1. Introduction

The digital revolution worldwide has affected the development of vehicles employed in all modes of transportation including road, rail, air, and shipping sectors. Recently, several organizations in developed countries in Europe and North America as well as selected countries in Asia such as the Republic of Korea, China, and Japan have concluded studies on the introduction of autonomous vessel technologies as well as preparing regulations for governing future vessels. Autonomous vehicles encompassing all types of transportation units used in all modes of transportation have also been receiving attention in many developing countries including Thailand, especially in the field of research and development prior to pushing research experience into commercialization.

The Society of Automotive Engineers (SAE) has classified autonomous vehicles into levels from 0 to 5 based on their stages of development. Level 0 is the level of traditional driving without autonomous driving at which the driver is responsible for all operations. Level 1 is defined as the level at which a vehicle contains driving assistance functions protecting the driver’s handling of the vehicle. Level 2 refers to the level where the automation system performs part of the driving operations, and the driver operates other functions such as monitoring driving circumstances. At level 3, driving is mostly automatically controlled but the driver can still control the driving in some requested circumstances, such as when the road conditions or environment are unstable. Level 4 is the level at which the automation performs all operations and monitors the driving environment. The driver is not required to control the vehicle but there is still room for the driver to intervene under certain circumstances. Level 5 is an unmanned vehicle using an automation system to fully control and monitor all driving under all conditions.

The concept of autonomous vehicles has also extended to maritime vessels due to the potential of minimizing operational costs, removing the difficulties of hiring crew members, reducing the discharge of garbage and sewage, and lowering the probability of human error-induced incidents during the voyage.

The objectives of the paper are to (a) review the concept of autonomous shipping; (b) explore lessons learned by stakeholders in Thailand on how to prepare for adopting autonomous vehicles and autonomous shipping; (c) evaluate opportunities and threats to the readiness of Thailand to engage in innovative autonomous shipping; and (d) propose guidelines for implementing autonomous shipping in Thailand.

2. Current Maritime Transport Situation in Thailand

Maritime transportation is essential to Thailand’s international trade, which accounts for more than 80 percent of all of Thailand’s international transportation. Thailand has a coastline of 3,219 kilometers, which is divided into two parts: the Gulf of Thailand and the Andaman coast. The coastline of the Gulf of Thailand extends for 1,660 kilometers through the Eastern region, Bangkok and the surrounding area, Lower Central region, Upper Southern region, and lower Southern region. There are about 220 ports along the coastline, which are categorized into 4 clusters: (1) Inner Thai gulf covering Bangkok and the surrounding area incorporating Bangkok.
key river ports such as Bangkok Port and other ports operated by private sectors along Chaopraya River: for example, Saha Thai Terminal, BMTP, and Bangkok Barge Terminals; (2) **Eastern Thai gulf** located in the Eastern region, which is the heart of container and industrial deep seaports, namely Laem Chabang Port, Maptaput Port, and Kerry Siam Seaport; (3) **Western Thai gulf**, combining parts of the Lower Central, Upper Southern, and Lower Southern regions, which mostly focus on fishing and bulk cargo. The main cargo ports in this region are the Songkhla and Prachub ports; and (4) the **Andaman coast** which mainly focuses on passenger ferries, offshore supply, and short voyages connecting Thailand and neighboring countries. There is a limited number of cargo ports in Andaman, which are mostly situated in the Ranong and Trang provinces.

As of the end of 2022, Thailand had merchant fleets comprising 376 vessels with a capacity of over 500 gross tonnage (GRT), which is equivalent to a total carrying capacity of 4.28 million deadweight tons (DWT). 55 percent of the total carrying capacity consisted of liquid cargo: mainly oil, gas, and chemical substances, while the remaining 45 percent were dry bulk, containerized products, and break bulk cargo. All vessels are owned and managed by private companies.

