Final Report

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Technical and Regulatory Framework for Autonomous Vehicles

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Technical and Regulatory Framework for Autonomous Vehicles

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Table of Contents

Page

Lists of Figures

Page

List of Tables

Page

List of Abbreviations and Acronyms

ADAS	Advanced Driver-Assistance Systems
AI	Artificial Intelligence
APM	Automated People Mover
AV	Autonomous vehicle
BEV	Battery Electric Vehicle
EV	Electric vehicle
HAV	Highly Automated Vehicles
HEV	Hybrid Electric Vehicle
HPC	High Performance Computing
ITS	Intelligent Transportation System
kph	Kilometers per hour
MaaS	Mobility-as-a-Service
NBTC	National Broadcasting and Telecommunications Commission
NHTSA	National Highway Transportation Safety Administration
ODD	Operational Design Domain
OEMs	Original Equipment Manufacturers
PHEV	Plug-in Hybrid Electric Vehicle
R&D	Research & Development
SAE	Society of Automotive Engineers
xEV	HEV +PHEV + BEV
ZEV	Zero emission vehicle

CHAPTER I INTRODUCTION

1.1 Rationale

With disruptive technology in future mobility around the world, Thailand has been preparing to transform current conventional automotive industry with internal combustion engine to next generation automotive industry focusing on Autonomous-Connected-Electric-Shared (A-C-E-S) Technology. In recent years, Thai government has been accommodating electric vehicles (EV) from Hybrid Electric Vehicle (HEV), Plug-in Hybrid Electric Vehicle (PHEV) to Battery Electric Vehicle (BEV) through technical and regulatory framework adopted from international setting into local environment. A number of xEVs can now be legally registered to use public road with some public charging infrastructure. In 2018, 20,056 new HEV/PHEV and 110 BEV sedan was registered to the accumulative 122,303 HEV/PHEV and 201 BEV sedan on the road with 220 public charging station. In addition, with changing behavior of car ownership among new generation, Mobility-as-a-Service (MaaS) has emerged out with shared vehicle service in the market. It will be just a matter of time for consumer to adapt Electric-Shared vehicles into the market.

On the other hand, Autonomous and Connected vehicle technologies, or sometimes called Connected Autonomous Vehicles (CAVs), are relatively new to Thailand with early stage of deciding which technical and regulatory frameworks to adopt. Since CAVs still heavily rely vehicle-connecting infrastructure like 5G, which is not readily available yet, demonstration and testing of CAVs are limited to research and development phases. As defined by Society of Automotive Engineers Internationals (SAE), National Highway Transportation Safety Administration (NHTSA) has adopted the definition for levels of automation, as shown in Fig. 1 [1], where

- ✓ **Level 0: this is driving as most people know it. The human controls everything.**
- ✓ **Level 1: the driver-assistance level, where certain functions like steering or accelerating can be done by the vehicle automatically**
- ✓ **Level 2: Driver does not have to have hands on steering wheel or pedals, but must be ready to take over**
- ✓ **Level 3: Drivers still necessary but most "safety-critical" functions are shifted to the vehicle**
- ✓ **Level 4: Fully-autonomous, car can drive itself**
- ✓ **Level 5: no steering wheel in the car**

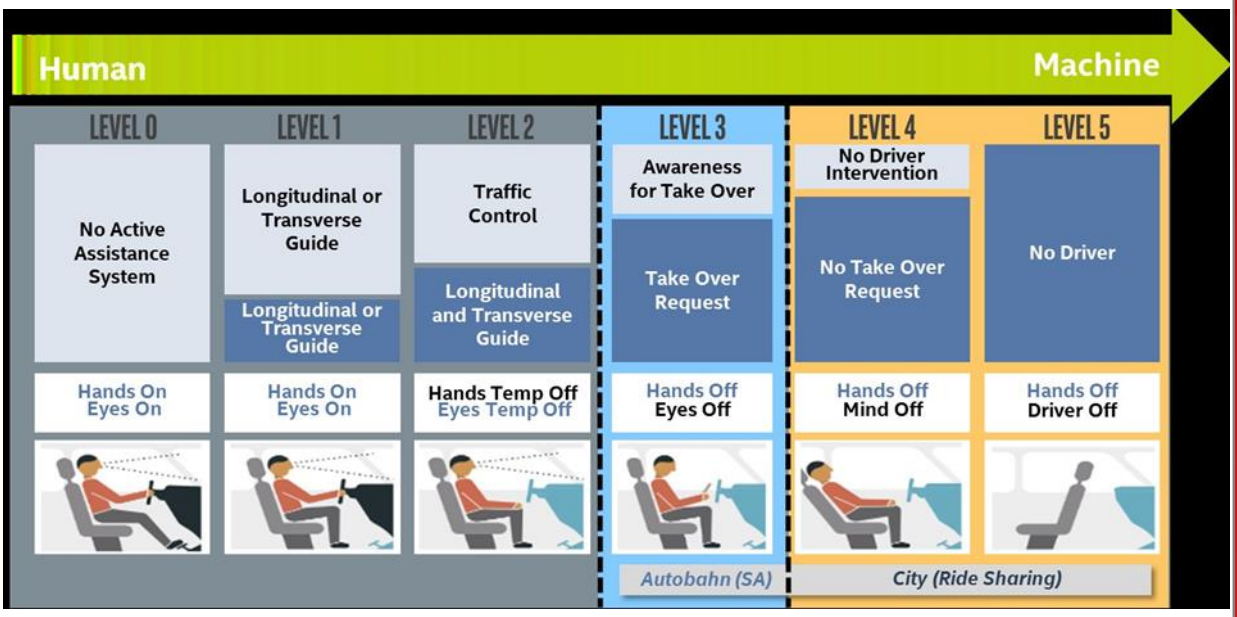


Fig. 1 SAE automation levels adopted by NHTSA

Note that some of today vehicles have already featured some automation with benefit in safety, not just comfort, such as automated emergency braking, lane departure warning and assisted parking, as shown in Fig. 2 [2]

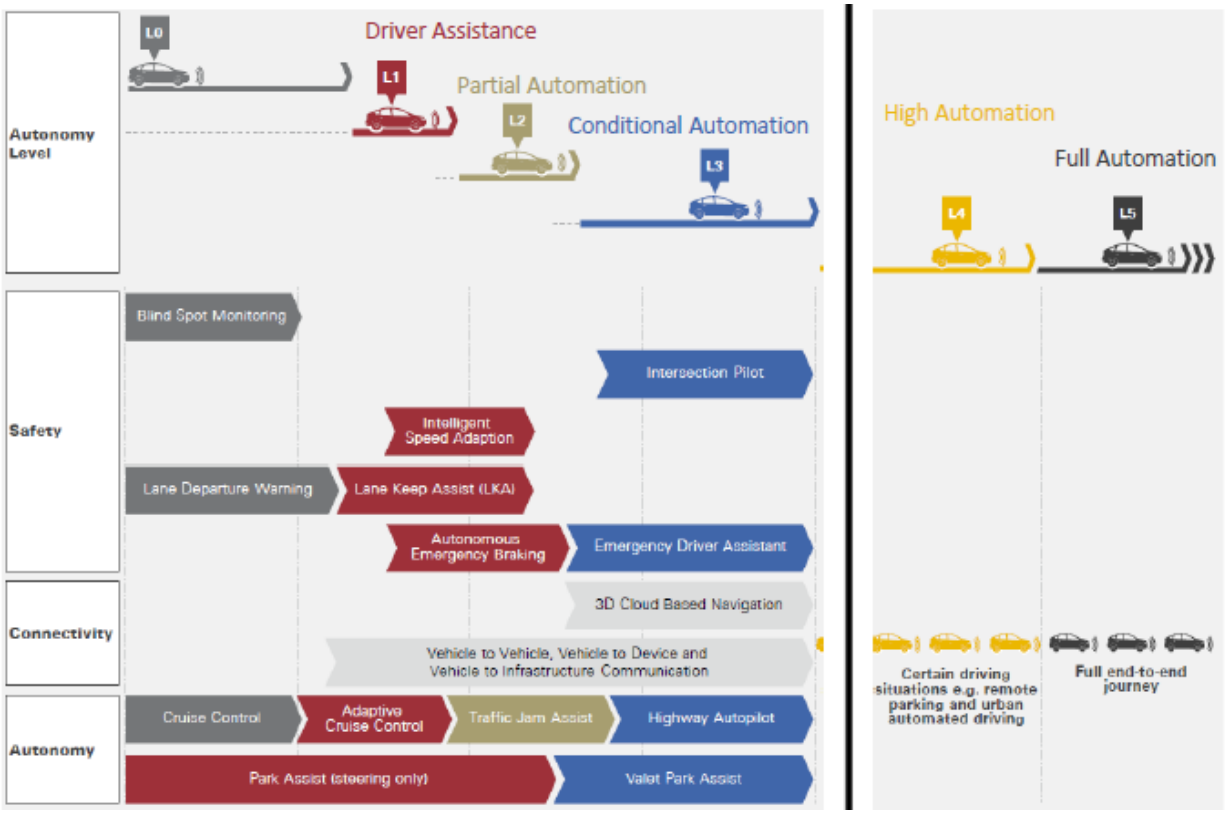


Fig. 2 Connected and autonomous vehicle technology

Over the past few years, Thailand has begun to put technical and regulatory framework of CAVs into perspective, where think-tank group composed of government organization, academic/research institutions and private sectors meets regularly on "CAV Roundtable" for technology and policy update and discussion on particular topics. With official support from Office of Industry Economics (OIE) under Ministry of Industry, a white paper on "Next Generation Automotive Industry Development in Thailand" was recently drafted [3] with policy recommendation on A-C-E-S technologies, where, for the first time, a target on CAV has been set coupled with Zero Emission Vehicle (ZEV) to fight recent PM2.5 crisis as follows

- ✓ **By 2030: 15% of new vehicle is ZEV with 60% for level 3 CAV**
- ✓ **By 2040: 100% of new vehicle is ZEV with 80% for level 4 CAV**

1.2 Objectives

The present study aims to investigate technical and regulatory framework for autonomous vehicles industry as a preparation for this industrial transition in Thailand, focusing on new automotive supply chain and potential new product champion sector.

1.3 Methodology

In order to systematically to investigate technical and regulatory framework for autonomous vehicles industry in Thailand, the following methodology is proposed

- **Update status of connected and autonomous vehicles (CAVs), from both technological and regulatory aspects.**
- **Analyze collected data to identify key enabling technical and regulatory framework.**
- **Deep dive into specific details for concrete actions with timeline for CAVs industry to adapt. Interview if needed.**
- **Conduct roundtable discussion with stakeholders to get feedback for final recommendation.**

CHAPTER 2 RESEARCH PLAN

2.1 Project Schedule

Table 1 shows the project planning schedule with project expenditure shown in Table 2. All project members are scheduled to meet regularly to discuss the technical results performed by project research assistant, and directions of the project. Occasionally, the progress report will be presented to the advisors to further seek guidelines and comments of the results and future direction.

Table 1: Project planning schedule

Activity	2020									2021		
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Update status of CAVs												
Analysis to identify key technical and regulatory framework												
Deep dive for concrete actions with timeline for CAVs industry												
Interview, meeting and discussion to finalize recommendations												
Inception report submission	30-Apr											
Interim report presentation					20-Aug							
Interim report submission						30-Sep						
Final report presentation at board meeting									11-Dec			
Final report presentation to IATSS									14/15 Dec			
Final report submission												31-Mar

2.2 Project Expenditure

Table 2 shows the breakdown of the project expenditure.

Table 2: Project expenditure

No	Item	Unit cost	# of units	Sub total
1	Project leader	3,000	12	36,000
2	2 Researchers (200 THB/hr x 5 hrs/day x 10 days/month) for 12 months)	10,000	24	240,000
3	Expenses for project meeting	3,000	6	18,000
4	Travel expenses to collect data and interview	2,000	6	12,000
5	Office & computer supply	3,000	6	18,000
6	Secretariat's participation portion	10,000	1	10,000

No	Item	Unit cost	# of units	Sub total
7	Publishing proportion of the report book	50,000	1	50,000
			Total	**384,000**

CHAPTER 3 RESULTS & DISCUSSION

3.1 Updates of Autonomous Vehicles Worldwide

Despite COVID-19 pandemic, the project members have tried to get updates of autonomous vehicle technology and regulation around the world. As shown in Fig. 1 and Fig. 2, 5 levels of autonomous vehicles are classified according to level of machine interaction in terms of safety and connectivity, Fig. 3 [4] has put timeline for 5 levels of vehicle autonomy in terms of self-driving abilities and conditions from 2000 till after 2021. On the other hand, if considering legal protection aspect, timeline for 5 levels of vehicle autonomy could span to after 2035, as shown in Fig. 4 [5], which really emphasizes how both technology and regulatory framework are needed to realize vehicle autonomy in the market. From industry point of view, Fig. 5 [6] shows key technologies from industries to help overcome challenges in each level of vehicle autonomy before autonomous vehicle can be integrated into public road, which prompts for necessity for level 5 technology development. However, it should be noted that Audi Traffic Jam Pilot was announced but was not deployed in a market because it could not get certification; whereas, Honda deployed Traffic Jam Pilot in Japanese market in March 2021, which was the 1st time in the world. With focus on level 5 vehicle autonomy, Fig. 6 [7] illustrates how level-5 vehicle autonomy could be accelerated through both technology and legal aspects, which further emphasizes necessity for legal aspects ramp up to accommodate technology innovation. In details, vehicle autonomy depends on 5 categories of vehicle sensors, as shown in Fig. 7 [8]. Hence, regulatory framework should correspond to each categories of core technologies for vehicle autonomy.

