

**Evercore ISI Fieldtrip**  
Munich, December 4, 2018

# Audi makes heavy upfront expenditure into strategic fields



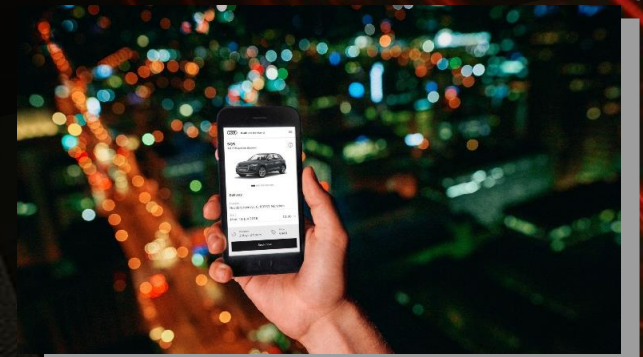
Autonomous Driving



Electric mobility



Digital Services



# spectacular upbeat for Audi e-tron

**e-tron**  
WORLD PREMIERE



**e-tron**

San Francisco, September 2018





**Audi e-tron GT**  
2020 \*

\*concept

# Audi Transformation Plan (ATP)

transforms  
and  
prioritizes  
resources

frees up  
a total of  
€ **10** bn  
until 2022

secures  
Operating RoS  
**8-10%**

2025

**focus on revenues and costs**



**strong C-/D-portfolio**

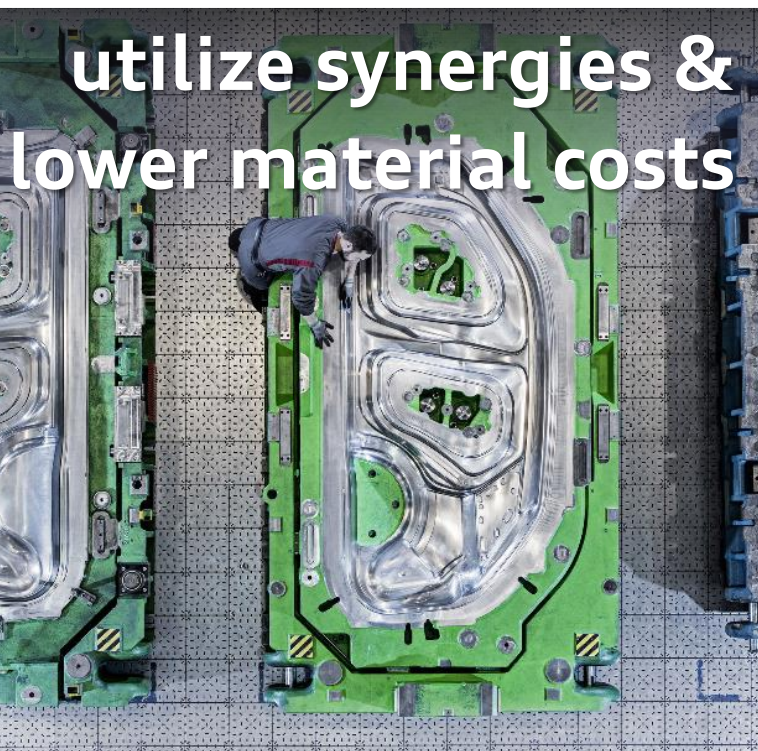


**enhance  
China business**



**transformation  
of skills**

**utilize synergies &  
lower material costs**



**reprioritize &  
focus on USPs**

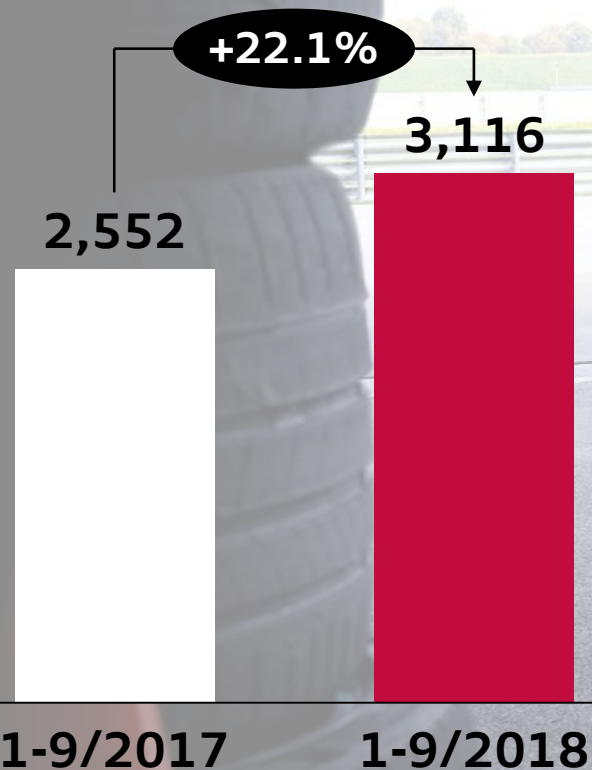


**MEB & PPE for  
profitable EV**























# strong focus on Cash Flow remains imminent

Net cash flow  
(EUR m)



