# Efficiency, intelligence and autonomy:

## Maximising the carbon benefit from transport innovations

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#LowCVP16

# Automated Vehicles: Automatically Low Carbon?

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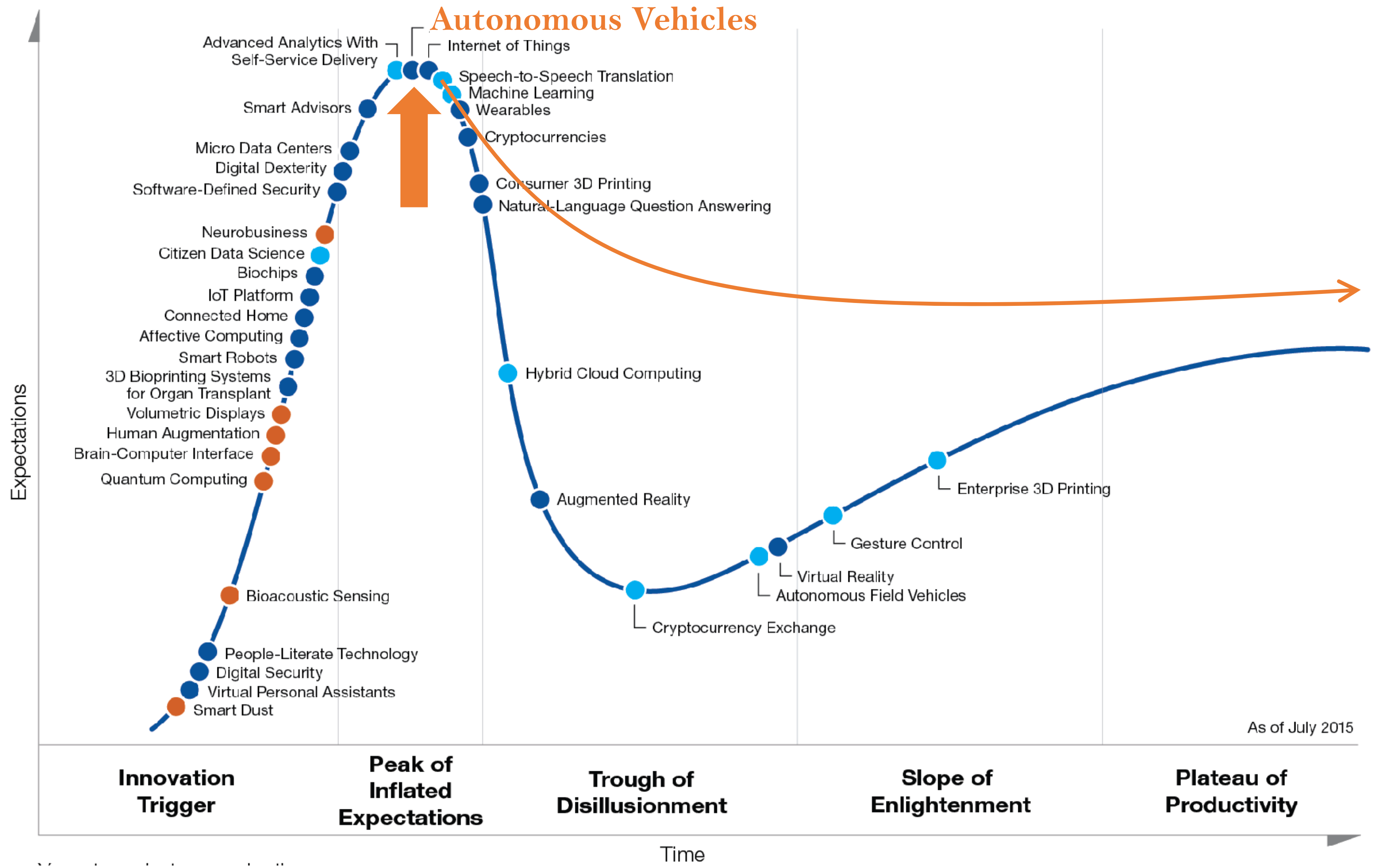
# Technology Hype Cycle!





