



# **Connected Places Catapult**

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## **Risk Assessment and Method Statement for Testing in a Controlled Car Park (RAMS3)**

December 2019

Autonomous Valet Parking

# Executive Summary

This document sets out the safety procedures that all participants are required to follow during testing of the autonomous control system in a controlled car park. The requirements and procedures should be read and understood by all involved in the trial, and adhered to at all times.

The Risk Assessment for the trial is also included.

# Table of Contents

<b>LIST OF TABLES .....</b>	<b>3</b>
<b>LIST OF FIGURES.....</b>	<b>3</b>
FUNDING:.....	5
AUTHORISATION: .....	6
RECORD OF CHANGES: .....	6
<b>1. INTRODUCTION .....</b>	<b>7</b>
OVERVIEW .....	7
TRIAL DESCRIPTION .....	7
<b>2. METHOD STATEMENT .....</b>	<b>8</b>
SCENARIOS .....	9
LIMITS OF OPERATION .....	10
MANAGING THE TRIALS.....	12
CONTROL OF THE ENVIRONMENT.....	12
OPERATIONAL REQUIREMENTS FOR THE TRIAL.....	13
EMERGENCY PROCEDURES.....	15
DEACTIVATING AUTONOMOUS MODE .....	15
<b>3. RISK ASSESSMENT.....</b>	<b>18</b>
<b>4. RAMS SIGN-OFF .....</b>	<b>26</b>
<b>5. REFERENCES.....</b>	<b>26</b>

## List of Tables

Table 1 Trial Safety roles and responsibilities .....	9
Table 2 List of operational requirements extracted from the AVP Requirement Capture document. ....	15
Table 3 Risk Assessment Overview .....	18
Table 4 Risk Assessment.....	24
Table 5 Sign-Off .....	26
Table 6 References .....	26

## List of Figures

Figure 1 A car navigates to a given spot on different parking scenarios (see section 2 for further details) using a map for localisation and navigation, and a path planner, motion control for parking .....	8
Figure 2 The autonomous system can be switched off by turning the black switch (centre) anticlockwise. The Safety Driver can deactivate the system by pressing the red button on the dash. (image courtesy of StreetDrone).....	16

Figure 3 The Safety Driver can deactivate the system by pressing the red button on the dash (image courtesy of StreetDrone)..... 16

Figure 4 The system will be deactivated if the red key is removed from its socket (image courtesy of StreetDrone)..... 17

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Any entity seeking to conduct autonomous vehicle trials will need to develop and publish a safety case specific to their own trials (as specified by the government’s Centre for Connected & Autonomous Vehicles (CCAV) Code of Practice for Automated Vehicle Trialling) and gain permission to do so.

This document has 27 pages including the cover.

## FUNDING:

The Autonomous Valet Parking project is part-funded by the Centre for Connected and Autonomous Vehicles (CCAV), delivered in partnership with Innovate UK. It is part of the government’s £100 million Intelligent Mobility Fund, supporting the Future of Mobility Grand Challenge.

As a key part of the UK government’s modern Industrial Strategy, the Future of Mobility Grand Challenge was announced in 2017 to encourage and support extraordinary innovation in UK engineering and technology, making the UK a world leader within the transport industries.

This includes facilitating profound changes in transport technologies and business models, to make the movement of people, goods and services across the nation greener, safer, easier and more reliable.

**Innovate UK**



**Centre for Connected  
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RECORD OF CHANGES:

RELEASED TO	VERSION	REASON FOR CHANGE	DATE
Parkopedia	0.1	Initial Draft (Derived from RAMS2)	15/02/19
Parkopedia	0.2	Updated after Parkopedia Review	28/02/19
Parkopedia	0.3	Updated in preparation for trials	08/10/19
Parkopedia	1.0	Final Release	18/11/19
Parkopedia	1.1	Ready for Publication	09/12/19

# 1. Introduction

## Overview

The purpose of this Risk Assessment and Method Statement is to ensure that the people carrying out the trial:

- Carry out the trial in a structured and controlled manner.
- Understand the hazards and risks associated with each sequence of the trial.
- Use the controls specified to reduce the risk of injury, ill health or damage.
- Carry out the trial safely.

The Safety Case for the trial considers both 'System Safety' (i.e. is the system designed to behave in a safe way and be robust against hazardous failures) and 'Operational Safety' (i.e. the external controls applied to ensure safety during trials). As an R&D trial, it is not feasible to ensure safety solely through robust engineering and testing of the system, and therefore Operational Safety becomes key to controlling hazards.

This Risk Assessment and Method Statement covers only the Operational Safety aspect of this Trial. It therefore provides the consortium with an understanding of the Trial safety by describing and communicating safe systems of work and summarising the output from Trial Risk assessments.

The management of the trials is the responsibility of Parkopedia, as lead partner within the consortium.

All safety drivers and participants should be made aware of the RAMS content prior to tests, demonstrate their knowledge and capability in acting accordingly, before signing this document.

## Trial Description

This Trial tests the performance of the StreetDrone vehicle fitted with the Autonomous Valet Parking (AVP) control system in a controlled car park environment, following successful completion of the previous phase of testing in a controlled environment (described in the RAMS2 document). Initial testing of the system within a car park must be done in an area segregated from public access, where the vehicle will follow a predetermined route from a 'drop-off' point near the carpark entrance to the area where the vehicle will park. There must be a safety driver within the vehicle who is ready and able to take control at any time and optionally, one marshall can be present.

