CCAM Technology Roadmap and Collaboration Initiatives
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Open Innovation
Autonomous Vehicle Development and Testing Platform

23.01.2025

Summary Version

Strategy and Technology Road Map Workshops

- 14 th of May 2019
- 10 th of December 2019
- 23 rd of February 2022

" Haberleşen,Otonom ve Elektrikli Araç Teknolojileri ve Hizmetleri Alanında Özgün Teknolojiler ve Yenilikçi Hizmetler ile Küresel Çapta bir Araştırma Odağı Olmak ve Küresel Pazarda Öncü Ülkeler Arasında Yer Almak"

23rd of Feb.2022

Vision

"To be one of the leading smart green mobility clusters and research centers to support development of advanced solutions worldwide."

Mission

"Innovate, Integrate, Test" for the next generation sustainable mobility".

Temel Strateji Alanları ve Alt Stratejiler

Temel Stratejik Alanlar:

1- Şehirlerde Temiz ve Kolay Ulaşım

2- Verimli Yük Taşıma, Lojistik

3- Güvenli Ulaşım

4- Türkiye'nin CAEVS Araştırma Odağı Olması

5- Türkiye'nin CAEVS Küresel Pazarda ilk Üç Ülke Arasında Yer Alması

Temel Stratejik Alanlara Yönelik Alt Stratejiler :

1- Şehirlerde Temiz ve Kolay Ulaşım :

1.1-Şehirlere özgü, hafif, yenilikçi otonom, haberleşen elektrikli araç

1.2- SAE4-5 için öncü çalışmalar

1.3- Şehir içi lojistik dağıtım araç ve sistemleri

1.4-Bütünleşik, verimli, temiz, akıllı toplu taşıma araç ve sistemleri

1.5- Uçan şehir içi araç sistemleri

1.6-Akıllı ulaşım sistemleri

1.7- Yenilikçi hizmetler

Temel Strateji Alanları ve Alt Stratejiler

2- Verimli Yük Taşıma, Lojistik

2.1- Akıllı konvoy sistemleri
2.2- Temiz, elektrikli ağır yük vasıtaları
2.3- Akıllı yollar
2.4- Yenilikçi lojistik optimizasyon sistemleri

3- Güvenli Ulaşım

3.1- Araç içi yolcu ve sürücü sağlığı güvenlik sistemleri
3.2- Çarpışma algılayan ve önleyici sistemler
3.3- Çarpışma sonrası acil durum sistemleri
3.4- Yazılım güvenliği
3.5- Toplu taşıma güvenlik sistemleri

Temel Strateji Alanları ve Alt Stratejiler

4- Türkiye'nin CAEVS Araştırma Odağı Olması

4.1- CAEVS araştırma platformu kurulması

4.2- AB projelerinde aktif olunması

4.3- CAEVS için test pistleri oluşturulması

4.4- CAEVS simulasyon sistemleri hazırlanması

4.5- CAEVS alanında ARGE fonları arttırılması ve takibi

4.6- Aşağıdaki alanlarda mükemmeliyet merkezleri ve araştırma ortaklıkları kurulması

* Haberleşme sistemleri
* SAE4-5 seviye yazılım ve yapay zeka
* Sensör füzyon teknolojileri
* Yenilikçi sensör Geliştirme
* Türkiye'ye özgü hammadde bulunabilecek, sürdürülebilir batarya hücre sistemleri geliştirilmesi
* Yenilikçi, Enerji ve Batarya Yönetim sistemleri
* Batarya paketleme sistemleri
* Elektrik makinaları, güç ve kontrol üniteleri
* Hafif ve verimli Elektrikli araç tasarımı