# LEVELS OF DRIVING AUTOMATION

	assisted	automated		autonomous	
<b>Driver to follow the intended use</b>	Present and fully responsible	Available and vigilant		Not necessary	
	<b>Level 1/2</b>	<b>Level 3</b>	<b>Level 4</b>	<b>Level 5</b>	
<b>Steering acceleration/braking</b>					 
<b>Monitoring of driving environment</b>					 
<b>Fallback</b>		 → 			 
<b>Availability</b>		Specific domains and situations			Every domain every street
<b>Examples</b>	ACC	Traffic Jam Pilot/ Highway Pilot L3	Highway Pilot L4	Robo Taxi/ Shuttle	





# AUTONOMOUS DRIVING – THE LOGIC IS CHANGING



Driving capability



Release criteria



Liability



Scalability



Homologation

## Assisted World (L1/2)



**Driver**



**Safety and controllability**



**Driver**



**Global**



**Known regulations**

## Automated/Autonomous World (L3/4)



**Technology**



**Safety and driving performance**



**Company**



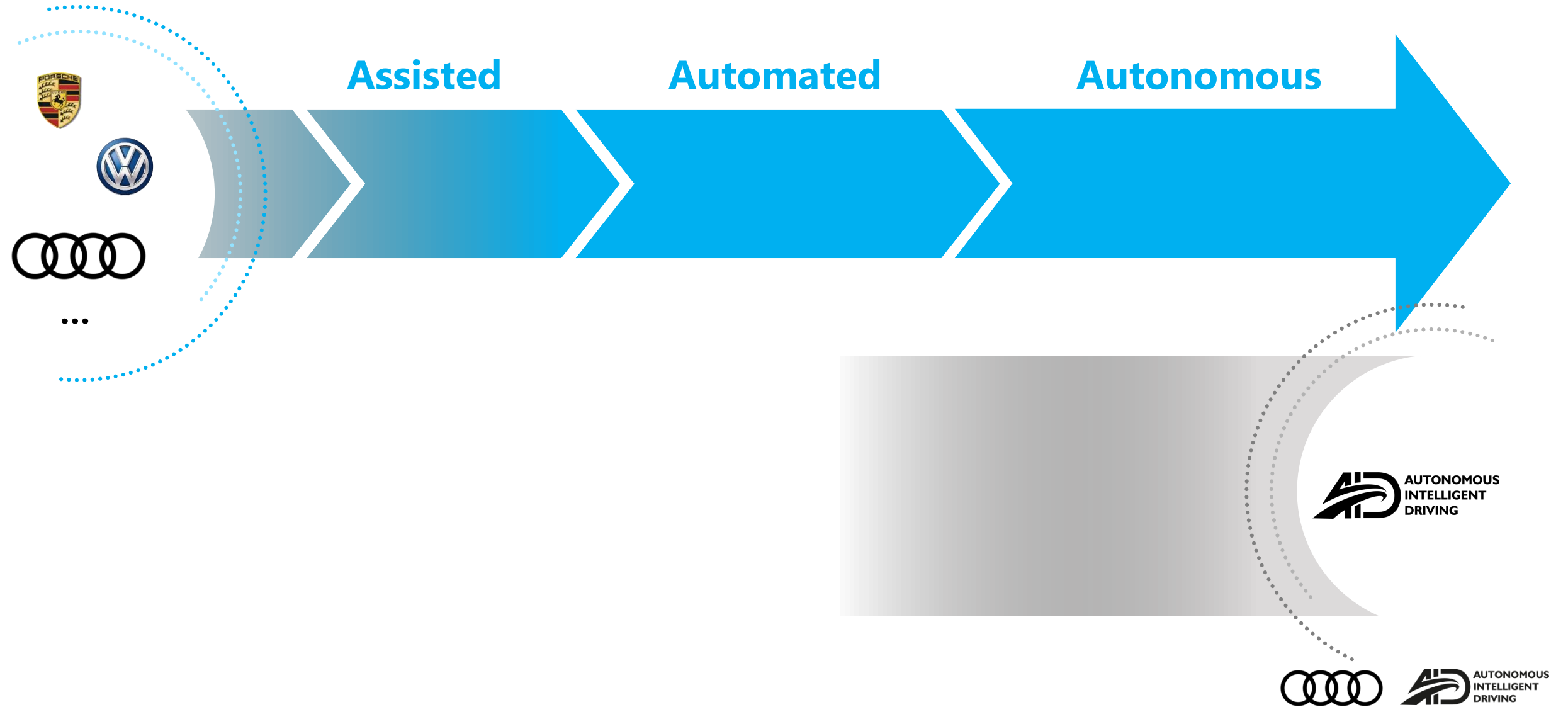
**Local**









**Regulations not yet defined**



# DIFFERENT APPROACHES TOWARDS AUTONOMY



# MASTERING HIGHWAY AND URBAN TRAFFIC DOMAINS IS QUITE A DIFFERENCE AND THE USE CASE HAS NOTICEABLE IMPACT ON THE SYSTEM DESIGN

	Highway 	Urban 
<b>Scenarios</b> 	<ul style="list-style-type: none"> <li>» Highway driving up to 130km/h</li> <li>» Lane Changing</li> <li>» Limited sideline activities</li> </ul>	<ul style="list-style-type: none"> <li>» 50km/h</li> <li>» Lane Changing, Intersections</li> <li>» All sideline activities</li> </ul>
<b>Corner Cases</b> 	<ul style="list-style-type: none"> <li>» Small Obstacles @ far distance</li> <li>» 360° perception @ lane changing</li> <li>» High availability of all functions (e.g. lane keeping)</li> </ul>	<ul style="list-style-type: none"> <li>» Pedestrians, crowded streets, crossing bikes, intersections – 360° perception @ all times</li> <li>» rear approaches, blind spots</li> </ul>
