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Information technology in a global society
Higher level
Paper 3 – case study: On the road to driverless cars

For use in May and November 2019

Instructions to candidates

- Case study booklet required for higher level paper 3 information technology in a global society examinations.

Foreword

The ITGS case study, *On the road to driverless cars*, is the stimulus material for the research investigation required for May and November 2019 higher level paper 3. All of the work related to the case study should reflect the integrated approach explained on pages 15–17 of the ITGS guide.

Candidates should consider *On the road to driverless cars* with respect to:
- relevant IT systems in a social context
- both local and global areas of impact
- social and ethical impacts on individuals and societies
- current challenges and solutions
- future developments.

Candidates are expected to research real-life situations similar to *On the road to driverless cars* and relate their findings to first-hand experiences wherever possible. Information may be collected through a range of activities: secondary and primary research, field trips, guest speakers, personal interviews and email correspondence.

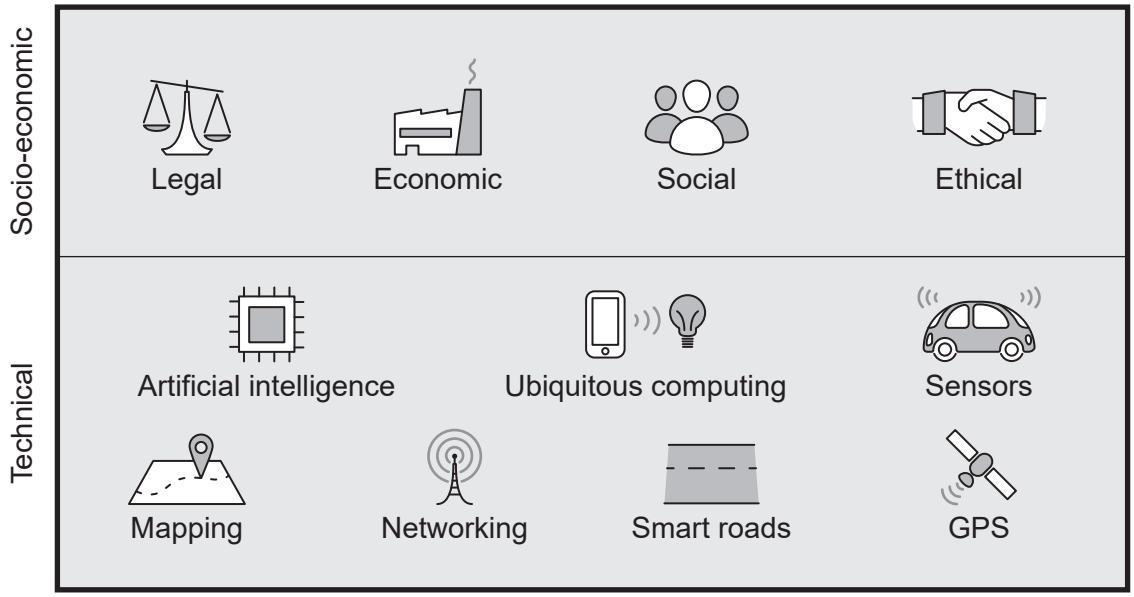
Responses to examination questions **must** reflect the synthesis of knowledge and experiences that the candidates have gained from their investigations. In some instances, additional information may be provided in examination questions to allow candidates to generate new ideas.

Overview

The World Driverless Vehicle Federation (WDVF) is a multinational, apolitical organization that has been set up to promote the research, development and deployment of self-driving vehicles. It is recognized by world bodies and governments, and represents groups from over 75 countries that are interested in the development of driverless vehicles. The WDVF links more than five thousand members from academia and industry. Within the WDVF there are 12 advisory committees and over 50 working groups.

As driverless vehicles form part of a much larger socio-technical system, the WDVF is organized into two tiers: socio-economic and technical, see **Figure 1**. The advisory committees work across both tiers and address the wider issues linked to driverless vehicles, whereas the working groups are more specialized and focus on a particular area of interest, such as developing sensors. Some of the working groups may be sponsored by third parties that are developing the technologies that will be linked to driverless cars.

