Public Lighting Group.

Smart City Concept Deck.

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Arup
Rebecca Chau, Matthew Dunn,
Tim Hunt, Matt Low

ARUP

User Guide

Arup was commissioned to explore what smart city projects could leverage smart lighting and other connectivity. The team took a design-led approach to identifying what smart city opportunities are applicable to the nine Victorian Councils.

The Smart City Concept Deck, one of five Resource documents (see below) presents a series of inspiration cards for smart city use cases to educate and inspire the Public Lighting Group about what smart city infrastructure they could consider deploying and what is happening elsewhere in the world.

For each concept the degree to which smart lighting infrastructure could be leveraged is shown on a bar. Consideration has been given to the likely bandwidth, power and location needs. Notably not all smart city use cases explored in this process benefit from smart lighting as there are sometimes more appropriate forms of connectivity, or connectivity is not required at all.

To understand more about how smart lighting supports smart city infrastructure see the *Smart Lighting Feasibility Study*.

The Concept Deck is a pack of concepts designed in the workshops and inspiration from around Australia and around the world. Inspiration comes in the form of exemplar case studies and concepts designs.

The concepts that were designed or developed in the workshops included:

- On-Street Community Participation
- Smart Parking Spaces
- Council Kiosks
- ParkBuys
- Real-time Emergency Notification System
- Smart Meter Data Analysis
- Community Energy Trading Scheme
- Sensor Kit
- Footfall Analytics

To read more about the process of co-designing these concepts refer to the *Smart Lighting & Smart Cities* document. As outlined further in that document, following the workshop attendees filled out a survey to select two of the concepts that would progress to business cases. The selected concepts: On-Street Community Participation, and Smart Parking Spaces are described in the most detail. The associated *Mini Business Cases* are further supplements to the Concept Deck. These two concepts are suitable pilot projects for council to start experimenting with smart lighting and smart cities.

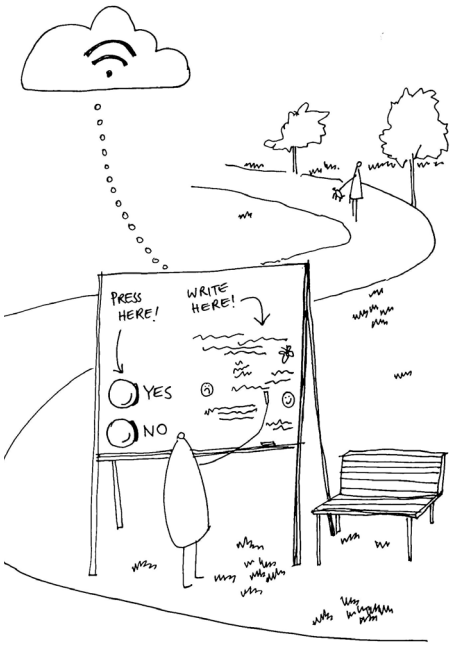
Most of these smart city concepts rely on power and connectivity. Smart lighting is one conduit for providing these services, as was explored in the *Smart Lighting Feasibility Study*. Each type of connectivity operates at a bandwidth and will draw power. As a supplement to the description of each concept in the Deck, a range of connectivity options are described and the bandwidth and power needs for each smart city concept are outlined (see page 18).

On-Street Community Participation

A physical voting system that can engage the community in decision-making by using on-street interactions to collect real-time opinion. The questions could be crowd-sourced or council-led, they could be serious or silly, and help to get a gauge on public opinion or engage people in a particular space. The tech would be movable and could be used with different parts of the community at different times and could be shared or scaled across Councils. It could combine qualitative (e.g. phone booth, chalk board or voice recognition tech) and quantitative (e.g. buttons or gates) data collection.

Smart lighting

Smart lighting is an option for connectivity for sending the data from the street to a database, but unless the data is being sent in real-time connectivity may not required.



Community opinions in physical and digital space.

Vote with your feet

Market Street Prototyping, San Francisco

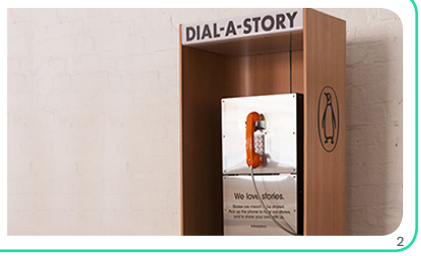
On-street interventions capturing public sentiment to crowd-sourced questions. It could be used by government to see what the public thinks by giving visibility to policy issues or simply find out how happy people are today.

1

Dial-a-Story

Sandpit, for Penguin Australia, Adelaide, Melbourne

Interactive multi-platform for sharing and hearing stories. You can pick up the phone or listen on the website to Penguin authors sharing personal stories, or tell them stories of yourself. All the stories live in an online story archive.



