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INTEGRATING ROAD TRAFFIC SAFETY POLICY IN VIETNAM

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ABSTRACT

Transportation policy in general and road traffic safety policy in particular play an important role in the national economy and have been studied for a long time by many countries around the world, but have only recently been studied by developing countries like Vietnam, and announced recently. The paper clearly states the goals and roles of road traffic safety policy, summarizes the approach and methods of conducting research. The paper introduces and analyzes the construction of transportation policies of the road sub-sector in the world and in Vietnam. Next, the paper states the main research results with the following contents: analysis and evaluation of road traffic safety policies implemented to date according to road traffic safety criteria/indicators proposed, selected by the author, and integrate those criteria, preliminary a loss/effectiveness assessment. Finally, the paper proposes the solutions on integration of road traffic safety development policies for the coming time to contribute to turning Vietnam into a developing country with modern industry and high average income by 2030 and the following years.

KEYWORDS:- Traffic safety; sub-sector road traffic policies.

1. INTRODUCTION

1.1 ***Road traffic safety role:*** Traffic safety plays a very important role in every economy, especially road traffic safety. The goal of the paper is to develop an integrated traffic safety policy for the Vietnamese road transport, including specialized traffic safety policies; policies and planning (called policies) for the development of five areas: road infrastructure, road transport vehicles (new building, assembly, repair of road vehicles, technical safety inspection &environmental protection), and people (participating in road traffic such as: drivers of road traffic vehicles - drivers, compliance with traffic rules, road signs; people who train, test, issue driving licenses; road motorists, cyclists, pedestrians,passengers and others-participants) and combination of 2 or 3 of

them. In addition, the article also provides a preliminary assessment of the level of integration in 2024 and forecasts for 2030 and 2050 regarding the road sub-sector traffic safety policy. The system of factors/criteria and integration of those factors using a multi-criteria, multi-dimensional mathematical model proposed by the author is considered quite complete and comprehensive, and has not been published until recently in Vietnam.

1.2 The role and importance of integrating road traffic safety policy: To help Vietnam's policy-making organizations, stakeholder as well as state management agencies in building overall policies and strategies, planning for road safety; promulgate legal documents, including international treaties related to traffic safety, such as: investment projects to build and upgrade the road infrastructure network (budget and non-budget capital sources); road vehicles: cars,buses, trucks, and similar vehicles; motorbikes, bicycles... To guide the businesses, organizations and individuals operating in the field of transportation to invest in the construction projects of road infrastructure, means of transport, road transport and public transport service activities, fields automobile and motorbike industry to implement the road traffic safety policy.

1.3 Overview of the work countries have done on road traffic safety policy integration: Abroad, research by Hull A. (2005) and John Preston (2012) proposed an integrated scale of 9 levels related to urban public transport, from easy to difficult. Hull A. states the levels of difficulty as the integration process takes place technically and organizationally. According to this scale, it is possible to distinguish levels of horizontal integration (level 1-4) and vertical integration (level 5-9). Depending on the development conditions of urban public transport modes, there will be different levels of integration between different modes [12]. Similarly, John Preston started from disintegrated, unsustainable public transport system, and the result was an integrated & sustainable public transport system [14]. The elements of level integration are introduced in Appendix 1. In this study, the authors also introduce an overview of public transport system integration and difficulties when applying of urban public transport system integration solutions, model of public transport management authority. Urban areas have rebuilt their management agency model into an Integrated Transport Authority System - ITAS. Through the table can see that, although at different times, two papers have 9 level according to the criteria.

Nguyen Tran Hiep (2021, Proceedings of the Traffic Safety Conference - Proceedings, p.550) introduced that Europe has measures on road infrastructure such as fences, median strips, intersections. Place sensors to detect pedestrians and cyclists in blind spots near the front; separate lanes for bicycles.About people: ensuring pedestrian safety, driver training; international police inspection of cargo trucks in Europe; regulations that after 2 hours of continuous driving, the driver must rest for at least 15 minutes. Regarding vehicles: request to install automatic emergency brakes [25]. However, the article does not mention the integration of the road trafficfactors.

Michael Matthew Reynolds (2009) identifies the need to limit the use of personal cars and replace them with bicycles, walking and the role of public transport; raises the question of how to encourage higher levels of service integration (between walking, cycling and public transport). Next, the thesis presents a theoretical transportation network model, integrated ticketing with the participation of private enterprises [18].

JICA launched the integration of the city bus network with the inter-city coach network and provided bus terminals to promote integration with other modes of transport in the master plan of the transport network in greater Tripoli [13]. Similarly, PARK Junsik & Seong Cheol KANG (2011) introduced the link between urban railway lines and urban bus lines in Korea [27].

Gerald Ollivier and colleagues (2021) introduce the link between TOD and road safety that is effectively planned, ensuring the seamless integration of public transport with other modes of transport, that are public transport with other modes of transport, more accessible, safe, less obstructive and more comfortable. The highest priority is given to pedestrians, followed by cycling, and the least priority is given to private cars. Accordingly, the TOD project will integrate best practices in transportation planning, land use planning and urban design [6]. The TOD Toolkit is updated, developed with support from UK Aid through GRSF, incorporating recent updates related to road safety [5]. Similarly, the webinar series "Integrating Road Safety Considerations in TOD Projects" described how to systematically integrate Road Traffic Safety into the planning, design, implementation, and financing of Road Traffic Safety Programs. TOD program and builds on the new WB/WRI India Note titled Good Practice Note: Integrating Road Safety Considerations in TOD Projects [5,6].

Thus, research abroad introduces the combination of three elements of road infrastructure, road vehicles and people participating in road traffic, but not much; focus on integration between public transportation development, between transportation and land use [5,6,12-14,18,19,27]; integrating urban bus and urban railway operations; urban buses and inter-provincial and inter-city buses; integrated at transit points, bus stations, TOD projects (between walking, cycling and public transport), integrated ticketing. However, the studies do not clearly indicate whether there is integration in space and over time, whether there is mixed/cross integration, synthetic integration or not and if so, at what scale or degree.

Countries around the world have used applied research and approaches to evaluate traffic safety policies and propose solutions to improve road traffic safety or limit and minimize road traffic accidents in the future.

Domestically, Alina F. Burlacu and the WB Global Transport Group in Vietnam (2021, Proceedings, p.47) have stated the importance of a comprehensive systematic database on road safety. With some key components, Vietnam already has its own data repositories but they have not been linked, supplemented and integrated to become a common database. After presenting the research results, the author has two opinions:

i) Establishment of the National Road Safety Observatory (NRSO);
ii) A series of recommendations are mentioned for a complete analysis; improve data collection processes and data sets; improve database management and data sources on road traffic safety [2].