# Objectives

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- What are the potential travel, energy and carbon impacts?

- Do we let market decide the development? Or, do we need to plan ahead to reap the carbon benefits?

- What are the key areas that require attention from policymakers?

# Autonomous, automated, connected?

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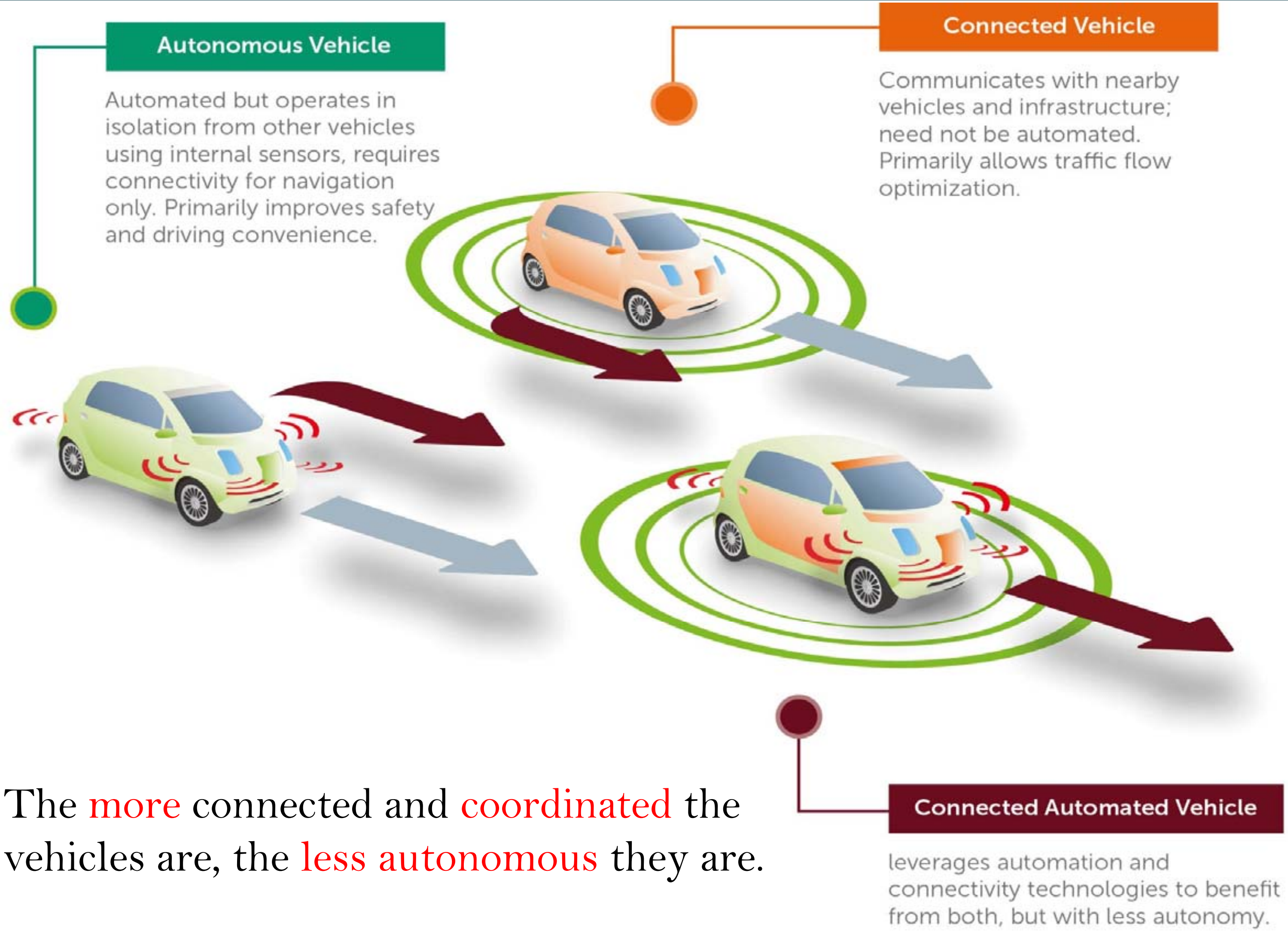


The more connected and coordinated the vehicles are, the less autonomous they are.