Temel Strateji Alanları ve Alt Stratejiler

5- Türkiye'nin CAEVS Küresel Pazarda öncü ülkelerden birisi olarak Yer Alması

5.1- CAEVS için Yenilikçi Üretim alt yapıları

5.2- CAEVS alanında uzman yetiştirme platformu ve eğitim sistemi kurulması

5.3- CAEVS alanında Girişimcilik çalışmalarına fon sağlanması ve hızlandırılması

5.4- CAEVS girişimcilerinin yurt dışına açılmasının sağlanması

OPINA PESTEL Analysis

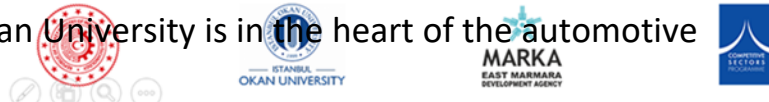| Political	Economic	Social	Technological	Legal	Environment
• Governments support R&D activities in CCAM areas and related technologies. • EU Horizon Europe program includes work programmes and budget allocated for smart mobility and transportation. • EU has an official road map to reduce traffic accidents (Vision Zero Program) and AV industry is a strong tool for this purpose. AV has also potential contributing solutions for UN's Sustainable Development Goals • The EU has the biggest R&D investment amount for automobile industry in the world. • Ministry of Industry and Technology has published a mobility roadmap for Türkiye includes specific targets and policies for CCAM. • of the determined approach	• Türkiye is an important automotive producer in EU and global market. • Increasing foreign direct investments is a sign of attractiveness of Türkiye. • Many global OEMs operate in Türkiye. • In Türkiye, important universities, OEMs, and motor vehicle producers have increased their focus to automotive and AV industry. The EU is the biggest motor vehicle producer in the world. • Chip crisis and supply chain problems in the world along with after-pandemic	• R&D activities are accepted critical for almost all economies. • R&D activities ensure sustainable GDP increase. • R&D effects young entrepreneurship young employment positively • AV has potentials for enabling mobility options for ageing society and there will be n increasing need for that group since. • Gen-Z will be the next 10-20 years decision makers and this group is characterized by their commitment to sustainability and sharing economy. Both trends are supported by CCAM. • Smart City initiatives are directed to more on cleaner, greener, easier, connected urban mobility systems. • All these trends (ageing society and related mobility solutions, smart city initiatives, Gen Z interest to pay more to economic and environmental	• R&D investments and the number of R&D centers have been increasing in Türkiye. • Universities and techno parks more aware to automobile industry • The number of patents in the smart mobility area is increasing. • Investments to smart mobility ecosystem players are increasing. • Recent technology roadmaps in the mobility area include specific targets for the next 10 years. • Motor vehicle producers and OEMs in Turkey has willingness for CCAM.	• Legal studies on insurance, road safety and cyber security are current and important agenda in EU. • Turkey is a party to the Geneva and Vienna Conventions, international law relating to the driverless vehicles. • On the other hand, there is not yet a direct legal regulation on autonomous vehicles. • Automated system vehicle manufacturers are also obliged to show all the care they can during the design and factory stages.	• Technological developments in the automotive sector also consider ecological and environmental perspectives. • Green Deal initiative and policy deployment along with circular economy principles are effective in automotive industry especially in EU countries. •

OPINA SWOT Analysis

STRENGHTS	WEAKNESSES
• OPINA is the first open innovative software development platform on autonomous vehicles in Türkiye	• OPINA is a new starter and requires time to increase to have visibility both in EU market and Turkey.
• Infrastructure of OPINA: state of the art equipment, installations, and software	• Limited interest from local community
• Enriched content of services such as simulation testing, certification, training, consultancy, mentoring, key-turn Project management and delivery, strong development facility	• OEMs, suppliers, and SMEs global dependency in Turkey.
• Okan University's previous concrete experiences, its know-how and strong enthusiasm	• Lack of strong support of OEMs in Turkey
• Strong network coming from former strong ecosystem of Okan University based on e-hike and e-hike link clusters.	• The OEMs cannot initiate a smart mobility program without negotiating with the mother company in Europe. That makes it difficult to support a platform like OPINA.
• The cost advantage of qualified technical professionals compared to European industry,	• Lack of international partners
• Fully integrated end to end software and hardware development workflow,	• Lack of fully dedicated experts' availability
• Credibility through EU financial & institutional support and branding,	• Risk of decreased number of users due to service/charging model
• Partners' support and contribution	• Even Okan University has successful initiative on CCAM in the past, as OPINA there is not any concrete customer yet.
• Integration with EU policy makers and CCAM community	• Some of the leading technology companies (like Adastec, Leo Drive,) are a member of similar platforms
• Being member of all relevant EU associations	• There is a limited number of start-ups that are operate in CCAM area in Turkey.
• Capability on domain integration	• The number of academicians who has expertise on CAV is limited in Turkey.
• Location of the Okan University is in the heart of the automotive industry,	• There is an increasing brain-draing from Turkey, especially on software expertise.

OPINA SWOT Analysis

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• Okan University has the capability to get their own students and graduates' involvement in supporting OPINA, • OPINA enables collaboration and cooperation within the OPUG, • Capability in ~~providing services to all advanced vehicle technologies~~ (Automotive, Marine, Defence, Agriculture, Aviation)	• There is no common understanding and solid education program with other leading universities on joint degree programs or similar ones (to attract new graduates).
OPPORTUNITIES	**THREATS**
• Strong interest and fast development on autonomy, mobility, and connected vehicle technologies of other universities such as İstanbul Technical University, Koç University and Galatasaray University. • SMEs' need for technology and the increase in demand for technological change in order not to fall behind in competition. • Trained manpower and intermediate staff needed by the sector. • National Mobility Roadmap supports the activities on CCAM and has clear goals for the next 5 years . • Talents in AI, and automotive industry. • Strong and good relations with countries having significant automotive industry growth. • Supports and incentives to R&D activities in Turkey, ???? • Strategical compatibility in meeting the EU green deal and mobility criteria, • Increasing number of young engineers interested in high technology to be employed in autonomous vehicle research under OPINA Platform,	• Rapid changes in the technological developments • Unclear legal aspects regarding autonomy • Similar platforms to come in place if OPINA becomes a sustainable role model. • Not enough Research in the field • Not enough demand in the filed • No effort for regulations • No professional sensor development and production in Turkey • Insufficient infrastructure to test CAEV. • Difficulties on interdisciplinary collaboration for CAV • CAEV Technologies will shift the value and reduce operating profits of OEM's. • In Germany and in UK there are many platforms, established organizations and support for smart mobility. They are acting as attraction centers for the community. İstanbul is not one of the favorable cities currently.

