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Legal Challenges for Autonomous Vehicles in Thailand and ASEAN

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List of Abbreviations and Acronyms

AV	Autonomous vehicle
CASE	Connected, Autonomous, Shared, Electric
CAV	Connected Autonomous Vehicle
CETRAN	Centre of Excellence for Testing & Research of Autonomous Vehicles NTU, Singapore
DOT	Department of Transportation, USA
DSRC	Dedicated Short-Range Communications
EV	Electric vehicle
EVAT	Electric Vehicle Association of Thailand
FMVSS	Federal Motor Vehicle Safety Standards
HAV	Highly Automated Vehicles
MANETs	Mobile Ad hoc Networks
NAC2019	2019 NSTDA Annual Conference
NBTC	National Broadcasting and Telecommunications Commission
NCSL	National Conference of States Legislatures, USA
NHTSA	National Highway Transportation Safety Administration
NSTDA	National Science and Technology Development Agency, Thailand
NTU	Nanyang Technological University, Singapore
NXPO	Office of National Higher Education, Science, Research and Innovation Policy Council
ODD	Operational Design Domain
OTP	Office of Transport and Traffic Policy and Planning, Thailand
PKI	Public Key Infrastructure
R&D	Research and Development
SAE	Society of Automotive Engineers
TAI	Thailand Automotive Institute
TISOC	Transport and infrastructure senior officials' committee, Australia
TR	Technical Reference
UNECE	United Nations Economic Commission for Europe
V2V	Vehicle to vehicle
VANETs	Vehicular Ad hoc Networks
VCS	Vehicular Communication Systems
WLAN	Wireless Local Area Network
WPAN	Wireless Personal Area Network
ZEV	Zero Emission Vehicle

CHAPTER I INTRODUCTION

1.1 Rationale

With advances in vehicle technologies, electric vehicle (EV) has recently disrupted how we mobilize in the world today, transforming from a more complicated internal combustion engine to a simpler motor-battery system with precision electronic control to achieve better energy efficiency and less polluted emission. Together with advances in digital technologies, EV boundary has been stretched further to enhance personal mobility experience with self-driving (autonomous) capability.

As predicted by IHS Automotive, the number of cars connected to the internet world would grow from 23 million in 2013 to 152 million in 2020, with as many as 21 million autonomous vehicles on the road in 2035 [1]. 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 [2]. Note that some of today vehicles have already featured some automation, such as automated emergency braking, lane departure warning and assisted parking. NHTSA has also defined Highly Automated Vehicles (HAVs) to include Levels 3, 4 and 5, where intensive development has been focused on. Level 3 vehicles are encountered with "hands-off" problem, where automotive engineers have not yet found a practical way to get a distracted driver respond to an alert and retake control of the car in a split second as required in an emergency. This is why Google and some car manufacturers are skipping Level 3 cars and developing Level 4 and 5 cars. Other manufacturers will address the hands-off problem by design limitations. For example, Audi's Level 3 system for its 2018 A8 will function only at 35 mph or lower speeds [3].

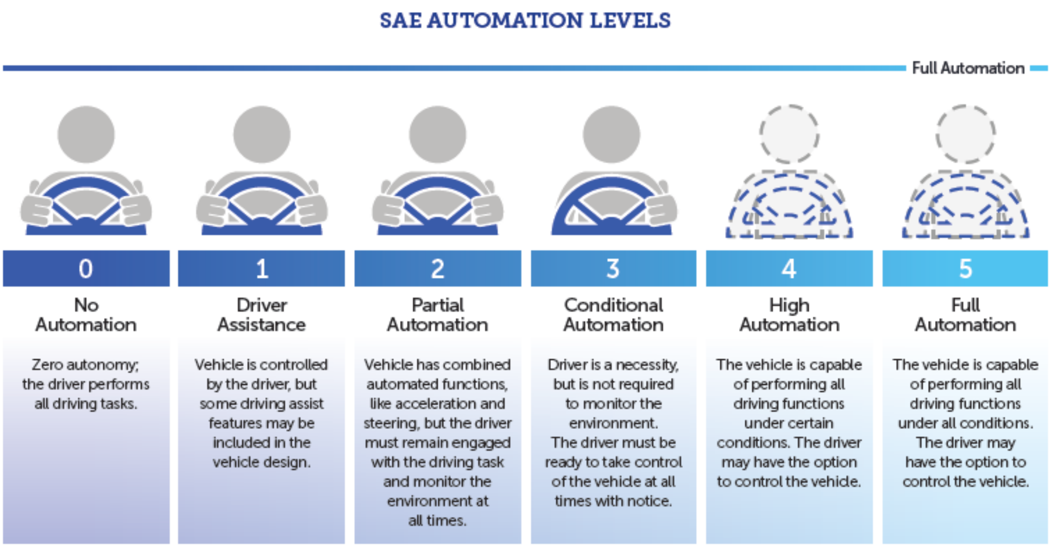


Fig. 1 SAE automation levels adopted by NHTSA

The benefit of autonomous driving lies not only on the users' comfort, but also road safety as 94% of annual 30,000 car accident fatalities come from human error [3]. In addition, other benefits have been identified and classified into segments, such as passengers, local authorities and cities, as shown in Fig. 2 [4]. For passengers, AV could offer practical service to elderly passengers, who could not drive anymore, so that they feel connected to other family members. AV services can be flexible and always available to passengers at off-peak/late night hours. For local authorities, AV can be cost-effective in both traffic-controlling for minimum idling and public bus optimization. In particular, public transportation service (bus and taxi) can be integrated with other modes of transportation for inclusive (children and elderly) and expanded service. For cities, AV can help urban planning to achieve sustainable, secure, accessible and friendly community with opened up opportunity for future arrangement.