2

Amazon Echo

Amazon

Alexa voice reconigtion technology can be used to activate an installation, or collect qualitative information from the public about an issue. Technology like this could be incorporated into any on-street installation.

3

Exemplars

Smart Parking Spaces

Dynamic management of vehicle and cycling parking spaces for vehicle storage and other flexible uses (markets, parklets, etc.). Understanding parking trends over time to develop an accurate demand profile, adjust parking signs to meet demand, justify alternative uses in off-peak periods for pop-ups from a few hours to a few months and justify rationalising parking spaces where not required. Sensing real-time parking occupancy can be communicated, using physical (e.g. e-ink) and digital (e.g. an app) infrastructure, to drivers and cyclists to encourage them to choose alternative modes during periods of high demand for parking. This will reduce congestion and improve air quality.

Smart lighting

Real-time parking usage data could be sent along smart lighting infrastructure, however, the low power consumption and small data transfer requirements in some cases mean other connectivity options could be more appropriate.

Parking lots as public space.
& Parking efficiencies.

Smart Parking

City of Melbourne

Parking sensors installed under each carpark to encourage compliance with parking restrictions, increased efficiency of on street compliance, and understand and predict demand for parking.

4

Better Block Project

Kansas City

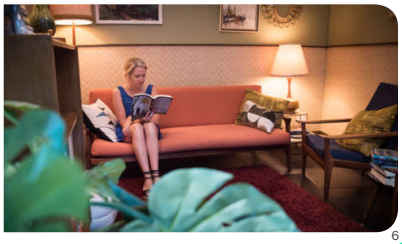
Temporary interventions that allow parking spaces to be allocated to other uses. They are often used to demonstrate the value of repurposing a space. These could be more dynamic and data-driven.

5

The Nook

Federation Square, Melbourne

Temporary undercover *third spaces* for people to socialise. The Nook is located inside Fed Square but these winter spaces could be housed in carved out shipping containers and put along the street temporarily in underutilised parking spaces.



6

Exemplars

Movable Smart Bins

A portable waste bin that can be placed in locations during peak events (e.g. events or during the season) and sense when it needs to be emptied, or provide additional capacity using a solar compactor. The particular tech will be defined by whether the problem is, insufficient capacity, a constrained collection environment, the need to reduce congestion, optimise operations, or a combination thereof.

Smart lighting

When using the data in real-time smart lighting could be used to provide connectivity.

7

8

Smart Bins

City of Melbourne, Melbourne

Solar compactor bins pilot that measures the fullness of the bins and compacts the contents. It has been implemented to manage overflow of rubbish in high use areas, and reduce congestion and emissions associated with collection vehicles. The pilot is scheduled to be rolled out across the city.

Council Kiosks

Using on-street kiosks to provide an interactive way for Councils to communicate with the community and provide Council services. Including, information from Council, daily shop deals / discounts, Wi-Fi, translation service, pay Council bills and rates, wayfinding, key landmarks (dog parks, playgrounds, bike paths).
The kiosks could be located in activity centres and demonstrate the Council's presence in the community. Could be complemented with an app that shares the same content and services, but can be designed with push notifications.

Smart lighting

For higher functionality of the kiosk they could use the power and connectivity of smart lighting.

9

10

Soofa Sign

Soofa, Boston

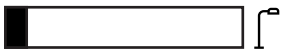
A digital bulletin board shares information about public transport, events and advertisements in real-time. It is solar powered and a cellular network.

ParkBuys

A rewards app for giving rewards for active transport for local trips to an activity centre. A reward would be given to people who don't use a car space, thereby using car parking and time of day as a currency, with peak periods earning greater rewards. Opportunity to include features such as push notifications for promotions, community gatherings, grass roots activities and polling. The point scheme could be developed by local traders (e.g. 100 points = 1 coffee), and joint-funded by Councils and traders. Councils benefit by limiting the cost of providing parking, and encourages active transport and local trips. It helps traders by getting more people in the door, by unlinking the number of visitors and parking spaces, by having the rewards redeemed at their stores. Requires a data ownership policy to be developed by Council. The app could be developed at a hack-a-thon or other crowd-sourced development.

Concept design

Smart lighting



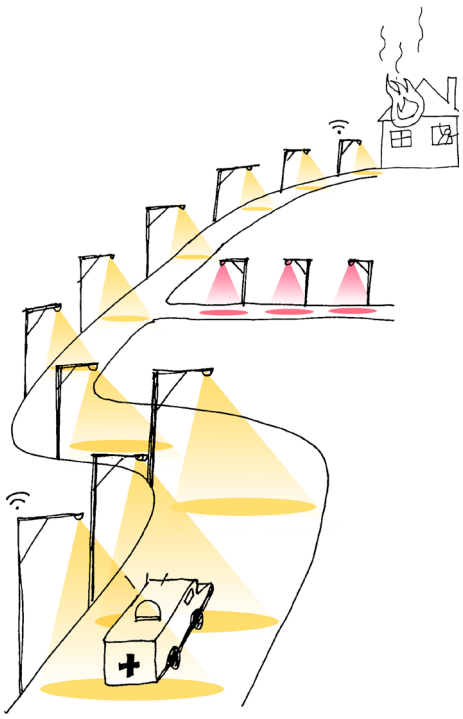
The ParkBuys app does not require smart lighting connectivity as it is an app-based platform. If pedestrian counters and other tech were incorporated in the public realm there could be a role for smart lighting.

