Department of Rail Transport

Executive Summary Report

The study and analysis of rail vehicles types and specifications in accordance with Thailand rail infrastructure

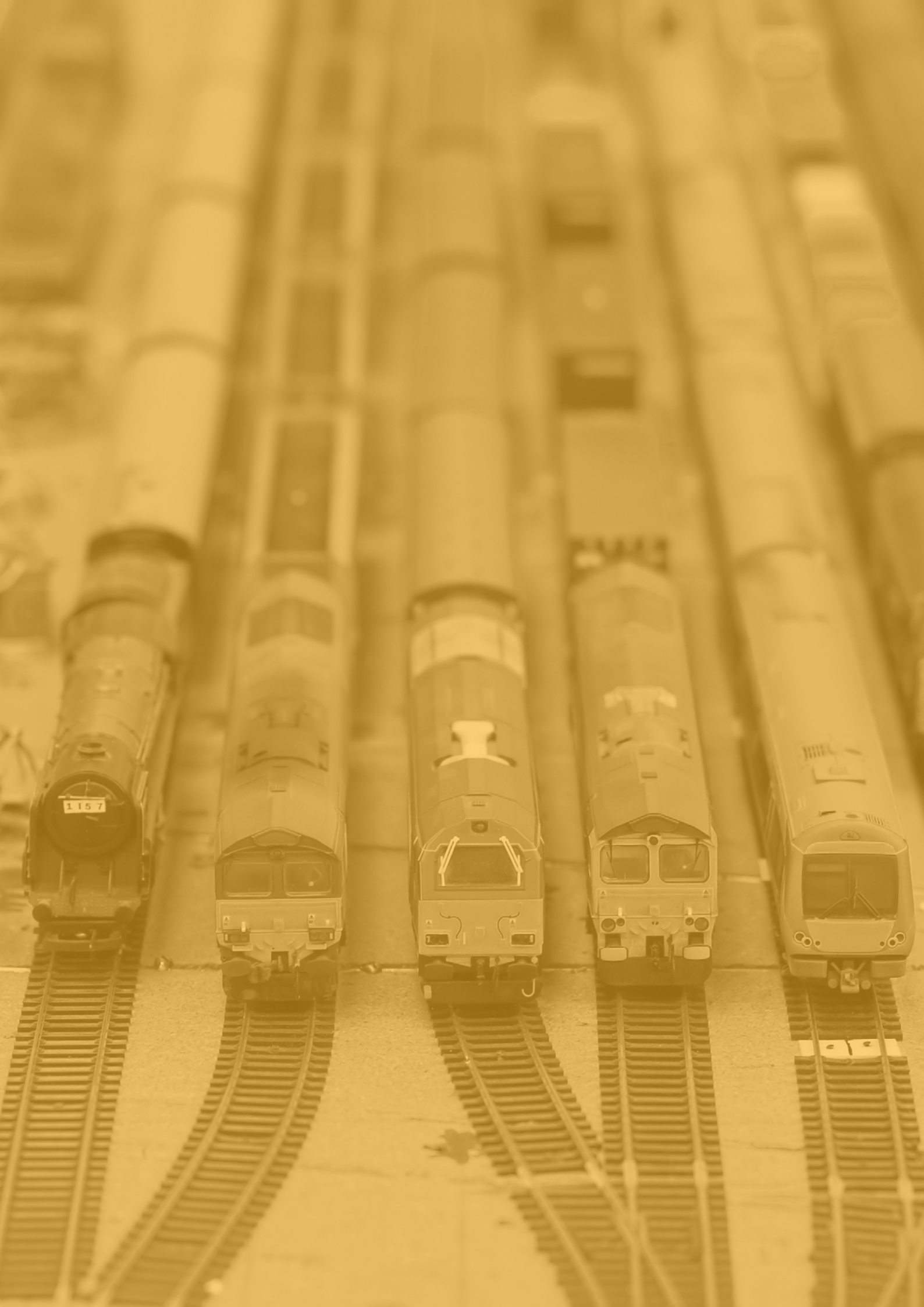
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TABLE OF CONTENT

01 Overview

According to the National Strategy (2018-2037) strategy on stabilizing and developing governmental management system Item 4.3.1 regarding suitable size of government system organizing a public system that distinguishes roles of public agencies with directorial duties and servicing duties to increase operational efficiency and hold fair competition under missions organized by the state; stipulate to provide opportunities to work on a cost-effective mission. Able to manage public affairs effectively and efficiently and the strategy of building competitiveness errors 4.4.4 namely “Develop modern technology infrastructure”. To meet the needs of technology users in both the public and private sectors under the 7th National Strategy

“Transport Infrastructure and Logistics Systems”. Give priority to the development of the rail vehicles system to be the main transportation network of the country and to support the linkage with other transportation modes. The Ministry of Transport has an approach to accelerate the development and improvement of the structure of a meter gauge railway and a high-speed train as illustrated on Figures 1 and 2. Increase the potential of rail vehicles by providing rail related facilities and rail vehicles in accordance with the recent technology. To increase competitiveness by improving and revising measures and factors that will empower entrepreneurs which are the key mechanisms for driving the sustainable development of Thailand economy.

The classification and specification of Rail Vehicles such as type, axle load, seats, braking system, engine, speed, and suitable dimensions are the significant information for Rail Vehicles to be certified and registered with a responsible agency to ensure public safety for passengers prior to commencing of service. Therefore, in foreign countries, there are laws and procedures for registration of rail vehicles, which are enforced in differently by various agencies in the country such as in Japan, China, Australia, European Union countries and USA. In Thailand, the Department of Land Transport is responsible for regulating vehicles to be used, enforcing several relevant laws relating to vehicle registration and certification, such as the Automobile Act of 1979. However, Thailand the current law lacks the regulations, process, and specification requirements for rail vehicle approval and registration prior to commencing service.

Therefore, the Department of Rail Transport’s Safety and Maintenance Standards Division needs to conduct a study in order to establish specifications of rail vehicle and draft sub-ordinances for the registration process and standard guidelines for equipment and critical components of rolling, for the purpose of infrastructure technological development and innovation.

1.1 Challenges

- **Increased number of rail track, variety of rail vehicles, quality and higher frequency of services, increased quantity and load, and higher speed**

Various forms of rail vehicles systems in Thailand are emerging in the near future, such as intercity trains, regional trains, commuter trains, heavy rail and light rail trains with various types of track and specifications. The lack of supervision on rail vehicles conditions can lead to accidents and passenger services disruption as shown in Figures 3 and 4.

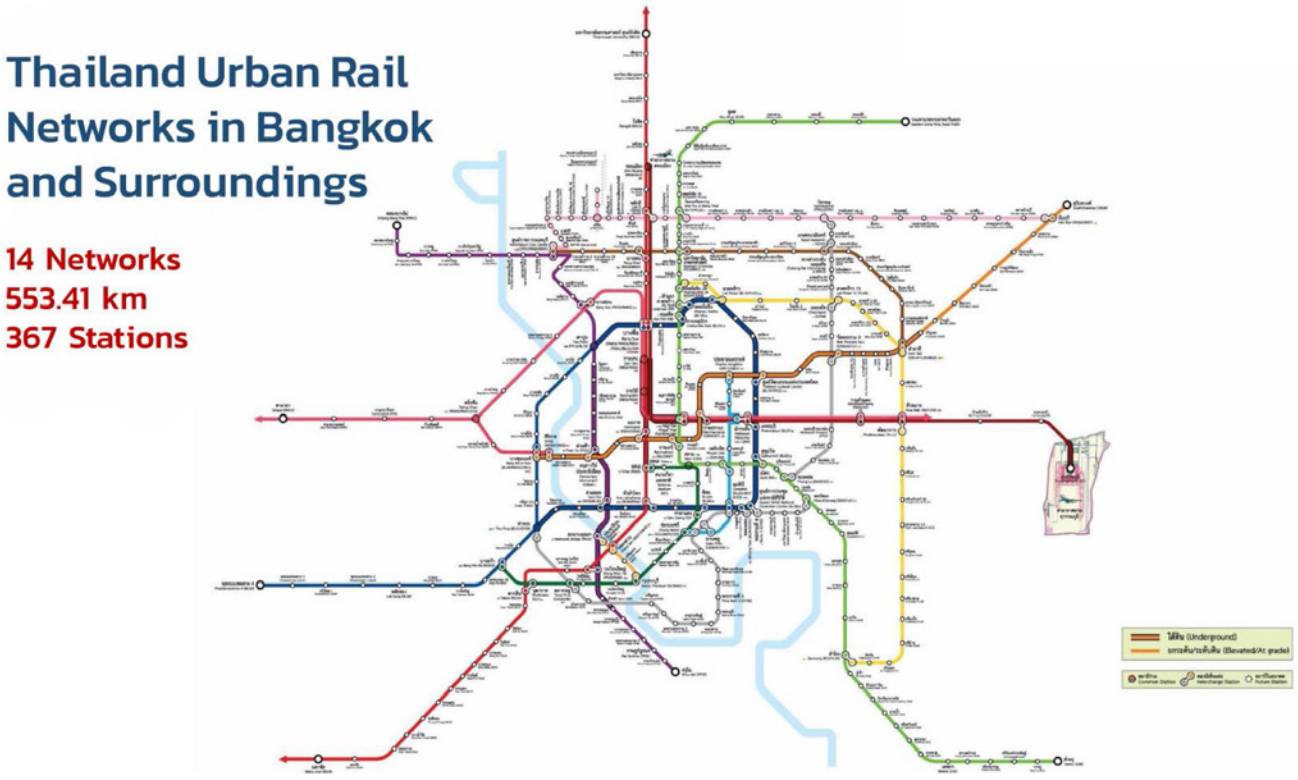


Figure 1 : The Completed Routes of Bangkok Urban Rail Networks

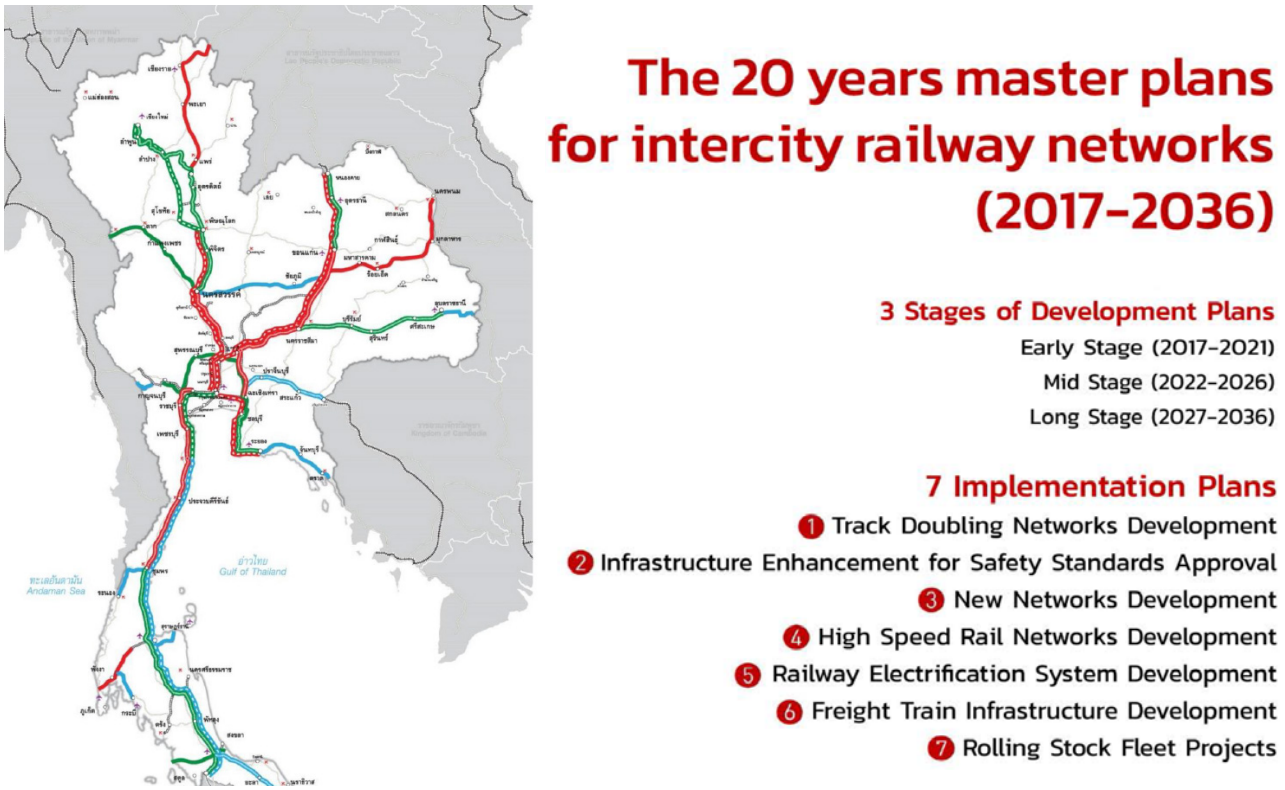


Figure 2 : Master Plans of Inter-City Rail Networks (2017-2036)

Figure 3 : Train Derailment Due to The Failure of Braking System at Lampang Province Since 1989 (8 Peoples Dead)

Figure 4 : Germany's Worst Train Disaster Due to the Broken Rail Since 1998 Killed 101 Peoples

• There are more types of rail vehicles available in the market, but all of which are self–regulated

From the data collected, it was found that within the year 2023, Thailand will have a total of 10,534 rail units of different types in service as shown on Figures 5 and 6. Currently all of rail vehicles are supervised by vehicles operators or owners.

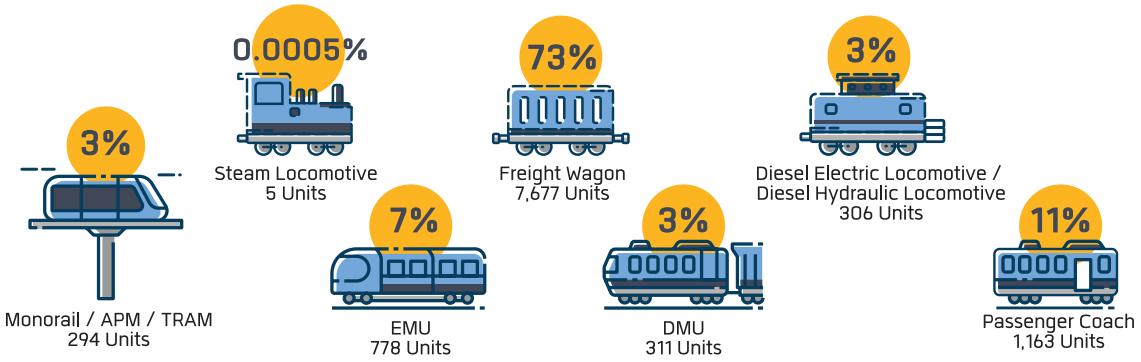


Figure 5 : Summary of rail vehicles types and quantity that will be serviced in Thailand in 2023

	Railway Operators	Type of Rail Vehicles
Intercity and Commuter Rail System	SRT	Locomotive, DMU, BMU, Passenger Coach, Power Car
	SRT, SRTET	EMU, DMU, BMU
	SRT, EHS	EMU
	SRT	Locomotive, Freight Wagon, Tank Wagon, Special Wagon
Urban Rail Transit System	BTS, BEM	EMU
	NBM, EBM	Monorail
	N/A	Street Wheel–Rail and Rubber Tire Trams
	BTS	APM

Figure 6 : Rail Vehicle Types and Operators in Thailand

• Lack of laws and regulations governing the conditions and registration of the rail vehicles.