# Levels of automation

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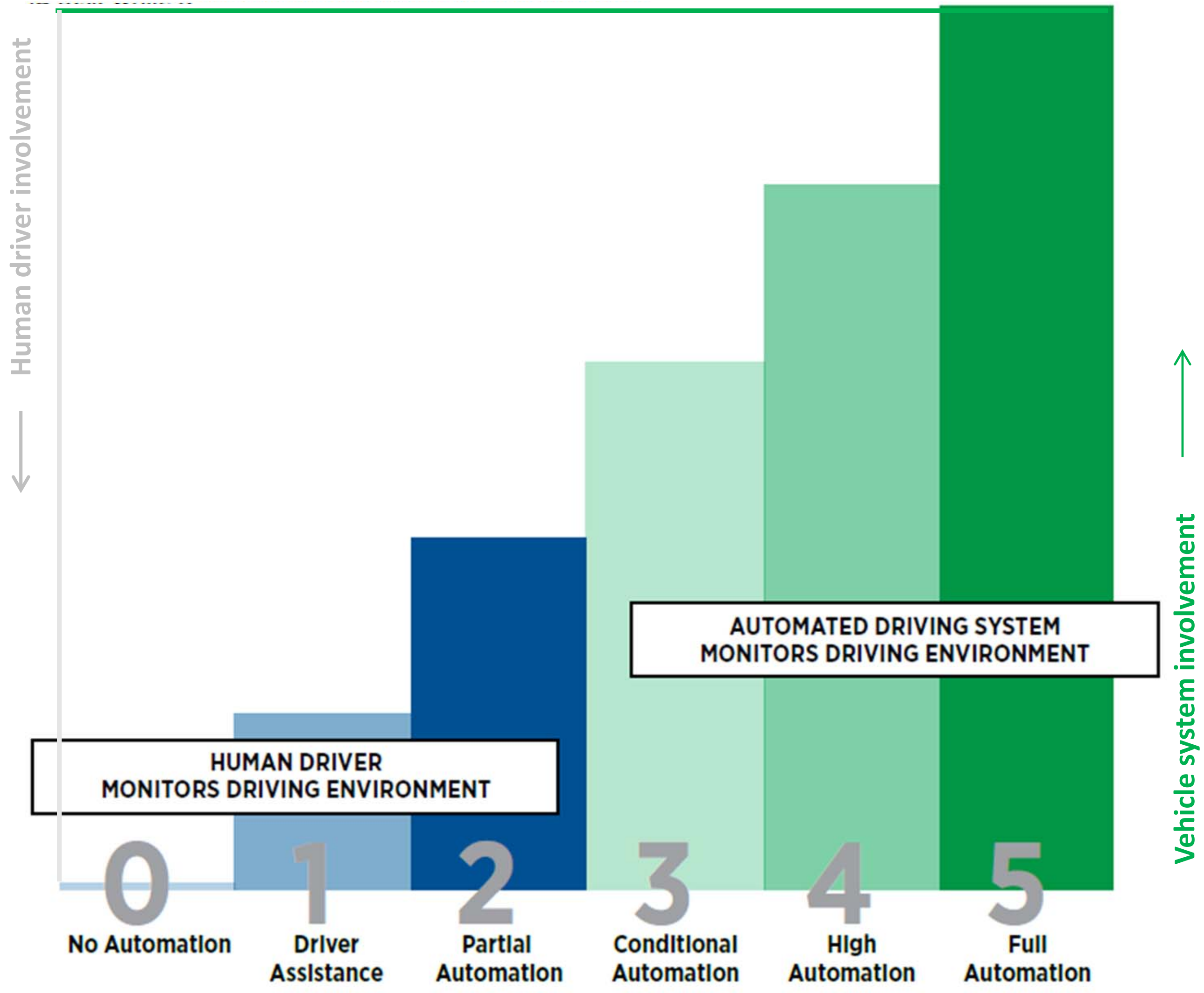

