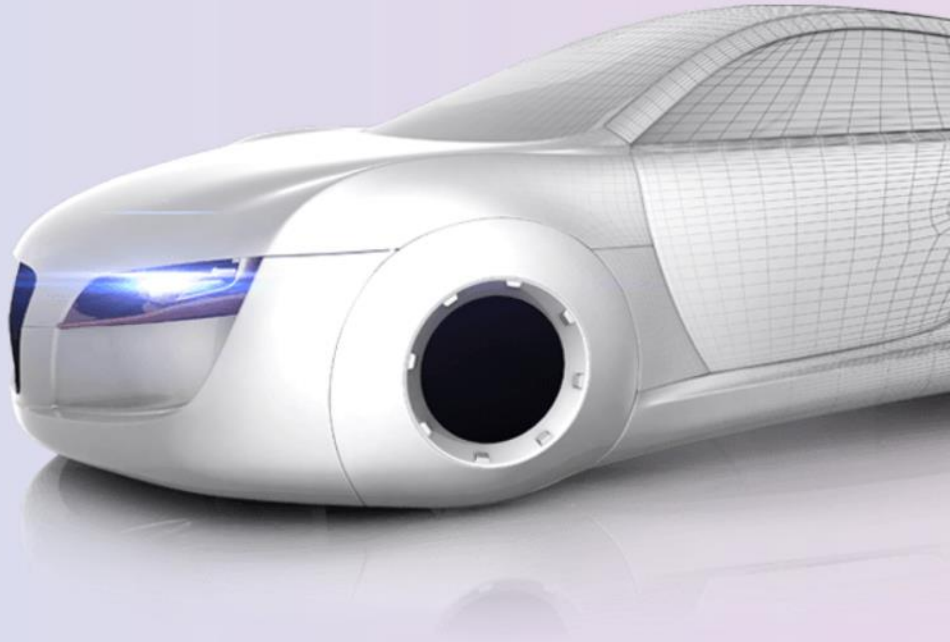
DUBAI WORLD CONGRESS
FOR SELF-DRIVING TRANSPORT
OCT | 2019

Preparing Dubai and the UAE's Road Infrastructure for Autonomous and Self Driving Transport

Scott Fennelly

Director of ITS and Transportation

SurfaceMobility consultants



www.sdcongress.com

CONTENTS

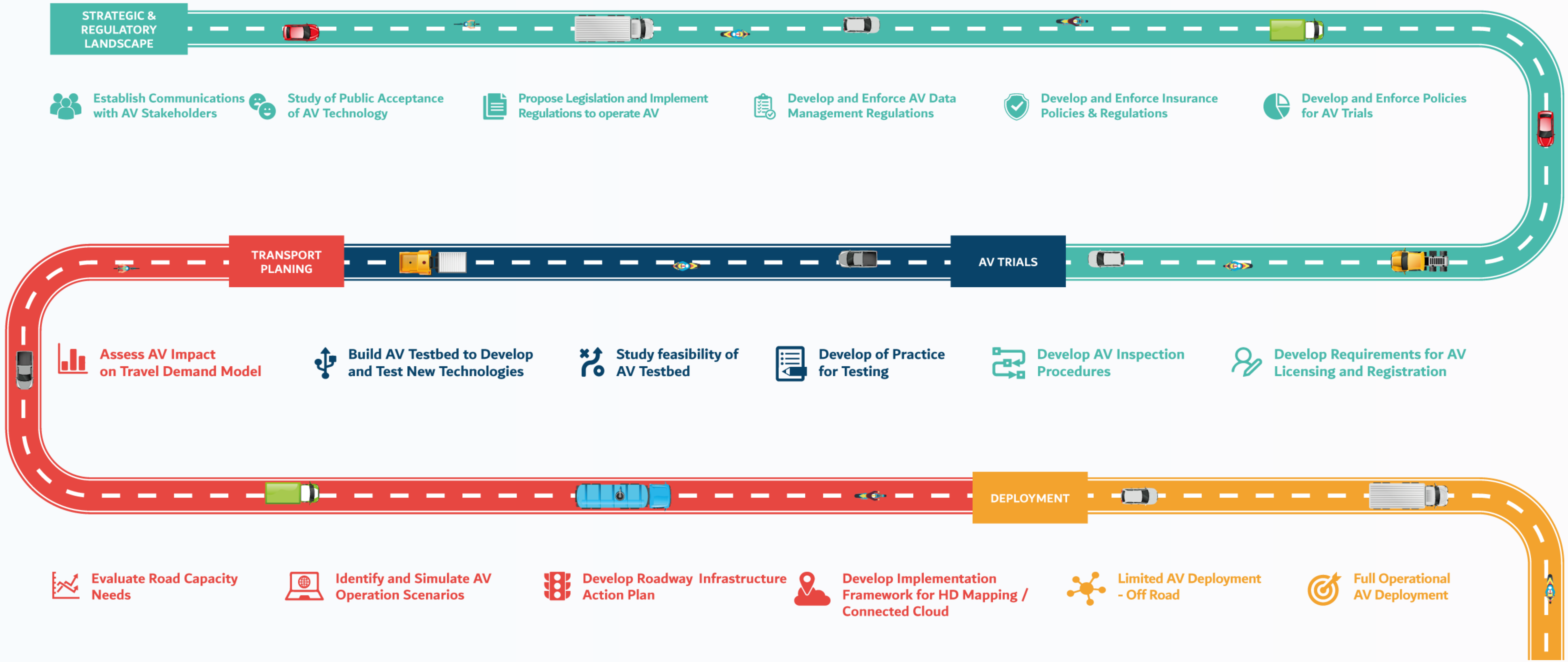
Where Does Infrastructure sit in the SDT / AV Roadmap to Deployment

Where Does Infrastructure sit in the SDT / AV Roadmap to Deployment

The main pillars forming the Autonomous Vehicles Readiness Index (AVRI) are:

Autonomous Vehicles will be in constant contact with the infrastructure network

Source: KPMG – Autonomous Vehicles Readiness Index


STRATEGIC & REGULATORY LANDSCAPE
Establish Communications with AV Stakeholders
Study of Public Acceptance of AV Technology
Propose Legislation and Implement Regulations to operate AV
Develop and Enforce AV Data Management Regulations
Develop and Enforce Insurance Policies & Regulations
Develop and Enforce Policies for AV Trials
AV TRIALS
TRANSPORT PLANING
Assess AV Impact on Travel Demand Model
Build AV Testbed to Develop and Test New Technologies
Study feasibility of AV Testbed
Develop of Practice for Testing
Develop AV Inspection Procedures
Develop Requirements for AV Licensing and Registration
DEPLOYMENT
Evaluate Road Capacity Needs
Identify and Simulate AV Operation Scenarios
Develop Roadway Infrastructure Action Plan
Develop Implementation Framework for HD Mapping / Connected Cloud
Limited AV Deployment - Off Road
Full Operational AV Deployment

Evaluate Road Capacity Needs

Update long-range plans based on updated travel demand model to consider whether
AV will increase or decrease congestion, and develop strategies to address increased congestion if likely.

Identify and Simulate AV Operation Scenarios

Study different scenarios of AV vehicles paths (buses, taxis, and private cars) using Micro-Simulation. Assess transit service delivery plans and fleet requirements.

Develop Roadway Infrastructure Action Plan

Develop geo database of deficiencies, infrastructure analytics in order for AV to operate efficiently and safely. Make required infrastructure modifications such as AV compliant signs, road markings and communication devices.

Technology incorporated into Infrastructure

Technology

Traffic Control and Traffic Signals

- Optimize traffic signal timing plans based on CAVs
- Control inputs
- Warning Signs

Smart and Green Infrastructure

- Traffic Guidance
- V2X
- Electric Charging Points
- Charge whilst driving

Pedestrian Crossings

- V2P
- Pedestrian Safety
- Safety of People of Determination

Communications Infrastructure

- Vehicle to grid communication
- Communication Protocols
- DSRC
- LTE – V2X (Evolution to 5G)

Cyber Security

- Security
- Hacking
- Viruses,
- Hijacking

Mobility Platforms

- Realtime notifications
- Increased data
- Increased reaction time

Connections to Traffic Control Centers

- Remote Control technology
- Management and monitoring of road network

Data Analysis from Infrastructure

- Real-time data for planning and analysis
- Predictive Analysis
- Predictive Maintenance

Parking Infrastructure

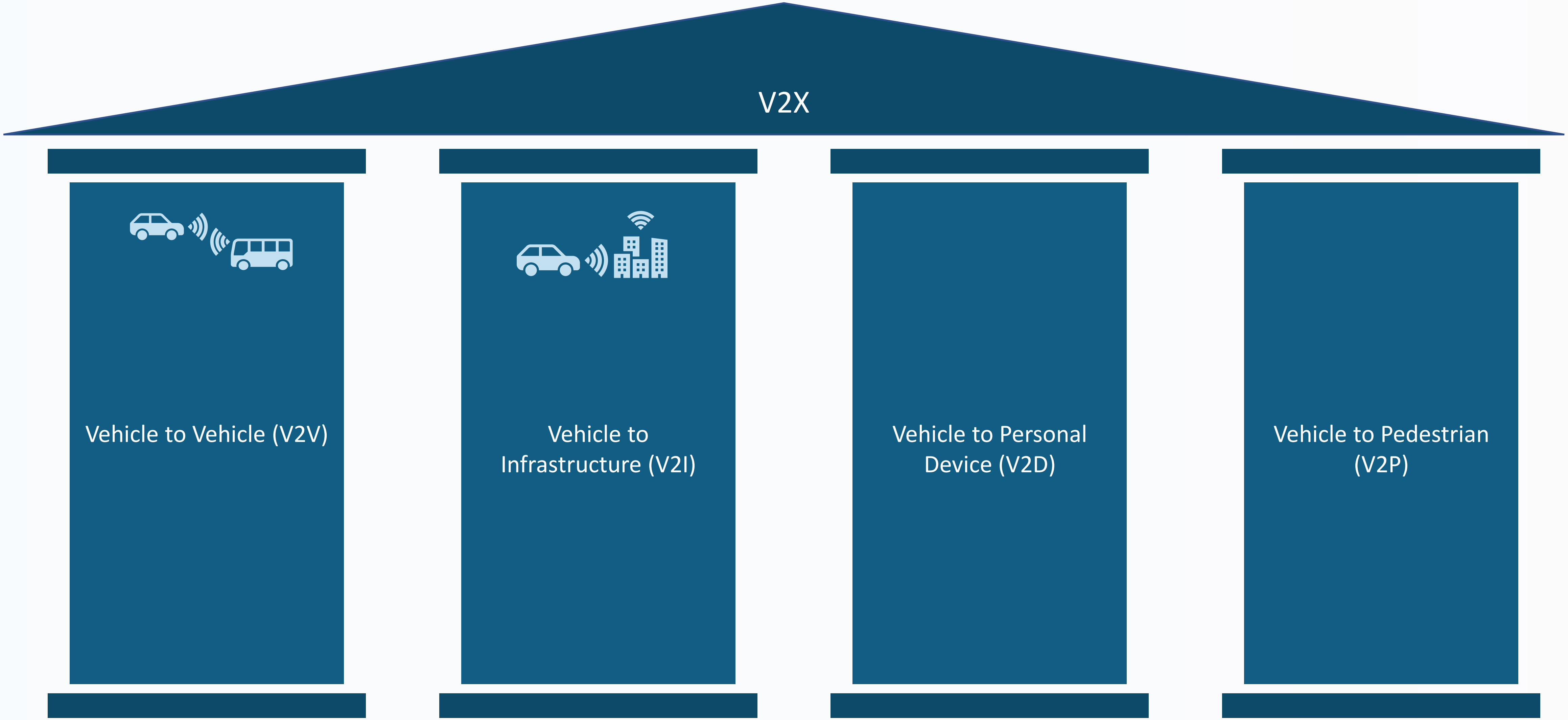
- Autonomous Parking
- In car parking notifications