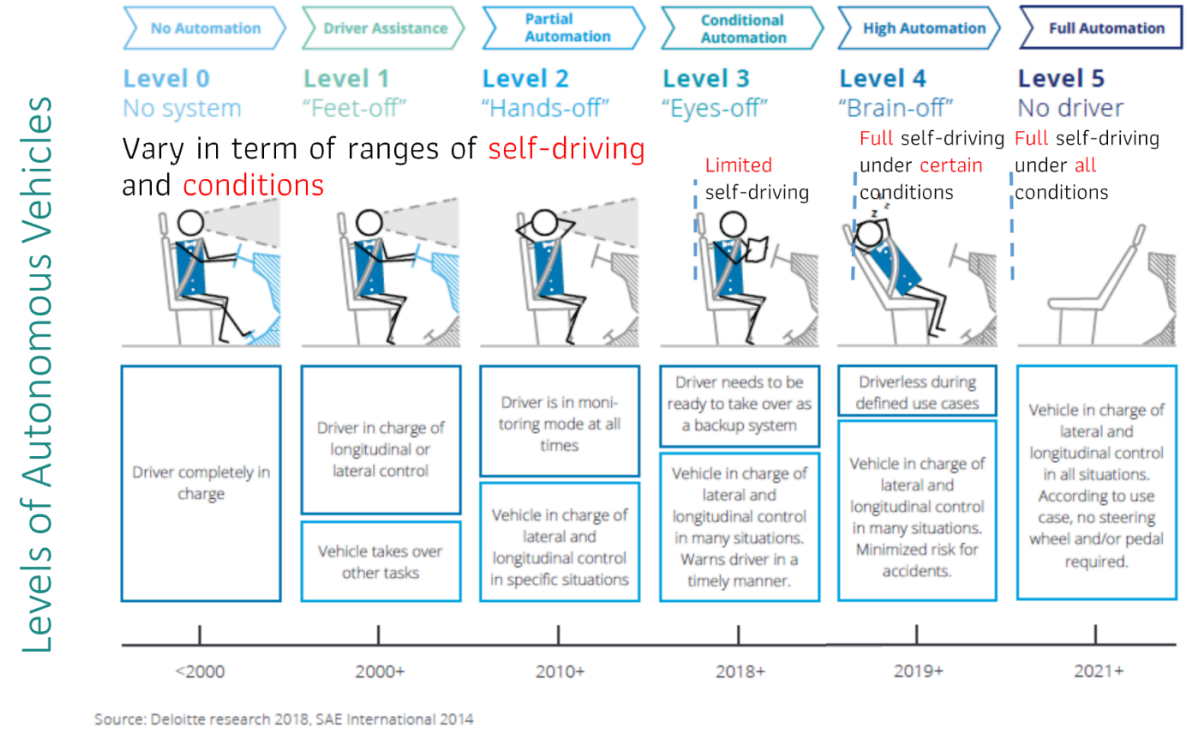


Fig. 3 Timeline for autonomous vehicle technology in terms of self-driving abilities and conditions

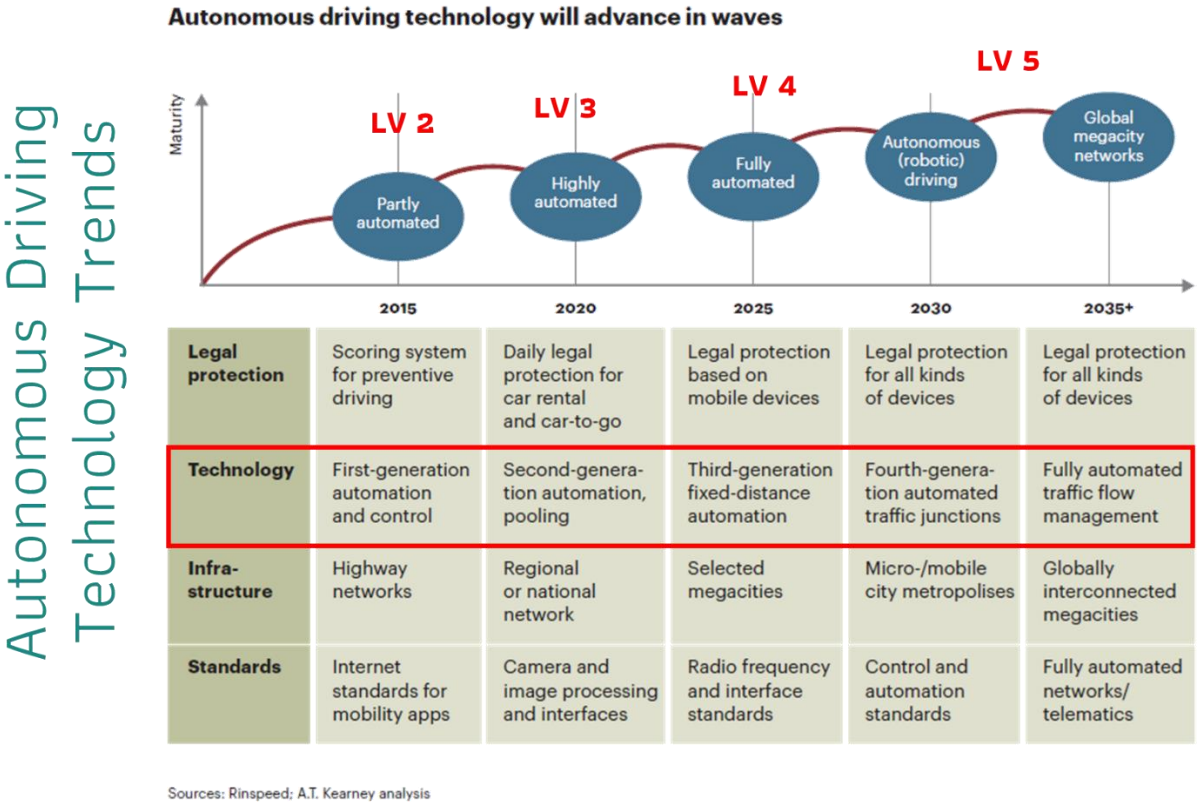


Fig. 4 Timeline for autonomous vehicle technology with legal aspect consideration

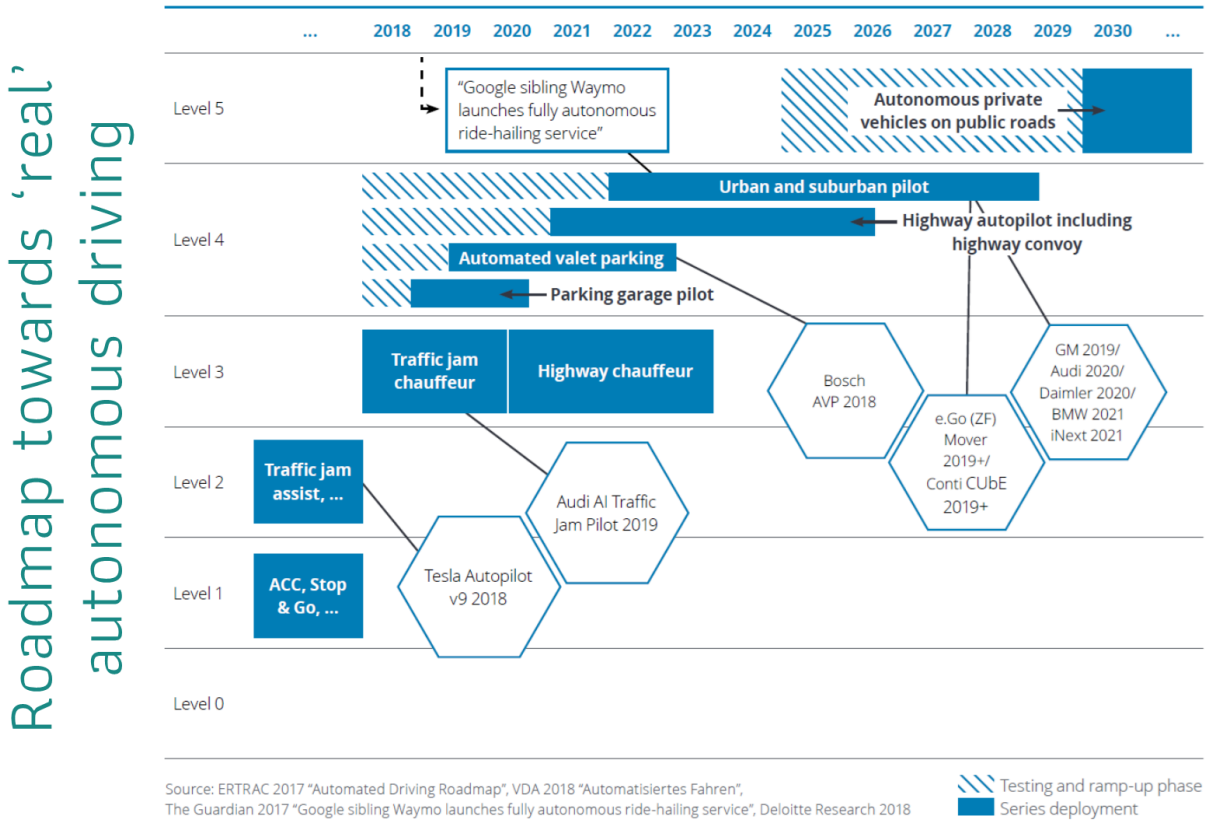


Fig. 5 Timeline for autonomous vehicle technology with industrial readiness

Deep-dive autonomous driving: Mainstream ramp-up of level 5 autonomous driving is expected no earlier than 2027–28

