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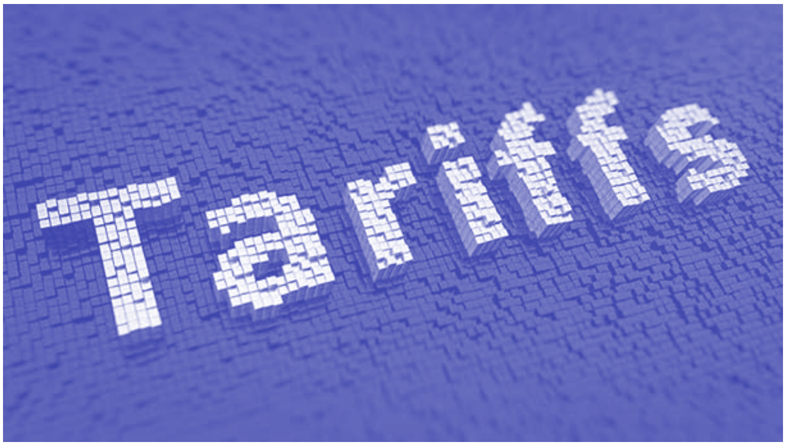

NON-TARIFF MEASURES IN THAILAND*

*Chedtha Intaravitak***

ABSTRACT

This paper provides a descriptive analysis of a newly constructed database of non-tariff measures (NTMs) in Thailand. A total of 1,630 NTMs were classified; they were extracted from 425 official regulations of Thailand. Analysis of the database indicates that NTMs are pervasive, affecting 99 percent of products under national tariff lines. For each product group, defined by Harmonized System (HS) codes at the two-digit level, 100 percent of NTM incidence was found in almost all product groups. The depth of NTM is particularly strong in animal products, vegetable products, foodstuffs, and mineral products. In some other products, a significant intensity is found for some NTM types.

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1. INTRODUCTION

This paper is a descriptive analysis of the database of Thai NTMs, which was constructed from January to August 2015 using the methodology of the United Nations Conference on Trade and Development (UNCTAD) and its NTM classification.[1] The comprehensiveness of the database was evaluated by computing proxies for the incidence, depth, and intensity of the NTMs. NTMs imposed on some products (at the eight-digit tariff line level) are explained in detail in order to highlight their layers and complexity. Briefly mentioned are a number of policy recommendations aimed at streamlining NTMs in Thailand. In section 2, an overview of Thailand's NTMs is provided, along with a description of the comprehensiveness of the database, the types of NTMs imposed, and regulatory institutions. In Section 3, the incidence and the depth of NTMs are discussed by product group. Section 4 contains an analysis of the intensity of NTMs for each product group obtained by computing the average number of NTMs per tariff line. Products with a particularly high average number of NTMs imposed are emphasized by explaining their NTMs in detail to give perspectives on the procedures with which importers/exporters have to comply. Section 5 provides a brief set of policy recommendations, and Section 6 concludes the study.

2. OVERVIEW OF THAILAND'S NON-TARIFF MEASURES

2.1 Comprehensiveness of the database

Table 1 shows a total of 425 regulations coded out of the approximately 600 regulations reviewed. Some regulations are not mandatory, or are unofficial, or have been revoked; according to the UNCTAD methodology, these were not included in the database. Counted were only 250 non-tariff measures[2] "in force" reported to the World Trade Organization (WTO); measures "in initiation" were not included. A total of 1,630 NTMs were classified using decentralized methods, i.e., analyzing regulations of each regulatory agency at the most disaggregated level starting from ministerial notices and then moving up to higher levels of regulation, such as royal decrees or acts. A very thorough and careful interpretation of contents/clauses of each regulation resulted in identifying 9,558 affected products (at eight-digit national tariff lines), which constitute 98.90 percent of all tariff lines (9,664 lines at the eight-digit level). NTMs related to international conventions were also classified. Two D321 (volume-based ag-

[1] *See UNCTAD (2014) and (2012), respectively.*

[2] *NTMs reported to the World Trade Organization are "measures" and not "regulations," although some reported measures provide links to regulation sources.*

Table 1: Comprehensiveness of the Database of Non-Tariff Measures

Comprehensiveness	
Total number of coded regulations	425
Total number of "NTMs" reported to the WTO (measures in force)	250
Total number of coded NTMs	1,630
Total affected products (HS lines, national tariff lines)	
Total number of affected products[a]	9,558
Share of the number of affected products to the number of total products[b] (%)	98.9
Total number of "regulatory agencies"	26

[a] A product may be affected by more than one measure, but the same HS-coded product is counted as one product, e.g., HS 840731 has three NTMs; yet it would be counted as "one affected product."

[b] Thailand adopts HS-8 digits at national tariff lines and has 9,664 tariff lines.

Abbreviations: HS = Harmonized System, NTM = non-tariff measure, WTO = World Trade Organization.

Source: Thai NTM database (2015).

ricultural special safeguard) measures were found in Thailand-New Zealand and Thailand-Australia free trade agreements. These were not included in the database since NTMs related to foreign trade agreements are considered by related international organizations. A limited number of anti-dumping and safeguard measures have been included in the database.[3] The other types of NTMs that have been incorporated into the database were those reported to WTO. The author considers reporting the number of "regulatory agencies" at the sub-ministerial level more meaningful than reporting the number of "issuing institutions" at the ministerial level,[4] as the latter is too aggregated to provide a meaningful perspective on just how diverse are NTM-related government agencies. Accurate understanding of this issue is crucial in designing the correct institution to streamline NTMs.

[3] *Type D NTM measure*, *which includes anti-dumping, countervailing, and safeguard measures, is not the focus of this data collection. UNCTAD, however, has added some anti-dumping measures to the Thai database based on anti-dumping measures reported to WTO.*

[4] *Most regulations classified are ministerial notices and are issued by relevant ministries.*

2.2 Types of Non-Tariff Measures

Table 2 shows sanitary and phyto-sanitary (SPS) measures and technical barriers to trade (TBT), measures which comprise 82.8 percent of all NTMs and affect 54.8 percent of national tariff lines.[5] Price control measures (F type) contribute 1.3 percent of NTMs but actually affect a relatively large number of product lines: 15.8 percent of tariff lines. Detailed inspection of F type measures indicates that "special fees" are applied on some sensitive agricultural products, such as F69 (additional charges, not elsewhere specified (n.e.s.)) for the import of maize and soybean meal. Other important F measures include, for example, F65 (import license fee) for chemical weapons, F72 (excise tax) for tobacco and liquor, and F9 (price control measures, n.e.s.) for alcoholic beverages. Non-automatic licensing/quotas/prohibitions (E) affect about 5.4 percent of tariff lines. Detailed inspection of E measures indicates only a small number of measures and affected products with the clear objective of protecting domestic industry. These are measures aimed at

[5] *With some double counting because some tariff lines are affected by both type A and B NTMs.*

Table 2: Types of Non-Tariff Measures Imposed, and Number and Percentage of Products Affected

Code	NTM by type	No. of NTMs	Percentage of total coded NTMs	No. of products affected (national tariff lines)	Percentage of products affected[b]
A	Sanitary and phyto-sanitary measures (SPS)	788	48.34	2,136	22.10
B	Technical barriers to trade (TBT)	562	34.48	3,164	32.74
C	Pre-shipment inspection and other formalities	44	2.70	157	1.62
D	Contingent trade protective measures	44	2.70	109	1.13
E	Non-automatic licensing, quotas, prohibitions, and quantity control measures other than SPS or TBT reasons	40	2.45	525	5.43
F	Price control measures, including additional taxes and charges	21	1.29	1,527	15.80
G	Finance measures				
H	Measures affecting competition	3	0.18	25	0.26
I	Trade-related investment measures				
J[a]	Distribution restrictions				
K[a]	Restrictions on post-sales services				
L[a]	Subsidies (excluding export subsidies under P7)				
M[a]	Government procurement restrictions				
N[a]	Intellectual property				
O[a]	Rules of origin				
P	Export-related measures	128	7.85	9,558	98.90
	Total coded NTMs	1,630	100.00	17,201	

[a] Data on J to O types of non-tariff measures (NTMs) were not collected in this project.

[b] The percentage of products affected is the proportion of product lines affected by the corresponding NTM types to the total number of eight-digit national tariff lines (9,664).

Source: Thai NTM database (2015).

some sensitive agricultural products, such as E113 (licensing linked to local production) for milk. To import milk, importers must buy domestic milk in the ratio of 1:2 by weight. Other such sensitive products are soybean/coconut/palm oil (to control effects on vegetable oil sold in the domestic market), coconuts/onions (in the event of shortages, imports are allowed within certain limits in terms of quantity and timeframe). It was found that only three H11 measures (state-trading enterprise, for importing) affected 25 product lines. Soybean oil, palm oil, and palm kernel are examples of products that could be imported only by Thailand's Public Warehouse Organization. P measures (export-related measures) affect almost all tariff lines, but, depending on products, the measures range from simple inspection to registration and issuing licenses/granting permits and even to export prohibition.

2.3. Regulatory Institutions

Regulatory agencies for NTMs are quite diverse across different ministries, offices, and

Table 3: Non-Tariff Measure Regulatory Institutions

Number		Regulatory institution	Number of NTMs	Percentage of total number of NTMs
1		Ministry of Public Health	697	42.6
	1.1	General[a]	116	7.1
	1.2	Food and Drug Administration	574	35.1
	1.3	Bureau of Pathogens and Animal Toxins Act	7	0.4
2		Ministry of Agriculture and Cooperatives	476	29.1
	2.1	General[a]	37	2.3
	2.2	Department of Agriculture	420	25.7
	2.3	Department of Fisheries	18	1.1
	2.4	Department of Livestock Development	1	0.1
3		Ministry of Industry	238	14.5
	3.1	General[a]	2	0.1
	3.2	Thai Industrial Standard Institute	189	11.5
	3.3	Department of Industrial Works	31	1.9
	3.4	Office of the Cane and Sugar Board	12	0.7
	3.5	Department of Primary Industries and Mines	4	0.2
4		Ministry of Commerce	147	9.0
	4.1	General[a]	3	0.2
	4.2	Department of Foreign Trade	113	6.9
	4.3	Office of the Central Commission on Prices of Goods and Services	26	1.6
	4.4	Department of Internal Trade	3	0.2
	4.5	Central Bureau of Weights and Measures	1	0.1
	4.6	Committee for Grain Trade Act	1	0.1
5		Ministry of Finance	15	0.9
	5.1	Excise Department	15	0.9
6		Ministry of Natural Resources and Environment	10	0.6
	6.1	General[a]	4	0.2
	6.2	Department of National Parks, Wildlife and Plant Conservation	6	0.4
7		Office of The National Broadcasting and Telecommunications Commission	7	0.4
8		Prime Minister's Office	3	0.2
	8.1	Consumer Protection Board	3	0.2
9		Ministry of Defense	1	0.1
	9.1	Defense Industry Department	1	0.1
10		WTO-related committees	43	2.6
	10.1	General[a]	37	2.3
	10.2	Committee on Anti-dumping Practices, Subsidies and Countervailing Measures	3	0.2
	10.3	Committee on Safeguard Measures	3	0.2
Total			1,637[b]	100.0

[a] NTMs under the regulatory institution "General" are those issued by ministries but with no lower-level units indicated as responsible, such as departments, and bureaus. They are issued usually by the secretariat of the relevant ministry.