Approximately 10 to 12 percent of Thailand’s merchandise trade is transported on national-flagged vessels. Restrictions on foreign ownership remain in place. In order to be registered as a Thai-flagged vessel providing international shipping services, an operator must be at least 51 percent Thai-owned and at least 50 percent of crew must be Thai nationals. If the vessel is to operate on domestic routes, the Thai ownership requirement increases to 70 percent, and all crew members must be Thai nationals. At the same time, foreign vessels are not permitted to engage in domestic waterborne trade as indicated in the Thai Vessels Act. The main public and private organizational stakeholders involved in promoting the shipping industry are the Ministry of Transport, Marine Department, Customs Department, Revenue Department, Ministry of Commerce, Port Authorities of Thailand, Thailand National Shipper Council (TNSC), Thai Chamber of Commerce (TCC), Thai Federation of Industries (FTI), Thai Shipowners Association (TSA), Bangkok Shipowners and Agents Association (BSAA), Thailand International Freight Forwarders Association (TIFFA), and Thai International Cargo and Container Association (TICCA).

Regarding the shipbuilding and repair sector, there are currently 260 operators running shipbuilding and repair dockyards, most of which are located along major rivers in Bangkok and surrounding areas as well as along Thai Gulf coastlines. Compared to other countries in ASEAN, Thailand's shipbuilding and repair sector is still far behind that of Singapore, Malaysia, Indonesia, the Philippines, and Vietnam. About two-thirds of dockyards in Thailand are small dockyards with the capability of building and repairing ships smaller than 500 GRT. These dockyards are not equipped with modern advanced equipment and are focused on serving local demand, especially wooden fishing trawlers. The country is focusing on repairing existing ships rather than building new ships.

The main legislations concerning the maritime and waterborne transportation sector encompass the Navigation in Thai Waters Act, Thai Vessels Act, Mercantile Marine Promotion Act, Carriage of Goods by Sea Act, General Average in Maritime Adventure Act, Preventing Ship Collision Act, Ship Mortgage and Maritime Lien Act, Arrest of Ship Act, Multimodal Transportation Act, Port Authorities Act, Immigration Act, and Customs Act. The Marine Department under the Ministry of Transport continues to be the sectoral regulator. It oversees law enforcement, navigation safety, ship registration, and inspection, certifying ships' equipment and facilities, maintenance of navigation channels, providing pilot services for seagoing vessels, port construction and extension, and minimizing environmental impacts caused by navigation and port activities. It is also responsible for the promotion and
development of maritime transport, including infrastructure development.

As of 2022, there were about 220 international ports throughout the country, most of which are small- or medium-sized privately owned and operated ports. Thailand’s main ports are ports owned by the Port Authorities of Thailand and the Ministry of Transport, namely Laem Chabang Port and Bangkok Port. Laem Chabang Port, the largest and highest maritime liner connectivity port, is owned by the Port Authority of Thailand and allows private container terminal operators to operate under concession. The private sector participation in port operations may take the form of either a leasehold agreement or a BOT agreement. Private terminal operations are usually granted 25 to 30 years concession to manage terminals and other port facilities. Other main government ports are Map Taput Port in the east of Thailand, owned by the Industrial Estate of Thailand and Ministry of Industry, and Songkhla Port in the south of Thailand, the port business of which the government allows private companies to manage under concession. Other container ports and ports used for serving liner shipping in Thailand are run by private operators, including Kerry Siam Seaport and Siam Commercial Seaport near the Laem Chabang Area and BMTP, Sahathai Terminal, Bangkok Barge Terminal, Sukswat Terminal, Thai Connectivity Terminal, and Unithai port, which are located along the Chaopraya River.

In general, Thailand has a relatively good port infrastructure, and the government has provided investment incentives with certain conditions to increase investment in a number of maritime transport services and related businesses such as modernized cargo ports, container yards, inland container depots, and smart logistics service centers. However, the investment incentives granted may seek prior approval from relevant authorities and may limit foreign equity participation to no more than 49 percent.

Ships calling at Thailand’s ports, regardless of their nationality, receive most-favored-nation treatment, and port access is available on a "first come, first served" basis. All port tariffs and service fees are subject to a 7 percent value-added tax (VAT), while VAT on maritime transport services is zero-rated. In general, port fees on export cargo are collected at lower rates than on imported cargo due to the fact that export cargo generally involves less use of port facilities and services.