Main Areas and Use Cases

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DOMAIN	USE CASE	ENABLERS (Vehicle Technology, Validation, Standardisation)
HIGHWAYS AND CORRIDORS	Traffic Jam Chauffeur Highway Chauffeur Safe Auto-follow Hub-to-hub transport (L4):	Affordable vehicles with L2-L4 enabling capabilities. Defined parameters for real-time-reaction baseline of CCAM safety functions. Functional Safety of the whole traffic system. Efficient validation toolchain complying with certification requirements. Connectivity Interfaces for V2X e.g., ITS-G5, LTE and 5G technology.
CONFINED AREAS	L4 Car valet parking L4 Shuttles in slower speed in restricted areas L4 Bus self-maneuvering L4 Unmanned truck/trailer operation in-Terminal/Hub	L4 capable vehicles with parameter setting. Realtime reaction on connected safety functions Functional Safety of the whole traffic system Efficient validation toolchain complying with certification requirements
URBAN MIXED TRAFFIC	Automated parking Residential last mile transport Bus(-like) applications on pre-defined routes in mixed traffic. Taxi-like operations working on flexible routes	The ability of sensing and perception technologies to cope with m ore and more complex traffic situations. Digital map information validated by sensors. V2X to fleet management / vehicle control center Integration of safety-critical scenarios specific to urban traffic in EU wide scenario database
RURAL ROADS	Automatic Emergency Braking Lane Departure Warning Adaptive Cruise Control Steering and Lane Control Assistant Systems IN RURAL AREAS Driverless shared and/or public shuttle services First mile/last mile delivery services	Improved environment perception Increased use of virtual validation methods for cost reduction Inclusion of human-machine interaction in validation procedures Integration of safety-critical scenarios specific to rural roads in EU wide scenario database

Technology Road Map for OPINA;
22nd of Feb. 2022

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Technology Roadmap Study for OPINA

CATEGORIES		Short-Term	Mid-Term	Long-Term
APPLICATIONS	Adaptive signalling systems		AI technologies	
	AI Technologies	AI technologies	Open data exchange	
	Technologies used for predictive maintenance		Technologies used for predictive maintenance	
			Payment systems	
ARCHITECTURE		Cloud Computing (cloud technologies)	Central Processing instead of Distributed Processing	
		Connected Big Data analysis		
		Edge Computing		
COMMUNICATION	In-Vehicle		Automotive ethernet	
	V2X	5G		6G
		Other connectivity technologies		7G
	Communication protocols	In-Vehicle		
HARDWARE	Computing Devices	Computation Units	Functional mini HW equipment	Central computation capabilities
		Real-time computation platforms incl. OS, CPU, GPU, microcontroller etc.	More CPU/GPU power at processors	High computing power , new integrated circuits
				Quantum computers
	Sensors	High-quality sensor systems	Integrated sensor systems	Low-Energy sensors
		Low light camera systems	Low-cost sensors	Smaller, cheaper lidars, radars
		Sensor development	More precise positioning satellites	
			Reliability of sensors	
			Smart cameras	
	Storage devices	Storage devices		
SIMULATION	Digital Twin	High-fidelity simulation tools	Metaverse	
			AR Technologies	
	Visualization technologies		VR technologies	
			New Generation Simulators	

Technology Road Map for OPINA; 22nd of Feb. 2022

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Category	Sub-category		
SIMULATION	Digital Twin		
			AR Technologies
	Visualization technologies		VR technologies
			New Generation Simulators
SOFTWARE	AI Technologies	AI/ML/DL/RL algorithms	Advanced AI algorithms to enable rapid decision making with less data
		Hybrid and explainable AI	Foreseeable AI technologies
	Architecture	Advanced software engineering concepts	Over-the-air updates
	Cybersecurity	Blockchain	Data privacy
	Data preparation&processing	Data augmentation	HD Maps – HD Map generation via unsupervised methods
			Lean control and perception algorithms
		Sensor Fusion	Rapid decision making algorithms (in milisecond)
	Real-time processing		Next. Gen. Sensor Fusion
			Vehicle behavior prediction, decision making
TEST	Dynamic Code Analysis	Dynamic Code Analysis	
	EMI	EMI	
		A-Spice	
		AUTOSAR	
	Functional Safety	Cyber security	
		HMI	
		ISO- 26262 adapted techn.	
	New component development test		Rapid test and verification tools
	Certification, Regulation	ISO 21434	Test automation and automatic test scenario generation
OTHER	HMI		HMI
	V2G		V2G

- Driving comfort
- Flexible and intelligent interiors
- Safety and Security
- User-centric design

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Product & Project	2024 - 2026	2027 - 2030	2030+
Valet Parking	▓		
Traffic Jam Driver	▓		
Highway Driver	▓	▓	
Highway Autopilot	▓	▓	
Urban/ Suburban Autopilot		▓	
L3/L4 Driver Handover	▓		
Human Machine Interaction	▓		
Platooning	▓		
Robo-taxis	▓		
Interstate Pilot Using Driver for Extended Availability	▓		
Full Automation Using Driver for Extended Availability		▓	
Vehicle on Demand	▓	▓	
Safe Auto-follow	▓		
Hub-to-hub transport		▓	
L4 Shuttles in slower speed in restricted areas without safety driver	▓		
L4 Bus self-maneuvering in depot operation		▓	
L4 Unmanned truck/trailer operation in-Terminal/Hub		▓	
Residential last mile transport of people and goods	▓		
Driverless shared and/or public shuttle services operating on pre-defined routes		▓	
First /last mile delivery services with very compact, low-speed automated vehicles	▓		
Transport of goods and parking in restricted areas in low speed		▓	
Transport of goods in dedicated lane on primary road		▓	
Transport of goods and people on predefined routes		▓	
Transport of goods and people in urban areas			▓
Transport of goods and people on highways on flexible routes on highways			▓
Improving interaction with road users		▓	
Non-standard and unstructured road conditions		▓	
Low visibility and adverse weather conditions		▓	
Improved perception of objects in complex urban traffic, and low visibility conditions		▓	
Real-time decision making under non-standard traffic		▓	
Vehicle functional safety and cybersecurity	▓		
Solutions on using different sets of sensing devices	▓		
Sensor fusion for real-time decision making & reliable on-board decision making	▓		
5G implementation use cases	▓		
Fleet and traffic management in CCAM eco-system	▓		

