Autonomy & PNT: A New paradigm

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Agenda

JLR & Artificial Intelligence

Autonomy & PNT: A New paradigm

JLR – More than car manufacturer – A brand with strong heritage, modern desirable luxury products

Over 70 years of historic products embracing innovation

1953

ABS 1990

1997

1999

2003

2006

2012

2013

2018

2020

Always on
Always connected
Always up to date

2024

JLR mission - Delight our customers by making our vehicles cleaner, safer, and smarter though innovation

RECENT BUSINESS HIGHLIGHTS

Robust Q3 performance delivered

Highest Q3 revenue on record

Jaguar Type 00 revealed at Miami Art Week

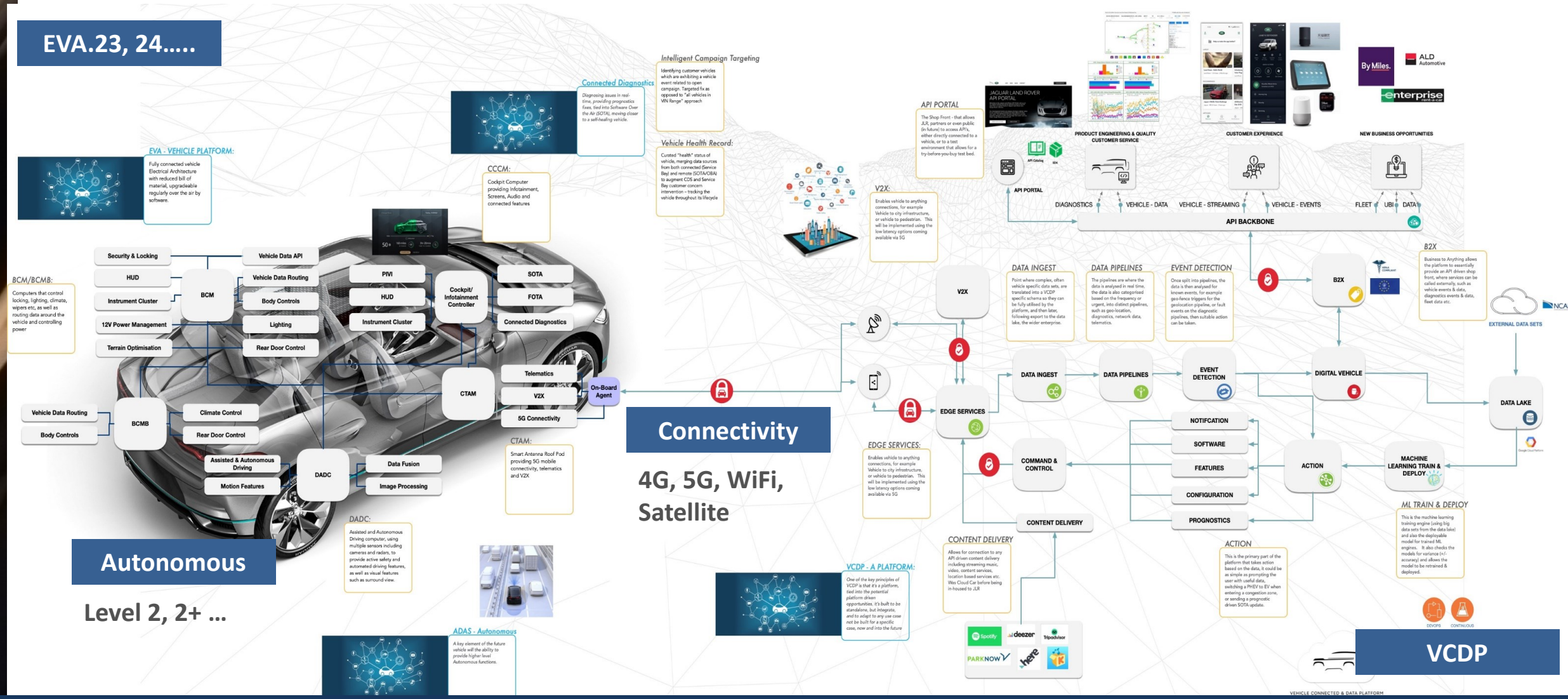
Defender OCTA Global Media Drive acclaim

Range Rover Electric testing nears completion

Recycled seat foam proven in Circularity Lab

Range Rover wins Walpole 'Made in UK' award

E2E architecture – moving car to be cloud on wheels



JLR vehicles are capable end to end digital platform within all vehicles produced today.