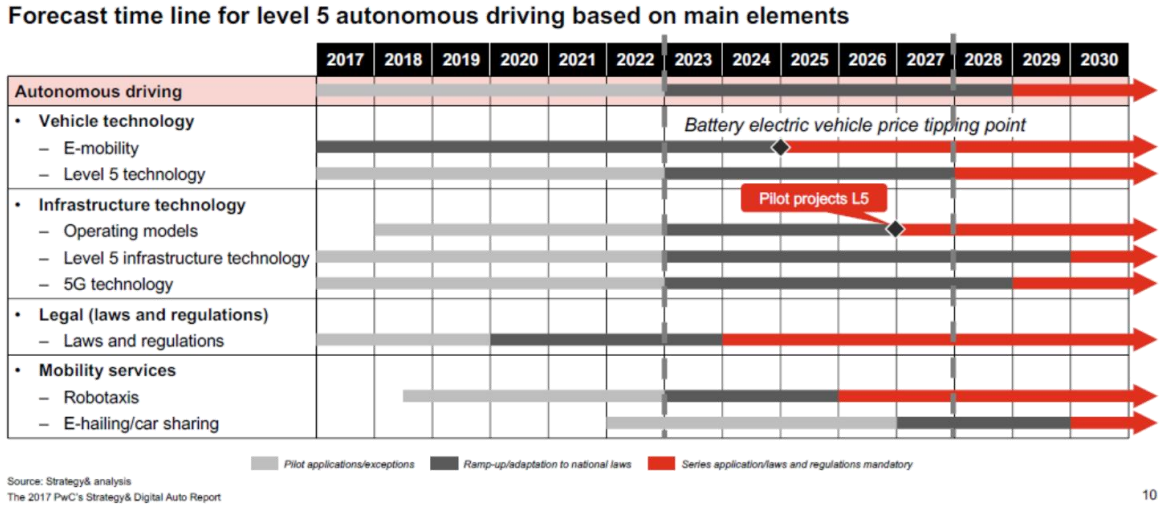


Fig. 6 Timeline for level-5 autonomous vehicle technology acceleration

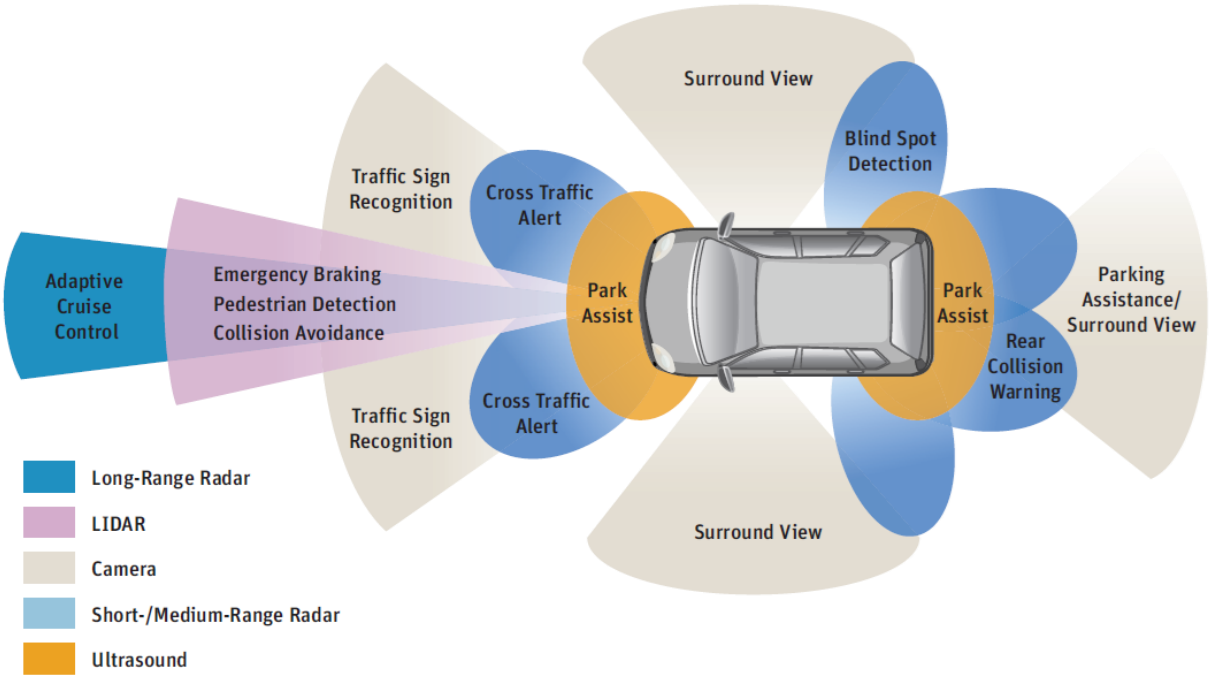


Fig. 7 5 categories of vehicle sensor for autonomous vehicle technology

3.2 Updates of Autonomous Vehicle Activities in Thailand

From global trends on autonomous vehicle in previous section, this section reports related activities on autonomous vehicle as Thailand is still in the early stage of AV technology, regulation and public awareness. Official target on AV was first identified at 2030 to have 15% of automotive production be BEV with 60% of Level-3 autonomous in "Policy recommendations on Thailand development of Next-Generation Automotive Industry [9]" by Thailand Automotive Institute (TAI) with related partners such as Office of National Higher Education Science Research and Innovation Policy Council (NXPO), National Science and Technology Development Agency (NSTDA), and Chulalongkorn University on 25 September 2019. Table 3 shows summary of action plans for next generation automotive industry including autonomous vehicle. This policy recommendations were then proposed to National Electric Vehicle Policy Committee meeting on 11 March 2020 for adopting a target of 30% xEV of estimated total vehicle production 2.5 million units by 2030. Later in September 2020, NXPO has update [9] as shown in Fig. 8 with the following targets [10].

- ✓ **30% of vehicle registration be ZEV (zero emission vehicle) with 60% of Level-3 autonomous in 2030**
- ✓ **100% of vehicle registration be ZEV with 80% of Level-4 autonomous in 2035 with Local Capacity Building Plan and Technology Localization Plan.**

Table 3: Summary of action plans for next generation automotive industry

Summary table of plans that must be completed within 5 years in order to achieve the goals of the Automotive Industry by 2030

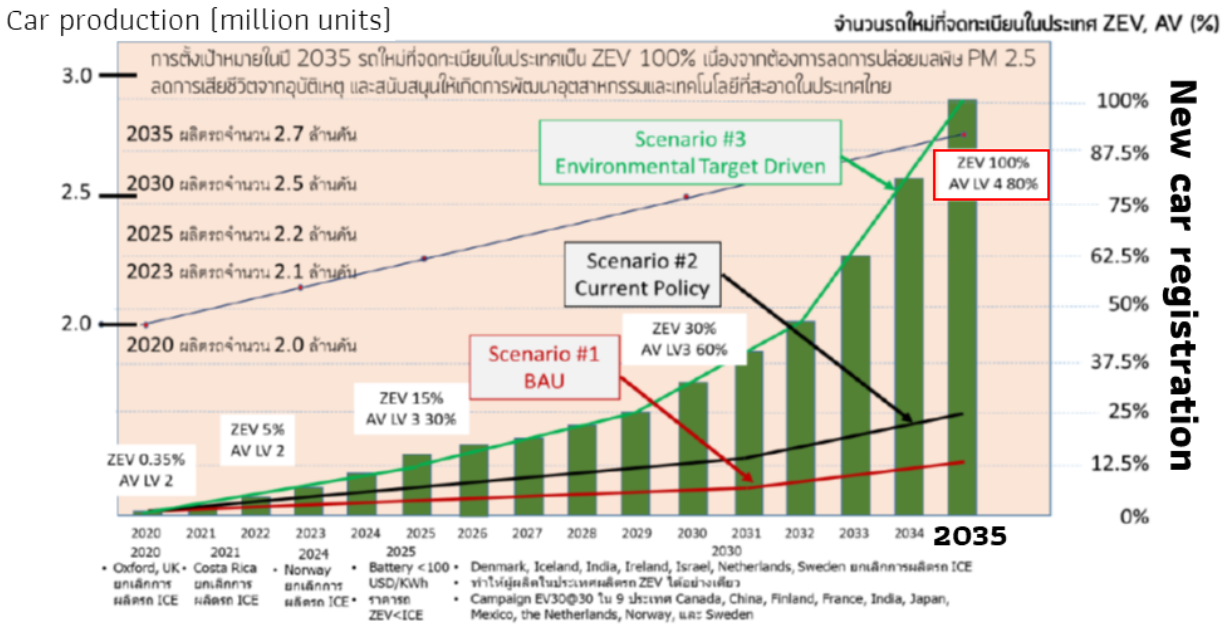
Plans \ Ministry of	Finance	Tourism and Sports	Transport	Natural Resources	Digital	Energy	Commerce	Interior	Labour	MHESI	Industry	Others	NAIDC	entrepreneur
Urgent actions														
(1) Establish 'National Automotive Industry Development Committee'	/		/		/	/	/		/	/	/	Prime Minister ✱	/	/
(2) Reform tax structure related to automotive products	✱		/								/		/	
(3) Define incentive for consumers	✱		/			✱		/			/		/	
(4) Revise rules and regulations for EV charging business						✱	/	/			/	EGAT	/	
(5) Elevate Thai entrepreneur capabilities									/	/	✱	BOI	/	/
(6) Human resources development (Reskill and Upskill) and prepare new skill labor to be ready for the Next-Generation Industry									✱	✱	/	BOI EEC OHEC TAI	/	/
(7) Prepare infrastructure, law, and regulations for the new form of mobility business	/		✱		✱		/	/		/	/	BOI	/	/
1-2 years plans														
(8) Use Next-Generation vehicles in the pilot area	/	/	/		/			✱			/	Bangkok Pattaya and other Smart Cities	/	/
(9) Define new Next-Generation vehicles standards and regulations and provide testing facilities			/							/	✱	TAI	/	
(10) Encourage R&D activities										✱	✱	EEC TAI TSRI	/	/
(11) Establish R&D Consortiums to develop Next-Generation vehicle prototype			/		/					✱	✱	EEC TAI TSRI	/	/
(12) Define an AV road map			✱		/					/	/	NAIDC TAI	/	/
2-5 years plans														
(13) Preparation for Autonomous vehicles													/	
(13.1) Define standards and compatibility			✱		/						✱	Ministry Of Justice NAIDC	/	
(13.2) Create HD Map			✱		/					/	/		/	/
(13.3) Define standards related to Connected vehicles with everything (V2X) and provide infrastructure for 'Intelligence Traffic System'			/		/	/					/	NBTC	/	/
(13.4) Develop support infrastructure, i.e. satellite navigation system, and related regulations					/							NBTC	/	/
(13.5) Cybersecurity and data privacy					✱							NBTC	/	
(13.6) Set up AV standard, law, and regulations for public use			✱									Ministry Of Justice NAVSC RTP	/	
(14) AV adoption													/	
(14.1) Demonstration of AV in real case			/		/			✱			/	EEC Smart city NAVSC RTP	/	
(14.2) AV testing in verified roads			/		/						✱	NAVSC	/	
(14.3) Start AV level 3 usage in verified roads			✱									NAVSC RTP	/	
(14.4) Zero emission and accident zoning		/	/					✱				NAVSC Bangkok Pattaya EEC Smart City RTP	/	

Remark: ✱ main responsible institute

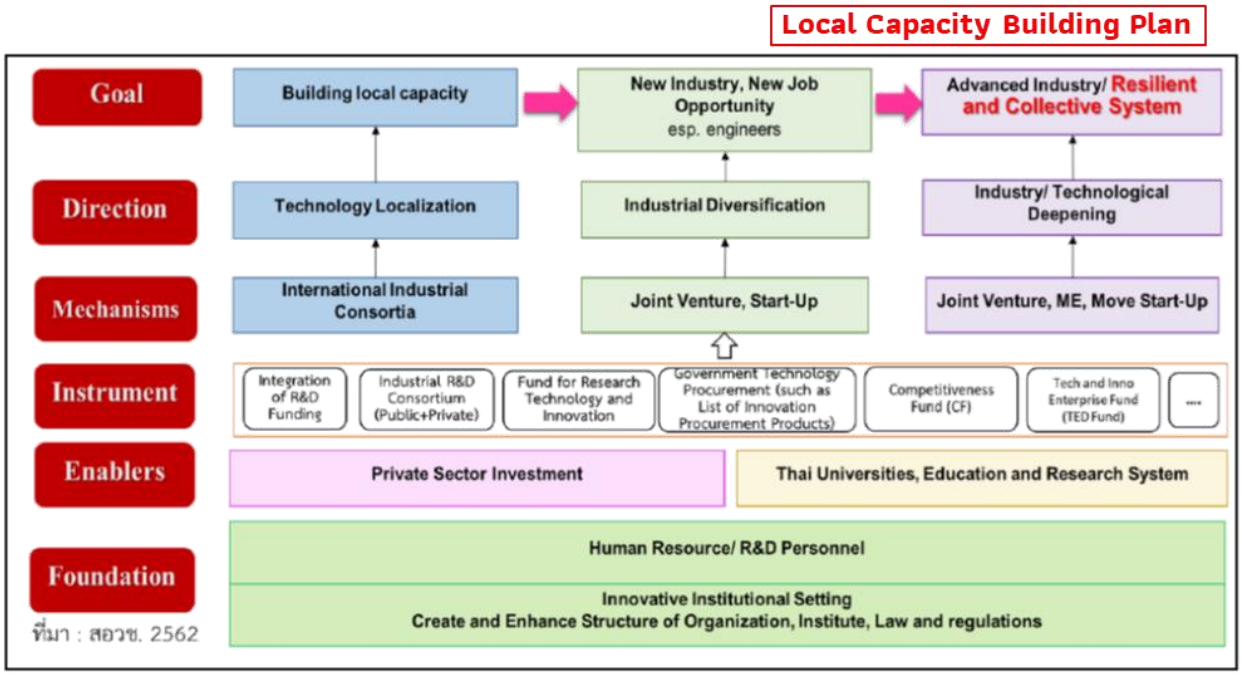
MHESI: Ministry of Higher Education, Science, Research and Innovation
NAIDC: National Automotive Industry Development Committee
NBTC: National Broadcasting and Telecommunication Commission
OHEC: Office of the Higher Education Commission
RTP: Royal Thai Police
TAI: Thailand Automotive Institute
TSRI: Thailand Science Research and Innovation
NAVSC: National Autonomous Vehicles Sub-committee


แนวทางการส่งเสริมและพัฒนายานยนต์สมัยใหม่
Next - Generation Automotive : Promotion & Development
Towards Zero Emissions & Future Mobility:
Autonomous, Connected, Electric and Shared Vehicles (ACES)
AUTOMOTIVE TRANSITION
GOALS 2035
PROVIDE A DIRECTION TO A SUSTAINABLE AUTOMOTIVE INNOVATIONS
ENSURE A SMOOTH TRANSITION TO A SUSTAINABLE NEXT - GENERATION AUTOMOTIVE INDUSTRY
2020
2030
2040
2050
AUTOMOTIVE INDUSTRY FORESIGHT & TARGETS
SOCIO - ECONOMIC ASPECTS OF FUTURE MOBILITY
INDUSTRY & LOCAL CAPABILITIES & INFRA DEVELOPMENT
ACCELERATION IMPLEMENTATION INDUSTRIALIZATION
ที่มา: สอวช. 2563