Testing will take place to assess the ability of the vehicle to follow a path to a parking space, enter and leave the parking space, as illustrated in Figure 1.

A stationary object will be included to test the ability of the 'Safety Cage' within the system to brake the vehicle to a stop to avoid a collision. However, the vehicle will not be required to react to moving objects and will not be required to adjust its path in response to any obstacles, and the track shall be clear other than obstacles specifically present as part of test cases to verify the Safety Cage functionality. Preliminary tests will check the Safety Drivers ability and capacity to take control, and familiarity with the system.

For further details of the test plan, refer to the document "Trials Plan - Testing in a Car Park".

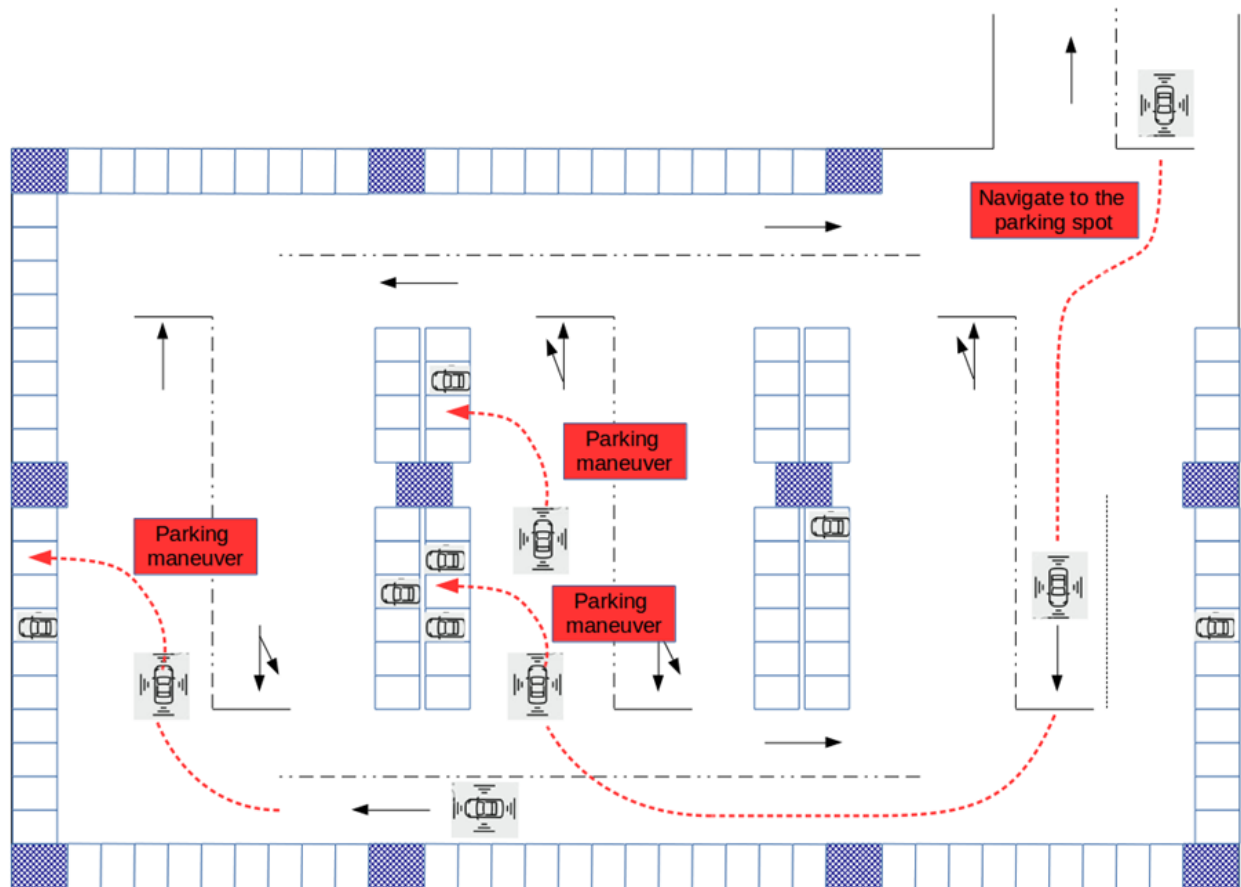


Figure 1 A car navigates to a given spot on different parking scenarios (see section 2 for further details) using a map for localisation and navigation, and a path planner, motion control for parking

## 2. Method Statement

### Safety roles and responsibilities

The supervision of the day-to-day trial operation and the monitoring of the safety arrangements are under the responsibility of Parkopedia, with CPC having responsibility for authoring this RAMS document and ensuring that the test plan is compatible with it. The designated persons in charge for the duration of the trial are:

Role	Safety Responsibilities	Individual
Trial Manager	Overseeing and signing off the test including the Test Plan and this Method Statement. Not necessarily required to be present during every testing session.	Maysun Hassanaly (CPC) Lovedeep Brar (CPC)
Trial Coordinator	Overseeing trial on the day and managing those involved.	Brian Holt (Parkopedia)