Real-time Emergency Notification System

Using sensors to detect emergency events in real-time that can notify people in close proximity of danger. Emergency events could include bushfires, floods, car accidents, or other threats. The system could use geo-located push notifications to users' mobile phones, create visual cues such as strobing lights or colour changes or an play an announcement. Street lighting could be connected to sensors and used to provide visual alerts.

Smart lighting

This could be used to send sensor data if street poles were spaced at reasonable distances in rural areas, and to display visual feedback from the sensors.



Concept design

Smart Meter Data Analysis

Using existing smart meter data in a coordinated way to help traders implement energy saving practices by using analytics to monitor usage. The same system can be applied at Council buildings.

11

Smart Meters

Existing household tech

Energy sensors that monitor consumption in real-time.

Energy Sensing in Buildings

Using sensors in public or private buildings to communicate energy usage to current or future users of space to encourage responsible use of energy. The same data can also feed reporting channels.

12

Numan

Ecoecnetric

Prototype of a tech that can use machine learning to identify patterns in energy usage and segment out different uses to target behaviour change.

Energy Sensors on the Street

On-street sensors to collect energy and traffic data, using visualisations to communicate the NO_2 and CO_2 on the street, providing feedback in order to influence energy use behaviours.

13

Climate Street

Utrechtsestraat, Amsterdam

Integrated sustainable smart meters, street lighting and sensors to collect energy data and provide public feedback.

Community Energy Trading Scheme

Due to high-energy usage of Council buildings and facilities during the day while at the same time generally low energy consumption of individuals/residents, there is an opportunity to develop a trading scheme that draws from local residents who have the capability to generate electricity.

14

Power Ledger x Landcorp

Fremantle, Western Australia

A system that allows renewable energy asset owners to decide who they want to sell their surplus energy to and at what price, at a micro-grid scale.

Sensor Kit

A kit of commonly used sensors, easily deployed to better understand public places and facilities, including what resources are used. Enabling councils to deploy sensors to collect data associated with a perceived problem. It can be deployed temporarily or permanently to measure the impact of interventions or observe changes over time. The kit responds to the need to monitor and measure the build environment in order to achieve long-term goals. With the technology maturing sensors are now affordable for local government. The challenge is to create a kit of tech that can be applied to a variety of use cases for testing (e.g. parking, pedestrian counting, noise mapping etc.), and managed centrally on an asset management platform.

Smart lighting

Smart lighting could provide the connectivity for a movable sensor kit.

15

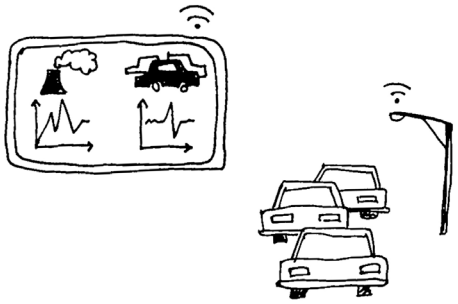
Portable Urban Comfort

City of Perth

A portable, battery powered urban sensor deployed across the Perth CBD to understand amenity and comfort in the city. Factors such as noise and pollution are sensed in real time using the cellular network. The data can then be used to understand the impact of changes in the city. For example, the impact on pedestrian amenity (noise, carbon monoxide exposure) after changing traffic light sequences.

Kerbside Sensor Corridor

Using a key highway as a living lab for how to do transport tech differently, and do construction tech differently. An array of sensors measuring phenomena along the corridor. Creating the base for an ecosystem of smart mobility, smart city tech providers. Roll out with an initial use case, such as pollution monitoring, or congestion tech that is smarter than Bluetooth.



Concept design

Community Flood Network

An inexpensive sensor network installed by the community to notify the community understand when a flood is approaching.

16

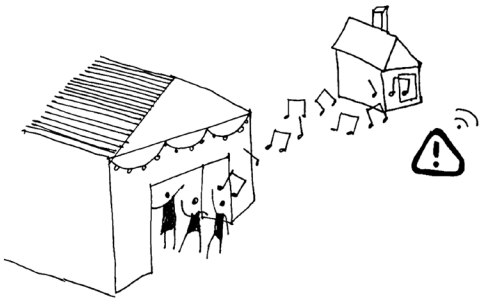
The Flood Network 17

Oxford, UK

Citizens purchase flood monitors and install them locally to get data on the water level in waterways, culverts, rivers, ditches and groundwater. Devices are battery powered and use LoRaWAN connectivity.