Bu proje Avrupa Birliği ve Türkiye Cumhuriyeti tarafından finanse edilmektedir
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Teknoloji Öngörü Çalışması
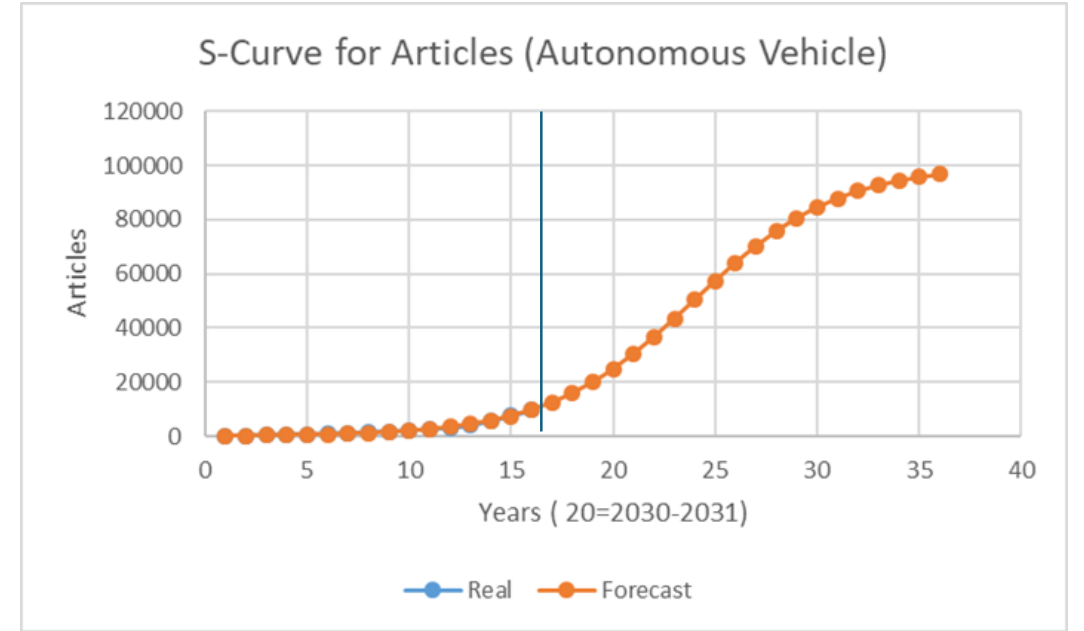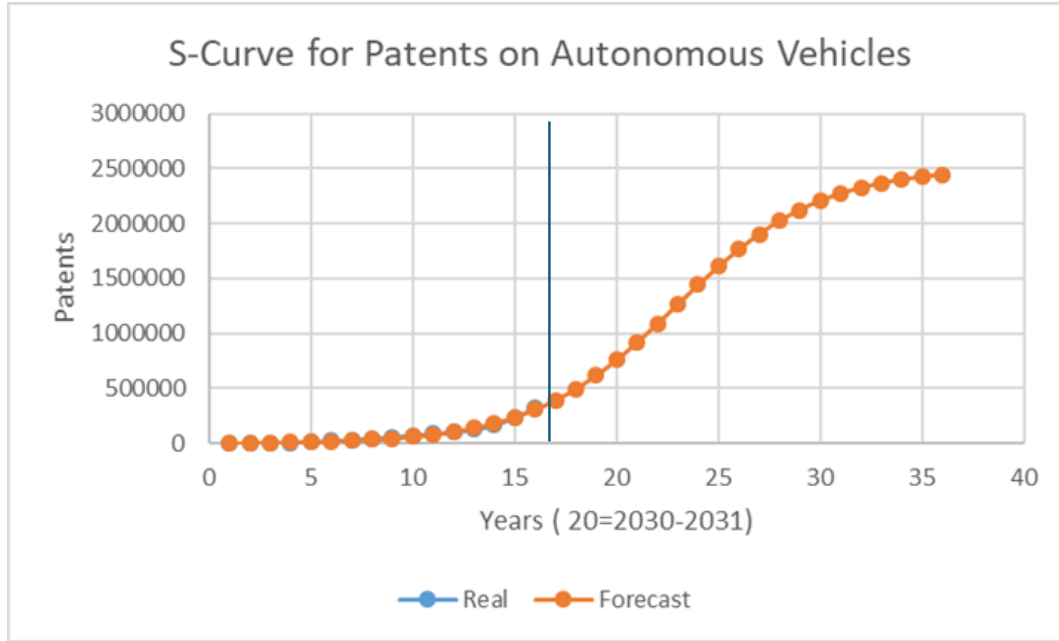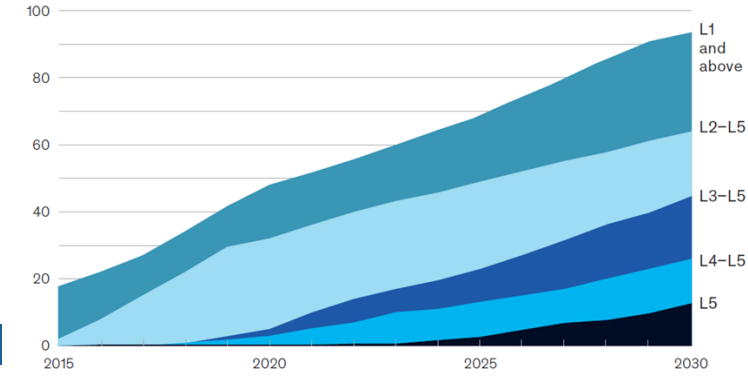
The trend transforming mobility's future", McKinsey, March 2019