Chu Tien Dung [2021, Proceedings-3, p.238], based on research conducted around the world, has summarized and evaluated the factors affecting the behavior of running red lights, solutions to minimize the possibility of running red lights of participants run through red lights. The results

show that characteristics of traffic participants, intersections, traffic characteristics, time and environmental factors affect the ability to run red lights. Among the solutions, surveillance cameras combined with cold penalties through cameras are considered the most effective solutions [3].

Ha Thanh Tung (2023), Research on solutions to integrate urban public transport systems in Vietnam - Application in Hanoi city. The thesis proposes 3 scales of space, function, management organization and 9 levels of integration, stating integrated solutions for: route network, transit points, urban public transportation system services, ticket system, organizing and managing Vietnam's urban public transport system [9, p.53].

Hoang Xuan Thao [2021, Proceedings, p.198] provides statistics from the Vietnam Register on vehicles that are past their expiration date and inspection deadline to detect and propose solutions: revoke license plates number, notify vehicle owners, sanction administrative violations[11].

Three articles by Le Thu Huyen (2023), clearly highlight traffic law violations by students in mixed traffic [16, p.64]; Dang Danh Huong (2021 Proceedings), Traffic safety education in high schools [4, p.250] and Ta Thi Hue and Nguyen Thi Quynh Nhu (2021) propose solutions to raise awareness of traffic participants, especially young people of school age [35, Proceedings, p.262]. Le Minh Chau (2021), whose Vietnamese driver's license is recognized by 85 countries, recommends that temporary driver's licenses should be issued to people who have just passed the test in the near future [15,Proceedings p.533].

Research by MOT and JICA (2010) in Vietnam proposed 32 transportation corridors to (connect, link) integrate transportation within the territory of Vietnam and Vietnam's transportation with regional and international countries [21]. Similarly, the plans for the road, railway, seaway, IWT, air transport networks and especially the inland container deport network planning- ICD [24-34] approved in 2021 and 2023 also aim to link/integrate Vietnam's transportation system, including integrate the road traffic safety system.

Nguyen Ngoc Thach (2015), Researching synchronous solutions to enhance road traffic safety in Vietnam proposes 5 levels of synchronous solutions according to 4 groups of factors: infrastructure, vehicles, people and other factors/unidentified factor. Based on 5 specific groups for regions, propose criteria and indicators for synchronous solutions including indicators of the above factors' groups. At the same time, the author evaluates the impact of synchronous solutions with the expected results of reducing and limiting traffic accidents for the years 2020, 2030 and 2040 [24].

Pham Duc Long (2021) clearly stated that legal documents have been issued to implement the work of ensuring the quality of technical safety of vehicles. The author also offers a number of solutions to improve the quality of vehicles, vehicle safety and vehicle emissions control [28, Proceedings,p.198].

Article by Tran Trong Vinh (2023) talks about using Intelligent Transport System - ITS and Artificial Intelligent- AI to connect vehicles, traffic signals, toll stations and other infrastructure to prevent road traffic accidents. At the same time, also build and develop a centralized monitoring

solution to integrate smart warnings and ensure traffic safety based on management software [36, p.9].

1.4 Number of road traffic accidents: National Traffic Safety Committee-NTSC (2023, 2012-2023) annually evaluates the number of incidents, deaths, injuries, economic losses/damages to road vehicles; number of deaths/100,000 people and over 10,000 vehicles due to road traffic accidents [22]. Figure 1 introduces the number of accidents, deaths, and injuries due to road traffic accidents in 2022 and 2023. Figure 2 introduces the number of deaths/10^4 people due to road traffic accidents in 4 years 2019-2022 and figure 3, introducing the number of deaths/10,000 vehicles in the period 2018-2022.

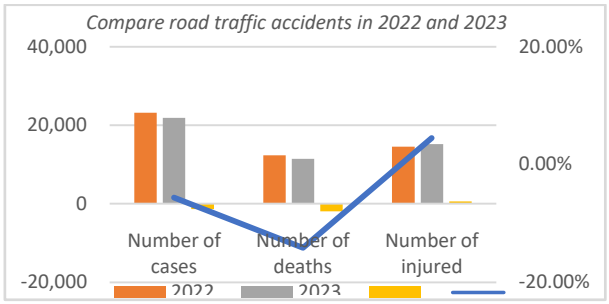
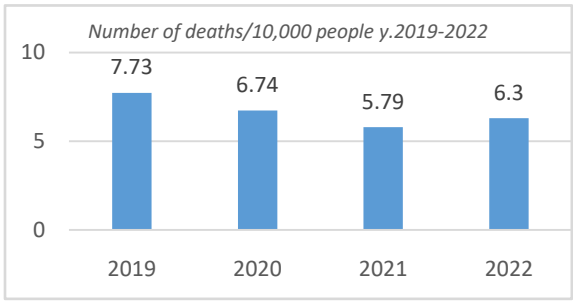


Figure 1. Number of cases, of deaths and number of injured by road in 2023, 2022 in Vietnam



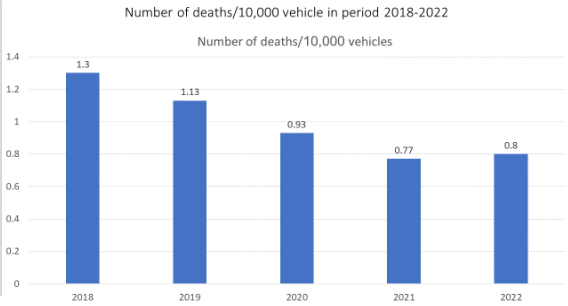


Fig 2. Number of deaths/10^4 people by road in period 2019-2022 Fig.3. Number of deaths/10^4 vehicles in period 2018-2022

Through the two figures, it can see that the number of deaths/population; the number of deaths/road vehicles has decreased over time. This is good trend for Vietnam in the past.

Vuong Xuan Can, Cu Thi Thuc Anh (2021, Proceedings) clearly stated that the driver's violation of road traffic laws is a major factor causing accidents in order to reduce the number of road traffic accidents. Driver errors have become an urgent problem that needs to be addressed. Training, testing and issuance of driving licenses must be placed at the forefront of proposed programs, strategies and solutions [37, p.256].

Research and works in the country all talk about the factors/elements that make up traffic safety on the road, but have only been linked, partially integrated and/or in a sustainable direction [9-11,16,17,24,26,28]. In the country, also introduces synchronous policies on traffic safety on the road and propose solutions to handle drivers and driver training; development of road infrastructure,

road transport service, people, but almost no talk about policies integrating 4 or 5 elements, especially at transit, ICD, and TOD points.