Next Gen Planning

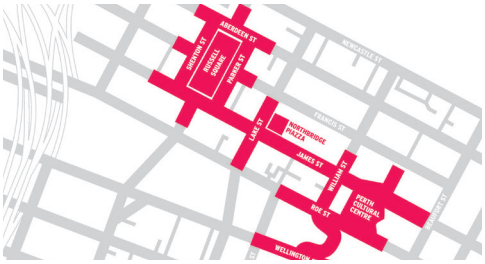
Redesign the permitting process for urban manufacturing and events, or for managing complaints in residential areas. Based on an outcomes based planning system, rather than pre-empting what may happen. E.g. flag if a manufacturing business exceeds traffic generation limits, or noise limits using sensors, if an event is too noisy or there is a complaint in a residential area.



Concept design

Free Public Wi-Fi

Wi-Fi can be used to design how a space is used. It can attract people to key activity centres and help provide internet access to the homeless population.



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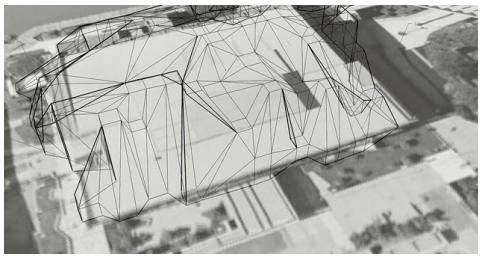
Free City Wi-Fi

City of Perth

Free public Wi-Fi across the CBD.

Wi-Fi Evaluation

Using Wi-Fi quality across indoor and outdoor spaces to explore the physical impact of digital design. Wi-Fi strength can be used to direct where people congregate and how they use spaces.



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Space usage

Arup, Queensland Library, Queensland

A study demonstrating how the strength of Wi-Fi dictated how people used spaces.

Smart Street Furniture

Street furniture that provides connectivity, charging points and collects data on how people use the street. These can be movable, and used to service events during peak holiday seasons.

20

Soofa Bench

Soofa, Boston

A solar powered street bench that has usb charging ports and Wi-Fi.

Community Data Storytelling

Visualising data to communicate to the community about consumption and drive behaviour change. Situating communications in the public realm means the outputs of data are accessible to all - with or without smart devices or data plans.

21

Melbourne Urban Forest

City of Melbourne, Melbourne

Inventory of Melbourne's trees visualised on the web. Citizens can email their favourite trees.

Environmental Art

A real-time visualisation of the condition of air quality. The expansion rate and colour of the installation changed in synchronisation with the changing environmental readings.

22

Tree Lungs

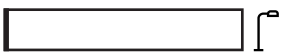
EDF & Lille3000, Loop.pH, Lille , France

A real time visualisation of the condition of local air quality. The expansion rate and colour of the 'lungs' changed in synchronisation with the changing environmental sensor readings.

Crowd Granting Platform

A physical or digital platform to enable the community to define local projects. This could be a pitch evening where the money collected at the door goes to the best idea of the night. Local partners or government can match funding. The Council can define the problems that the ideas need to respond to or open it to any ideas. It could be as small as a street barbecue.

Smart lighting



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Patronicity Crowdgranting Platform

Patronicity

Platform for gauging community support for civic and social projects and matching these with funding.

For more see Brickstarter

24

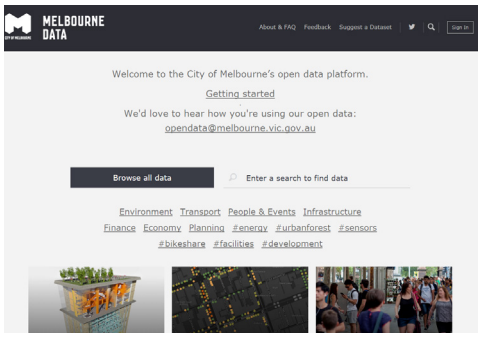
Detroit SOUP

Detroit SOUP, Detroit

SOUP pitch nights are a place where people share their ideas and the attendees vote to fund them. $5 gets you soup, bread and a vote.

Open Data Platform

Opening up Council data, and sharing it online to enable others solve Council problems.



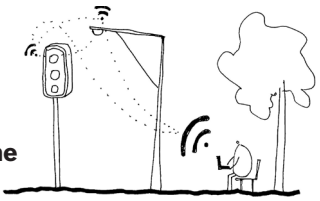
25

Open Data Platform

City of Melbourne, Melbourne

Open Infrastructure

Opening up public infrastructure, such as the TAFE facilities, to allow industry to make and test products making use of world-class facilities and skilled trainers.