To implement the government's policies on shifting modes of transport from road to rail and waterway, as well as to strengthen the role of primary seaports in Thailand, the Port Authorities of Thailand (PAT) launched mega projects at Laem Chabang Port. These projects comprise the third phase of Laem Chabang Port development to expand the capacity up to 10 million TEU per year, the Single Rail Transfer Operator (SRTO), and a coastal terminal project.

Thailand's trade and logistics policy is formulated within the broader framework of the 20-Year National Strategy (2018-2037) and the National Social and Economic Development Plan, which will be used from time to time. The 12th National Social and Economic Development Plan, used from 2017 to 2022, addresses the importance of:

(a) Utilizing trade cooperation and trade liberalization agreements to increase export and investment volume, especially agreements applied to ASEAN countries and dialogue partners.

(b) Developing transport infrastructure, especially rail and water transport, to shift cargo volume from road transport to reduce traffic congestion and pollution.

(c) Improving trade and transport facilitation, especially the national single window, to increase the speed and accuracy of information exchange among relevant organizations related to international trade.

(d) Promoting the utilization of existing river ports and coastal ports in the region, as well as
providing road access to the ports.

(c) Promoting connectivity between international ports and coastal ports.

(f) Monitoring the operations and concession payments of private container terminal operators under concession in Laem Chabang Port to ensure compliance with their obligations under the concession contract.

(g) Expanding the service capacity of Laem Chabang Port.

(h) Enhancing the capacity of logistics service providers by granting tax and financial privileges, establishing quality standards, and extending business networks with local and international partners.

(i) Adjusting laws and regulations to reduce barriers to doing business efficiently by taking into account international standards and acceptable practices.

(j) Developing environmentally friendly industries, such as automotive, electronic, smart machinery, agro-based technology and food, logistics villages, health care, and hospitality in potential areas.

3. Compendium of Initiatives related to Autonomous Vehicles and Vessels

The origin of Thailand’s interest in developing the autonomous vehicle industry began in 2015 as the automation industry (including robots, automation systems, and autonomous vehicles) was listed in one of the top ten new generation industries in Thailand's 4.0 policy, which could potentially drive the country to graduate from the middle-income trap to become a high-income country in the future. Robots and automation systems have played vital roles in engaging in daily life and work. The use of robots and automation can help improve operating efficiency in various fields including manufacturing, agriculture, services, transportation, and logistics services.

On August 29, 2017, the Thai government approved three main mechanisms to build a favorable ecosystem to propel the development of the robot and automation system industry containing (1) accelerating all manufacturing and service industries to enhance efficiency by utilizing robotic and automation systems as well as to create local demand for robot and automation industry; (2) promoting the production of system integrator (SI) to ensure the supply of SI will meet the demand; (3) instituting the Center of Robotics Excellence (CORE) to provide technological and advisory support for the existing robot and automation system enterprises to advance their operations to other planned products such as elderly care robots, police robots, hospitality robots, autonomous vehicles, autonomous buses, robot taxis, autonomous ships, and autonomous aerospace systems. To achieve the government's objective of becoming a leader in ASEAN in developing and using robots and automation in various fields by 2026, the government of Thailand has launched five broad measures, incorporating:

1. Marketing Promotion Strategy: The following actions have been undertaken to motivate all manufacturing and service industries in Thailand to voluntarily and gradually shift from conventional systems to autonomous systems:

   - Exempting income tax for three years for any enterprise that changes from current conventional systems to automated systems.

   - Granting certain subsidies or special interest loans for small and medium enterprises that can convert from conventional systems to automation systems.

   - Arranging business matching between SMEs and startups in related fields.
- Supporting enterprises to engage in relevant international trade exhibitions.

2. Grooming System Integration: The following actions have been commenced to increase the supply of System Integration (SI) to accommodate the growing investment in manufacturing robots and automation systems:

- Temporarily removing import duties on materials and parts used in manufacturing robots and automation systems for five years.
- Granting investment incentives by exempting income tax for up to eight years for enterprises engaged in the manufacturing of automation machinery and/or automation equipment with engineering design and control system configuration.