Role	Safety Responsibilities	Individual
	In event of emergency will lead and direct all parties. Oversees vehicle safety checks and charging.	
First Aider	To provide first aid if required	Brian Holt (Parkopedia) Adrian Bedford (Parkopedia)
Marshalls (optional)	Ensuring access to the site is controlled	Maysun Hassanaly or Lovedeep Brar (CPC)
Safety Driver	Responsible for monitoring the system and intervening when necessary to ensure safety. Requires detailed knowledge of system limits	Adrian Bedford (Parkopedia)
Trial Engineer	Responsible for monitoring and inputting data to all computer/ tablet/ phone app interfaces, to ensure safety driver isn't distracted by this task. Must warn safety driver if system malfunction identified	Punnu Phairatt (Parkopedia)

*Table 1 Trial Safety roles and responsibilities*

Over and above the role descriptions in Table 1, everyone involved in the trial has a Health & Safety role and the duty to report any hazard or unsafe situation, must have knowledge of and follow the risk assessment included in Section 3 and shall support one another in mitigating any unsafe situation.

The Trial Coordinator, a Marshal, the Trial Engineer or the Safety Driver may stop the trial at any point if they are concerned that the requirements of this document are not being met or that safety is being compromised in some other way; the trial may only proceed if all persons in these roles are in agreement (i.e following the procedures laid out in this document and the Requirements document).

## Scenarios

The trial shall be limited to a controlled area within the car park where marshalls and signage/ barriers will be used to prevent public access (this will have been agreed with the organisation responsible for the car park in advance). The testing shall be to demonstrate the ability to park in an empty parking space where the spaces on either side are also empty, to confirm the ability to plan and follow a suitable path and successfully locate the parking space. The testing shall also incorporate leaving the parking space. Optionally, the vehicle may be tested reversing into the space and driving forwards to exit it, driving forwards into the space and reversing out, or in both orientations. However, if the vehicle is only tested in one orientation at this stage, it must not be tested parking in the other orientation at a later stage of testing.

Note that the Renault Twizy base vehicle is significantly narrower than a typical car, allowing a greater error margin and more time for the safety driver to make corrections if required. Avoidance of dynamic obstacles are outside the scope of the AVP project because the purpose of the project is to develop and test maps for navigation and localisation.

Testing will start from a 'drop off' point (to imitate the use case of a user dropping off the car for a commercially available autonomous valet parking service), travelling through a controlled area where the

vehicle will park in a parking space, then exiting the parking space and travelling back to a 'pick up' point, again requiring movement through an area that is non-accessible to the public. The vehicle must be accompanied by at least one marshall if travelling through publicly accessible areas.

Finally, once testing in the car park is proven safe and achievable, the AVP mobile application will be tested on the vehicle. The mobile application supports the system and commands the vehicle.

The following features of the AVP app will be tested:

- Park
- Summon
- Stop
- State check

The test will start at a designated drop-off bay. To start the test, the trial coordinator or a marshall (acting as the user) will open the AVP application. They will use the AVP app to instruct the vehicle to park in a pre-designated spot. Once the vehicle is parked in the desired spot, the marshall/trial coordinator will summon the vehicle to come back to the drop-off point (also used as pick up point) using the AVP app. During this time, the Safety Driver will stay in the vehicle and monitor the path, ready to take control at any time. Vehicle will be secured by password access for communication between vehicle and app.

The app will also feature a stop functionality, to stop the vehicle in an emergency case. This feature will be tested as well to check the vehicle performs the safe stop routine. The state functionality will be tested as well to check the state of parking and location with the help of a visual map indicating where the vehicle is.

The system is not designed to adjust its path in response to dynamic objects, and therefore the safety driver should immediately halt the vehicle if any other car park users stray close to the AVP vehicle. This reduces ambiguity for the Safety driver, as there is clarity that the system is not designed to react to other cars, pedestrians etc., and therefore there will be no temptation for the safety driver to delay intervening to assess the vehicle's autonomous response.

## Limits of Operation

### Vehicle:

The vehicle used for the test is a Renault Twizy modified for autonomous driving by StreetDrone, with the autonomous control system provided by the AVP consortium.

For the trial, it has been confirmed that no additional hardware beyond that on the type-approved base vehicle shall be located in an area that could be contacted by the head or torso of any vehicle occupant or pedestrian in the event of an accident. As a production vehicle, it is reasonable to assume that all unmodified aspects of the vehicle are acceptably safe, meaning that there is no need to repeat any of the safety tests undertaken using the Type-Approval process.

### Weather variation and visibility:

The trial will happen during daylight hours with good visibility. Facilitators shall monitor weather during the trial. If the trial experiences adverse weather such as heavy rain or snow, which could hinder driver safety/wellbeing, the trial shall be postponed. However, the trial may proceed in light to medium rain. If

the trial is taking place in a covered car park (e.g. multi-storey), it must be ensured that there is adequate lighting throughout the test area such that the vehicle sensors, the safety driver and the marshalls have adequate visibility.

### **Road Rules:**

The safety driver shall not use their mobile phone while the vehicle is in motion, control any the equipment (e.g. radio) or eat while driving. A Trial Engineer will be present at all times to monitor data and make computer inputs as required. This role may be done from within or outside the vehicle; however, if the Trial Engineer is outside the vehicle, they must have a radio/ walkie-talkie or other such means to communicate verbally with the driver.