Hackable Spine

Concept Design

A layer of connectivity and associated infra-structure (power, poles) that anybody (tech companies, citizens, academics) can attach sensors or actuators to at a city/precinct level. Designed for experimentation, getting kit out quickly, and learning. Supplements secure layers. Can extends across any number of Councils.

Dynamic E-ink Signs

'Paper-like' display technology for dynamic digital signage, could include location-based messaging, live transit information, personalised signage, real-time maintenance data, community engagement and time-based messaging.

26

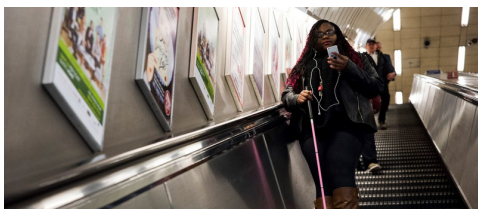
Quiet signs

Future Cities Catapult, Concept Design

A concept of e-ink displays that could provide activity information in parks.

Wireless Visually Impaired Wayfinding System

Using wireless beacons to trigger an audio guide app, to help visually impaired people navigate public spaces, while also creating a benchmark for inclusive wayfinding systems.



27

Wayfinrd

Transport for London, London, UK

A pilot project in the London underground used beacons to send directions through an app to help guide visually impaired users around stations.

Personalised Crossing Experience

Increased crossing times at busy streets for the elderly and those with mobility issues with swipe of ID card or another token.

28

Extended Crossing Time 29

Land Transport Authority, Singapore

Citizens who are over 60 years or have disabilities can apply for a special version of their transit card, which can be tapped onto a sensor to get an extra 3 to 13 seconds to walk across.

Sensing Priority Lights

Traffic light that priority for non-vehicle traffic during wet or windy weather. Using moisture sensing panel to trigger alternative timings, reducing the amount of time pedestrians or cyclists need to wait in inclement weather.

30

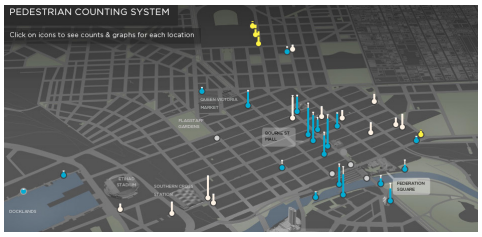
Priority Cycling Lights

Government of Rotterdam, Netherlands

This pilot scheme uses a moisture-de-tecting sensor to reduce the wait time for cyclists at traffic lights during wet weather from three minutes to 40 second.

Footfall Analytics

Using sensors to count pedestrians to help Council officers to understand impact of their activations (before and after testing), and to help stores and real-estate agents optimise opening times, attract tenants with evidence.



31

Pedestrian Counters

City of Melbourne, Melbourne

Pedestrian sensors to understand the impact of events and other changes to the city on pedestrian movement.

Asset Utilisation Platform

A data tool to understand the utilisation of Council assets (open space, community centres, roads) to inform planning and investment.

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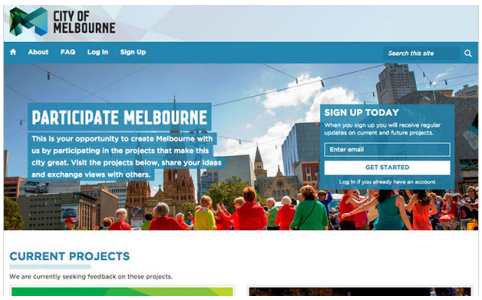
Participation Platform

A single point of contact for the community to discuss the future of the Council, get feedback on policies.



33

Participate Melbourne

City of Melbourne

Community participation platform.

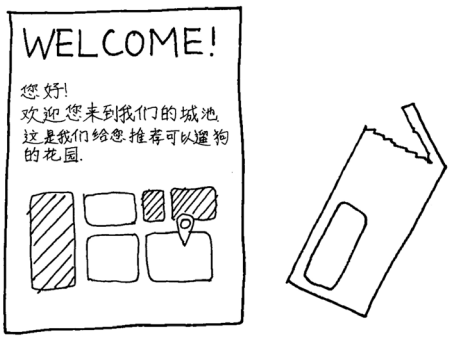
Community Needs Platform

Collection of data from residents, particularly new residents, to quantify service and infrastructure needs.

34

Bespoke Resident Messaging

Sending bespoke messages to residents based upon their interests and previous interactions with Council.



Concept design

Demand Responsive Public Transport

Collecting data to allow local public transport services to best respond to transit needs or special events. This would include analysing the best routes and pick-up schedules.

35

Dynamic Microtransit Service

Bridj, previously operational in Boston, USA

Low capacity demand-responsive public transit services that develops routes based on riders' trips.

Healthy Interventions

A playful take on tech for healthy citizens.