# Connectivity & coordination

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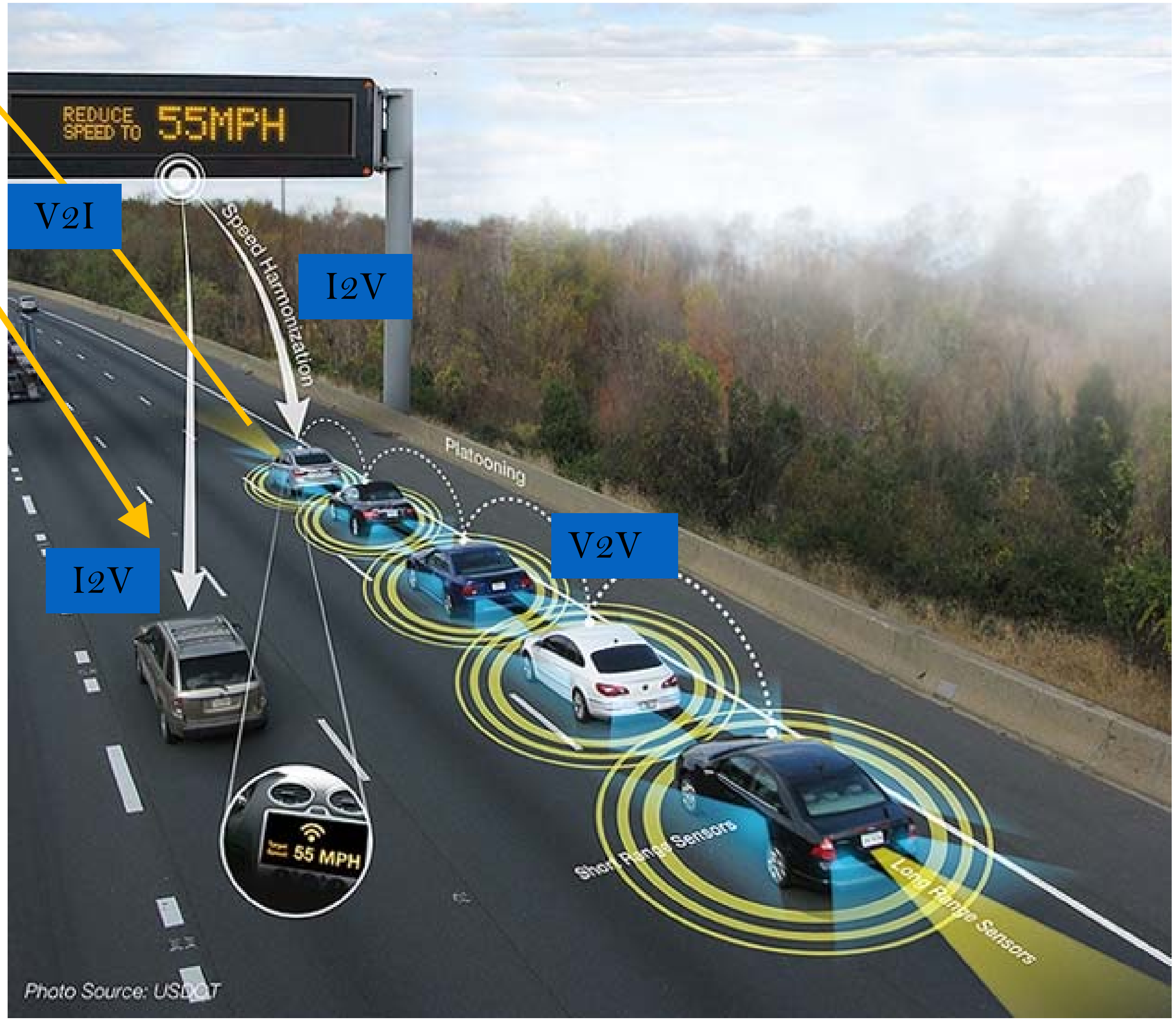