[b] The 1,637 NTMs exceed what was previously reported (1,630) because seven of the measures reported here are regulated by both the Department of Agriculture and the Department of Industrial Works.

Source: Thai NTM database (2015).

committees (see Table 3). NTMs regulated by each ministry are, however, not fragmented in lower-level agencies; instead, they are usually "lumped" together under one or two sub-ministerial agencies. The Ministry of Public Health, for example, contributes 42.6 percent of the total number of NTMs, 35.1 percent of which come from the Food and Drug Administration alone. The Ministry of Agriculture and Cooperatives imposes 29.1 percent of the NTMs, of which the Department of Agriculture alone contributes 25.7 percent. The Ministry of Industry imposes 14.5 percent of the NTMs, of which the Thai Industrial Standard Institute accounts for 11.5 percent. The Ministry of Commerce contributes 9 percent of the NTMs, of which 6.9 percent are applied by the Department of Foreign Trade. These aspects, however, should not obscure the great difficulty involved in coordinating these sub-ministerial units in order to streamline NTMs.

3. INCIDENCE AND DEPTH OF NON-TARIFF MEASURES

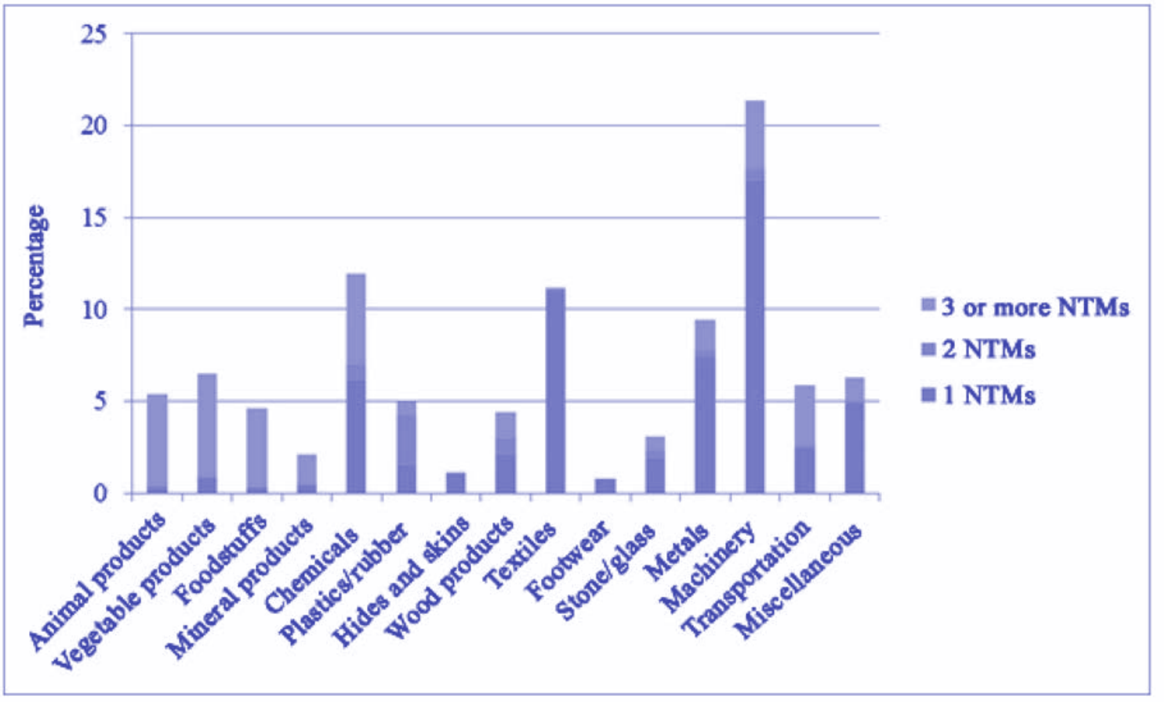
The incidence of NTMs is defined as the proportion of tariff lines in each product group (to be defined later) affected by at least one NTM. The depth of NTMs is defined as the proportion of tariff lines in each product group affected by three or more NTMs. The division of products into groups according to their HS code at the two-digit level is shown in Table 4.

Figure 1 shows that machinery products comprise 21.4 percent of the tariff lines affected by one or more NTMs. Of these products, 17 percent have only one NTM. Textiles and metal products comprise 11.2 percent and 9.4 percent, respectively, of the total, with the majority of products for each group having one NTM. Chemical products comprise 12 percent, with approximately equal shares of products affected by one and three or more NTMs. Not surprisingly, the majority of products under animal products, vegetables products, and foodstuffs are affected by three or more NTMs. The "depth" of NTMs for these product groups may be anticipated

Table 4: Product Groups Classified by HS Code at Two-digit Level

HS code	Product groups
01-05	Animal and animal products
06-15	Vegetable products
16-24	Foodstuffs
25-27	Mineral products
28-38	Chemicals and allied industries
39-40	Plastics/rubber
41-43	Raw hides, skins, leather, and furs
44-49	Wood and wood products
50-63	Textiles
64-67	Footwear/headgear
68-71	Stone/glass
72-83	Metals
84-85	Machinery/electrical
86-89	Transportation
90-99	Miscellaneous

Figure 1: Incidence and Depth of Non-Tariff Measures, Computed as Percentage of 9,664 Tariff Lines



NTM = non-tariff measure.
Source: Thai NTM database (2015).

due to the complexity and details of SPS and TBT measures.

A major drawback of the analysis based on Figure 1 is that the percentage is computed as a percentage of the total number of tariff lines (9,664 lines). A more interesting representation would involve using the number of tariff lines affected by one or more NTMs in each product group divided by *the number of the tariff lines in each product group* (Figure 2).

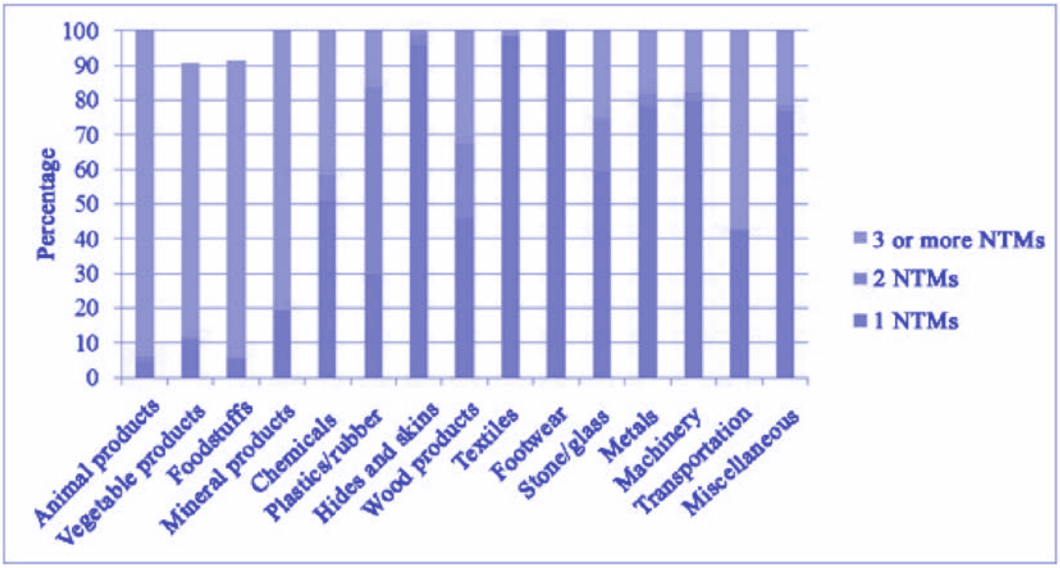
All tariff lines in all product groups, except vegetable products and foodstuffs, are affected by at least one NTM. This is a striking result compared with the previous literature on Thailand's NTMs. Cadot, Munadi, and Ing (2013), using the 2009 ASEAN Secretariat NTM Database, found the highest incidence of NTMs in textiles, where approximately 23 percent of tariff lines are affected by one or more NTMs (see Figure 3). The major reason for this discrepancy is the different methods of NTM collection. The ASEAN Secretariat Database is based on reports by government officials, whereas the Thai database was constructed using first-hand analysis of actual regulations by independent researchers. Methodologies used in classifying NTMs in the two databases may also differ.

According to the new Thai database, it may be concluded that Thailand has 100 percent incidence of NTMs in all product groups, except vegetable products and foodstuffs where the incidence is 90.8 percent and 91.3 percent, respectively. Figure 2 highlights the depth of NTMs for animal products, vegetable products, foodstuffs, and mineral products, where the majority of tariff lines have three or more NTMs.