Currently, Thailand still lacks laws and regulations related to vehicle registration systems that ensure safety and enforce level of services like overseas as illustrated on Figures 7 and 8.

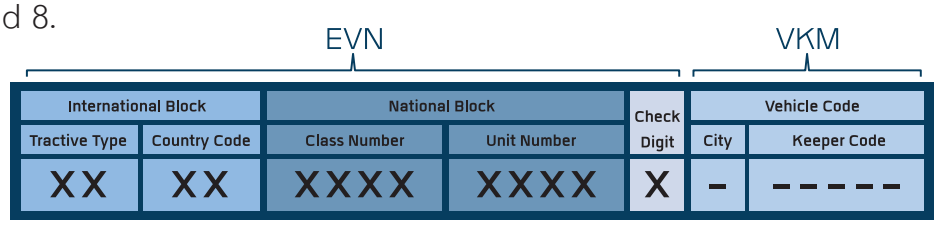


Figure 7 : European Vehicle Number for Rail Vehicles Registration in Europe

ระเบียบกรมการขนส่งทางบก
ว่าด้วยการตรวจสภาพรถของพนักงานตรวจสภาพตามกฎหมายว่าด้วยการขนส่งทางบก
พ.ศ. ๒๕๕๕

ตามที่ได้มีระเบียบกรมการขนส่งทางบกว่าด้วยการตรวจสภาพรถของพนักงานตรวจสภาพตามกฎหมายว่าด้วยการขนส่งทางบก พ.ศ. ๒๕๕๔ ลงวันที่ ๒๔ กุมภาพันธ์ พ.ศ. ๒๕๕๔ ไว้แล้ว นั้น

โดยที่เป็นการสมควรปรับปรุงระเบียบกรมการขนส่งทางบกดังกล่าวให้เหมาะสมยิ่งขึ้น และสมควรนำหลักเกณฑ์ วิธีการตรวจและวินิจฉัยผลการตรวจสภาพรถตามกฎหมายว่าด้วยการขนส่งทางบกมากำหนดรวมไว้เป็นฉบับเดียวกัน เพื่อให้สะดวกต่อการใช้ปฏิบัติงานของพนักงานตรวจสภาพ และเพื่อความสะดวกในการตรวจสอบและอ้างอิง อธิบดีกรมการขนส่งทางบกวางระเบียบไว้ ดังต่อไปนี้

ข้อ ๑ ระเบียบนี้เรียกว่า "ระเบียบกรมการขนส่งทางบกว่าด้วยการตรวจสภาพรถของพนักงานตรวจสภาพตามกฎหมายว่าด้วยการขนส่งทางบก พ.ศ. ๒๕๕๕"

ข้อ ๒ ระเบียบนี้ให้ใช้บังคับตั้งแต่วันที่ ๑ พฤศจิกายน ๒๕๕๕ เป็นต้นไป

ข้อ ๓ ให้ยกเลิกระเบียบกรมการขนส่งทางบกว่าด้วยการตรวจสภาพรถของพนักงานตรวจสภาพตามกฎหมายว่าด้วยการขนส่งทางบก พ.ศ. ๒๕๕๔ ลงวันที่ ๒๔ กุมภาพันธ์ พ.ศ. ๒๕๕๔

ข้อ ๔ บรรดาระเบียบ ประกาศ ข้อบังคับ หรือคำสั่งอื่นใดในส่วนที่กำหนดไว้แล้วในระเบียบนี้ หรือซึ่งขัดหรือแย้งกับระเบียบนี้ ให้ใช้ระเบียบนี้แทน

ข้อ ๕ ในระเบียบนี้

Figure 8 : Car Approval Regulation of Department of Rail Transport

1.2 Objectives

- To determine the type and specification of rail vehicles suitable for the Thailand rail vehicles infrastructure leading to energy saving, proper use, and sustainability.
- To develop technology and innovation in accordance with the stability of national development
- To be used as information for regulating rail vehicles in Thailand.

1.3 Outputs obtained from the study

- **Rail Vehicles Database:**

The data obtained of current and planned rail vehicles projects to be operated in Thailand over the next 8 years (2020 - 2027) are compiled in the rail vehicles database on the website. The database contains information on the characteristics of all types of Rail Vehicles, a total of 10,534 units as shown in Table 1. Table 2 indicates type and general specification of rail vehicles within Thailand's rail vehicles infrastructure. Within the rail vehicles database, each type of vehicle consists of subsystem and main components as shown in Figures 9 and 11. All specifications are listed on the website database on the website as shown in Figure 10.

Table 1 : Quantities of vehicles under Thai ownership

Vehicle Operator		Quantity (Vehicles)
Current Rail Vehicles in Service	State Railway of Thailand	
	• Passenger Train, freight wagon	9,462
	• EMU (Red Line)	130
	Bangkok Mass Transit System (BTS)	392
	Bangkok Expressway and Metro (BEM)	225
	S.R.T. Electrified Train Company Limited	31
Rail Vehicles added in 2023 - 2026		294
Total		10,534

Table 2 : Type and General Specification of Thailand Rail Vehicles

Main Characteristics	Intercity and Commuter Rail System				Urban Rail Transit System			
Type of Services	Intercity & Regional	Commuter	High Speed	Freight	Heavy Rail	Light Rail: Monorail	Light Rail: Trams	Light Rail: APM
Distance of Service (km)	> 50	20-100	>100	>100	20-40	10-30	5-15	5-15
Distance between Stations (km)	10-20	2-5	50	N/A	0.5-12	0.5-1.2	0.3-0.5	0.3-0.5
Maximum Service Speed (km/h)	120-160	160	250	60-100	80	80	80	80
Maximum Weight (ton)	20	20	25	20	20	N/A	N/A	N/A
Width of Track (m)	1.000	1.000 & 1.435	1.435	1.000	1.435	N/A	N/A	N/A
Passenger Capacity (person/track/h)	5,000-20,000	10,000-20,000	10,000-20,000	N/A	>20,000	10,000-20,000	5,000-15,000	3,000-5,000
Routes in Service (Currently in service or commence by 2023)	State Railway of Thailand Tracks: Northern, Northeastern, Southern, Eastern, Mae Klong and Double Track Railway Project	Airport Rail Link, Red Line	High Speed Rail Bangkok-Krat-Nongkhai and High Speed rail Link 3 Airports	State Railway of Thailand Tracks	Green, Blue, Orange, and Purple Line	Yellow, Pink line	N/A	Gold line
Operators	SR	SRT, SRTET	SRT, EHS	SRT	BTS, BEM	NBM, EBM	N/A	BTS
Types of Rail Vehicles	Locomotive, DMU, Passenger Coach, BMU, Power Car	EMU, DMU, BMU	EMU	Locomotive, Freight Wagon, Tank Wagon, Special Wagon	EMU	Monorail	Street Wheel-Rail and Rubber Tire Trams	APM

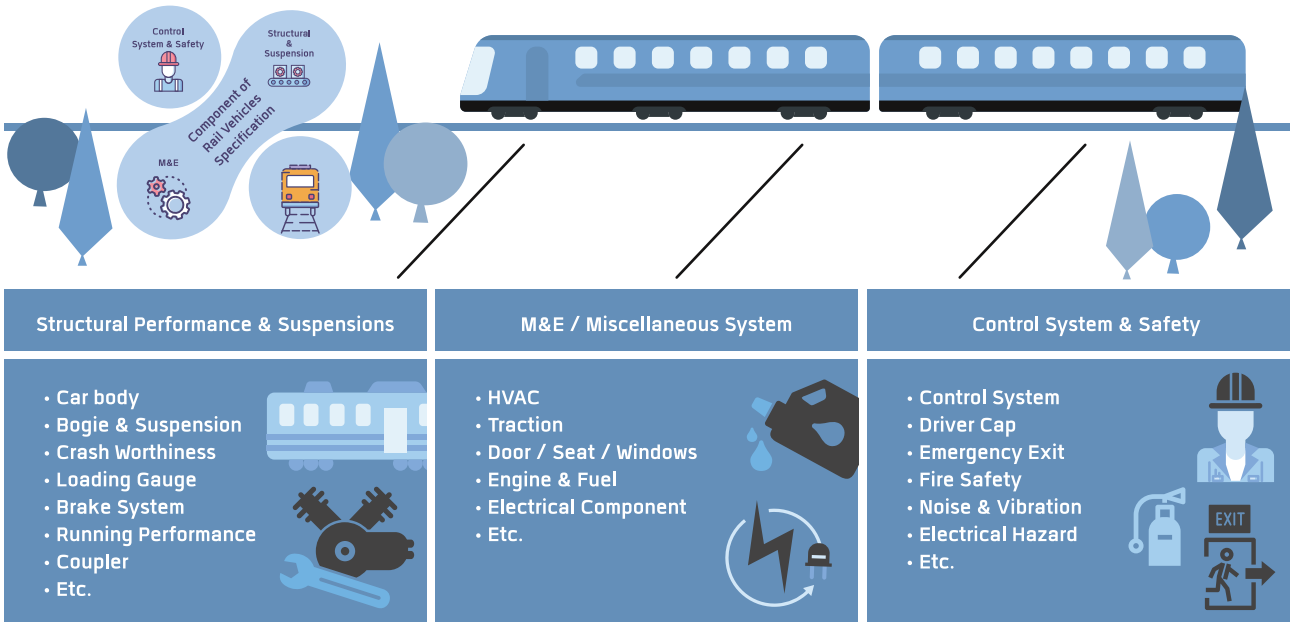


Figure 9 : Subsystems and Components of Rail Vehicles

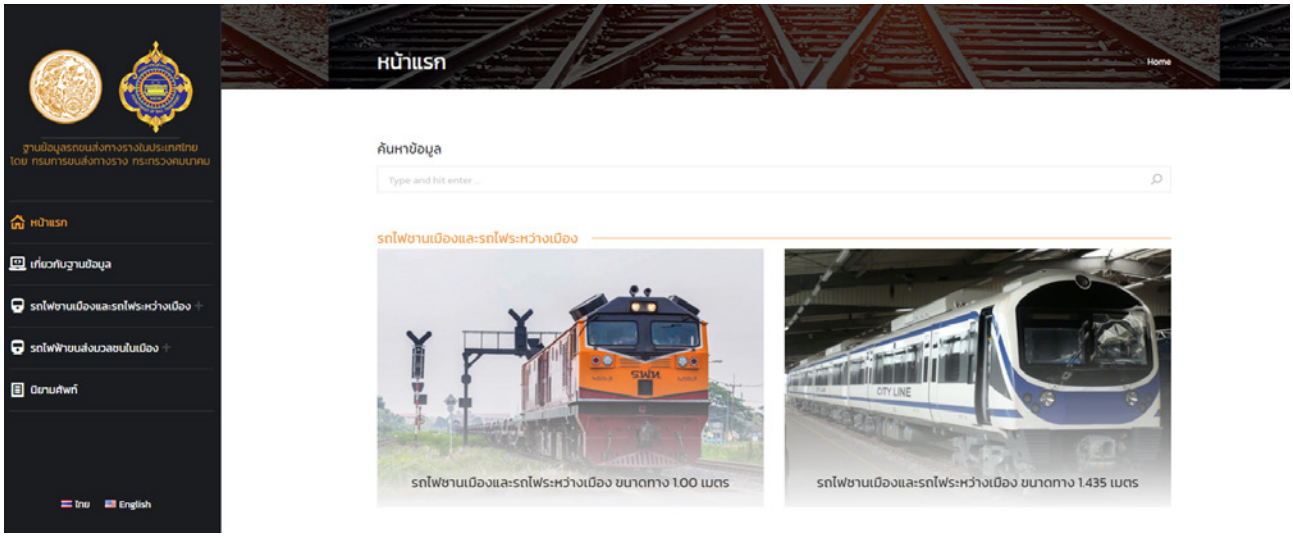


Figure 10 : Rail Vehicles Database Website

• Engineering techniques to reduce track deterioration:

Based on the compilation of technical data from research and study reports overseas, it was found that the main factors affecting the destruction of rail and track due to the running of rail vehicles are 1) Type of Train, 2) Axle Load, 3) Speed, 4) Impact and Vibration, 5) Wheel-Rail Interaction, 6) Suspension system and Unsprung Mass, and 7) Track Condition. All factors will affect the destruction of the rail and track that impacts rail vehicles service in terms of safety, serviceability, and maintenance costs.

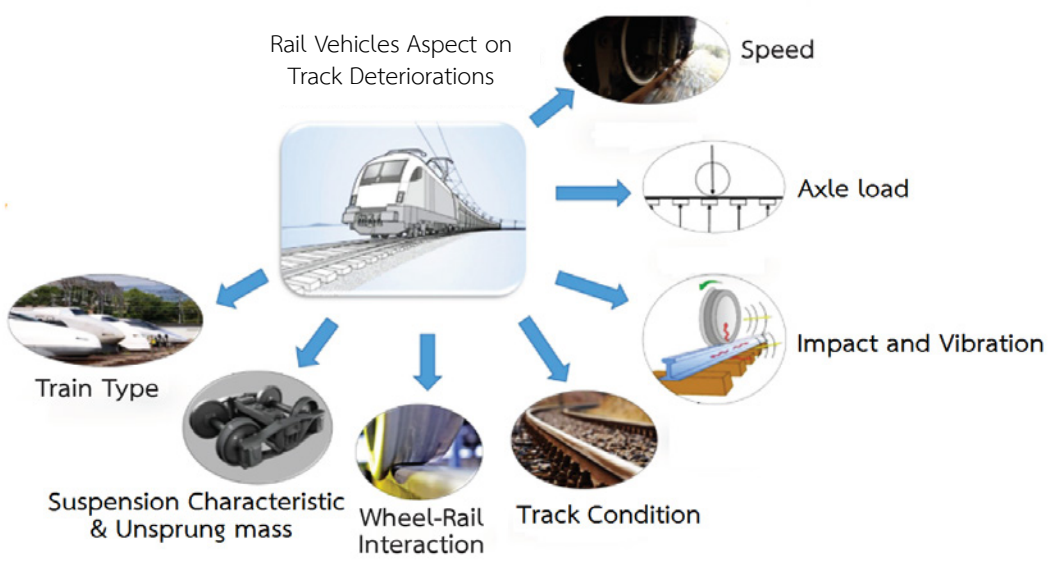


Figure 11 : Factors which have strong effects on track deterioration

• Approval and registration approaches of rail vehicles in Thailand:

As a results of the data obtained from registration regulations of foreign countries such as Japan, China, the European Union as well as different types of vehicles registration laws and guidelines (e.g. land and air transportation) in Thailand, the approval and registration approaches of European Union and Switzerland are applied to Thailand's rail vehicles registration process and registration number designation. The rail transport regulator in Thailand namely "Department of Rail Transport (DRT)" will be the responsible organization in almost of registration processes like FOT (Federal of Transport) in Switzerland. The vehicle registration number will be composed of 2 series number: 11 digits rail vehicle code and vehicle keeper code as shows in Figure 12. As the agency is responsible for processing vehicle registration, the vehicle owner or operator is responsible for submitting evidence of rail vehicle specification approval to the database in order for the Department of Rail Transport to designate a vehicle registration number.