S-Curve for Patents on Autonomous Vehicles

S-Curve for Articles (Autonomous Vehicle)

SAE Seviye 5 Otonom Araçlar 2050 yıllarında hazır olabilir gibi görünüyor. Fakat veri henüz ilk aşamalarda.

Orhan B. Alankus, "Technological Forecast for SAE Level 5 Autonomous Vehicles", Know-How of INNODARE Platform, April, 2023, www.innodareplatform.com

Problem Tree for CAEV and CCAM Problem Drivers

No Support for Sustainable Development Objectives

Possible skilled engineer migration abroad

Import dependent production

Innovation gap increase with developed countries

Decrease in local automotive sector profit margins

Possible shift of production

No infrastructure for CAEV testing

In Turkey, CAEV Technologies and Services could not be developed from a concept stage to a technology demonstration phase, a possible potential can not be used

No test systems with accreditation

Not effective collaboration among universities and research centers

No deep expertise

Lack of National Autonomous Vehicle Road Map

Not enough demand from Local OEM's

Not effective coordination of Research

SME's could not develop technologies

Not enough skilled engineers in new technology

Lack of Global Approach

Not enough Support for start-ups

Not enough integration with EU Projects

Public do not have enough knowledge

Simulation and development systems are expensive

Not enough graduate programmes in the field

PD1:
Insufficient demand as society does not yet understand the potential benefits of CCAM enabled mobility. The long-term implications, benefits and impacts of integrating CCAM solutions into the mobility system are not sufficiently examined.

PD2:
CCAM solutions are not yet sufficiently mature for market take-up, and current investment levels in CCAM R&I are inadequate to maintain and extend EU industrial leadership.

PD3:
Current R&I efforts are fragmented and lack a coherent, longer-term vision and strategy for targeting systemic solutions.

PD4:
Demonstration and scale-up is limited, since a well organised, extensive and complex cross-sectorial value chain is still required to build complete CCAM solutions.

CHALLENGES TO DEPLOY CCAM SOLUTIONS

Limitation

•Speed •(e.g. below 40 kph),	Operational domain (e.g. confined areas)	Ability to handle complex traffic (e.g. motorway only)	•Limiting ambiental factors.

Advance these technologies and systems, pushing the boundaries

•Higher speeds: •80 – 120 kph;	•Extended operational domains: hub-to-hub transport; road network;	•Complex traffic: urban driving	•All weather conditions

CCAM
CONNECTED, COOPERATIVE
& AUTOMATED MOBILITY

CCAM CLUSTERS

Successful implementation requires understanding:

the **user needs and societal aspects** of mobility

technical details, contributions, requirements and risks from **key enabling technologies**

