The Development of Autonomous Vehicles and Its Applications in West Kowloon Cultural District

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Content

• Development of Driverless Technology and Examples
• Social Economic Impacts and Current Issues
• The WKCD’s Driverless Shuttle Pilot Project
Definition of Driverless Vehicles

Driverless Vehicle
- A driverless vehicle is a vehicle that can guide itself without human conduction.

The Technology
- Detect surroundings using a variety of techniques such as:
  - Radar
  - Lidar (Light Detection and Ranging)
  - GPS
  - Odometry (Motion Sensors)
  - Computer Vision, etc.
- Detection of vehicles, obstacles and signage
- Systems interpret sensory information to identify appropriate navigation paths
The Driverless Sensor Technology

Google driving to be driverless
Google's modified Toyota Prius uses an array of sensors to navigate public roads without a human driver. Other components, not shown, include a GPS receiver and an inertial motion sensor.

Laser-guided mapping
A rotating sensor with lasers called a LIDAR on the roof scans more than 200 feet in all directions to generate a precise three-dimensional map of the car's surroundings.

Video camera
A camera mounted near the rear-view mirror detects traffic lights and helps the car's onboard computers recognize moving obstacles—such as pedestrians and bicyclists.

Radar
Four standard automotive radar sensors, three in front and one in the rear, help determine the positions of distant objects.

Position estimator
A sensor mounted on the left rear wheel measures small movements made by the car and helps to accurately locate its position on the map.

Source: Google

NEW YORK TIMES PHOTOGRAPHS BY RAVIN RAHUMAN FOR THE NEW YORK TIMES
Classification of Driverless Technology

NHTSA Automated Vehicle Classification
- Classification established by the National Highway Traffic Safety Administration (NHTSA)
- 5-level system from full human control to full automation

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<td>Driver in complete and sole control at all times</td>
<td>Involves automation of at least 2 primary control functions working in unison (e.g., adaptive cruise control in combination with lane centering)</td>
<td>Driver must be available to take over controls</td>
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<td>Driver can regain control or stop faster than if driving without these driving functions</td>
<td>Enables all safety-critical functions to be automated (incl. steering, throttle, brake). The vehicle monitors any changes in conditions that require a transition back to driver control</td>
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<td>Driver is temporarily relieved of these driving functions</td>
<td>Vehicle is designed to perform all safety-critical driving functions and monitor road conditions for an entire trip (includes both occupied and unoccupied vehicles)</td>
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<td>Driver not expected to take control at any time</td>
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DEVELOPMENT OF DRIVERLESS TECHNOLOGY
History and Development of Driverless Cars

1990s
- Use of camera vision to detect and respond to object movement; Automated Highway
- *e.g.*, VaMP Driverless Car (Germany); NAHSC project

2000s
- Google Self-Driving Project began in 2009
- *e.g.*, Google Self-driving Car (US); DARPA Grand Challenge

2010s
- Tesla’s camera based Autopilot released
- *e.g.*, Tesla Model S (US)

Development of Driverless Technology and Examples

Current Development - Based on market growth projection

- **2015** Passive Autonomous
- Driver and parking assistance systems
- **2020** Limited Autonomous
- Driver intervenes in critical situations
- G2X communication
- Fully autonomous Mercedes S-class
- Google driverless cars
- Renault-Nissan autonomous cars
- **2016** Audi A8 piloted driving
- Mercedes F105 prototype
- **2016-18** BMW i3 semi-autonomous prototype
- **2018** Tesla autopilot mode
- **2017-20**
- **2022** Non-premium OEMs to adapt the semi/full autonomous technology
- **2025** Semi-Autonomous
- Driver attention required with manual override
- **2030** Fully Autonomous
- Driverless cars with no driver backup
- Fully autonomous mode shared-commuting

Source: PwC Ltd., a US market research company
Driverless Vehicles Examples

Driverless Cars Examples

Google Self-driving Car
US

Mercedes-Benz Future Bus
Germany
Driverless Vehicles Examples

Driverless Cars Examples

Catapult Transport Systems
UK

Tesla Model S
US

Driverless Taxi / truck Examples

Robokeko™ (Robot cat)
Japan

Robot Taxi
Japan
Driverless Vehicles Examples

Driverless Car Examples

大白
China

Baidu – BMW Partnership
China

Changan Preton (長安睿騁)
China

SOCIAL ECONOMIC IMPACTS
AND CURRENT ISSUES
Potential Advantages of Driverless Technology

- **Enhancing Safety**
  - Perceiving surrounding environment
  - Elimination of human driver errors

- **Elimination of ability, age factors and driving test**
  - Can be used by the disabled, under / overaged
  - Operation will not be influenced by drunk or drugged drivers

- Saves labour costs

- Reduction in insurance premiums

- Coordination / communications between vehicles allowing smoother rides and increased road capacity

- Reduce the car parking demand for the city

Current Issues

- **Legislation of Driverless Vehicles**
  - Amending regulations on how vehicles are used and maintained
  - Criminal and civil liabilities

**United States**

- Legislatures in automated driving is being considered in the number of States

**Germany**

- Under current laws, self-driven or robot cars are not allowed on Germany’s motorways, because according to the 1968 Vienna Convention on Road Traffic to which the country is enrolled, a human driver must be behind the wheel.