3. Supply Generation: The following actions have been conducted to raise the quality of robot and autonomous products:

- Arranging education in colleges and non-degree training and development programs to increase human capital working in the robot and automatic system industry by at least 300 people per year.
- Establishing a Mutual Recognition Agreement (MRA) with other countries to enlarge the market size for robot and autonomous products.

4. Forming Center of Excellence: The government has established the Center of Robotics Excellence (CORE) to support the development of robot and autonomous technologies. This involves strategically allying relevant technical institutes and universities to work together on selected tasks, such as:

- Creating a database of automation machinery building and automation system integrator.
- Collaborating with business enterprises to develop industry prototypes in priority sectors such as agriculture, industry, healthcare, and logistics.
- Enhancing the skills of human resources in the robot and automation system industry.
- Transferring knowledge related to the robot and automation system industry.
- Developing laboratory tests on the safety and performance of products, as well as accreditation of related standards.

The main organization in Thailand driving the policy initiatives related to robots, autonomous vehicles, and automation systems is the Ministry of Industry, working in cooperation with relevant agencies including the Office of Industry Economy, Office of Industrial Standard, Department of Industrial Promotion, National Science and Technology Development Agency, Board of Investment (BOI), Thai-German Institute, and Electrical and Electronics Institute (EEI). To date, it is noticed that all organizations closely working in the team are from the Ministry of Industry and the Ministry of Higher Education, Science, Research and Innovation (MHESI) but not yet extended to the Ministry of Transportation. Hence, with the current existing coordinating mechanism having no engagement with transport authorities, there may be a delay in the progress made on inventing and commercializing autonomous vehicles used in the transportation and shipping sector.

The Board of Investment (BOI) has diligently followed the government's policy to promote the robot and automation system industries within specific subsectors, which include: (a) The manufacturing of automation machinery and/or automation equipment with engineering
design and control system configuration; (b) The assembly of robots or automation equipment and/or automation parts; (c) The manufacturing of equipment for electric vehicles; (d) The manufacturing of electric vehicles.

Companies that have been approved for investment promotion by BOI can enjoy a package of privileges, including an exemption from income tax for up to eight years, an exemption of import duties for raw materials and parts, and various non-tax privileges. These non-tax privileges encompass permits to bring foreign experts and skilled workers to work, the ability to own land, and the freedom to take out or remit money abroad in foreign currency. Additionally, BOI facilitates connections between promoted companies and the Center of Robotics Excellence (CORE) to strengthen technological consortia and business alliances.

In terms of advancing the policy to promote the robot and automation system industry through industrialization and commercialization, this paper utilizes a database of companies that have received promotion packages from BOI between 2017 and September 2023 for investments in robots, automation systems, and autonomous vehicles, as presented in Table 1. The purpose of this analysis is to identify investment projects that may be related to autonomous vehicles, with a specific focus on autonomous shipping.

As of 2023, no enterprise has applied for investment promotion to engage in the production of autonomous vehicles for commercial use in public spaces such as roads and waterways. However, there are a few enterprises involved in the manufacturing of drones used for agricultural purposes and automated guide vehicles (AGVs) that are exclusively used within factory premises, warehouses, or closed facilities.

Table 1: Promoted Company Database in Robots, Automation System, and Autonomous Vehicles