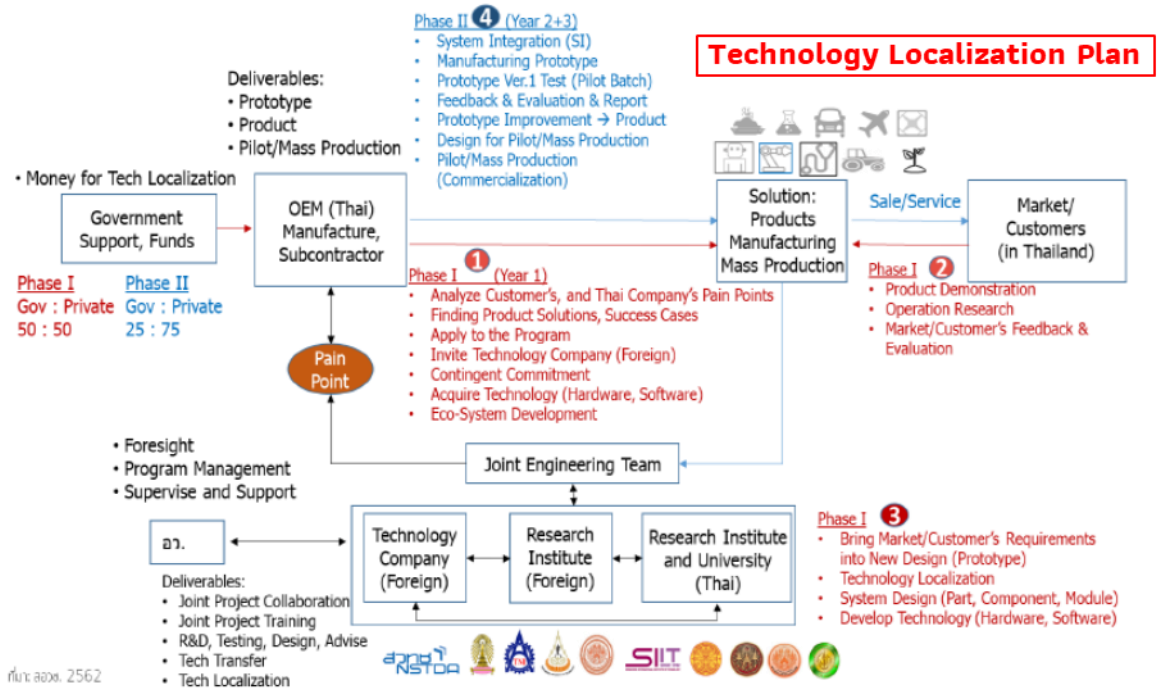
(a)


Car production (million units)
จำนวนรถใหม่ที่จดทะเบียนในประเทศ ZEV, AV (%)
การตั้งเป้าหมายในปี 2035 รถใหม่ที่จดทะเบียนในประเทศเป็น ZEV 100% เนื่องจากต้องการลดการปล่อยมลพิษ PM 2.5 ลดการเสียชีวิตจากอุบัติเหตุ และสนับสนุนให้เกิดการพัฒนาอุตสาหกรรมและเทคโนโลยีที่สะอาดในประเทศไทย
2035 ผลิตรถจำนวน 2.7 ล้านคัน
2030 ผลิตรถจำนวน 2.5 ล้านคัน
2025 ผลิตรถจำนวน 2.2 ล้านคัน
2023 ผลิตรถจำนวน 2.1 ล้านคัน
2020 ผลิตรถจำนวน 2.0 ล้านคัน
3.0
2.5
2.0
Scenario #3 Environmental Target Driven
ZEV 100% AV LV 4 80%
Scenario #2 Current Policy
Scenario #1 BAU
ZEV 30% AV LV3 60%
ZEV 15% AV LV 3 30%
ZEV 5% AV LV 2
ZEV 0.35% AV LV 2
100%
87.5%
75%
62.5%
50%
37.5%
25%
12.5%
0%
New car registration
2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035
2020 • Oxford, UK • ยกเลิกการผลิตรถ ICE
2021 • Costa Rica ยกเลิกการผลิตรถ ICE
2024 • Norway ยกเลิกการผลิตรถ ICE
2025 • Battery <100 USD/KWh ราคารถ ZEV<ICE
2030 • Denmark, Iceland, India, Ireland, Israel, Netherlands, Sweden ยกเลิกการผลิตรถ ICE
• ทำให้ผู้ผลิตในประเทศผลิตรถ ZEV ได้อย่างเดียว
• Campaign EV30@30 ใน 9 ประเทศ Canada, China, Finland, France, India, Japan, Mexico, the Netherlands, Norway, และ Sweden

(b)



(c)



(d)

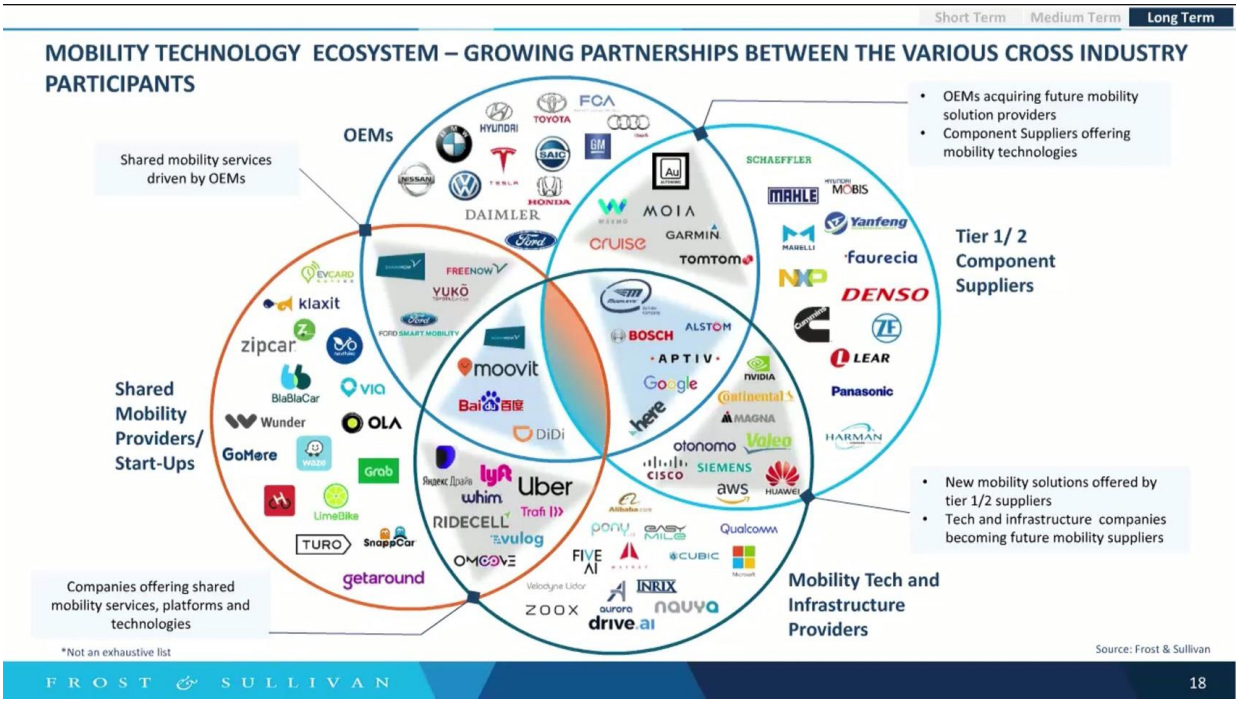
Fig. 8 (a) Next-Generation Automotive Promotion & Development Plan with (b) target till 2035 through (c) Local Capacity Building Plan and (d) Technology Localization Plan

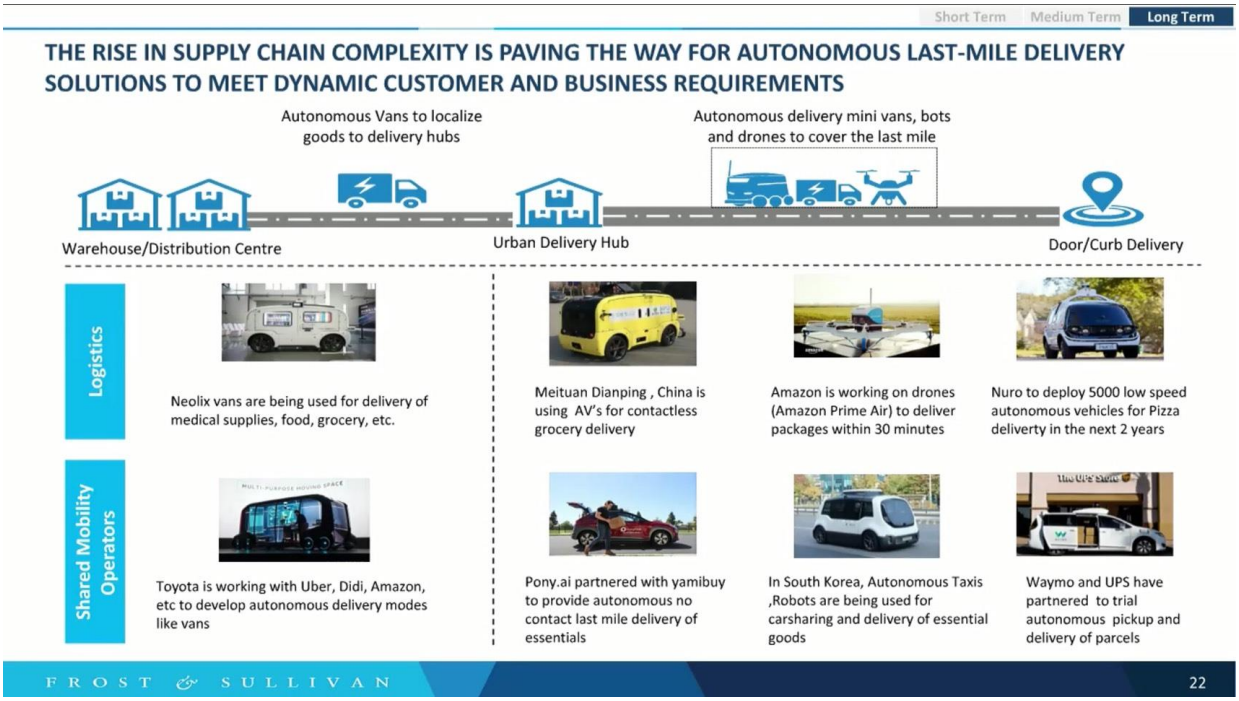
In addition to official plan, various activities related to autonomous vehicle are as follows. On 25 January 2020, Thailand's first industrial use case for remote-controlled forklift via 5G was successfully demonstrated by SCG, AIS and PSU, as shown in Fig. 9 [11, 12]. This shows expansion of operational design domain of AV to industrial factory offering more

efficiency and safety operation, where unmanned forklift at SCG plant in Saraburi was controlled by the operator at SCG headquater in Bangsue, Bangkok.

Fig. 9 Thailand's first industrial use case for remote-controlled forklift via 5G

On 4 June 2020, Frost & Sullivan held autonomous vehicle webinar, as shown in Fig. 10, highlighting cross-cutting ecosystem among OEMs, Tier 1/2 component suppliers, mobility tech/infrastructure providers and shared mobility providers with new market for autonomous last-mile deliveries of goods and people. Analysis was done on post-covid market, where consolidation may take place to achieve economy of scale in this sector.





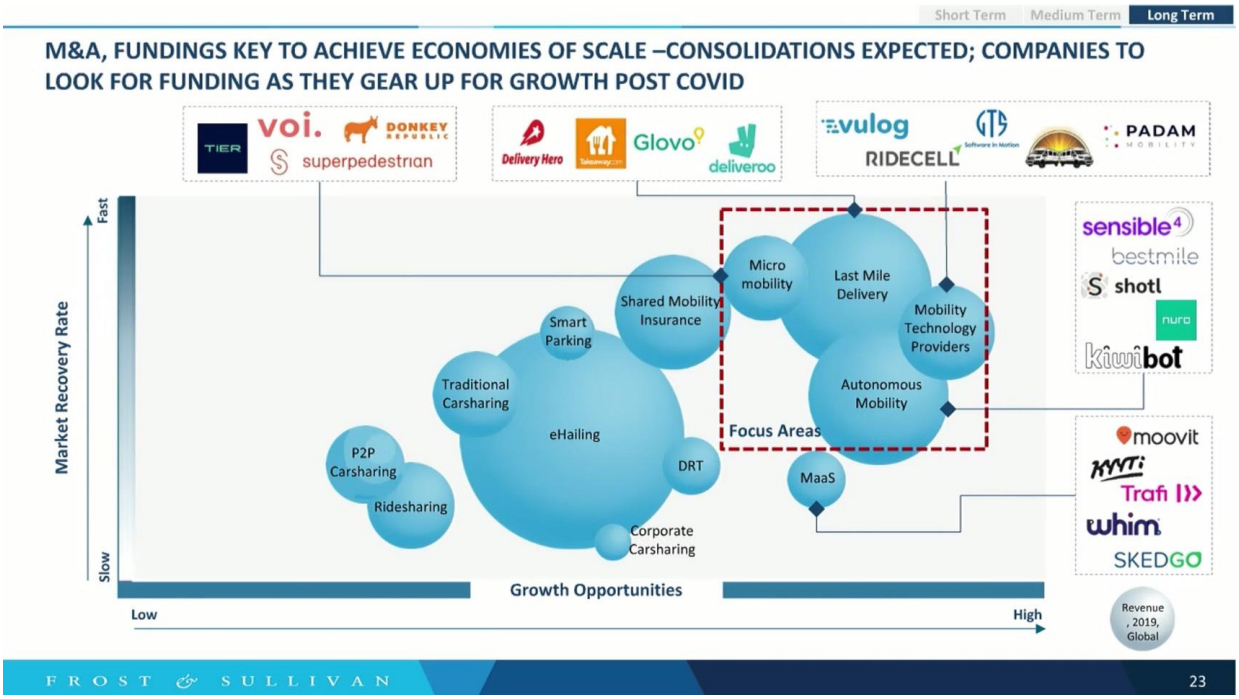


Fig. 10 Frost & Sullivan held autonomous vehicle webinar

On 9 June 2020, there was an attempt on legal framework of autonomous vehicle at senator level through Standing Sub-Committee on Information Technology, Communication, Telecommunication meeting, as shown in Fig. 11, to consider government support for autonomous vehicle, where ATRANS member, Assoc.PRof.Dr. Sorawit Narupiti, was called to present. However, this matter was not pushed forward by this Sub-Committee.