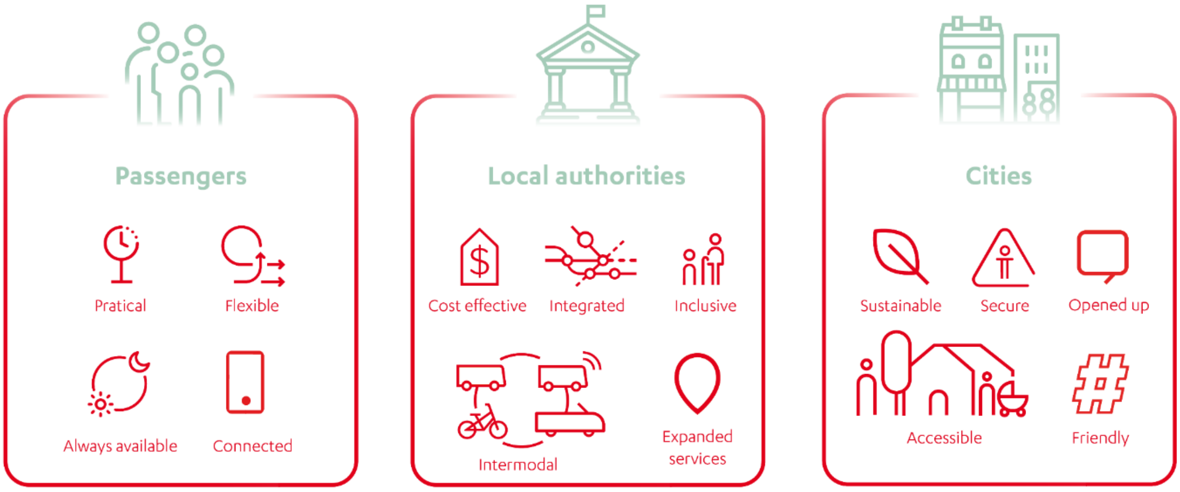
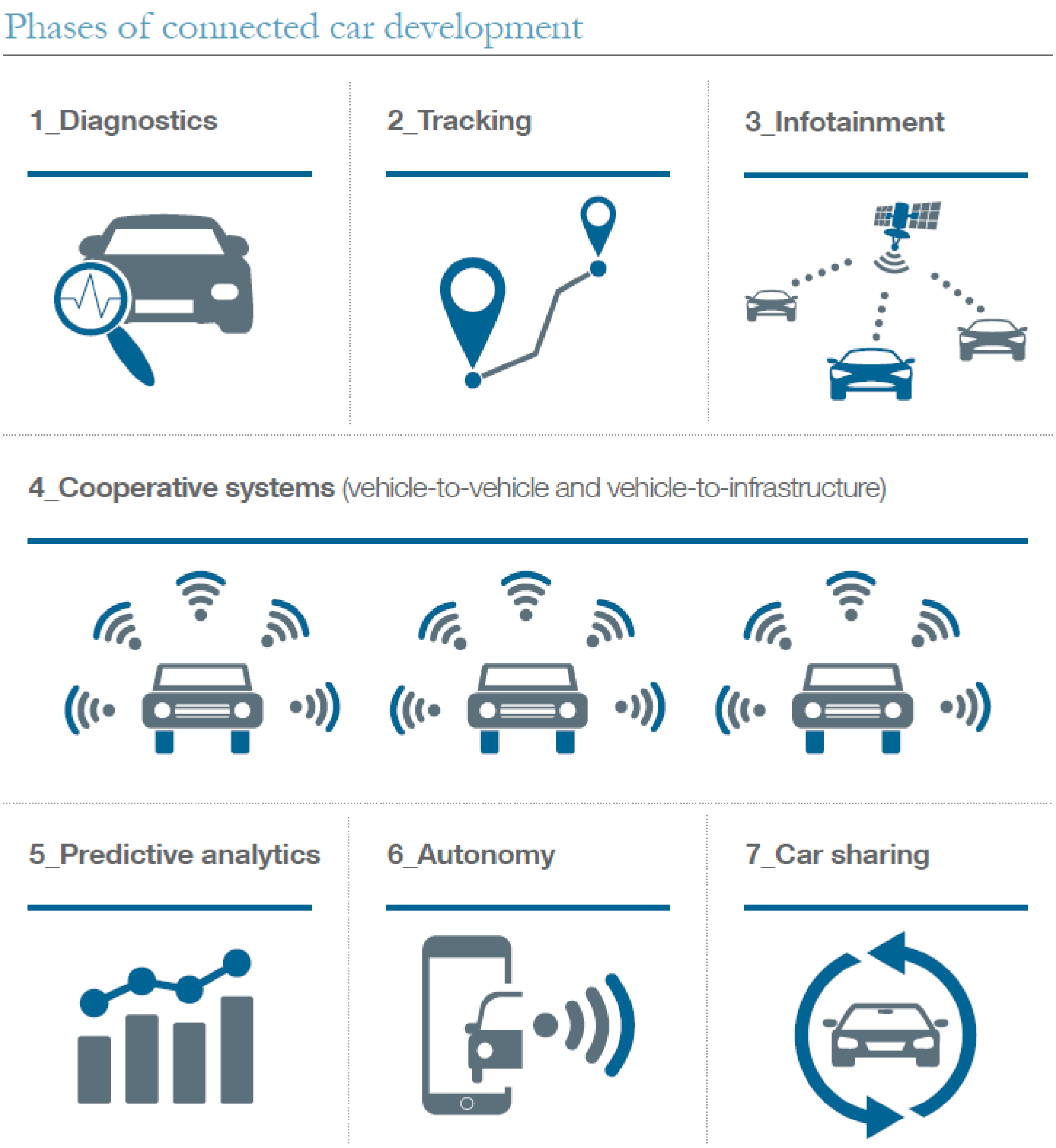
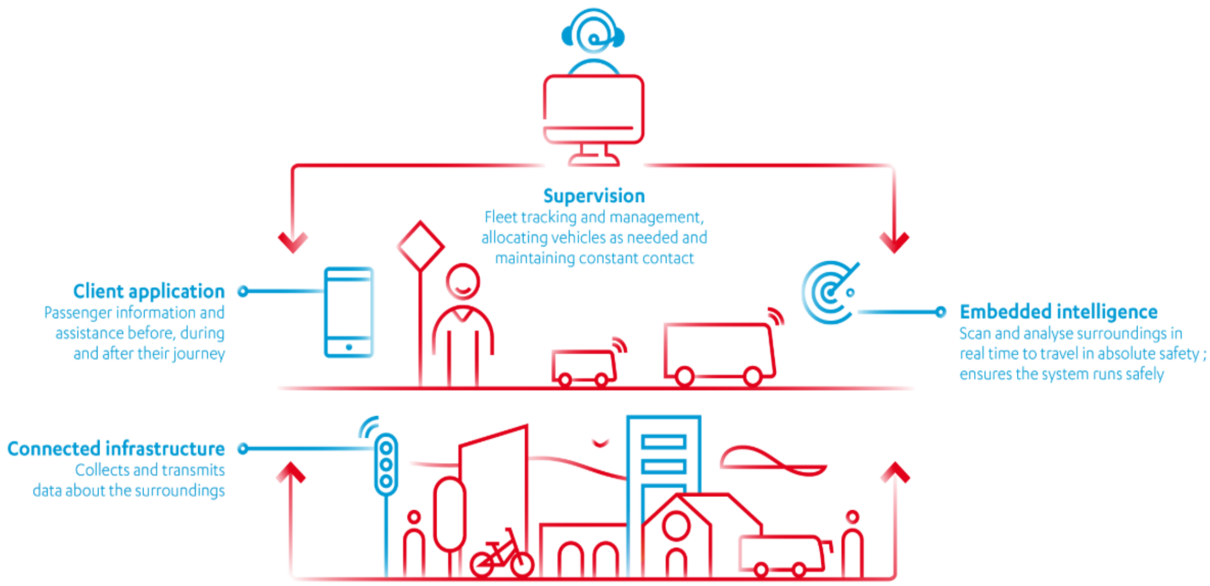


Fig. 2 Expected benefits of Autonomous Transportation

However, before autonomous driving can be utilized in full scale, necessary technologies, infrastructure and more mature vehicle navigation technologies need to be established, such as those shown in Fig. 3 [1, 4]. AV needs to have diagnostics capability to self check for normal operation, tracking capability to map location with pathway, infotainment capability to locate AV and among other AVs, and predictive analytics to make decision in case of emergency, as shown in Fig. 3(a). Furthermore, if AVs are put in fleet, proper management is needed to connect client application and connected infrastructure to embedded intelligence in AV under human supervision, as shown in Fig. 3(b).


Phases of connected car development
1_Diagnostics
2_Tracking
3_Infotainment
4_Cooperative systems (vehicle-to-vehicle and vehicle-to-infrastructure)
5_Predictive analytics
6_Autonomy
7_Car sharing

(a)


Supervision
Fleet tracking and management, allocating vehicles as needed and maintaining constant contact
Client application
Passenger information and assistance before, during and after their journey
Embedded intelligence
Scan and analyse surroundings in real time to travel in absolute safety ; ensures the system runs safely
Connected infrastructure
Collects and transmits data about the surroundings

(b)

Fig. 3 (a) Phases of connected car development and (b) complete system to manage a fleet of autonomous vehicles

While technological development would take some time to perfection, rules and regulations, especially legal guidance, need to be prepared to ease out potential future conflicts. Existing rules and regulations, ranging from licensing to litigation, need to be modified to embrace future mobility without driver. Recent few accidents have tested if legal framework for autonomous driving is ready, especially on the liability of accident damages, or sometimes casualties.

Recently, governments around the world have deemed HAVs as a safer, more energy and environmental friendly (through traffic control) solution with added mobility to disabled and senior citizens. Hence, it is not surprising to see many legal framework being developed. For example, U.S. House of Representatives has passed a bill that will exempt 50,000 or more HAVs from current safety standards (as long as the technology provides a level of safety comparable to current standards) to allow HAVs to be on the road. U.S. Department of Transportation (DOT) is directed to remove or update references to human drivers and occupants in the Federal Motor Vehicle Safety Standards (FMVSS). In EU, the United Nations Economic Commission for Europe (UNECE) has approved amendments to the Vienna Convention on Road Traffic to allow automated driving if the driver can override or switch off the technologies. Germany's Federal Ministry of Transport and Digital Infrastructure has issued the world's first ethical guidelines for partly and fully automated vehicles, which address decisions between human life and property damages (of course, humans must be given priority) and the more difficult decision between one human life and another. In Japan, autonomous vehicle of various types and levels have been tested, as well as raising public awareness on HAVs like the case of autonomous bus operating in the rural area, as shown in [5]. In November 2015, Japanese Prime Minister Abe announced that driverless mobility services and automated driving car will be on highways for the 2020 Olympic and Paralympic Games. Later in September 2017, National Strategic Special Zones Law was passed to support commercial activities focused on demonstrating the viability of automated driving systems. The National Police Agency has also published guidelines concerning the testing of automated vehicles on public roads.

Fig. 4 Raising public awareness of autonomous bus in Japan

The present study aims to address various legal challenges and on-going framework for autonomous vehicles from prior experience around the worlds. Case studies from various countries will be analyzed for lesson learned and best practices for future development in countries with not yet preparation for autonomous vehicle like Thailand and ASEAN.

1.2 Objectives

To understand legal challenge for autonomous vehicles in Thailand and ASEAN, first the landscape of using conventional vehicle must be laid out in order to examine how the landscape needs adjustment in order to cope with autonomous vehicles (AV). Current status and lesson learned from developed countries with some usage of AVs could be useful in applying to system in Thailand and ASEAN. Hence, the objectives of the proposed investigation are

1. To map out landscape of using conventional vehicle on the road in Thailand and ASEAN.
2. To systematically address legal challenges, categorized into human, vehicle and infrastructure, for autonomous vehicles (AV) with lessons learned and best practices from developed countries with some usage of AV.

1.3 Methodology

In order to systematically address legal challenges of AV, the following methodologies are proposed.

- **Conduct literature reviews on current status of autonomous vehicles (AV), from both technological and legal aspects. Interview if needed.**
- **Analyze collected data for lessons learned and best practices for countries with some usage of AV.**
- **Take a case study on Thailand & ASEAN to identify relevant laws (and proposed organizations) that need to be modified. 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	2016									2017		
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Literature review on current status												
Analysis for lessons learned and best practices from around the world												
Review of relevant laws/organizations in Thailand for recommendations												
Interview, meeting and discussion to finalize recommendations												
Inception report submission	26 Apr											
Progress report presentation						6 Sep						
Interim report presentation						30 Sep						
Interim report submission									13 Dec			
Final report presentation									13 Dec			
Final report submission												29 Mar

2.2 Project Expenditure

Table 2 shows the breakdown of the project expenditure.