<table>
<thead>
<tr>
<th>Number</th>
<th>Promoted Company</th>
<th>Automation System used only in Factory</th>
<th>Autonomous Vehicle used in Public Space</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A.I. Technology Company</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Age Thai</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>AI and Robotics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>ANCA Manufacturing (Thailand)</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>BKWell Intelligent Equipment (Thailand)</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>BR Machinery Asia</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Cal Comp Automation and Industrial 4.0 Services (Thailand)</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Colibri Automation (Thailand)</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Eureka Automation</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Expert Automation</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Haru System Development (Thailand)</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Heads Robotech Thailand</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Japan Support System (Thailand)</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Kaneta Mechatronic Engineering</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Kuroitsu (Thailand)</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Lertvilai and Sons</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Menam Mechanika</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Mitsubishi Electric Factory Automation</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>New Wave Automation</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Nipponkikai Engineering</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>PFM Asia Pacific</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Planet Mokara Factory Automation</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Number</td>
<td>Promoted Company</td>
<td>Automation System used only in Factory</td>
<td>Autonomous Vehicle used in Public Space</td>
</tr>
<tr>
<td>--------</td>
<td>----------------------------------------</td>
<td>----------------------------------------</td>
<td>----------------------------------------</td>
</tr>
<tr>
<td>23</td>
<td>Robo Automation</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>Thermatech</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>Tokai Welding Automation</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>Vista Automation (Thailand)</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Welbot</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>Worakulchai Innovations</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>Yamaha Robotics Manufacturing Asia</td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>

Source: Board of Investment of Thailand

Although there is not much progress made in investing in autonomous vehicle and autonomous shipping for transportation purposes, there is progress made in research and development (R&D) projects in small scale funded by the government. Examples of pilot R&D projects related to autonomous shipping in Thailand are listed below:

1) In 2015, the Ministry of Higher Education, Science, Research and Innovation (MHESI) granted financial support to Hydro Informatics Institute (HII), Department of Science Services (DSS), and Rajamangala University of Technology Thanyaburi (RMUTT) invented the small sized remotely controlled autonomous ship for surveying and collecting data of water quality and maritime resources to minimize human work risks. The autonomous ship can either move to designated locations by using 2.4 GHz radio waves that pilot the ship remotely or move autonomously by employing a GPS device and inertial measurement unit. The ship, driven by podded propulsion, can reach a maximum speed of 3 meters per second and does not release any noise from the motor while being able to carry up to 90 kilograms of goods of any type.

![Thai Autonomous Ship invented by HII, DSS, and RMUTT in 2015](http://oldweb.most.go.th/main/index.php/org/4527.html)

2) Satlab Geosolutions Thailand is a company in Thailand importing autonomous ships from overseas to provide water-related investigation services such as exploring river depth and crafting navigation maps. The company is utilizing SATLAB USV SBS2 Unmanned Surface Vessel with Echo Sounder to investigate canals and rivers. The vessel can survey the water surface continuously for up to 4 hours with a maximum speed of 5 meters per second and can be controlled remotely by radio up to 1 kilometer away from the ship.

3) In 2021, Mr. Saithan Muangpongeon, an electrical engineer from a new generation of agricultural entrepreneurs from the Nakhonpatom province near Bangkok, constructed the automatic watering robot “RIM” to help save on labor costs related to watering banana plantations and to reduce production costs. The water robot is made of fiberglass, weighs 50 kilograms, is 72 centimeters wide and 140 centimeters long. It is equipped with a water pump and can work continuously for up to 3 hours via remote control.

So far, Thailand has a limited implementation of automation in the shipping sector. The most distinguished case of implementation automation system in this field is perhaps the introduction of autonomous electrical trucks controlled by artificial intelligence (AI) to carry containers within designated areas in the terminal undertaken by Hutchison Ports Thailand (HPT). Hutchison Ports Thailand is a leading container terminal operator in Laem Chabang port, contributing to Hutchison Ports Group's mission to achieve a reduction of 11 percent...
in carbon emission per TEU by 2030 by adding more electrically operated autonomous trucks, remote-controlled electric yard cranes, and switching to electronic gate pass since the early months of 2022.

**Autonomous Truck introduced by HPT in Laem Chabangkok Port**

Source: [https://www.salika.co/2021/12/19/hutchison-port-thailand-digital-platform/](https://www.salika.co/2021/12/19/hutchison-port-thailand-digital-platform/)

In addition, to prepare for rapid change in automation technologies, the public and private sector in maritime transport in Thailand has adopted the automatic identification system (AIS) which is an automatic tracking system that uses transceivers on ships and is used by vessel traffic services (VTS). When satellites are used to receive AIS signature, the Satellite AIS (S-AIS) is utilized, then AIS information supplements marine radar which continues to be the primary method of collision avoidance for water transport. The Information provided by AIS equipment such as IMO number, vessel name, vessel type, dimension, position, course, speed, cargo type, destination, and estimated time of arrival can be displayed on a screen or an electronic chart display and information system which allow maritime authorities to track and monitor vessels movements as well as prepare to aid navigation, search and rescue, and control maritime security.