Thus, Vietnam has used common approaches and research methods to evaluate the road traffic safety policy and propose solutions to improve road traffic safetyin future. However, there are very few articles on integrating road safety policy according to three main factors of road traffic: road infrastructure, road transport vehicles, people; and the combination of 2 or 3 factors or other factors.

1.5 Causes of road traffic traffic accidents: According to 4 main factors in Vietnam such as road infrastructure, road vehicles, people participating in road traffic and other factors (in %). In addition, a number of studies have evaluated the level of damage in VND or USD, % compared to GDP, number of vehicles lost and damaged...The National Traffic Safety Committee-NTSC, has also evaluated the results for the period 2012-2022 and 2020- 2023 on the number of cases, deaths and injuries by 5 sub-sectors/majors (including road), by province and city; according to the classification of road such as road system (National, provincial, district, communal, urban, and specialized roads), by type of vehicle like trucks, buses; passenger, private cars), specialized cars, motorbikes participating in traffic; rudimentary vehicles like bicycles, cyclos...According to the cause of the accident: due to road infrastructure, road vehicles, behaviors of road traffic participants (such as not complying with regulations on road signs; avoiding illegal overtaking, using alcohol, going in the wrong road direction), road section, lane...); according to the age of traffic participants, according to time of day, according to gender of traffic participants...[22].

For example, figure 4 states the causes of traffic accidents on the road according to behavioral causes such as: not paying attention, driving on the wrong side of the road or wrong lane; improper navigation, not keeping a safe distance...

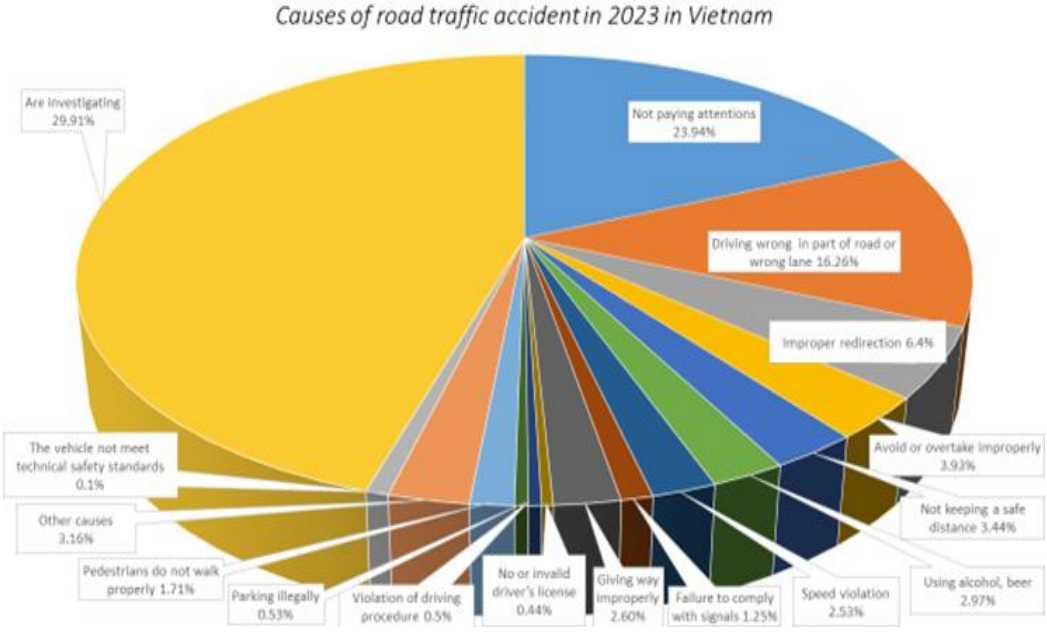


Figure 4. Causes of road traffic accident in 2023 in Vietnam (Full version); Source [NTSC]

Figure 5 states some of the main causes of traffic accidents in 2023 (short version) [22]. Through the figures, can see that there are too many factors/criteria (16) affecting road traffic safety, each

criteria only has a small impact and the factor under investigation accounts for a quite high proportion (45%), while the factors that do not guarantee technical standards of vehicles account for a very small proportion (0.1%).

The main causes are: driver not pays attention (23.94%); driving in wrong part of road or wrong lane (16.26%), improper redirection (6.4%), avoid or overtake improperly (3.91%), not keeping save distance (3.44%)…

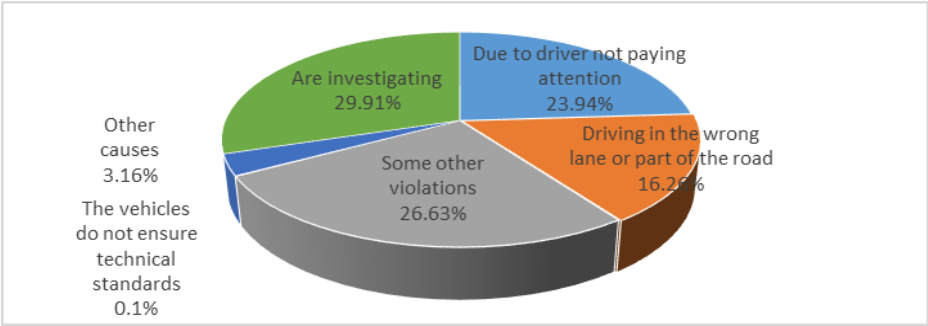


Figure 5. Causes of road traffic accident in 2023 in Vietnam (Shortened version)
Source [NTSC]

Vehicle drivers are the main cause of traffic accidents on the road in 2021, accounting for 43.53%. Causes due to road traffic vehicles account for 0.27% and road infrastructure causes account for 0.24% [MOT, @mot.gov.vn].

1.6 The costs of road accidents

Developed countries in the world have undertaken road traffic accident cost analysis and have method of calculating the level of damage/losses based on GDP. Depending on available data and the time of calculation, the losses from road traffic accidents ranges from 0.3 to 2% of GDP according to data of the country [38]. In India, the level of loss caused by road traffic accidents is quite high (2% of GDP); while in Nagpur, Maharashtra only accounts for 0.09% of this city's GDP. In Iran, the estimated cost of road traffic crashes in Iran using the human capital - HC method was 1.41% of GNP in 2009 [38]. Total accident cost from 2010-2012 is estimated at 0.38% of GDP of Purbalingga, Indonesia and Road Traffic Accident Cost Using Human Capital Method (case study in Purbalingga, Central Java, Indonesia) accounted for 1.27% GDP in 2014. In Sudan, it accounted for 0.57% of GDP in 2010 and 0.62% of GDP in 2011 [38].