Figure 1: A schematic outline of the socio-technical system associated with driverless vehicles



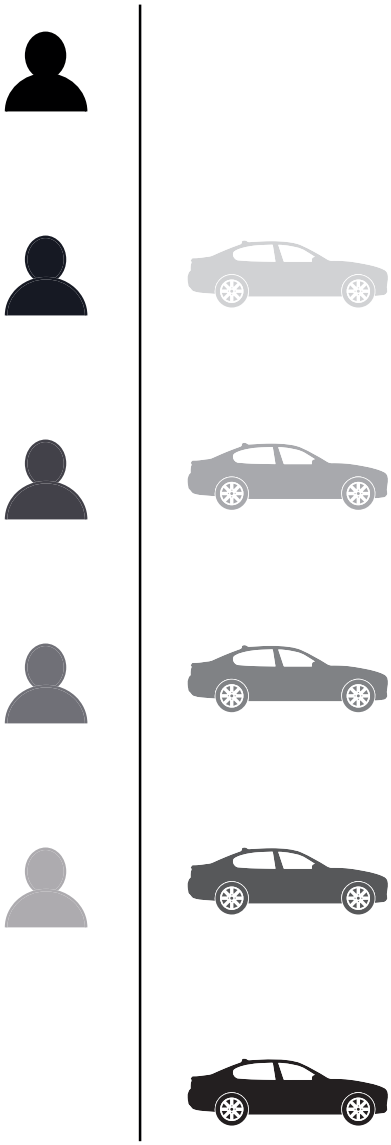
[Source: © International Baccalaureate Organization 2019]

Current situation

A number of influential organizations have carried out research into driverless vehicles, such as *Intel*, *Apple*, *Tesla*, *Google*, *Volvo*, *Toyota*, *Hyundai* and *Uber*. Many countries are also striving to facilitate the adoption of these technologies.

Currently there are many technologies that provide assistance to the driver up to level 2 on the Society of Automotive Engineers (SAE) scale, such as automated braking and speed control, see **Figure 2**. The crucial change occurs between levels 2 and 3, where control passes from the driver to the vehicle. Research into vehicles at level 3 has identified a number of problems that seem difficult to resolve, so research and development is now mainly focusing on levels 4 and 5.

Figure 2: The five levels of vehicle autonomy



Level 0 - No automation
Full driver control.

Level 1 - Driver assistance
Vehicle can assist or take over control of basic systems (such as speed control).

Level 2 - Partial automation
Vehicle can fully control of steering, acceleration and lane position in some situations (for example, on a freeway).

Level 3 - Conditional automation
Vehicle can take full control in certain situations and monitors trafic to alert the driver when they are required to take control of the vehicle.

Level 4 - High automation
Vehicle has full control for the duration of a trip.
The driver can still override automation if required.

Level 5 - Full automation
Vehicle operates without human driver at all times.
No driver assistance or oversight is required.

[Source: © International Baccalaureate Organization 2019]

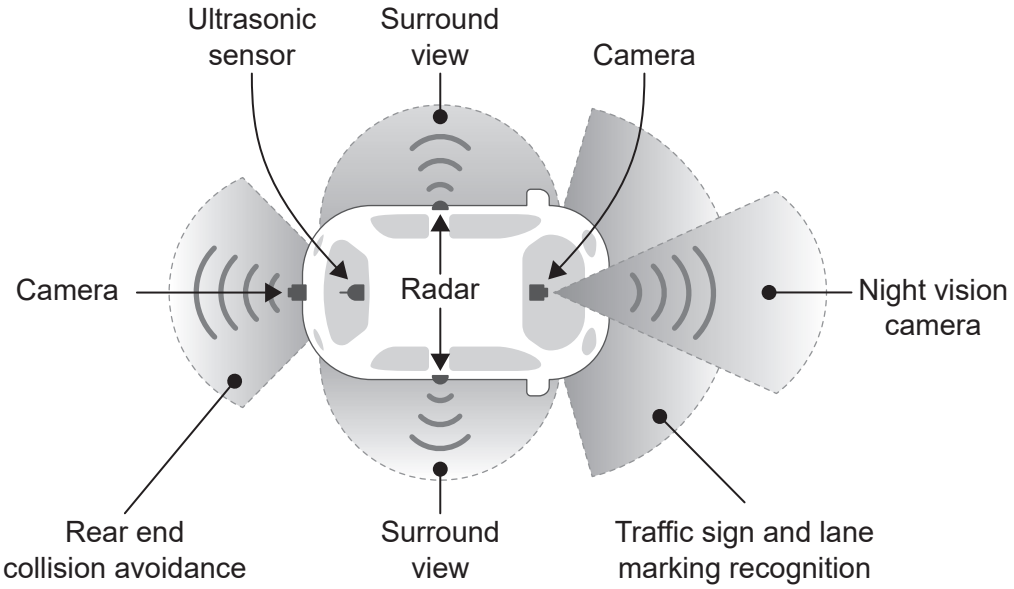
The coordinating committee of the WDVF meets annually, and the chair of each advisory committee provides a report on its current findings and proposed development plans. The most recent meeting, WDVL 24, was held between 3 and 8 March 2018 in San José, Costa Rica.