No safety driver shall drive for more than two hours continuously without taking a break of at least half an hour. The safety driver and/or the Trial Engineer have the right to stop the trial drive at any time when they do not feel comfortable. If the safety driver feels it necessary, they will take a break to maintain concentration.

The vehicle shall not exceed 6 mph whilst driving autonomously, and the safety driver shall override manually if they feel that the speed, acceleration or path of the vehicle are unsafe. The vehicle speed shall also be kept low enough that the vehicle can perform autonomous emergency braking when a hazard is detected within the 'Safety Cage'; due to the limited range of the ultrasonic sensors, it may be necessary to restrict the maximum speed to less than 6mph to ensure that the vehicle is able to stop for all hazards, bearing in mind the time required for the system to track an object, decide a response, and actuate the brakes.

When carrying out the actual parking manoeuvre (as opposed to navigating towards the area where the parking space is), the vehicle shall not exceed 5mph (2.2m/s).

### **Safety Driver(s):**

The Safety Driver of a vehicle operating autonomously shall remain alert and continue to monitor the vehicle at all times while the vehicle is in autonomous mode (including when the vehicle is stationary). They shall ensure that all driving is in accordance with this Method Statement, the Highway Code where it is applicable to parking scenarios, and with the Safety Driver's own subjective judgement of what feels safe, which may require intervention to override the autonomous system.

This intervention can be achieved through applying an input to the steering wheel, brake or accelerator, or alternatively by disengaging the autonomous system (this can be achieved with a 'soft' switch to trigger the system to change to an off state, or a 'hard' switch that physically breaks the electrical connection to the autonomous system).

All Safety Drivers must hold a current UK Driving License and must be suitably fit to drive and not aware of any medical reason why they should not be responsible for the vehicle. Safety Drivers must be familiar with the contents of this Method Statement, including the scope of the testing, the system limitations and the means to disable or override autonomous control. Safety Drivers must have experience of operating the vehicle in a Controlled Environment on a private track (as described in RAMS 2 and the Test Report) before being responsible for the vehicle in a real car park, with this including practical experience of overriding the system. Any new safety drivers joining during the car park testing phase must therefore undergo track testing in accordance with RAMS 2 beforehand, in order to gain experience.

### **Mobile Application**

The mobile application will need sufficient GSM bandwidth to allow user interface on the mobile application. Prior to testing, car park connectivity will be checked.

## **Managing the Trials**

The study procedure shall be followed at all times ensuring:

- A briefing is done on each day before the trials to ensure all participants understand the aim, roles, and emergency procedures
- Only the Safety Driver can drive the vehicle, and before driving, this person should be familiar with all details in the vehicle.
- Testing will always be conducted with at least 1 Trial Engineer in attendance at all times (in addition to the safety driver).
- Other personnel on the site in the vicinity of the vehicle must always be aware of the vehicle movement and intended direction.
- The trial shall only take place within operational limits defined in this section and in section 2.3
- Marshalls can be provided to ensure that the area is not accessible to the public; if any members of the public do enter the area, the trial shall be halted immediately (the safety driver must be notified, and must take manual control and stop the vehicle). If testing in a publicly accessible area, at least one marshall shall accompany the vehicle, and shall stop the trial if any members of the public approach the immediate vicinity of the vehicle.

### **Trial drive:**

The coordinator shall ensure that the Safety Driver is familiar with this Method Statement. The facilitator shall stop the trial if they feel that the test is proceeding in a manner that they deem unsafe.

Parkopedia are responsible for and have arranged insurance to cover the trials.

## **Control of the Environment**

The controlled area where autonomous parking will take place shall be secured to ensure it cannot be accessed by members of the public or other organisations; it may be secured by physical means (e.g. fencing) or by clear markings (e.g. traffic cones and 'keep out' signs). In the latter case, marshalls must have a clear view of the perimeter of the test area to ensure the signs are obeyed, and the number of marshalls should therefore be selected with this requirement in mind.

Due to the fact that the vehicle uses an R&D system at an early stage of the development and testing process, it would not be acceptable for the vehicle to be exposed to a situation where it has to take emergency action to prevent a collision with a person or vehicle straying onto the track. It is therefore the responsibility of the Trial Coordinator to ensure all of the following:

- All personnel who are permitted to be on site as part of the test must be made aware that they must stay well clear of the path of the vehicle
- Sufficient marshals, barriers and signage shall be provided to ensure that it is impossible for a person who is not part of the test to access the site without being detected. This includes accessing as a pedestrian, a cyclist or a motorist.
- The trial will be stopped immediately if any person enters the path of the vehicle OR if a person accesses the site without permission. In these cases, any member of the trial team should alert the rest of the team by the fastest means available (radio, call, shout).
- All individuals within the area marked off for the trial to take place shall be wearing a high visibility vest or jacket at all times
- All personnel shall maintain awareness of the position and motion of the vehicle (e.g. not be engrossed in their mobile phone, conversation etc.) when in the immediate vicinity of the test path (it is permissible for persons onsite to be engaged in other tasks if away from the path of the vehicle; this will be essential for engineers to monitor data on laptops etc.)

## Operational Requirements for the Trial

Table 2 shows the requirements for the AVP project, as found in the Requirement Capture document, that relate to safety of the trials and specify how the trials should be conducted in a safe manner (Operational Requirements). Requirements not related to safety, and requirements related to how the system itself should perform (System Requirements) are not included, as this Method Statement refers to how to deploy the vehicle safely rather than how to engineer the vehicle.