We grow this capability, using customer data, to enhance our products to meet customer needs, create new markets & new services

Artificial Intelligence Application Pillars in Automotive

Ethics, Legislations, Standards

Cyber Security

A – autonomous

Situational awareness, reasoning, decision making, safety, actuation, learning

C – connected

Vehicle to vehicle, vehicle to infrastructure, mobile to vehicle, wearable to vehicle, Cloud Computing

E – electrified

Increased need for **health management** systems to enable graceful degradation and logistic services (e.g. battery charging points)

S – shared

Fleet data collection to enable just in time logistics and access to apps and services for the vehicle, Cloud Services, Vehicle to vehicle information sharing & learning (swarm intelligence)

Intelligent Modelling and Simulation – Establishing an AI Model Based design

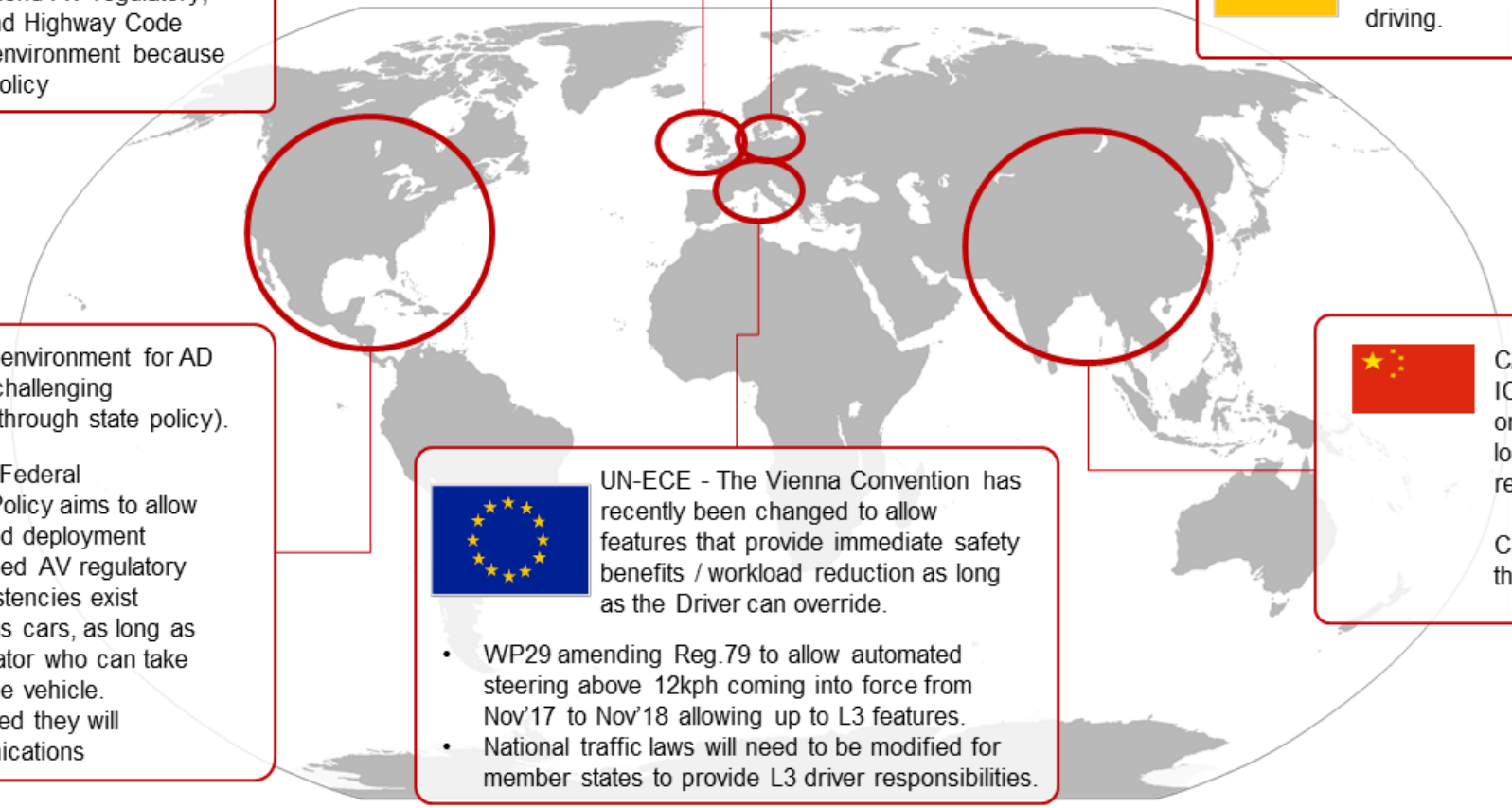
Vertical technologies approaches do not suffice to address increased software complexity & AI technology insertion within automotive