V2X=V2V+V2I

# Carbon equation

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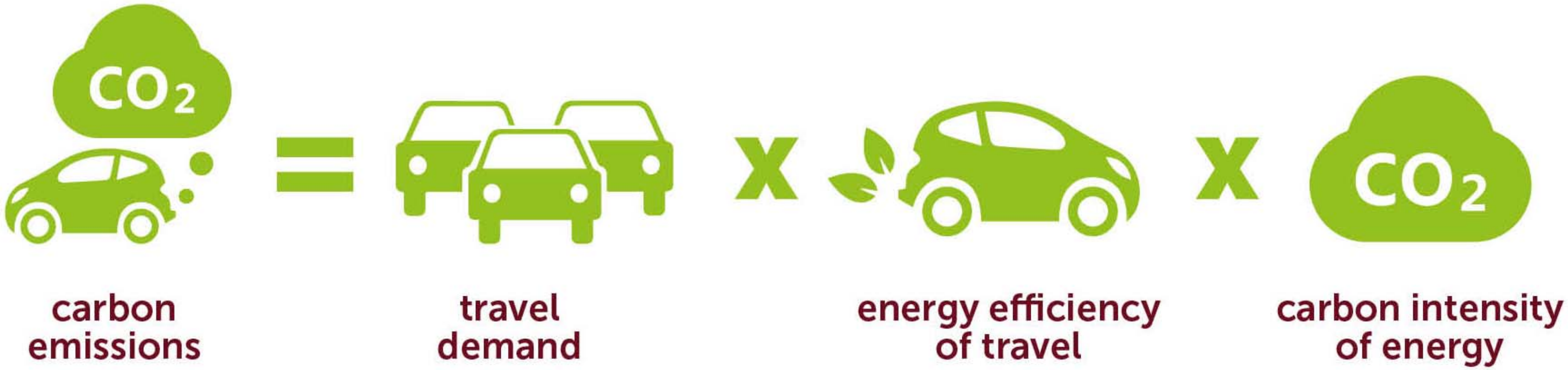