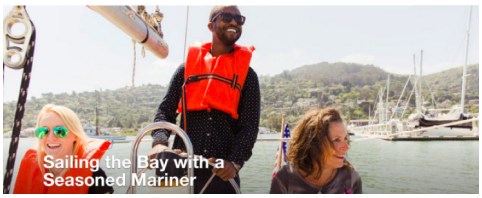
36

Onefootball HQ

TKEZ Architects, Berlin, Germany

Local Experience Tourism

Making tourism personal. Locals sharing local experiences with visitors or giving a human touch to tourism by having prospective tourists ask locals for advice.



37

Airbnb Experience

Airbnb

Hosts can be chefs, hikers, or knowledgeable locals who want to show others pockets of their community.

References

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Connectivity

There are a number of connectivity options to connect smart city hardware to the internet. When considering which connectivity option is most appropriate, the bandwidth required to send data needs to be considered, and the power requirements.

Bandwidth

Bandwidth refers to the quantity and frequency of data being sent from a device. The appropriate connectivity is driven by the bandwidth requirements, power available at a given location, and the location itself.

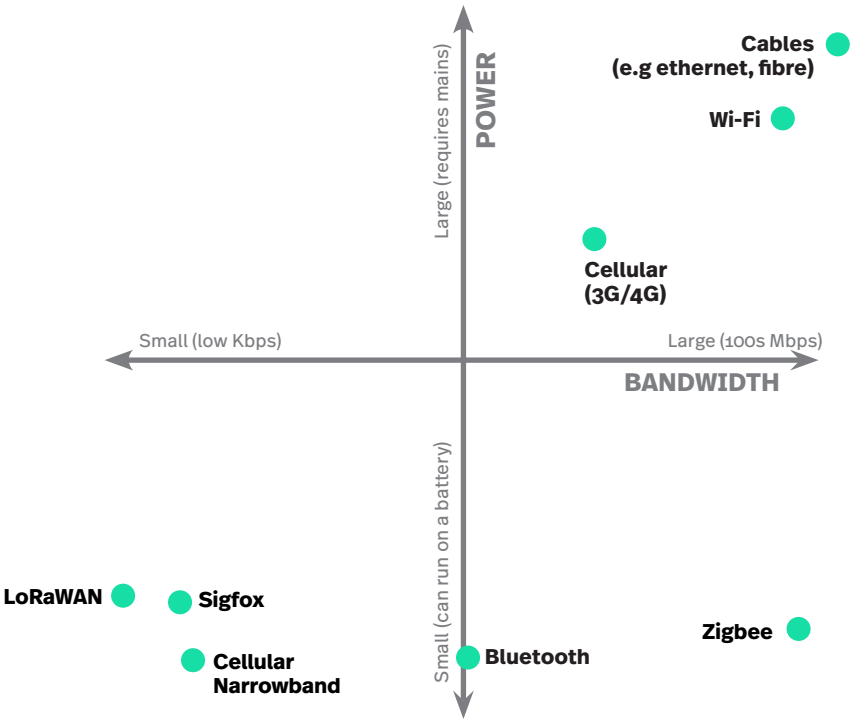
Power source

There are three important options for powering sensors each with different use cases: battery power, solar power and mains power.

Battery power is good when you are only sending small amounts of data, a project is short term, or portable. It is not good when sending a lot of data. If they are not self-charging, they will need to be periodically replaced.

Solar power is good when you have access to open space and sun exposure. It is not good in higher density environments with overshadowing, or when you are sending a lot of data. Solar panels can be bulky.

Mains power is good when you have large quantities of data and/or the data frequency is high. Mains power is not good when a light pole or other power infrastructure is not nearby, you don't have a approval to connect or it is only a short-term installation. Connection may require some special approvals.



Connectivity Types

Connectivity

There are a number of connectivity types used to connect the hardware from the smart city concepts to the internet. Some general considerations for selecting a connectivity type, as well as some of the features of each are outlined.

Connectivity Types

Each type of connectivity can operate at a particular bandwidth, and will draw an amount of power in the process. Some common connectivity types are described below. Details about their attributes are on the following table.

Wi-Fi. Public Wi-Fi systems might be deployed that provide connectivity for smart city technologies. Often already deployed, or more feasible to deploy, in activity centres (density of activity/users). Sometimes provided by other infrastructure (e.g. smart bins, or Telstra phoneboxes).

Cellular 3G / 4G. Mobile phone-like SIM card inserted in sensor to communicate with mobile network. Covers most areas of cities.

Cellular Narrowband. Upcoming technology, uses existing mobile network.

Sigfox. Proprietary sensor network provided by Thinxtra in Australia.

LoRaWAN. Long-range connectivity that requires special configuration.

Cables (e.g. Ethernet). Would require Ethernet access. Probably most relevant if attaching sensor to council building that already has Internet access.

General Considerations

There are a number of general considerations when choosing a connectivity type:

Spectrum. Australian Communications and Media Authority (ACMA) regulates radio frequencies (the spectrum) that different communication systems are allowed to use. If using a custom connectivity, in particular, there is a need to ensure that connectivity is in keeping with ACMA requirements.