The Legislative Framework

DfT Promoting AV legislation through the "Pathway to Driverless Cars"

- DfT's consultation to amend AV regulatory, insurance framework and Highway Code
- Favourable AV testing environment because of the 'test anywhere'' policy

The government has recently adopted a bill on traffic rules for automated driving.



More favourable environment for AD deployment but challenging standardisation (through state policy).

- USDOT's non-binding Federal Autonomous Vehicle Policy aims to allow safe, secure testing and deployment
- 9 states have established AV regulatory framework but inconsistencies exist
- Florida allows driverless cars, as long as there is a remote operator who can take immediate control of the vehicle.
- The US have announced they will mandate V2V communications

UN-ECE - The Vienna Convention has recently been changed to allow features that provide immediate safety benefits / workload reduction as long as the Driver can override.

- WP29 amending Reg.79 to allow automated steering above 12kph coming into force from Nov'17 to Nov'18 allowing up to L3 features.
- National traffic laws will need to be modified for member states to provide L3 driver responsibilities.

CATARC is working on ICV/ADAS with focus on regulation, expect to localise UN-ECE regulations

China have announced they will mandate V2X

Governments pushing Automated Driving legislation across the globe – but with caution more recently

Automated Driving definition (source SAE)

SAE level	Name	Narrative Definition	Execution of Steering and Acceleration/ Deceleration	*Monitoring* of Driving Environment	Fallback Performance of *Dynamic Driving Task*	System Capability *(Driving Modes)*
***Human driver* monitors the driving environment**						
0	**No Automation**	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	**Driver Assistance**	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes
2	**Partial Automation**	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/ deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	**System**	Human driver	Human driver	Some driving modes
***Automated driving system* ("system") monitors the driving environment**						
3	**Conditional Automation**	the *driving mode*-specific performance by an *automated driving system* of all aspects of the dynamic driving task with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	**System**	Human driver	Some driving modes
4	**High Automation**	the *driving mode*-specific performance by an automated driving system of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*	System	System	**System**	Some driving modes
5	**Full Automation**	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	**All driving modes**

In each industry, a definition of level of autonomy is provided by regulation bodies – SAE defines the ones in automotive
Autonomous Systems for cyber-physical systems require triple redundancies to guarantee their safety and the level of autonomy defines the human involvement in carrying out a task