These requirements are up-to-date as of 18/11/2019, and are maintained within the Requirement Management Spreadsheet, which is a live document and therefore should serve as the single source of the latest version of the requirements.

A review of the Highway Code and the CCAV Code of Practice for autonomous vehicle testing was undertaken within CPC, which was similarly used to generate a set of System Requirements and Operational Requirements to conduct a safe trial of an autonomous vehicle.

Note that the tables contain requirements that were not present in the RAMS2 document that applied to the previous phase of testing; these requirements have been added as they become relevant when testing in a car park environment (as opposed to a private track).

ID	Requirement Text
36	In the event of an error condition (30cm deviation), the system will handover control to the safety driver or come to emergency stop & come out of autonomous mode
37	In case of a breach of the virtual safety cage, the vehicle will come to an immediate stop and handover control to the safety driver
42	The testing area shall be made safe for any kind of agreed user (car park users, staff, safety driver, car driver, media etc)
129	The trial shall happen in good visibility

ID	Requirement Text
50	The maximum driving speed is 10 mph for manual Mode The maximum driving speed is 5 mph for Autonomous Mode
38	The safety driver must take manual control in the events of failures or activities that the vehicle cannot support (eg. Stop the vehicle to check something or speak to the team)
39	The safety driver must be able to take control of the vehicle at all times, when handed over
54	The safety driver shall be able to drive, is licensed, has a good vision and is a healthy individual (shall not be under the influence of illegal drugs or legal medicines that preclude driving (for medicines that can cause drowsiness and could potentially be incompatible with driving, the discretion of the driver should be used to judge whether they are affected), and shall not exceed the legal limit for blood alcohol concentration)
130	The safety driver shall not drive for more than 2 hours continuously without taking a break of at least half an hour.
55	The safety driver shall be trained on the functionality of the system
56	The safety driver shall be trained to drive the vehicle in a safe manner
57	The safety driver shall be trained according to the requirements of the Car Parking operator
100	Vehicle shall not be capable of powered movement when any e-stop (autonomous stop & manual by safety driver in Vehicle) is engaged.
61	Mobile reception (or wi-fi) shall be available in the pick-up/drop-off location
92	The vehicle shall not be capable of powered movement when the app stop functionality is engaged
93	The app must include a "park" functionality to be tested
94	The app must include a "summon" functionality to be tested
96	The app must include a "state" functionality to be tested
45	Marshalls shall be suitably trained/briefed
44	Sufficient number of marshalls to ensure minimal risk of collision with other car park users
34	Each module shall consider their inputs and raise an error condition if outside of the normal range
135	Testing shall be stopped at any time that the Event Data Recorder is unable to function
131	All Safety Drivers shall have no more than 6 penalty points on their driving license
132	All Safety Drivers shall have never been disqualified from driving
136	The vehicle shall be inspected to ensure it is in good condition at least once per 5 days of testing

ID	Requirement Text
	(e.g. check tyre pressures, all equipment secure, fluid levels correct etc.)
133	The Safety Driver shall gain familiarity with the vehicle on a private test rack before testing on the public road
134	The Safety Driver must wear seatbelts at all times that the vehicle is in motion

*Table 2 List of operational requirements extracted from the AVP Requirement Capture document.*

This only lists the requirements that are safety related and refer to the operation of the system in a safe manner, as opposed to specifying the system itself

It is the responsibility of the Trial Coordinator to ensure that all personnel involved in the trial are familiar with these requirements.

## Emergency Procedures

- **Vehicle breakdown / out of charge:** Trial is stopped immediately. The vehicle presents no further threat as it is unable to operate. However, if multiple autonomous vehicles are being tested simultaneously, other vehicles shall be stopped until the affected vehicle has been removed from the track or repaired/ recharged.
- **Accident:** Trial is stopped immediately. 999 Emergency Services support will also be requested if needed, and the designated first aider will perform any required first aid. All personnel should maintain a safe distance from any vehicle involved in an accident unless absolutely necessary to approach the vehicle for purposes of rescue, recovery or damage limitation. This is to reduce the risk of injury due sharp surfaces, fire etc. The accident shall not be communicated to the media other than through communications agreed by the whole consortium.

## Deactivating Autonomous Mode

All safety drivers and any engineers travelling in the vehicle shall be familiar with the methods of deactivating autonomous mode such that the vehicle functions as a standard Renault Twizy. These methods are detailed in the StreetDrone User Manual, and are as follows:

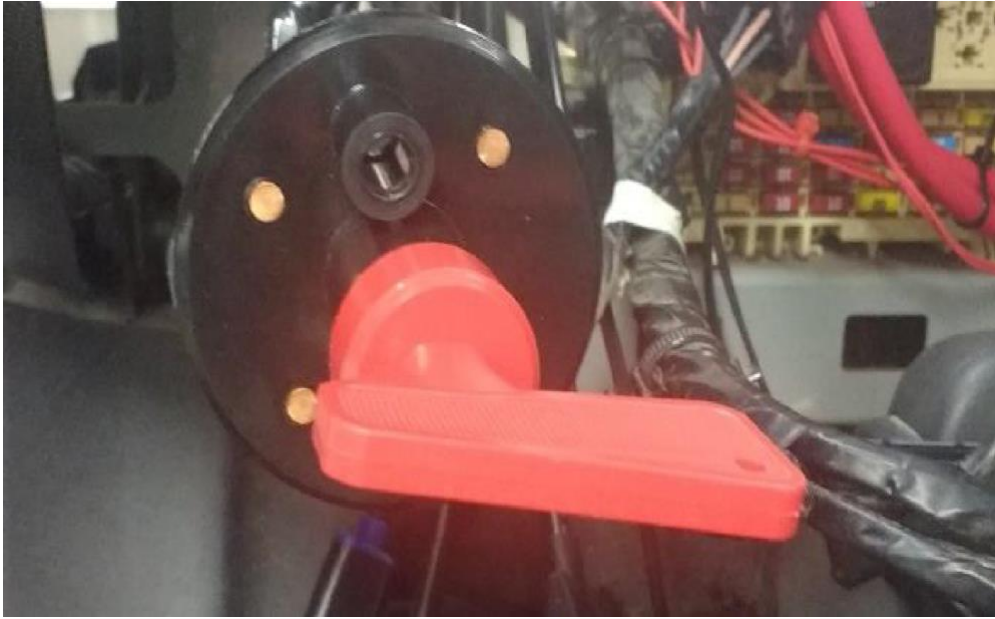
- Switch the black switch to the left (see Figure 2)
- Set Torque and Steer Request bit to False using the PX2 Customer CAN connection.
- Press the red button on the dash (see Figure 4)
- The Driver can retake control of the vehicle and cancel autonomous mode by exerting a small force on the steering, brake. In order to use the throttle, one of: red button, black switch or key have also to be used.
- Unplug the left-hand side red key (see Figure 4)
- Faults detected in sensors or loss in CAN communications will also deactivate autonomous mode



*Figure 2 The autonomous system can be switched off by turning the black switch (centre) anticlockwise. The Safety Driver can deactivate the system by pressing the red button on the dash. (image courtesy of StreetDrone)*



*Figure 3 The Safety Driver can deactivate the system by pressing the red button on the dash (image courtesy of StreetDrone)*



*Figure 4 The system will be deactivated if the red key is removed from its socket (image courtesy of StreetDrone)*

### 3. Risk Assessment

<p><b>PROJECT OVERVIEW</b></p> <p>The Autonomous Valet Parking consortium consists of Parkopedia (lead partner), University of Surrey and Transport Systems Catapult, and is looking to deliver a proof of concept involving an autonomous vehicle that will fulfil the valet parking function by navigating the vehicle to a free parking space, executing the parking manoeuvre automatically and responding to a summon request by navigating the vehicle back to the driver.</p> <p>The consortium's key objective is to identify obstacles to full deployment of Autonomous Valet Parking through the development of a technology demonstrator. It aims to achieve this goal by:</p> <ol style="list-style-type: none"> <li>1. Developing automotive-grade indoor parking maps required for autonomous vehicles to localise and navigate within a multi-storey car park.</li> <li>2. Developing the associated localisation algorithms – targeting a minimal sensor set of cameras, ultrasonic sensors and inertial measurement units – that make best use of these maps.</li> <li>3. Demonstrating this self-parking technology in a variety of car parks.</li> <li>4. Developing the safety case and prepare for in-car-park trials.</li> <li>5. Engaging with stakeholders to evaluate perceptions around AVP technology.</li> </ol> <p><b>ACTIVITY BEING ASSESSED:</b></p> <p>The activity being assessed is the <b>autonomous driving of the AVP vehicle in a real car park</b></p> <p>The StreetDrone ONE vehicle, which is derived from a road certified Renault Twizy vehicle, will be autonomously driven within a car park at low speed (5mph, 2.2m/s) ) in order to confirm basic functionality of the vehicle and verify that the requirements have been met. Testing will take place in a controlled area (with no public access, no other parked or moving cars). The vehicle must be accompanied by at least one marshall during all testing in a public area, and testing must cease if any members of the public are able to breach the safety cordons put in place and approach the vicinity of the AVP vehicle. During the testing, the safety driver will be in radio communication with the engineer who will monitor the equipment. The activity is scheduled to take place from November 2019 to February 2020.</p>	<p><b>Assessed by:</b> <b>Maysun Hassanaly</b></p> <p><b>Date:</b> <b>18/11/2019</b></p>	<p><b>Endorsed by:</b> <b>Brian Holt</b></p> <p><b>Date:</b> <b>21/11/2019</b></p>
<p><b>Who might be harmed:</b></p> <ul style="list-style-type: none"> <li>• StreetDrone ONE driver / passenger (e.g. engineer)</li> <li>• Authorised personnel on the test site (e.g. marshals, other facilitators that are part of the project)</li> <li>• Unauthorised persons on the test site (e.g. members of the public or other organisations who don't have permission to be there)</li> </ul> <p>Any accidents or near miss incidents will be logged and appropriate actions taken before recommencing the test</p> <p><b>How many exposed to risk: &lt;5</b></p>		