4. INTENSITY OF NON-TARIFF MEASURES

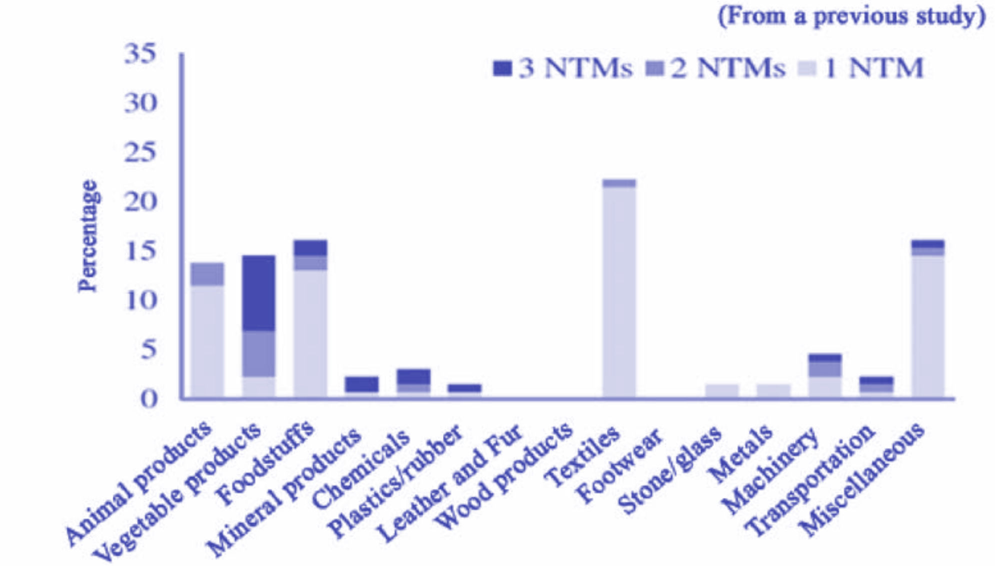
The intensity of NTMs is defined as the average number of NTMs per tariff line for each product group. The average number of measures for each tariff line is further classified into the average

Figure 2: Incidence and Depth of Non-Tariff Measures, Computed as a Percentage of the Number of Tariff Lines in Each Product Group



NTM = non-tariff measure.
Source: Thai NTM database (2015).

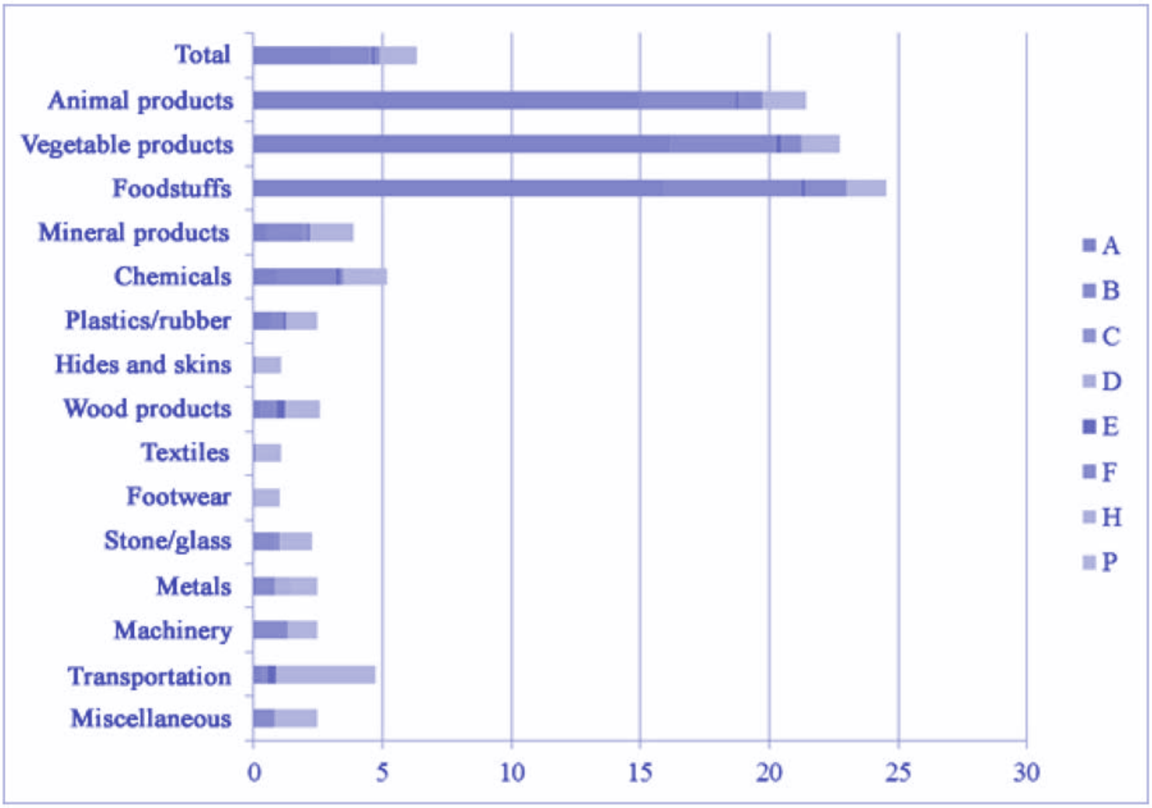
Figure 3: Incidence and Depth of Thai Non-Tariff Measures: Percentage of Tariff Lines Affected by One or More Non-Tariff Measures



NTM = non-tariff measure.
Source: Cadot, Munadi, and Ing (2013).

number of measures of A, B, C, D, E, F, H, and P types. The overall average number of NTMs per tariff line for Thailand is 6.4 (see Figure 4). Animal products, vegetable products, and foodstuffs have the highest intensity of NTMs: the average numbers of NTMs per tariff line for those products are 21.4, 22.7, and 24.6, respectively. Most measures for these product groups fall under the SPS and TBT categories. Mineral products, chemicals, and transportation products have, on average, from three to five measures per tariff line, with the B and P types having the most. Other product groups have

Figure 4: Intensity of Non-Tariff Measures: Average Number of Non-Tariff Measures per Tariff Line for Each Product Group



Source: Thai NTM database (2015).

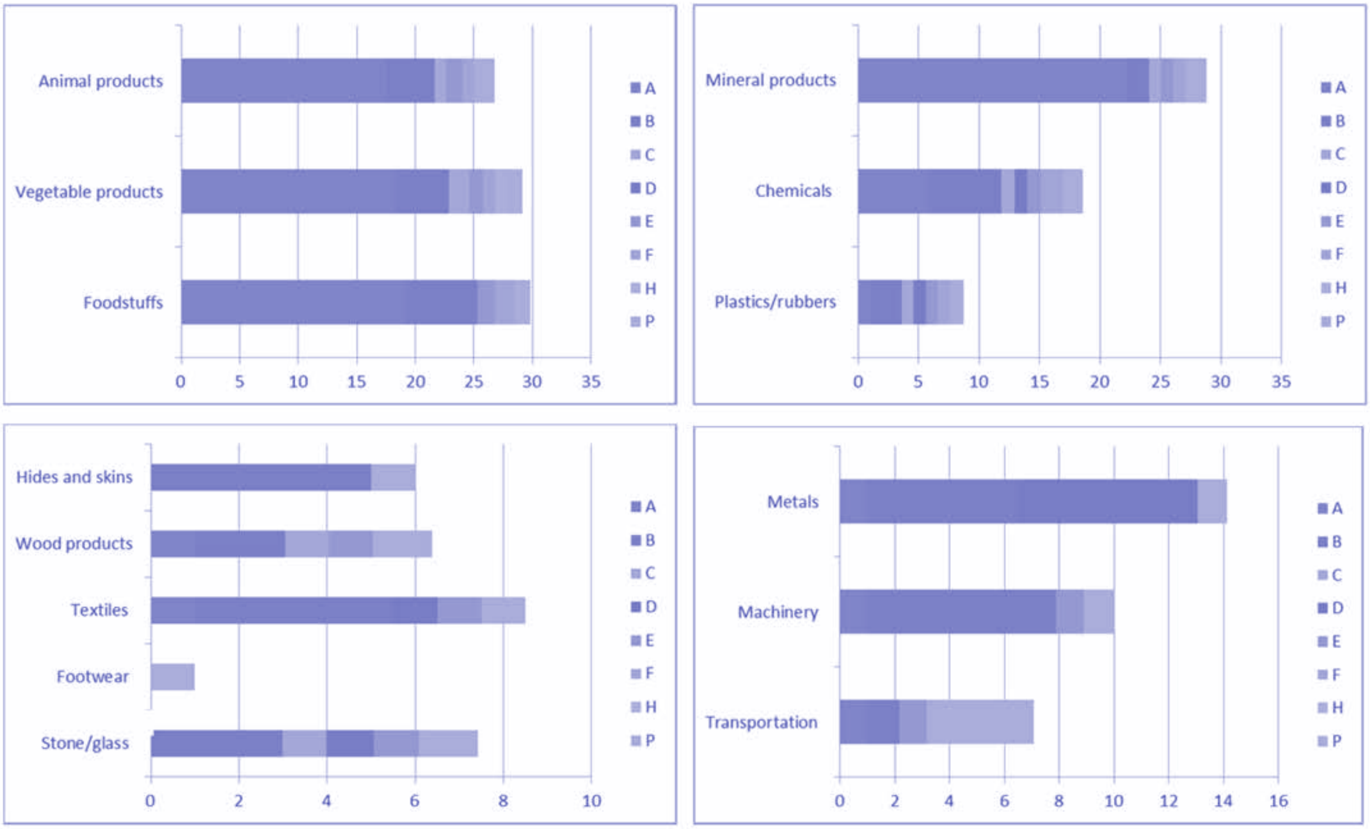
an average of fewer than three NTMs per tariff line. Figure 4 presents a very different result from previous work on Thailand's NTMs. Intaravitak, Luksanapanyakul, and Tunmunthong (2013), also using the 2009 ASEAN Secretariat Database, found the average number of NTMs to be less than one per tariff line for all product groups.

The analysis based on Figure 4 may underestimate the severity of NTMs. Each NTM type tends to be associated with certain types of products. For example, SPS measures in general are applicable to vegetable/animal products and foodstuffs. Many TBT measures concerning product performance/quality are particularly applicable to metal and machinery products. For this reason, for each product group, *the average number of measures of each NTM type have been computed among those tariff lines affected by that particular NTM type* (Figure 5).

Within the animal products group, certain tariff lines are affected by type A NTMs. The average number of type A NTMs imposed on this product group is 17.6. Using the same logic within the animal products group, certain tariff lines are affected by type B NTMs. The average number of type B NTMs imposed on these products is 4.1.

Using this method to compute the intensity (or severity) of NTMs is more precise than that used in Figure 4. According to Figure 4, mineral products have, on average, 3.9 NTMs per tariff line, with an insignificant proportion having type A NTMs. With regard to Figure 5, on the other hand, it is shown that for tariff lines in the mineral products group affected by type A NTMs, the average number of type A measures is 22.3 per tariff line. For example, HS 25010010 (salt, including table salt and denatured salt; and pure sodium chloride) contains type A measures ranging from a tolerance

Figure 5: Intensity of Non-Tariff Measures: Average Number of Measures of Each Non-Tariff



Source: Thai NTM database (2015).

limit for contamination to hygienic practices during production and to packing, storage, and labeling requirements. Similarly, it is striking to note that the average numbers of type A NTMs faced by tariff lines affected by type A NTMs in the animal products, vegetable products, and foodstuffs groups are 17.6, 18.5, and 19.3, respectively. For textile products, an average of 4.5 measures are applied to the tariff lines affected by type B NTMs, mostly to ensure that imported fiber wastes are properly reported and managed. On average, 5.5 measures are applied to metal products subject to type B measures (product quality or performance requirements). For metal products subject to type D measures 6.5 measures are applied on average; most are anti-dumping measures. Similarly, for machinery products subject to type B measures (product quality or performance requirements), an average of 6.9 measures are applied.