- Testing is however allowed on public roads provided that driver is on board and will take full legal responsibility.

- Present a draft bill on autonomous driving in end July 2016
  - Driver is required
  - Driver’s liability shift
  - Equipped with “black box”
Current Issues

- **Cyber Security**
  - Manual override in case of emergency or malfunction
  - Control system should be “fail safe / virus safe” and protected from unauthorized access

- **Insurance**
  - Should the insurance cover the vehicle? the manufacturer? or the driver?
  - Will premiums be reduced due to the elimination of human error

**United Kingdom**

A Code of Practice for Testing of Driverless Cars was published in July 2015

- Driverless vehicle can be tested on public roads with a driver present, who must take responsibility for the safe operation of the vehicle
- Test vehicles do not need to obtain specific certificates or permits
- Insurance must be arranged to cover the testing

Other Issues

- **Job Reduction**
  - Lack of need for drivers, including lorry and bus drivers

- **Worry of computer crashing or malfunctioning**
  - Resulting in major collision

**The Tesla Autopilot Accident**

A driver was killed in the 7 May 2016 crash of a Tesla Motors car while using Autopilot driving-assist software.
THE WKCD’S DRIVERLESS SHUTTLE PILOT PROJECT

Site Location
West Kowloon Cultural District Overview

- Key design concept in the Development Plan
- Vehicular traffic, ancillary parking, loading/unloading underground
- Free up space for arts and cultural use
- Pedestrian friendly environment at ground level
Phase 1 – Pilot Run at the Park (2018 – 2022)

Non-Peak Period
- Passenger demands lower
- Point-to-point "on demand" service
- Service request performed at designated pick-up points, or via booking hotline / smartphone app.

Peak Period
- Passenger demands higher
- Operated as shuttle service
- Predefined route and stop at fixed stations

Before Completion of M+

After Completion of M+

Phase 2 - Implementation at the whole WKCD
(Upon completion of the Avenue and Waterfront Promenade)

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Peak Period
- Passenger demands higher
- Operated as shuttle service
- Predefined route and stop at fixed stations
In parallel to testing, investigation to the following:

- Suitable license maybe required if pilot run is fare charged
- Insurance maybe required to cover for safety of the general public passengers or any other damages
- Current legislations or regulations may need to be amended

Subject to the satisfaction of all testing results, WKCDA may consider to proceed to Phase 1 pilot run.

### Implementation Time Line

**2017**
- In parallel to testing, investigation to the following:
  - Suitable license maybe required if pilot run is fare charged
  - Insurance maybe required to cover for safety of the general public passengers or any other damages
  - Current legislations or regulations may need to be amended

**2018 - 2022**
- Subject to the satisfaction of all testing results, WKCDA may consider to proceed to Phase 1 pilot run
- Phase 1: Pilot run at the Park

**2022 onwards**
- Phase 2: Implementation at the whole WKCD

*Year of full implementation shall be subject to the development program of WKCD (subject to the completion of The Avenue and Waterfront Promenade)
Testing of Driverless Vehicles in WKCD

Technical Specifications

- **Range per Charge:** ≥ 100km
- **Passenger Capacity:** ≥ 12 (seating and standing)
  Accessible by wheelchair
- **Size (LxWxH):** ≤ 6300 x 2300 x 2000mm
  (TPDM specification for maximum private car)
- **Power:** Electric battery
- **Charge:** ≤ 4 hours (battery should be replaceable to minimize idling time or be recharged during operation)
- **Speed:** 30km/hr (Maximum speed)
  15km/hr (Proposed operation speed)
- **Turning Radius:** ≤ 6m
- **Gradient:** ≥ 15%
- **Navigating System:** GPS, Lidar, Radar, Camera
- **Safety Feature:** Collision avoidance system must be the vehicle, the system should be able to avoid and respond to all pedestrian movements within its operation area.

Proposed Testing Schedule

- **Stage 1:** No obstacles and passengers
  - Test for: • Maneuverability • Ability to follow preset course

- **Stage 2:** With fixed obstacles
  - Test for: • Response to fixed objects such as stationary vehicles, signages, buildings, road kerbs, etc.

- **Stage 3:** With moving objects
  - Test for: • Response to moving objects such as vehicles, bicycles, pedestrians, etc. (objects of different size and speed)

- **Stage 4:** With passengers
  - Test for: • Response to passengers’ request such as ability to stop at designated locations for pick-up / drop-off

- **Stage 5:** With pedestrians, passengers* & obstacles
  - Test for: • Operational performance similar to real life situation

2017 Q1

*Test passengers can be WKCDA’s staffs or volunteers from the public
THANK YOU