the overall **transport system** requirements and set-up

what **vehicle technologies** are required and how to implement them

how to **validate** safe system functioning

Finally **demonstrate** all aspects at a **large scale**
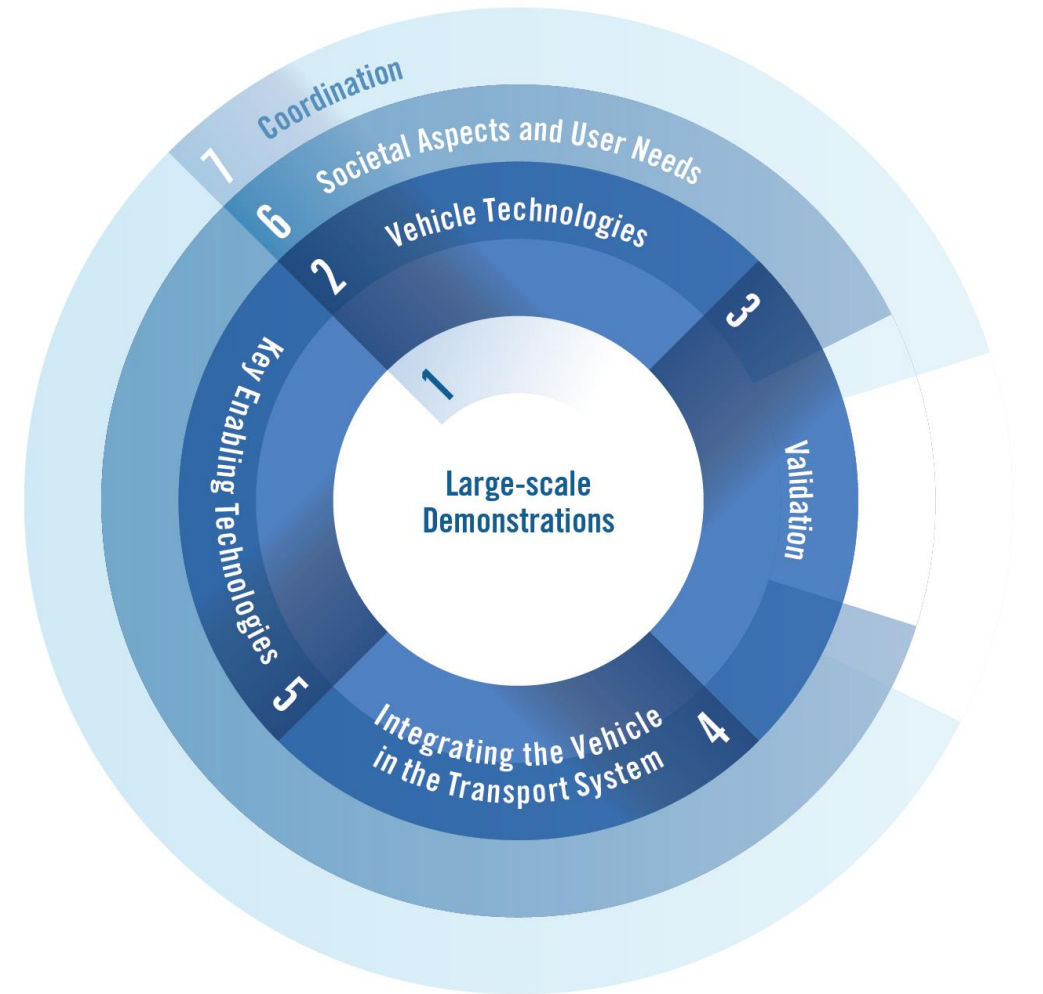
- «A Roadmap for Connected & Autonomous Vehicles», Automotive Council UK,2017
- «Road Transport Vision 2050»,ERTRAC,06/2024
- «Automated and Autonomous Driving; State of the Art and Roadmap for the Future», ACEA,2022
- «How Automakers can Survive the Self-Driving ERA», ATKearney,2016
- «Technology Roadmap for Intelligent & Connected Vehicles 2.0», CAICV,2021

➢ Optimised user-centric energy efficiency design
➢ Advancing CCAM towards large-scale demonstrations (CCAM Partnership)
➢ Federated CCAM data exchange platform
➢ Predicting and avoiding crashes based on AI and big data

➢ Advancing remote operations as an enabler of sustainable and smart mobility of people and goods: operational and societal needs (CCAM Partnership)
➢ Integration of human driving behaviour in the validation of CCAM systems (CCAM Partnership)

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OPINA ve Benzer Açık İnovasyon Otonom Araç Geliştirme Platformları
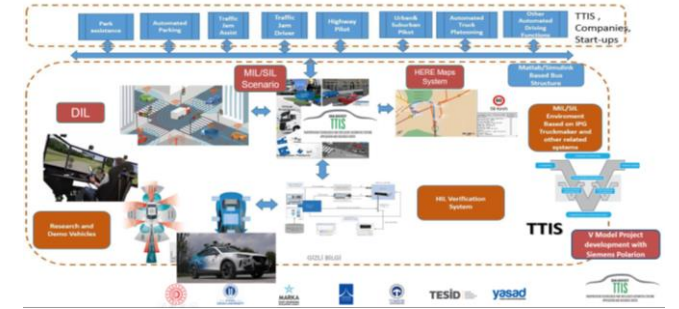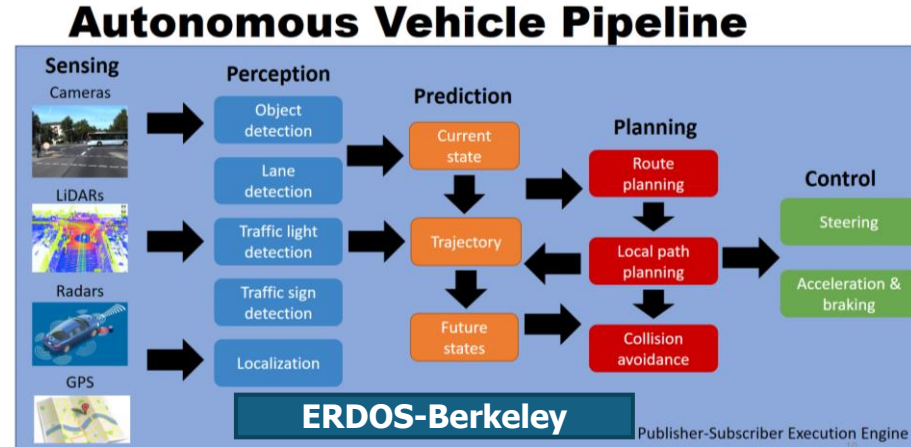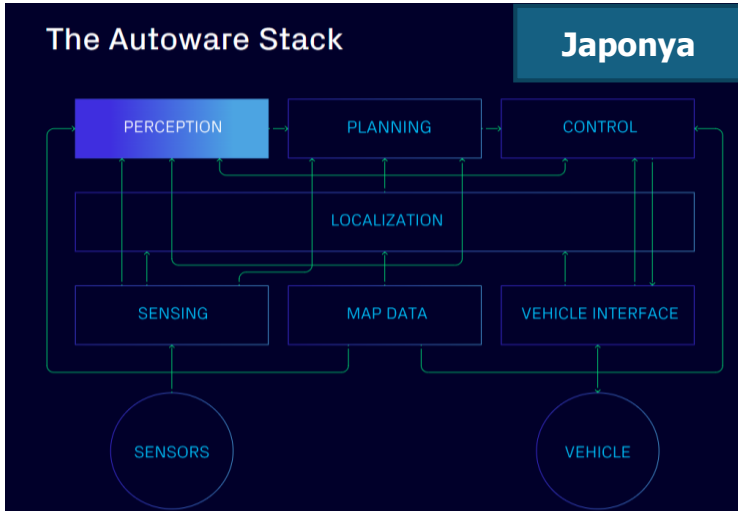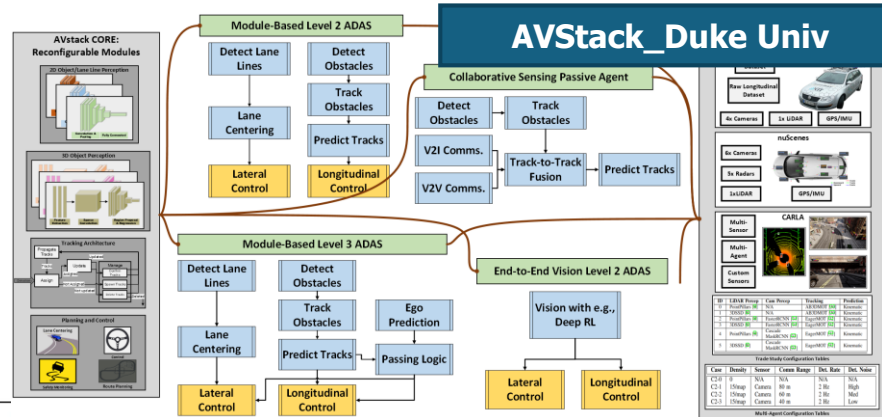
OPINA Avrupa'nın ilk ve en gelişmiş Bağlantılı, Otonom Araç Geliştirme Platformu