The article of Anh, Trinh Thuy; Dao, Nguyen Xuan & Anh, Trinh Thi Tu (2005) [1] states that, road traffic accidents in Vietnam have caused a significant and increasing loss in terms of monetary and pain, grief and suffering. It is time to study the costs of road accidents. The paper aims to review accident costing methodologies which are applied in developed countries in the world and developing countries in the region. Considering current economic situation and database of road safety in Vietnam, an appropriate method would be chosen to estimate an initial approximation of the cost of road traffic accidents. Accident data and cost figures of the year 2002, 2003 and 2004 are considered to make the estimation of annual accident cost of Vietnam. Moreover, accident cost of Hanoi and Hochiminh City were calculated to compare the loss of each city among total loss of the country.In Vietnam, there are also regulations that victims are compensated for losses/damages

when vehicle owners and drivers cause road traffic accidents according to the provisions of civil law and criminal law.

1.7 Some measures and solutions applied in Vietnam:

Because Vietnam's traffic accidents are at a high level, causing great loss of life and property, Vietnam has applied many measures and solutions, regularly and continuously, to limit and minimize road traffic accidents and environmental pollution, such as:

Regarding the road infrastructure: building many sections and expressway routes, upgrading the national highway system-NH, building many large, modern bridges; building grade-level intersections, overpasses, and underpasses for pedestrians, vehicles in big cities; construction of mass rapid transport infrastructure such as urban railways, metro, BRT, etc. [20,23,31,34].

Regarding road vehicles: investment in purchasing new, modern road vehicles; remove old and expired vehicles; putting into use green, clean, environmental friendly vehicles (no/less environmental pollution) such as electric cars, buses; buses using CNG, LPG; electric motorbikes, bicycles. Build a process and equip a system of technical safety and environmental protection registration stations with many modern lines, suitable for Vietnam's conditions like other countries in the region [8,11,23,24,28].

***Regarding peopleparticipating in road traffic**:* impose strict administrative penalties on people who use alcohol or other psychotropic stimulants while driving; acts of not paying attention and driving over the speed limit according to regulations; going on the wrong side of the road or lane; failure to give way, failure to comply with signals, road signs...Develop a process for training, testing, and granting a motor vehicle driving license: hundreds of training centers and driving testing centers have been built and assembled, equipped with modern machinery and equipment [4,20,23,24,35].

Regarding other tasks: completing legal documents, policies to encourage public transport, restricting personal vehicles (pull and push); establish and implement strategies, planning, program and project plans, ICD [23,34]; strengthen propaganda and legal education for the people, especially pupils and students; patrolling and controlling drivers and vehicles on the road; develop regulations for close and effective cooperation, coordination between relevant agencies and organizations, and organize implementation policy on road traffic safety [16,24].

2. RESEARCH APPROACH AND METHODS

In addition to common research approaches and methods, the paper uses a systematic approach; expert methods, combined quantitative and qualitative research. In particular, the article uses multi-criteria, multi-dimensional, mathematical modeling methods, with attention to the software of factors/criteria and indicators that make up the 9-level road safety system with the goal is to help policy makers, the government, the Ministry of Transport-MOT, the NTSC, and the Vietnam Road Administration-VRA make appropriate decisions to limit and reduce road traffic accidents and sustainably develop road traffic safety:

- *Systems approach:* following a systems approach to the research framework, considering the road traffic safety major as an overarching system, with subsystems representing the constituent elements as the road infrastructure, vehicles, people and integrating those 2,3 criteria. This approach allows for a comprehensive assessment of road traffic safety policy from different aspects.
- *Modeling:* Mathematical and statistical modeling is employed to analyze and interpret quantitative data, facilitating the identification of trends, patterns, and causal relationships within the road traffic safety policy landscape.
- *Consultation:* Stakeholder consultations are conducted to validate quantitative findings and gain further insights from experts and practitioners in the field of road traffic safety policy.
- *Multi-criteria model:* elements/criteria are mixed integration; synthesized integration of all elements, both hardware and software.
- *Multi-dimensional model:* going from the bottom- single/-dimensional (not integrated, not sustainable) to 4 dimensions and to 5-9 dimensions, integrating a mixture of elements and integrating in space, over time, the software is integrated and finally the road traffic safety system is integrated and sustainable.

Figure 6 introduces a diagram of the article's approach and research method.

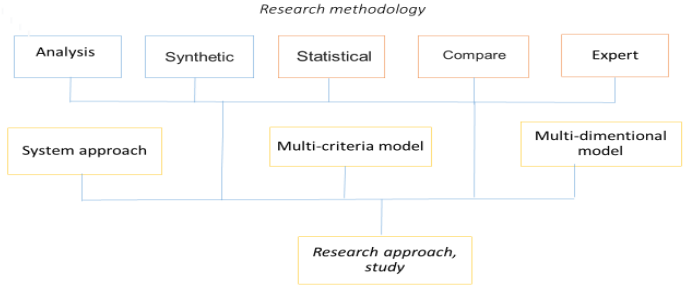


Figure 6. Approach and research method

In Vietnam up to now, there has been no integrated research on road traffic safety published recently; has not updated and used multi-criteria, multi-dimensional mathematical models related to factors affecting road traffic safety. That is not to mention the factors/criteria for road traffic safety that need to be integrated in a mixed form of horizontal - vertical, time - space, and level; mixed horizontal -vertical-level; mixed time-space-level and horizontal-vertical, time-space-level synthesis integration, both in hardware and software. The integration of factors/criteria needs to be specifically introduced, both in the development and implementation of policies and legal documents on road traffic safety. That is the urgency issue.

3. MAIN RESEARCH RESULTS

3.1 Integrated ladder by level

Applying the integrated model of urban public transportation [8,12,14], the integrated scale of road traffic safety with 9 degrees is introduced in figure 7.