5. POLICY RECOMMENDATIONS FOR STREAMLINING NON-TARIFF MEASURES

The focus of this paper is a descriptive analysis of the Thai NTM database and not so much on designing policies to streamline NTMs. In this section, some ideas are briefly discussed concerning how to address the NTM issues that came to light during NTM data collection. The author generally concurs with the methods proposed in the World Bank toolkit on streamlining NTMs (see Cadot, Malouche, and Saez (2012)). This general approach, however, should be modified to suit the local context in each country. In particular, the following steps are proposed to streamline NTMs:

- **On NTM data collection**. Establish a one-stop NTM service center where importers/exporters can report and be notified of NTMs in a timely manner.

- **On reviewing NTMs.** The cost-benefit of an NTM should be carefully analyzed. Equally important is understanding who benefits and who bears the cost of such measures. Sometimes, NTMs represent economic rents for some third parties, causing unnecessary inefficiency.
- **On streamlining NTMs.** The following step are proposed:
    - Establish a strong independent oversight body;
    - Focus on regional mutual recognition agreements (MRAs) as an intermediate, short-to-medium-term solution;
    - Encourage adoption of international standards in place of national/regional standards.

6. CONCLUSION

A relatively comprehensive database of Thai NTMs has been constructed by analyzing official regulations and using UNCTAD methodology; a total of 1,630 NTMs have been identified in 425 regulations and classified. These NTMs affect 9,558 products at eight-digit national tariff lines, which comprise 98.90 percent of all tariff lines (9,664 lines at the eight-digit level). Of these NTMs, 83 percent are SPS and TBT measures that affect 55 percent of tariff lines. Limited use of price control measures (F type) was found, although they affect a relatively large number of tariff lines. Type E measures, especially those with the clear objective of protecting domestic industry, such as E113 (licensing linked with local production), are barely used. It was also found that there is limited use of the H11 (state-trading enterprise, for importing) measure. P measures (export-related measures) affect almost all tariff lines but, depending on the products, the measures range from simple inspection to registration and the issuing of licenses/permits and even to export prohibition. NTM-related regulatory institutions are quite diverse because they are part of different ministries. However, NTMs tend to "lump together" in some sub-ministerial agencies. The database indicates that Thailand has 100 percent incidence of NTMs in all product groups except vegetable products and foodstuffs where the author found incidence of 90.8 percent and 91.3 percent, respectively. Animal products, vegetable products, foodstuffs, and mineral products feature more

"depth" of NTMs since the majority of tariff lines in these product groups are subject to three or more NTMs. For each product group, the author devised a new method to serve as a proxy for the intensity (or severity) of NTMs by computing an average number of measures of each NTM type among the tariff lines affected by a particular NTM type. As a result, significant NTM severity was found for some NTM types in various products. For example, for those tariff lines in the mineral products group affected by type A NTMs, the average number of type A measures is 22.3 per tariff line. Similarly, for tariff lines affected by type A NTMs in the animal products, vegetable products, and foodstuffs group, the average numbers of type A NTMs are 17.6, 18.5, and 19.3, respectively.

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TRENDS AND DEVELOPMENT OF GPS TECHNOLOGY FOR ROAD SAFETY IN THAILAND

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1. INTRODUCTION

Road accidents are a leading problem in Thailand as they cause significant loss of life and economic damage. Such accidents may be caused by one of three factors or related issues: drivers, vehicles, and circumstances.

According to the World Health Organization (WHO), Thailand ranks number 2 in the world in the number of deaths caused by road accidents, with the death rate being 36.2 persons per 100,000 population. Libya, with a population of only 6.5 million, holds the distinction of being number 1 in road accident deaths. However, the traffic casualty statistics collected by Thai authorities are rather different from the WHO estimation. Two Thai agencies that collect traffic casualty statistics are the Ministry of Public Health, which recorded 15,045 deaths (22.45 per 100,000 population) in 2014, and the Royal Thai Police, which recorded 6,985 deaths (10.42 per 100,000 population) in the same year. Due to the huge difference in these statistics, the Department of Disease Control of the Ministry of Public Health in 2014 conducted a study to consolidate the statistics on road traffic deaths; it concluded that the number of deaths from traffic accidents in Thailand in 2013 was 20,029.

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Obviously, the collection of such statistics needs further improvement, preferably with a single agency being made responsible for compiling accurate statistics on road accident casualties.

Not only are traffic casualties important, but also the number of accidents as well as the causes of the accidents. Accident statistics provided by the Bureau of Highway Safety of the Department of Highways[1] have been showing a rise since 2012. The total number of accidents in 2016 was 15,579, and the top three causes of accidents were speeding (exceeding the speed limit), overtaking in a critical situation, and tailgating. These three situations accounted for more than one-third of the total number of accidents. All three causes can be considered as human errors, especially speeding.

Self-awareness and law enforcement can be applied in these cases, but these factors will not be completely effective as there are many limitations involved. Therefore, this article has two purposes: first, to show how Geographic Positioning System (GPS) technology can be applied to achieve better road safety, and second, to describe how GPS technology can be applied to various aspects of land transportation.

[1] *http://bhs.doh.go.th/statistic*

2. STUDY AND REVIEW OF THE APPLICATION OF GPS TECHNOLOGY

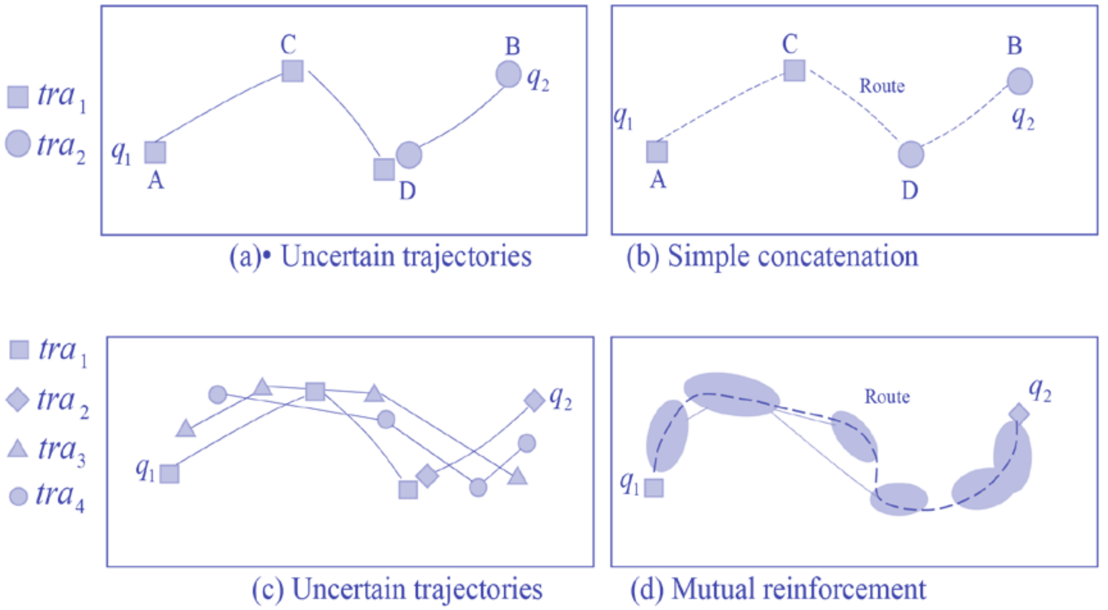
A study of driver behaviors through the use of GPS produces general data on road accidents, such as location, direction, and speed. However, development of applications for road safety control is necessary for conducting behavior analysis. Therefore, the authors reviewed various research studies relating to GPS applications in Thailand and abroad, using GPS technology as a development tool so that this project would be effective and reliable. The details are described in the following sections.

2.1 Discovering pattern-awareness routes

Wei et al. (2012) proposed a method to determine the best route to reach multiple destinations by collecting GPS data from each destination before considering the user's preferred route and then summarizing the most appropriate route from the determined starting point to the ending point. Such data can be applied to create the best road map based on the user's preferred routes.

Moreover, Wang et al. (2008) proposed the novel non-parametric Bayesian model, dual hierarchical Dirichlet processes (Dual-HDP) to detect unsupervised abnormal activities, which are based

Figure 1: Discovering pattern-awareness routes from trajectories to create the best road map



on deviations from other activities. To make the system easier to understand, data are clustered into smaller regions, and each region is checked to detect any abnormality, as shown in Figure 2.

However, the pattern used to detect abnormal trajectories can be applied well to detect human errors in driving. Ge et al. (2011) used GPS data from taxis to analyze routes and identify whether the trajectory was abnormal (i.e., taking a shortcut, or detour). Also, abnormal trajectory detection can be used to detect tricky drivers. First, the system considers the preferred route between two locations. Distance and time should be similar to the preferred routes. A taxi taking a different route would be suspected of cheating the passenger by taking a longer detour.