<b>Technical implications</b> 	<ul style="list-style-type: none"> <li>» Sensors: High resolution @ far range, wide FoV</li> <li>» Platform: Redundancies, timing</li> <li>» Vehicle: Fail-Op architecture incl. braking, steering</li> </ul>	<ul style="list-style-type: none"> <li>» Sensors: Mid-Range, Wide FoV, medium resolution</li> <li>» Platform: Redundancies, timing, &gt;10x interpret. effort</li> <li>» Vehicle: Fail-Op architecture for shorter times</li> </ul>
<b>Cost driver</b> 	<ul style="list-style-type: none"> <li>» Validation / approval for vehicle lifetime (ownership)</li> <li>» Sensor frontends, semi-conductors, redundancies</li> <li>» Dimension: 10k€</li> </ul>	<ul style="list-style-type: none"> <li>» Validation / approval for veh. lifetime (serviced cars)</li> <li>» Different service concept over lifetime</li> <li>» Dimension: 50k€<sup>1)</sup></li> </ul>

1) Estimation incl. external references

# USE CASES OF AUTONOMOUS DRIVING CAN BE DIVIDED INTO URBAN AND HIGHWAY AS WELL AS OWNED AND SHARED



	Highway	Urban
<b>Owned</b>	Highway Pilot (HWP) L3	Valet Parking
	Traffic Jam Pilot (TJP) L3	
	Traffic Jam Assist (TJA+) L2	
	ADAS functions and Integral Safety L2	
<b>Shared</b>  Mobility as a service (MaaS)	<b>Transportation of people</b>	
	<b>Transportation of goods</b>	



# AUDI'S ROADMAP TOWARDS AUTONOMOUS DRIVING

**L1/2**

ADVANCED  
DRIVER ASSISTED  
SYSTEM

**L3**

TRAFFIC  
JAM PILOT

**L3**

HIGHWAY  
PILOT

**L4**

AICON



# THE CURRENT GENERATION OF VEHICLES ALREADY OFFERS A WIDE SCALE OF ADAS SENSORS & SOFTWARE WITH A STRONG FINANCIAL CONTRIBUTION

Sensor areas for environment observation  
07/17

Serie	Parken S	Parken L	Fahren S	Fahren L	FAS XL	HAF Pilot XXL
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Serie	Parken S	Parken L	Fahren S	Fahren L	FAS XL	Pilot XXL
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Serie	Parken S	Parken L	Fahren S	Fahren L	FAS XL	Pilot XXL
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Serie	Parken S	Parken L	Fahren S	Fahren L	FAS XL	Pilot XXL
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>