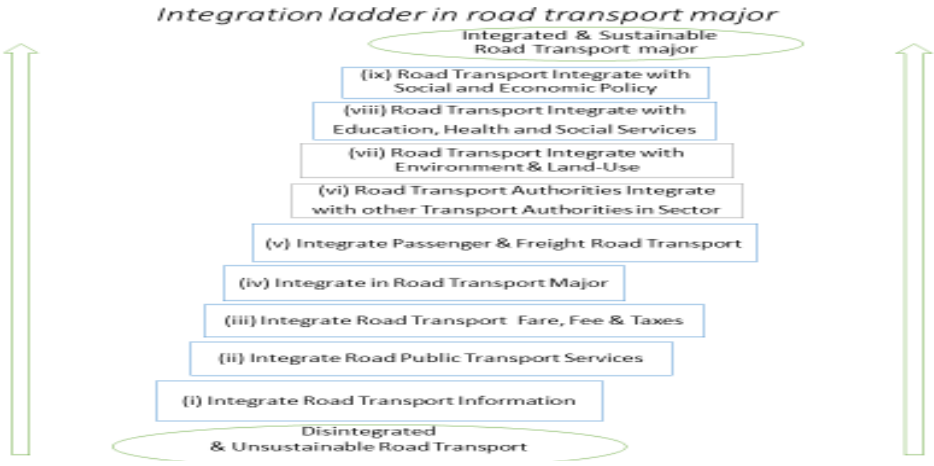


Figure 7. Integrated ladder of road traffic safety with 9 degrees

Explanation of figure number 7:

i) Integration of road transport information systems, for example integration between information systems on road traffic safety in the Hanoi Capital area;

ii) Integration of road public transport services, for example integrating services between Hanoi Transport Corporation and Vinbus-Vingroup Company on urban public transport in Hanoi;

iii) Integrate tickets, fares, fees, for example, integrate monthly tickets with daily tickets according to the ratio (%) based on statistics or annual surveys to determine the compensation, support amount for urban public transport enterprises in Hanoi and road terminal entry/exit fees for interprovincial passenger transport;

iv) Horizontal integration in the road transport sub-sector, for example integration between departments of the VRA; divisions in the VNA; between provincial Departments of Transport-DOTs;

v) Horizontal integration between passenger and goods transport, for example at Noi Bai International Airport, Ho Chi Minh City gateway seaport or seaport in Ba Ria-Vung Tau province; vi) Vertical/horizontal integration between road management agencies, eg. integration between VRA (MOT) and/with provincial and cities' DOT;

vii) Vertical integration between VRA and environment, road and land use rights, for example integration between VRA (MOT) and General Department of Land Management/General Department of Environment (Ministry of Natural Resources and Environment- MONROE);

viii) Vertical integration between VRA (MOT) and Ministry of Education and Training or Ministry of Health, for example between VRA and Ministry of Health;

ix) Vertical integration between VRA and the Ministry of Planning and Investment-MPI or the Ministry of Finance-MOF.

The above model does not clearly introduce integration by space, time and software, so the multi-factor/criteria integration model has been further developed. It is a multi-factor/multi-criteria, multi-dimensional model, specifically applied to the 5 factors of road traffic safety in Vietnam.

3.2 Mathematical formulation for integrated models

From the general model above, the author develops the mathematical models with the followingformulas:

Horizontal integration between information systems:

$$\sum_{i=1}^{m} IShor \qquad (3.1)$$

Horizontal integration between road public transport service systems (urban and inter-provincial transport):

$$\sum_{j=1}^{n} PThor \qquad (3.2)$$

Horizontal integration between ticket prices, public transportation charges, and terminal (entry and exit) fees:

$$\sum_{j=1}^{n} FaFeTahor \quad (3.3)$$

Horizontal integration between local DOT-s; organizations/units in the road sub-sector:

$$\sum_{j=1}^{n} DOThor \qquad (3.4)$$

Horizontal integration & vertical integration (mixed) between passenger and goods transport by road:

$$\sum_{j=1}^{n} Frt \,\&\, Pashorver \ (3.5)$$

Horizontal integration & vertical integration (mixed) between VRA and other departments, agencies and organizations in the transportation sector:

$$\sum_{j=1}^{n} Roadhorver \sum_{k=1}^{o} Othorver \ (3.6)$$

Horizontal integration, vertical integration & level integration (mixed) between VRA and General Department of Land, General Department of Environment-Ministry of Natural Resources and Environment - MONROE:

$$\sum_{i=1}^{m} \quad \sum_{j=1}^{n} \quad \sum_{l=1}^{p} \mathrm{RoadLandEnv}_{\mathrm{horverh3}} \ (3.7)$$

Horizontal integration, vertical integration & level integration (mixed) between VRA and Ministry of Health or Ministry of Education & Training:

$$\sum_{i=1}^{m} \quad \sum_{j=1}^{n} \quad \sum_{l=1}^{p} \mathrm{RoadHealtEdu}_{\mathrm{horverh3}} \ (3.8)$$

Synthetic integration between VRA and socio-economic policies:

$$\sum_{i=1}^{m} \quad \sum_{j=1}^{n} \quad \sum_{k=1}^{o} \quad \sum_{l=1}^{p} \varepsilon.\, \mathrm{IntRoadEcSo}_{\mathrm{horverlevth3}} \rightarrow \max \ (3.9)$$

***In which**:* ε is the experimental coefficient; $\mathrm{IntRoadEcSo}_{\mathrm{horverlevth3}}$ is a binary variable that depends on the horizontal integration between the VRA (MOT) and other sectors or between sub-sectors of the MOT; vertical integration between management levels in the same road sub-sector; integrating levels within the same road major; mixed integration between horizontal, vertical & level and synthetic integration between all the above factors/elements and with software.
Here is the function with binary variable:

$$\mathrm{IntRoadEcSo}_{\mathrm{horverlevth3}} = \begin{cases} 1, if \quad x \ni [\mathrm{horverlevth3}] \\ 0, if \quad x \notin [\mathrm{horverlevth3}] \end{cases} \quad (3.10)$$

In which: *Road* is the VRA under the MOT; *other* is another major (such as environment, land...); *hor* is horizontal integration; *ver* is vertical integration; *lev* is level integration; *hhorver* is mixed horizontal-vertical integration; *h3* is horizontal, vertical, and level integration; *m* is the number of major or majors; *n* is the number of management levels in the same sub-sector; *y* is the number of levels of an integration type; *l* is the level of synthetic integration of the road traffic major; *With Following constraints:*

m,n,o,p > 0; min < horizontal, vertical, level links; mixed, synthesic integration< max; where, $Int_{horverlevh3}$→min =minimum integration (no integration yet, only connection/link > 0); $IntRoadECSo_{horverlevhhorverth3}$ max =>horizontal, vertical, level (mixed) and maximum synthetic integration, both hardware and software.

3.3 Multi-factor/criteria, multi-dimensional model of integrated road traffic safety

Similar to Maslow's hierarchy of needs, the 9-level model of integrated road safety policy is proposed in figure 8 as follows:

Figure 8.Integration model 9 level in road traffic safety policy

a) Multi-factor, multi-dimensional model of integrated road safety policy based on different dimensions of the factors/elements of the general model shown in figure 8 above:

Onedimension/1stdimension basic level has no connection or link. The system's elements are still fragmented: not yet horizontally or vertically integrated; not yet integrated in space, time, and level; not yet sustainable.