2.2 Travel time estimation

The authors reviewed a project of the Expressway Authority of Thailand on travel time analysis based on vehicles' speed and density; they then developed an algorithm to analyze travel time based on data from the GPS data source of taxis. Basically, the details, including latitude, longitude, speed, heading, and time-stamp, are sent back to the server in real time. The system then compares these data with routes on the map to identify the

Figure 2: When data are clustered into regions, abnormalities are detected if object B takes a different route

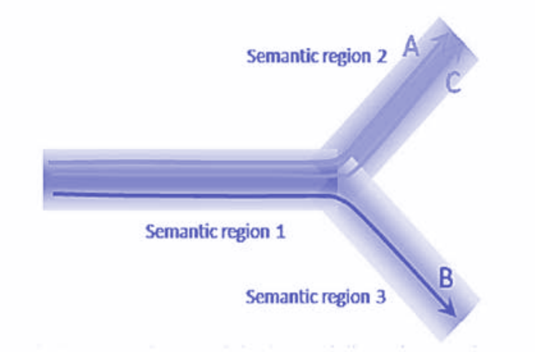


Figure 3: Sample of abnormal trajectory detection

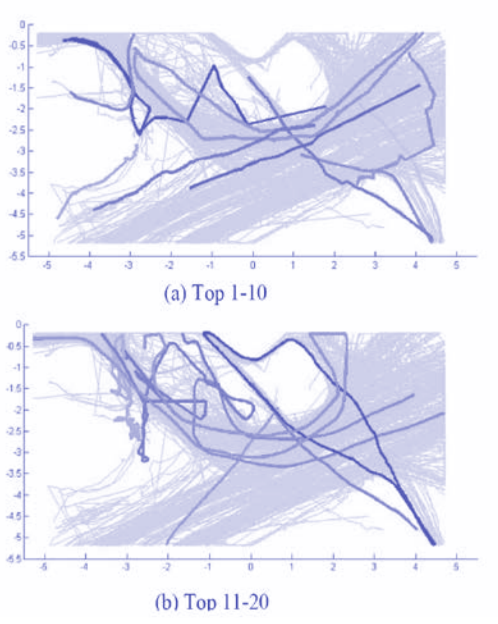
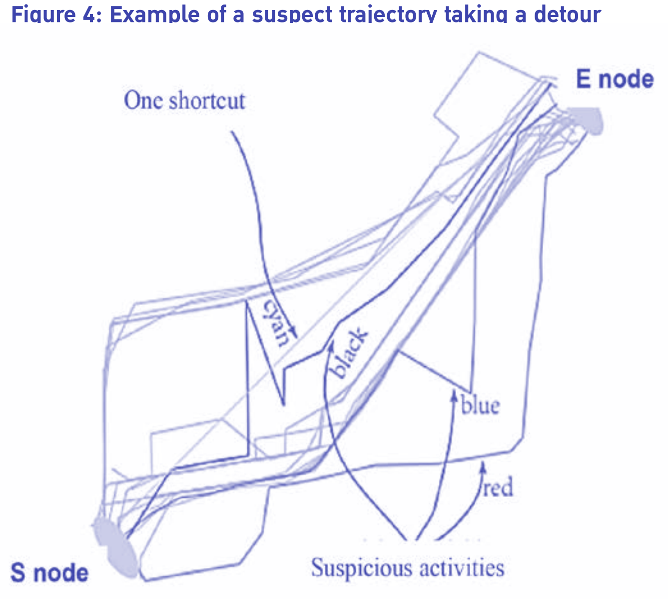


Figure 4: Example of a suspect trajectory taking a detour



vehicles' location. Routes are divided into what are called "links." For example, the route from Bang Khun Thian to Bang Kru is considered as "1 link." Location and speed data from the taxis' GPS is used to estimate travel time, which requires two types of data:

(a) Spot speed — The system filters and aggregates a vehicle's real speeds in a certain link sent from GPS to estimate travel time: for example, the time between 10:00 a.m. and 10:05 a.m. Twenty records of location data are sent from the taxi's GPS in Bang Khun Thian, i.e., the Bang Kru link. These data are used to estimate travel time in the link, as shown in Table 1.

Table 1: Spot speed data sample for estimation

GPS_ID	Latitude	Longitude	Time-stamp (May 15, 2012)	Speed (km/hr)
1311042	13.581726	100.867721	10:00:13	84
1310992	13.581680	100.867248	10:00:14	114
1311751	13.581893	100.867095	10:00:22	45
65679	13.582565	100.861358	10:00:26	77
1311401	13.583236	100.860351	10:01:07	63
1310969	13.582931	100.859588	10:01:25	69
1311751	13.583587	100.858612	10:01:32	80
65878	13.583694	100.858566	10:01:06	92
1311791	13.583969	100.854690	10:02:11	32
65890	13.584228	100.854324	10:02:58	89
65723	13.584457	100.854217	10:02:44	78
1310992	13.584487	100.854049	10:02:18	118
65679	13.584213	100.853500	10:03:55	64
1311106	13.584274	100.853286	10:03:00	74
1310969	13.584518	100.852249	10:03:17	69
1311365	13.584625	100.851654	10:03:29	74
65746	13.584625	100.851654	10:04:32	84
1311854	13.584915	100.850662	10:04:59	23
1311542	13.584915	100.850601	10:05:23	57

(b) GPS link — These data can be acquired only when the data are sent from the same taxi in the same link more than once during a certain period. This means that there is displacement of a taxi that gives two different locations at two specific times, as shown in Table 2.

Table 2: GPS link data sample

Link_ID	GPS_ID	Lat1 -Long1	Lat2-Long2	Time1 (May 16, 2012)	Time2 (May 16, 2012)
1649	51288	13.6911 100.52476	13.69136 100.52516	17:36:16	17:36:43
3820	1311502	13.75369 100.56437	13.75366 100.56381	17:35:20	17:36:01
1912	1310852	13.81317 100.62178	13.79470 100.61286	17:35:18	17:36:54
1912	1310852	13.80320 100.61680	13.79470 100.61286	17:35:18	17:36:07
1650	51288	13.69171 100.52571	13.69203 100.52615	17:35:13	17:35:43
2728	1311326	13.89981 100.54121	13.89942 100.54244	17:34:38	17:35:24
1934	1311277	13.74197 100.63064	13.74075 100.62464	17:34:37	17:36:02
1934	1311277	13.74133 100.62760	13.74075 100.62464	17:34:37	17:35:23
2727	1311326	13.89942 100.54244	13.89926 100.54298	17:33:53	17:34:38
1907	1310852	13.78596 100.60882	13.77705 100.60749	17:33:52	17:34:38

After "spot speed" and the GPS link are known, travel time can be estimated using the following equation.

$$v = s / t$$

In order to acquire the most accurate traffic data, it is necessary to filter out abnormal data in three steps.

The first step is "time-window filtering," in which the location and speed obtained from a taxi are filtered. Any abnormality caused by GPS and by vehicles unable to move in congested traffic are removed. Thus, the actual travel time is obtained. For example, in high-traffic flow situations, the speed of some vehicles may be more than 160 km/hr, while that of others may be zero. In such cases, that taxi might be parked or waiting for a passenger. Therefore, the data from its GPS would be filtered by the time-window filtering facility.

Another example of time-window filtering of the speed of vehicles is shown in Table 3. The standard deviation of this data set can be found using the following equation:

$$\sigma = \sqrt{\frac{\sum (x-\bar{x})^2}{n}}$$

The speed obtained is $\bar{x} \pm \sigma$.

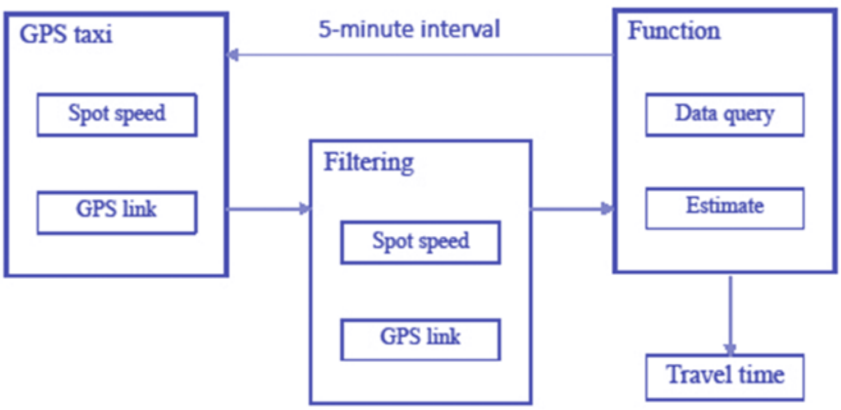
This time-window is used in the next step, which produces a data set ranging from 57 to 64, from 69 to 80, and from 84 to 92 km/hr.

After time-window filtering, the data undergo dynamic stratified sampling before the travel time estimation is applied. In cases when the data are widely distributed, the system will narrow the data ranges of the sample and randomly sample the same amount of data from each range to estimate the travel time. For example, there are 14 data points in the set after time-window filtering, namely 57, 63, 64, 69, 69, 74, 74, 77, 78, 80, 84, 84, 89, and 92 km/hr. The system therefore divides the speed data into three ranges and randomly picks speeds from the range with the least number of data points to calculate the average. In this case, the sample of ranges is shown in Table 3. Sampling obtained from the speed range of 57-68 (least number of data) is three. According to Table 3, the system samples data from each speed range and calculates the average

Table 3: The data samples from each data range

Speed range (km/hr)	Number of data points	Data from sampling (km/hr)
57 - 68	3	57, 63, 64
69 - 80	12	69, 74, 80
81 - 92	4	84, 89, 92

Figure 5: Travel time estimation procedure



to estimate speed. As a result, the average speed in the Bang Khun Thian – Bang Kru link is 74 km/hr, and the travel time is equal to 10 minutes.

The flow of the algorithm for travel time estimation is shown in Figure 5, starting from the spot speed data collected and the GPS link. The data are collected every 5 minutes. After that, the application in the database requests data and passes them through the filtering process to obtain data for calculating in the last step of travel time estimation for 5-minute intervals.

3. APPLICATION OF GPS TECHNOLOGY FOR IMPROVING ROAD SAFETY IN THAILAND

The Department of Land Transport under the Ministry of Transport is the main department in Thailand for maintaining effective transportation and road safety, including traffic discipline, for the general public. In 2011, the Department launched a project called "Study on GPS Installation in Public Transportation." The main objective was to study, analyze, and design a public transportation control system architecture (composition, responsibility, and system connectivity) for the Department's GPS Transit Management Center. The application included inspection of the transit system to ensure that it complied with the Center's objectives, raised safety awareness using GPS, and engaged all parties.

In 2013, the project called "The GPS Transit Management Center Establishment Project for Safety Monitoring" was launched. At first, it was applied to trucks hauling dangerous goods, and buses owned by the Transport Co., Ltd., through an announcement requiring the installation of GPS by January 1, 2015. The operation of the project showed that it could effectively control drivers' behavior in terms of speed. The Department of Land Transport subsequently (in late 2015) announced a regulation

Table 4: Statistics on vans with GPS installed as of January 31, 2017

Vehicle type	Number of registered vehicles	Number of vehicles that require GPS	Number of vehicles with GPS installed
Public transportation	**151,281**	**84,573**	**26,771**
Fixed route	77,788	26,346	6,510
– Type 1	19,226	5,138	1,036
– Type 2	8,913	8,913	3,553
– Type 3	12,295	12,295	1,799
– Type 4	37,354	0	122
Unfixed route	61,274	58,227	20,131
Personal	12,219	0	130
Trucks	**1,056,068**	**394,361**	**91,361**
Unfixed route	275,169	117,204	55,117
Personal	780,899	277,157	36,244
Others			**21,191**
Total	**1,207,349**	**478,934**	**139,323**

Source: GPS Management Control Center, Department of Land Transport.