Uptime. More established connectivity types (e.g. 3G) generally have a strong track record of uptime, whereas custom and niche connectivity types might not yet have demonstrated high levels of resilience.

Cost. The cost of connectivity generally has two components. The first is setup (fixed) costs, such as communication chips on board the sensor, and setting up a gateway if required. The second is an ongoing cost (generally subscription for use of data services, similar to a mobile phone SIM card plan).

Openness. Some connectivity types (e.g. Sigfox) are based upon proprietary technology that can increase the cost of connectivity (both the fixed and ongoing costs). This doesn't mean the data generated is closed, just the connectivity.

Proximity and availability of routers/gateways. For shorter range connectivity (e.g. Wi-Fi, Bluetooth, Zigbee), there is a need to ensure that the sensor is within range of a router, gateway or repeater (see range notes in table below).

Connectivity

Each connectivity type as a range, bandwidth, power draw, cost structure and key considerations. These are outlined below.

Tech	Range	Bandwidth	Power draw	Costs	Considerations
Wi-Fi	Low Approx. 50m	High 100-200Mbps	High	Some set up costs. No ongoing costs generally	Requires stable Wi-Fi network (public Wi-Fi networks are often not stable) Security and encryption on Wi-Fi can be a larger concern Councils often own secure, directional Wi-Fi or similar for CCTV and other networks, that may be able to be appropriated for other uses
Cellular (3G and 4G)	High Kms	High 1Mbps+ on 4G	Low	No set up costs Medium ongoing costs (expensive for high quantities of data)	The cost of frequently sending large amounts of data can be considerable (mobile phone company subscription costs).
Cellular Narrowband	High Up to 30kms	Low	Low	No set up costs Australian NB pricing not available yet	Currently in pilot in Australia.
Sigfox	High Kms	Low 10-1000bps	Low	Variable	Requires access to a gateway. Commercial providers such as Thinxtra provide connectivity.
LoRaWAN	High Kms	Low 0.3-50Kbps	Low	Variable set up costs Variable ongoing costs	Requires access to gateway. Commercial providers and open access providers (The Things Network) active in Melbourne market.
Cables (e.g. ethernet)	Direct contact required	High	Mixed	High set up costs Low ongoing costs	Power can be provided over Ethernet (PoE)
Bluetooth	Low 50-150mm (Smart/BLE)	Medium 1Mbps (Smart/BLE)	Low with BLE (Bluetooth Low Energy)	No ongoing costs generally	
Zigbee	Low 10-100m	Low 250Kbps	Low	High set up costs. No ongoing costs generally.	Not widely used among hardware providers