Twodimensions integration (link) includes integration: horizontal-vertical, time-space; horizontal-level, vertical-level, time-level, space-level, horizontal-space, vertical-space.

Threedimensions integration and linkage include: horizontal-vertical-level integration; integration of time - space-level.

Fourdimensions integration includes: mixed horizontal - vertical - level-spatial integration.

Fivedimensions integration includes: mixed horizontal - vertical - level - time- space integration.

Sixdimensions integration includes: mixed horizontal-vertical - level - time-space and hardware integration.

Sevendimensions integration includes: mixed horizontal - vertical - level - time-space and software integration.

Eightdimensions integration includes: mixed horizontal - vertical - level - time-space integration of hardware, software and

Ninedimensions integration includes comprehensive integration of all the above types, including with other types of transport means/with other ministries and branches. Integrated policy of theoretical but also ideal sustainability. Six or more dimensions can change the position of the integrated dimensions in certain cases, not necessarily in a rigid order from bottom to top.

b) Criteria and indicators on road traffic safety

Criteria and indicators for road traffic safety are introduced in table 2.

Order	Factors/Criteria	Indicator
1	Road infrastructure	Kilometers number of expressways and main roads Kilometers of high quality, maintained roads Number of traffic accidents/10^4 km of road The number of black points according to the road system Traffic accidents by road system and road type Traffic accidents by province and city Number of traffic safety equipment currently available on road infrastructure
2	Road vehicles	Number of road vehicles by type Total number of registered road vehicles Total number of inspected road vehicles Number of traffic accidents by type of road vehicles Number of traffic safety equipment on the road
3	People	Driver, assistant driver; driver and assistant driver management Road traffic participants Road passengers State management of roads Road business management
4	Environment	Natural geographical environment according to terrain The social environment; urban and indoor environments Natural disasters; climate, weather Combining 2 or 3 elements of infrastructure, road vehicles and people

5	General criteria	Number of traffic accidents, number of traffic accidents/10^4 people Number of deaths (person); Number of deaths/10^4 people; number of deaths/10^6Pax.Km; number of deaths/T.Km Number of injured people (person) Damaged assets (VND, USD), losses in % GDP

Table 2. Factors/criteria and indicators for road traffic safety
Source [Compiled by the author]

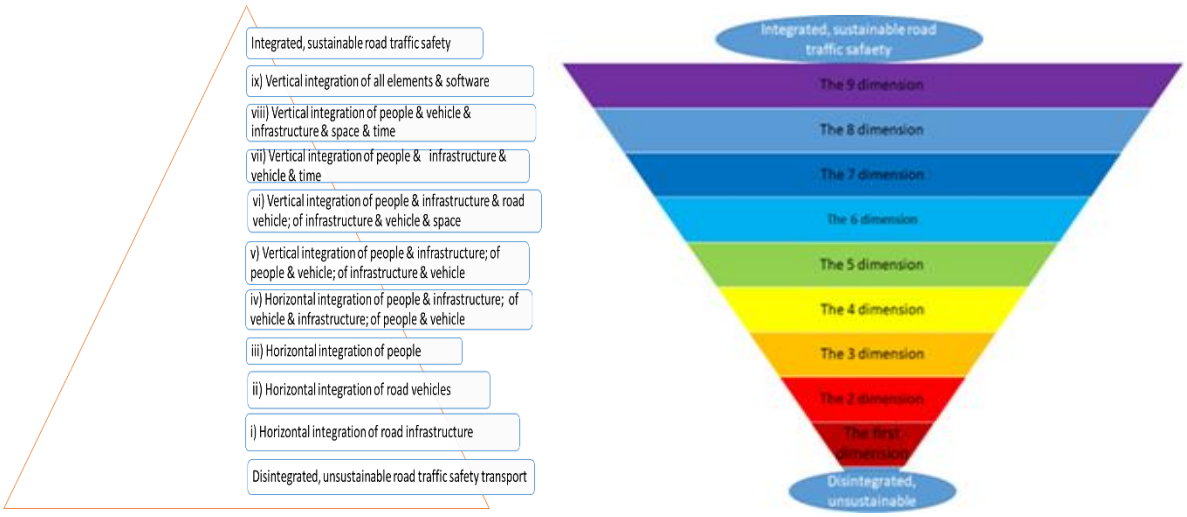


Figure 9a.Nine-degrees ladder tower model and 9b. Nine multi-dimension tower

Figure 9a introduces the 9-level ladder tower model applied [12,14]. Figure 9b develop multi-dimension tower by author.

Explanation of figure 9b with modified ladder by author:

c) Specific application to the road safety policy: from the above general model, applied to the development of road safety policy, the system's elements have not been integrated (possible connected/linked) with 5 separate factors/criteria: road infrastructure, road vehicles, road transportparticipants and a combination of two or three of those factors or factorsthat have not been determined.

When the policy was first developed, it was not possible to have an integrated policy right away, but only connected and linked elements of road safety such as: road infrastructure, road traffic vehicles, people; link/combine 2 or 3 of those elements.

- *First dimension:* the factor/criteria have not been integrated/linked, are still fragmented and not sustainable.

- *Two dimensions* connection/integration/2^{nd} dimension: between road infrastructure and road traffic vehicle; between road infrastructure and road transport participants; between participants in road traffic and road vehicles; between the road systems national road-NR, provincial road, district road,

communal road, urban road and specialized road; between types of road traffic vehicles; among road traffic participants.

- *Threedimensions* integration (linkage): horizontal-vertical and level, for example between road infrastructure, road traffic vehicles and road traffic participants (drivers, road traffic operators, workers on repair and maintenance of road infrastructure).

- *Fourdimensionsintegration* between 3 factors (or some indicators belonging to the above 4 factors), for example between road infrastructure, road vehicles, road traffic participants and the 4th factor or space; between organizations under the VRA-MOT (horizontal integration- coordination, vertical direction-reporting up, direction down), under the provincial DOT or territorial level (space).

- *Five dimensions integration*, for example between the road infrastructure, road vehicles, road traffic participants (or one/two indicators of the above 3 factors), in space (provinces, cities, territories), and over time as coordinate/cooperate schedules, operating charts; train and road vehicle operating charts.

- *Six dimensions integration*, in addition to the elements/criteria of 5 dimensions integration, there are additional hardware (physical) elements/criteria such as sections of transport route, at-grade and different-level intersections, stereoscopic intersections, transfer station, transporting of goods and passengers; terminal; O, D points; ICD, TOD terminal.

- *Seven dimensions integration*, in addition to the 5 dimensions integration factor, there are additional software criteria/indicators institutions: organizational structure, people; policies, mechanisms for integration.