Table 2: Project expenditure

No.	Item	Unit cost	Number of units	Sub total
1	Project leader	3,000	12	36,000
2	2 Researchers			

No.	Item	Unit cost	Number of units	Sub total
	-200 THB/hr x 5 hrs/day x 10 days/month for 12 months	10,000	12	120,000
	-200 THB/hr x 5 hrs/day x 20 days/month for 12 months	20,000	12	240,000
3	Expenses for project meeting	5,000	6	30,000
4	Travel expenses to collect database	2,000	6	12,000
5	Office & computer supply	3,000	6	18,000
6	Secretariat's participation portion	10,000	1	10,000
7	Publishing proportion of the report book	50,000	1	50,000
Total				**516,000**

CHAPTER 3 RESULTS & DISCUSSION

This chapter will consist of 4 sections. First, selected countries with leading readiness in autonomous vehicles (AVs) are reviewed in comparison with Thailand. Second, law and regulation preparation to solve barriers of legal issues are compared between leading countries and Thailand. Third, reviews of autonomous vehicle related activities in Thailand. Fourth, considering all research finding, conclusion will be made.

3.1 Reviews of Autonomous Vehicles in Selected Countries

From 2019 ranking of Autonomous Vehicles Readiness [6], 25 countries have been assessed on 25 different measures under four pillars, as shown in Table 3, with top 5 countries. The overall ranking for the top 15 countries are shown in Table 4, where Singapore, USA, Japan, South Korea and Australia are reviewed here for comparison with Thailand in Section 3.3.

Table 3: Criteria for Autonomous Vehicle Readiness

Criteria		Top 5 Rankings
Pillars	Sub-pillars	
Policy and legislation	• AV regulations, • Government-funded AV pilots • AV-focused agency • Government readiness for change • Effectiveness of legislative process • Efficiency of the legal system in challenging regulations • Data-sharing environment	1. Singapore 2. UK 3. New Zealand 4. Finland 5. The Netherlands
Technology and innovation	• Industry partnerships • AV technology firm headquarters • AV-related patents • Industry investments in AV • Availability of the latest technology • Capacity for innovation • Market share of electric cars	1. Israel 2. Norway 3. USA 4. Germany 5. Japan
Infrastructure	• Density of EV charging stations • Quality of mobile internet • 4G coverage • Quality of roads	1. The Netherlands 2. Singapore 3. Japan 4. South Korea

Criteria		Top 5 Rankings
Pillars	Sub-pillars	
	• Logistics infrastructure • Technology infrastructure change readiness	5. UAE
Consumer acceptance	• Consumer opinions of AVs • Population living in test areas • Civil society technology use • Consumer adoption of technology • Online ride-hailing market penetration	1. Singapore 2. The Netherlands 3. Norway 4. Sweden 5. Finland

Table 4: Top 15 countries for 2019 Autonomous Vehicle Readiness

Index results

Rank		Country	2019 score
2019	2018		
1	1	The Netherlands	25.05
2	2	Singapore	24.32
3	n/a	Norway	23.75
4	3	United States	22.58
5	4	Sweden	22.48
6	n/a	Finland	22.28
7	5	United Kingdom	21.58
8	6	Germany	21.15
9	8	United Arab Emirates	20.69
10	11	Japan	20.53
11	9	New Zealand	19.87
12	7	Canada	19.80
13	10	South Korea	19.79
14	n/a	Israel	19.60
15	14	Australia	19.01

Singapore

Singapore has construct roadmap for autonomous vehicle in 3 phases, as shown in Fig. 5, where Phase 1 focusing on trial test-bed in dedicated area, Phase 2 focusing on limited deployment in dedicated town and Phase 3 aims for island-wide full operation. Important benchmarks [7] include development of testing regime by CETRAN, Nanyang Technological University [8] in November 2017, development of AV standards in January 2019 and target to launch demonstration in 3 towns by early 2020s, as shown in Fig. 6.

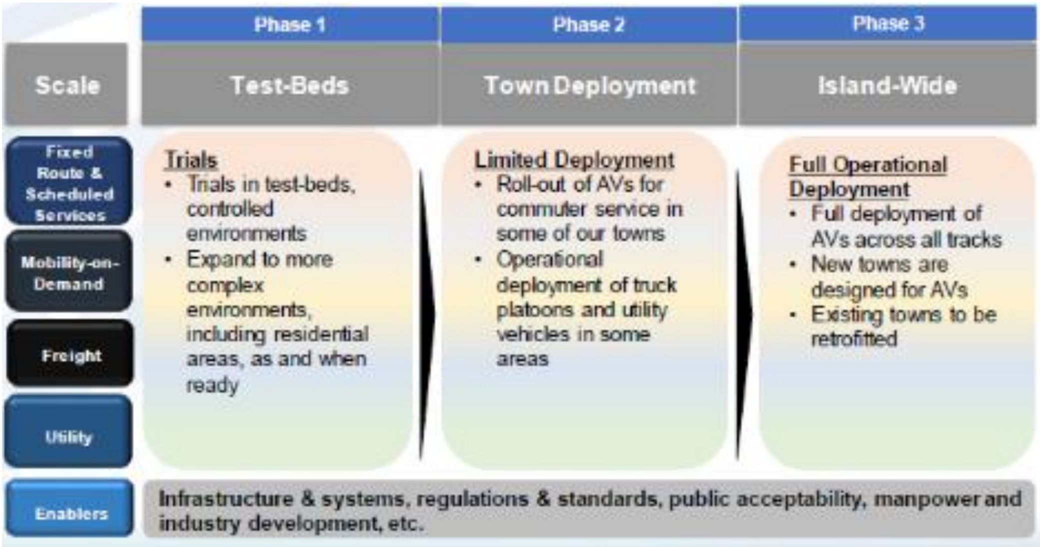
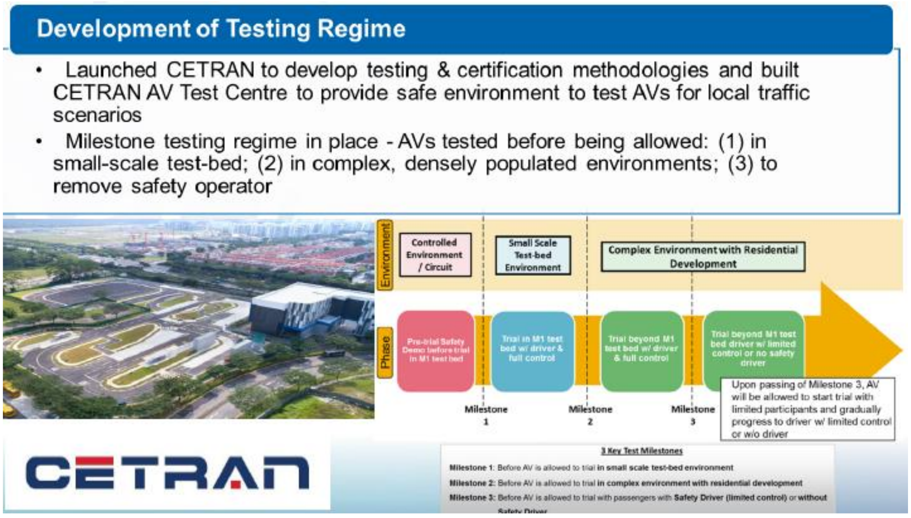
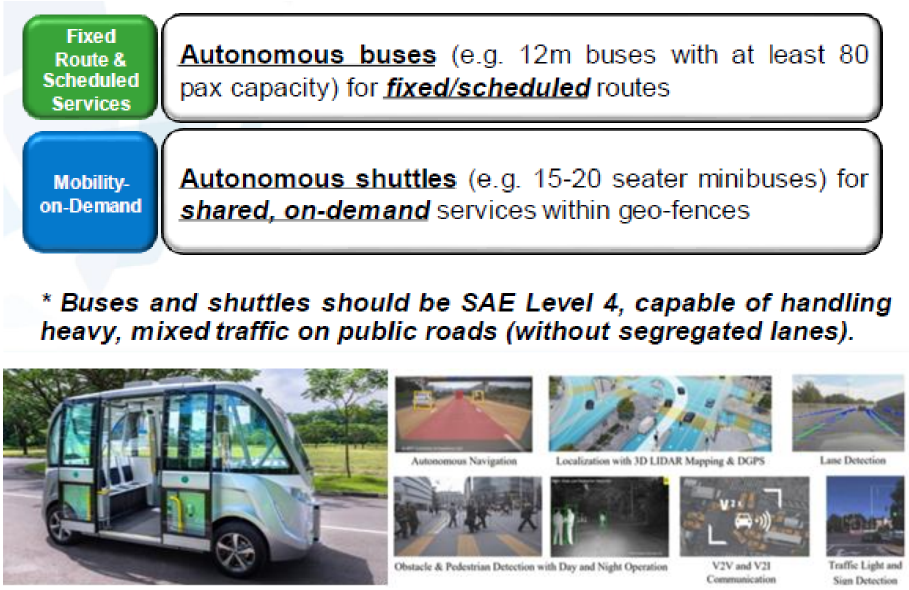