Other Factors

- New technology advances
- Reduction in CO_2
- Increased safety

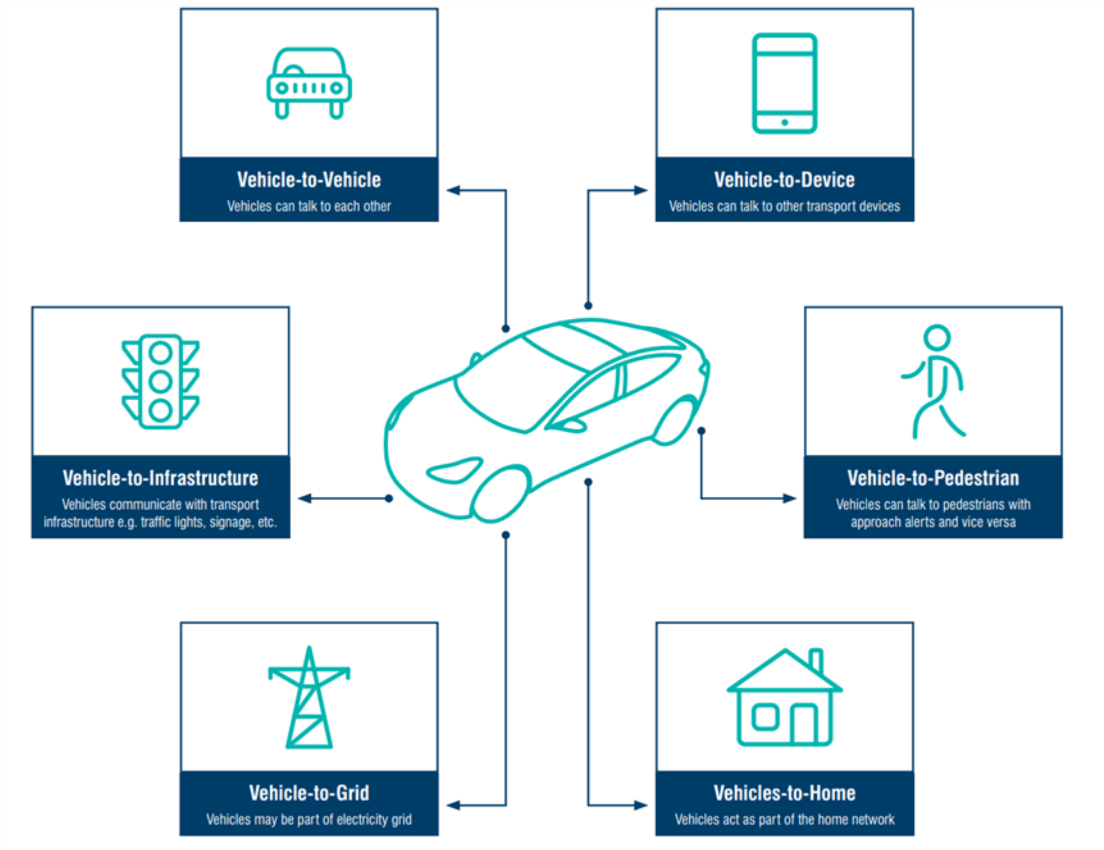
Key Connectivity Pillars

Key connectivity Pillars



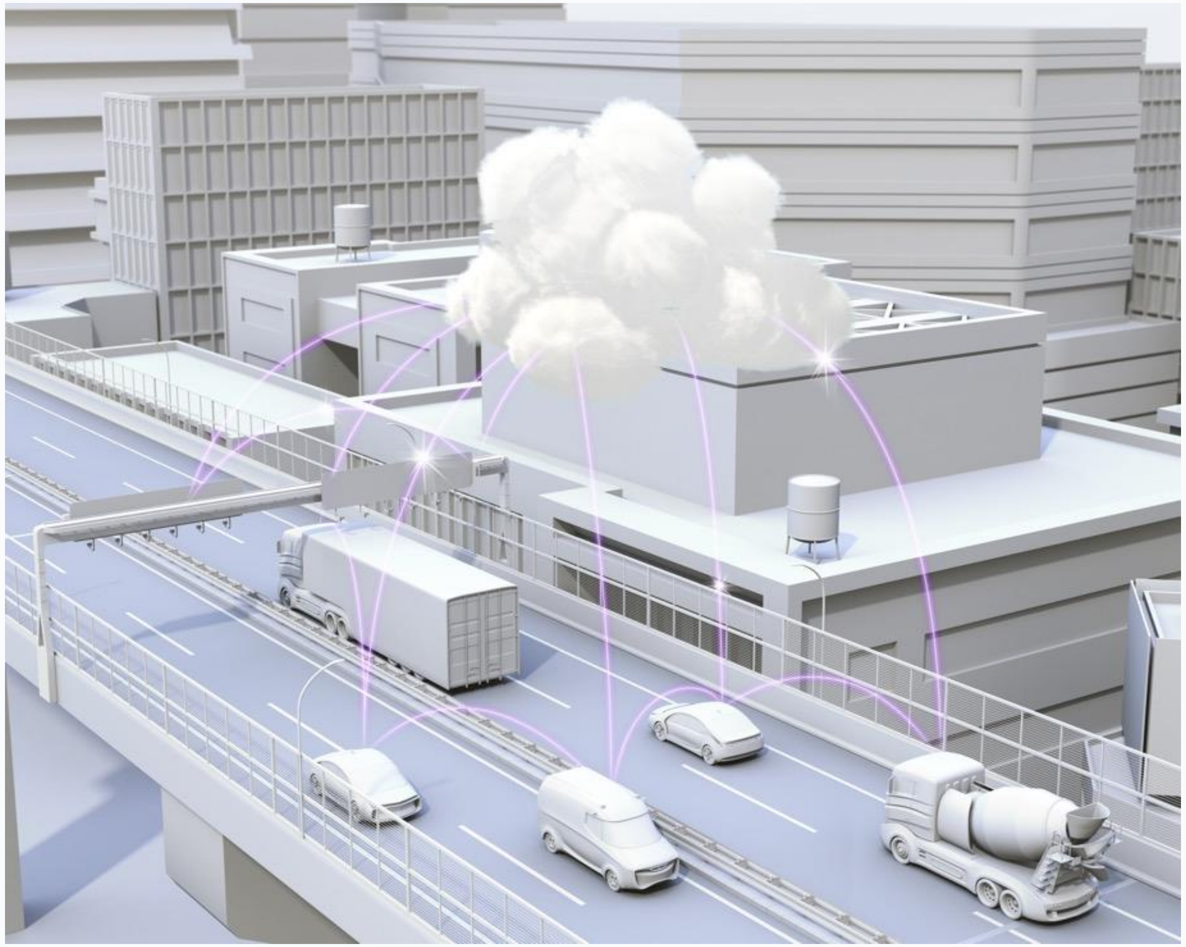
Key connectivity Pillars

- The deployment of automated and connected vehicles provides an opportunity to adapt our infrastructure to a connected world.
- V2X incorporated into our infrastructure will enable additional data sharing functions.
- V2X communications must continuously capture and interpret complete data concerning the surrounding environment.
- Fully autonomous vehicles will require all surrounding environment information.
