BUROHAPPOLD ENGINEERING

URBAN STREETS IN THE AGE OF CONNECTED AND AUTONOMOUS VEHICLES

GLOBAL DESIGN SPRINT - SEPTEMBER 2016

GLOBAL DESIGN SPRINT

Connected and Autonomous Vehicles (CAVs) are on everyone's mind, with the race on among global vehicle manufacturers to create the first fully automated CAV before 2020 mimicking the space race of the mid-20th century. While it is unclear how fast they are likely to become business as usual, it is almost impossible to ignore that they will be part of our environment in the not too distant future.

Our research has shown that there are a range of ideas emerging (summarised here) around how the built environment will be transformed by the introduction of CAVs, there are however few examples of specific urban sites in actual cities and how they may be adapted to suit the various types of CAVs and the people travelling through the sites.

As a result of this, BuroHappold plan to undertake a series of Global Design Sprints in six of our offices across the globe (Bath, London, New York, Berlin, Riyadh and Kuala Lumpur) to address the following question:

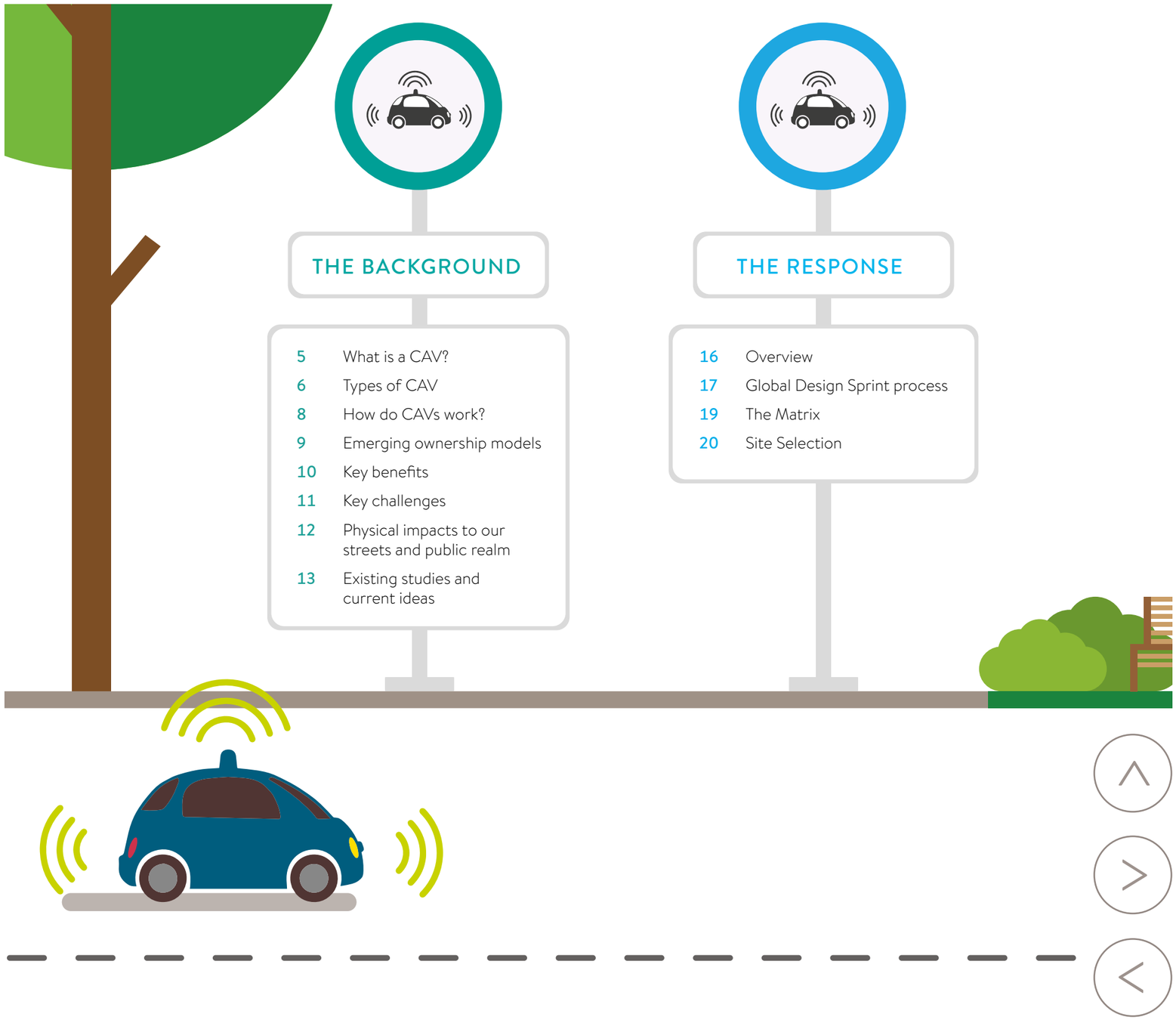
'HOW CAN URBAN STREETS BE RECLAIMED AND REIMAGINED THROUGH THE INTRODUCTION OF CONNECTED AND AUTONOMOUS VEHICLES?'

Global Design Sprints bring a diverse group of people with various skills and expertise together to solve a problem by thinking collaboratively, innovatively, and creatively. The format of a Global Design Sprint is to follow the design process to develop an answer to a specific question within a limited amount of time, but also to have some fun.