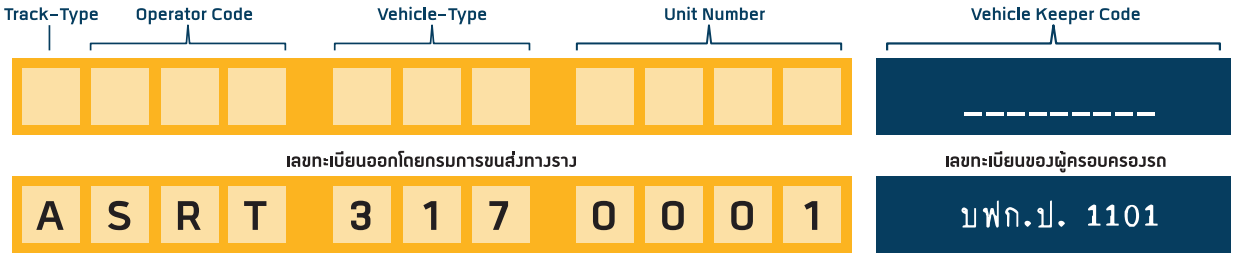


Figure 12 The proposed rail vehicles number in Thailand

• Guidelines for the initial risk assessment of rail vehicles:

The risk assessment in this study used the application of Failure Mode Event Analysis (FMEA), considering 7 key hazardous events that may arise from the defect of various components on the rail vehicle as shows in the Figure 13. Each component will be evaluated and given a total risk score by integrating the severity rating and occurrence rating as shows in Figure 14. The resulting risk score of each component will be ranked and considered for regulatory approach.

Figure 13 The seven hazardous may occurred due to the failure of rail vehicle components

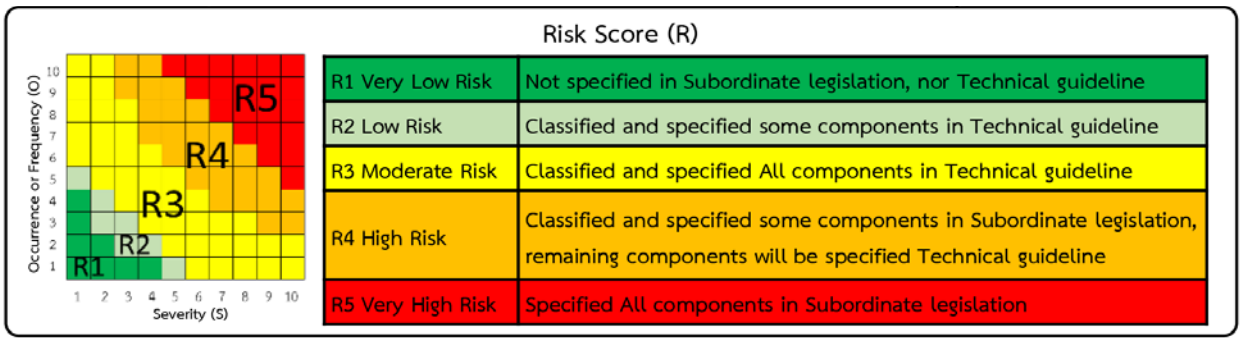


Figure 14 : A Matrix Used to Calculate the Risk Score and Approaches to Implement the Score

• Guideline Specifications and Ministerial Regulations:

The guideline specifications and ministerial regulations of rail vehicles was drafted based on the results obtained in this study, including the addition legal provisions in Rail Transport Act 20XX, making the regulatory structure complete and effective for implementation as illustrated on Figures 15.

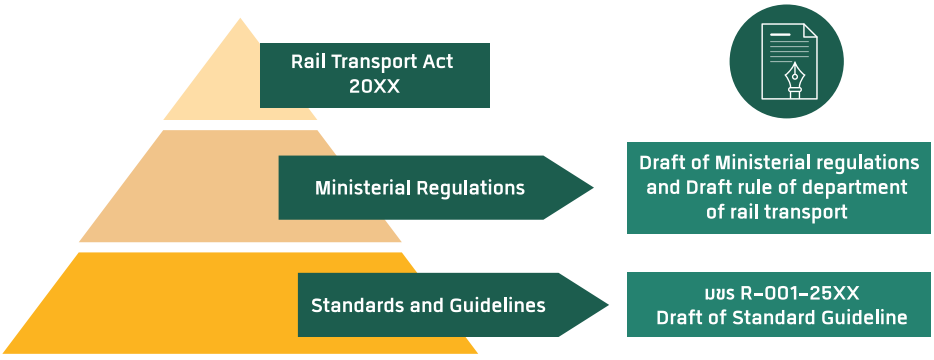
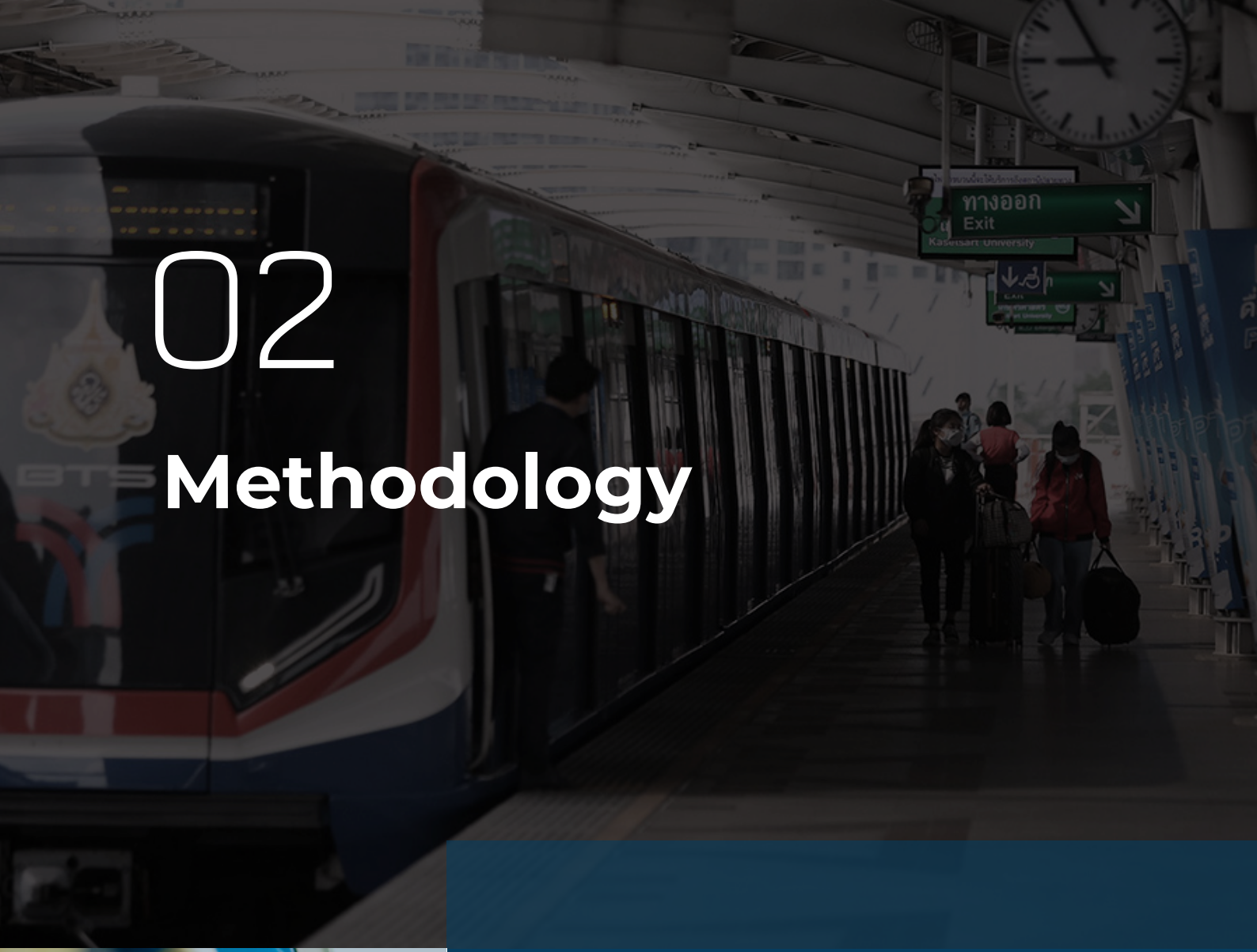


Figure 15 : Structure of Rail Transport Regulatory and Standards.



02
Methodology

The methodology of this study consists of 5 main steps (shown in Figures 16) as follows:

1) Review of information related to the registration of rail vehicles overseas and other modes of domestic vehicles.

2) Review technical data including types and components of rail vehicles, factors affecting the track deterioration and perform a risk assessment.

3) Develop a database of rail vehicles, risk assessment guidelines, draft ministerial regulations, rail transport registration approach, and specification guidelines of rail vehicles.

4) Stakeholders engagement

5) Prepare of Final Report

Figure 16 : Brief Methodology of this Study

03

Summary of rail vehicles data collection

Currently, types of rail vehicles in Thailand are classified by the use and characterization of rail vehicles as summarized in Table 3. The various types of rail vehicles in Thailand divided into two main categories: Heavy Rail Vehicle and Light Rail Vehicle. The key factors in categorization of rail vehicles are the passenger capacity and the service distance of the vehicle. These two categories can be further divided into sub-categories by technologies and different types of services as shown in Figure 17

Table 3 : Types of Rail Vehicles and Characteristics Related Rail Infrastructure

Main Characteristics	Intercity and Commuter Rail System				Urban Rail Transit System			
Type of Services	Intercity & Regional	Commuter	High Speed	Freight	Heavy Rail	Light Rail: Monorail	Light Rail: Trams	Light Rail: APM
Distance of Service (km)	> 50	20-100	>100	>100	20-40	10-30	5-15	5-15
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Maximum Service Speed (km/h)	120-160	160	250	60-100	80	80	80	80
Maximum Weight (ton)	20	20	25	20	20	N/A	N/A	N/A
Width of Track (m)	1.000	1.000 & 1.435	1.435	1.000	1.435	N/A	N/A	N/A
Passenger Capacity (person/track/h)	5,000-20,000	10,000-20,000	10,000-20,000	N/A	>20,000	10,000-20,000	5,000-15,000	3,000-5,000
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Operators	SR	SRT, SRTET	SRT, EHS	SRT	BTS, BEM	NBM, EBM	N/A	BTS
Types of Rail Vehicles	Locomotive, DMU, Passenger Coach, BMU, Power Car	EMU, DMU, BMU	EMU	Locomotive, Freight Wagon, Tank Wagon, Special Wagon	EMU	Monorail	Street Wheel-Rail and Rubber Tire Trams	APM

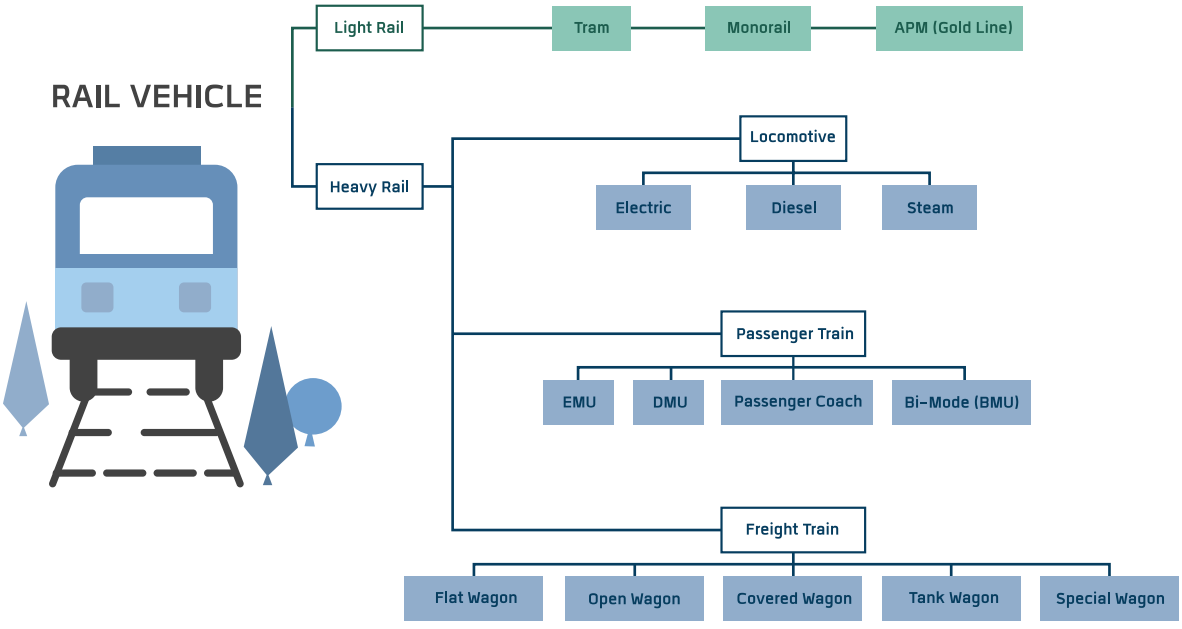

Figure 17 : Classifications of Rail Vehicles

3.1 Quantity of Rail Vehicles in Thailand

• Quantity of Rail Vehicles in Thailand

From data collected from the service providers including, State Railway of Thailand, Mass Rapid Transit (MRT) Authority of Thailand, S.R.T. Electrified Train Co., Ltd., Bangkok Mass Transit System (BTS) Public Co. Ltd., Bangkok Expressway and Metro Public Co., Ltd., other operators of current rail vehicles such as TPI Co. Ltd. and projects in construction, etc., it was found that by 2023 Thailand will have a total of 10,543 rail transit vehicles with different types as shown in Table 3 Analysis results of various types of vehicles concluded that Rail Vehicles are as high as 7,677 units which is 73 percent of all vehicle types. Compared to the total of passenger serviced, the quantity of EMU passenger within urban area equal to 778 units or 7 percent, while the total quantity of electric trains owns by the State Railway of Thailand is 306 units or 3 percent. Figure 18 shows the distribution of rail vehicle quantities in Thailand.