## City assistance package

- » Audi side assist
- » Exit warning
- » Audi pre sense rear
- » Park assist plus
- » Rear cross-traffic assist
- » Reversing camera

## Standard features

- » Hold assist
- » Audi pre sense basic
- » Audi pre sense city
- » Park assist rear
- » Adjustable speed limiter
- » Cruise control system
- » Break recommendation function

## Parking assistance package

- » Surroundings camera
- » Park assist

## Additional options

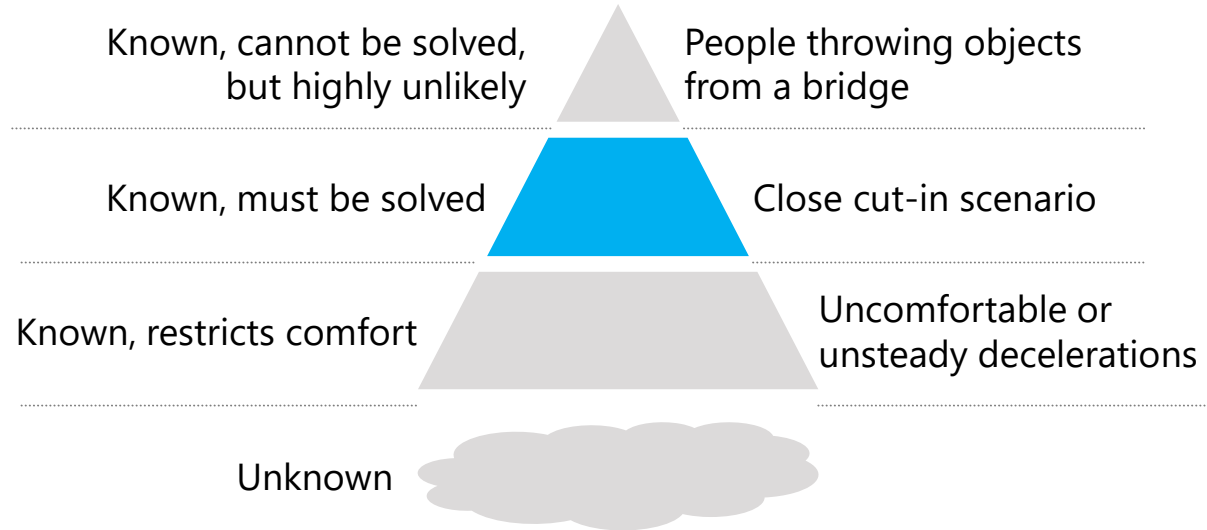
- » Trailer assist
- » Main beam assist
- » MMI navigation plus with MMI touch
- » Night vision assistant

## Tour assistance package

- » Turn assist left
- » Adaptive cruise control
- » Audi active lane assist
- » Audi pre sense front
- » Obstacle avoidance assist
- » Camera-based traffic sign recognition
- » Predictive efficiency assistant
- » Traffic jam assist