Following our Global Design Sprints, we will publish a paper featuring each team's final ideas and images. Selected teams with outstanding outputs will be asked to prepare a 2 minute presentation, which will be published on BuroHappold's website.

This brief contains background information on CAVs and their impact on the built environment and explains in detail the process of a Global Design Sprint. If you are attending one of our official sprints we will provide all the tools required, if you wish to hold your own sprint you can contact globaldesignsprints@burohappold.com and we will be happy to send you a copy of the tools that you will require to run the sprint. This brief focuses primarily on passenger vehicles but we also encourage consideration of the movement of goods and services for the Global Design Sprints.

Please feel free to use this brief and organize Global Design Sprints with colleagues in your city.



THE BACKGROUND

THE BACKGROUND

Connected and Autonomous Vehicles (CAVs) present an opportunity to rid ourselves of the bad associated with cars, and to keep and enhance the good by providing a safer, smarter, cheaper and cleaner way to travel.

As a result of introducing CAVs, our cities and societies are likely to face enormous changes, just as they did when the Model T Ford was introduced as a horse-drawn cart without a horse.

At the time, very few foresaw the impact this would have on cities and on our lives. Whereas at the beginning of the twentieth century very few could have even imagined what a cart would look like without a horse, we have become gently prepared for the arrival of CAVs through media, including a range of popular science fiction movies and endless articles and stories. This presents an opportunity to pro-actively reimagine possible futures in a world of CAVs. As engineers, urban planners, designers and transportation planners, we have a responsibility to learn from past mistakes and harness the potential benefits of new technologies to create more liveable cities and urban places, not only for our own benefit, but for the benefit of future generations (Hodson, 2016).

The Global Design Sprint aims to focus on the question of how urban streets can be reclaimed and reimagined through the introduction of fully autonomous vehicles. To tackle this question in the four hours allocated for a Design Sprint, the following information will help you get familiar with the topic of CAVs, the different definitions and types, the projected timeline of their introduction, and the associated benefits and challenges.

WHAT IS A CAV?

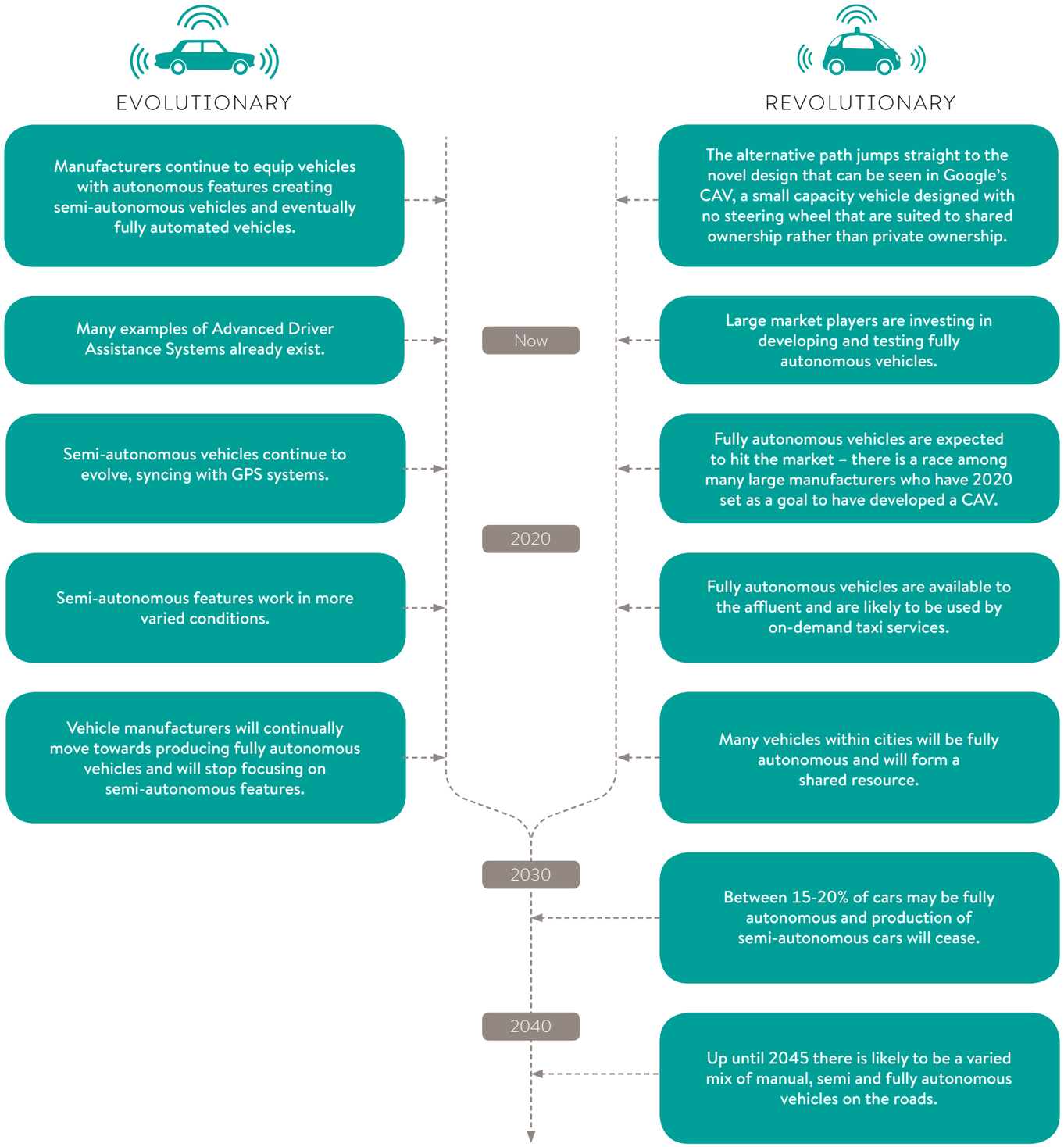
There is a lot written and talked about CAVs, yet the term is not always clearly defined. Generally speaking, an autonomous vehicle is a vehicle that can drive itself with little or no human input. For the purposes of this brief, we also define that these vehicles are travelling along road based guideways. There are, however, varying degrees of automation.