**Automatic Identification System (AIS) in maritime transport**

Source: [https://www.hydro.navy.mi.th/download/aisbook.pdf](https://www.hydro.navy.mi.th/download/aisbook.pdf)

4. **Challenges of Developing Innovative Autonomous Shipping**
Up until now, the demand for autonomous shipping used for commercial transportation in Thailand is limited which is opposite to the growing demand for environmentally friendly and clean energy vessels as well as the growing application of internet and digital communication in maritime shipping and port business. In order to commercialize the autonomous vessel in the maritime transportation sector in Thailand, it is necessary to explore challenges in various aspects as follows.

1. Legal Concerns

1.1 Prevention of Collision of Ship Act

The convention on the International Regulations for Preventing Collisions at Sea, 1972 (COLREGs) was designed to ensure safety in ocean navigation. Thailand adopted the Prevention of Collision of Ships Act, 1979, after the country became a member state of COLREGs. The duty of good seamanship is one of the most significant principles of maritime navigation and is expressly stipulated in COLREG’s Rule 2. COLREG’s Rule 5 requires maintenance of a proper lookout by sight and hearing, as well as by all available means at all times, meaning there must always be both radar and actual lookout. COLREG’s Rule 6 considers a safe speed appropriate for the existing conditions. With the advent of technology and autonomous ships, the question is how these regulations are applied to an autonomous ship that would not be able to comply with these regulations, particularly where human perception or decision is required to cope with any difficult circumstances in navigation. However, it is arguable that an autonomous ship with sufficiently good technology can comply with these regulations as (1) A properly qualified shore-based controller would be able to respond to any situation promptly; (2) An autonomous ship with remote control function is likely to meet the contemplation of Rule 5 as it is assisted with cameras, audio equipment and satellite The function of crew onboard having radar and actual watch by sight and hearing can be done via a shore-based controller; and (3) An autonomous ship equipped with satellite communication, spatial sensors, and control algorithms will acquire more precise data available more quickly, resulting in a more accurate determination of safe Thus, the COLREGs may apply to the operation of an autonomous ship, notwithstanding that it was designed for conventional vessels operated by humans. Presently, it is reported that 75-96% of marine accidents and casualties are caused by human error, and it remains to be seen whether autonomous ships may reduce this figure appreciably.

1.2 Navigation in Thai Waters Act

The different level of autonomous ship indicates the different degree of participation of ship crew in intervening or controlling activities during the journey. The introduction of autonomous ships in Thai water territories will require a series of corrections of existing legislations comprising the following issues: (a) the duties and responsibilities of the ship master who controls the ship in preventing ship collision and report to relevant authorities; (b) the mechanism and format of informing the arrival and departure of ships to relevant authorities, including the marine department and port operators; (c) the ability to prevent autonomous ships from entering into the prohibited navigation areas; (d) the withdrawal or confiscation of ship master licenses of autonomous ships that enter into the prohibited navigation areas; and (e) the ability to order an autonomous ship to sail only on designated routes and anchor in designated premises.

1.3 Thai Customs Act
The introduction of autonomous ships in Thai water territories will require changes in many issues in the current law including (a) the duties and responsibilities of ship masters to accommodate customs officers to be on board and answer questions concerning the ship, ship crew, and cargo; (b) the ability of customs officers to delay the autonomous ship in the case that cargo handling cannot finish on the given dateline or escape from customs control; and (c) the mechanism and format of informing the arrival and departure of ship to customs officer;

2. Human Resources
Current education and training programs and facilities offered in universities, vocational schools, and training institutes have not yet catered to support the adoption of autonomous shipping and put Thailand in a difficult position to prepare human resources in public and private sectors to accommodate the implementation of autonomous shipping in the short and medium term. The courses offered in universities and colleges specializing in maritime transport studies still focus on conventional subjects such as cargo handling and stowage, ship communication, IMO convention and maritime laws, oceanography, prevention of marine pollution, advanced ship passage planning, electronic navigation, celestial navigation, navigational watch keeping, ship stability, ship construction, seamanship, and cargo ship training. In addition, several institutes have not fully improved courses and innovative teaching methods to cope with new technological mega trends to prepare seafarers for the future in fields such as robotics, digitalization, future mobility, and other disruptive innovations.