ระเบียบวาระการประชุม
คณะอนุกรรมาธิการพิจารณากฎหมาย โครงสร้าง หน้าที่และอำนาจ
ของหน่วยงานที่เกี่ยวข้องกับการเทคโนโลยีสารสนเทศ การสื่อสาร และการโทรคมนาคม
ในคณะกรรมาธิการการเทคโนโลยีสารสนเทศ การสื่อสาร และการโทรคมนาคม วุฒิสภา
ครั้งที่ ๘/๒๕๖๓
วันอังคารที่ ๙ มิถุนายน ๒๕๖๓ เวลา ๑๓.๓๐ นาฬิกา
ณ ห้องประชุม หมายเลข ๓๐๘ ชั้น ๓ อาคารรัฐสภา (เกียกกาย)

ระเบียบวาระที่ ๑ เรื่องที่ประธานจะแจ้งต่อที่ประชุม

๑.๑ ตามที่คณะกรรมาธิการการเทคโนโลยีสารสนเทศฯ ได้มีมติให้จัดทำหนังสือสอบถามความคิดเห็นต่อร่างพระราชบัญญัติองค์กรจัดสรรคลื่นความถี่และกำกับการประกอบกิจการวิทยุกระจายเสียง วิทยุโทรทัศน์ และกิจการโทรคมนาคม (ฉบับที่ ..) พ.ศ. .... ร่วมกับคณะกรรมาธิการสิทธิมนุษยชน สิทธิเสรีภาพและการคุ้มครองผู้บริโภค นั้น คณะกรรมาธิการทั้ง ๒ คณะได้พิจารณาให้ความเห็นชอบแบบสอบถามดังกล่าว และประธานคณะกรรมาธิการได้ลงนามในหนังสือแล้ว

๑.๒ ตามที่คณะอนุกรรมาธิการได้เสนอต่อคณะกรรมาธิการการเทคโนโลยีสารสนเทศฯ เพื่อพิจารณาให้ความเห็นชอบในเรื่องดังต่อไปนี้

๑) การขอข้อมูลเพิ่มเติมจากสำนักงานการบินพลเรือนแห่งประเทศไทย

๒) การเร่งรัดร่างพระราชบัญญัติกิจการอวกาศ พ.ศ. .... ไปยังกระทรวงดิจิทัลเพื่อเศรษฐกิจและสังคม

คณะกรรมาธิการได้ให้ความเห็นชอบ และประธานคณะกรรมาธิการได้ลงนามหนังสือดังกล่าวแล้ว

ระเบียบวาระที่ ๒ รับรองบันทึกการประชุม

- บันทึกการประชุม ครั้งที่ ๗/๒๕๖๓ วันอังคารที่ ๒๖ พฤษภาคม ๒๕๖๓

ระเบียบวาระที่ ๓ เรื่องที่เสนอเพื่อพิจารณา

๓.๑ พิจารณาทิศทางและแนวโน้มของเทคโนโลยีรถยนต์ขับเคลื่อนอัตโนมัติ และข้อเสนอการส่งเสริมสนับสนุนจากภาครัฐเพื่อการพัฒนาและใช้ประโยชน์เชิงพาณิชย์ โดยมีผู้เข้าร่วมประชุม ดังนี้

๑)	รศ.ดร.สรวิศ นฤปิติ	คณะวิศวกรรมศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย
๒)	ผศ.ดร.นักสิทธ์ นุ่มวงษ์	คณะวิศวกรรมศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย
๓)	นางสาวณัฐวรา ชั้นสกุล	คณะวิศวกรรมศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย
๔)	ดร.ปาษาณ กุลวานิช	กรมวิทยาศาสตร์บริการ
๕)	ดร.ต้องการ แก้วเฉลิมทอง	โรงเรียนนายร้อยพระจุลจอมเกล้า

๓.๒ พิจารณารายงานการเตรียมความพร้อมในการตราพระราชกฤษฎีกาตามมาตรา ๓๐ แห่งพระราชบัญญัติองค์กรจัดสรรคลื่นความถี่และกำกับการประกอบกิจการวิทยุกระจายเสียง วิทยุโทรทัศน์ และกิจการโทรคมนาคม (ฉบับที่ ๓) พ.ศ. ๒๕๖๒

ระเบียบวาระที่ ๔ เรื่องอื่น ๆ

- กำหนดนัดประชุมครั้งต่อไป

****

Fig. 11 Meeting agenda on Standing Sub-Committee on Information Technology, Communication, Telecommunication meeting

On 24 June 2020, Smart Road Asset and Data Services webinar was held by ITS Thailand, ITS Isarel and MobileEye to highlight technology trend for autonomous vehicle, as shown in Fig. 12, with many ATRANS members' participation. As 1.25 million people die each year from road accident (more than 2 deaths per minute), autonomous vehicle technology could offer as a way to reduce this fatality through enhancement of human eye capability during driving via various sensors. Mobileye has become a global leader in driver assistance and autonomous vehicle technology with current strategy focusing on 3 pillars, namely Advanced Driver-Assistance Systems (ADAS), Self-Driving System and Mobility-as-a-Service (MaaS) and Data Services. Road experience management is also important when dealing with high density map during harvesting, aggregating and localization. Mapping of Japanese highway with 25,000km, 300K poles, 250K lane markings and 320K signs could only take 400MB map size. Mobileye has done road survey in Bangkok, as shown in Fig. 13.

Fig. 12 Smart Road Asset and Data Services webinar was held by ITS Thailand, ITS Isarel and Mobileye

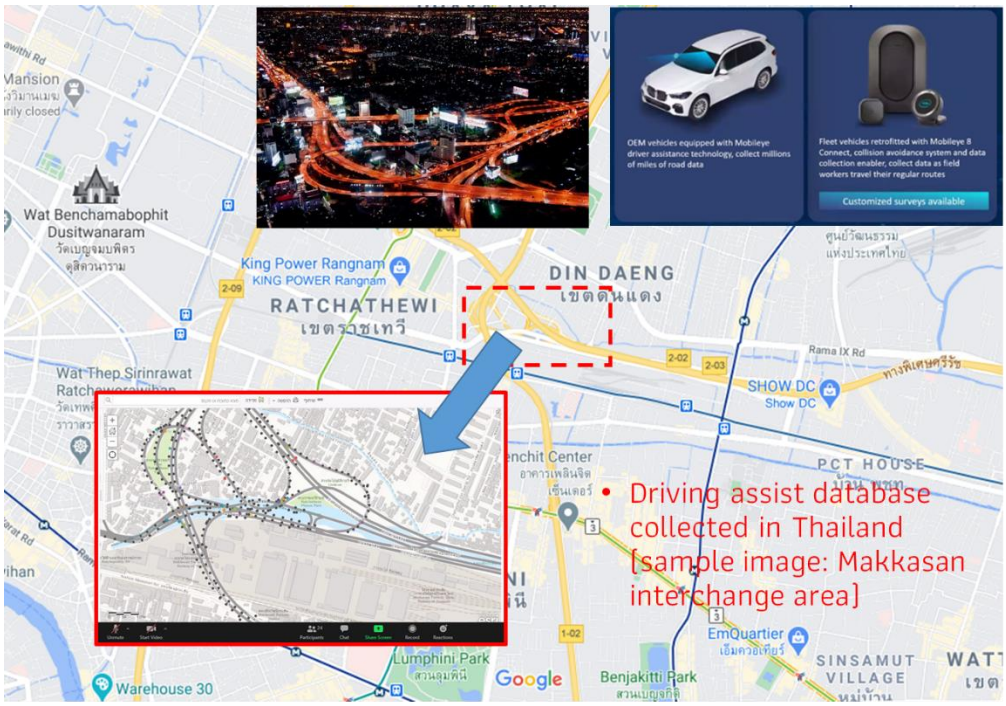


Fig. 13 Mobileye road survey in Thailand

On 25 June 2020, AV demonstration by Office of the National Broadcasting and Telecommunications Commission (NBTC) and Huawei at Siriraj hospital for COVID-19 safety handling of medical supplies, as shown in Fig. 14 [13, 14].

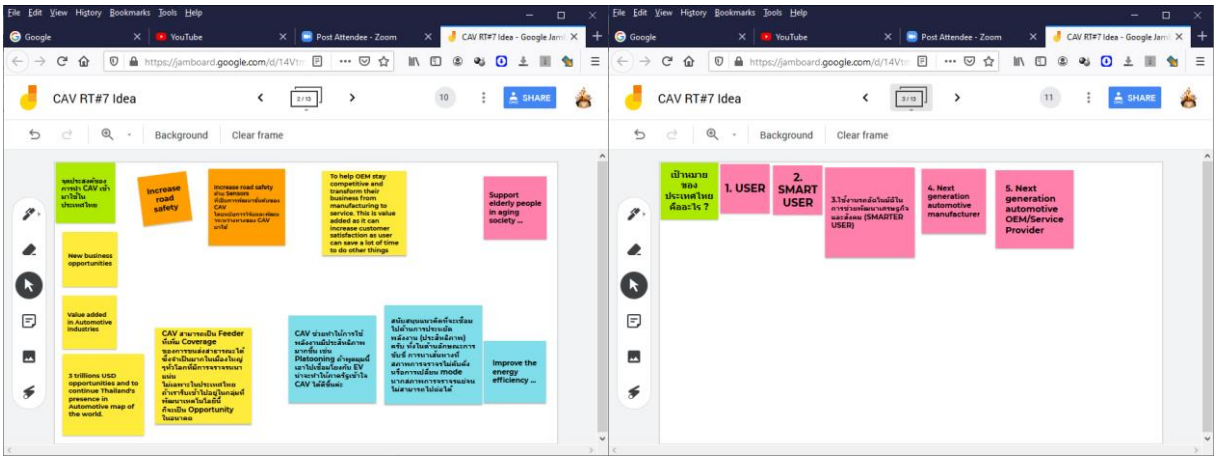
Fig. 14 AV demonstration by NBTC and Huawei at Siriraj hospital

On 30 June 2020, 6th CAV Roundtable was organized online to discuss the following issues, as shown in Fig. 15 and Fig. 16.