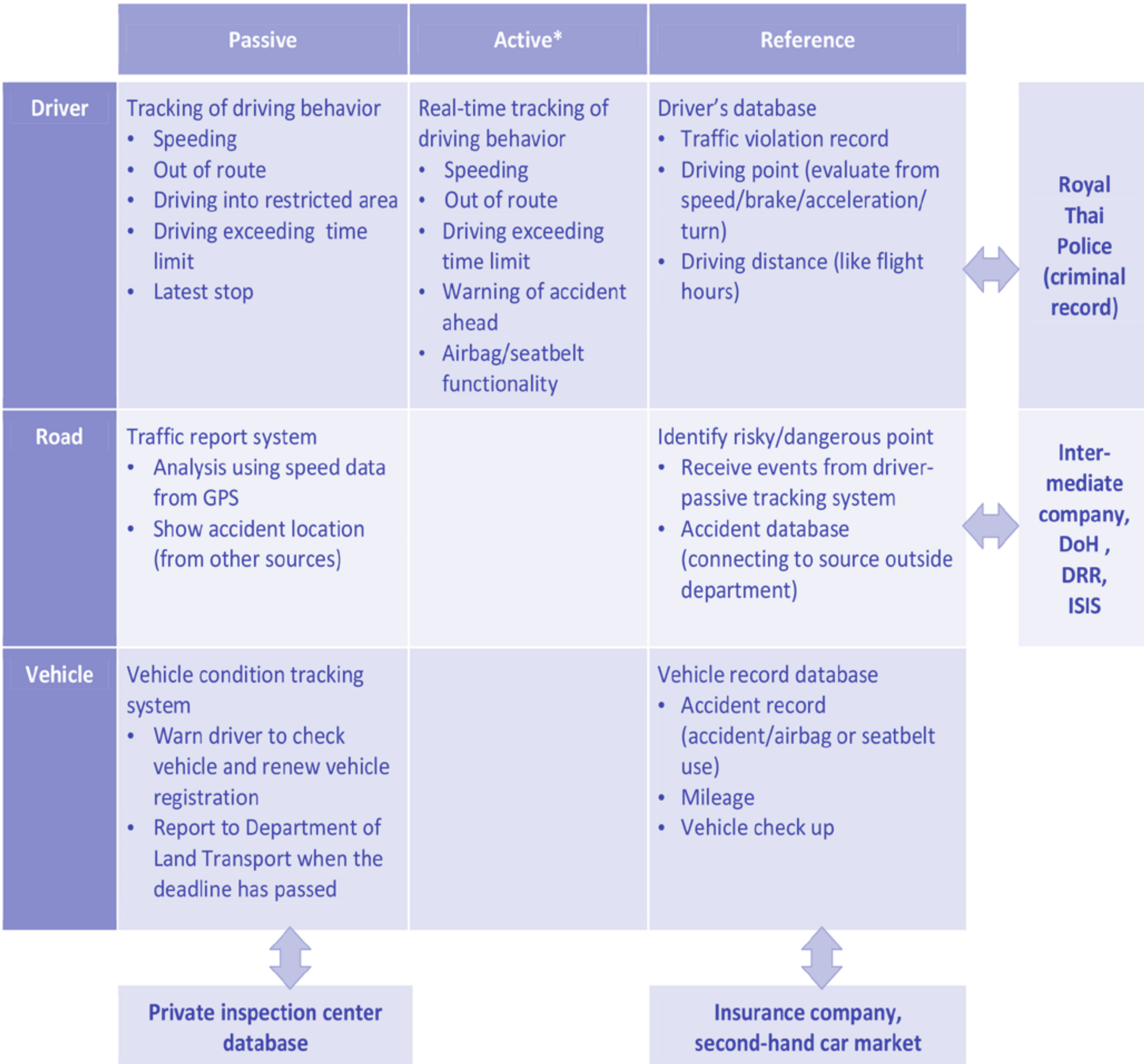
requiring that all forms of public transportation and trucks must install GPS onboard under the project entitled "Nationwide Confidence with GPS Onboard."

Under the project, all types of public transport and vans (except buses with two rows of seats, type-4 buses, and type-1 provincial buses), as well as trailers and large trucks (10 wheels or more) registered after January 25, 2016, must install GPS that complies with the Department's announcement. The system is composed of the GPS itself and a magnetic card reader that connects to the Department's GPS Transportation Management Center.

For the various forms of public transport and trucks that were registered before January 25, 2016, the Department of Land Transport required that the different types of vehicles comply with the announcement within 2016, so that the owners and vendors would have had time to prepare and fix the data connection system, and install GPS as specified. For public transport vehicles, trailers, and large trucks (10 wheels or more) the deadline was within 2016, but the use of current GPS models was later extended to 2019. Double-decker buses were also required to have GPS installed within the tax year 2016. For any other forms of public transportation, GPS needs to be installed within the tax year 2017. For all trailers, GPS needs to be installed within the tax year 2018, and for personal trucks (10 wheels or more), the deadline for installation is the tax year 2019.

However, in the wake of an accident during the New Year holiday period involving a van and a pickup truck that caused 25 deaths, the Department of Land Transport announced, on an urgent basis, that all public vans cooperating with the Transport Company departing from Bangkok to any destination

Figure 6: Concept of GPS application usage classification



* Device must be installed.
Abbreviations: DoH = Department of Highways; DRR = Department of Rural Roads; and ISIS = Injury Surveillance Information System.

in Thailand must have a GPS tracking system installed by March 31, 2017. Currently, 139,323 of the target vehicles covered under this announcement have already installed GPS tracking systems; they represent 29 percent of the target. Details are shown in Table 4.

4. ROAD SAFETY CONTROLLED BY GPS TECHNOLOGY

According to a GPS data technology needs assessment survey of various sections in the Ministry of Land Transport, which is overall in charge of Thailand's road safety, those needs could be classified into three types of uses: passive, active, and reference. Also, the needs could be classified according to three factors: drivers, roads, and vehicles. Figure 6 shows the usage of data from route recorders, classified by application type. There are seven types of applications classified by usage and main factors analysis. Details are shown in Figure 6.

4.1 Passive application

Passive data usage from GPS can be classified into three types: drivers, roads, and vehicles.

For drivers, the Department of Land Transport applies data from its tracking recorder in developing of "**Tracking of driving behavior,**" which monitors:

- Driver's speed
- Detour route
- Violation by driving into controlled/ restricted area
- Driving hours exceed limit
- Latest stop

Data from the vehicle travel record can be used to develop the "**Traffic report system,**" as follows:

- Data on speed from the GPS device installed onboard can be used to analyze traffic flow or route
- Vehicle travel record can be used to analyze and show an accident point along the route

Data from the vehicle travel record can be used to develop the "Vehicle condition tracking system," which is connected to a private inspection center. Its application is as follows:

- The Department of Land Transport uses the application to warn vendors when to check their vehicles or renew their registration
- The system can report data to the Department of Land Transport when the vehicle owner does not follow the warning within the deadline, so that the Department can issue a warning or terminate the legal use of that vehicle

In this type of passive GPS data usage system, after a mistake has occurred, it can be analyzed and action taken. In this context, the action would be a warning or a punishment. This kind of application can be activated soon after a GPS device has been installed and connected to the Department of Land Transport's GPS Traffic Center.

4.2 Active application

The active data usage report obtained from GPS can be applied to drivers. The Department of Land Transport can use data from the travel record to develop a **"real-time driving inspection system,"** which works as described below:

- Show the real-time travel route of each vehicle from the recorder, and control speeding by sending a warning directly to the driver of that vehicle in real time in order to prevent an accident
- Show the real-time location of each vehicle from the recorder to assess the route of each vehicle. If any vehicle is out of route, a warning would be sent directly to the driver of that vehicle
- Monitor driving hours that exceed the limit established by the Department of Land Transport, display driver's driving hours from a magnetic reader, and send warning to the driver to switch drivers or get some rest
- Send a warning about an accident ahead by getting road accident information from various sources or from a previous vehicle's traffic tracking, and inform other vehicles heading toward the accident area
- Check status of devices, such as airbag or seatbelt, by monitoring their real-time functional status, and warn the driver in case that device is not functioning in order to prevent an incident that might occur

To use active GPS device data, it is necessary to install some devices other than a GPS device. Therefore, action cannot be taken right away on the basis of active GPS device data alone.

4.3 Reference application

Reference to GPS device data usage records can be made to three groups: drivers, roads, and vehicles.

For drivers, the Department of Land Transport uses data from its recorder to develop the "**Driver record database.**" The system is connected to the Royal Thai Police for application, as described below.

- Check driver's traffic violation record. When database is completely connected to the Royal Thai Police, the Department of Land Transport can effectively monitor driving license status and filter out of public transport drivers with a record of past dangerous behavior
- Use data from the vehicle's GPS device to analyze each driver's behavior and score driving points. Evaluation includes driving speed, or pattern of braking or acceleration. The score obtained from the system would be considered when the driver attempts to renew his or her driving license
- Use data from the vehicle's GPS device to analyze total driving distance of each driver to evaluate their personal experience

The Department of Land Transport can apply data obtained from its travel recorder to risky or dangerous points along the route, and connect to an intermediate organization under the Department of Rural Roads in order to:

- Receive data or any matter needed to track and monitor driving, analyze risky or dangerous points along the route, and inform related parties, such as the Department of Highways or the Department of Rural Roads
- Create an accident database based on accident reports from related parties, analyze risky or dangerous points, and use the data as a database to send warnings to drivers

The Department of Land Transport has developed the "**Vehicle record database,"** which provides data to insurance companies or the second-hand market, as follows:

- Vehicle database development enables rapid checking of each vehicle's accident detailed record
- Vehicle database stores the travel record of all vehicles and analyzes or uses as criteria to define a data-monitoring pattern for each vehicle
- Vehicle database stores detailed check-up history of each vehicle

5. CONCEPT OF THE OVERALL-SYSTEM TRAFFIC CONTROL USING GPS

The design of overall-system traffic control using GPS developed by the Department of Land Transport is divided into two layers: the database layer and the application layer. The application layer itself also has two parts, one for use inside the Department of Land Transport and the other for outside.