- Surroundings will need to actively communicate their state and changing conditions around them to the vehicle.



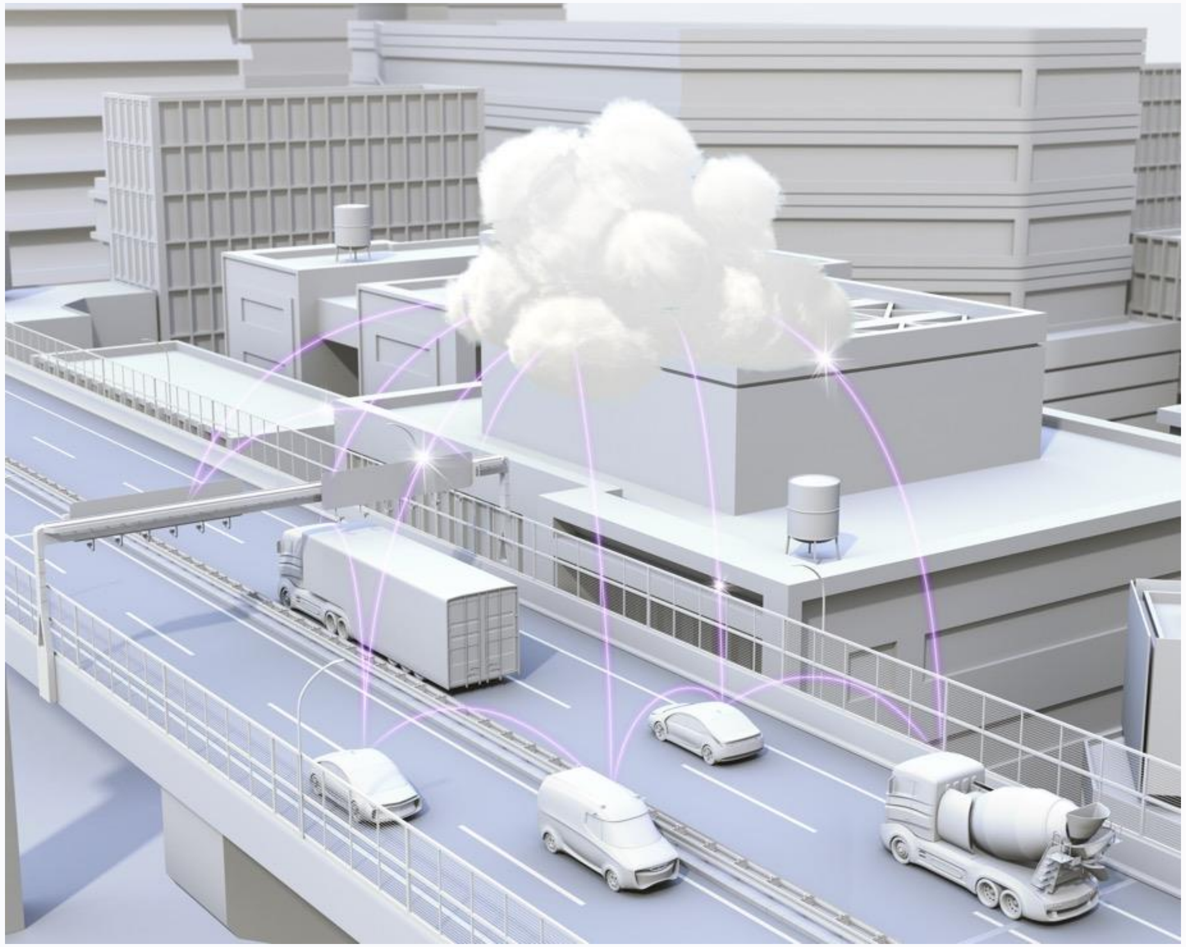
Key connectivity Pillars

- As digital infrastructure becomes ever more critical within our road network, transportation authorities need to increase their:
  - Expertise;
  - Knowledge; and
  - Budgets for mission critical data management and communications.



Key connectivity Pillars

- This is a significant risk for many agencies who have not yet prepared to cope with requirements such as:
  - Data sharing agreements;
  - Privacy policies;
  - IT/network security; and
  - Introduction of technologies aimed at improving safety and efficiency.