- ✓ **Updates on related CAV activities in Thailand**
- ✓ **Follow-up on the meeting with Standing Sub-Committee on Information Technology, Communication, Telecommunication on 9 June 2020**
- ✓ **Brainstorming on various aspects of CAV**
  - **Purpose of CAV in Thailand**
  - **Target of CAV in Thailand**
  - **Policy & Roadmap of CAV in Thailand**
  - **Law & Regulation of CAV in Thailand**

- **Industry & Entrepreneur for CAV in the future in Thailand**
- **User acceptance of CAV in Thailand**
- **Technology readiness of CAV in Thailand**
- **Other concerns of CAV in Thailand**

Fig. 15 7th CAV Roundtable held online



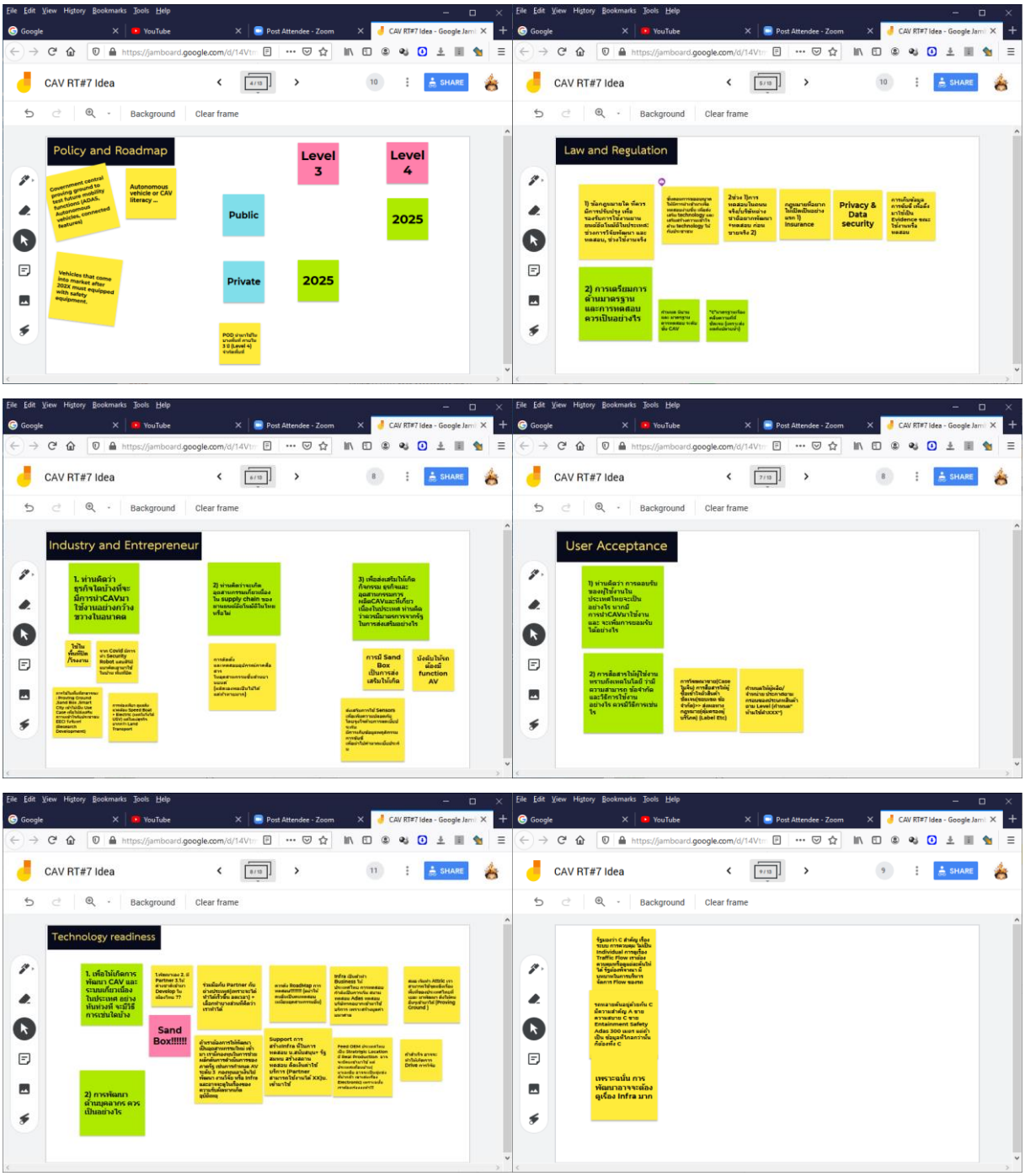


Fig. 16 7th CAV Roundtable held online

On 17 July 2020, New Suvarnabhumi Airport Terminal received Siemens' First Automated People Mover (APM), as shown in Fig. 17, where each APM has two carriages with room for 210 passengers per trip or 6,000 per hour. The APM will run underground at speeds up to 80 kph, covering the 1 kilometer distance between the two terminals in less than two minutes. This shows expansion of operational design domain of AV to airport offering more efficiency and safety operation.

Fig. 17 First Automated People Mover (APM) in Suvarnabhumi airport

On 3 December 2020, NVIDIA signed a memorandum of understanding with a consortium of 6 Thai universities, namely Chulalongkorn University, CMKL University, King Mongkut's Institute of Technology Ladkrabang, Khon Kaen University, Mahidol University, and Prince of Songkla University, to drive research and accelerate scientific breakthroughs in Artificial Intelligence (AI) and High Performance Computing (HPC), including AV, as shown in Fig. 18 [15].

Fig. 18 MOU between NVIDIA and a consortium of 6 Thai universities on AI and HPC

On 25 February 2021, IATSS held online symposium on "International perspective to the new traffic system with autonomous vehicle: UK, Germany, France and Japan's approaches to implementation of the autonomous driving techniques of Level 3, 4 and the Dilemma situation," as shown in Fig. 19. With over 100 participants online, this online symposium was a success for sharing AV perspective from UK, Germany, France and Japan, followed by discussion on way forward in driving international effort to promote and support autonomous vehicle technology and regulation. Many helpful points and concerns were collected for further consideration in Thailand.

IATSS 2005C Project

[International perspective to the new traffic system with autonomous vehicle
(the UK, Germany, France and Japan's approaches to implementation of the automous driving techniques of Level 3,4 and the Dilemma situation)]

Organizer:International Association of Traffic and Safety Sciences

■Date and Time：February 25,2021 18:00~21:00
■Form：Zoom
■Apply:Email to hiroya hiroya@iatss.or.jp
■Deadline:：February 23,2021

Lecture Introduction

Ms. Jessica Uguccioni Lecture ①
Automated Vehicles Review - Lead Lawyer, at Law Commission of England and Wales ,Member of the UNECE Global Forum for Road Traffic Safety WP.1-IGEAD (Informal Group of Experts on Automated Driving)

Dr. Mirja Feldmann Lecture ②
Regional Court Judge seconded to the German Federal Public Prosecutor's Office, University Lecturer (esp. Cybercrime, Criminal and Constitutional Law)
Comparative law expert holding a PhD in Germany and Spain
Former expert for administrative and EU law as well as international cooperation at the Ministry of the Environment, Climate Protection and the Energy Sector of the
Former Criminal Procedure Expert at the Federal Ministry of Justice

Dr. Eric Andreas Hilgendorf Lecture ③
Prof. Dr. Eric Hilgendorf, Faculty of Law, Julius Maximilian University of Würzburg, Chair of the Würzburg Research Center for Robot Law,Member of the Ethics Committee of the BMVI on automated driving,Director at the Bavarian Research Institute for Digital Transformation (bidt),Member of the Bavarian AI Council.

Prof. Jean-Christophe Roda Lecture ④
French professor of private law. Director of the master of Commercial Law at Lyon 3 University. Specialized in international commercial law, contract law and competition law.

今井 猛嘉 Prof. Takeyoshi Imai
Professor of criminal law at the Law School of Hosei University
Committee of the criminal law devision of the Legislative Council of the Ministry of Justice of Japan
Vice Chair of the Bid Oversight Committee of the Cabinet Office and the Cabinet Secretariat of Japan
High Level Advisor to the Secretary General of the OECD
Member of the Focus Group on AI for Autonomous Driving (FG-AI4AD)
Project leader of the Research Group on autonomous vehicle in the IATTS(research number 2005C)

Ms. Caroline Lebreton
Researcher at Hosei University

Schedule

Symposium

International perspective to the new traffic system with autonomous vehicle
the UK, Germany, France and Japan's approaches to implementation of the automous driving techniques of Level 3,4 and the Dilemma situation

●Opening Speech
18:00 - 18:05 **Takeyoshi Imai**

●Lecture
Every speaker will be given 25 minutes,among which 10 minutes will be used to answer the questions and opinions of the other participants.

18:05 - 18:30 Lecture ① **Ms. Jessica Uguccioni**
「How to Ensure the Safety of Self-Driving Cars in Level4 : Responses to Dilemmas from the UK perspective」

18:30 - 18:55 Lecture ② **Dr. Mirja Feldmann**
「How to Ensure the Safety of Self-Driving Cars in Level4 : Responses to Dilemmas from the German(judges) perspective」

18:55 - 19:20 Lecture ③ **Dr. Eric Andreas Hilgendorf**
「How to Ensure the Safety of Self-Driving Cars in Level4 : Responses to Dilemmas from the German(researchers) perspective」

19:20 - 19:45 Lecture ④ **Prof. Jean-Christophe Roda**
「How to Ensure the Safety of Self-Driving Cars in Level4 : Responses to Dilemmas from the French(researchers) perspective」

●Break
19:45 - 19:55

●Panel discussion
19:55 - 20:55 【Moderator】 Takeyoshi Imai
【Panelist】 4Lectures
Ms. Caroline Lebreton (Translator)

●Closing
20:55 - 21:00 Satoshi Kamada
Executive Director, International Association of Traffic and Safety Sciences

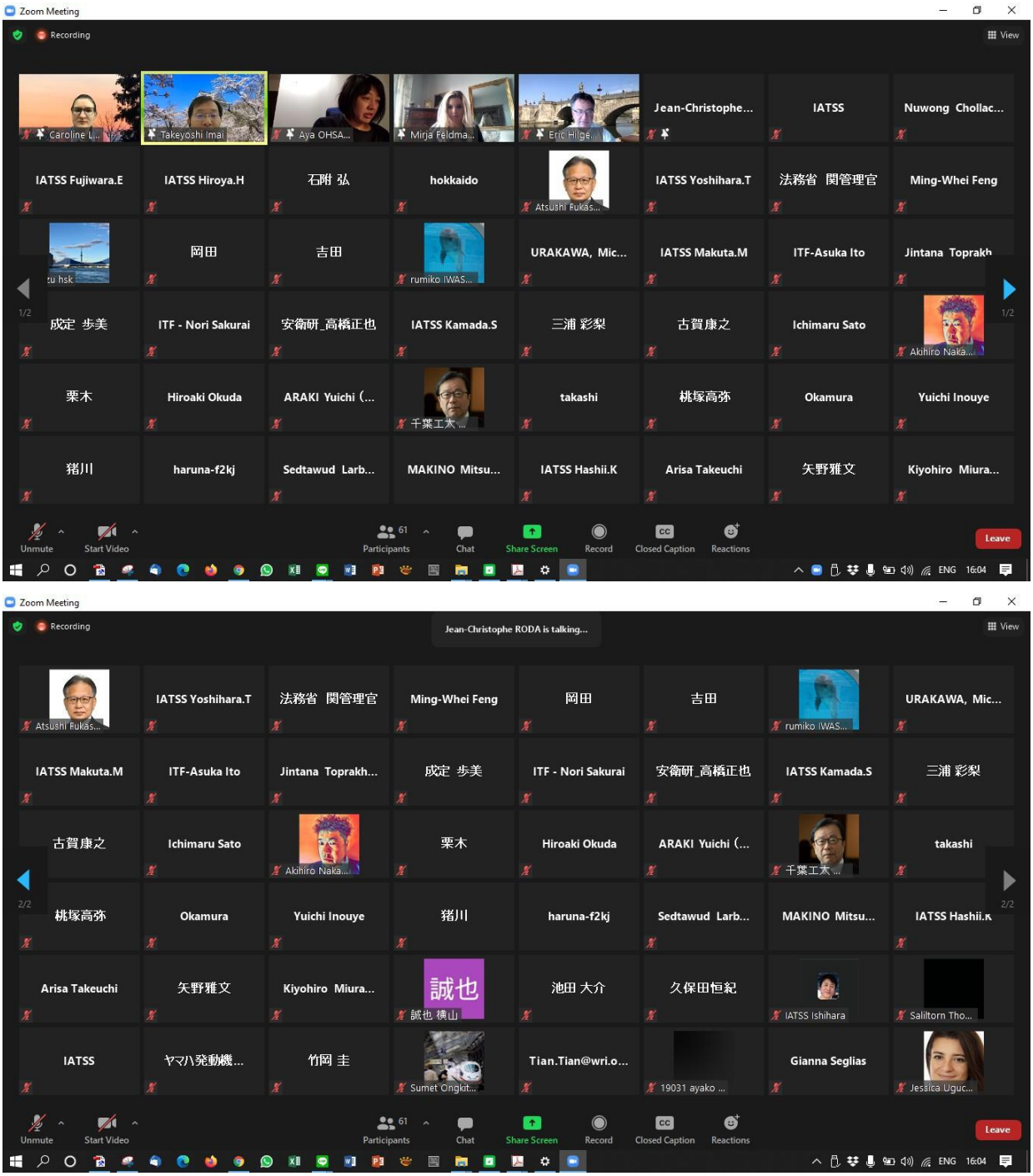


Fig. 19 IATSS Symposium on AV

On 18 March 2021, Department of Philosophy, Chulalongkorn University and Karel Čapek Center for Values in Science and Technology, Czech Republic held online seminar on "An Ethics of Autonomous Vehicles: A Bottom Up Approach", as shown in Fig. 20 with recorded presentation available at [16]. As vehicles become more autonomous, the task of designing guiding-systems for morally-acceptable decision making is urgent. Sometimes, one solution across various cultures may be acceptable but importance of inter-cultural perspectives, in particular with possible insights derived from Buddhist philosophy, for autonomous vehicles in supervised situations may affect different levels of decision-making

ability for human experts within a given culture to deem satisfactory. Apart from problems of ethical pluralism within a given culture, there are also problems with different moral preferences across cultures. One way that the problem might be addressed is to introduce a machine-learning training curriculum that would provide AVs a process comparable for a novice human driver learning to drive and passing own driving license test.