➤ Açık yazılım, AUTOSAR, ASAM ve ISO Norm Integrasyonu
➤ MIL/SIL/HIL/DIL Desteği
➤ Araç ile yol testi
➤ HD Map
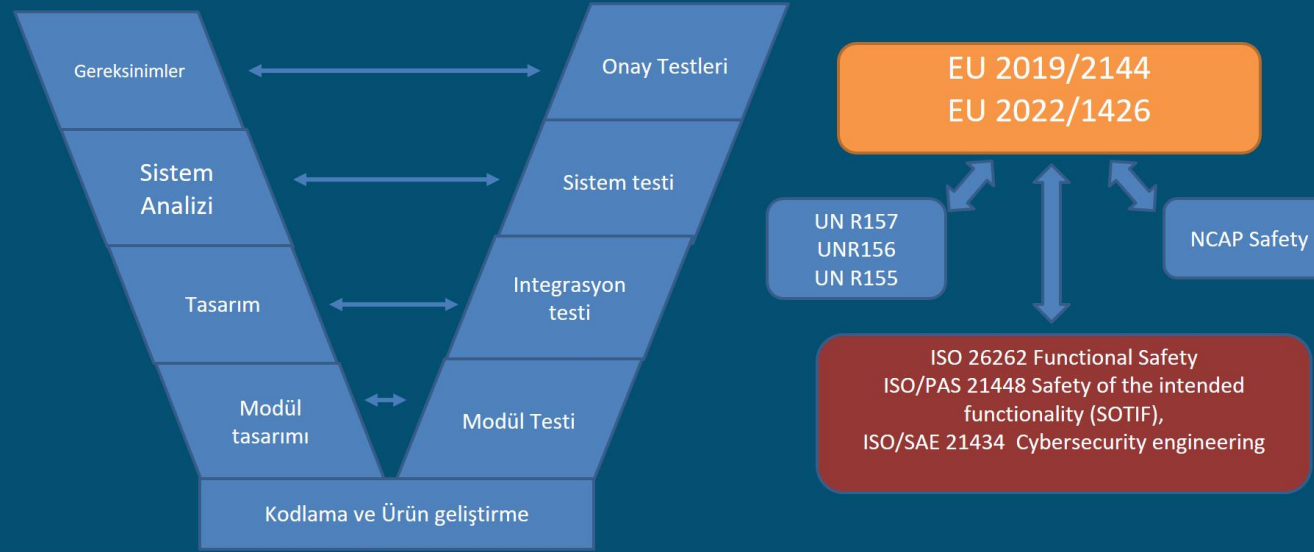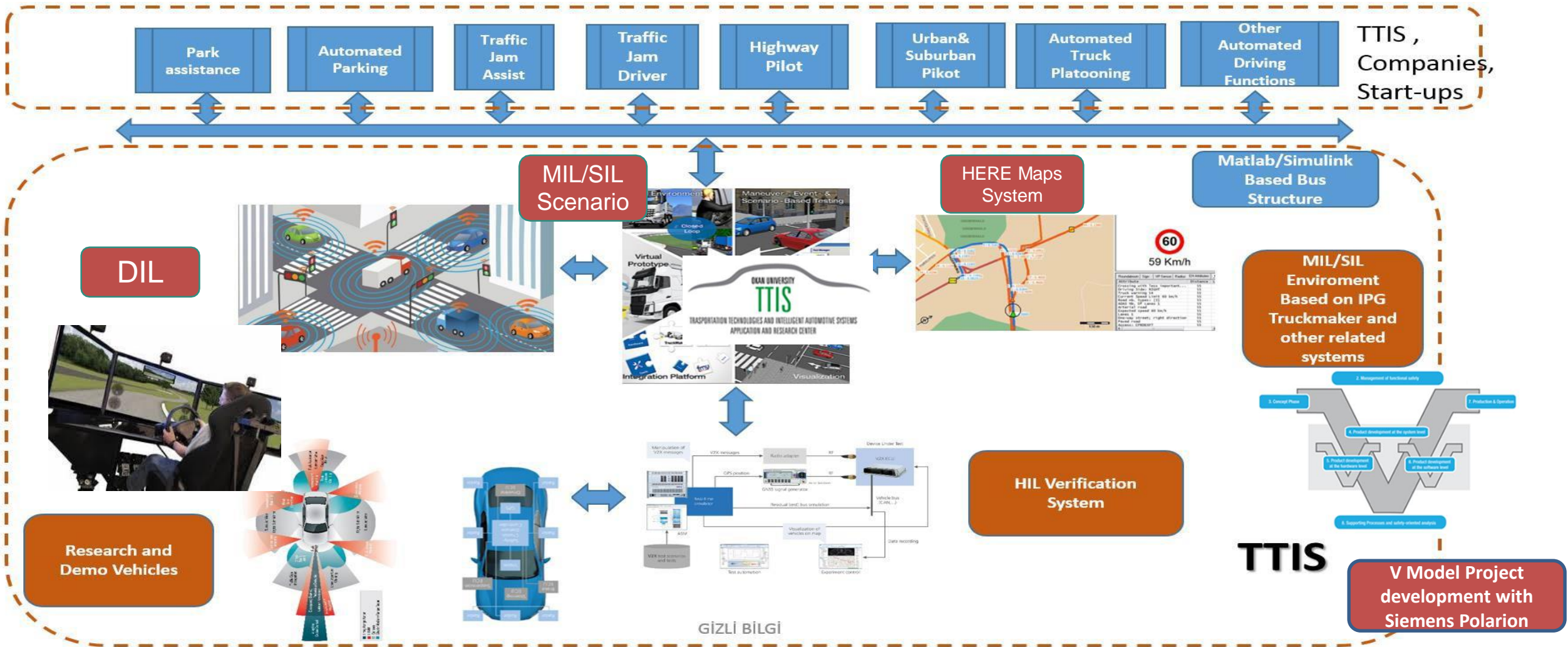➤ Sertifikasyon
➤ Eğitim, mentorlük