3. Cybersecurity
Cybersecurity problems arose when the vessel began to utilize a digital system based on computer programming. Autonomous vessels are especially vulnerable to cyber threats, as they heavily rely on complicated computerized systems, large data transfers through satellite links, and satellite navigation. Without navigational information, the vessels cannot continue their voyage. Unmanned vessels controlled from the shore and fully autonomous vessels that are remotely controlled, when required, depend largely on the exchange of large amounts of information via a satellite link. Breaking communication, or providing false information, may lead to total loss of control.

4. Protection of Marine Environment
Operation of autonomous ships with reduced crew is reckoned to reduce environmental impact, due to the decrease of discharge of garbage and sewage. Yet there remains a concern regarding the ability of unmanned vessels to cope with pollution from their tanks and cargo. For the time being, there is no practical solution in the form of equipment capable of containing and cleaning up spillage without a crew. Without solving this problem, it might be difficult to prove that autonomous ships represent the same level of environmental protection as their manned ships. The obligation to report incidents that may result in pollution also needs some attention as the MARPOL convention requires the ship master or person in charge of the vessel to report on all pollution-related incidents. Manned and remotely controlled vessels can comply with the convention, but fully autonomous vessels cannot.
5. Guidelines of Implementing Autonomous Shipping in Thailand

Based on recent development of autonomous shipping in developed countries and policy initiatives to ultimately drive Thailand to become a leader in automation system industry in the region as well as consideration of current constraints in regulatory and human resource aspects, the paper proposes pragmatic measures to promote autonomous vessels in Thailand are the medium to long terms as follows:

1) Establishing Forum on Autonomous Vessel is needed to raise awareness and strategies to promote the progressive adoption of autonomous vessel in domestic and international water territory, especially there is a must to incorporate representatives of marine transportation sector in working team to drive robot, autonomous vehicle, and automation system industry which is now headed and mostly governed by representatives from Ministry of Industry to reduce gap of development and to accelerate progress made on inventing and commercializing autonomous vehicles used in transportation sector.

2) Opening Mindset: the philosophy of launching autonomous vessels into commercial services to save cost and energy should predominantly focus on the safety management of operations, design, construction, and liability to stakeholders while relevant stakeholders should open their minds to accept new technological advancements.

3) Innovating education and human resource training and development: the current education courses offered in universities, colleges, and training institutes in the country remain focused on conventional maritime transport subjects but have not yet innovated to cater to changing technological advancements such as robotics, digitalization, future mobility, and other disruptive innovation.

4) Experiment in a closed system (Sandbox) must be done to ensure the commercialization of autonomous vessels by (a) designating a specific sandbox in a closed water territory to experiment in the context of domestic and international navigation by conducting a pilot project in low-density routes to ensure that the operationalization of the pilot run is safe such as routes linking between foreign ports and coastal port and Ranong Port (regional ports operated by Port Authority of Thailand in the south of Thailand in Andaman Sea); (b) developing a standard of autonomous vessels based on international standards accepted by IMO or global professional engineering societies.

5) Modernizing Regulations: The Thai government should prepare to modernize or introduce regulations related to autonomous vessel design and construction, ship licensing, ship owner and ship controller licensing and qualification, safety management, safety assurance, cybersecurity, ship registration, and ship navigation in water territory, by basing on fact findings in sandbox experiment, if applicable.

6) Technological Platform: The government should consider establishing a technological platform to monitor and communicate with autonomous vessels and ship owners/controllers as well as a mechanism capable of creating reports in emergency or collision circumstances, ship arrival and departures from ports, and liability for ship owners/controllers to relevant stakeholders.
References