The Key Physical Infrastructure Requirements

Key Infrastructure Requirements

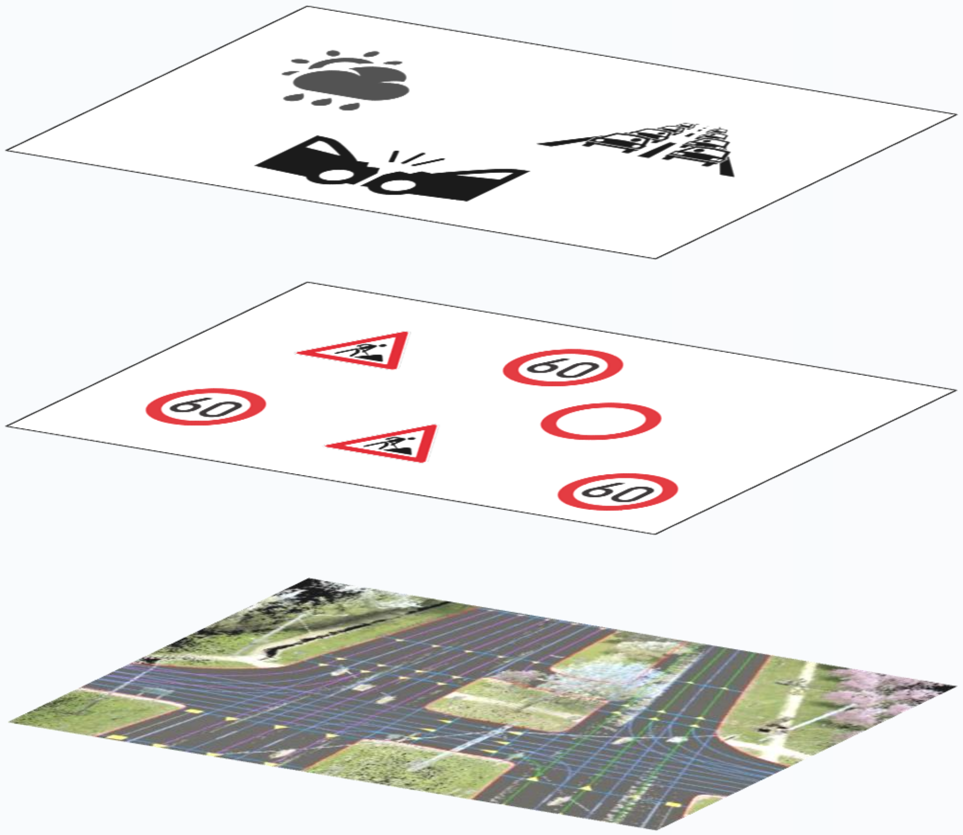
DIGITAL INFRASTRUCTURE

- A significant element critical to safety is security of the digital infrastructure.
- This includes security of communications between vehicles, protection of content from outside interference, security of in-vehicle systems and data security.
- Since CAVs are connected to the internet, other vehicles, infrastructure and sensors, it becomes susceptible to security risks.
- CAVs will be required to be protected against vulnerabilities such as attacks, theft or hacking and a robust security framework that addresses these areas should be developed.

PHYSICAL INFRASTRUCTURE

- Infrastructure necessary for CAVs to be able to operate efficiently and safely
- including geometry, surface conditions, intersection design, dedicated lanes, islands, road markings, signage and traffic signals, will need to be designed in compliance with a countries street design standards and guidance
- As CAVs are a nascent form of transportation, and dedicated standards may not be available for all infrastructure requirements, all designs should conform to emerging international standards and best practices.
- In addition, infrastructure designs should be subject to road safety audit at the appropriate stages.

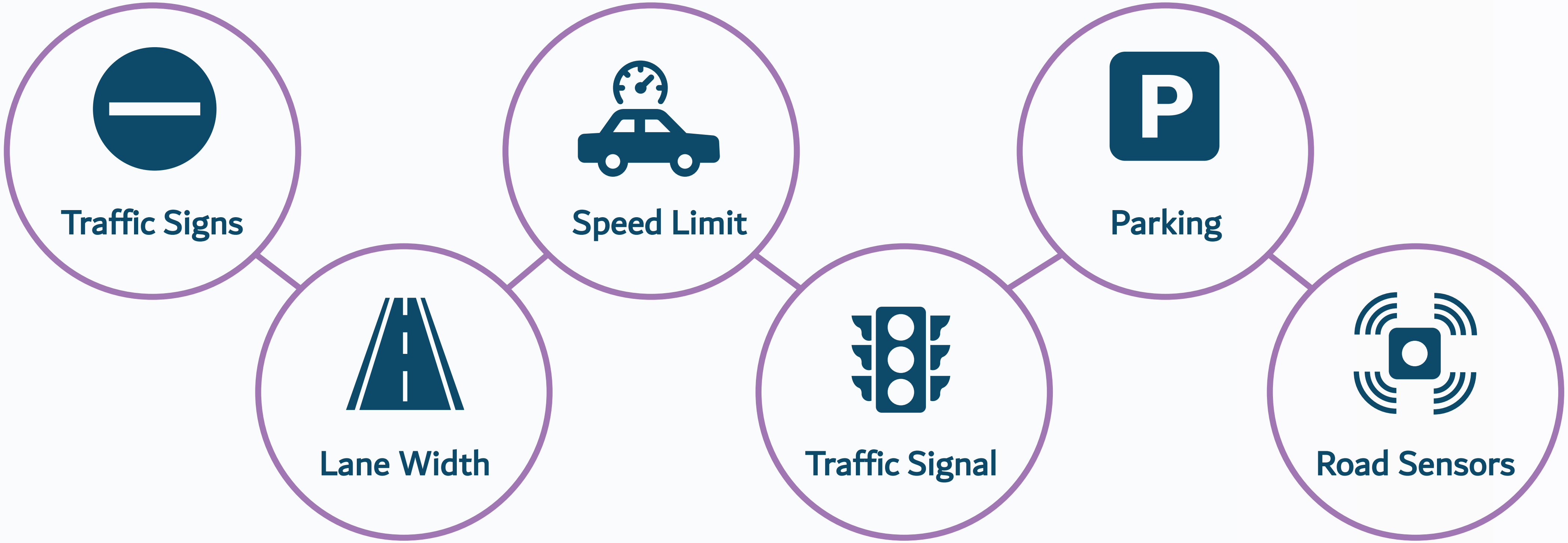
Key Infrastructure Requirements - Mapping