- A fully autonomous vehicle operates entirely self-guided. While drivers might have the option to resume control, they are not needed to operate the vehicle.
- A semi-autonomous vehicle contains certain automated features such as autopilot. The vehicle however still depends on a qualified driver who can control the vehicle as needed.
- A connected and autonomous vehicle may be fully or semi-autonomous and connects to other technology at various levels, including devices within the car, other vehicles (V2V), and surrounding infrastructure (V2I).

EVOLUTIONARY VERSUS REVOLUTIONARY PATH TO FULLY AUTONOMOUS VEHICLES

While fully autonomous vehicles will almost certainly take over our streets and cities sometime in the future, there is a lively debate regarding which path the transition will take: The "evolutionary" path sees increasing automation and connectivity of current vehicles (e.g. autopilot features and GPS systems that already exist) towards fully autonomous vehicles. The "revolutionary" path sees fully autonomous vehicles like the one built by Google, become increasingly mainstream.

The graphic demonstrates the two paths (Bhuiyan, 2016).



TYPES OF CAVS - EVOLUTIONARY

While images of autonomous cars are becoming ubiquitous, it is important to understand the range of CAV types that are existing and also those that are emerging. Looking further into the future we are unable to predict what types of CAVs will emerge, so this will be left to your imagination.

Name	CAV Type	Ownership	Description	Image
Highway automation	Evolutionary	Private	Optional system sold on new vehicles allowing hands free driving on limited access highways.	
Driverless valet	Evolutionary	Private	Optional systems within old and new vehicles allowing a vehicle to park itself without a human driver behind the steering wheel.	
Truck platooning	Evolutionary	Private/Shared	Optional equipment on a HGV allowing the vehicle to engage in a close formation platoon with other similarly equipped vehicles.	

Name	CAV Type	Ownership	Description	Image
After market highly automated vehicle kit	Evolutionary	Private	Third party add-on system for existing production vehicles providing highly automated capabilities. This is equipped sometime after the vehicle is originally purchased.	
Highly automated conventionally designed vehicle	Evolutionary	Shared	A vehicle that conforms with design conventions and is capable of fully-automated driving in most or all conditions	

(Kim et al, 2016)

TYPE OF CAVS - REVOLUTIONARY

Name	CAV Type	Ownership	Description	Image
Highly automated with advanced design	Revolutionary	Shared	Capable of truly driverless operation and does not feature any manual controls – no steering wheel or pedals. The drivers seat is still positioned in a similar way that it is currently.	
Highly automated with novel design	Revolutionary	Shared	Capable of truly driverless operation and does not feature any manual controls – no steering wheel or pedals. The seating arrangement is unconventional.	
Riderless delivery motorcycle	Revolutionary	Private/Shared	A 2-3 wheeled vehicle that has a cargo compartment. This operates along a programmed route with no rider. The motorcycle receives remote destination instructions and operates with built-in automation capability.	

Name	CAV Type	Ownership	Description	Image
Driverless delivery vehicle (light duty and heavy duty)	Revolutionary	Private/Shared	Operates along a programmed route with no driver. The vehicle receives remote destination instructions and operates with built-in automation capability.	
Highly autonomous bus with advanced design	Revolutionary	Public/Private	A bus that can operate on existing roads and knows when to stop and pull out of bus stops.	
Low speed highly automated bus with novel design	Revolutionary	Public/Private	A bus that is small in scale that transports users between defined points – generally used within campus style developments.	

(Kim et al, 2016)

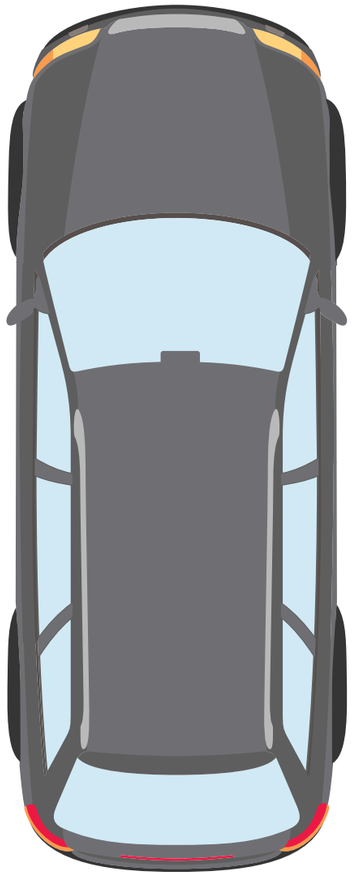
HOW DO CAVS WORK?