- *Eight dimensions integration*, in addition to the 6 dimensions integration mentioned above, there is additional software integration.

- *Nine dimensions integration* includes comprehensive integration of all the factors/indicators mentioned above and integration of road infrastructure, road vehicles, people in the specialty, the entire transportation sector and/or with other industries (especially other sectors) related economics and techniques such as land use, environment, irrigation, planning and investment, finance; national defense, security...).

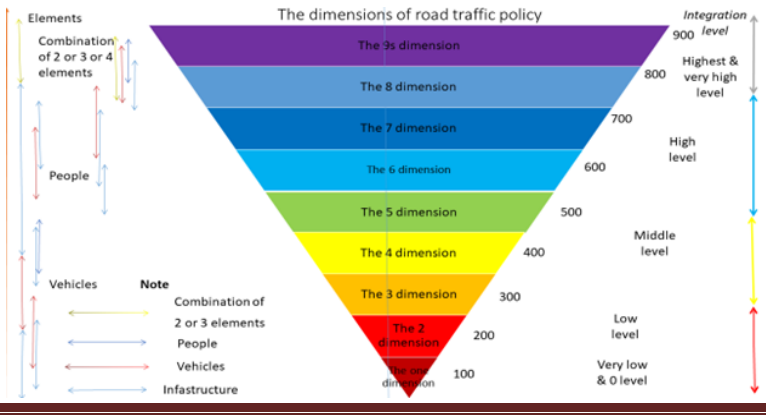


Figure 9c. The integrated tower with 9 dimensions

Figure 9a,b,c introduces the integrated tower according to the multi-dimensional model developed by the author.

Explanation of figure 9c:
Regarding space: transport routes, stations, stops, transfer points, terminals of urban public transport; bus stations and road infrastructure for passenger transport services (including inter-provincial passenger transport), especially at bus stations and TOD points; transit/transshipment point, ICD for transportation services at international airports, gateway seaports, international transshipment, IWT ports.

Regarding level: institutional-software integration (management organization, policy, mechanism); fares, tickets, terminal fees; customer service information system; information between agencies and organizations related to traffic safety on the road; information about route networks, cargo flows, and passenger flows; vehicle company owner, consignor, consignee...

About time: bus, coach, train schedules and itineraries; customs inspection, import and export of goods; immigration of passengers and other people; congestion, traffic safety on the road routes, at intersections....

When placing (combining) the integration levels into a scale from 0 to 900, divided by level from very low to highest, it is can see: very low to low level from 1-300; the average level is from over 300 to 600; highs from above 600 to 800; the highest level is about 900 (points). This assessment level is similar to a scoring scale in many cases, but represents the integration between factors/criteria within the same level (horizontal integration), different levels (vertical integration), and in space (between provinces, cities, regions, countries...), integrating a mixture of factors and over time. Thus, the higher the level of integration and the assessed score, the policy managers only have to "use the invisible means/hand, with little intervention" to influence factors and integrate elements of road traffic safety.

d) Solutions that integrate road traffic safety elements/criteria and reduce traffic accidents
In policy formulation and implementation, both at the lead agency and organization, and at the coordinating agency and organization, integrated solutions are implemented at the following levels:

- *Horizontal integration:* between the Ministry of Transport-MOT and the Ministry of Public Security; ministries, organizations in the NTSC; between agencies and organizations in the VRA (between departments and road management districts in VRA); between types of road vehicles like long-distance run and short-distance run vehicles; between large tonnage and medium/small tonnage vehicles; between truck vehicles and passenger vehicles; time coordination (operating chart/running chart) between two or more types of vehicles at one location such as between intercity buses and urban buses; between type of road transport and other types of transport means (railway, sea).

- *Vertical integration:* between the NTSC and the Provincial Traffic Safety Board; between the MOT and the Provincial People's Committee/ People Assembly; between the VRA and the lower level agencies and organizations of the VRA (road management districts -road management sections in VRA); transport corporation-transport company-transport enterprise); VRA- provincial DOT-district transport department...

- *Mixed horizontal and vertical integration:* on the transport route, there is integration between transport service businesses operating on the route and management agencies; integration between logistics businesses and loading and unloading businesses, warehouses, and shippers/receivers; between passenger enterprise and the bus station management board/company to cooperate, coordinate operating charts, assign operating hours, sell tickets, and let vehicles, passengers enter and exit the station; integration of ticket prices, fees, entrance and exit fees to bus stations and ports.
- *Integration of levels:* 3-level models can be applied with poor, average, good; 4 levels with poor, average, fair, good; 5 levels: poor, low average, average, good, very good; and 7 levels: very poor, poor, average, above average, good, very good, extremely good. In this paper, the 5 levels are chosen. And combined with the 0-900 scale mentioned above according to expert opinions/survey results. Thus, the results will be more objective, suitable, and feasible.

- *Mixed integration at intersections and terminal points:* regarding hardware, trains and vehicles are allowed to run directly, without having to stop to transfer goods and passengers. Regarding software: assign the organization and management unit to maintain and repair intersections and O-D points; clearly define functions and tasks; assign the presiding agency, coordinating agency and regulations for coordinating the management of route sections, intersections and points.

- *Regarding hardware:* building road routes like expressways, upgrading national highways, upgrading from provincial road to national road and vice versa..., urban bypasses, intersections at different levels, interchanges, overpasses, tunnels underground on main routes and urban trunk roads. Separating lanes for bicycles and non-motorized vehicles in sections with allowable road surface width. Organize traffic on the route where traffic accidents, traffic congestion, and environmental pollution often occur.

- *Regarding software:* build a new/rebuild organizational structure, reorganize existing agencies with a management apparatus with clearly defined functions and tasks according to the mechanism: clearly define the mechanism lead agency and coordinating agency, coordination regulations, specific responsibilities of each agency and organization, including when performing well and when not performing well/not completing tasks or works.

- *Mixed integration of time and space:* build and publicly announce the operation chart of passenger transport, inter-provincial or long-distance passenger transport; clarify responsibilities when not implemented well, without close and effective coordination and cooperation between agencies, organizations and businesses.

- *TOD for public transport:* Integration in the TOD area-according to public transport orientation, is integration between pedestrians and types of traffic such as bicycles, motorbikes, public transport

means of road traffic. Determine priority order: i) pedestrians, ii) bicycles (including electric bicycles and bicycle sharing); iii) motorbike/motorcycle sharing; iv) public transport by road. Arrange and classify entrances and exits to the TOD area for people (including people with disabilities) and road vehicles, ensuring traffic safety and order in the area, not causing traffic congestion.