DESCRIPTION	EXAMPLES FOR CONTENT
Dynamic layer Data of the extended surroundings mostly regarding traffic and other circumstantial information	▪ Congestion ▪ Accidents ▪ Weather
Semi-static layer Data changes which can be planned and forecasted. Origin of changes is usually public authorities	▪ Speed limit changes ▪ Road closures ▪ Construction work
Static layer Elements not subject to frequent changes. High resolution (sub-decimeter level) spatial data including all key elements required for SDT	▪ Road borders ▪ Lane centerlines ▪ Characteristic waypoints

Key Physical Infrastructure Requirements

This section highlights the infrastructure upgrades and changes necessary for AV to be able to operate efficiently and safely, using C-ITS



Traffic Signs and On-Road Telematics

Traffic Signs

- Update and standardize traffic signs such that they are visually distinctive and immediately recognizable to AVs.
- Currently signs can change overnight in the UAE! Keep change consistent.
- Today's AVs mostly use an image recognition approach when reading road signs.
- Machine-readable code will have to be embedded in signs and transmitted or broadcast.
- These messages will be invisible to humans but detectable by computers.
- Well maintained roads with clear road markings is also critical.
- Work zone warnings to inform drivers of road works, diversions, temporary traffic signals etc.
- School zone warnings

Lane Widths and Road markings

- AV may not require the traditional 3-4 metre lane widths on local roads or highways.
- Reducing the width of lanes might not be a necessity, but it could increase the capacity of roadways, provide added space for bike lanes, and/or improve walkability.
- Poor road markings are forcing automakers to develop more sophisticated sensors and maps, but they definitely don’t encourage the broader adoption of AVs.
- Self-driving cars will require machine-readable radar-reflective road markings.
- These can be manufactured out of cold plastic to make lidar’s job easier at night and in nasty weather.

Speed Limits and Changing Circumstances

- SDT can be programmed to travel at or below the speed limit specified on roads.
- Optimal Speed Advisory can be put in place to inform drivers of the optimum speed to take to ensure efficient traffic flow
- C-ITS can detect the flow of traffic, its speed and density. Using this information it is possible to impose variable speed limits, to determine whether to open or close traffic lanes and to help avert accidents via SDT.

Adjust Traffic Signal Locations and Timing

- A fully driverless vehicle society will likely introduce entirely new travel patterns.
- There will be a need to alter traffic signal locations and timing to take into account both SDT and human drivers.
- Traffic signal timings alerts, for example to warn drivers that a traffic signal is about to change phase, or that a red-light violation is probable.
- Improved operations of traffic signal systems via V2I communications between vehicles and traffic signal controllers enables signal timings for an intersection or group of intersections to be optimized.
- Data from in car Bluetooth devices and current ECall devices are already capable of providing real-time measures which may allow objective signal control and measurable improvements in efficiency.

Parking and SDT

Parking

- Many parking spaces may be unnecessary due to the potential for reduced private vehicle ownership and the ability of driverless vehicles to park themselves in remote locations.
- An assumption of significant parking demand reductions once AVs become common place.
- General agreement that full AV implementation (and the anticipated parking demand reductions) are 20-30 years
- away.
- An acknowledgment that parking structures are designed for 50-75 year lifecyles and that any parking structures being built should consider new design approaches that consider adaptive reuse.
- The importance and impact of shared-use mobility options to provide a full range of mobility options

Road Sensors for road curves and environmental monitoring

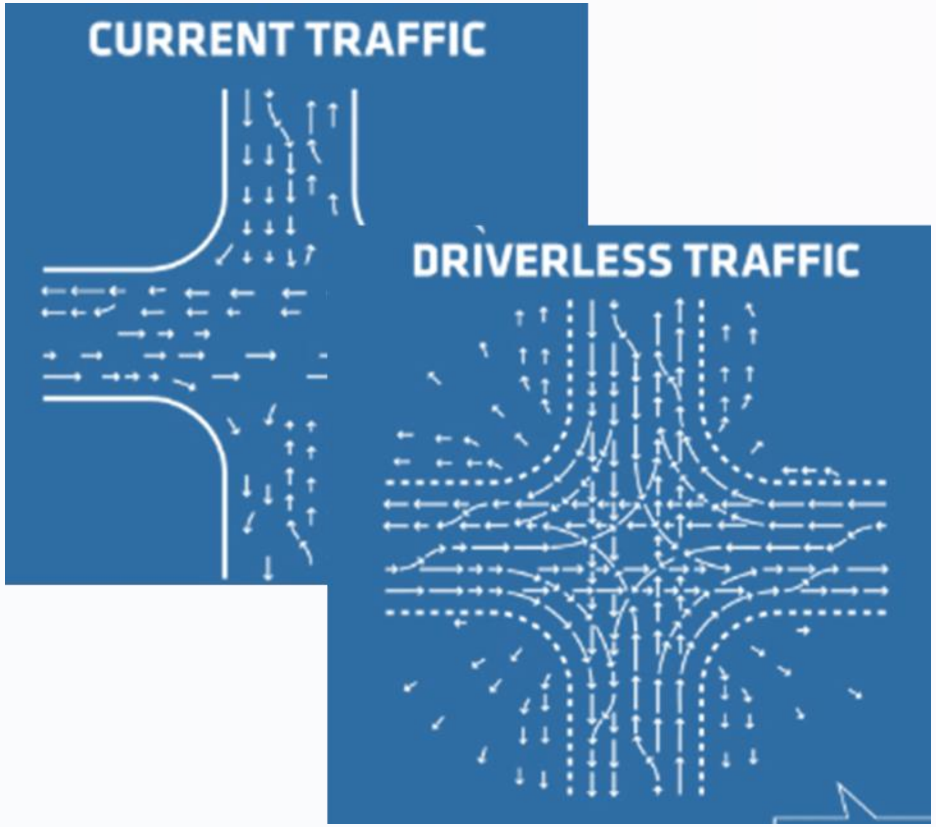
Road Sensors

- When designing new or upgraded roads, city planners should be including SDT in their conditions for elements such as roadside sensors on lanes, curbs, and sidewalks to allow vehicles to foresee dangerous or unexpected situations far ahead.
- Devices should also include for a wide range of traffic, environmental, and emissions data, including:
    - Current status information from local field devices
    - Junction status,
    - Sensor data, and signage data,
    - Real time traffic information,
    - Speed limits,
    - Parking information.
- Designating or certifying roads during planning for driverless vehicles requires some framework to be provided for evaluating and confirming that a roadway is acceptable for a specified usage.