There are three key components required to turn a regular vehicle into a CAV.

The first is a GPS system similar to those found in many vehicles today. A GPS system is a vital part of a CAV's over-arching technology. No different than Google Maps' driving directions, it defines the "mission" of the CAV by setting the starting and ending point of the route. It looks at all the roads and chooses the best path for the journey.

The second is a system to recognize dynamic conditions on the roads, generally in the form of radar, camera, LiDAR and ultrasound. Select the buttons below to see what is detected by each part of the system:

The GPS and recognition of dynamic conditions systems form the CAV's 'world model' (Pullen, 2015). The third component turns the information from these two systems into actions for the vehicle (Pullen, 2015). This is generally called the 'CAN bus' (which stands for controller area network). This in-vehicle electronic network has been in vehicles for decades and is a central computing system that analyses all the data from the various sensors to manipulate the steering, braking, and acceleration (Armstrong, 2016).



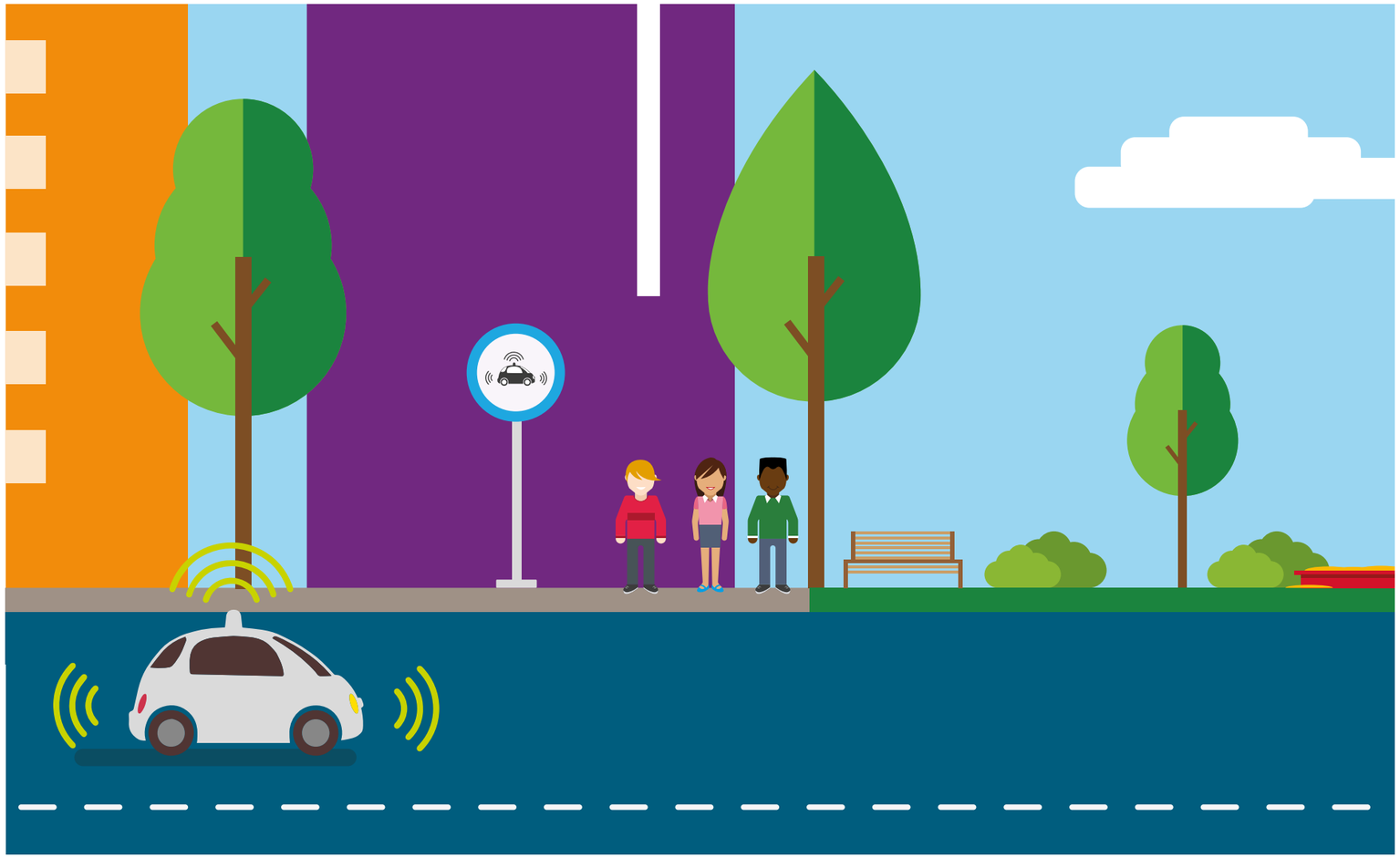
WHAT OWNERSHIP MODELS WILL EMERGE WITH THE INTRODUCTION OF CAVS?