Fig. 5 Singapore AV roadmap



(a)

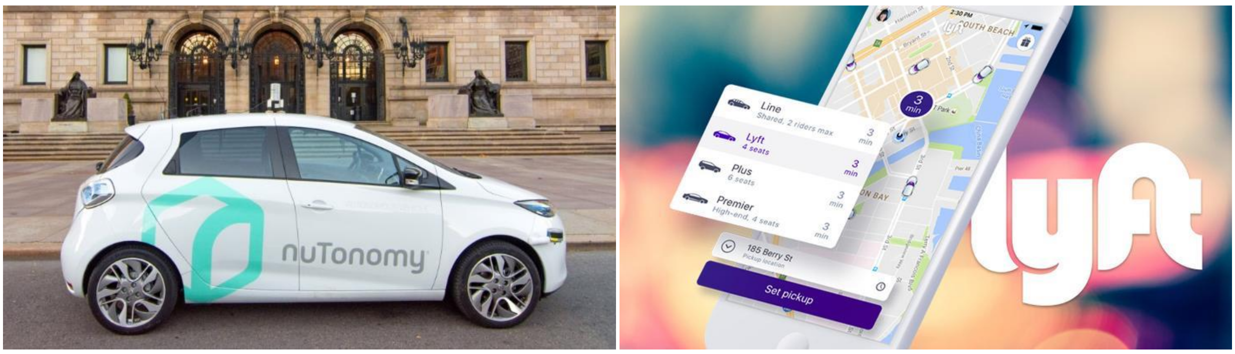
(b)



(c)

Fig. 6 Important benchmark for AV development in Singapore: (a) CETRAN testing center, (b) AV standard and (c) Town-level demonstration

Case study of Singapore is an example of the country with outstanding effort in promoting and supporting autonomous vehicles (AV). Beginning in 2016, the Start-Up company named nuTonomy [9], which was acquired by Delphi in 2017 to become Aptiv PLC [10], was established in Singapore as an autonomous taxi service in the city using Mitsubishi i-MiEVs in collaboration with Grab, as shown in Fig. 7(a). With collaboration with Lyft, a transportation network company (TNC) in the Boston, United States, a mobile application is linked with Robo-Taxi with SAE Level 4-5 automated vehicles [11, 12], as shown in Fig. 7(b).



(a) (b)

Fig. 7 (a) Autonomous vehicle by nuTonomy with (b) mobile application by Lyft

In 2017, Singapore launched the first Auto Testing Center to support the testing and research of AV at Jurong Innovation District. In addition, Ministry of Transport Singapore (MOT) has revised the law to support AV running on the road legally as the first country in the world, after 5 years experiment testing. In 2018, Singapore was considered as top country

with policy and regulations for AV, where Land Transport Authority (LTA) has introduced the regulatory framework for AV service providers, including a requirement to have drivers for emergency, third party insurance and share data center. In 2019, the Technical Reference 68 standard was announced (TR 68) for AV used level 4 and 5 focusing on 4 important aspects (basic driving behavior, passenger safety, cybersecurity & assessment framework and vehicular data types & formats) in addition to ISO [13].

USA

AV development in USA has evolved around 3 pillars, namely research, rule-making and communication, as shown in Table 5 [14, 15, 16]. As for legislation, each state has some flexibility but must adhere to key federal regulation, as shown in Fig. 8.

Table 5: AV development in USA

Pillars	Focuses		
Research (Vehicle and Equipment Safety)	Safety Framework	Component & Cybersecurity Safety	Passenger Safety
	• Voluntary Guidance 2.0 and 3.0 • Removing assumption of a driver from current standards - adapting current standards • Evaluating vehicle safety performance: How do we test a vehicle without a human driver? • Functional safety test design: How do we test software and account for software updates?	• Component safety such as sensors (cameras, radar, lidar) and software decision-making • Cybersecurity best practices • Hardening the vehicle against potential cyber attacks	• Developing crash dummies and tests for reclining/lying down and rear-facing seats and other potential seating arrangements • Alternative occupant protection systems such as new seat belt and air bag configurations
Rulemaking to Update Safety Regulations	Update Exemption Process	Removing Barriers & Assuring Safety	Passenger Safety
	• Streamlining process by reducing steps agency must take before seeking public comment on petitions • Updating petition requirements to remove	• Updating and modernizing standards, including controls, tell-tales, and indicators needed by a human driver	• Incorporating crash dummies and tests for reclining/lay-flat and rear-facing seats and other potential seating arrangements

Pillars	Focuses		
	artificial constraints on permissible safety evidence	• Vehicle safety assurance	
Public Awareness and Communication	Safety Framework	Component & Cybersecurity Safety	Passenger Safety
	• Building public confidence through, e.g., encouraging companies to issue voluntary safety self-assessments • Awareness of testing and deployment	• Inform the public how to interact with self-driving vehicles • Vehicle occupants - controls, tell-tales and indicators • Pedestrians and other road users, including those with disabilities • Vehicle intent – How does a self-driving vehicle communicate its intent to other road users?	• Collaborate with Consumer Reports and SAE on consistent advanced vehicle terminology • Engage online automotive community, manufacturers, and dealers • Use social and paid media to increase consumer familiarity of advanced vehicle technologies • Outreach at consumer events • Enhance advanced vehicle technology material on NHTSA.gov

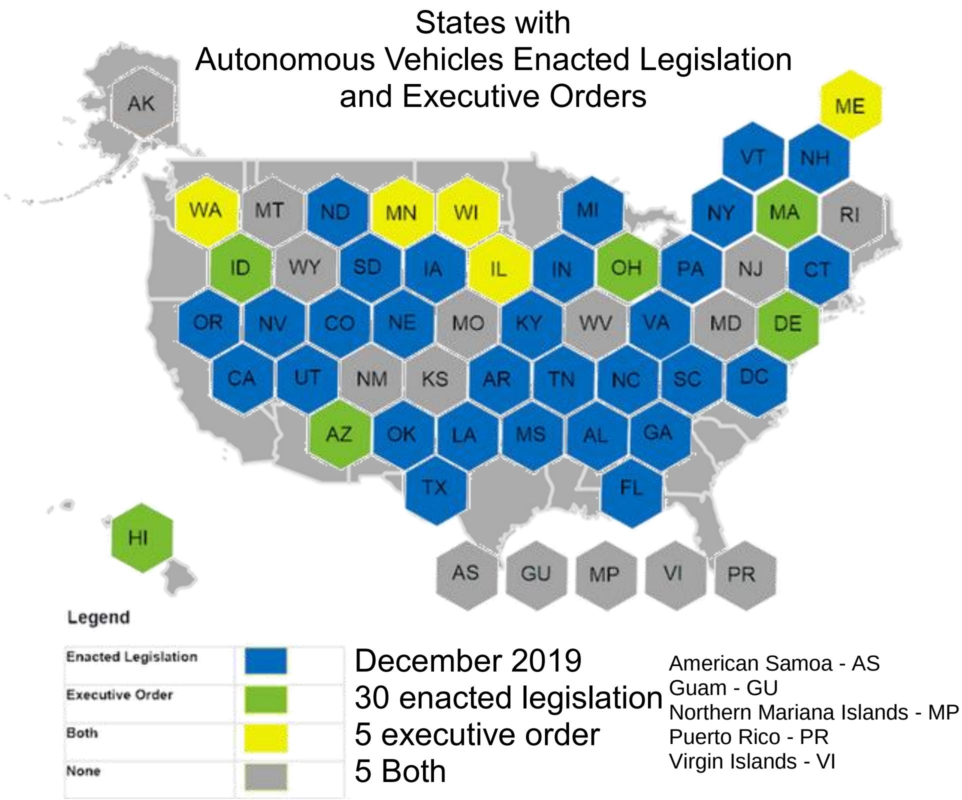


Fig. 8 Status of US legislation for AV

In 2018, as autonomous vehicle (AV) has drawn much attention in the US [17], reports from the Nation league Cities (NLC) found that more than 50% of US cities are preparing their roads for AV, which increased to 10% from the past 3 years. During 2011-2017, there were 22 states sending 46 relevant requests for AV to allow the government to support their development and US government provides support for AV projects. NLC has also compiled a report of case studies in the overview of the 6 cities around the US to illustrate how AV-related projects started.

Examples of AV projects are as follows. A collaboration between Arlington's Conventions and Visitors Bureau in 2017 has launched a test of 12-seat AV shuttle bus on a specific route in Arlington with initial phase to have human driver on AV in case of emergency and later phase to take passengers a parts of the city using GPS navigation systems [18], as shown in Fig. 9(a). As part of Smart City Challenge by US Department of Transportation [19], Boston has started to use research to focus on mobility in 2015 [20]. Although Boston did not win Smart City Challenge, Boston was later recognized by the World Economic Forum as a focus city for future mobility in September 2016. In January 2017, Boston began an AV pilot program on a fixed route with a rideshare program, working with nuTonomy and Optimus Ride, as shown in Fig. 9(b).