Traffic Signals, UTC and Control Centres - Now and the Future

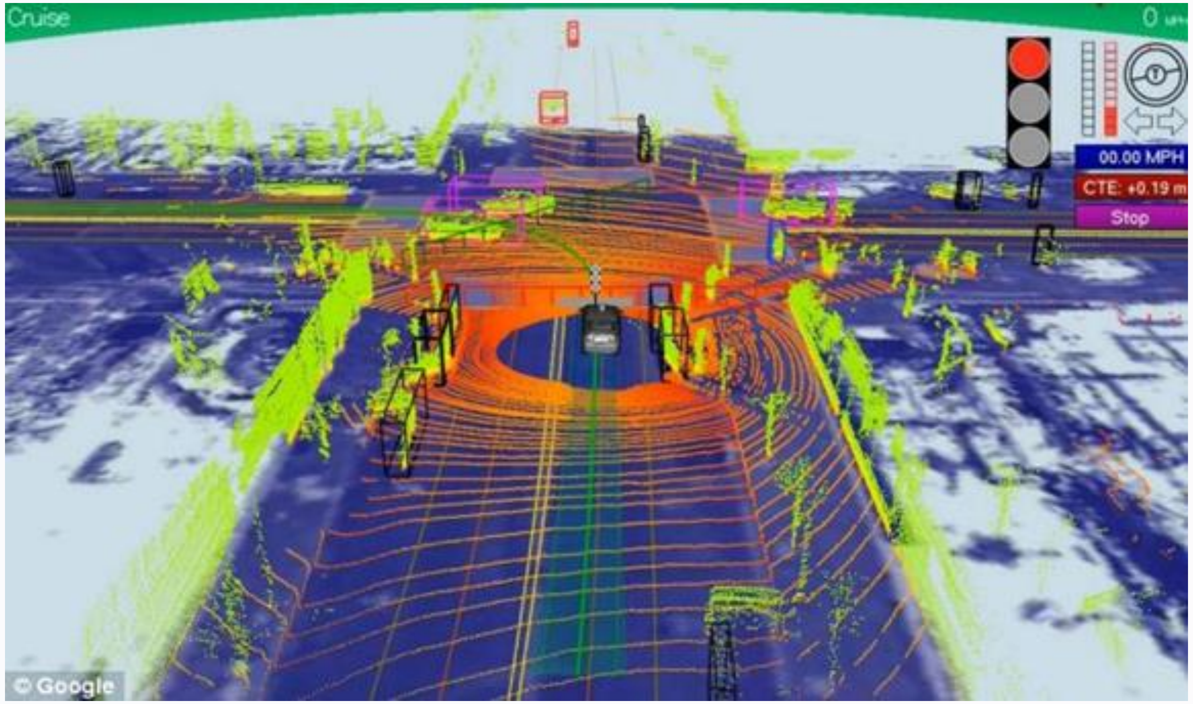
Traffic Signals and UTC's interaction with AV

- Today, basic traffic light detection is a solved problem.
- Advancements will include incorporating important information onto in-car displays.
- These "car status" units, will enable drivers to add their driving route and communicate with a centralized traffic control system.
- We will then be able to optimize signals across the road network using origin-destination data.
- In return, the system, utilizing traffic control plan data and surveillance data from traffic control CCTV, may then graphically show navigational aids to the driver.



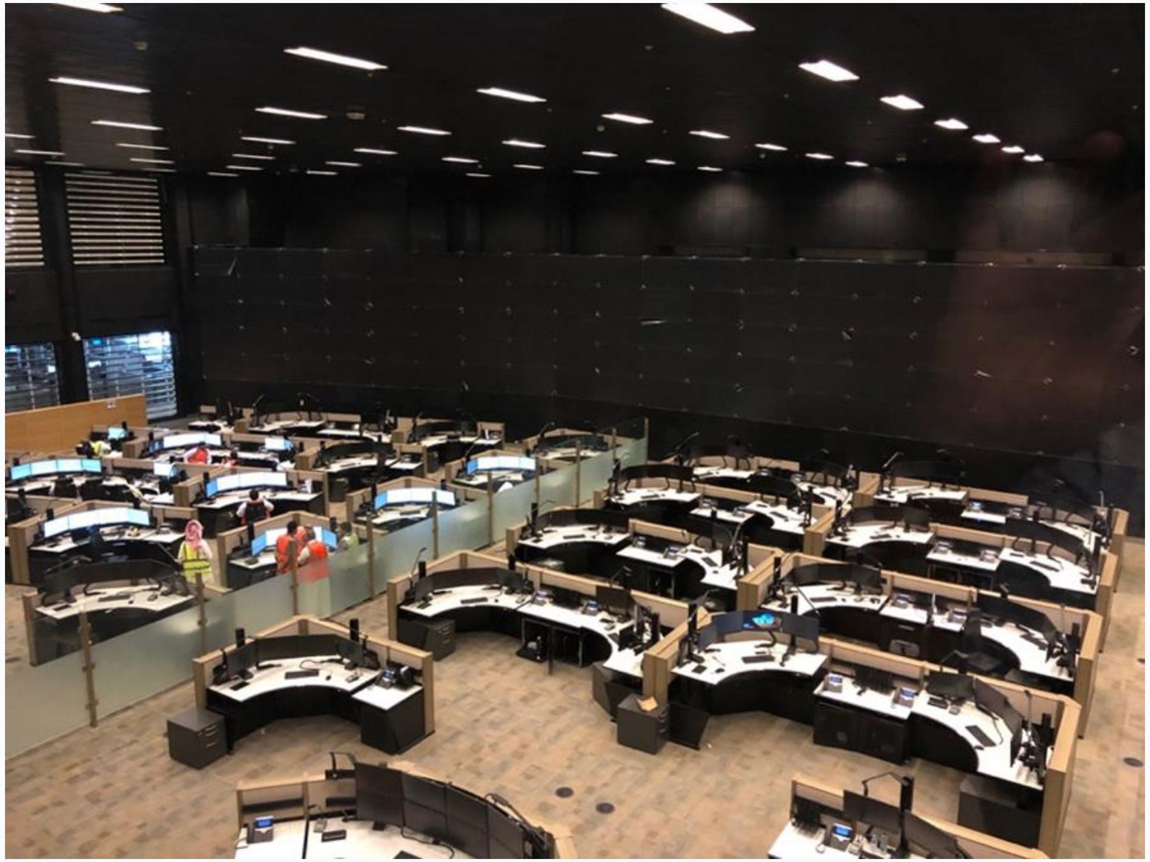
Traffic Signals and UTC's interaction with AV