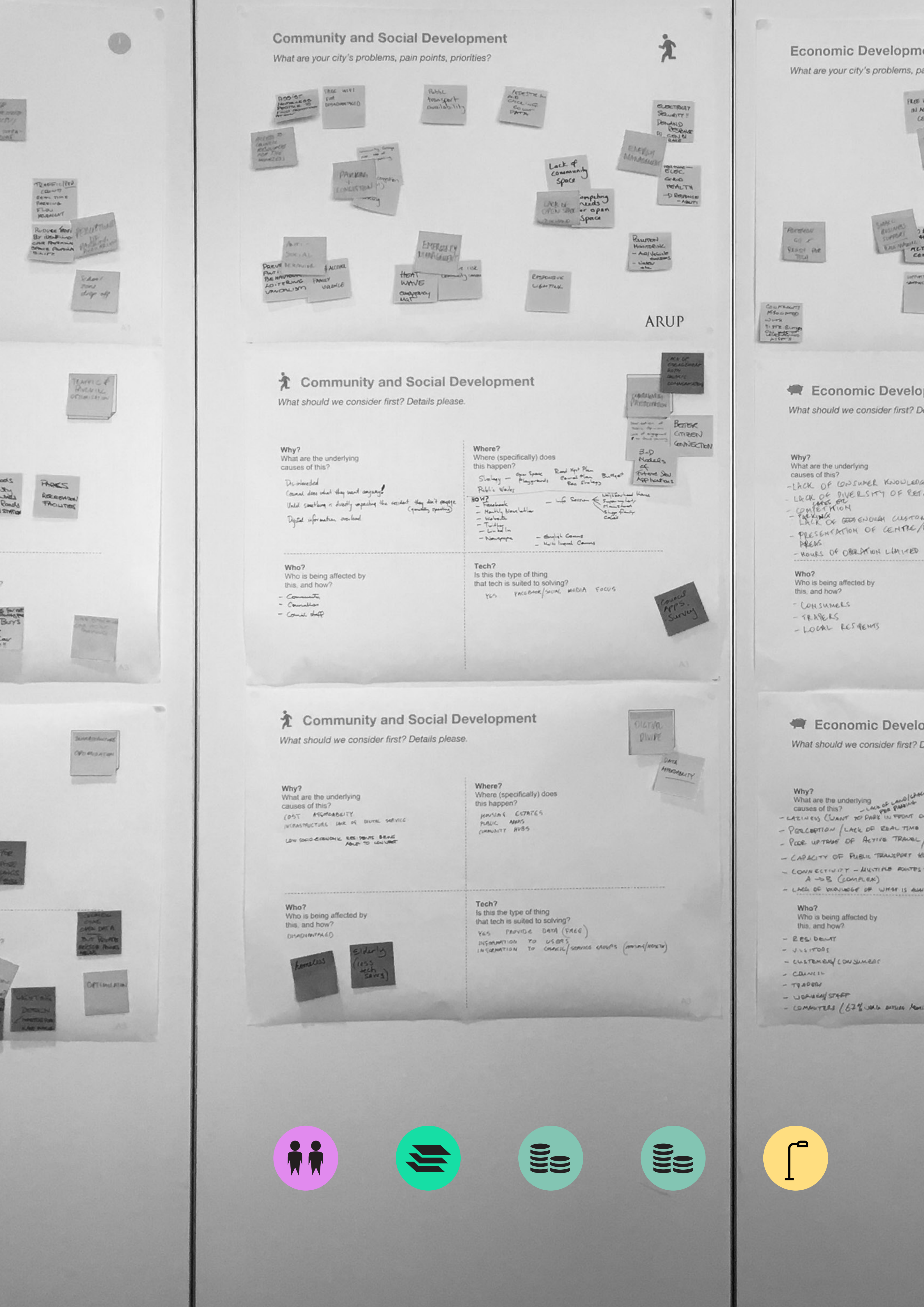
Connectivity for Concepts

Some guideance on the bandwidth and power for each concept is marked in the table below. Power is required to feed the connectivity, as well as features such as screens, sensors and other components. The likely location of an intervention (e.g. building vs. public realm) will also impact whether smart lighting is useful.

Bandwidth
Small = Kbps (e.g. infrequent temperature data)
Medium = Mbps (e.g. audio data)
Large = 100s Mbps (e.g. streaming video data)

Power
Small = small battery
Medium = solar power
Large = mains power

Smart City Use	Bandwidth	Power	Locatable near Smart Lighting
On-Street Community Participation	Small	Large	Yes
Smart Parking Spaces	Small	Medium	Yes
Movable Smart Bins	Small	Medium	Yes
Council Kiosks	Medium	Medium	Yes
ParkBuys	-	Small	No
Real-time Emergency Notification System	Small	Small	Yes
Smart Meter Data Analysis	-	-	No
Energy Sensing in Buildings	-	-	No
Energy Sensors on the Street	Medium	Medium	Yes
Community Energy Trading Scheme	-	-	No
Sensor Kit	Medium	Medium	Yes
Kerbside Sensor Corridor	Small	Medium	Yes
Community Flood Network	Small	Small	Yes
Next Gen Planning	Small	Medium	Yes
Free Public Wi-Fi	Large	Large	Yes
Wi-Fi Evaluation	Large	Large	Yes
Smart Street Furniture	Medium	Medium	Yes
Community Data Storytelling	-	-	No
Environmental Art	Medium	Large	Yes
Crowd Granting Platform	-	-	No
Open Data Platform	-	-	No
Open Infrastructure	Large	Large	Yes
Dynamic E-ink Signs	Small	Small	Yes
Wireless Visually Impaired Wayfinding System	Small	Small	Yes
Personalised Crossing Experience	-	Small	Yes
Sensing Priority Lights	-	Large	Yes
Footfall Analytics	Medium	Medium	Yes
Asset Utilisation Platform	Small	Large	No
Participation Platform	-	-	No
Community Needs Platform	-	-	No
Bespoke Resident Messaging	-	-	No
Demand Responsive Public Transport	-	-	No
Healthy Interventions	Medium	Medium	Yes
Local Experience Tourism	-	-	No



Community and Social Development
What are your city's problems, pain points, priorities?
Lack of community Space
Heat Wave
ARUP
Community and Social Development
What should we consider first? Details please.
Better Citizen Connection
Why?
What are the underlying causes of this?
Where?
Where (specifically) does this happen?
Who?
Who is being affected by this, and how?
Tech?
Is this the type of thing that tech is suited to solving?
Council Apps Survey
Community and Social Development
What should we consider first? Details please.
Why?
What are the underlying causes of this?
Where?
Where (specifically) does this happen?
Who?
Who is being affected by this, and how?
Tech?
Is this the type of thing that tech is suited to solving?
homeless
Elderly (less tech savvy)
Economic Development
What are your city's problems, pain points, priorities?
Economic Development
What should we consider first? Details please.
Why?
What are the underlying causes of this?
Who?
Who is being affected by this, and how?