Artificial Intelligence

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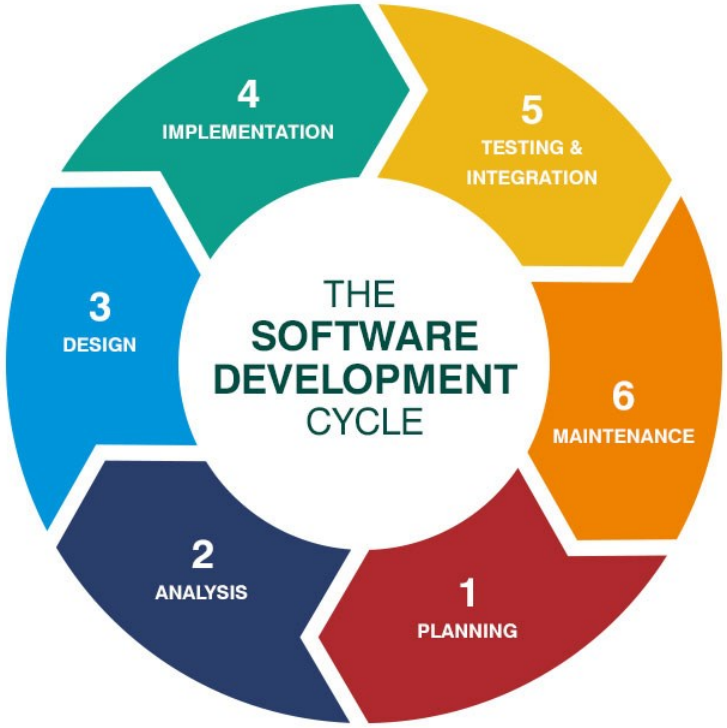
An Engineering definition for Artificial Intelligence (AI)

- AI can be defined as the field, the technology that aim to embed into the machines self-modulated responses, which will enable machines to be self-driven towards a primary goal: the system survival in itself. (I. Panella)

- AI can be thought as the combination of various technologies that will provide machines with the sense of survival, hence **adaptation capabilities**.

- Adaptation requires the machines to:
  - ***Sense*** the environment and themselves;
  - Create an inner ***representation*** of what they sense;
  - Be able to ***reason and make inferences*** about the environment;
  - ***React*** to the environment;
  - ***Learn*** and update knowledge;
  - ***Re-plan*** their course of action;
  - ***Actuate*** the new plan.