Technical

Loykie Ropartz, the chair of the technical advisory committee, provided the following information in a brief overview of the technologies associated with driverless vehicles and the driverless vehicle ecosystem:

- Driverless vehicles are an example of ubiquitous computing.
- Driverless vehicles are equipped with a number of sensors and control systems, depending on their level of autonomy. **Figure 3** shows some of the sensors that may be found in a driverless vehicle.

Figure 3: Environmental detection system on a driverless vehicle

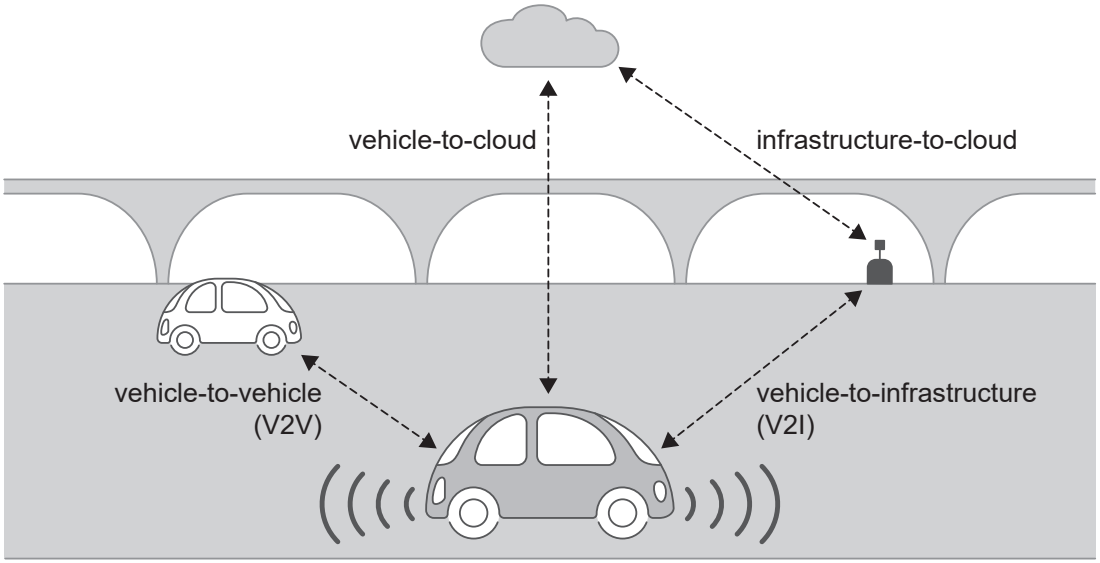


[Source: image provided with kind permission from 3M]

- Driverless vehicles with full autonomy need to continuously perform a considerable number of activities simultaneously. For completely safe fully autonomous driving, the position of the driverless vehicle needs to be known to within a few centimetres and the vehicle must be able to determine its relationship to all the other objects in its immediate vicinity. The precision of the interaction of the driverless vehicle with the elements in the ecosystem will be dependent on the quality of the hardware and, critically, on the processing power available in the driverless vehicle's "brain". The decision-making of the "brain" of the driverless vehicle needs to be faster, more accurate and less prone to error than a human brain in order to minimize the risk of accidents occurring.
- A driverless vehicle can minimize the risk of accidents by:
  - being able to perceive the car's immediate environment using sensors
  - making the correct driving decisions using a rule-based artificial intelligence (AI) system
  - having a low latency.
- Future driverless vehicles that will operate from SAE level 2 upwards will require the development of reliable communication between the driverless vehicle and its environment. These driverless vehicles will need to:
  - know the car's exact location using an accurate GPS linked to precise maps
  - communicate with other vehicles using a vehicle-to-vehicle (V2V) protocol
  - communicate with the immediate road infrastructure using a vehicle-to-infrastructure (V2I) protocol.

Figure 4 shows the driverless vehicle ecosystem and the communications using V2V and V2I within the driverless vehicle ecosystem.

Figure 4: The driverless vehicle ecosystem



[Source: image provided with kind permission from 3M]

It is estimated that in 2017 there were 64 million kilometres of road globally. Loykie commented that it would be desirable for these roads to have infrastructures suitable for driverless vehicles.

Social

The social advisory committee, led by Dheepa Dev, consists of representatives from each of the 75 participating countries. They meet to discuss the impact of driverless vehicles in their countries and to consider how their societies will be affected at a national, local and individual level. The committee members are excited about the opportunities that driverless vehicles can bring to their countries.

With many countries having aging populations, improved transportation for those unable to drive will bring many benefits, leading to a significant increase in quality of life. Safer roads, due to a reduction in the number of accidents, will be advantageous for their struggling healthcare services.

There may be other benefits to citizens. Commuters can make more effective use of their journeys to and from work, carpooling may flourish and cars can be used 24 hours a day.