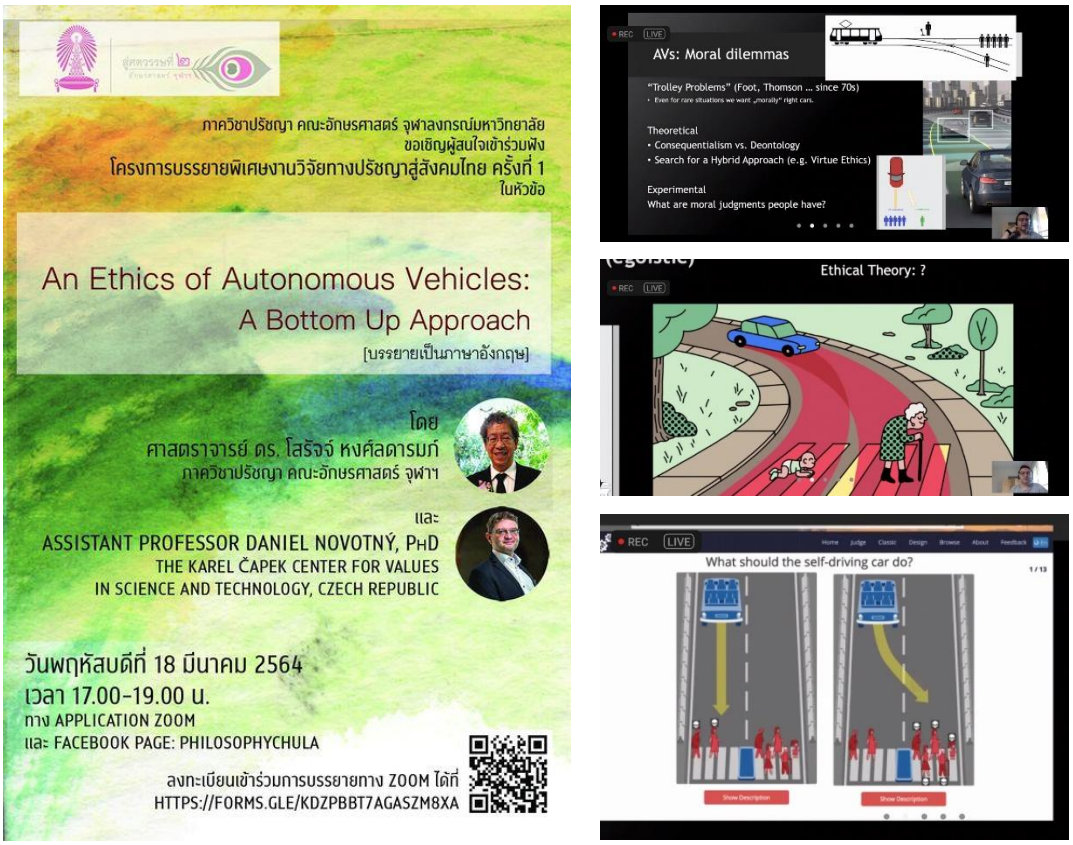


Fig. 20 Online seminar on "An Ethics of Autonomous Vehicles: A Bottom Up Approach"

3.3 Bibliometric Analysis of CAV

In order to technically promote connected and autonomous vehicle in Thailand, technically-competent personnel is crucial for linkage with technology abroad for local condition. As shown in Fig. 21, a tool called "Bibliometric analysis" is employed to map active researchers with existing collaborative network abroad to support both Local Capacity Building Plan and Technology Localization Plan, as identified in Fig. 8(c) and Fig. 8(d), respectively. Fig. 21 [17] shows schematic flow of Bibliometric analysis, which starts with R&D database, such as Scopus, Web of Science and PubMed, where keywords are defined for queries, before exporting to text mining software (such as Biblioshiny running on R platform) for graphical interpretation to map out research collaboration based on 3 principles as follows

- ✓ **Activity measurement by counting publications,**
- ✓ **Impact measurement by counting subsequent citations of a publication and**

- ✓ **Linkage measurement involving co-citations and keywords used from paper to paper**

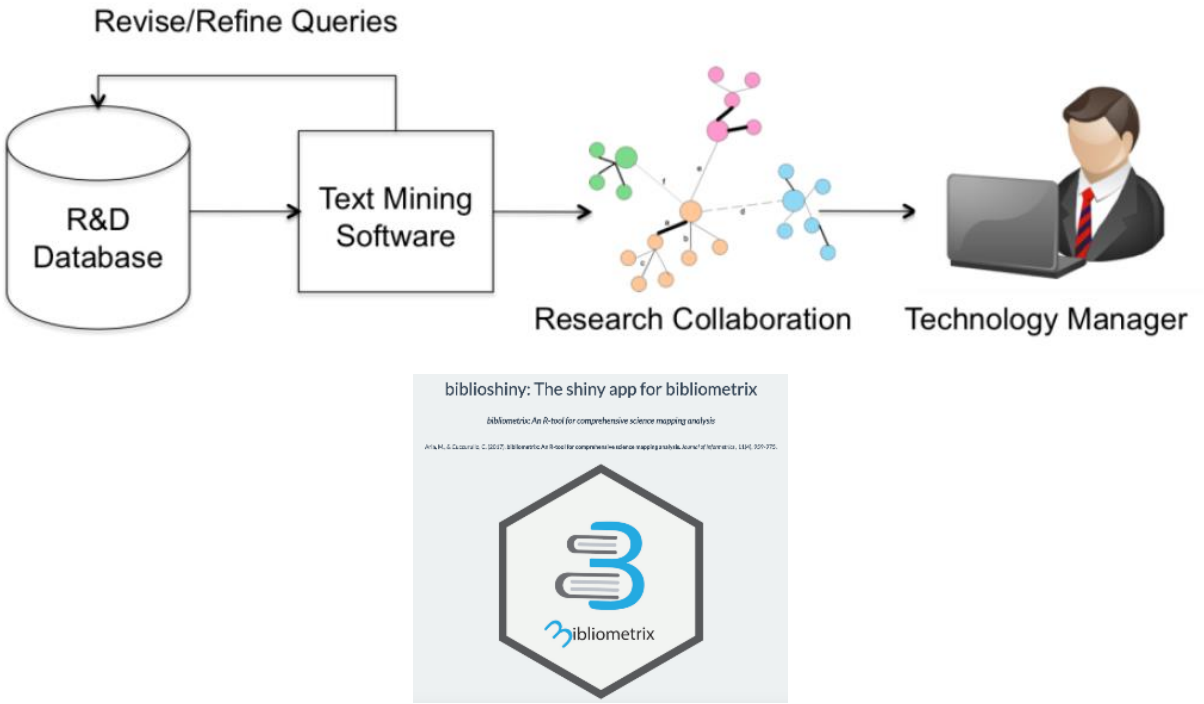
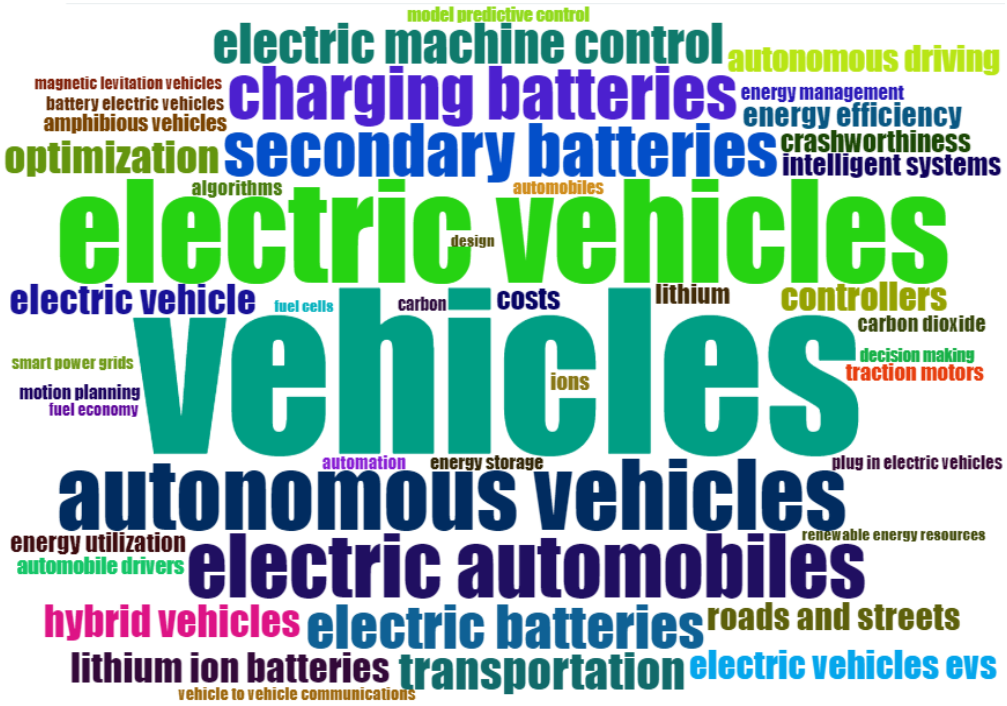
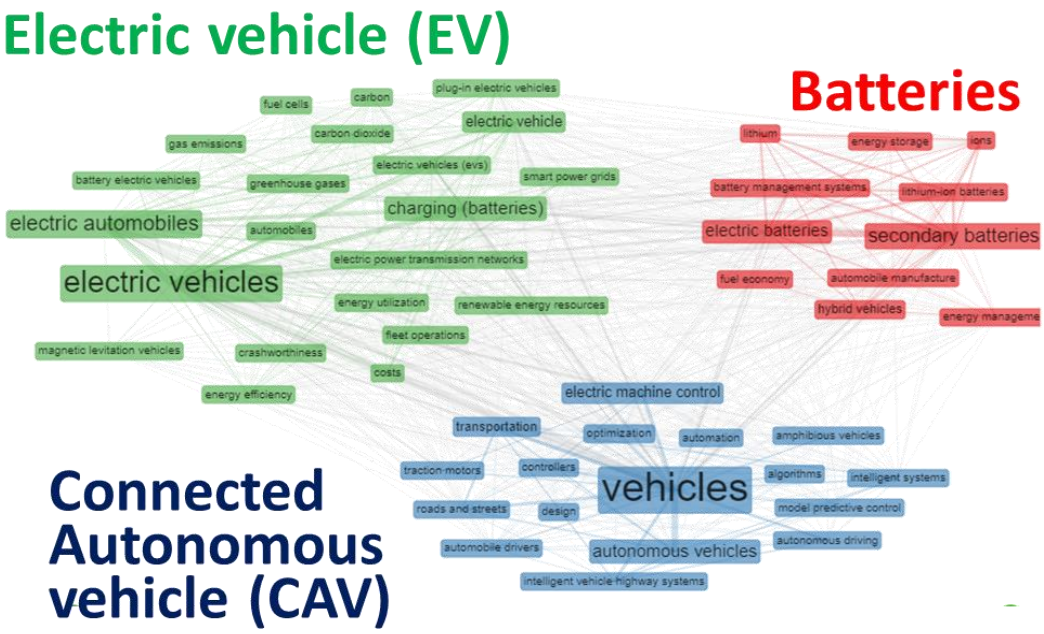


Fig. 21 Bibliomatric analysis of CAV for Thai universities

Fig. 22 shows output from Bibliomatric analysis with keyword on "Next generation automotive", where popular sub-keywords are shown in Fig. 22(a) with size depending on the frequency of keywords (the more frequent keyword, the bigger the size). Further text mining analysis on the "Next generation automotive" query can categorize sub-keywords into 3 groups, namely Electric vehicle (EV), Batteries and Connected autonomous vehicle (CAV), as shown in Fig. 22(b). Focusing on CAV, Fig. 22(c) and Fig. 22(d) show mapping of authors, affiliations and research topics, which can help identify which researchers from which research institutions are doing which research topics. Similar analysis can be performed on all 3 research topics in Fig. 22(b) for linkage analysis with foreign research institution, as shown in Fig. 22(e). All these output research landscape can be used to support both Local Capacity Building Plan and Technology Localization Plan, as identified in Fig. 8(c) and Fig. 8(d), respectively.