One of the most exciting opportunities of CAVs, at least discussed among progressive transportation planners, is the potential for shared ownership and usage. The rise of on-demand transportation provides a glimpse of what this future could look like, and the first sign of the adoption of CAVs within this model has emerged sooner than expected with two separate announcements in August 2016, one from Uber in Pittsburgh, America, and one from nuTonomy in Singapore, both declaring that they are to begin trialling CAVs as on-demand services in these locations (Harris, 2016). People no longer own their individual cars, but use smart phone applications to access the particular vehicle needed at a specific point in time – be it a mini-van for moving households on a Saturday, a vehicle to drive to the country side on a Sunday, or a shared taxi ride home after a Friday night out in the city.

This provides enormous opportunities to further increase the efficiencies (details on the following page) introduced by CAVs. Studies show that individual cars remain unused for around 95% of the time (Metz, 2016). Compared to this inefficient use of vehicles, a fleet of autonomous taxis could circulate non-stop, instantly matching supply with demand. This would drastically reduce the need for vehicles. Researchers at the MIT's Senseable City Lab analyzed the 170 million taxi trips taking place in New York over the course of a year and showed that if people shared rides, the number of trips could be reduced by 40% with minimal inconvenience to the people. This would not only save riders money, but would have beneficial impact on road congestion, air quality, and the environment in general (http://hubcab.org/).

It is however far from certain that this will be the future model of ownership. Millennials, the generation born between the mid-1980s and 2000s, seem to increasingly embrace this sharing model with car ownership and even driver licenses dropping significantly among this cohort. It is, however, doubtful that many car makers see car sharing as their future business model. The most likely outcome will be a hybrid of different ownership models, from full individual ownership, to subscription and pay per ride models that are already emerging, to own and share models where you can rent out your car similar to how you can already rent out your apartment on Airbnb.

Even if we will not have a fully shared ownership model, it is anticipated that the sharing model, especially in dense urban centers, will grow and we will therefore be able to benefit from the greater efficiency in our road networks. This impacts the way we have to rethink (and potentially reclaim!) our roads and streets, our squares and intersections.



SAFETY

SOCIAL

KEY BENEFITS

*SELECT EACH OF THE BUTTONS FOR DETAILS

ENVIRONMENT

ECONOMIC

LEGISLATION

SOCIAL

ETHICAL

KEY CHALLENGES

*SELECT EACH OF THE BUTTONS FOR DETAILS

TECHNOLOGY

SAFETY

CYBER SECURITY

THE IMPACTS OF CAVS ON OUR CURRENT STREETS AND PUBLIC REALM

EXISTING RESEARCH AND CURRENT IDEAS

CURRENT RESEARCH ON HOW CAVS MAY IMPACT OUR STREETS AND PUBLIC REALM

BuroHappold is not alone in its quest for finding innovative solutions to how we plan our cities for the age of CAVs. However, none of the below mentioned studies have looked at specific cities and locations to grapple with the question.

Name	Authors	Date	Description
Making Better Places: Autonomous Vehicles and Future Opportunities	WSP | Parsons Brinckerhoff in association with Farrells	2016	This study explores the potential benefits and impacts of CAVs by location type, including: city centers; suburban spaces; motorways and rural areas.
Re-Programming Mobility	NYU Wagner, Rudin Center	2016	This report presents a set of four alternative future scenarios set in major American metropolitan cities in the year 2030.
The Death of the Traffic Light	Massachusetts Institute of Technology (MIT), the Swiss Institute of Technology (ETHZ), and the Italian National Research Council (CNR)	2016	These researchers have developed slot-based intersections that could replace traditional traffic lights, significantly reducing queues and delays.
U.K. City Is Designing a Future of Fewer Cars — By Focusing on Its Roads	NextCity	2015	An article setting out the ambitions of Milton Keynes, a UK city that is currently the host of a set of driverless car trials funded indirectly by the UK government.
How Driverless Cars Can Reshape Our Cities	Curbed	2016	Curbed spoke with 5 urban design experts to speculate how CAVs may reshape our cities.
Driver(less) is more	Bjarke Ingels Group (BIG)	2010	BIG's proposal for the Audi Urban Future Award five finalists of the competition.
Interzone	Curbed	2016	As part of a challenge posed by Ford Motor Company, six teams of students at Parsons School of Design in New York imagined mobility as something entirely different.
The Disruption of the Automotive Industry and Reinvention of Mobility	Johann Jungwirth – Chief Digital Officer at Volkswagen AG	2016	A blog post about the mobility revolution that is currently happening.
Autonomous Vehicle Technology – A Guide for Policymakers	RAND Corporation	2016	This report acknowledges that careful policymaking will be necessary to maximise the benefits of CAVs, and aims to assist policymakers in making wise policy decisions.
Connected and Autonomous Vehicle Blog Series	BuroHappold Engineering	2016	A blog series written by BuroHappold's Transport and Mobility team revolving around our research on CAVs.

THE RESPONSE

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The aim of the Global Design Sprint is to bring people with different backgrounds and expertise together and provide a platform to stimulate innovative design thinking in response to a specific question or problem. It is an outcome-driven process completed within a limited time period (in this case, four hours).

The focus of this Global Design Sprint is to reimagine how our streets may look and be used in a future of CAVs, taking into account different user groups and various types of CAVs that may exist. The specific question to tackle is: How can urban streets be reclaimed and reimagined through the introduction of connected and autonomous vehicles? The question will be tackled in the specific urban context of the city in which the Global Design Sprint is being held.