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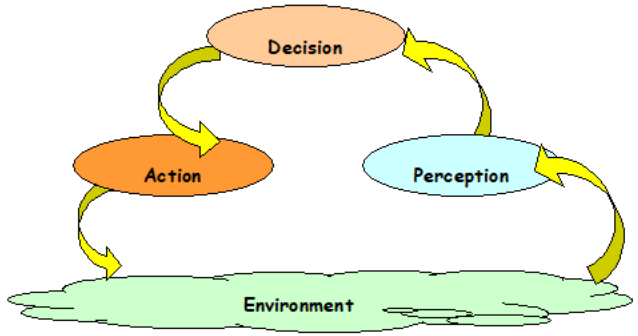
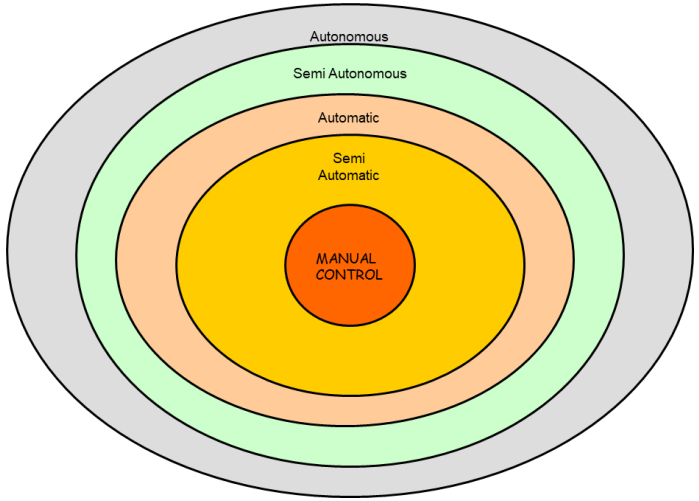
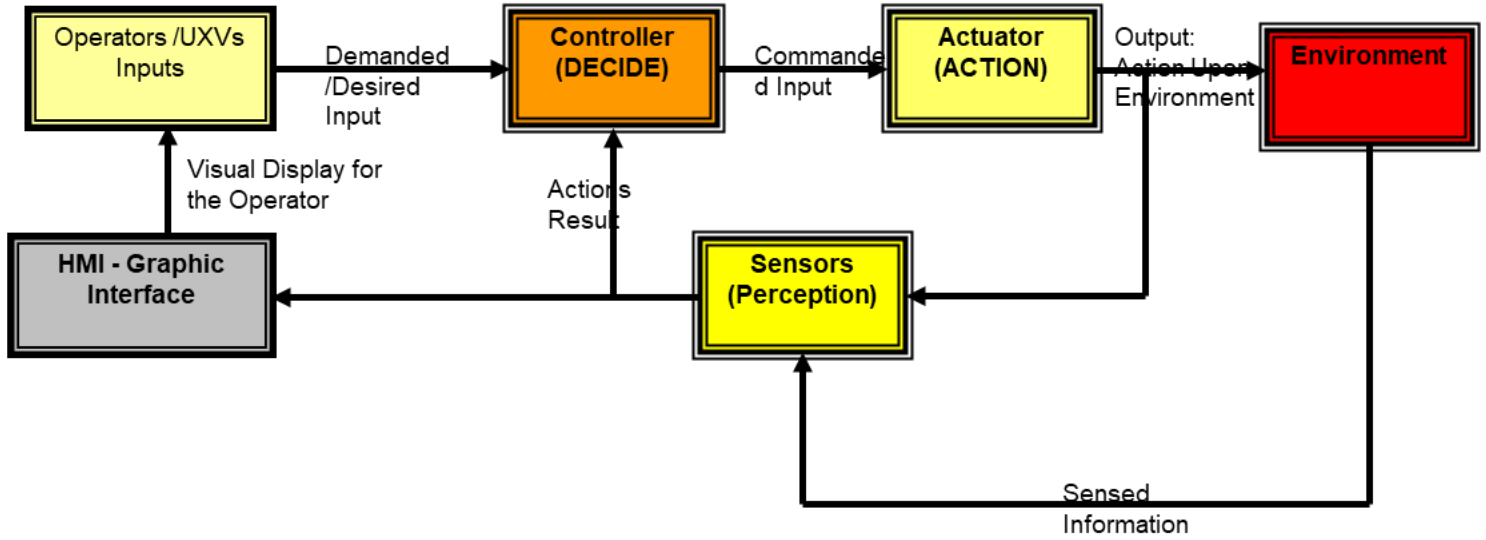
AI is implemented though software algorithms – Software and Systems Life Cycle best practices must be observed

Intelligent Systems as an evolution of Control Theory







Whilst control systems are evaluated through robustness criteria, AI systems need a paradigm shift and we need to look at resilience and repeatability of achieving a goal within the safety criteria dictated by the industry in question