# LESSON LEARNED FROM TRAFFIC JAM PILOT DEVELOPMENT: IT'S NOT ONLY IMPORTANT HOW MANY MILES, BUT WHICH MILES

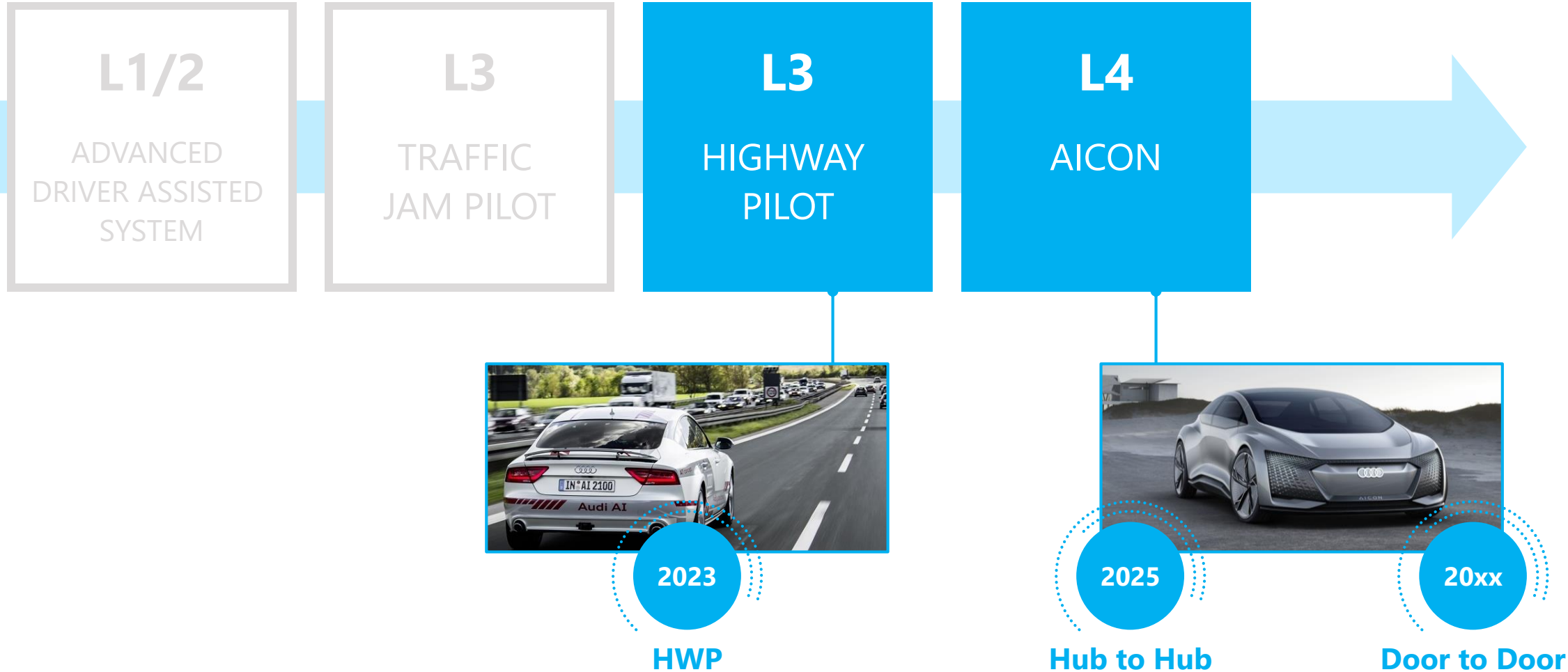


**One use case is enough to cause a complete system redesign, i.e. vertical