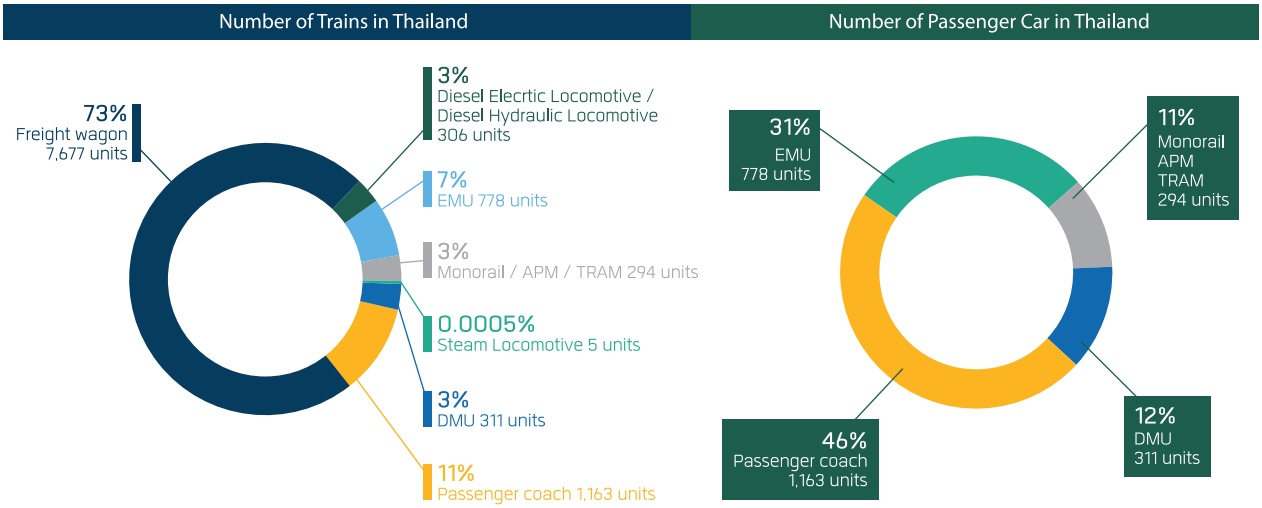

Figure 18 : Types and Quantities of Rail Vehicle Types Chart

• Service Life of rail vehicles in Thailand

From the data collected from the rail vehicles operators, the average service life of all types of rail vehicles is approximately 23 years. Vehicles from the Intercity and Commuter rails system that are owned by the State Railway of Thailand has an average service life of 30 years, while vehicles in the Urban Rail System have an average service life of 6 year. Service life information of rail vehicles are illustrated in Table 4, Figure 19 and Figure 20 shows the service life of each type of locomotive and DMU servicing the State Railway of Thailand.

Table 4 : Quantities of vehicles under Thai ownership

Vehicle Operator		Quantity (Vehicles)
Current Rail Vehicles in Service	State Railway of Thailand	
	• Passenger Train, freight wagon	9,462
	• EMU (Red Line)	130
	Bangkok Mass Transit System (BTS)	392
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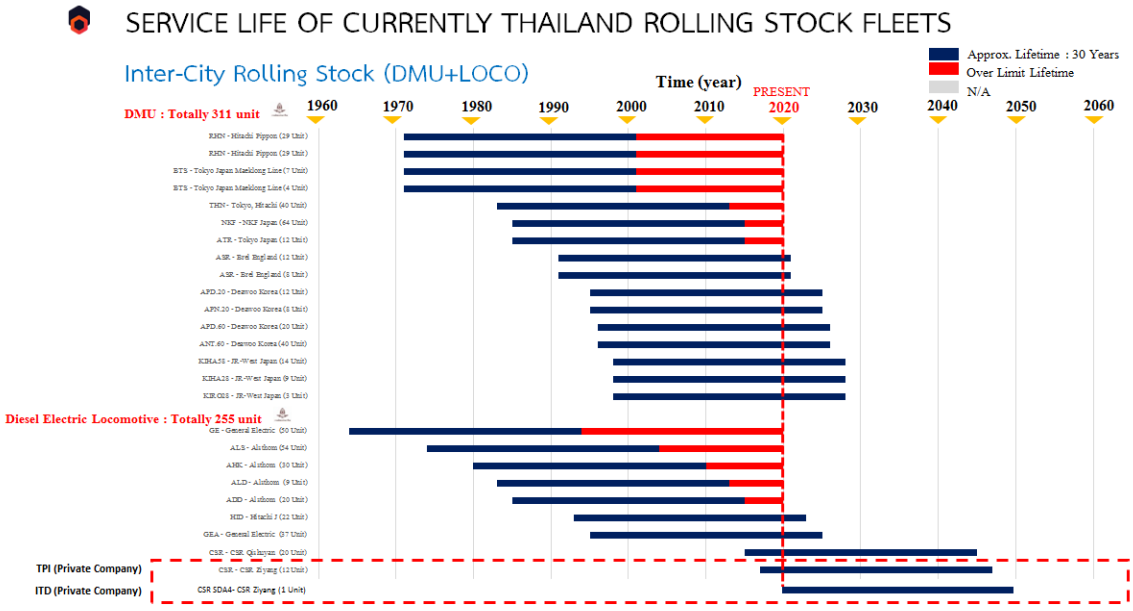


Figure 19 : Summary Chart of DMU Locomotive of the State Railway of Thailand

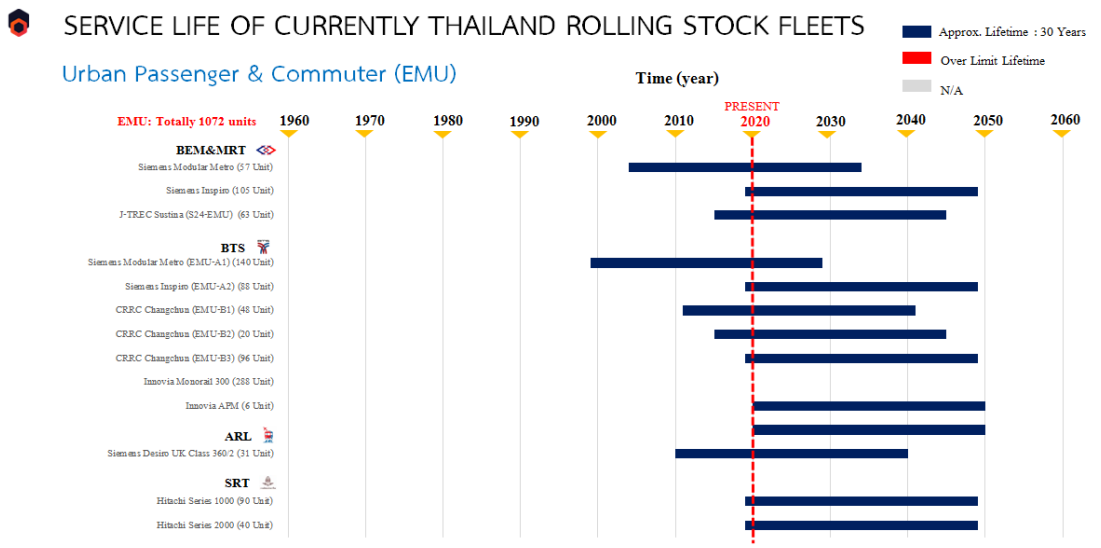


Figure 20 : Summary of Life in Service of EMU within the Metropolitan area of Bangkok

3.2 Significant Components of rail vehicles

- **Main components of Rail Vehicles**

Current design and manufacturing technologies have resulted in the development of various types of rail vehicle to meet specific needs. However, Rail Vehicles will have 3 main Subsystems as shown in Figure 21 and described as follows:

- **Structure, Running Gear and Suspension** which consists of Main Frame, Car Body, Bogie, Brake, Wheelset, Coupler, etc.
- **Mechanical & Electrical System** such as Doors and Windows, Toilet System, Lighting System, Air Conditioning System, Ventilation System, Pneumatic System, Traction, Car Exterior, Passenger Cabin, etc.
- **Control and Safety System** such as various types of control system related to operating rail vehicles, Driver Cab Layout, Fire Safety, Safety Devices, Emergency Situation Plan, etc..

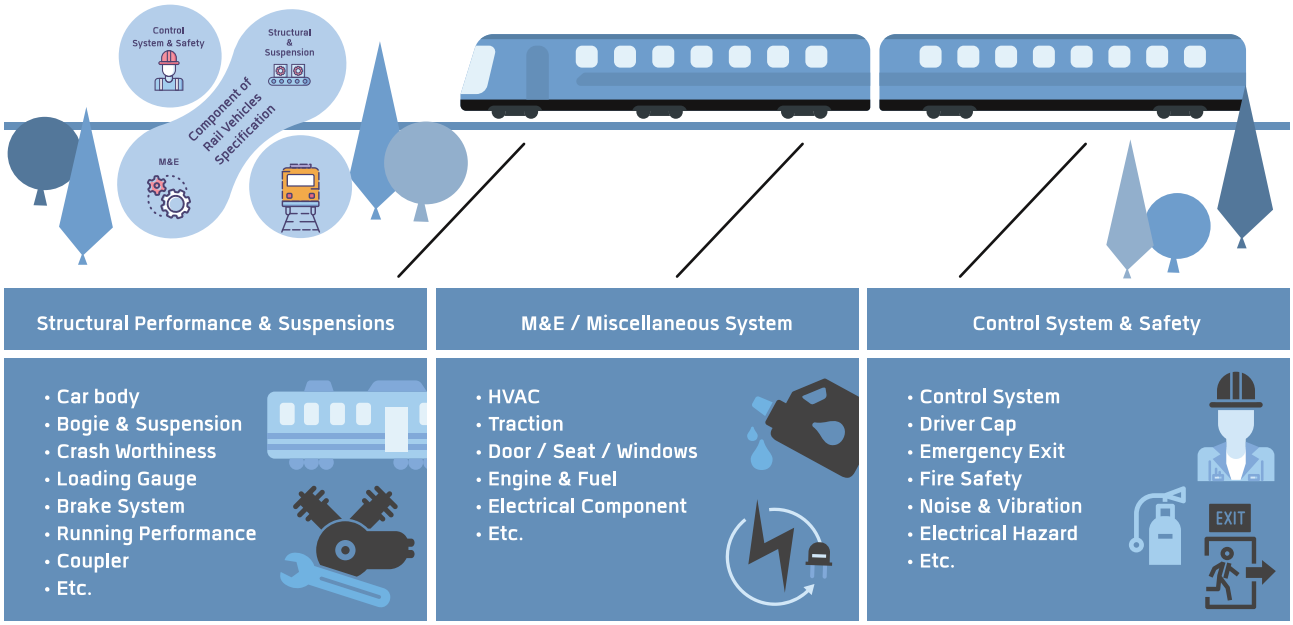


Figure 21 : Subsystems of Rail Vehicles Main Components

3.3 Establishing the Rail Vehicles Database

3.3.1 Specification of Rail Vehicles

Data on the Specification of Rail Vehicles were collected from applicable railway agencies in Thailand such as the State Railway of Thailand, Mass Rapid Transit Authority of Thailand, SRT Company Limited, Bangkok Mass Transit System Co. Ltd., Bangkok Expressway and Metro Public Co. Ltd., and projects under construction in order to establish a database consisting of all 7 types of rail vehicles shown in Figure 22 with detail example of the Airport Rail Link shown in Table 5. Details on the technical specification of all rail vehicles are organized and compiled in this report, while the General Specification are organized in the rail transport online website database.

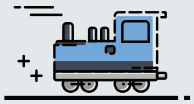
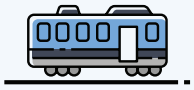
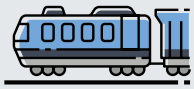
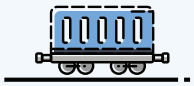
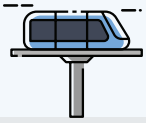
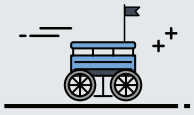
Number	Types of Rail Transport Vehicle	
1	Locomotive	
2	Passenger Coach	
3	Diesel Multiple Unit / DMU	
4	Freight Wagon	
5	Electric Multiple Unit / EMU	
6	Light Rail Vehicles	
7	Service Vehicles	

Figure 22 : Types of Rail Vehicles used in Thailand

Table 5 : Specification of Airport Rail Link Rail Vehicles

Airport Rail Link – Electric Multiple Unit								
Rail Authority	SRT	Network	Metro / Commuter	Rail Operation	SRTET	Status	Operating	
No.	Item		Specification	Regulation/ Standard Reference	Remarks			
1	Type of Rolling Stock		EMU					
2	Model		Siemens Desiro					
3	General		– Seat: 150 seat (City Train), 170 seat (Express Train) – Standing places 6 person/sq.m. : 595 (City Train), 343 (Express Train) – Total : 745 (City Train), 513 (Express Train)					
4	Dimensions	Length (mm)	19,700/20,000					
		Width (mm)	2,796.00					
		Height (mm)	4,200.00					
5	Weight	Tare Load	– Maximum Weight per car (AW0) : 43.4 t	EN 15663 : Railway applicattions– Definition of train reference masses				
		Full Load (kg)	64,000.00					
		Maximum Axle Load	– Axle load at AW4, exceptional load :16.0 t (all seats occupied and 10 persons/m^2) – Maximum Axle load:16.5 t					

3.3.2 Rail Vehicles Website Database

The Rail Vehicles Website Database was created a centralized online platform with information related to rail transit in Thailand. This includes current rail vehicle in service and potential future rail projects as well as terminologies that would make these information more easily accessible through the internet. Examples of the website database are shown in Figure 23 and Figure 24