# Carbon, energy & travel ripple

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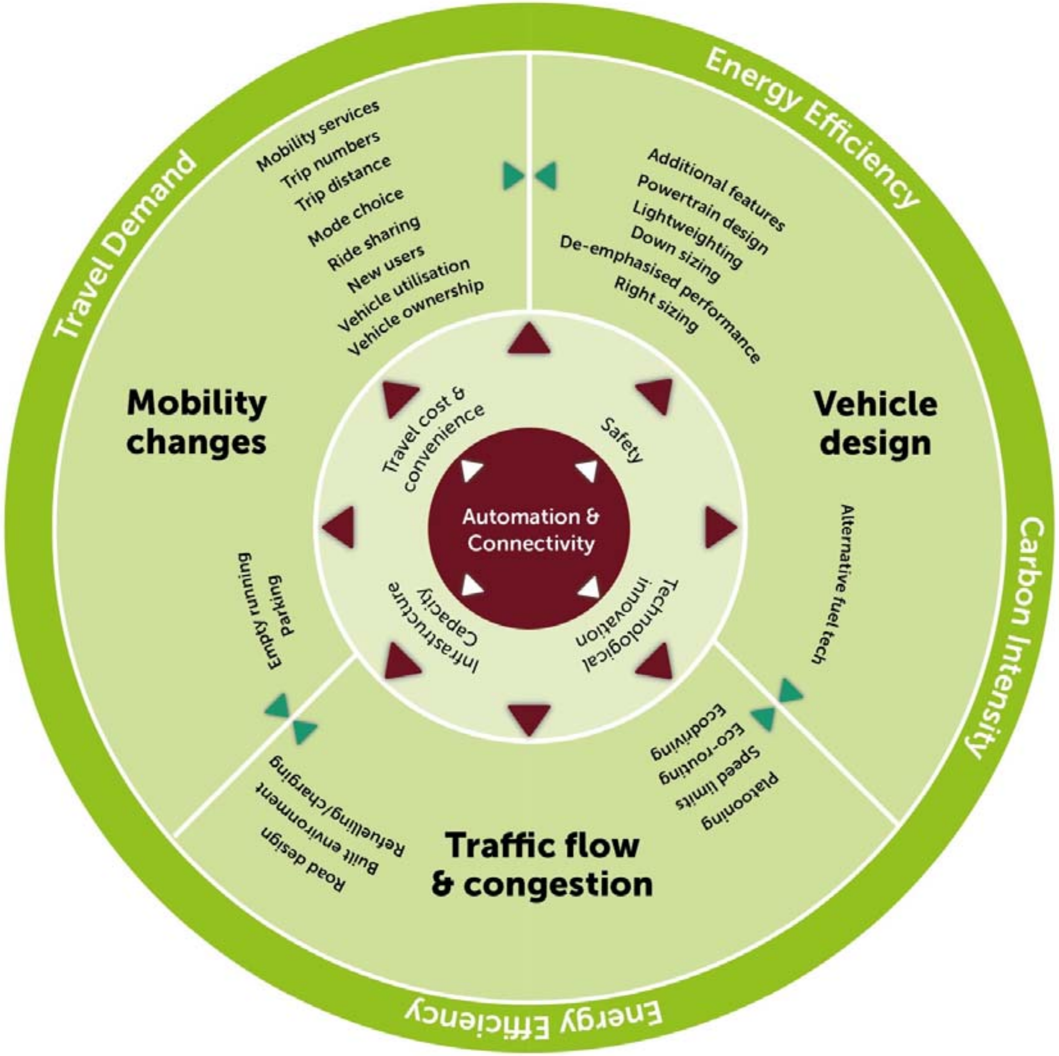

# Energy efficiency

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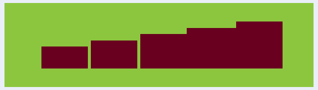
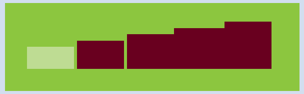
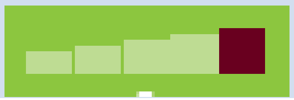
| Mechanisms | Energy effects | Automation level | Connectivity level |
|---|---|---|---|
| Traffic flow improvement | ✓ |  | V2X |
| Eco-routing | ✓ ✓ |  | V2X |
| Eco-driving | ✓ |  | V2X |
| Sp | | | |
| P | | | |
| A | | | |
| De-emphasized performance | ✓ ✓ |  | I2V |
| Lightweighting | ✓ ✓ |  | V2X |
| Rightsizing | ✓ ✓ ✓ |  | V2I, I2V |

Early benefits from connectivity and connectedness

Potentially large benefits at high levels of automation and connectivity,
………… but these benefits are highly uncertain, too
…….. and depends on innovations in other areas

# Travel demand

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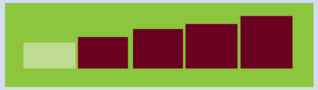
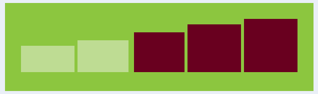
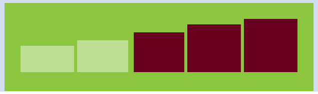
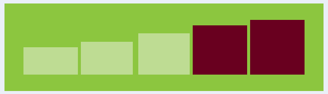
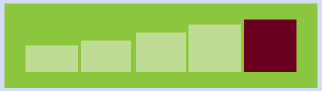
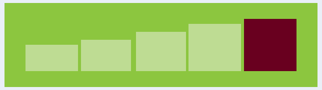
| Mechanisms | Energy effects | Automation level | Connectivity level |
|---|---|---|---|
| Distances (location choice) | ✗ ✗ |  | I2V |
| Modal shift | ✗ ✗ ✗ |  | I2V |
| Trip number | ✗ |  | I2V |
| New user groups | ✗ |  | I2V, V2I |
| Mobility on demand, MaaS | ✓✓✓ / ✗ |  | I2V, V2I |
| Empty running | ✗ |  | I2V, V2I |