- *ICD, transit points, post-port logistics for transport:* organize and classify traffic routes for the road, IWT, sea, and railways at these points; loading and unloading, warehousing; sorting, distributing and collecting goods; packing, arranging and classifying goods; arrange space for container repair, transportation, loading and unloading; import-export and customs procedures for imported, exported and transited goods.

- *Integrating software and institutions:* innovating, reorganizing, and more boldly reforming the organizational structure, building new policies on organizing the activities of some agencies such as converting the public transport management agency into integrated public transportation management agency. Collect and process traffic safety data, share information between domestic and foreign agencies, organizations and businesses.

Using appropriate methods, the author synthesizes assessments of the integration of factors/criteria for traffic safety on the road in 2024 and forecasts for the years 2030 and 2050. The results of the integration are introduced in Table 3.

TT	Integration\ Year	2024		2030		2050
		Point	Rank	Point	Rank	Point
1	Between road infrastructure and road vehicles	7.0	VH/770	7.42	VH/780	9.25
2	Between road vehicles and people	7.5	H/740	7.67	VH/800	9.58
3	Between road infrastructure and people	7.75	VH/750	7.92	VH/790	9.42
4	Between road infrastructure & road vehicles & people	7.75	VH/760	7.83	VH/780	9.25
5	Between road infrastructure & road vehicle & people & unknown factors	7.08	H/730	7.75	VH/770	9.08

Table 3. Integration of elements of road safety in 2024, forecasts for 2030 & 2050 in Vietnam
Note: Points in 10 scale; rank in 900 points scale; VH: very high; H: high
Source [Compiled by the author]

Table 3 introduces a preliminary assessment of the level of integration between the elements/criteria constituting road traffic safety at the present time (2024), forecasts for 2030 and 2050 such as: between road infrastructure and road vehicles (7.0); between road traffic vehicles and road traffic participants-people (7.50); between road infrastructure and people (7.75); between road infrastructure and road vehicle and people (7.75); and between road infrastructure and road vehicles and undetermined factors (7.08). The table collects an expert opinions (Figure 9.c) on a 900 rating scale with very high ($800 < X < 900$) and high ($700 < X < 800$) levels. It can be seen from the table

that the current level of integration is quite high, at a high and very high level on a 10-point scale. By 2030, the assessment will have changes in scores, but in terms of rankings, it will hardly change. This assessment appears to be quite consistent with reality in terms of hardware integration, but software integration may not reflect completely correct or be close to reality. By 2050, it will almost reach very high levels. There will be further research to make adjustments when conditions allow.

e) Assess the losses/effectiveness of proposed solutions

Similarly, according to estimates, applying integrated solutions to road traffic safety policies can annually reduce the number of deaths and injuries by at least 6-10% (the target of NTSC-National Traffic Safety Committee, is 5-10%/year in transport sector). By 2030 there will be a 50% reduction compared to 2020 in the transport sector) due to road traffic accidents, a decrease of ~ 0.1-0.3% of GDP if current damages account for about 1.3-1.5% of GDP. In this study, the author also applies the method of calculating human capital-HC losses for road traffic accidents. According to quick calculations, the effectiveness of the proposed integrated solution can increase by 0.1-0.3% of GDP and damage caused by road traffic accidents accounts for 0.8-1.2% of GDP by 2030 if integrated solutions are applying in road sub-sector. This is a very impressive and significant number, requires efforts from the entire transport sector, road sub-sector, people, society, especially road traffic participants.

f) Evaluate the feasibility of the proposed solution

It is very difficult to evaluate the effectiveness of the integration qualitatively of elements/criteria constituting the road traffic safety, but it can be evaluated quantitatively as follows: when applying one/several horizontal or vertical integrations, according to space or time, there will be clear results, for example at ICD or TOD, passengers and goods transfer points or on some transport route sections due to increased passengers number and goods throughput, shorten travel/delivery time; reduce traffic congestion, decrease environmental pollution (with measureable indicators), reduce the number of road traffic accidents cases, and number of deaths&injuries; and property damage due to traffic accidents compared to the same period last year/previous period. This needs further study in near future.

4. CONCLUSION

Traffic safety always receives the special attention of government leaders in many countries, including Vietnam. In our country, road traffic safety also receives deep attention from the state, the entire society and all agencies, organizations and individuals. The article used a universal and appropriate research methodology to overview foreign and domestic research, evaluate the current situation and integrate the factors/criteria that make up the road safety policy. Based on the analysis of the general model of the integrated level, using a systematic approach, combining qualitative and quantitative methods, the author builds a mathematical formula, multi-criteria, multi-dimensional model and proposes integrated policies and solutions for road traffic safety policy in Vietnam, preliminary assessment of losses, effectiveness and the feasibility of proposed models, policies. Horizontal, vertical, mixed and integrated solutions in the road transport sub-sector are being implemented, both in policy formulation and implementation. However, mixed integration and synthesized integration solutions have not been given due attention, especially in the organization

of software implementation of the policy. It is necessary to continue to implement the mechanism of cooperation, sharing, exchange of information and databases on road traffic safety in the combined with the completion of legal documents, and especially there needs to be effective coordination and comprehensive cooperation. Only between participating agencies, organizations and individuals can we reduce and limit traffic accidents and reduce the number of serious traffic accidents, especially serious in the field of road traffic safety policy.

We recommend that organizations advising on road traffic safety policies, advisory agencies, leaders of the NTSC, the MOT and relevant organizations pay more attention to consider and as soon as possible put into practice some research results. To limit and minimize road traffic accidents because they cause huge loss of life and property, reducing the direct workforce, thereby building specific programs and plans to implement and make policies. Road traffic safety is effective and feasible, contributing to the development of Vietnam's economy, improving people's and family's income and living standards, reducing traffic accidents, environmental pollution, and raising awareness of law enforcement among people participating in road traffic. That is the goal, object and at the same time the aspiration and desire of the entire society and many Vietnamese people.

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Appendix 1. Summary table of integration levels and criteria

Hull A. (2005*) Integration*:	John Preston (2012) *Integration*:
Information system on public transport	Public transport information system
Route network space of public transport modes	
Ticket prices of public transport	Public transport service
Infrastructure, public transportation price management and operators' operations	Public transport ticket price
Between passenger and freight transport	Between passenger and freight transport
Between public transport management authority	Between public transport management authority
Between public transport and land use planning	Between transportation and land use
Between transportation services and other service policies	Between transportation and education, health and social services
Between transportation policy and socio-economic development environment	Between transportation policy and socio-economic and environmental policy

Source [12, 14]

Comment: Both of the above studies provide 9 levels of urban public transport integration, however the criteria names are some different.