(a) **(b)**

Fig. 9 (a) Arlington 12-seat AV, (b) nuTonomy (Renault Zoes) in Smart City Challenge

In terms of legal support for AV in the US, when an AV car in Uber service was involved in a pedestrian collision casualty in Tempe, Arizona on 18 March 2018 [21] as shown in Fig. 10(a), Uber has stopped testing AV immediately. Later on 23 March 2018, an AV Tesla user caused an accident at Mountain View, California [22] but Tesla did not suspend the Driverless service system while the Highway Traffic Safety Administration (NHTSA) was searching for the cause. Since then, standards have been set and tested for the safety of technology for AV seriously.

(a) **(b)**

Fig. 10 (a) Uber accident in Tempe, AZ and (b) Tesla accident at Mountain View , CA

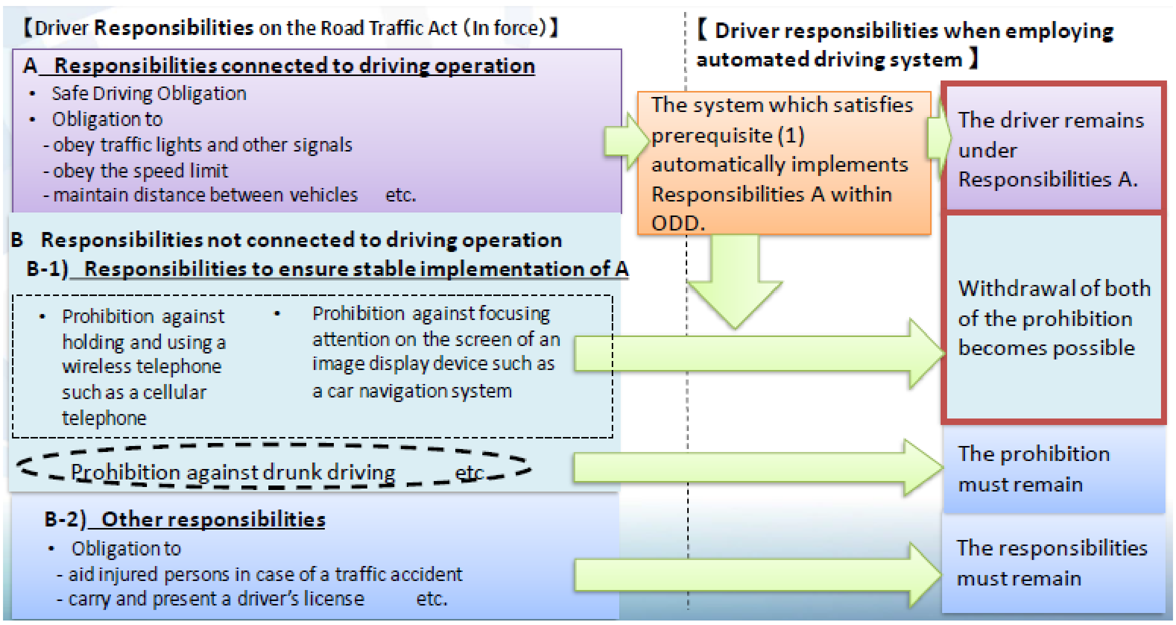
When onboard computer found the situation that AV cannot drive itself, driving conditions can be changed immediately requiring a driver to be alert at all times. However, with the advancement of driverless technology with minimal driver's input, such as no steering and no throttle, the computer is solely controlled by AV, which are under testing in Las Vegas and California [23, 24]. While the US Department of Transportation and NHTSA have periodically updated the data samples for their AV [25], government have also adopted laws for AV as well. However, the laws of each state can be different. For example, Tennessee

[26] allows AV users to be responsible while Texas requires the responsible person [27], and Georgia takes service providers as drivers to take part all of the responsibility.

Japan

For AV development in Japan, the focus is on the regulation, rather than technology, as clear responsibilities of drivers and system has been illustrated in Fig. 11 [28], with Japanese guideline regarding safety technology for AV with two targets. First, to promote the development and commercialization of safe automated vehicles by prescribing safety requirements to be met by level 3 or 4 vehicles as a guideline before the establishment of international standards. Second, to set the world's first safety vision to realize automated driving and clarifies the significance of the development and commercialization of such vehicles. Hence, Japan is focusing on 10 elements of vehicle safety as follows.

- (i) Establishment of operational design domain (ODD)
- (ii) Safety of automated driving system
- (iii) Compliance with safety regulations, etc.
- (iv) Human Machine Interface (HMI)
- (v) Mounting of a data recording device
- (vi) Cyber security
- (vii) Safety of vehicles for unmanned automated driving transportation service (additional)
- (viii) Safety evaluation
- (ix) Ensuring safety in use process
- (x) Provision of information to users of AV



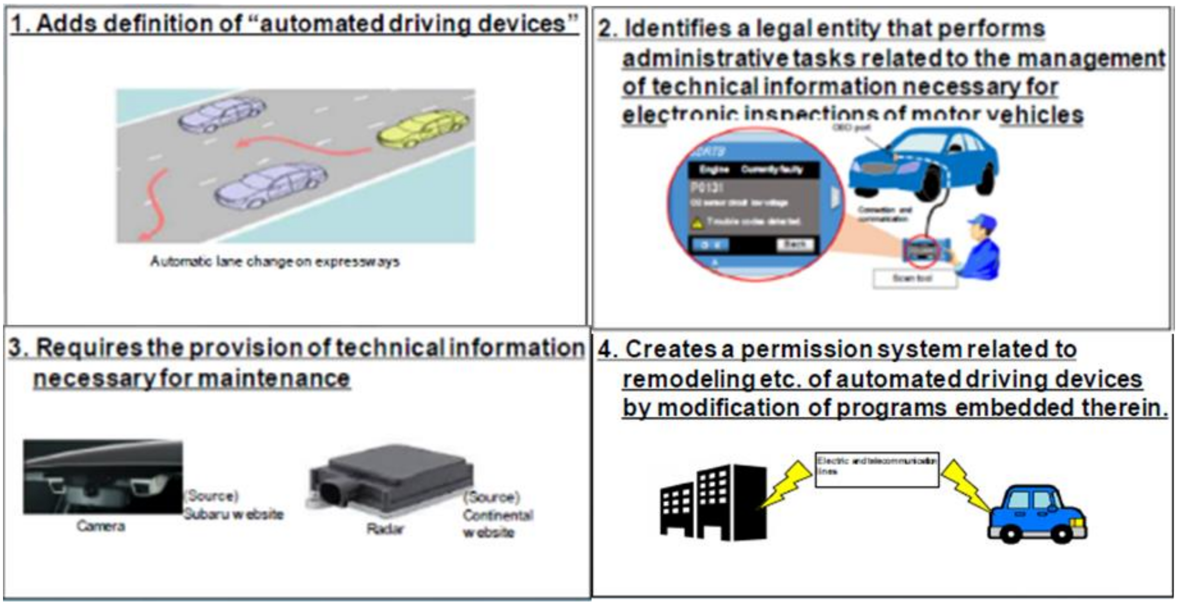


Fig. 11 Responsibilities for AV in Japan

Prior to starting AV project, the government and system developers must have a meeting to ensure that the laws and guidelines for system development are consistent, as a prerequisite for the automatic vehicle of Japan, namely (1) the design of the AV system must be under the traffic laws of Japan and (2) the AV system must alert the controller to be able to can control the vehicle immediately when encountering a problem that the AV system cannot decide.

In August 2016, a Tokyo-based company Dena has serviced 12-passenger buses that can be driven by an electrical system for the first time in the area of 21,000 square meters, around Yosuna Park in Chiba. Later in 2018, ZMP company has developed automatic driving technology with Hinomaru Kotsu in a modified Toyota minivan for testing as unmanned taxi in Tokyo with the first fare in the world. The service route is between Otemachi and Roppongi covering a distance of 5.3 kilometers with the service fee of 1,500 yen per trip payable via the app on the smartphone, as shown in Fig. 12.

Fig. 12 First taxi with fare in the world

Japan plans to use level-4 AV to launch at the 2020 Olympics, where humans may still have to enter commands or help decide in certain situations. The level-4 driverless car project is part of the national development plan under the push of the Japanese government to accelerate economic growth with technology and innovation.

South Korea

With Korean competitiveness in outstanding 5G communication network, there are many collaborative projects between Korean automotive companies and ICT companies to progress AV with new roadmap to develop future car industry and world's largest (320,000 sq.m.) autonomous vehicle test bed (K-city) located in Hwaseong, Gyeonggi province, an hour south of Seoul, as shown in Fig. 13. In addition, Hyundai Mobi has been operating an AV proving ground (1.1 million sq.m.) since 2016 in Seosan, South of Chungcheong Province aiming for level 3 system by 2022, among many other infrastructure support throughout Korea as shown in Fig. 14.