Table 3 Risk Assessment Overview

Hazards Identified (state the potential harm)	Existing Control Measures	S	L	Risk Level	Additional Control Measures	S	L	Risk Level
<p><b>Hazard</b> – Collision of vehicle with solid obstacle</p> <p>a) The collision of the vehicle with another vehicle.</p> <p>b) The collision of the vehicle with carpark furniture (i.e. posts, bollards) or other large obstacles.</p> <p><b>Potential harm -</b></p> <p>Like with any powered road vehicles there is the potential for a fatality or serious injury in the event of an accident. However, given the speeds involved this would be extremely unlikely as occupants of the test vehicle or other vehicles would be well protected</p> <p>Other outcome possibilities include cuts, bruises, broken bones, and whiplash injuries.</p>	<p><u>Hardware and Software Controls Measures</u></p> <p>The vehicle has a number of complex hardware and software monitoring systems to ensure safe operation. These include:</p> <ul style="list-style-type: none"> <li>Vehicle Footbrake (usual manual vehicle controls)</li> <li>Various methods to disable autonomous control (detailed in Method Statement)</li> <li>Steering wheel</li> </ul> <p><u>Other Control Measures:</u></p> <ul style="list-style-type: none"> <li>The vehicle has been tested away near obstacles until acceptable performance has been demonstrated (Test Report)</li> <li>The test will be in a controlled area, secured so that unauthorised vehicles cannot access it (barriers, signage, marshalls etc.), until suitable performance has been demonstrated. If any vehicle enters this area, testing shall cease.</li> <li>Any obstacles in the test area shall be stationary, and the vehicle shall not be required to adjust its path to avoid them.</li> <li>The vehicle will be operated at speeds of 5mph (2.2m/s) or below</li> <li>Seat belts for the Safety Driver and the Engineer</li> <li>Safety driver(s) must have a valid full UK driving license or an overseas full valid driving license with authorisation to drive on UK roads</li> </ul>	4	2	8	<ul style="list-style-type: none"> <li>Training for Driver</li> <li>Validate system safety (LiDAR and USS)</li> </ul>	2	2	4

Hazards Identified (state the potential harm)	Existing Control Measures	S	L	Risk Level	Additional Control Measures	S	L	Risk Level
	<ul style="list-style-type: none"> <li>In the event of a collision the trial coordinator shall immediately contact the emergency services (if required)</li> <li>Any accidents or near miss incidents will be logged in the Incident Reporting Spreadsheet and appropriate actions taken before recommencing the activity.</li> <li>A first aid kit will be available in the event of a minor injury. This will be held and used by their first aider trained staff.</li> <li>Raw data from the sensors shall be logged to a suitable database such that in the event of an accident it is possible to replay the scenario and investigate the root cause of the autonomous system failure.</li> <li>As the control system is an R&amp;D prototype, it is expected to produce erroneous control outputs. However, the presence of a Safety driver, plus suitable space around the vehicle to allow the safety driver to regain control, mean the risk of an incident is low.</li> </ul>							
<p><b>Hazard</b> – Collision of vehicle with a Vulnerable Road User (e.g. pedestrian, cyclist)</p> <p><b>Potential harm</b> - Like with any powered road vehicles there is the potential for a fatality or serious injury in the</p>	<p><u>Hardware and Software Controls Measures</u></p> <p>The vehicle has a number of complex hardware and software monitoring systems to ensure safe operation. These include:</p> <ul style="list-style-type: none"> <li>Vehicle Footbrake (usual manual vehicle controls)</li> <li>Various methods to disable autonomous control (detailed in Method Statement)</li> </ul> <p><u>Other Control Measures:</u></p>	4	1	4	No further action is necessary.			

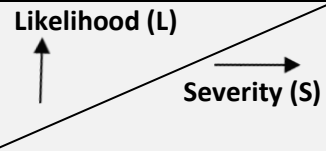
Hazards Identified (state the potential harm)	Existing Control Measures	S	L	Risk Level	Additional Control Measures	S	L	Risk Level
<p>event of an accident. However, given the speeds involved, death would be an unlikely outcome. Other outcome possibilities include cuts, bruises, broken bones, and whiplash injuries</p>	<ul style="list-style-type: none"> <li>The vehicle shall be tested away from obstacles it could collide with until acceptable performance has been demonstrated</li> <li>The test will be in a controlled area, secured so that unauthorised vehicles cannot access it (barriers, signage, marshalls etc.), until suitable performance has been demonstrated. If testing does take place in public areas after this, the vehicle shall be accompanied by a marshall, and testing shall cease if pedestrians or other vulnerable road users are in the vicinity of the AVP vehicle</li> <li>The vehicle will be operated at speeds of 5mph (2.2m/s) or below</li> <li>Safety drivers must have a valid full UK driving license or an overseas full valid driving license with authorisation to drive on UK roads</li> <li>All personnel shall wear a high visibility vest</li> <li>Any pedestrians performing a role within a test case shall be familiar with the intended movements within that test case and the safety measures described in this document, and shall maintain awareness of the vehicle motion and readiness to take evasive action. Test cases shall not include emergency avoidance, meaning the AVP vehicle should maintain a safe distance from the pedestrian at all times</li> </ul> <p>All personnel outside the vehicle shall be aware of the intended path of the vehicle, and shall only engage in other activities that would distract</p>							