- Small impact at low levels of automation
- Step changes at high levels of automation
- Large uncertainty at high levels of automation
- Car ownership vs. car-share/mobility services major uncertainty

## Synergy with low carbon fuels

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- Automation does not automatically mean EVs or FCVs, but several synergies between automation and low carbon fuel

- Unattended refuelling/recharging : annoyance reduced
- High utilisation in a mobility services future: cost efficiency
- Lightweighting allows more batteries: range anxiety reduced
- … … all related to full (driverless) automation

- Automatic electric driving for HEVs/PHEVs using Geofencing

## Conclusions & policy pointers

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Planning & coordination of stakeholders needed to align individual mechanisms toward the desired outcome

Incentivize manufacturers to provide efficiency optimizing features

Establishing data safeguarding & sharing protocols, and provisions for smart connectivity vital at early stages of development

Demand management key to mitigate any increases in car use

-Road user charge, LEZs, regulation of empty running

Support for new mobility services

Incentivize/limit sales and use of highly or fully automated cars to vulnerable users, mobility & transport service providers, or, only for low carbon propulsion

Public engagement necessary for acceptance & positive use behaviours

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Automated Vehicles:
Automatically Low Carbon?

..... Not yet, but holds promise!!

**Thank you**

# Conclusions

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- Planning & coordination of stakeholders needed to align individual mechanisms toward the desired outcome
- Establish data safety & sharing protocol to ensure smart connectivity at early stages
- Demand management will be required to mitigate against potential net increase in travel demand
- Policies to provide direction toward shared mobility services
- Beware of unintended travel & energy effects!!

# Carbon emissions

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| Mechanisms | Energy effect direction & size | Automation level required | Connectivity level required | Remarks |
|---|---|---|---|---|
| Traffic flow improvement & congestion mitigation | ☺ | 1-5 | V2X-2way | Step change at higher levels of automation & connectivity |
| Dynamic eco-routing | ☺☺ | 1-5 | V2X-2 way | |
| Automated eco-driving | ☺ | 2-5 | V2X, 2way | |
| Higher motorway speed limits | ☹ | 2-5 | V2X-2way | Only with regulatory changes |
| Vehicle platooning in motorways | ☺ | 3-5 | V2V | |
| Additional comfort & convenience features | ☹ | 3-5 | I2V | |
| De-emphasized performance | ☺☺ | 4-5 | I2V | |
| Light-weighting in city cars | ☺☺ | 4-5 | V2X-2way | Only with very high uptake & regulatory changes |
| Right-sizing | ☺☺☺ | 5 | V2I-2way | Only for MOD services |

# Carbon emissions

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**Table 2:** Potential mechanisms for changes in **travel demand** due to automation and connectivity and their **energy effects** (adapted from Wadud et al.) [iv]

| Mechanisms | Energy effect direction & size | Automation level required | Connectivity level required | Remarks |
|---|---|---|---|---|
| Distances travelled (location choice) | ☹☹ | 2-5 | I2V | Step changes at levels 4-5 |
| Modal shift | ☹☹☹ | 3-5 | I2V | Step changes at levels 4-5 |
| Trip Numbers | ☹ | 3-5 | I2V | Step changes at levels 4-5 |
| New user groups | ☹ | 4-5 | I2V, V2I | Primarily at Level 5 |
| Mobility on Demand | ☺☺☺/☹ | 5 | I2V, V2I | Right-sizing needed for large reduction |
| Empty running of vehicles | ☹ | 5 | I2V, V2I | Only at Level 5 |

☺ Reduction in energy use.
☹ Increase in energy use.