Fig. 13 World's largest autonomous vehicle test bed (K-city)

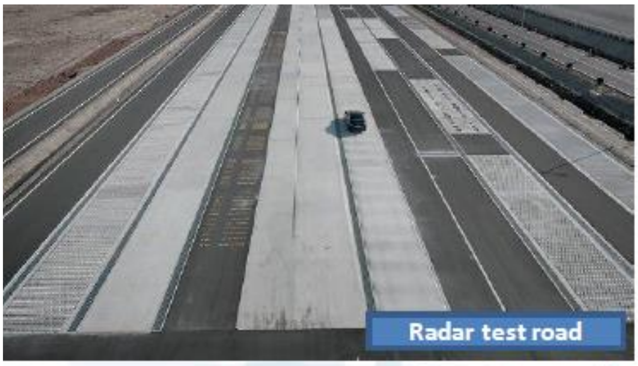


Fig. 14 Infrastructure support for AV throughout South Korea

Australia

Australia is another country focusing on the autonomous vehicle regulation with the structure [29] shown in Fig. 15 and action plan shown in Table 6 under the following key themes

- **Safety as the priority**
- **Legal certainty**
- **Responsibilities are on parties best able to manage the risk**
- **Performance-based, not prescriptive**
- **Internationally aligned**
- **Flexibility for different business models, applications and technologies**
- **Ability to evolve over time**

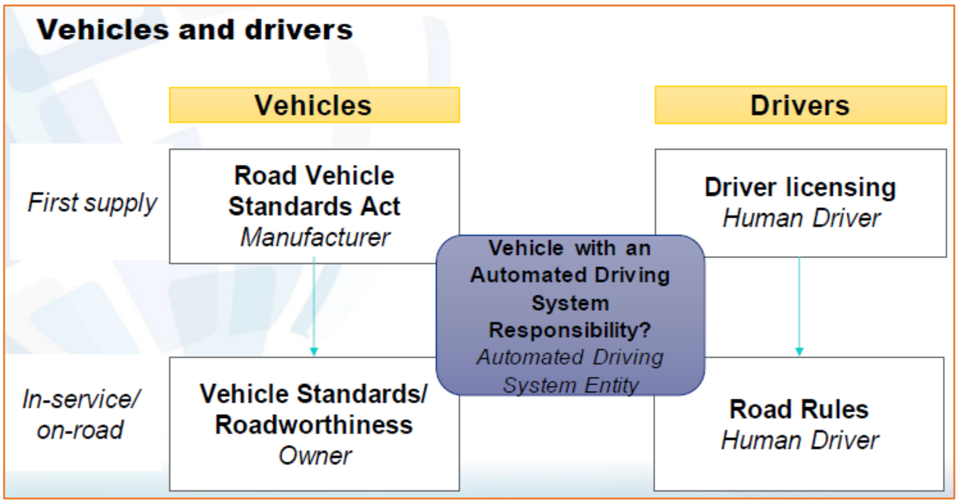


Fig. 15 Structure of AV regulation in Australia

Table 6: AV action plan with lead organization

No.	Action Item	Lead Org.
1.	Establish a regulatory framework for testing automated vehicles	TISOC / National transport commission
2.	Develop national operational guidelines to support the on-road use of automated vehicles	Austroads
3.	Undertake priority trails and research of intelligent transport systems	TISOC
4.	Develop a connected vehicle (Cooperative ITS) infrastructure road map	TISOC
5.	Publish a connected vehicle (Cooperative ITS) statement of intent on standards and deployment models	TISOC/ Commonwealth
6.	Develop a nationally agreed deployment plan for the security management of connected and automated vehicles	TISOC/ Austroads
7.	Investigate options to provide enhanced geo-positioning information to the land transport sector	Commonwealth
8.	Improve the availability of open data in the transport sector	All jurisdictions
9.	Explore options to increase the uptake of telematics and other technologies for regulatory and revenue collection purposes	TISOC
10.	Evaluate low-cost technologies to improve safety at rail level crossings	TISOC

11.	Explore how data from telematics and other intelligent transport systems can be used to optimize operations and planning for port precincts and intermodal terminals	Commonwealth
12.	Investigate options for interoperable public transport ticketing	TISOC
13.	Investigate the costs, benefits, and possible deployment models for Automatic Crash Notification	TISOC/ Austroads
14.	Explore the merits of adopting new safety and traffic management technologies	TISOC

As shown by 5 frontier countries in AVs above, the concerned regulations can be categorized to 3 groups as follows.

- The driving license (driver)
- Vehicle standard (Safety)
- Infrastructure (Traffic and Communication)

3.2 Reviews of Autonomous Vehicle Activities in Thailand

Compared to those 5 frontier countries in autonomous vehicle above, Thailand is still in the early stage of AV technology, regulation and public awareness since AV seems to be the next wave after the current EV, which begins to gain public acceptance. This section then highlights AV-related activities in Thailand.

On 27 March 2019, NSTDA has organized a forum on "Transitioning to the Future of Autonomous Vehicle Innovations for Thailand 4.0" during NAC2019, as shown in Fig. 16, with the objective to understand a big picture of the next technology disruption. The forum was separated into 2 panel discussions

- "Autonomous Vehicle Technology Trends" in the order to focus on technical aspects of the AV technology
- "Planning-Policy-Regulation for AV Technology in Thailand" in the order to focus in interconnection between planning, policy and regulation for AV technology in Thailand. The AV issues found in foreign countries were highlighted, especially record of AV accidents. Those were compared to the situation of Thailand, including traffic condition, traffic infrastructure, regular habits of Thai people etc.

Fig. 16 Forum: Transitioning to the Future of Autonomous Vehicle Innovations for Thailand 4.0

On 7 May 2019, Thailand Automotive Institute (TAI) organized a workshop on "Future Image of Thailand Automotive Industry in 2030" focusing on technology foresight, as shown in Fig. 17, aiming to have public hearing for draft policy recommendation from attended stakeholder in September 2019.

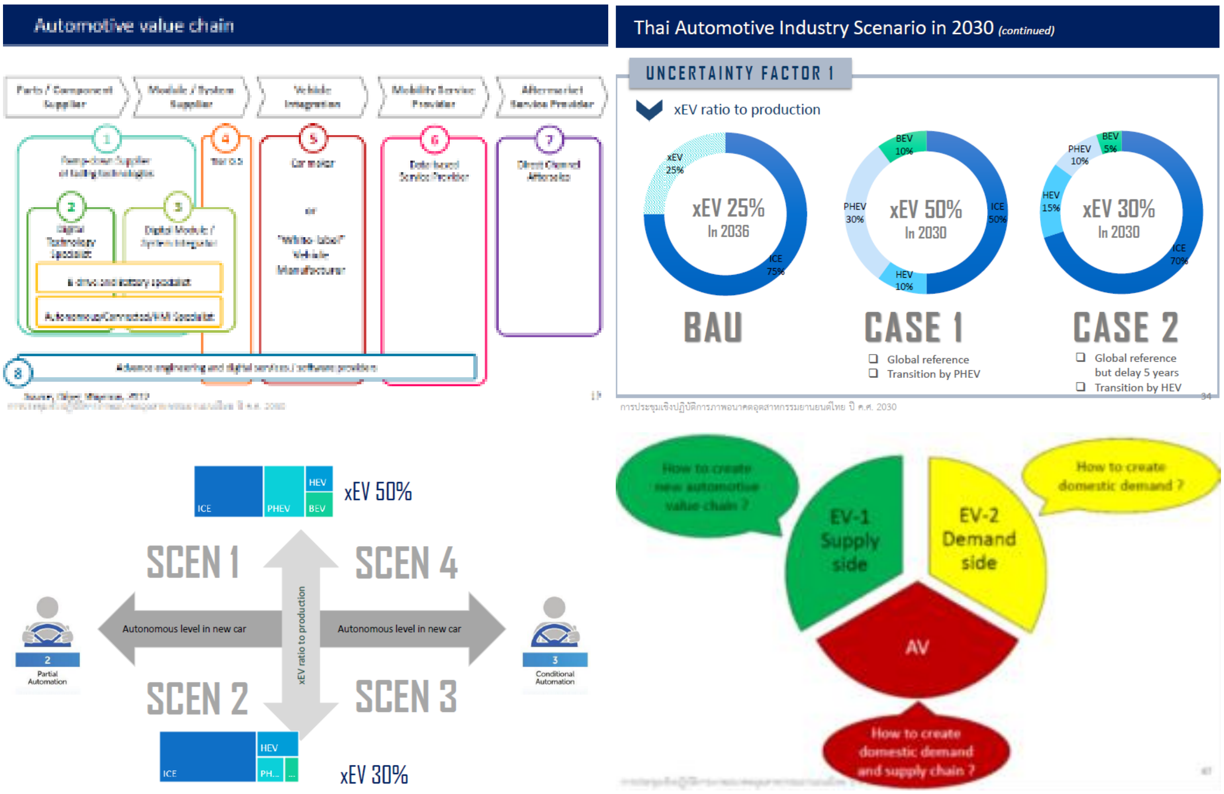


Fig. 17 AV technology foresight in Thailand

On 19 June 2019, Thailand Automotive Institute organized "Smart Mobility Driving Tomorrow's Society" in Automotive summit 2019 with both domestic and international

experts, as shown in Fig. 18. Successful research projects of automated vehicles were shared by various experts, including rationale sharing, key issues including raw & regulation in various countries, demonstration project, national roadmap. Then the panel discussion were conducted on Thailand context.