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BOA Çalışma Konusu Önerileri

Geliştirilmesi gereken ana teknoloji alanları	CCAM	ERTRAC	CAR
Yüksek hız otonom sürüş	X	X	
Karmaşık trafik, şehir içi	X	X	X
Kötü hava şartları	X		X
Karmaşık sürüş ortamları	X		
Sürüş güvenliği	X	X	X
Çevreyi tanıma	X	X	
İleri sensör füzyonu ve karar verme teknikleri	X	X	
Validasyon, onay süreçleri	X	X	X
İnsan/Araç Arayüz sistemleri	X	X	
Bağlantılı ve yardımlaşan sistemler	X	X	X
Dijital altyapı	X	X	
Çevre algılama için Yapay Zeka	X	X	X
Açıklanabilir yapay zeka ve eğitimi	X	X	X
Siber güvenlikli sistemler ve yazılımı	X	X	X
Sağlamlık, dayanıklılık	X	X	X
Yardımlaşmalı sürüş için alt yapı		X	X
Sürücü durum tespiti			X
Haberleşme sistemi, hızı, güvenilirliği			X
Bulut ve «edge» hesaplama		X	X

OPEN INNOVATION AUTONOMOUS VEHICLE DEVELOPMENT PLATFORM
(OPINA-IPAII PROJECT)

Proposal for Working Groups

Strategy and Technology Road Map and Monitoring
Applications
A.1- Yard Operations
A.2- Valet Parking
A.3- Seamless mobility of people and goods
A.5- Accident prevention systems

Vehicle Technologies (Cluster 2)
VT.1- Environment and Perception Technologies (all weather etc.)
VT.2- Safe and reliable decision making Technologies
VT.3- User-Centric Design (including driving comfort)
VT.4- Preventive and protective safety

Key Enabling Technologies (Cluster 5)
ET.1- Hardware and Software Architecture including cybersecurity (OPINA Platform for software development)
ET.2- Sensor Technologies
ET.3- AI for training and robust situational awareness and decision making

Proposal for Working Groups

Support Technologies (Cluster 4)

ST.1- Connectivity and cooperative systems

ST.2- Remote control systems for fleet and Traffic management

Enablers and Validation (Cluster 3)

ET.1- Simulation, testing

ET.2- Scenario Development and Certification (OPINA Scenario data base)

ET.3- Human reference driving for complex situations (OPINA Data Replay and DIL system)

ET.4- Homologation

ET.5-Regulations (OSD dedicated working group)

ET.6- Advanced and user-centric HMI

THANK YOU

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