Figure 23 : Sample Front Page of the Rail Vehicles Website Database

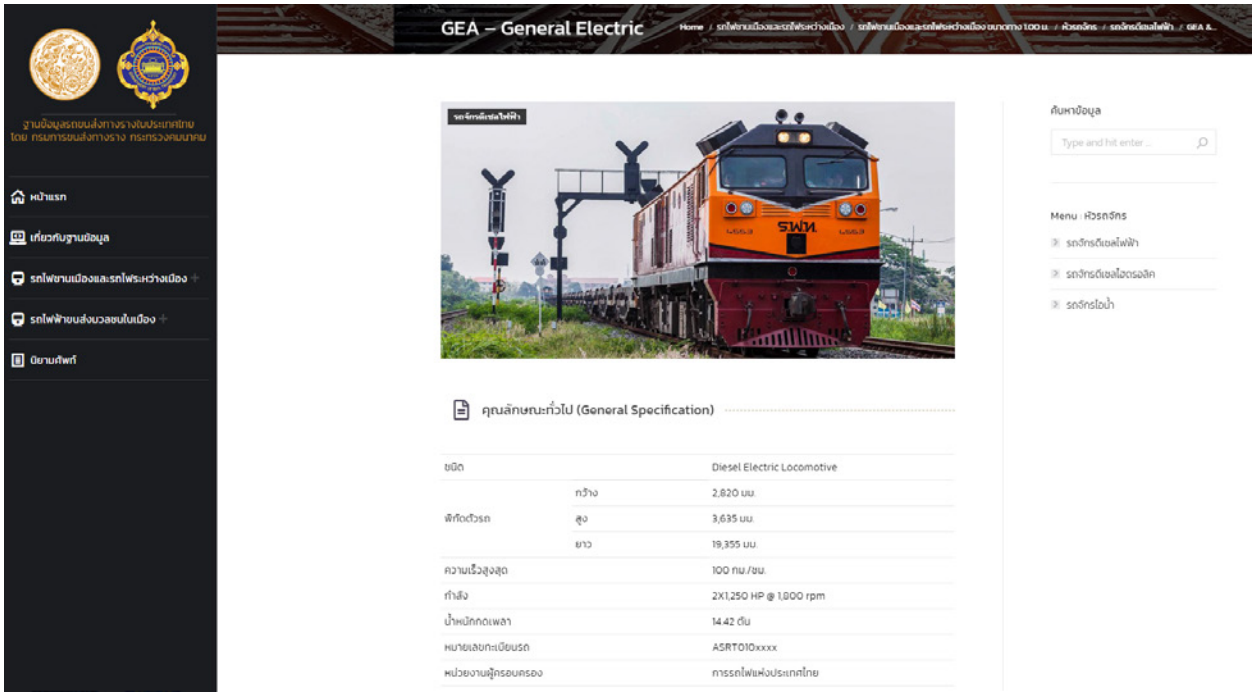


Figure 24 : Sample Specification of Locomotive Model GEA from the Rail Vehicles Website Database

04

Risk Assessment Process and Results

4.1 Risk Assessment and Evaluation of Rail Vehicles Failures

In this study, the risks of unexpected failures occurring due to Rail Vehicles components are identified, analyzed and evaluated. The Rail Vehicles components which are critical to the safety of rail vehicles such as Brake system, Coupler, Door, Bogie / Wheelset / Wheel and others are evaluated in order to be specified in the subordinate legislation and technical specification of rail vehicles as mentioned in the next chapter.

The railway risk assessment and evaluation in this study applied Hazard Identification (HI) method in conjunction with Failure Mode Effect Analysis (FMEA). Starting from, the cause and effect of 7 main hazard events due to rail vehicles components are analyzed by considering a total of 249 rail vehicles sub components, which are categorized under 30 main systems. Then, the 30 main systems are evaluated and ranked by considering input from international experts. The top 19 components are identified and ranked by level of risk score that could cause serious incidents and service disruption.

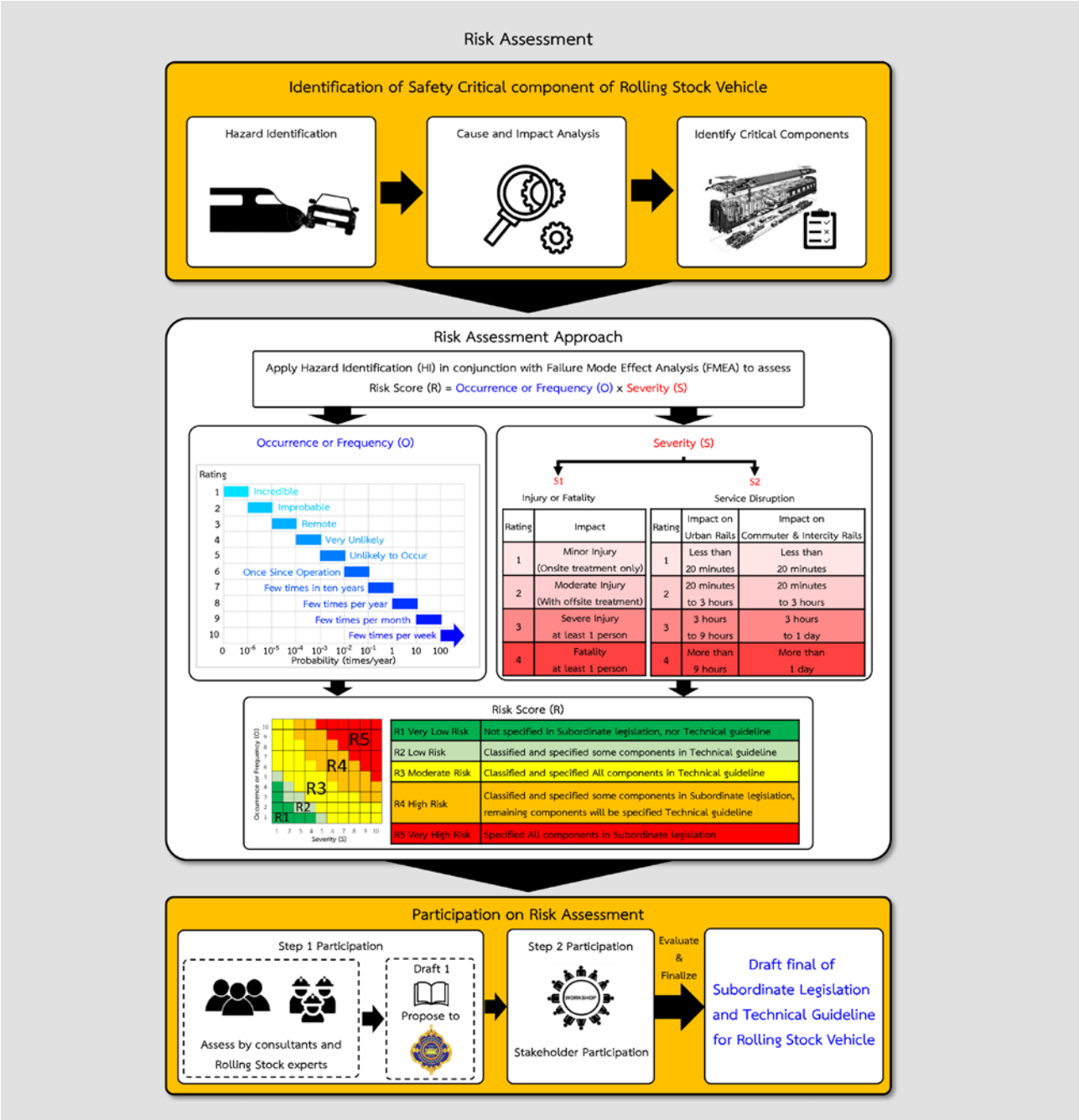


Figure 25 : Risk Assessment Approach and Process to evaluate the critical rail vehicles components to be specified in the subordinate legislation

Experts then took the 19 rail vehicles components to conduct a risk assessment by industry experts in railway operations i.e. SRT, MRTA, SRTET, BTS, BEM, Eastern High-Speed Rail Linking Three Airports Co., Ltd. by evaluating the frequency (Occurrence) and Severity. That if the component is damaged or disrupted, then it may primarily affect safety for rail operation. The risk score is calculated based on occurrence and severity level. With results from analysis by both internal and external experts, inputs from international railway experts with consideration of ministerial regulations and the technical rail vehicles guidelines of foreign countries such as Japan, Australia, and Switzerland, This study indicate the ranking of 19 components as shown in Table 6.

Table 6 : Summary of 19 major rail vehicles components

Rank	Rail Vehicles Components
1	Bogie / Wheelset / Wheel
2	Brake system
3	Fire Safety
4	Train control system
5	Vehicle superstructure / Crashworthiness / Joint and Welding
6	Doors & Windows
7	Running behavior & Aerodynamics
8	Cab operation / Driver-machine interface
9	Safety devices
10	Electrical system / Lighting
11	Coupler / Draw & Buffer gear
12	Dimensions & Loading Gauge
13	Concept for faults, accidents and emergency situation
14	Traction system
15	Diesel Engine & Component
16	Energy supply & Current collector
17	HVAC (Heating, Ventilation and Air Conditioning system)
18	Test required (loading, guage compatibility / running performance)
19	Miscellaneous (seat, camera etc.)

However, if considering the possibility of costs and the impact on the domestic service providers, the 1st to 13th set of components are identified as the most critical components that when damaged contribute the most impact on railway safety and service disruption. These top 13 components will be specified in the Ministerial Regulation, while the technical specification guideline will include all 19 rail vehicles components to serve as a reference for the Ministerial Regulation and as a recommended standard.

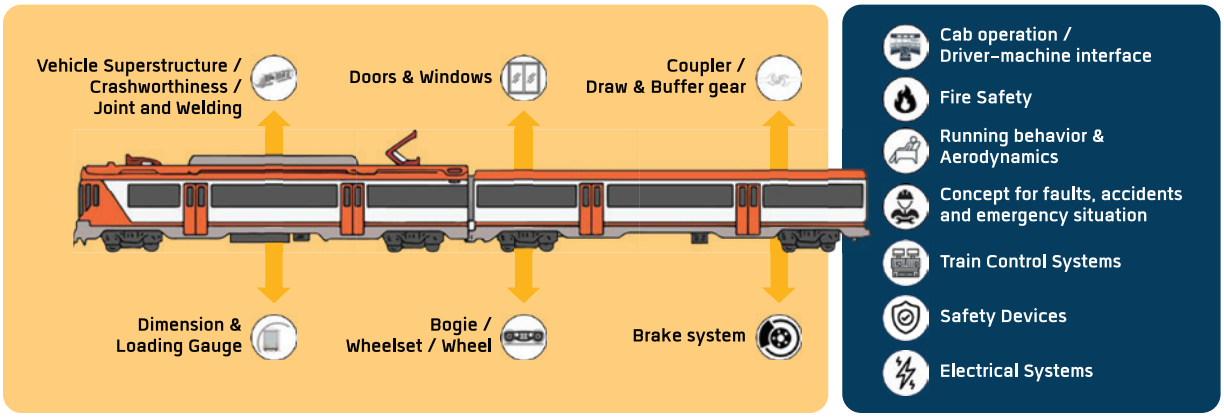


Figure 26 : Critical Subsystems on Safety of Rail Vehicles

4.2 Challenges

• Lack of guidelines for data collection and database building as a centralized system

Currently, the information is stored by various rail operators e.g. BTS, BEM or the responsible agencies and submitted to relevant regulatory agencies such as Bangkok Thanakom or the Department of Rail Transport. Such data reports are not centralized, not officially established in standardized database. As a result, the analysis of Thailand's rail vehicles system is not possible or reveal its useful. In other leading countries such as the United States, Europe, the Netherlands and Japan, there is a central agency responsible for developing a database system, managing data storage process, maintaining data and analyzing statistical regular reports for daily, monthly and yearly. This lead ability of being analyze root cause, impact and even predictions for incidents and plan for preventive maintenance.

• Establish an agency responsible for the provision of statistics, reference values and forecast analysis (Safety Data & Reporting Dashboard)

Stats based on interests (shown in Figures 26), such as

- Train Accident / Incident Count and Rates
- Train Accident Trend - Summary statistics / Charts & Graphs
- Train Accident by Groups / Lines (type of railway), sort by type of accidents, by Primary cause of Accidents, by time etc.
- Railroad Safety Statistics Report - Annual report

05

Techniques to Reduce Effect of Rail Vehicles on Track Deterioration

The main factor from rail vehicles that affects the deterioration of railway track include Axle Load, Speed, Suspension Characteristics, Running Behavior, Brake and Acceleration characteristics, Tonage, and Wheel-Rail Interaction as shown in Figure 27

Nevertheless, the efforts to reduce impact on rail track deterioration works in conjunction with both the rail vehicles and the track, since both components affect one another (train-track interaction) while the train is in motion. Therefore, the method or technique used to reduce the track deterioration will include actions involving both vehicle and the rail way as described herein:

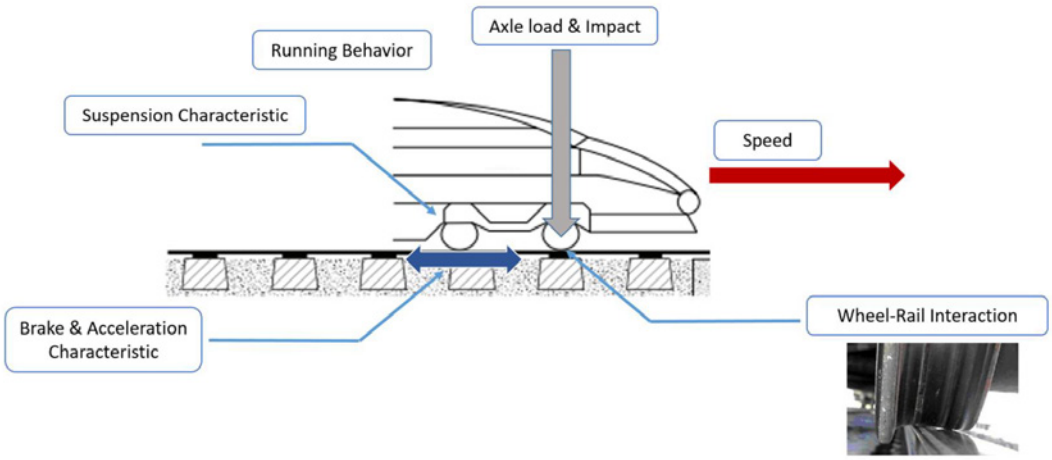


Figure 27 : The parameters influenced to track and rail deterioration

• **Maintaining good track conditions** by measuring and estimating any track irregularity as well as inspect various parts of the track such as turnout, the track, fastener, sleeper, the ballast rock, etc. (shown in Figures 28)

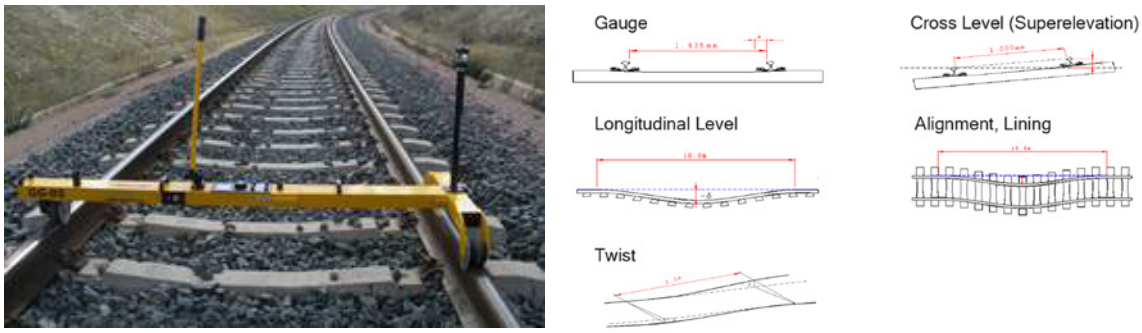


Figure 28 : *Left)* **Example Instruments Used in Track Irregularity Measurements,** *Right)* **Example of track irregularities**

• **Rail grinding** is used to maintain smooth surface of the track and reduce issues stem from roughness regarding short wavelength / corrugation which occurs when the train passes causing vibration with high frequency and resulting in jolting and noise that is higher than usual as illustrated on Figures 29.