5.1 Database layer

For the database layer, data are collected into the GPS system Management Center's database, which includes the following:

- Driver database — This database stores the driver's name and surname, sex, age, driving history, type of driving license, accident record, and driving score calculated from GPS data
- Vehicle database — This database stores any data related to vehicles, such as registration plate, brand, model, color, size, load weight, engine number, owner's name and address, trading record, accident record, mileage, check-up record, any other data calculated from GPS, license, and permitted route
- Operator database — This database stores operator records, scores, and assigned

licenses. The Cargo Transport Office and Passenger Transport Office would consider license renewal based on these data

- Road safety database — This database stores details on unsafe driving on each road that trucks with GPS are using, such as sudden braking or speeding, in order to warn drivers to be more cautious when driving on that road. It is also used as a reference when requesting related parties to improve safety in an unsafe area
- Traffic database — This database is used to evaluate traffic flow based on speed obtained from GPS data, and informs drivers about appropriate routes
- Logistics database — This database stores information on starting and ending points, vehicle kilometers travelled (VKT), and transport routes. Related parties may arrange rest areas or truck terminals, or plan road maps based on such data

5.2 Application layer

5.2.1 Internal usage for the Department of Land Transport

For the application layer, data are collected as follows:

- The Department of Land Transport Inspector and the Transport Provincial Office have web and mobile applications to randomly inspect traffic violations. The Inspector can check a driver's score and license type, check whether the GPS model is the registered one, and check other licenses
- The Cargo Transport Office has a web application to check cargo vendors' traffic violation records in order to issue, suspend, terminate, or renew licenses
- The Passenger Transport Office also has a web application to check passenger vendors' traffic violation records in order to issue, suspend, terminate, or renew licenses
- The Land Transport Safety Office and the Planning Division have a web application to check the records of drivers, vendors, and vehicles
- The Automotive Engineering Office has a web application to check the services of GPS providers in order to certify, suspend, or terminate GPS devices. Moreover, data from application can be used to score providers as well
- The Provincial Transport Office has the same authority as the head office, but the scope of duty is limited to only the province concerned. For example, to inspect speeding, issue passenger/cargo transport licenses, check the records of drivers and vendors, and inspect, install, and connect to GPS data sources

5.2.2 External usage

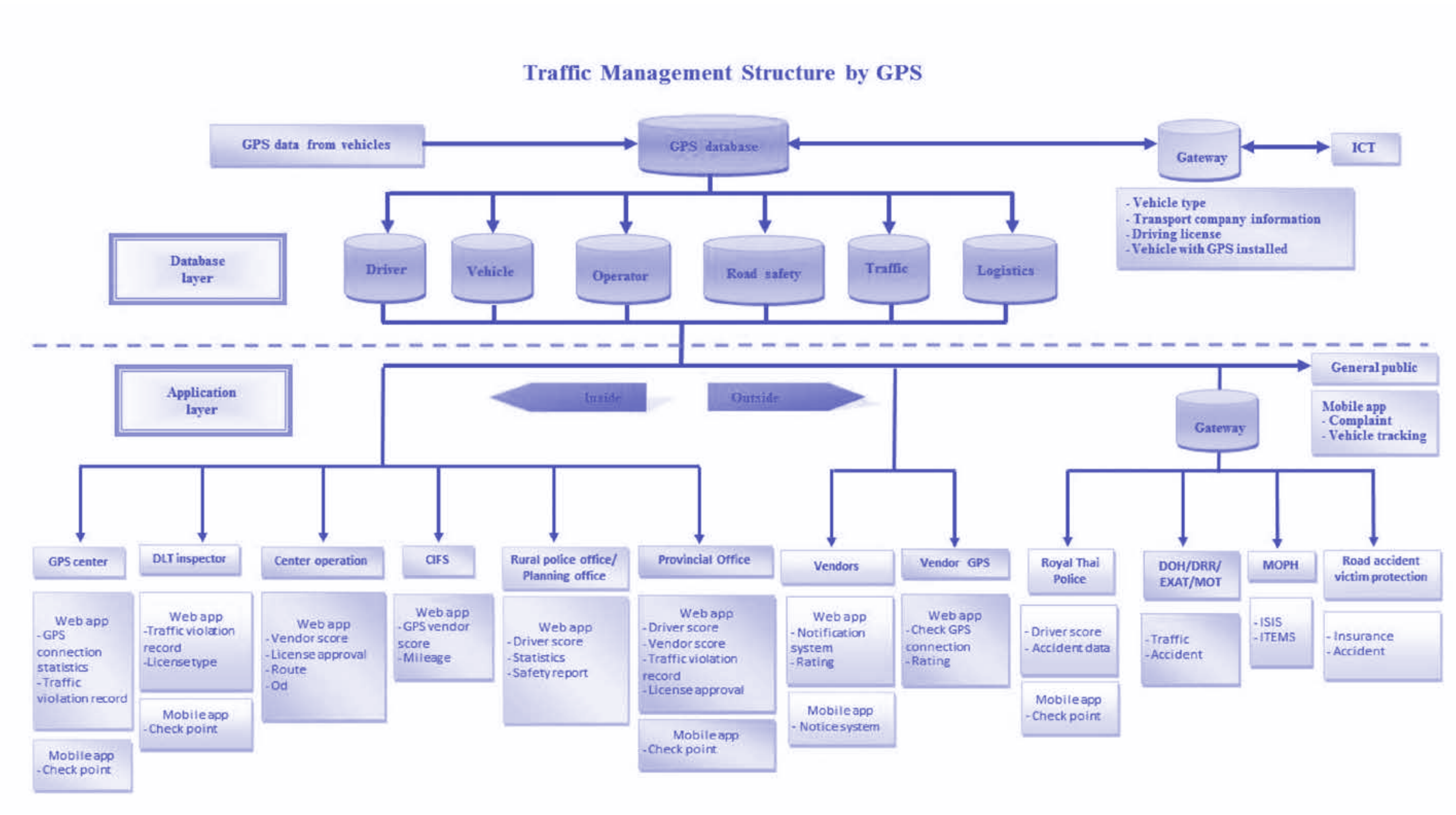
Outsider users, such as the Royal Thai Police, the Department of Highways, the Department of Rural Roads, the Expressway Authority of Thailand, the Ministry of Public Health, and Road Accident Victims Protection Co., Ltd., need to exchange data through a gateway, as shown in Figure 7. Each department is eligible to exchange certain data according to its information system, as follows:

- Royal Thai Police: score system and accident data
- Department of Highways, Department of Rural Roads, Expressway Authority of Thailand, and Ministry of Transport: traffic flow and accident data
- Ministry of Public Health: exchange data from Injury Surveillance Information System (ISIS) and Information Technology for Emergency Medical System (ITEMS) database of the Department of Land Transport

5.3 Traffic control development plan using GPS technology

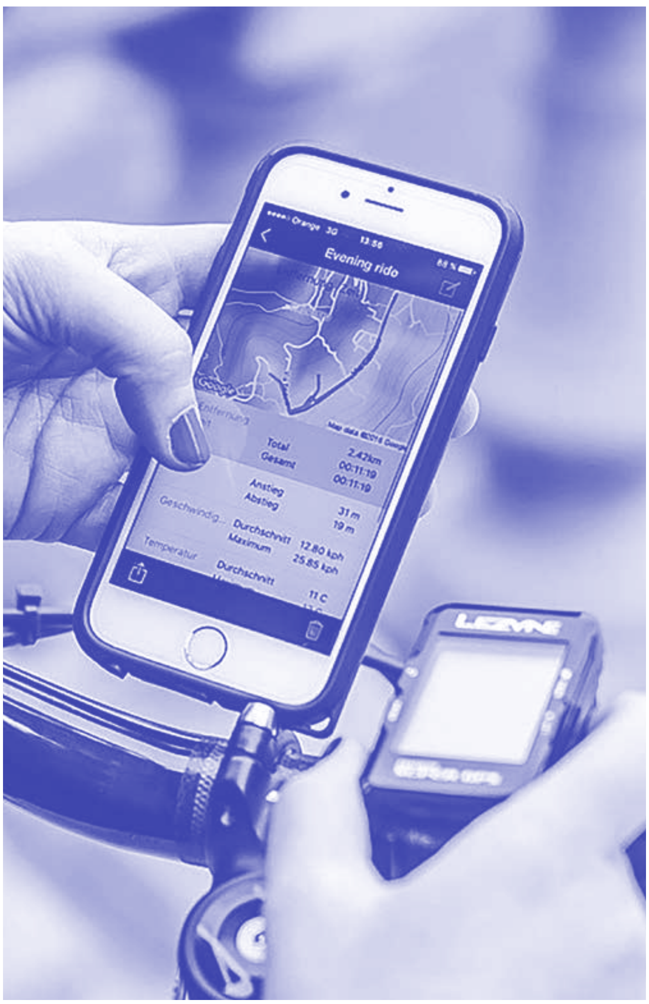
In order to effectively control traffic using

Figure 7: GPS usage by outside parties



Abbreviations: App = application; DoH = Department of Highways; DRR = Department of Rural Roads; EXAT = Expressway Authority of Thailand; MOT= Ministry of Transport; MOPH = Ministry of Public Health; ISIS = Injury Surveillance Information System; and ITEMS = Information Technology for Emergency Medical System.

GPS technology, continuous development is necessary. In the first stage in 2016, an announcement stated that passenger transport vehicles and cargo transport vehicles would have to install GPS tracking devices and send data back to the GPS Traffic Control Center. These data were used to develop a GPS connection system, traffic violation system to detect such violations as speeding, unidentified drivers, and driving exceeding the time limit, as well as pairing GPS data with the Information Technology Center to inspect the data's reliability. In the second stage, the aim is to develop automatic traffic violation warning (active system) and establish a GPS Traffic Control Center in rural areas to promote road safety. In the third stage, applications should be developed in accordance with the Department's needs. In the fourth step, Business Intelligence (BI) uses data processing to improve the potential and quality development of vendors and drivers. In the last stage, when the GPS Traffic Control System has enough data and the processing system becomes more complicated, it would be necessary to establish a GPS Data Providing Office as a new section in the Department of Land Transport. All stages are expected to be complete within 2019 because by that time all transport vehicles should have GPS devices installed in order to be certified for road safety.