resolution insufficient:**

- » New sensor
- » new package, new design
- » more ECU Power, more cooling, more voltage etc.
- » new architecture
- » etc.

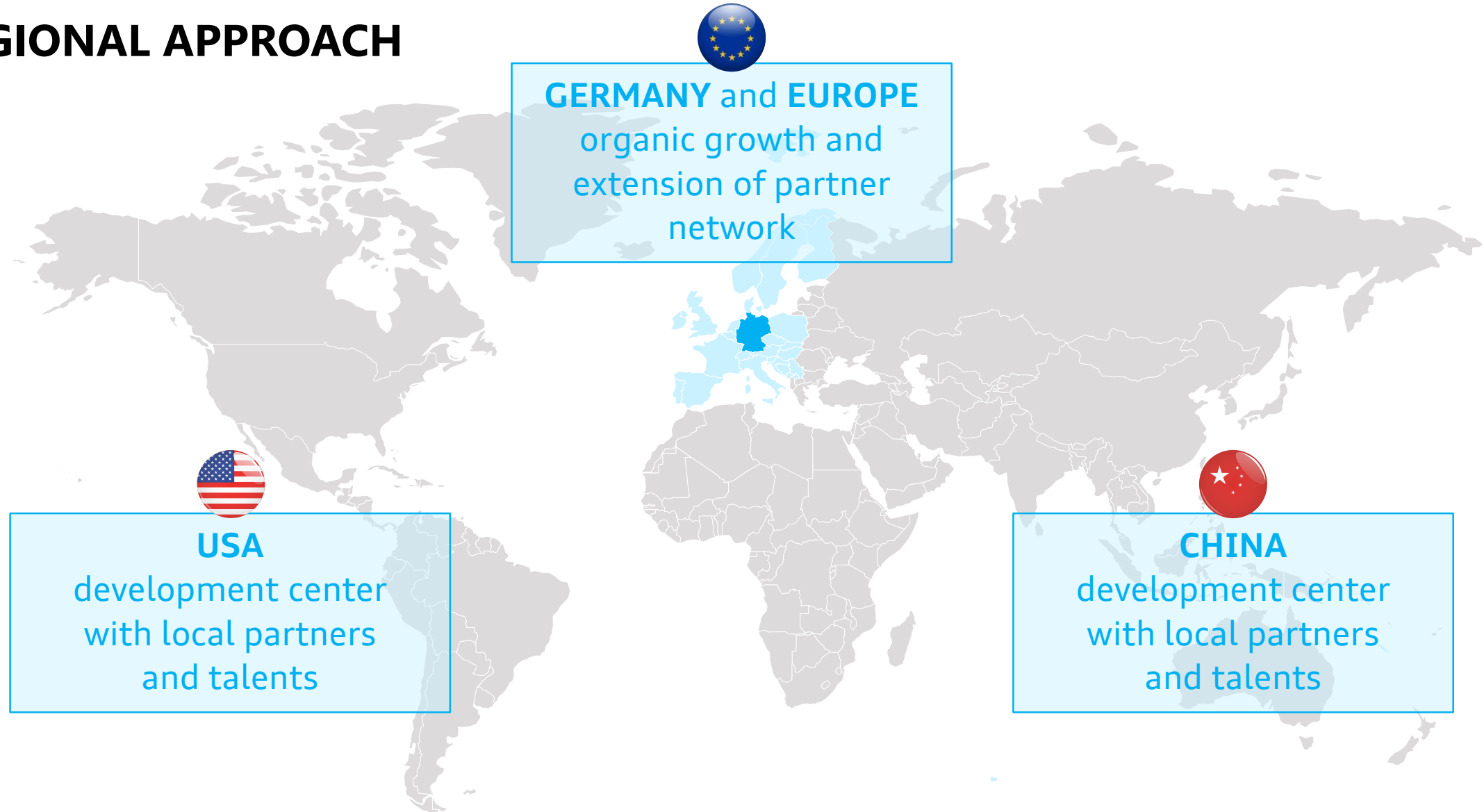
**Years & Millions  
out of one use case!**