The following six step approach to a Global Design Sprint will guide your group through the process and help you with organizing and structuring a Global Design Sprint, from brainstorming and selecting ideas to designing a solution. The approach is a guide and meant to provide help to get to an outcome within the four hours, but please feel free to bring in your own ideas and working style where preferred.

The outcome of the Global Design Sprint will be a series of images presenting solutions to the question above. As BuroHappold is organizing these Sprints in cities across the world, we expect a wide range of ideas, perspectives, and solutions to the question. BuroHappold will publish the different solutions, film presentations of the best ideas, and present the different perspectives on our website and at a Happold Foundation Cities Conversation event.

THE OVERVIEW

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The Supplies:

You are free to choose how you want to work during the design process (i.e. work on paper, use a computer/tablet, or any other preferred means). We will provide:

- Sticky notes (normal size and super size)
- Timer (one that rings very loud when the time is over!)
- A3 paper
- Water and coffee
- Marker pens

You will need to bring:

- Laptops

Please contact us with any suggestions or facilitation material you may require and our team will try and accommodate where possible.

The Tools:

You will require a number of tools throughout the sprint. If you are attending one of our official sprints these will be provided. If you are holding you own sprint you will be able to download the materials here to print your own.

- Sprint Canvas (page 1 and 2)
- Matrix
- Site Images
- Site Plans
- Rating Sheets
- Crib Sheet

1	Understand	What we already know	Introduction to Sprint	10 (mins)
2	Define	Setting the focus	The Question	5
3	Discover	Be a curious explorer	Discovering and Exploring Key Themes	50
4	Decide	Selection of the best idea	Setting the Challenge	10
BREAK				15
5	Design	Develop a concise design together	Design Stage	90
6	Validate	Hone your design	Analysis and Rating	40

1. UNDERSTAND

BACKGROUND – BEFORE THE SPRINT

Before you take part in the sprint it is highly recommended that you familiarise yourself with the topic of connected and autonomous vehicles. We have made this as easy as possible for you by compiling our research on CAVs into the background section of this interactive brief. This should give you a basic knowledge of:

- The various types of CAVs and when they are expected to be on our urban streets;
- How the technology behind CAVs work;
- The types of ownership models are currently emerging;
- Key benefits and challenges of connected and autonomous vehicles;
- The potential impacts CAVs may have on our streets and public realm;
- A summary of recent studies on CAVs, with more details of each study in the back catalogue.

If you are now familiar with all of the above, you are ready to take part in one of our Global Design Sprints.

*INTRODUCTION TO SPRINT – **15 MINUTES***

When you arrive at your sprint the room will be set up and ready for you to get into your designated teams of 4-5 people, please familiarise yourself with others at the sprint and find the table with your name on it.

At the beginning of the sprint there will be a short introduction to what you are going to be doing, during which time the process of the design sprint approach (shown below) will be explained.

TIP: Take a look at the **sprint canvas** that will be on the wall somewhere in the room—there are two pages, one of which is designed to simplify the whole sprint process and the other to allow your team to dynamically track the progress of your sprint.

GLOBAL DESIGN SPRINT PROCESS -

2. DEFINE

*THE QUESTION – **5 MINUTES***

You will be introduced to the question that you will be responding to during the sprint:

"How can urban streets be reclaimed and reimagined through the introduction of connected and autonomous vehicles?"

Collectively, the ideas resulting from the Sprint will help us to explore what the answer to this question may be.

3. DISCOVER

*DISCOVERING AND EXPLORING KEY THEMES – **50 MINUTES***

At this stage, teams will be provided with the key emerging themes from the brief, relating to the benefits, challenges and physical impacts of CAVs on our streets and public realm.

Having been provided with a **crib sheet** of information from the brief, each team will then be given time to discuss the key themes to understand them and interpret them in their own way to assess what the associated opportunities and challenges are for each theme.

After some time discussing the key themes as a team, the discussion will open out to the entire Sprint where teams will share their thoughts with everyone and continue to develop the discussion.

Having been provided with a crib sheet of information from the brief, each team will then be given time to discuss the key themes to understand them and interpret them in their own way to assess what the associated opportunities and challenges are for each theme under the following topics: economic impacts, social impacts, environmental impacts, policy, future-proofing and technology.

4. DECIDE

*SETTING THE CHALLENGE – **10 MINUTES***

In your team you will take key considerations from the Discover stage forward to build an idea of what you would like to focus on for the rest of the Sprint.

In order to focus your output for the remainder of the Sprint, you will use the **Matrix** to choose a site and a year to focus on, and also to choose some CAV types and user groups to help influence the design of your idea.

TAKE A (SHORT) BREAK

5. DESIGN

*DESIGN STAGE–**90 MINUTES***

It is now time to flesh out the initial idea in more detail. All ideas should be drawn on to site images and maps where relevant and then pinned on your team's designated canvas area. You are welcome to present your ideas in a different way if you feel that it would better suit your idea.

In preparation for the validation stage, as well as to assist and influence you throughout the design of your idea your team may also consider how it meets the key themes:

- The potential benefits and risks associated with the idea;
- The social and economic impact of your idea;
- An idea of what policy could back up your design;
- The environmental impact of your design;
- How your design will stand the test of time;
- What kind of technology could enhance a users experience of your site.