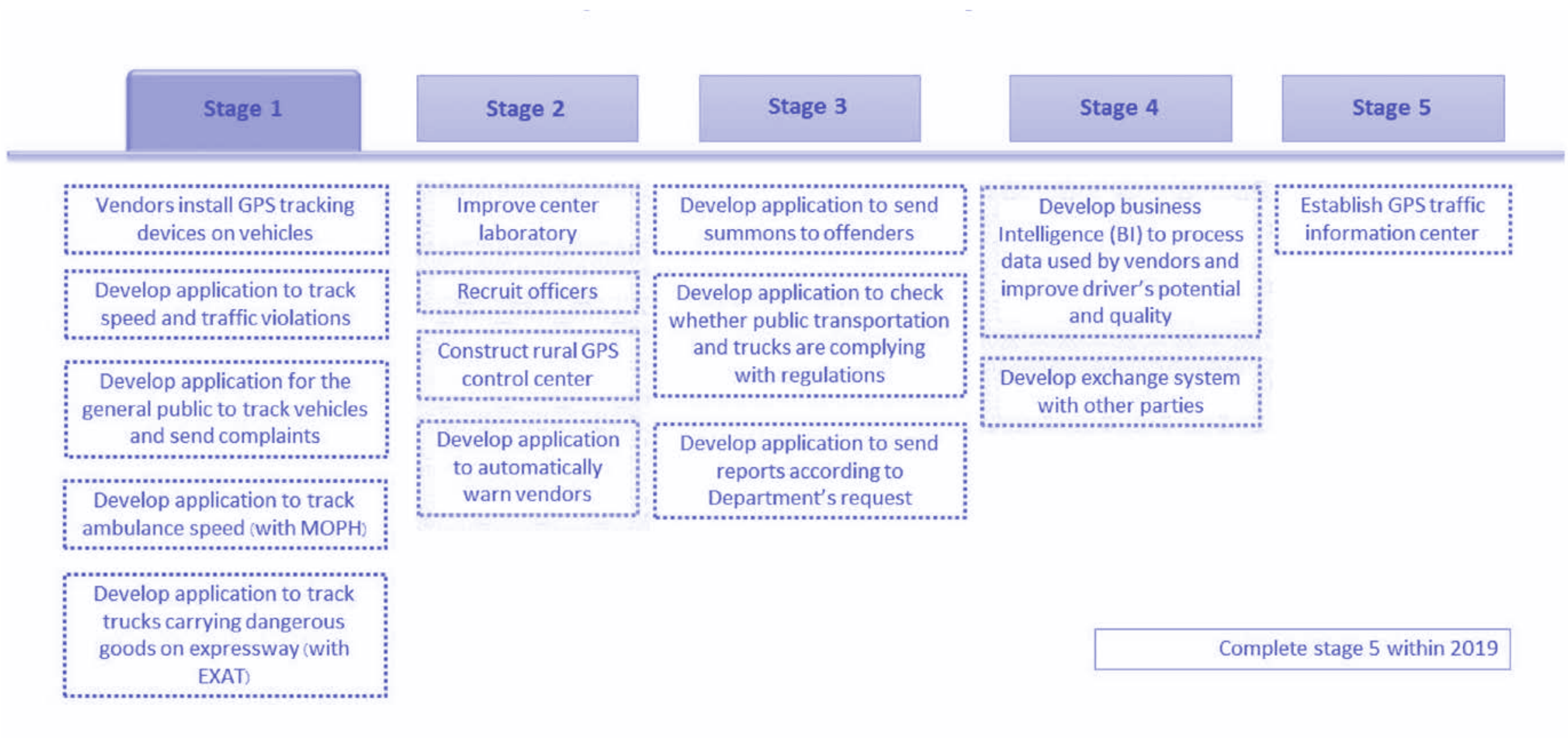
6. APPLICATION OF DATA FROM GPS SYSTEM

6.1 Safety

- **Analysis of speeding**

According to data from the GPS traffic control system, 195,194 vehicles in January 2017 violated speed limits (over 90 km/hr for more than 2 minutes). Most of them were buses with an unfixed route (89,144 cases). However, the percentage of vehicle types shows that 41 percent of the cases regarding this type of transport involved buses with fixed route standard 2. For trucks, the number of speeding vehicles according to the number of trucks in each transport type was only 3 percent. Of these, type-2 personal trucks accounted for the greatest number (7%) of this type of transport vehicle.

Figure 8: GPS Traffic Control Development Plan



Abbreviations: MOPH = Ministry of Public Health; and EXAT = Expressway Authority of Thailand.

Table 5: Top 10 highways with the highest number of speeding vehicles (daytime)

Rank	Controlled link	Route No.	District	Province	km
1	Srinagarindra Road - Bang Pakong	7	Bang Pakong	Chachoengsao	0+000
2	Bang Na - Road to Suvarnabhumi Airport	34	Bang Phli	Samut Prakan	13+000
3	Khlong 26 - Khlong Rapheephat	3902	Wang Noi	Ayutthaya	1+000
4	Pratunam Pra In - Nong Khae	1	Wang Noi	Ayutthaya	62+000
5	Dao Khanong - Samae Dam	35	Bang Khun Thian	Bangkok	13+000
6	Samrong - Bhumibol Bridge	3113	Phra Pradaeng	Samut Prakan	6+000
7	Din Daeng - Ngam Wong Wan	31	Phaya Thai	Bangkok	0+000
8	Si Racha – Pattaya	3	Si Racha	Chonburi	128+000
9	Samrong - Bang Phli	3268	Samut Prakan	Samut Prakan	8+000
10	Khlong Maha Sawat - Khlong Bang Luang	9	Bang Bua Thong	Nonthaburi	49+000

Table 6: Top 10 highways with the greatest number of speeding vehicles (night time)

Rank	Controlled link	Route No.	District	Province	km
1	Srinagarindra Road - Latkrabang	7	Latkrabang	Bangkok	8+000
2	Tandeaw - Sabbon	2	Kaeng Khoi	Saraburi	16+000
3	Bang Na - Sanphawut	3102	Bang Na	Bangkok	0+000
4	Din Daeng - Ngam Wong Wan	31	Chatuchak	Bangkok	10+000
5	Bang Na Road to Suvarnabhumi Airport	34	Bang Phli	Samut Prakan	13+000
6	Pratunam Pra In - Nong Khae	1	Wang Noi	Ayutthaya	62+000
7	Phra Pradaeng - Bang Khae	3902	Phra Pradaeng	Samut Prakan	1+000
8	Udom Suk - Samut Prakan	3344	Samut Prakan	Samut Prakan	18+000
9	Samrong - Bhumibol Bridge	3113	Phra Pradaeng	Samut Prakan	6+000
10	Samrong - Bang Phli	3268	Samut Prakan	Samut Prakan	8+000

Table 7: Points with sudden decreases in speed

Latitude	Longitude	Controlled link	Route No.	District	Province	km	Brake count (times)
14.8400621	101.6076211	Bo Thong - Mo Chabok	2	Sikhio	Nakhon Ratchasima	92+000	1,208
8.096911939	98.97789939	Talat Kao - Khlong Thom	4	Nuea Khlong	Krabi	981+000	1,118
13.72948733	100.7423789	Srinagarindra Road - Bang Pakong	7	Latkrabang	Bangkok	11+000	1,106
13.39128992	101.0467656	Bang Pakong - Khao Kheow	7	Chonburi	Chonburi	67+000	1,015
12.94416428	100.9125277	Ban Pong interchange - Pattaya	3702	Bang Lamung	Chonburi	125+000	992
15.57657177	100.1250173	Hang Nam Nong Khaem - Ban Wa	1	Krok Phra	Nakhon Sawan	327+000	889
15.54799003	102.5480106	Kaeng Sanam Nang - Don Tanin	2	Sida	Nakhon Ratchasima	233+000	879
15.81321012	102.6075382	Nong Waeng Sok Phra - Phon	2	Phon	Khon Kaen	263+000	867
13.38459475	101.0448949	Don Hua Ro - Nong Khang Khok	3702	Chonburi	Chonburi	68+000	857
13.67040362	100.8432737	Latkrabang - Bang Khwai	7	Bang Sao Thong	Samut Prakan	26+000	852

Furthermore, based on data from the GPS device in each vehicle, it is possible to identify the top 10 highways with the most speeding vehicles both during the day and at night, as shown in Tables 5 and 6 respectively.

- **Analysis of points with sudden speed decrease**

Data on speeding can be used to analyze points with a sudden decrease in speed that helps in understanding driving behavior. Sudden velocity change can be significantly used in in-depth analysis, which provides information on route physical data, such as curved, intersected, or damaged roads. This factor might cause abnormal driving because the driver may lack experience with that route, or highway safety equipment or signs may not be provided.

A sudden brake detected by the GPS system means decreasing speed from over 80 km/hr to half that speed within a minute, cause red points to become smaller and disappear within 2 minutes. Analysis provides information on where the most sudden speed decrease occurs, as listed in Table 7.

6.2 Transport and logistics

- **Analysis of starting and ending points**

For applications to transport and logistics management, the location of the GPS device can be used to find a vehicle's location on a road map. The system stores starting and ending points by using GPS applications from various types of vehicles, and transforms the GPS data signals into travel information from starting to ending points. Map data provide information on the behavior of each vehicle type.

- **Rest area analysis**

When transport and logistics data application is used to find a rest area, the density of vehicles in each area is also known. Therefore, we know density on a road map as well as the number of trips made by cargo trucks on truck routes, travel needs, and number of trips from points of origin to destinations, which can be used to plan whether to add or remove any rest area.

7. CONCLUSION AND RECOMMENDATIONS

Connecting and exchanging data from a vehicle's GPS device and analysis of large amounts of data to produce understandable information makes it possible to add value to that information. The result of nationwide road map analysis obtained from GPS clearly shows the behavior of drivers of vehicles with GPS installed. Speed analysis can be applied for road safety management. It is not only control of vehicle speeding or traffic flow on a road map that government agencies would know, but also data on highways with vehicles exceeding the speed limit; therefore, it would become possible to manage the process of accident prevention. Sudden brakes in speed data can be analyzed, and driving behavior can be better understood. A sudden decrease in speed reflects physical characteristics of a route that is curved, intersected, or damaged. These factors might cause abnormal driving if the driver lack experience in driving on that route or no highway safety facility or sign is provided. Speeding data can be used in many applications, or as a guideline for law enforcement, physical improvement of routes, and installation of signs and safety facilities, such as a sign warning drivers to decrease speed ahead. Transportation and logistics management by analyzing starting and ending points enables better understanding of travel patterns, transportation routes and rest areas, and therefore understanding of the distribution and needs along the routes, which can be used to plan whether to add or remove any rest area.

In conclusion, GPS can satisfy the needs of the Department in terms of management and control, which is beneficial to management procedures and promotes road safety, increases transport and logistics efficiency, and encourages research related to transport development.

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