The Importance of PNT for autonomous driving– A change in paradigm

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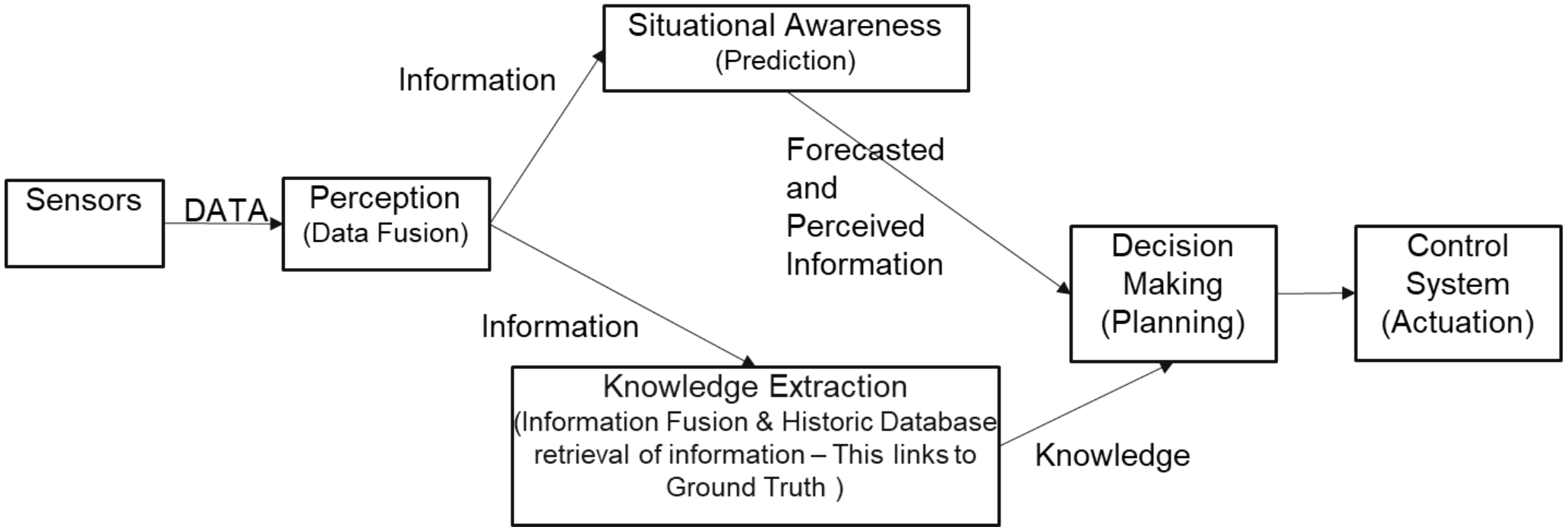
Decision Making



Decision Making in autonomous driving is represented by the ability for a car to reach safely a destination without causing harm to living or inanimate objects – Path Planning and Collision Avoidance

Path Planning & Localisation – The importance of PNT

Localization – Where am I?	Navigation – Where do I want to go?	Collision Avoidance – What is around me?
•Existing spatial localization techniques for autonomous vehicles mostly rely on a pre-built 3D-High Definition (HD) map, often constructed using a survey-grade 3D mapping vehicle, which is expensive, time consuming, and limiting its exploitation to a very well-established path. •Consumer-based GPS solutions degrade significantly in GPS denied areas **ARTIFICIAL INTELLIGENCE Content - Occupancy grid, Game theory, Belief networks , Information Fusion**	• Process of monitoring and controlling the movement of a vehicle from one place to another. •The approach of GPS based autonomous navigation utilises a GPS receiver that receives signals from a constellation of GPS satellites. The receiver then computes its position on the earth surface and a navigation algorithm will computes other parameters such as direction and distances in order to aid autonomous navigation **ARTIFICIAL INTELLIGENCE Content - Route Planning – Decision Making & Forecasting, Machine Learning, Factor Graph Optimisation**	•An autonomous car will have to determine what's around it. Referred to as Situational Awareness •Collision avoidance is the ability of a dynamic systems to take actions to avoid obstacles (static or dynamic) •Requires real time ability for the vehicle to understand the environment and re-plan **ARTIFICIAL INTELLIGENCE Content - Real Time Information Fusion, Decision Making, Bayesian Networks, Vector Field Optimisation, Machine Learning**

= PATH PLANNING

PNT technologies are key to enabling enhanced localisation of autonomous vehicles as well as future collaborative, multi domains integrated traffic management solutions

Conclusions

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Conclusions

- Automotive Industry no longer solely driven by electromechanical design
- Software has become core to automotive technology delivery
- Automotive OEMs moving towards Software Defined Vehicle architectures and more into Software Development in house solutions rather than Systems Integrators
- Autonomous driving development requires a cross-sector holistic approach to be successful – Technology development becomes horizontal – no longer Vertical
- AI technology insertion requires triple redundancies
- Reliability, robustness, safety, continuous connectivity, and increased accuracy required in real time are driving the need for PNT technologies to be considered as integral part of Localisation systems in vehicles

Thank you!

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