Moderator

Asst. Prof. Dr. Nuksit Noomwongs
Faculty of Engineering, Chulalongkorn University

Time	Topics
12.00 - 13.30 hrs.	**Registration** **Panel Discussion: "Connected Autonomous Vehicle (CAV); Solution for global road safety?"** by **Prof. Tetsunori Haraguchi** Senior Researcher College of Industrial Technology Nihon University by **Mr.Bijoy Bhaskaran** Senior Principle Engineer, Lead, Automotive Systems and Autonomous Driving, ASEAN TÜV SÜD by **Dr.Hyoung Gu,Kim** Chief Researcher Korea Automobile Testing & Research Institute by **Dr. Ma Di Benjamin** Senior Specialist (Autonomous Systems) and Senior Lecturer (SSP&SLTR) Nanyang Polytechnic University by **Assoc. Prof. Sorawit Narupiti, Ph.D.** Department of Civil Engineering Chulalongkorn University
15.50 - 16.00 hrs.	**Q&A**

Fig. 18 "Smart Mobility Driving Tomorrow's Society" in Automotive summit 2019

On 12 July 2019, 5th CAV Roundtable was organized at Digital Economy Promotion Agency, Ministry of Digital Economy and Society, as shown in Fig. 19, to have discussion on supporting CAV initiative in Thailand through the following topics

- Updating on current situation
- Discussion on AV white paper drafting
- AV obstacle discussion in Thailand context

Fig. 19 5th CAV Roundtable at Digital Economy Promotion Agency, Ministry of Digital Economy and Society

On 26 August 2019, 6th CAV Roundtable was organized at Smart Mobility Research Center, Chulalongkorn University to discuss the following issues

- **Updating on current situation e.g. progress of CAV sandbox project**
- **Discussion on AV white paper drafting**
- **The upcoming events such as "Thailand's Vision on Future Mobility", arranged by TAI was also publicized.**

Fig. 20 6th CAV Roundtable at Smart Mobility Research Center, Chulalongkorn University

On 2 September 2019, Thailand Automotive Institute organized a seminar "Thailand's Vision on Future Mobility" with preliminary analysis, as shown in Fig. 21, under the following concepts with new automotive supply chain mapping to elevate Thai entrepreneur capabilities.

- **Promote foreign direct investment to induce local supplier**
- **Encourage Thai start up entrepreneur in new mobility business**
- **Smooth transition for existing auto part maker**

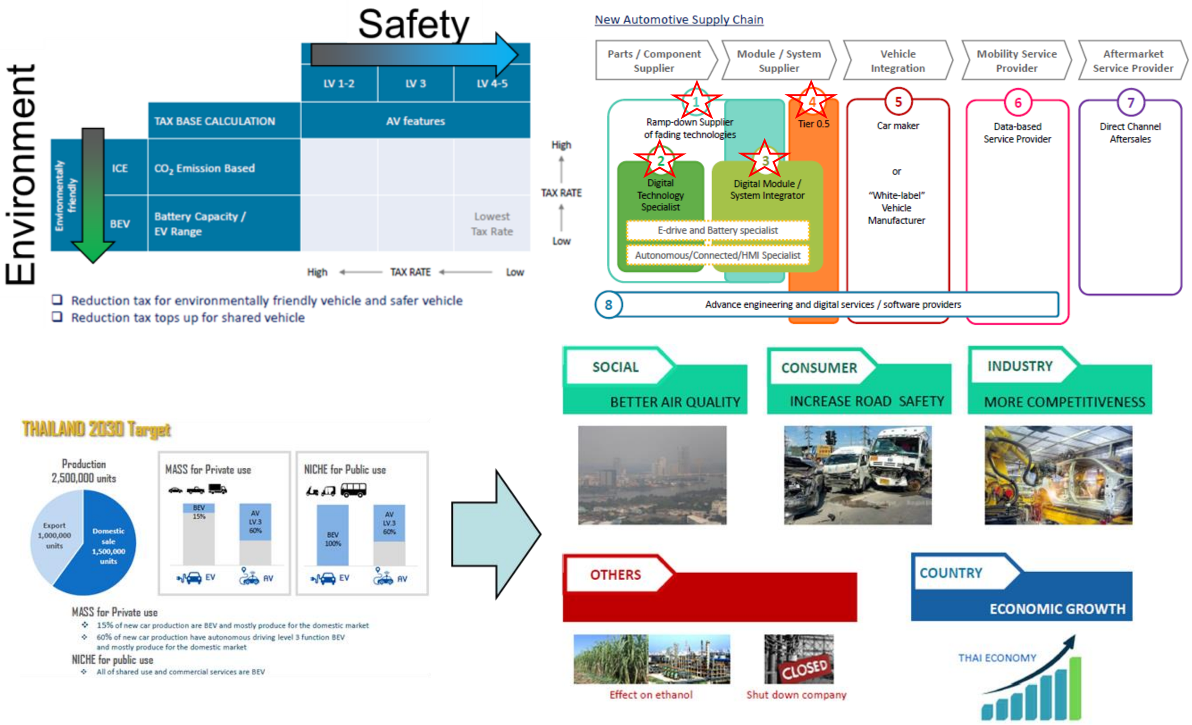


Fig. 21 Thailand's Vision on Future Mobility

On 25 September 2019, TAI and Office of National Higher Education, Science, Research and Innovation Policy Council (NXPO) have co-organized a public hearing on "White paper of Promotion and Development of Future Vehicle and Mobility" [30], as shown in Fig. 22, with the following key results

- Set targets for Zero Emission Vehicle (ZEV) & Autonomous Vehicle (AV)
  - 2030 >> 15%(ZEV) + 60%(Level 3) and
  - 2040 >> 100%(ZEV) + 80%(Level 4)
- Legal and regulation challenge involve on AV (Work plan #12, #13 & #14)
  - Vehicle registration for various vehicle category
  - Infrastructure preparation : R&D sandbox, Laboratory
  - Traffic law and regulation improvement
  - Communication infrastructure (5G for AV)
  - Enact new vehicle safety standard for ZEV and CASE

Fig. 22 White paper of Promotion and Development of Future Vehicle and Mobility

On 3 October 2019, an interview with transport policy maker on CAV from Office of Transport and Traffic Policy and Planning, Ministry of Transport, as shown in Fig. 23, to discuss the following topics

- Future mobility definition
- Projection of future mobility development
- TAI's Thailand's Vision on Future Mobility
- NXPO's White paper of Promotion and Development of Future Vehicle and Mobility
- The Royal Thai Police should be added to the stakeholder mapping as the Law enforcement authorities agency.

Fig. 23 An interview with transport policy maker from OTP

On 22 November 2019, Electric Vehicle Association of Thailand (EVAT) organized, EV Tech Forum 2019: "Smart and AI for Car Sharing Service", as shown in Fig. 24. In this technical forum, the progress of CAV technology in foreign countries were delivered along with the experience of CAV demonstration projects from the invited speakers. The key success factors were identified as law relaxation for CAV demonstration projects, collaboration from involved stakeholders (automotive part suppliers, network service provider). Case studies of CAV are highlighted such as Tuk-Tuk three wheeler, car rental, etc.

Fig. 24 EV Tech Forum 2019: "Smart and AI for Car Sharing Service"

3.3 Law and Regulation Preparation for Autonomous Vehicle

Since autonomous vehicle (AV) is new trend of future vehicle, existing law and regulation must be revised to accommodate coexisting of AV (especially level 3-5) and conventional vehicle. The following legal issues are discussed in the topics of benefits, projection of CAV development and key players [1].

- New regulations emerging to regulate the testing and deployment of autonomous and connected cars
- Autonomous vehicles give rise to new liability issues
- Big data and data analytics are driving new in-car technology, services and monetization opportunities
- Cyber security – the threats to connected car data and services, and cars themselves, evolve
- Automotive meets Tech. – collaborations and partnerships
- Cars as socially networked devices

Another study on Blueprint for Autonomous Urbanism [31] has designed vision for city streets in the automoated future for people covering the following issues for AV-friendly infrastructure.

- Supported ideal policies and actions
- New rules of road infrastructure such as dynamics of future street, street types
- New raw and regulation of road safety
- Vehicle and new mobility system
- Road side

Three current legal challenges of AVs for policymakers and regulators are also discussed in the following aspects [32]

- How to reduce legal interoperability barrier (syntactic level)? How to harmonizing legal operational requirement to avoid slowing down innovation and furthering unequal access to innovations
- How to determining the policy and legal regimes (morphological items) that will deliver the benefits of CAV quickly while minimizing their risks?
- What is the definitions at the core of concepts about what it means to be a driver and the nature of being "in control" of a vehicle?

Very limited study on legal challenger of AV was available in Thailand. There was a recent Master Thesis on "Legal Problems on Civil Liability from Autonomous Vehicle" in 2016 [33], which addressed the following issues regarding civil liability from AVs.