In order to inform the design of the idea your team may revert back to the Matrix and use the types of AVs and users to help influence your design further and add extra elements to your idea.

Teams should take a **mini break** in the middle of the design stage.

6. VALIDATE

*PROJECT ANALYSIS & RESPONSES – **40 MINUTES***

Each team is allocated a MAXIMUM of four minutes to present their developed idea to the other teams in the sprint. The pitches will be timed and no overrunning will be allowed.

Each team will be provided with a ratings sheet for each other team and will be asked to rate each teams idea under the key themes:

- Policy
- Environment
- Social
- Economics
- Future-proofing
- Technology

After rating each team on the above criteria, an explanation should be provided alongside the rating to explain why the rating was given and what additional things they could have considered to increase the rating.

*END OF SPRINT – **5 MINUTES***

All participants will be asked to fill in a feedback sheet asking how the design sprint went and what could be done better next time.

Global Design Sprints will continue to happen across our offices and once they are all completed, ideas will be collated into a report. Some teams will be asked to present their ideas in a presentation that will be recorded and posted on BuroHappold's website.

THE MATRIX

THE SITE

BATH		LONDON		NEW YORK		BERLIN		RIYADH		KUALA LUMPUR	
GREAT PULTENEY STREET	DORCHESTER STREET BUS STATION	EUSTON ROAD	WATERLOO BRIDGE	5TH AVENUE	FDR UNDERPASS AT 34TH STREET	SCHLOSSSTRASSE	FRIEDRICHSTRASSE	OLAYA STREET	PRINCE MAJED BIN ABDULAZIZ ROAD	BANGSAR VILLAGE	BUKIT BINTANG
ST JAMES PARADE JUNCTION	CHOOSE YOUR OWN	OLD STREET ROUNDABOUT	CHOOSE YOUR OWN	STATE STREET	CHOOSE YOUR OWN	HUFELANDSTRASSE/ BUETZOWSTRASSE	CHOOSE YOUR OWN	PRINCE MAMDUH BIN ABDULAZIZ STREET	CHOOSE YOUR OWN	MONT KIARA	CHOOSE YOUR OWN

2020 | 2030 | 2050

STREET FEATURES

BRIDGES | INTERCHANGES AND STATIONS | JUNCTIONS | CROSSING | PARKING | ALLOCATED LANES | PUBLIC REALM

USERS

YOUNG FAMILY | PHYSICALLY IMPAIRED | SENSORY IMPAIRED | PEDESTRIAN | CYCLIST | TOURISTS | COMMUTERS | ELDERLY CITIZEN

CAV TYPES

AUTONOMOUS FREIGHT/LOGISTICS VEHICLE | CONVENTIONAL DESIGN CAV | NOVEL DESIGN CAV | AUTONOMOUS BUS | AUTONOMOUS DELIVERY BIKE

BATH: WHY HAVE WE CHOSEN THESE SITES?

GREAT PULTENEY STREET

This picturesque street sits between the center of Bath and the A36, but does not allow any traffic (other than buses and taxis) to travel directly between the two as Pulteney Bridge is inaccessible to general traffic. It is a residential street with wide pavements and parking on both sides. The roundabout is very wide and spacious with not much traffic passing through, there is also parking on the street corners adjacent to the roundabout. Great Pulteney Street is also a cycle route. This presents a good example to think about how CAVs might affect our roads in residential areas and roundabouts, and how the introduction of CAVs may lead to better connections between the A36 and the center of Bath.

DORCHESTER STREET BUS STATION

This busy street has many buses pulling up along the bus stops outside the bus station throughout the day. Passengers waiting for these buses rest on benches outside the station, adding to the already busy pavement with many people passing through. It is also rather unpleasant for pedestrians due to the emissions from the buses. The bus station has bays for many buses behind it, and these exit via the side of the station onto the busy street. The street also feeds into the junction with St James Parade, which many pedestrians cross to enter Bath city center and visit the high street shops. It would be interesting to think about how CAVs might affect the design of streets with so many bus stations, buses and pedestrians to take into consideration.

ST JAMES PARADE JUNCTION

This junction provides an interesting site to study as it has lots of traffic coming through from St James Parade and the Somerset St junction just before it. There are also cars entering and exiting an underground parking facility from this street. At the junction, traffic can turn into Dorchester Street; those coming from the other direction (mainly buses and coaches) must turn at the junction and enter the A367. The junction is very busy with pedestrians as it leads to the city center and shops. There is a triangular island which pedestrians can be stranded on when the lights change, and at the entrance/exit to the underground parking it is difficult for cars to move due to the flow of pedestrians. With CAVs, this junction could be completely different with regards to how the vehicles exit/enter the junction and interact with pedestrians.

BERLIN: WHY HAVE WE CHOSEN THESE SITES?

SCHLOSSSTRASSE

The Schlossstrasse is the major shopping street of the district “Steglitz-Zehlendorf” and Berlin’s biggest retail location. It is highly frequented and well connected with the rest of the city. The introduction of CAVs could be a great opportunity to eliminate the park road attendant and create more space for pedestrians and roadside green.