- The centralized traffic control system could interface with both the vehicles and traffic signal controllers changing the approach and green time of each junction whilst receiving alarms and maintenance information.
- The future of traffic signal control will more than likely be a combination of V2I and Vehicle to Vehicle (V2V) control.
- Distance measuring through (V2V) systems is already being tested and the sharing of information from V2V devices with Traffic Control Systems
- The V2V capability combined with V2I will allow vehicles to share their position, destination and intended route etc……



Control Centres and AV / SDT

- Traffic Management Center will communicate with on- board units in vehicles, ITS field equipment and roadside units to monitor the condition of the roadway, surrounding environmental conditions, and field equipment status.
- Such a central ITS sub-system will facilitate data to be analyzed to optimize the transportation system by providing effective traffic management, administrative, information dissemination, and support functions.
- Connected Vehicle Infrastructure Management Centres (CVIMC) will support monitoring and maintenance of the CV infrastructure (road side units, support systems, and associated communications links).



Control Centres and AV / SDT

- The CVIMC should be incorporated into the Traffic Management Centre for optimal operational performance.
- Communications Links such as fiber optic cables or wireless technologies between roadside equipment and the TMC are fundamental.
- Support functions such as underlying technologies and processes to ensure that the data being transmitted is secure. This provides assurance that the messages originate from trusted sources (authorized) and are free from tampering (authenticated).

Next Steps to ensuring Infrastructure enables safe AV and SDT Deployment

Next Steps

Redundant and Real Time Architectures will be needed for Autonomous driving and increase demand for more and more reliable network-based structures.

Next Steps

High Speed Data Demand will require sophisticated electronic support. The inside of the driverless car will literally be an information highway which will be managed in switched networks with sufficient margin to ensure the car's safe operations.

Redundant and Real Time Architectures

Next Steps

External Connectivity for Safety
especially with V2X communications which must continuously capture and interpret complete data concerning the surrounding environment.

Redundant and Real Time Architectures

High Speed Data Demand

Next Steps

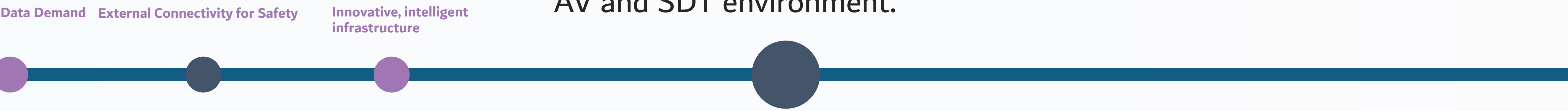
nt and Real Time
tures

High Speed Data Demand

External Connectivity for Safety

Innovative, intelligent infrastructure is needed to support a digital ecosystem and the success of autonomous and self-driving transport

Next Steps



No single technology or system will guarantee safety within the AV and SDT environment.

Next Steps

All vehicles and systems must work together to improve safety the readability of pavement markings, traffic signs, traffic signals and temporary traffic control signs and devices.

nectivity for Safety

Innovative, intelligent infrastructure

No single technology or system will guarantee

Next Steps

Redundant systems need to be put in place to take over when GPS is unable to work, such as in a tunnel, or when pavement markings are not visible to a vehicles' camera.

, intelligent
ture

No single technology or system will guarantee

All vehicles and systems must work together

Next Steps

Increased redundancies are required to help drivers, cameras, and sensors more easily sense and decode rules of the road

gy or system

All vehicles and systems must work together

Redundant systems need to be put in place

Next Steps

Transport Planners need to ensure that the planning of developments and Highrise buildings that may block a satellite or GPS are taken into account.

st

Redundant systems need to be put in place

Increased redundancies are required

Next Steps

stems need to be

Increased redundancies are required

Transport Planners need to ensure

State-of-the-art vehicles require state-of-the-art infrastructure.
Improving infrastructure through redundancies is how we drive innovation, increase safety, enhance mobility, and create roadways of the future.

Next Steps

- Redundant and Real Time Architectures
- High Speed Data Demand
- External Connectivity for Safety
- Innovative, intelligent infrastructure
- No single technology or system will guarantee
- All vehicles and systems must work together
- Redundant systems need to be put in place
- Increased redundancies are required
- Transport Planners need to ensure
- State-of-the-art vehicles require state-of-the-art infrastructure.

Sources

- International Journal of Information and Computer Science
- International Research Journal of Engineering and Technology (IRJET) Volume: 05 Issue: 05 | May-2018
- Investigating Network Efficiency Improvement Measures Using Simulation Technique
- Hackernoon - Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) Technologies
- Intelligent Transportation Systems JPO – ITS Deployment Research
- United States Department of Transportation, Bureau of Transportation Statistics
- Kimley Horn - Parking Planning White Paper Series, August 2017