Ethical

Diane Kreps, the chair of the ethical advisory committee, wants to ensure that the design of driverless cars is based on sound ethical principles. Diane's group is investigating the ethical decision-making that will occur when a driverless vehicle encounters a potentially hazardous situation. She has been advised that there are a variety of ethical decision frameworks that could be adopted, which may affect the rules that driverless cars follow or the rate at which higher levels of automation can be introduced. The question about who may be accountable if an accident occurs has already involved many lengthy discussions.

Economic

The initial prototyping of driverless vehicles has taken place in a number of economically developed countries. In these countries, the initial research has been carried out by multinational companies that are able to absorb these costs. The economic advisory committee, led by Carlos Piqué, is investigating the feasibility of introducing driverless vehicles into countries that have not been able to participate in the early research. There may be significant economic benefits for less economically developed countries.

Environmental

The environmental advisory committee discussed the potential for more efficient use of vehicles and of having fewer vehicles on the road. Members thought these changes could lead to many benefits for communities, such as less pollution, less congestion and more society-oriented use of land and buildings.

Route-finding software installed in the driverless vehicles will ensure that the most environmentally friendly route is chosen. This will aim to route the driverless vehicles to where a constant speed can be maintained and congestion can be avoided. Carole Rossignol, the president of WDVF, has suggested that investigation into route-finding software should be outsourced to third parties and should not be part of the task of the WDVF.

Legal

Carole is keen for governments to develop legislation addressing the liability issues that would result when driverless cars on public roads are involved in accidents. Currently, the introduction of legislation is very piecemeal, with some countries or states having limited legislation in place, while others have very little or none. Differences in the level of legislation between countries or states would hinder the introduction of driverless vehicles. There are differences between highway codes, driving license regulations, insurance requirements and road safety education in each country. The committee realizes the complexity of harmonizing the legal practices of so many countries.

Political

It is critical for organizations and lobby groups to engage with politicians and law-makers as driverless vehicles evolve, especially during the transition stage, which will necessarily involve cooperation between all stakeholder groups.

Challenges faced

The coordinating committee of WDVF has concluded that the introduction of driverless vehicles provides many opportunities, but there are a number of potential obstacles to overcome.

Ethical challenges

Diane Kreps reported that:

- the ethical decision-making framework used by driverless cars needs to address the potential for human and environmental harm
- implementing ethical decision-making frameworks in a driverless car will be problematic
- different countries may have different perceptions of what is ethical
- unanimity about exactly what constitutes an ethical decision is rare.

Social challenges

Dheepa Dev reported that:

- there is concern about the extent to which the population will trust and use driverless vehicles at different levels of the SAE scale
- many societies and infrastructures are built around car culture, and this may radically change with a shift to driverless cars.

Economic challenges

Carlos Piqué reported that:

- level 5 driverless cars are designed to drive along all types of roads, and governments would like to have infrastructure added to as many roads as possible to facilitate the introduction of driverless vehicles at earlier stages of the SAE scale. This will include locations beyond urban areas and freeways. There is concern that upgrading existing roads will incur significant infrastructure costs
- driverless vehicles should be affordable. The economic advisory committee is liaising with governments over possible strategies to encourage the adoption of driverless vehicles
- the increasing amount of potentially expensive software could need constant upgrading. This could lead to significantly increased costs for a range of stakeholders
- the introduction of driverless vehicles may lead to changing patterns of employment
- the development of driverless vehicles and their infrastructure must be appropriate to the local circumstances of each country.

Legal challenges

Carole Rossignol reported that:

- there will need to be a framework for determining accountability if a driverless vehicle is involved in an accident
- currently each country or state has its own laws for the use of vehicles. Will it be necessary, or possible, to harmonize the laws on the use of driverless vehicles between countries?
- regulations determining safety standards in driverless vehicles will need to be produced, such as the use of seat belts and the physical layout of the driver/occupant space.

Carole concluded that the coordinating committee is concerned about whether large multinational companies and politicians will be able to work together to overcome the difficulties at local, national and international levels.

[Source: WDVF is a fictitious organization, but its structure is based on that of IFIP – International Federation for Information Processing (www.ifip.org), established by UNESCO in 1960 and still functioning.]

Key terms associated with *On the road to driverless cars*

Assistive technology
Authentication
Authorization
Collaborative route planning
Consequentialism
Deontology
Global positioning system (GPS)
Intelligent transport system (ITS)
Latency
Light detection and ranging (LIDAR)
Markkula (Santa Clara) ethical decision-making model
Near field communication (NFC)
Radar
Smart roads
Society of Automotive Engineers (SAE) scale
Trolley problem
Ubiquitous computing
Utilitarianism
Vehicle-to-vehicle (V2V) protocol
Vehicle-to-infrastructure (V2I) protocol

Any individuals named in this case study are fictitious and any similarities with actual entities are purely coincidental.