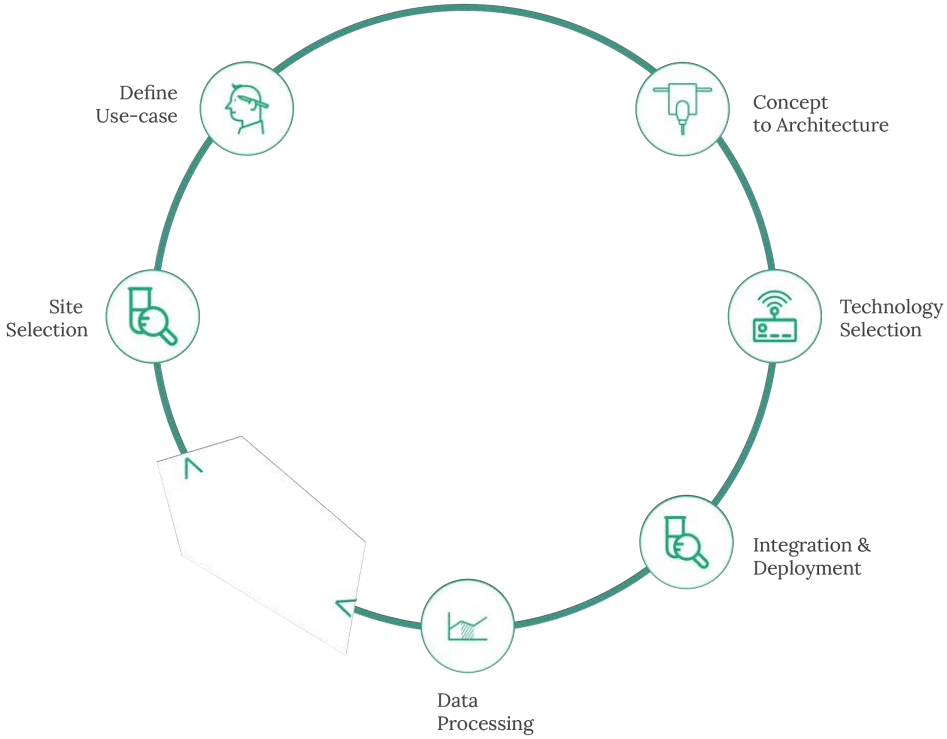




Activity in Downtown Crossing

Despite more people coming during weekdays, citizens tend to stay for longer periods of time during weekends.

Summary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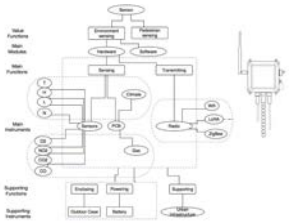

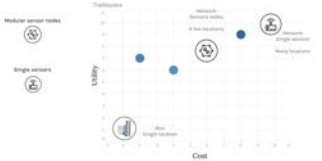


Environment
A
Human Activity
B
Noise
Light
Air
Activity

The team behind Bitsence

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BitSence.io

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Ammar El Seed
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