FRIEDRICHSTRASSE

The Friedrichstrasse is located in Berlin’s central district “Mitte”, it is one of Berlin’s most popular streets known for its big variety of cultural opportunities and shopping possibilities. The Friedrichstrasse runs from the northern part of old “Mitte” down south to the “Hallesches Tor” in the district “Kreuzberg”. Due to its north-southerly direction it forms important junctions with the east-western axes. The road is very narrow in comparison to other roads with a similar traffic volume and business density. The street segment around the train station Friedrichstrasse is one of Berlin’s hot spots and is connected to many different kinds of transportation modes like the tram, the underground and the regional railway.

HUFELANDSTRASSE/BUETZOWSTRASSE

The corner Hufelandstrasse/Boetzowstrasse in Berlin’s district “Prenzlauer Berg” is close to the park “Volkspark Friedrichshain” and is a mixed residential area with many small cafes and shops. It is planted very densely and has a calm and welcoming atmosphere and is dominated by local residents’ traffic. Through the introduction of CAVs there is the possibility to create an almost car-free zone and eliminate park place seeking.

LONDON: WHY HAVE WE CHOSEN THESE SITES?

EUSTON ROAD

Euston road is one of the most unpleasant thoroughfares in London – both for drivers and pedestrians. Its central connecting function from Regent's Park, via Euston to King's Cross makes it extremely busy throughout the whole day. Reimagining this multi-lane streetscape with the unattractive pavement for the age of CAVs might offer both to car-drivers and pedestrians a more enjoyable passage through this road.

WATERLOO BRIDGE

Waterloo Bridge is a central element to linking major tourist areas north of the Thames, such as Covent Garden, with Southbank. Regardless of the bridge's central role, it is purely dominated by the car and enjoying the great views is rather unpleasant. How might bridges be rethought and used in previously unimagined ways in the age of CAVs?

OLD STREET ROUNDABOUT

The Old Street Roundabout is a central node in east London, where major roads from all cardinal directions come together. The massive extent of this roundabout creates an awkward space in the middle with little appeal to linger. The age of CAVs might transform the whole interchange and give both street and island a new, interlinked purpose.

NEW YORK: WHY HAVE WE CHOSEN THESE SITES?

5TH AVENUE

5th Avenue in Manhattan is one of the most iconic shopping streets in the world, a street with five car lanes. Despite the relatively wide pavements and clear traffic signals, people regularly spill over into the street or jaywalk (any New Yorker's hobby), creating chaos. The junction 5th Avenue and 50th Street, with the Rockefeller Center at one corner of the intersection,and St. Patrick's Cathedral at the other corner, is one of the busiest intersections as commuters, shoppers, and tourists clash. Rethinking this street and more specifically this intersection in an era of autonomous vehicles will draw attention from around the world.

FDR UNDERPASS AT 34TH STREET

One of the most controversial urban planners, certainly in New York, is Robert Moses. Among many other things, he created New York's highway system to support his vision of the automotive city. New York's Franklin Delano Roosevelt (or FDR as New Yorkers call it) along the East River is part of this system. Reimagining a piece of infrastructure clearly built for twentieth century cars such as the FDR its underpass is exciting in and of itself. The section at 34th Street that takes up valuable waterfront land for roads and parking provides a great opportunity to reclaim our streets.

STATE STREET, BROOKLYN

A typical brownstone Brooklyn street provides an opportunity to rethink the residential street in an era of autonomous vehicles – will cars still be parked on the streets in front of the houses? How will kids play outside their front doors? Do streets remain divided between pavement and road space?

RIYADH: WHY HAVE WE CHOSEN THESE SITES?

OLAYA STREET

Olaya Street is one of the busiest streets in Riyadh during rush hour. However, during the day, it rather has the character of one big car park, due to its massive amount of parking lots alongside as well as in the middle of the road. The introduction of CAVs might give this streetscape a more pleasant appeal.

PRINCE MAJED BIN ABDULAZIZ ROAD

This site is located in the busy neighborhood of Ar Rayyan. It provides opportunities to go grocery shopping and offers a variety of restaurants. Considering the dense uses, there might be the possibility to transform this street scape into a more pedestrian friendly meeting place through the introduction of CAVs.

PRINCE MAMDUH BIN ABDULAZIZ STREET

A smaller version of Prince Majed Road, different shops and restaurants can be found here. Through the introduction of CAVs, the ground floor uses could profit from more open space in front of their doors, instead of directly facing a row of parking lots and a narrow pavement.

KUALA LUMPUR: WHY HAVE WE CHOSEN THESE SITES?

BANGSAR VILLAGE – TELAWI 3 STREET

Bangsar Village is a residential suburban neighbourhood as well as a vibrant entertainment and shopping area. Telawi 3 is one of the busiest streets, lined with bars and restaurants on one side and a shopping mall on the other. Heavy car traffic and parked cars on the road result in a dangerous and polluted environment.

BUKIT BINTANG – SULTAN ISMAIL INTERSECTION

The intersection is located in downtown Kuala Lumpur, surrounded by shopping centres, restaurants, hotels and a monorail stop, making it a prime tourist destination. Alleviating congestion and traffic pollution would help the neighbourhood to develop to its full potential.

MONT KIARA – JALAN KIARA

Mont Kiara is one of the many mixed use township area in Kuala Lumpur. It has residential areas as well as offices and educational facilities. Its use patterns result in high congestion during peak hours, with commuters moving in and out of the development through its access roads. Improving its connections and internal traffic will be important to ensure high quality of life for its residents.

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