Figure 29 : *Left)* **Short wave corrugation on the Rail Surface,** *Right)* **Example of Rail Grinding Tool**

• **Maintaining good wheel conditions** by inspecting wheel profile and mitigate irregularities such as wheel flat, etc. (shown in Figures 30)

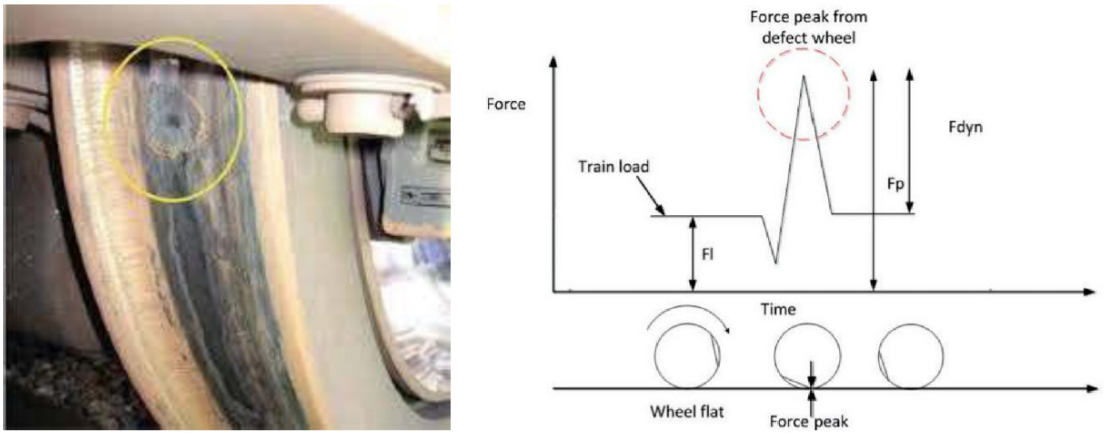


Figure 30 : *Left)* **Wheel Flat Damages,** *Right)* **Impact arise due to wheel flat**

• **Wheel Slide Protection – WSP** is a system, when the vehicle accelerate and decelerate, helps prevent the wheel from skidding on the track, preventing damages to the wheel and the track surfaces. The protection system consists of all level of complexity of tools from basic system with sandblasting to electrical technology that measures the speed in each wheel and control the oscillation of each wheel by evaluating with a computer. Most rail vehicles in the present will have a protection system installed with testing during handover.

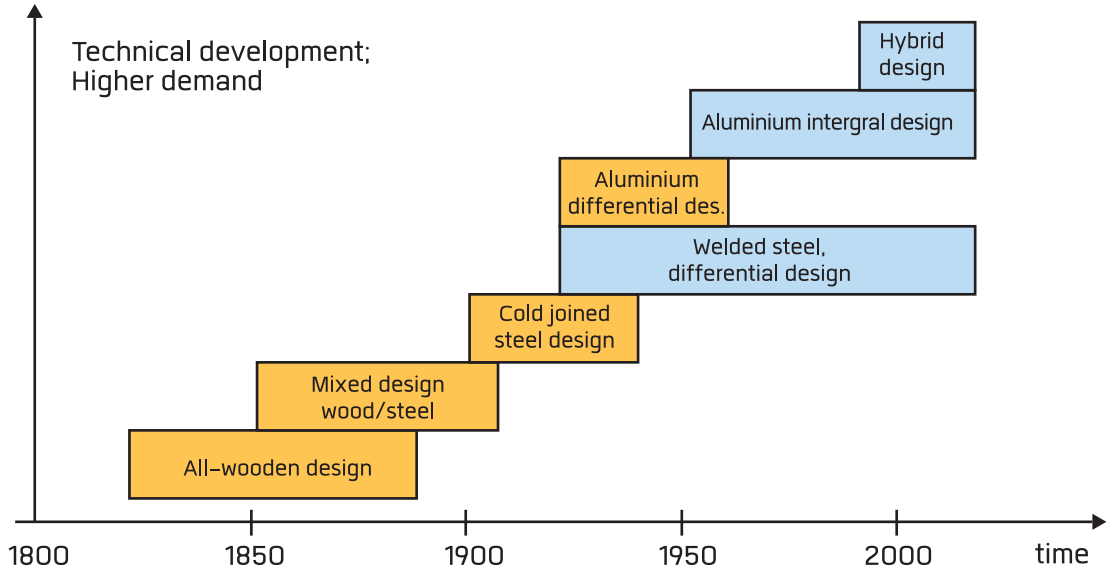
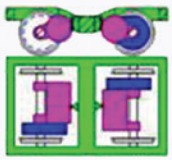
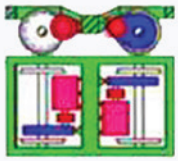
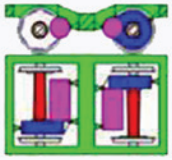


Figure 31 : The Evolution of Construction Materials used in Rail Vehicles Car–Body Production

PRINCIPLE

Name	Nose-suspended	Semi-suspended	Fully-suspended
Mounting characteristics	Motor riding the axle with bearing. Third connection point on the bogie middle beam.	Motor suspended on the bogie middle beam. Gear riding the axle. Coupling connecting both.	Drive fully supported on the bogie frame. Hollow shaft compensating the relative movement.
Typical application	Locomotives	Locomotives operating at higher speeds,passenger train with distributed power.	High-speed trains
Unsprung part of total drive moss	85%	20%	5%

Figure 32 : Design Differences in Traction Systems and Bogie that Affects Unsprung Mass

- **Design to reduce total train weight and unsprung mass** combines the technology with research for rail vehicle design that are lightweight but has adequate strength applying concepts of structural optimization and composite materials (Figure 31). Furthermore, research on suspended components to reduce unsprung mass can effectively lower the load between the wheels and the rails. (Figures 32 and Figures 33)

- **Optimization of Suspension Characteristic** were analyzed and designed to reduce damages of the wheel and rail caused by suspension behaviors. The suspension elements are designed to have suitable features for its application. For example, the use of urban rail may not require high speed but will require the ability to safely run on low radius curves. These designs will vary in suspension behaviors and various Bogie specification where objective values such as wheel-rail contact forces, wear and rolling contact fatigue are tested.

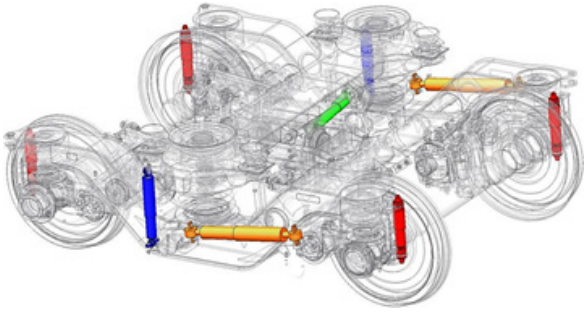


Figure 33 : Example Suspension Elements of Rail Vehicles

• **Optimization of Wheel & Rail Profiles.** There are various factors involved such as the axle load, speed, physical characteristics and rail conditions, suspension behaviors. During the design, targeted values will be specified such as critical speed, wear or rolling contact fatigue reduction, minimizing the possibility of derailment around the turnout regions. Figure 34 shows the crossing profile optimization to reduce impact on the nose.

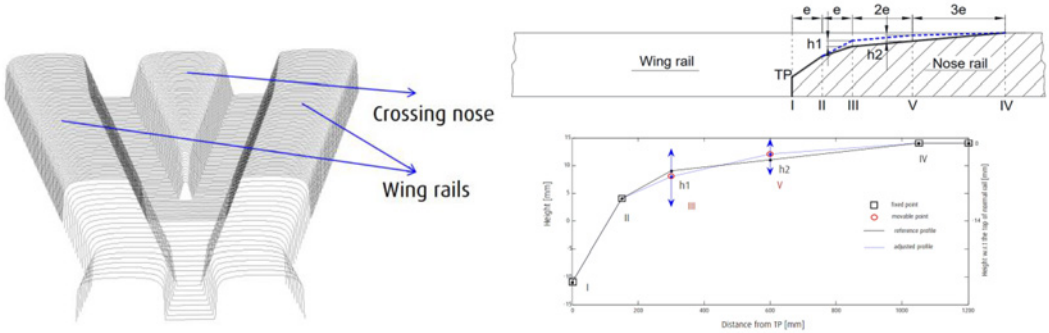


Figure 34 : Example of Crossing Nose Optimization to Reduce Impact Force

• **Track supporting structures** can be classified into ground supporting track, tunnel, and bridge. Such areas, called “Transition Zone” as illustrated on Figures 35 which has different structural properties, a discontinuity and stiffness occurs under the rail. This area can be found in joints between a ground railway, entrance to a tunnel or a bridge, etc. The issues arising from the impact between wheel and rail due to differential deflection of the running surface. This can be fixed by various techniques including auxiliary rails, approach slab, elastic elements and ballast bonding. (shown in Figures 36 and 37)

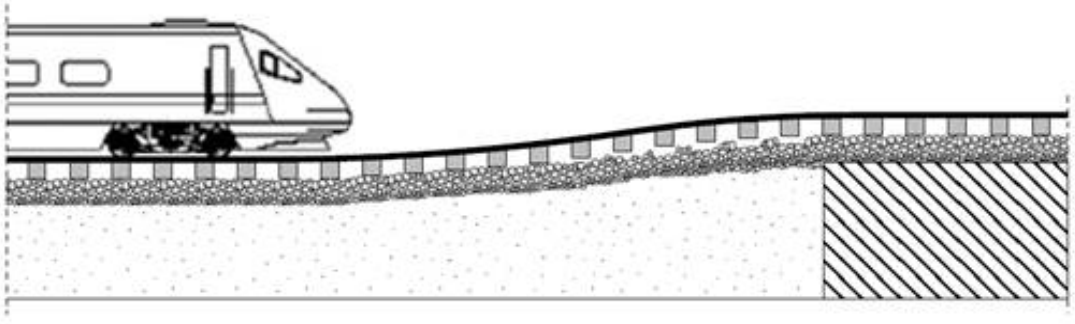


Figure 35 : Example of a Transition Zone between the Ground and a Bridge

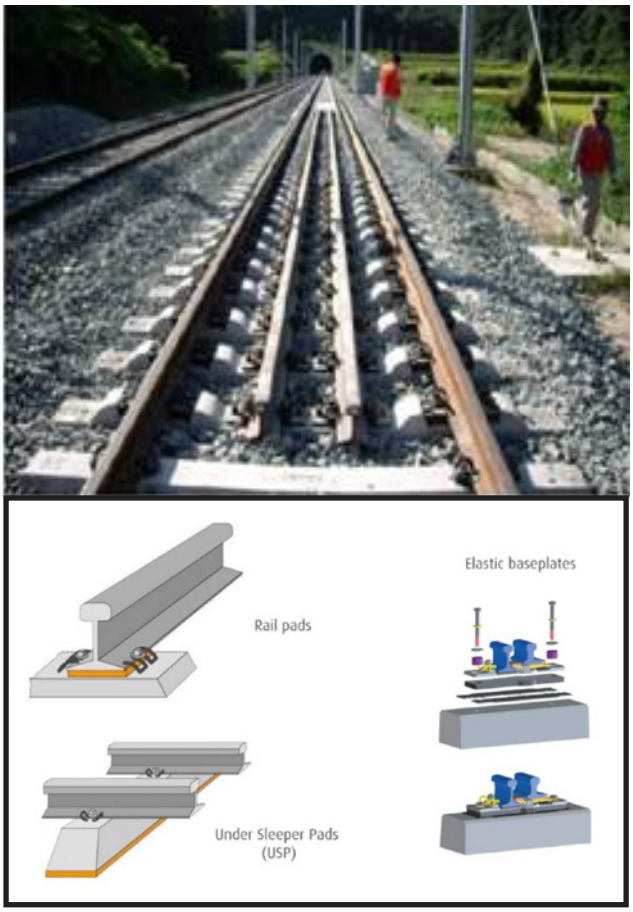


Figure 36 :
Example of Transition Zone Improvement :
Left) Installation of Auxiliary Rails
Right) Application of Elastic Elements

Figure 37 :
Example Transition Zone Improvement by Injecting a Binder to the Ballast Layer

• **Controlling the train–bridge interaction,** a result of resonance when the rail vehicles runs over the bridge, which can be a significant impact when the bridge is required to accommodate high speed rails (above 200 kilometer per hour) which is the typical speed of current high speed train operations. This solution requires designs to control the train-bridge interaction phenomena as well as monitoring and control the actual train-bridge interaction in during service as illustrated on Figures 38.