# Mechanisms for energy effects

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Energy Efficiency





Travel Demand

# Carbon emissions

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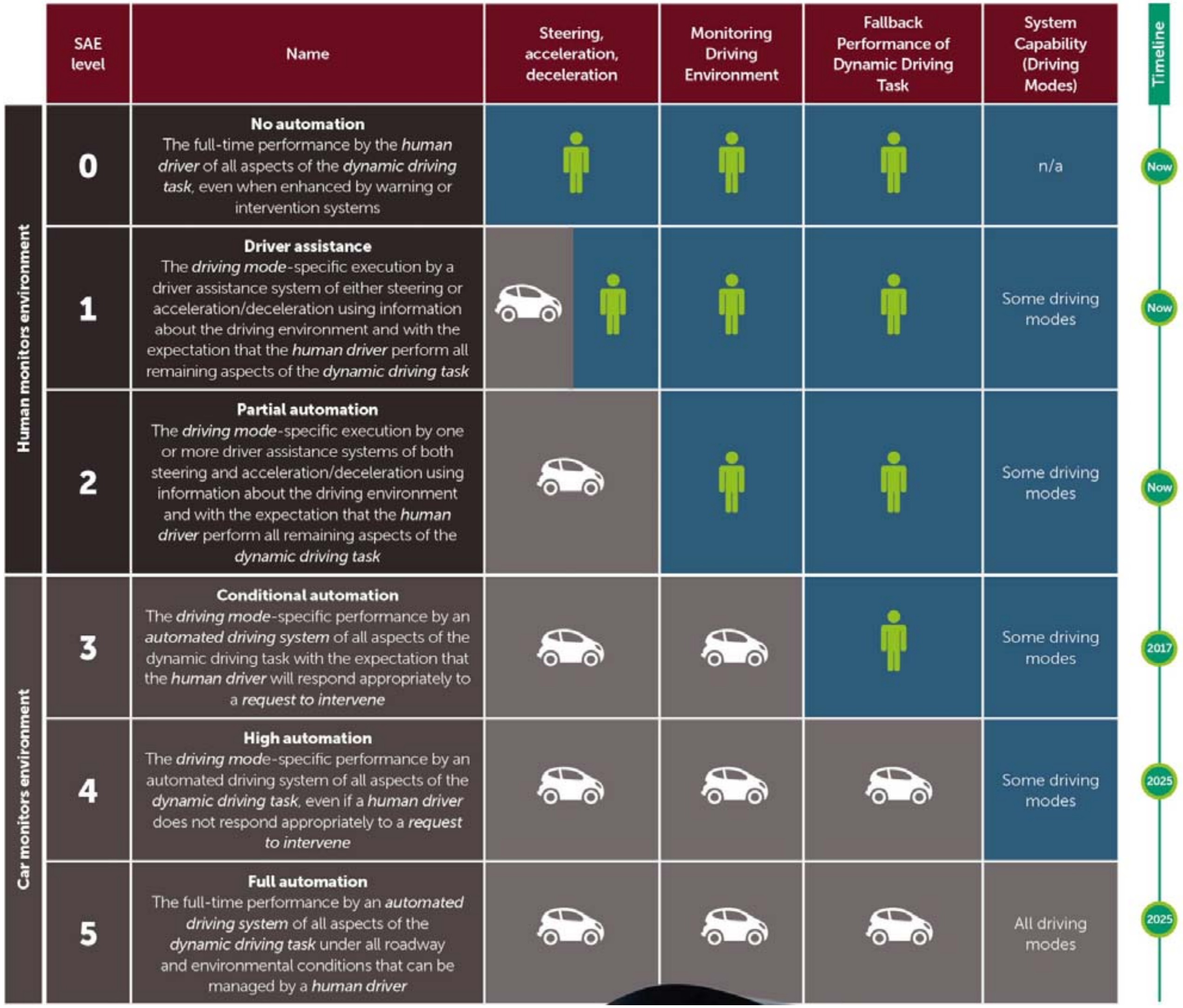

# Results (USA)

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