Hazards Identified (state the potential harm)	Existing Control Measures	S	L	Risk Level	Additional Control Measures	S	L	Risk Level
	<p>their attention (e.g. using laptop/ tablet) if well away from the immediate test area.</p> <ul style="list-style-type: none"><li>● All personnel outside the vehicle shall be aware of the intended path of the vehicle, and shall only engage in other activities that would distract their attention (e.g. using laptop/ tablet) if well away from the immediate test area</li><li>● In the event of a collision the trial coordinator shall immediately contact the emergency services (if required)</li><li>● Any accidents or near miss incidents will be logged in the Incident Reporting Spreadsheet and appropriate actions taken before recommencing the activity.</li><li>● A first aid kit will be available in the event of a minor injury. This will be held and used by driver (first aider trained staff).</li><li>● Raw data from the sensors shall be logged to a suitable database such that in the event of an accident it is possible to replay the scenario and investigate the root cause of the autonomous system failure.</li></ul> <p>As the control system is an R&amp;D prototype, it is expected to produce erroneous control outputs. However, the presence of a Safety driver, plus suitable space around the vehicle to allow the safety driver to regain control, mean the risk of an incident is very low.</p>							

Hazards Identified (state the potential harm)	Existing Control Measures	S	L	Risk Level	Additional Control Measures	S	L	Risk Level
<p><b>Hazard</b> - Fire</p> <ul style="list-style-type: none"> <li>• <b>Potential harm</b> — Burns, complex chemical fumes, asphyxiation.</li> <li>• There is the potential for a fatality or serious injury in the event of a fire due to carpark environment (i.e. close space)</li> </ul>	<ul style="list-style-type: none"> <li>• Small fires should only be tackled if there is absolute certainty that the fire doesn't involve the vehicle battery or other parts of the powertrain</li> <li>• Only extinguishers appropriate for the type of fire should be used. (Dry powder and CO2 for electrical wiring, not battery)</li> <li>• In the event of a major fire or a fire involving the battery/ powertrain, the emergency services should be contacted via dialling 999.</li> </ul> <p>The powertrain is part of the Renault Twizy base vehicle, and as such has been developed to a level of robustness appropriate for sale to and use by the general public. As such, the likelihood of the vehicle catching fire can be considered to be extremely low.</p>	5	2	10	No further action is possible.			
<p><b>Hazard</b> — Mechanical, electrical, control system failure</p> <p><b>Potential harm</b> — A wide variety of outcomes possible from causing the vehicle to collide to a warning light coming on.</p>	<p>The StreetDrone ONE has a large number of complex hardware and software monitoring systems to ensure safe operation. If any warning systems are activated, the issues will be investigated and any faults rectified before activity can continue.</p> <p>The Renault Twizy base vehicle has been developed to a level of robustness appropriate for sale to and use by the general public. As such, the likelihood of faults occurring in the base vehicle can be considered to be extremely low.</p> <p>As the control system is an R&amp;D prototype, it is expected to produce erroneous control outputs. However, the presence of a Safety driver, plus suitable space around the vehicle to allow the safety driver to regain control, mean the risk of an incident is very low. The safety override system will be checked at the start of each day of testing to ensure full functionality of the system.</p>	3	2	6	No further action is possible.			

*Table 4 Risk Assessment*

**RISK MATRIX: (To generate the risk level).**

Very likely 5	5	10	15	20	25
Likely 4	4	8	12	16	20
Possible 3	3	6	9	12	15
Unlikely 2	2	4	6	8	10
Extremely unlikely 1	1	2	3	4	5
Likelihood (L)  Severity (S)	Minor injury – No first aid treatment required 1	Minor injury – Requires First Aid Treatment 2	Injury - requires GP treatment or Hospital attendance 3	Major Injury/damage to vehicle 4	Fatality/ cat C or D damage to vehicle 5

**ACTION LEVEL: (To identify what action needs to be taken).**

POINTS:	RISK LEVEL:	ACTION:
1 – 5	NEGLIGIBLE	No further action is necessary.
6 - 10	MODERATE	Where possible, reduce the risk further
12 – 16	HIGH	Immediate action is necessary
20 - 25	INTOLERABLE	Stop the activity/ do not start the activity

## 4. RAMS Sign-Off

The below sign-off table is for the testing team members to indicate agreement on the information provided by the RAMS for this phase of testing. Once this sign-off is completed, it is then permissible for testing in a car park to proceed, provided that the testing is in accordance with the Safety Plan.

I have received the instructions; I understand them and I am able to fulfil my role as indicated in this document:

Name	Company	Date	I confirm my approval of the RAMS for this stage of testing (Y/ N)
Maysun Hassanaly	CPC	18/11/2019	Y
Lovedeep Brar	CPC	04/12/2019	Y
Brian Holt	Parkopedia	21/11/2019	Y
Adrian Bedford	Parkopedia	21/11/2019	Y
Punnu Phairatt	Parkopedia	21/11/2019	Y

*Table 5 Sign-Off*

## 5. References

Document Name	Owner	Release date and version
Safety Case Summary	CPC	18/11/2019 v1.0
Trials Plan - Testing in a Car Park	Parkopedia	18/11/2019 v1.0
Safety Plan	CPC	18/11/2019 v2.0
Test Report - Testing in a Controlled Environment	Parkopedia	18/11/2019 v1.0
Requirement Management Spreadsheet	CPC	18/11/19 v2.0

*Table 6 References*

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**CATAPULT**  
Connected Places