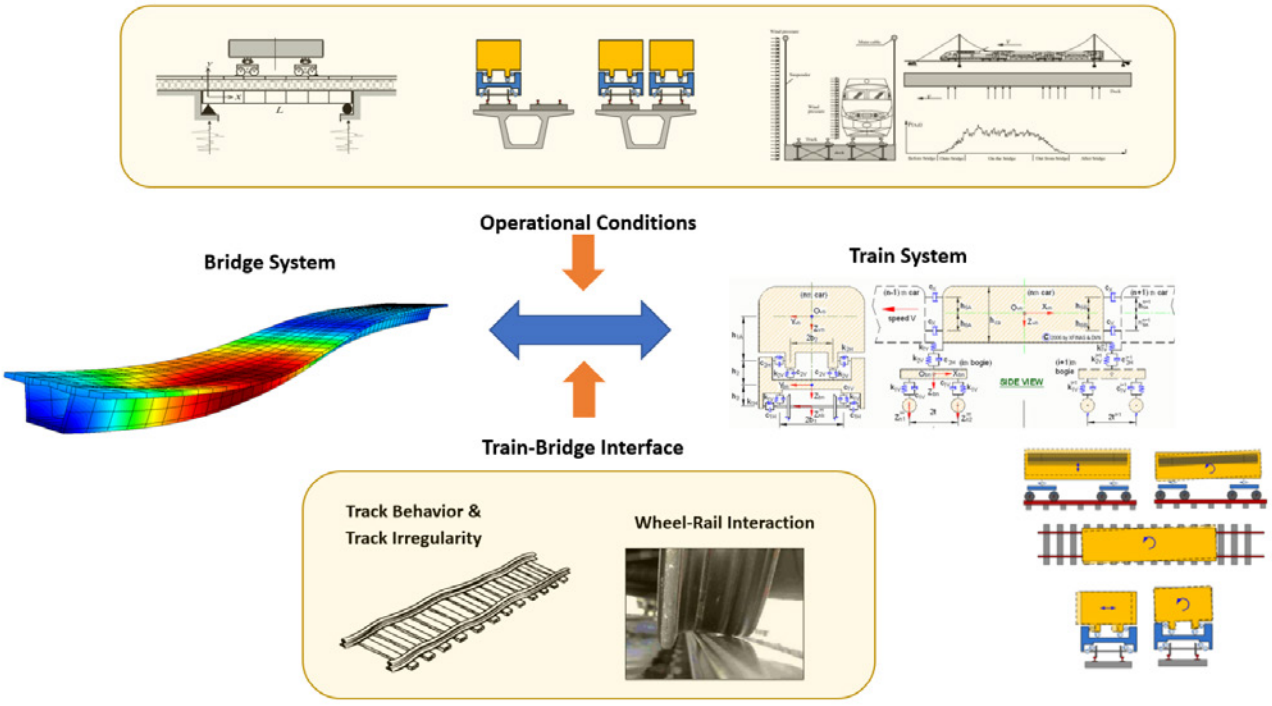


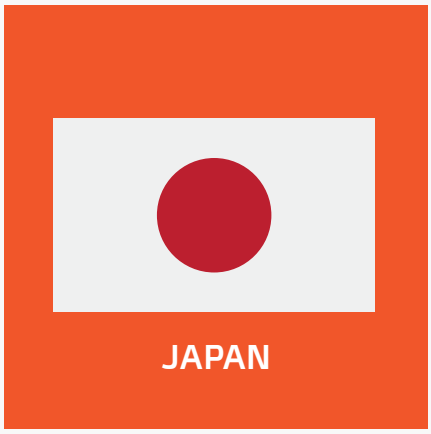
Figure 38 : Train–Bridge Interaction

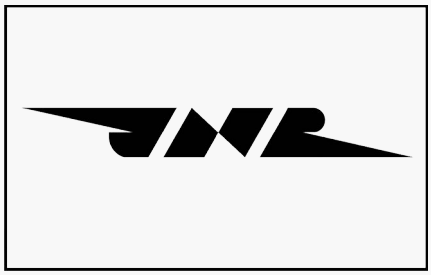
06

Registration of rail vehicles abroad and registration guidelines in Thailand

6.1 International rail vehicles registration

The registration of rail vehicles in a foreign country requires consideration of the relevant authorities in the process of registration and issuing registration numbers. Regulatory structures of those international countries, which can be observed by the differences or similarities, including the format of the registration number will be used as a guideline in determining the registration number for Thailand. This study targets to study the registration of rail vehicles in 4 countries, which are Japan, USA, Australia and the People's Republic of China with details as follows





6.1.1 Registration and Related Documentation of Rail Vehicles in Japan

Key agencies that are responsible for registration and administration of related documents for rail operations in Japan include the Minister of Land, Infrastructure, Transport and Tourism (MLIT), Japanese National Railway (JNR), and private companies such as Japan Railway (JR), or Japan Transport Engineering Company (JTREC). Each entity has different roles and duties where the MLIT is responsible for issuing the Ministry ordinance and Technical regulatory for private companies to use as reference for the registration process. Private companies will have to notify MLIT of any construction of a new rail way. The registration license number for each rail vehicle will depend on the type of train using certain numerical codes to indicate the train's technical characteristics of that type of train.

6.1.2 Registration and related Documentation of Rail Vehicles in the United States

Agencies that are responsible for registration and administration of related documents of rail operations in the United States include the Federal Railroad Administration (FRA), Association of American Railroads (AAR), American Public Transportation Association (APTA), and the private agency Railinc Corporation which has different roles and responsibilities. According to the regulatory structure, the FRA will issue the Regulation, while the AAR and APTA will issue the standards and recommendations that comply with the FRA's regulations, and the AAR will oversee registration.

The registration numbering process for rail vehicles in the United States uses the "Reporting Mark" system, formally known as "A Standard Carrier Alpha Code (SCAC)." Under the "Reporting Mark" system, the private agency, Railinc, will mark each train with four capital letters. This will be done in compliance to AAR's standards of assigning the initials of the train attendant as the four letters. This applies to all types of trains and includes freight wagons, which will have the owner's own train number. Trains that will share the same rail with other routes must also be marked with numbers.

In most cases, the train marking letters will be an abbreviation of the company name that owns the train. In the event of a merger of the company, the same numbers can still be used. Currently, there are over 4,000 markers registered for trains.

6.1.3 Registration and Administration of relevant documents of rail operations in Australia

Since Australia's rail network covers a vast area and crosses over state lines, many challenges usually arises between multiple stakeholders. Therefore, in 1990, the Chamber of Commerce and local government formed an agreement for a standard interstate rail transport. In 1997, the Australian Rail Track Corporation (ARTC) was established as a public organization under the Public Governance, Performance and Accountability Act 2013 section 5 (2) to manage the interstate standard gauge rail transport extending over 8,500 kilometers. In addition, ARTC supervises construction and maintenance of rail cargo routes in compliance to safety standards.

To achieve a mutual agreement on safety standards, The Australian Railway Association (ARR) established the "Code Management Company" in 2003, which later became the Rail Industry Safety and Standards Board (RISSB) in 2007. The RISSB is responsible for developing common requirements, practices, and standards that promote rail operations to be safe and efficient.

The registration number for trains in Australia is categorized as passenger train and cargo train. Passenger trains are assigned Base Code Letters that identifies the different classes of passenger trains.

中国铁路总公司
CHINA RAILWAY

中国中车
CRRC

6.1.4 Registration and related documentation of Rail Vehicles in the People's Republic of China

Key agencies involved in registrations and administration of related documents of Rail Vehicles in the People's Republic of China includes Ministry of Transport MOT, National Railway Administration (NRA), China Railway Company (CR), and China Railway Rollingstock Company (CRRC). According to regulatory structure, Registrations are maintained under the NRA and MOT. All companies manufacturing rail vehicles are required to apply for registration with the NRA for each rail vehicle. Registration numbers for rail trains are prepared by NRA to classify and number rail transport trains in the country. The Department of Railways will process requests for rail vehicles registration where each vehicle is classified by using English capital letters.

In summary, registration of rail vehicles is processed by private agencies in Australia, USA and Japan, while registration is processed by the public agencies in the People's Republic of China. Each country also has different formats for registration number: submitting a registration number by the owner of the rail train (USA), assigning registration number by classification of rail train type (Australia and the People's Republic of China), or designating numbers to indicate technical characteristics of each type of rail transport vehicle, such as the number of axles, axle press weight Maximum speed, etc. (Japan).

6.1.5 Registrations and related documentation of Rail Vehicles in European Union Countries

Several European Union (EU) countries are the world's leading developers of rail technology including rail transport for international boarder transfer. However, within the EU countries there are different requirements for rail design and operation, such as 5 different electrical systems, 21 different signaling systems, up to 5 different rail sizes, etc., making the interconnection of different rail systems in the region a challenging issue. In the past decade, the EU has made efforts to create an a Harmonization of Railway System. The EU has established an agency called the European Railway Agency (ERA) in 2004 with the main function of creating a common regulations and requirements. In this regard, the Central Interoperability Directive, Technical Specifications for Interoperability (TSI), has been established for the European Union's auditing, certification and registration of accounts.

• The European Railway Agency (ERA) is responsible for developing and updating Technical Specification of Interoperability (TSIs).

• The European Commission (EC) is responsible for ensuring that trains shared in the European Union meet the requirements of TSIs by establishing the NB-Rail Coordination Group to coordinate with the independent authorities (NoBos) for inspection, examinating and assessing the condition of the train.

• Notified Bodies (NoBos) is a third-party independent agency with expertise, tools and knowledge to conduct inspections and assess train characteristics. The agency will work with operators and manufacturers to inspect components and parts, and then report back to the European Commission NB-Rail group. The vehicle registration is shown in Figure 39

The registration number is assigned by the ERA and the registration format is shown in the Figure 40 where the vehicle identification number (European Vehicle Number, EVN) and the vehicle owner code (Vehicle Keeper Number, VKM) will be issued.

6.2 Guidelines for the registration of rail vehicles in Thailand

In Thailand, Rail Vehicles registration number are currently assigned by the vehicle owner or operator. Due to lack of existing regulations and enforcers, Thailand has never had laws that require owners or operators to register their rail vehicles before. The results of this study suggests that the rail vehicles bill should be drafted to set ministerial regulations and requirements for characteristics of Rail Vehicles to be registered, including Inspection procedures, and Registration number designation as shown in Figures 41 and 42. From this study, the consultanthas prepared a draft ministerial regulation stipulating registration standards, draft ministerial regulations prescribing registration conditions as well as draft standards for rail vehicles characteristics for the Department of Rail Transport.