# AUDI'S HIGHWAY PILOT AND AICON





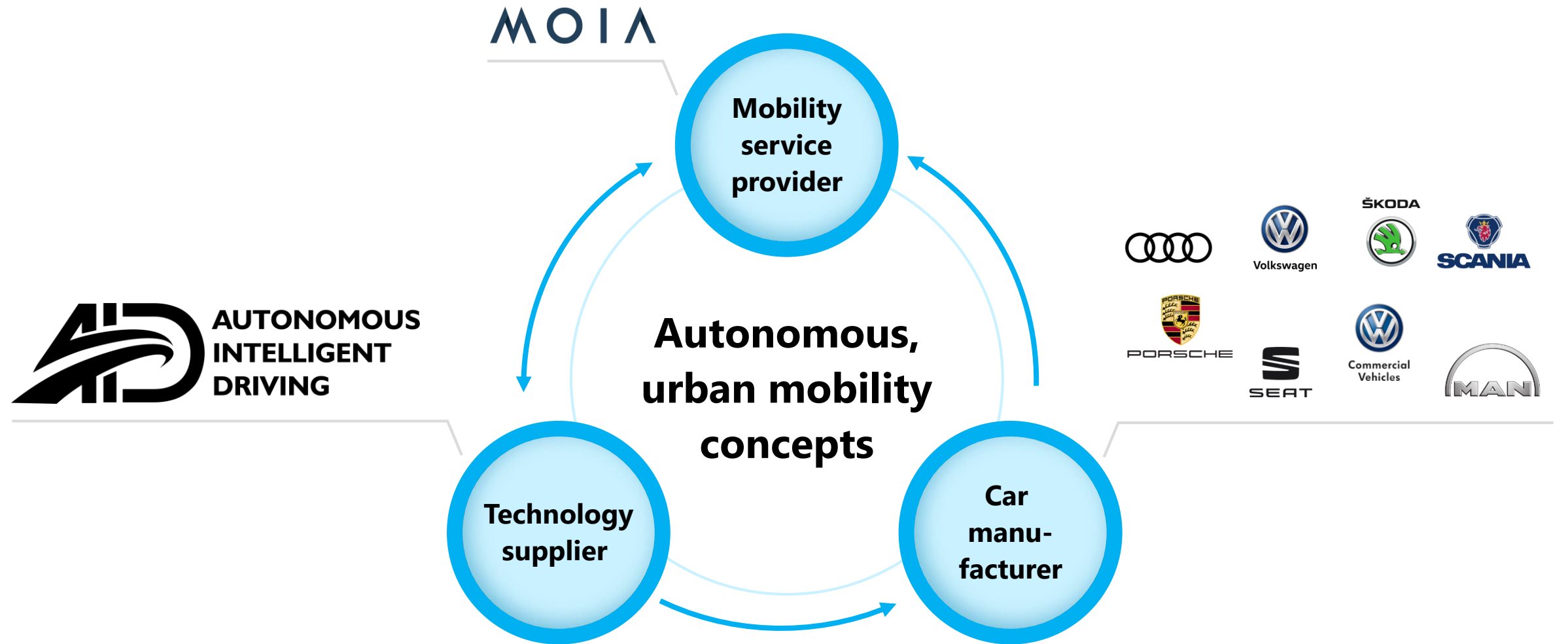
# REGIONAL APPROACH










**AID'S ROLE**

# AID'S ROLE IN THE VW GROUP



# VW GROUP MAAS LAYER ORGANIZATION AND ROLES IN THE GROUP

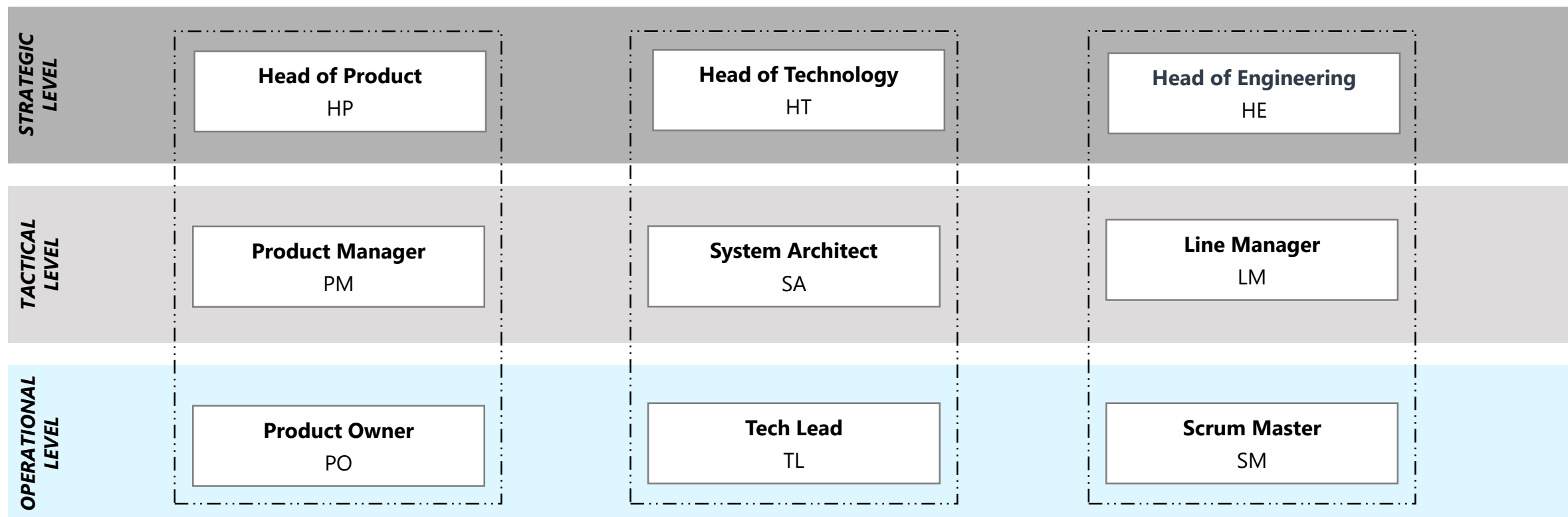
## MAAS LAYER

Layer 5 <b>Content</b> 	Content & Advertisement
Layer 4 <b>Mobility Platform &amp; Services</b> 	Mobility clients Mobility platform
Layer 3 <b>Fleet Operations</b> 	Fleet intelligence platform Fleet operations Fleet & service hubs Fleet ops platform
Layer 2 <b>Vehicle</b> 	SDV components Base vehicle interface Base vehicle
Layer 1 <b>Self-Driving System (HW/SW)</b> 	SDS software Map data SDS Hardware

# AID'S ORGANIZATION



# FOR THE STRATEGIC, TACTICAL AND OPERATIONAL LEVEL THERE ARE DIFFERENT ROLES



# MANY EXPERTS WORKING HARD ON ACHIEVING OUR MISSION: TO DRIVE COMPLETELY AUTONOMOUSLY BY 2021

AVERAGE AGE: 36 years

BROAD EXPERIENCES FROM A VARIETY OF DIFFERENT INDUSTRIES:



**INTERNATIONALITY - 30 DIFFERENT NATIONALITIES:**

Austria, Brazil, Bulgaria, Canada, China, Croatia, Czech Republic, Estonia, Finland, France, Germany, Greece, Hungary, India, Ireland, Israel, Italy, Lebanon, Mexico, Poland, Portugal, Romania, Russian Federation, Spain, Sweden, The Netherlands, Ukraine, United Kingdom, United States of America, Venezuela



**TECHNICAL  
DEVELOPMENT**



# CORE BELIEFS ON AUTONOMOUS DRIVING

» **This has never been done before and there is a lot of unknown. We plan for this by:**

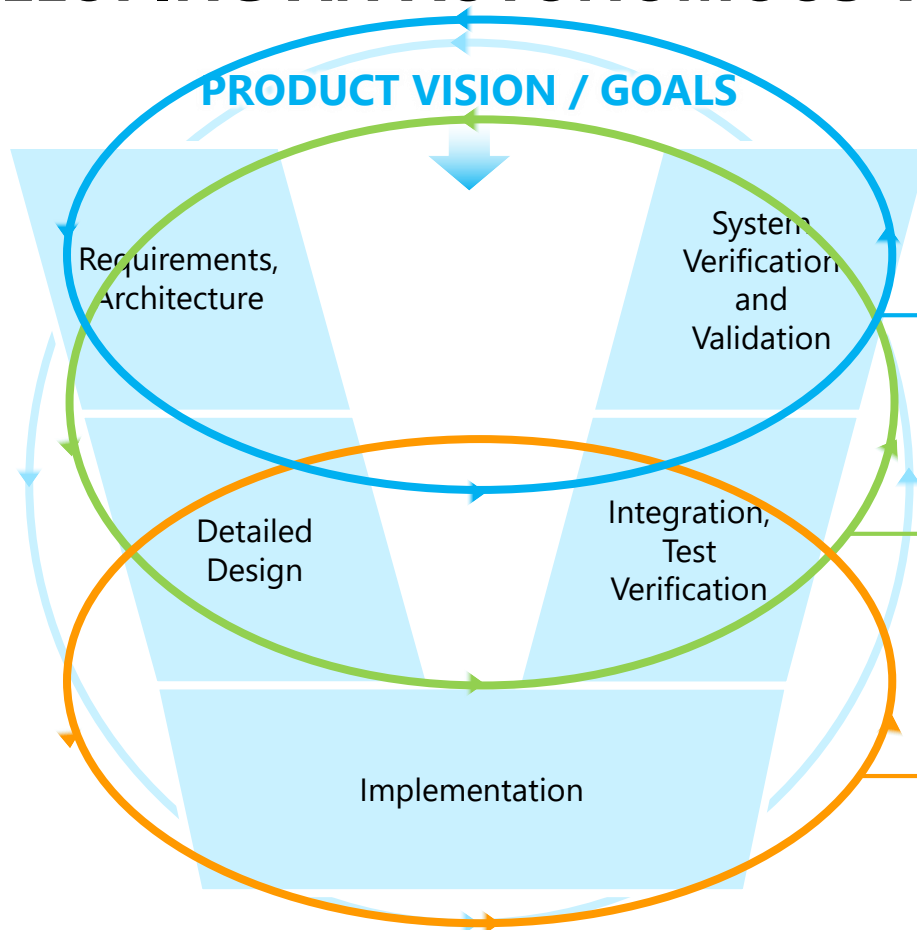
- Generating feedback quickly
- Building infrastructure that supports quick iterations
- Writing many automated tests to make changes and refactoring easier

**AUTONOMOUS  
DRIVING IS ONE OF  
THE HARDEST  
ENGINEERING  
CHALLENGE SINCE  
PUTTING A MAN ON  
THE MOON**

» **We'll need a system level optimization:**

- T-shaped people, cross-functional teams and mono-repository to avoid silos
- In car testing by engineers to build insight into the whole system
- Make data-driven design choices compatible with first principles

# DEVELOPING AN AUTONOMOUS VEHICLE



## Questions which product is possible

- » E.g. if a realistic sensor distance is  $\leq 250\text{m}$ , how much slower does a vehicle have to be, that we can still overtake
- Tools to analyze Use-Cases at physical / users limit

## Questions which system is best

- » E.g. which Interpretation & Prediction concept is most robust
- Tools to record & replay data, quickly mock / evaluate behavior and determine robustness of solution

## Questions which technology is best

- » E.g. best way to detect walls as landmark from LiDar data.
- Tools to quickly prototype solutions and break scenario tests down to component and unit tests

## » Large group of people having to iteratively work together on the same problem

- Need an environment that supports lots of developers in all of the tasks above, to enable all steps be done in high quality!

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