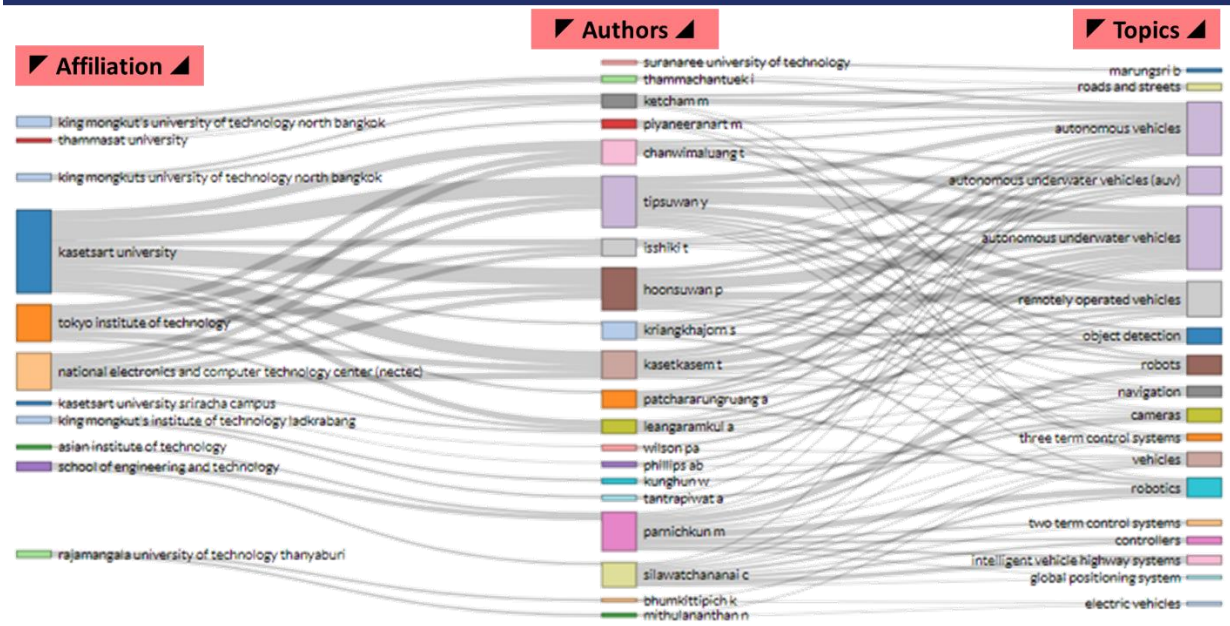

model predictive control
electric machine control
autonomous driving
magnetic levitation vehicles
battery electric vehicles
amphibious vehicles
charging batteries
energy management
energy efficiency
optimization
secondary batteries
crashworthiness
intelligent systems
algorithms
automobiles
electric vehicles
design
electric vehicle
fuel cells
carbon
costs
lithium
controllers
carbon dioxide
vehicles
smart power grids
motion planning
fuel economy
ions
decision making
traction motors
automation
energy storage
plug in electric vehicles
autonomous vehicles
energy utilization
automobile drivers
electric automobiles
renewable energy resources
hybrid vehicles
electric batteries
roads and streets
lithium ion batteries
transportation
electric vehicles evs
vehicle to vehicle communications

(a)


Electric vehicle (EV)
Batteries
fuel cells
carbon
plug-in electric vehicles
electric vehicle
carbon dioxide
gas emissions
electric vehicles (evs)
battery electric vehicles
greenhouse gases
smart power grids
charging (batteries)
electric automobiles
automobiles
electric power transmission networks
electric vehicles
energy utilization
renewable energy resources
fleet operations
magnetic levitation vehicles
crashworthiness
costs
energy efficiency
lithium
energy storage
ions
battery management systems
lithium-ion batteries
electric batteries
secondary batteries
fuel economy
automobile manufacture
hybrid vehicles
energy manageme
electric machine control
transportation
optimization
automation
amphibious vehicles
traction motors
controllers
vehicles
algorithms
intelligent systems
roads and streets
design
model predictive control
automobile drivers
autonomous vehicles
autonomous driving
intelligent vehicle highway systems
Connected
Autonomous
vehicle (CAV)

(b)

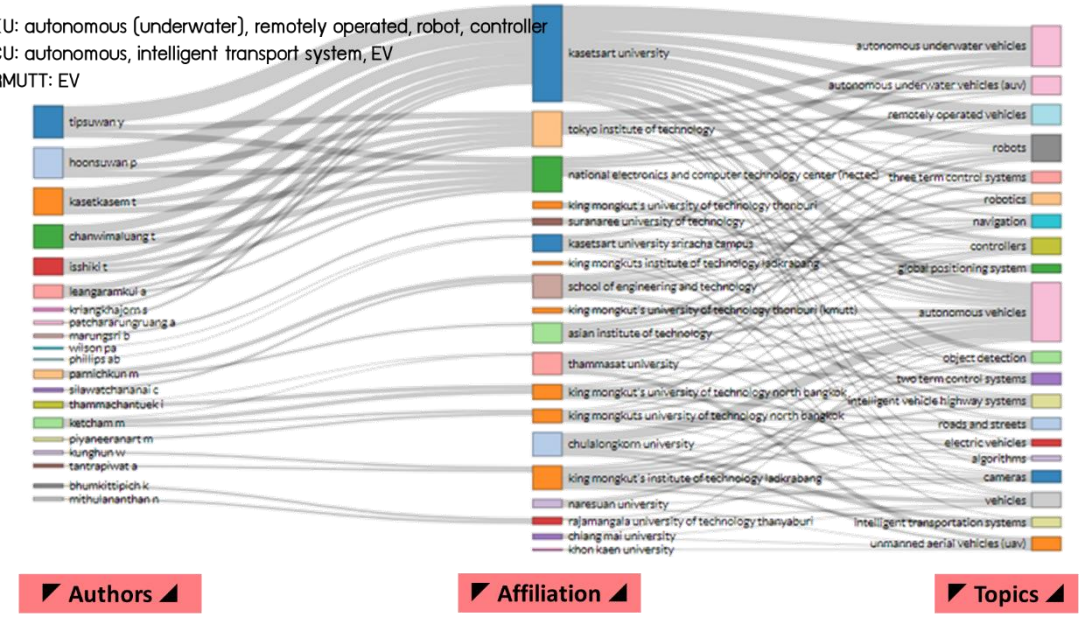
CONNECTED AUTONOMOUS VEHICLE: AUTHORS-KEYWORDS LINKAGE



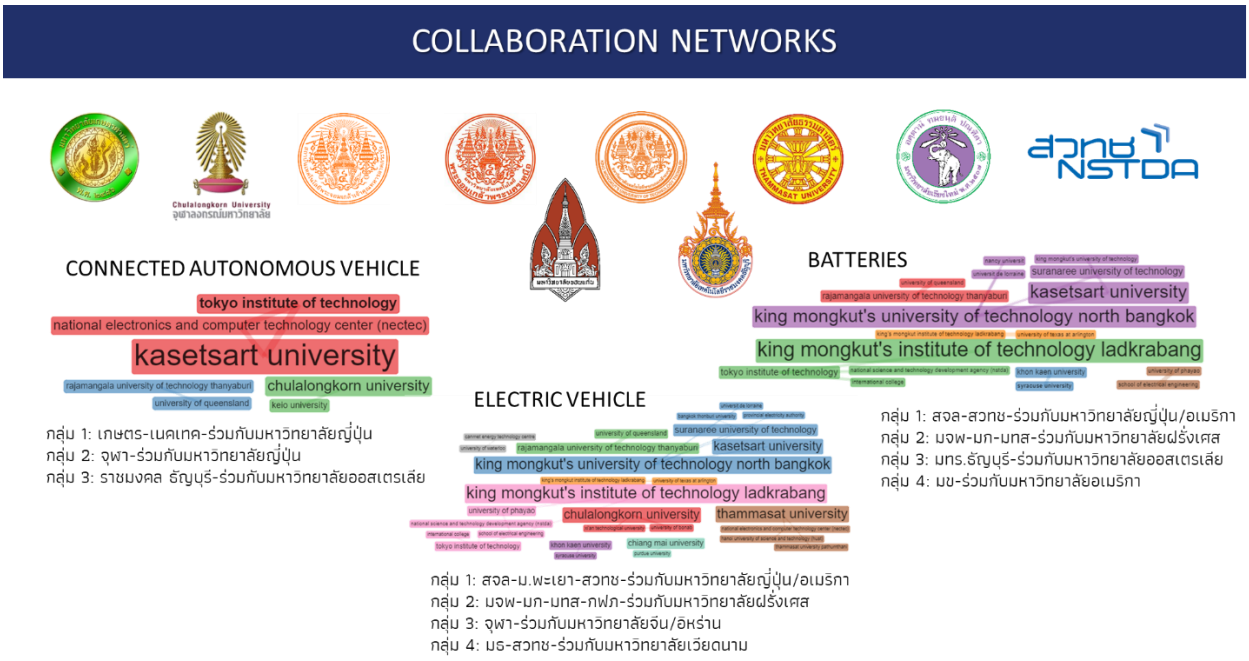
(c)

CONNECTED AUTONOMOUS VEHICLE: AFFILIATIONS-KEYWORDS LINKAGE

- KU: autonomous (underwater), remotely operated, robot, controller
- CU: autonomous, intelligent transport system, EV
- RMUTT: EV



(d)



(e)

Fig. 22 Bibliomatric analysis output on "next generation automotive" keyword: (a) word count with size depending on frequency, (b) sub-keyword classification, (c) researcher-focused map with affiliation and topic, (d) affiliation-focused map with researcher and topic, and (e) foreign institution mapping

3.4 Conclusion

From previously identified issues for AV in Thailand (Fig. 23) with stakeholder map (Table 4) [18], recommendations for way forward are as follows.

- ✓ **Keep following autonomous vehicle movement in Thailand for both technical and regulatory framework**
  - **Automated driving technologies are evolving but Levl-5 AVs may not be realistic by 2030 or later.**
  - **It is very critical to set objectives for CAVs deployment first. Goals and KPIs should be required in the viewpoints of those objectives, such as safety, traffic efficiency, or environmental issues. Technologies of CAV are just measures to achieve them.**
  - **Social issue for public acceptance is important for initiation**
- ✓ **Support both technical and regulatory updates to policy makers & public**
  - **Sandbox with appropriate Operational Design Domain (ODD) & autonomous level**
- ✓ **Expand "Next-Generation Automotive Promotion & Development Plan" and recommendation from "National Electric Vehicle Policy Committee" to push forward autonomous vehicle framework**

- ✓ **Initiation, continuation and expansion of autonomous vehicle services should be carefully planned**

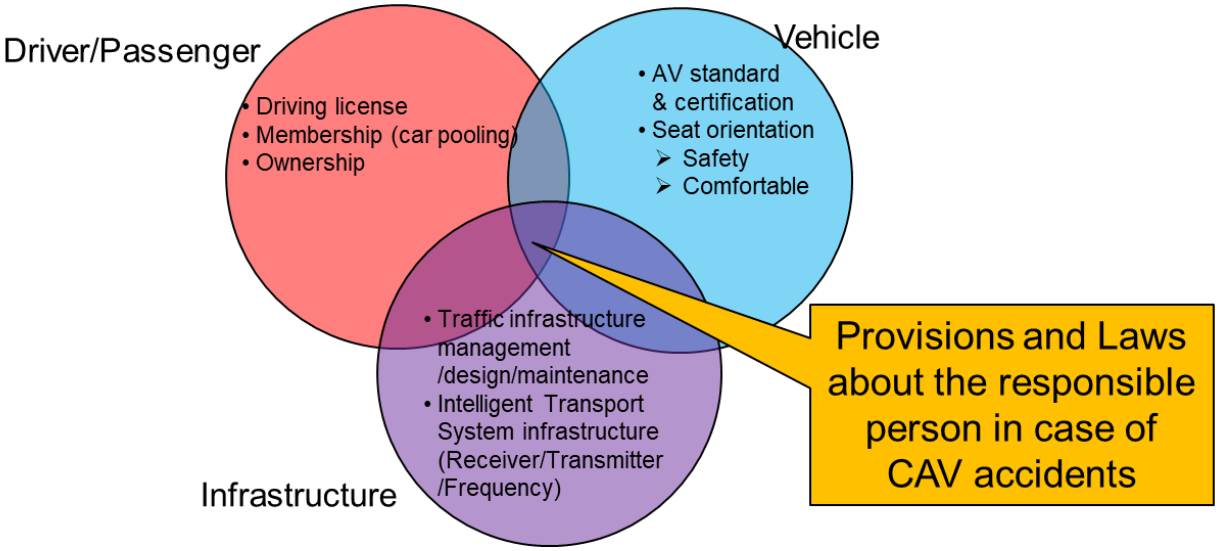


Fig. 23 List of issues for AV in Thailand from 3 aspects: driver/passenger, vehicle and infrastructure

Table 4: AV stakeholder mapping for Thailand

	Ministry of Transport	Ministry of Industry	Ministry of Digital Economy and Society
Policy leader	**Office of Transport and Traffic Policy and Planning (OTP)**	**Office of Industrial Economics (OIE)**	**Digital Economy Promotion Agency (DEPA)**
Regulated Organization	**Department of Land Transport (DLT)**	**Thai Industrial Standards Institute (TISI)**	**National Broadcasting and Telecommunication Commission (NBTC)**
Law enforcement	**The Royal Thai Police**		
Technical supporter	**Research laboratory in University / National Technology Center (e.g. NECTEC)**		

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Final Report

Research Grant 2020

ATRANS