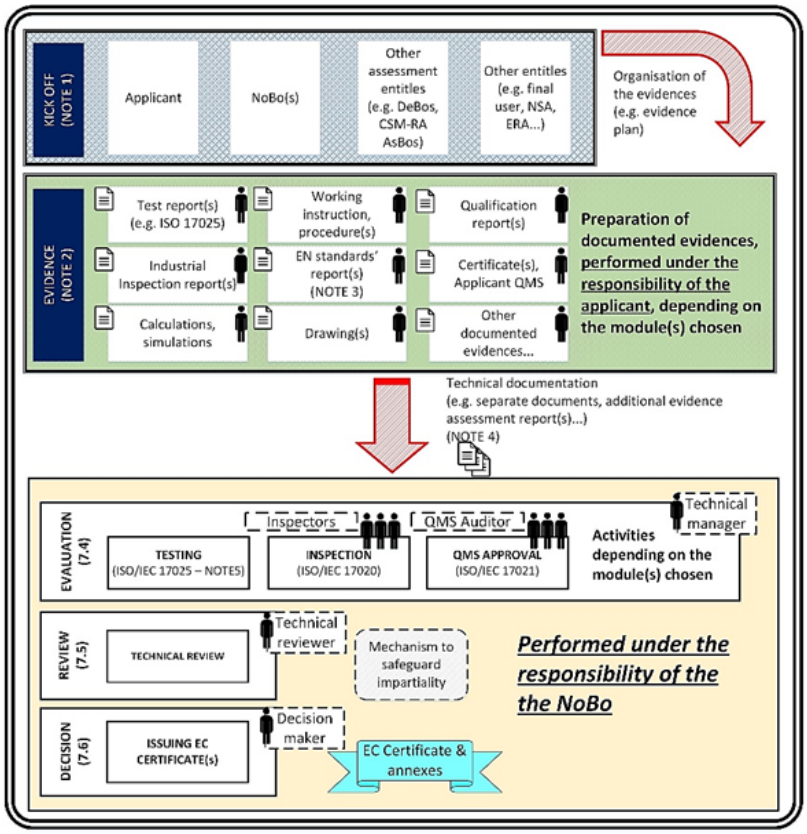


Figure 39 : Procedures for Rail Vehicles Registration in Europe

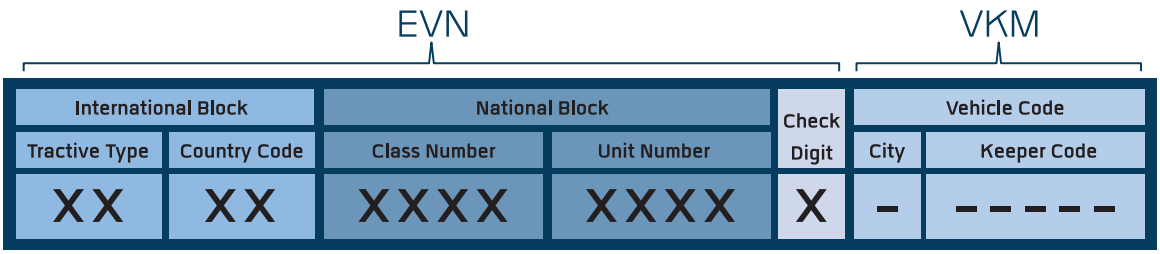


Figure 40 : Rail Vehicle Registration Code in Europe

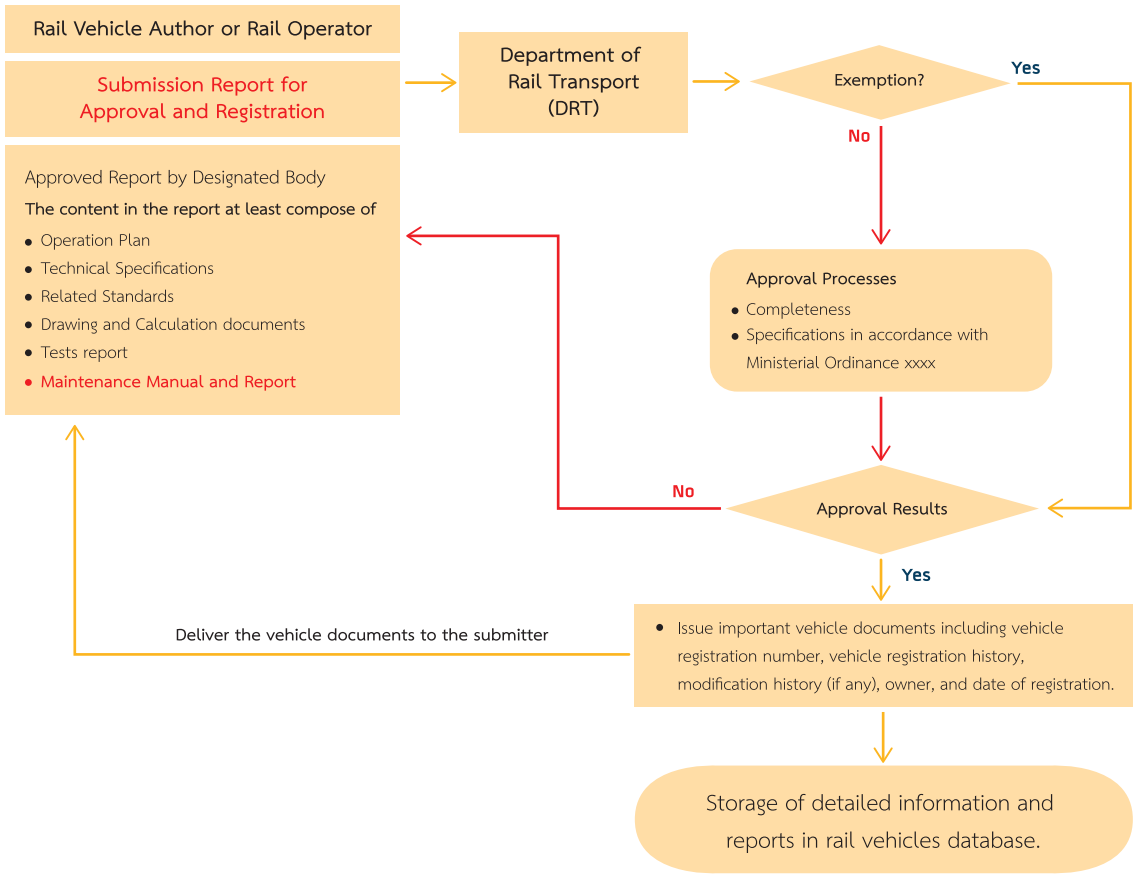


Figure 41 : Procedures for Rail Vehicles Inspection for Registration

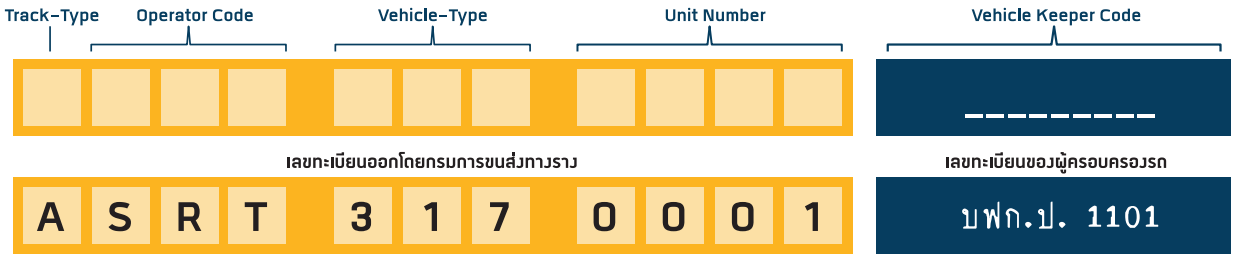


Figure 42 : Example Rail Vehicles Registration Number Designation

07

Summary of the ministerial regulation for rail vehicles registration in Thailand

In the rail transportation operation business, operators can be divided into 2 groups: 1. The former entrepreneur who has status as a state-owned enterprise (e.g. the State Railway of Thailand) and 2. private organizations. According to the Rail Transport Act established in [YEAR], Article 49 specifies three types of rail transport business licenses as follows:

(1) License to conduct rail transport business Category One
(2) License to conduct rail transport business Category Two
(3) License to conduct rail transport business Category Three

The types of license specified in the current draft rail transport bill (17/08/2020) was amended from the original draft (02/2020). Originally specified in Article 44, there are three types of rail transport business licenses:

(1) License to conduct business for rail transportation
(2) License to conduct business for rail transport operations
(3) License to conduct business for rail transportation and rail transport operations.

Application for a license to conduct business in rail transport business under the Rail Transport Act [YEAR] only applies to the private businesses, while state-owned enterprises are exempted from obtaining a license.

Inspection, Certification and the registration procedures for rail vehicles applies to the rail transport business Types 2 and 3 (i.e. business for rail transport operations, and business for rail transportation and rail transport operation. Business enterprises within Types 2 and 3 are required by law to register Rail Vehicles that will be used.

Considering the current draft law under review, there are no requirements set for the registration of Rail Vehicles, including requirements on inspections or conditions of Rail Vehicles. To establish standard certification, the Consultant recommends amending the Rail Transport Act on the following issues to ensure the safe and standardized rail transport operation:

The draft Rail Transport Act [YEAR] tasked the Department of Rail Transportation Article 15(7) to prepare standards business operations for rail vehicles to be presented to the committee as described as follow:

1) Setting standard specifications for Rail Vehicles to be used in rail transport, including engine, number of seats, load or method of loading;
2) Setting requirements for characteristics, important documents of Rail Vehicles or scheduled maintenance.

The Department of Rail Transport therefore is authorized to prepare standards and specifications that will be proposed to the Committee and the Minister to later develop into Ministerial Regulations. Considering the current draft provisions, the Act required a standardized rail vehicles and official documents in the form of a ministerial

regulation. However, the Act does not stipulate that the registration (the registration should be regarded as an important vehicle document) has a compulsory nature, that is, under this bill, registration is not required as a condition for conducting rail transport business.

If the registration is to be made compulsory for rail transport businesses, then it is necessary to include a section on the registration of Rail Vehicles specifically in the Act, as seen in laws regarding other types of vehicles, whether it is the Air Navigation Act 1954 or the Vehicle Act 1979, etc. The Consultant prepared a draft law for additional matters as follows:

1. Give the Minister authority to stipulate registration conditions in Article 7C (...) by adding this statement: "Set the conditions, characteristics and standards for Rail Vehicles that can be registered"

2. Add section xx on the registration of Rail Vehicles with the following Article

Article ... Licensees are prohibited from operating or using any unregistered Rail Vehicles for the operation of rail transport business.

Article ... Anyone who wish to register the rail vehicles must process the registration form to the registrar

The request of rail vehicles reglistration and rail vehicles documents must process by the rule of rail transport Director General

Article ... Rail Vehicles must have qualifications below:

(1) Specification by ministerial regulations

(2) Approved by certify body under the permission from rail transport Director General

Article ... Rail Vehicles list below are exempt from registration

(1) .....

(2) .....

Article ... The owner of rail infrastructure must process the information of Rail Vehicles belong to foreign State that operate in Thailand

Article ... Registered Rail Vehicles must carry and show their registration plates according to the rule of rail transport Director General

3. Registration methods and procedures for Rail Vehicles will comply the Department of Rail Transport Regulations.

4. Add provisions related to rail vehicles certification authorize the General Director of the Rail Transport Department to appoint an agency / institution responsible for inspection, as defined in Article 15 (...)

The structure of the legal and secondary legal system for the registration and certification of rail vehicles can be described as a diagram as shown on Figures 43 and 44.

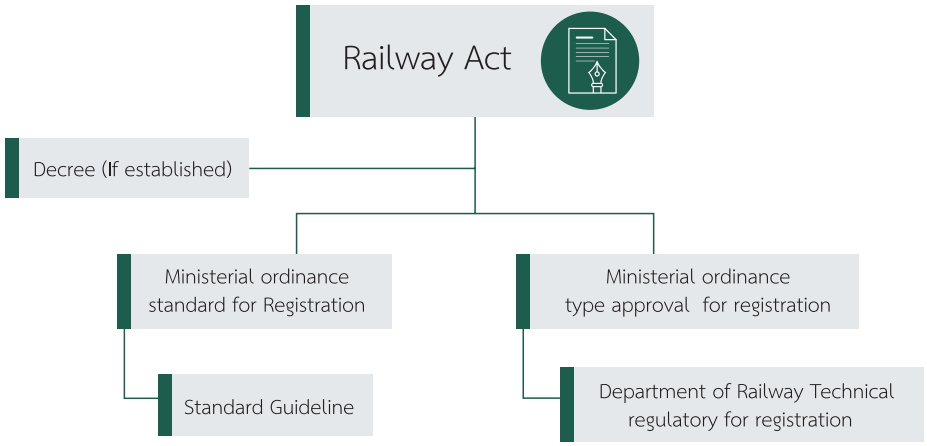


Figure 43 : Diagram of Registration Process

However, the consultant has also proposed guidelines for registration in addition to amendments to the provisions of the Rail Transport Act, including: make vehicle registration a condition in conjunction with rail transport business license, issue relevant Ministerial Regulation on certification and licensing as part of one procedure, and it shall be the duty of the Department of Rail Transport in assigning the registration number without the need for the operator to make a request.

The guidelines described above are be simple for the business owner since the owner will only need to process once. However, upon further evaluation, it was found that government agencies will be exempted from licenses. As a result, the registration will be waived by default.

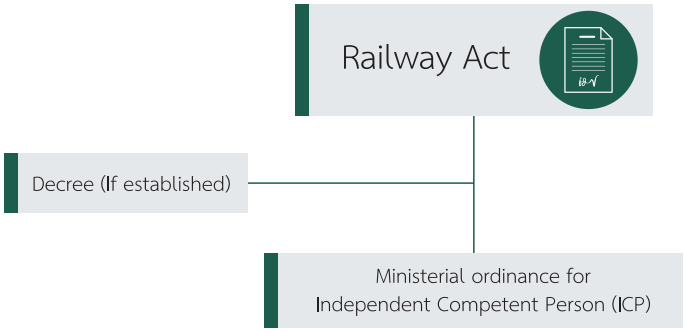


Figure 44 : Diagram showing Registration Process without Amendments to the Master Law

The consultant found that the suitable registration guideline for Rail Vehicles is the first method, where Amendments are made to the draft master law. Since the draft Rail Transport Bill is still under review by the Council of State, amendments can be made without interfering with the legislative process, improving the Master Law to be more comprehensive and clearer.

08

Summary of the guideline specifications for rail vehicles in Thailand

Today's design and manufacturing technology has resulted in the development of various types of Rail Vehicles to meet the needs of increasing applications. Each type of rail vehicles has different components depending on purpose of use as shown in Figures 45. However, for the purpose of simplicity, the rail vehicle components can be classified into three categories as follows:

1 **Structural, Running gear and Suspension**
consists of the main frame, car body, bogie, brake, wheelset and coupler, etc.

2 **Mechanical and electrical systems in trains (M&E system)**
such as doors & windows, toilet systems, lighting systems, air conditioning systems, ventilation systems Pneumatic system, traction system, outside the train (car exterior), passenger cabin, etc.

3 **Control and Safety system**
Control and Safety system such as various control systems about the Driver cab layout, Fire Safety, Safety devices, Emergency situation plan, etc.

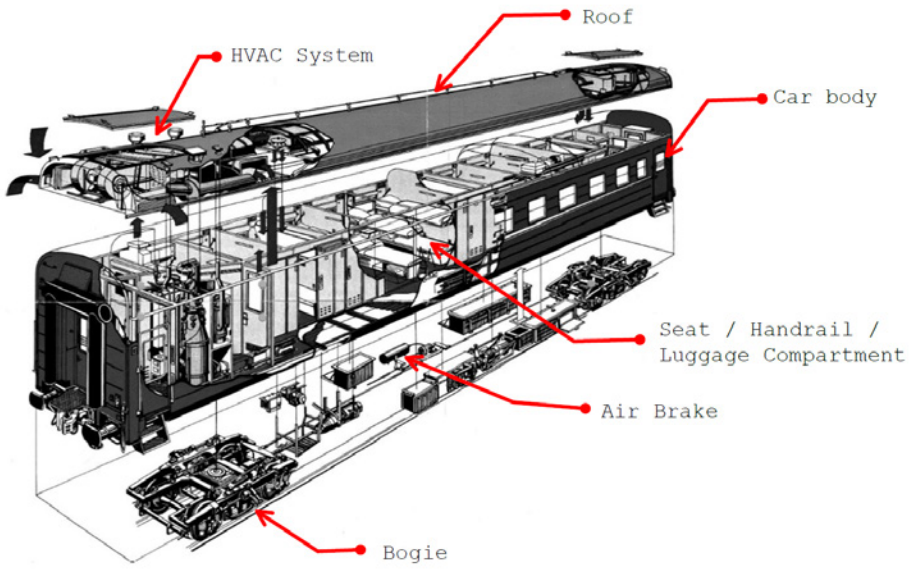


Figure 45 : Typical Key Components of Rail Vehicles

Components of Rail Vehicles are developed for different purposes. Considering safety as a priority, it is necessary to evaluate each component, rank the safety factor of each component, and weight each component depending on its safety factor ranking. The consultant has collected data of main components in accordance with international standards such as the European Standard TSIs (Technical Specifications for Interoperability), The Swiss Federal Office of Transport (FOT), information of rail transport agencies in Thailand, etc. In addition, a systematic analysis was performed as a risk analysis evaluating components associated with seven types of rail vehicles hazards, namely (Figure 46).

- Fire, smoke and respiratory hazards
- Train Collision
- Crash on Level/Grade Crossings
- Falling from train (people, animals, things)
- Collisions with objects or obstacles.
- Derailment
- Electrical Hazards.

Figure 46 : The seven hazardous may occurred due to the failure of rail vehicle components

Once the safety priorities of the critical components of Rail Vehicles have been analyzed, the critical rail vehicles components can be classified into the primary safety-critical subsystems as shown in Table 7. Other components that are not presented, although may have lower safety hazards, may be important in other areas, such as operation performance or maintenance cost, etc.

The results from the analysis and subsystem classification of the critical components will be used to develop the recommended standard, which will contain principles and basic requirements for inspecting the capacity of various critical components to maintain the safety of Rail Vehicles.

Table 7 : Analysis and Prioritization of Subsystem Safety

Item	Subsystem	Diesel Electric Loco-motive	Electric Loco-motive	DMU (Diesel Multiple Unit)	EMU (Electric Multiple Unit)	Passen-ger Coach	Freight Wagon	Service Vehicle	Light Rail Vehicle
1	Bogie / Wheelset / Wheel	✓	✓	✓	✓	✓	✓	✓	✓
2	Brake system	✓	✓	✓	✓	✓	✓	✓	✓
3	Fire Safety	✓	✓	✓	✓	✓	✓	✓	✓
4	Train control system	✓	✓	✓	✓	✓	N/A	✓	✓
5	Vehicle superstructure/ Crashworthiness / Joint and Welding	✓	✓	✓	✓	✓	✓	✓	✓
6	Doors & Windows	✓	✓	✓	✓	✓	N/A	✓	✓
7	Running behavior & Aerodynamics	✓	✓	✓	✓	✓	✓	✓	✓
8	Cab operation / Driver–machine interface	✓	✓	✓	✓	N/A	N/A	✓	✓
9	Safety devices	✓	✓	✓	✓	✓	✓	✓	✓
10	Electrical System / Lighting	✓	✓	✓	✓	✓	N/A	✓	✓
11	Coupler / Draw&Buffer gear	✓	✓	✓	✓	✓	✓	✓	✓
12	Dimensions & Loading Gauge	✓	✓	✓	✓	✓	✓	✓	✓
13	Concept for faults, accidents and emergency situation	✓	✓	✓	✓	✓	✓	✓	✓
14	Traction System	✓	✓	✓	✓	N/A	N/A	✓	✓
15	Diesel Engine & Component	✓	N/A	✓	N/A	N/A	N/A	✓	N/A
16	Energy supply & CurrentCollector	N/A	✓	N/A	✓	N/A	N/A	✓	✓
17	HVAC	✓	✓	✓	✓	✓	N/A	✓	✓
18	Test Required	✓	✓	✓	✓	✓	✓	✓	✓
19	Miscellaneous	✓	✓	✓	✓	✓	✓	✓	✓

Remark: Bi–mode trains are during consideration for specifications by SRT.

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