- **Presumption of liability's identification when autonomous vehicle's controller software becomes defective**
- **Possibility of using the fact of mechanical faulty as an excuse**
- **Liable person's right to recourse with the autonomous vehicle producer**
- **Dangerous product liability**

with the following recommendation

- **User of CAV level 3-4 should not be accountable since they do not control vehicle**
- **Liable person should be interpreted using principle of right rather than vehicle occupancy during accident**
- **Force majeure should only be applied when the accident is caused by external factors**
- **The following laws should be revised to cope with CAV technology usage and 3rd party liability**
    - **Thai Civil and Commercial Code: Article 437**
    - **Thai Production Liability Act 2008**

In addition to legal framework, another important aspect with AV regulation is communication channel allocation. Communication Vehicle to Vehicle (V2V) was first established by United States Congress back in 1999, where car manufacturers have installed such communication systems, such as Toyota, Honda, Daimler, Audi, BMW and Volvo, etc. The communication system is also known in the name of the Vehicular Ad hoc Networks (VANETs) [34], which was derived from Mobile Ad hoc Networks (MANETs). Even back then, the V2V was recognized as a tool to help realize blind spots and avoid accidents. In December 2016, US Department of Transportation has proposed draft communication regulations of vehicles and now begins to apply to small vehicles with a security encryption system called Public Key Infrastructure (PKI).

At present, the Vehicular Communication Systems (VCS) is popular by using Dedicated Short-Range Communications (DSRC) to communicate between devices. In a node to node on the frequency of 5.9GHz and the bandwidth (75MHz) with a distance of approximately 300 meters. Main objective of increasing security by sending data to other vehicles in the area. Many countries have set frequency bands to use for V2V [35, 36, 37, 38] as shown in Fig. 25.

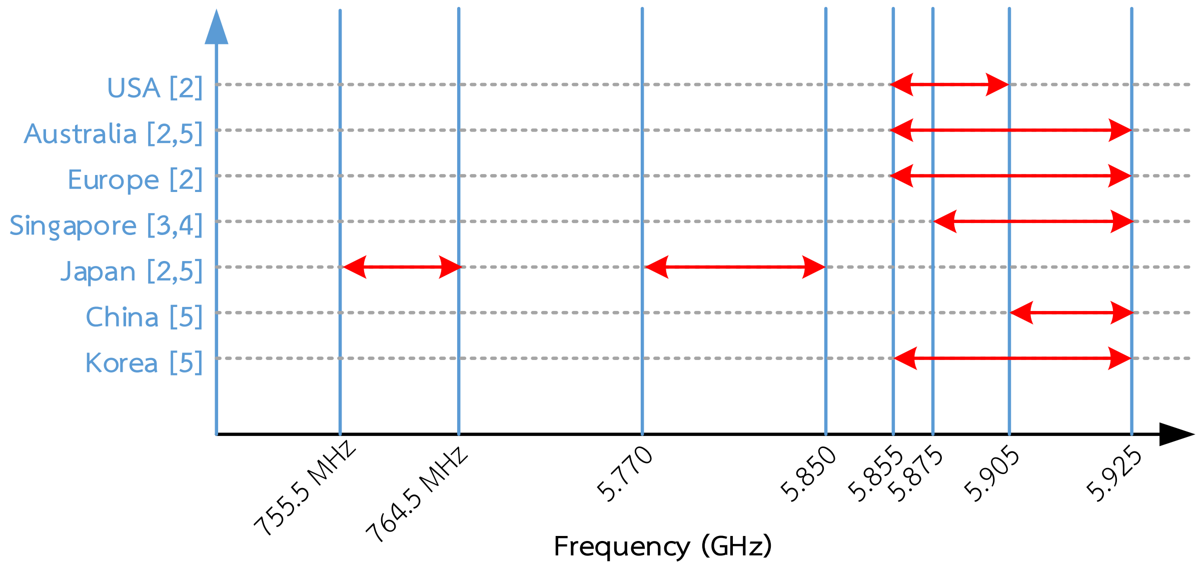


Fig. 25 Frequency allocation for communication equipment in vehicles

In Thailand, National Broadcasting and Telecommunications Commission (NBTC) currently regulates 5 frequency bands on broadcasting and telecommunications service, as shown in Fig. 26, according to NBTC document 1011–2017 for technical standards of telecommunications devices and frequency allocation for communication devices in vehicles announced on February 9, 2018

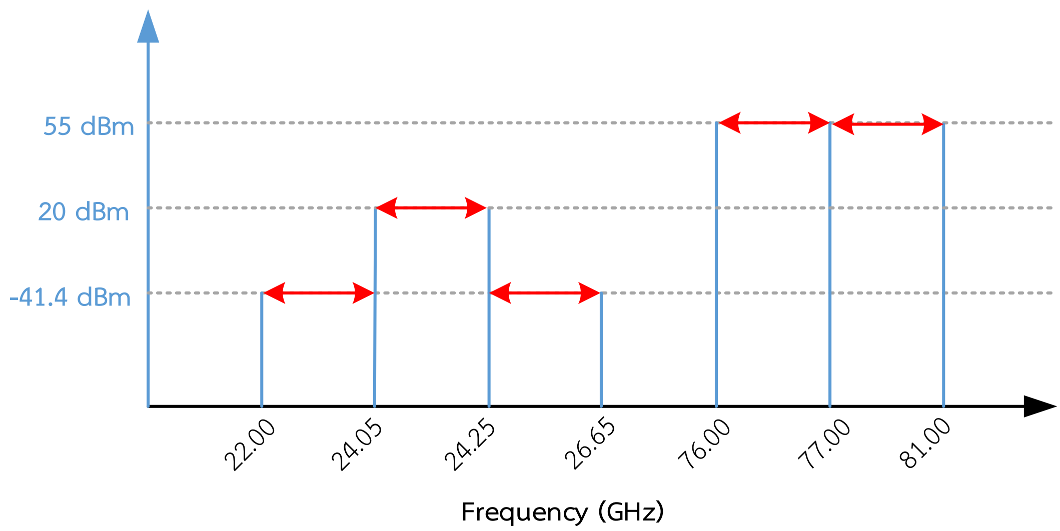


Fig. 26 Frequency allocation for communication equipment in vehicles in Thailand by NBTC

In addition, NBTC also regulates the use of short-range devices in the range of 57-66 GHz radio frequency on Wireless Local Area Network (WLAN) or Wireless Personal Area Network (WPAN). Hence, communication technology and standards in Thailand can support the development of AV and traffic devices on dedicated short-range communications (DSRC) through the mobile phone network (Cellular Phone) in the future.

3.4 Conclusion

From research finding above, legal challenges for autonomous vehicles in Thailand can be generalized as follows.

- The legal challenges of CAV in Thailand and ASEAN can be categorized into 3 groups: driving license, vehicle standard and infrastructure preparation.
- In addition, the provisions and laws involved on responsible person (or institution) should be clarified in case of CAV accident.
- Furthermore, the issue list noted in stakeholder mapping and the responsible government agency are drafted in this study.

where driver/passenger, vehicle and infrastructure should play the role to make clear liability of CAV accidents, as shown in Fig. 27. Furthermore, AV stakeholder mapping for Thailand is shown in

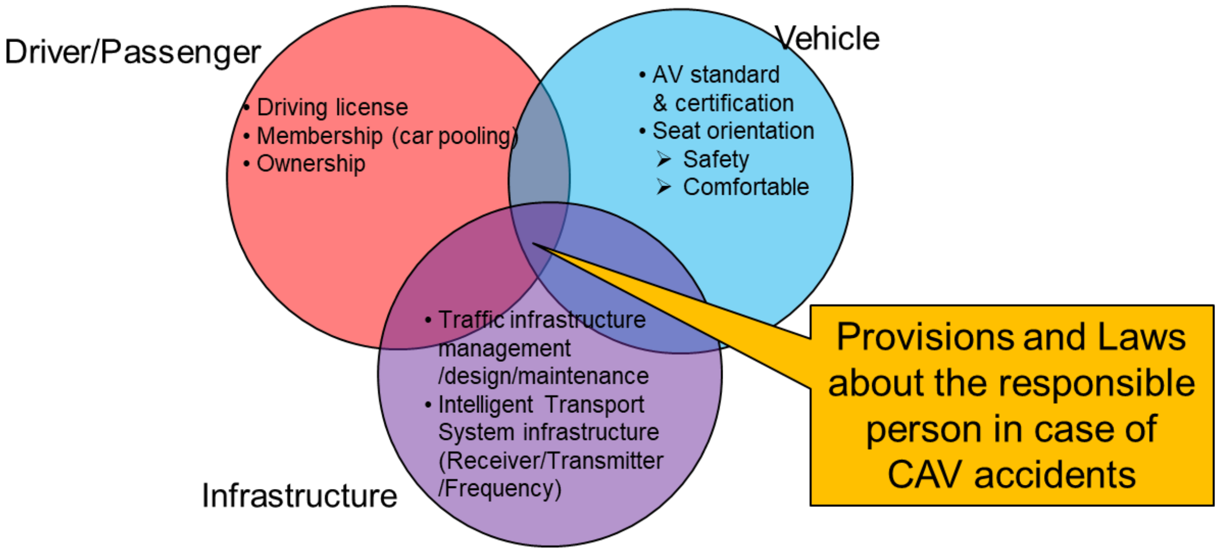


Fig. 27 List of issues for AV in Thailand from 3 aspects: driver/passenger, vehicle and infrastructure

Table 7: 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		

	Ministry of Transport	Ministry of Industry	Ministry of Digital Economy and Society
Technical supporter	**Research laboratory in University / National Technology Center (e.g. NECTEC)**		

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